

category of *faux damas*, or "false damascening." The true damascened barrel can only be produced in one way, and that by forging, which will be briefly described. What may be termed the literature of this interesting process does not appear to be very extensive, for so eminent an authority as Dr. Percy, the late president of the Iron and Steel Institute, in his *magnum opus*, "The Metallurgy of Iron and Steel," discusses the subject in very few words, and reserves all his admiration for what may be called the "acid process" of damascening, as practiced by a well-known West End gun maker, while he ignores almost entirely the effects produced by the mode in which the iron and steel fillets are forged, and as they subsequently appear in the real Damascus blade or gun barrel. This arises probably from the fact that the "damas" industry has been almost exclusively confined to one or two foreign countries, and, in consequence, perhaps, it escaped the great metallurgist's notice. In the main there are three processes in the manufacture of damascened gun barrels, viz., parallel fillets or ribbons of iron and steel, torsional, and mosaic. The torsional process seems to be the one most in vogue at present, and it is possible, it appears, to vary the patterns almost *ad infinitum* by a particular arrangement of the sizes and forms of the wires and fillets which enter into the damascened rod or *masse*. The accompanying illustrations are exact *fac-similes* of two of these rods, which form the basis of various popular patterns of gun barrels. No. 1 gives a



No. 1.



No. 2.

view of a number of exceedingly thin layers of iron and steel, the dark lines representing the steel, and the lighter ones the iron.

In the second view, the mass, it will be perceived, contains 81 squares, the darker ones being composed of steel and the lighter ones of iron. Out of this is made the well known Bernard "damas," while out of the material represented by No. 1 are forged the numerous varieties of plain striped damascened barrels produced by the Belgian makers, the closeness of the stripes as they appear in the twisted barrel being determined by the distances separating the iron from the steel fillets in the original rod. The common, or sham, damascened barrel is composed of a plain ribbon of iron or steel hammered into the shape of a gun barrel on a mandrel, the stripes or wavy lines which afterward appear on the surface being produced by certain acids, which help to bring out the natural fiber of the material, just as the grain of wood is brought out by polishing. By means of the rods represented in the second engraving, much finer patterns of the "damas" are produced than can be had from either of the foregoing processes.

In nearly every instance, however, the workman engaged in the "compilation" of the materials which enter into these rods has his own special sets of patterns, and none other than these will he attempt to produce. Those who are acquainted with the various patterns have no difficulty in ascertaining the forge from which the barrel has emanated, and, as in other branches of the small arms industry, the secrets of the handicraft are transmitted from father to son. The steel is bought in Germany and in England, the iron coming both from England and Belgium (Lowmoor iron and Bessemer steel are said to be much used, and good scrap, like old horseshoes, is in request for the stub or commoner barrels). The materials of which the *masse* is composed are handed to the barrel maker in the first instance, and by him arranged either as shown in the illustrations or in any other way necessary for the production of the pattern which he desires to produce. Sometimes they are inclosed in a thin casing of sheet iron or merely bound together with wire.

They are then sent to the rolling mills, where they are heated and drawn out by the rollers into long strips or rods about  $1\frac{1}{2}$  inch square. These strips are reheated and again drawn out in rods several yards long—according to the requirements of the barrel maker—and are generally from one-fourth to three-eighths of an inch square. The strips thus obtained constitute the "damascus." If the object be a finer quality, or a further variation of the pattern or design, the *baguettes* or "fagots" are again heated red hot, hammered together at the ends, and twisted each in a reverse manner to the other, the object of this counter twisting being to secure a more elaborate but still regular pattern. The threads running through the "fagot," though further mixed and twisted by this treatment, still retain their individuality in the mass.

Among the Liège makers five patterns are said to be in especial request, namely, the "Bernard," "Clou," "Turc," "Boston," and "Crolle." For the "Damascus Bernard" (first introduced by Messrs Bernard, Paris) it is necessary to have eighty-one rods (really wires) of iron and steel (see No. 2) superposed one above another in nine different lines. The iron wire is 14 millimeters square, the steel 12 millimeters, but when welded and drawn out, the rod thus formed is only  $8\frac{1}{4}$  millimeters square, and is cut into lengths of 50 centimeters. The "Damascus Clou" is made in a somewhat similar manner, except that the number of iron and steel wires entering into the *masse* is only twenty-six instead of eighty-one. In this case the iron wire is 12 centimeters wide by 6 millimeters thick, and the steel 12 by 4 millimeters. The mass is also cut in lengths of 50 centimeters, and drawn out to a thickness of  $7\frac{1}{2}$  millimeters. The "Damascus Turc" is nearly similar in character to the "Clou," with the exception that a finer quality both of iron and steel is used, and that the steel wire or thread is  $4\frac{1}{2}$  millimeters thick instead of 4. The "Damascus Boston" is very similar to the "Damascus Clou," but is inferior to the latter. In the "Damascus Crolle" sixteen iron and steel wires are employed, the iron being 12 centimeters wide and 10 millimeters thick, and the steel 12 by 7 centimeters. Among the other patterns may be mentioned the "Zebre," the "Mineur," the "Moire," the "Ruban Anglais," the "Ruban d'Acier," etc. As a general rule, the more steel used in the "damas," the better the quality of the pattern.

All the damascened barrels are used for sporting guns; they will therefore be found in double-barreled breech loaders, and to a very much lesser extent in the single-barreled guns, probably not more than three or four per cent. of them being in the latter. There is said

to be a somewhat brisk trade going on between these little forges and the rolling mills in which the materials for the "damas" are prepared for the workmen. The cost of these materials (per 100 lb.) is somewhat as follows: Flat bars (steel), 2l. 4s.; square ditto, 2l. 8s.; flat bars (iron), 1l. 4s.; square ditto, 1l. 8s. The cost of reducing these rods at the rolling mills to the required dimensions is: For steel (per 100 lb.), 4s. 5d.; iron, 4s.; heating and rolling the mass for ribbon strips, 6s. 11d. to 8s.—*Ironmonger*.

### THE MANUFACTURE OF GUNPOWDER.

Prepared in part by FREDERIC H. ROBINSON.

THE manufacture of gunpowder consists essentially in mixing the three ingredients, sulphur, saltpeter, and charcoal, in such proportions that, when heat is applied, the whole becomes ignited, generating great heat, which expands the gases formed. The process is most complete when the substances are wholly converted into gases and vapors. The object is to have CO<sub>2</sub>, not CO, formed. The latter arises from incomplete combustion. The gases come from the combination of the C of the charcoal with the O of the nitrate of potash. The S facilitates the liberation of the O, combining with the metal, forming sulphuret of potassium.

Walking a few rods from the office of Du Pont's powder mills, Wilmington, Delaware, we entered the wood yard, where were great stacks of willow and poplar, part of which was already barked and stacked to dry. This wood, before being charred, is separated into two grades, the smaller of which contains mere branches, not more than an inch in diameter. For the manufacture of gunpowder the smaller wood is preferred, since it is easily charred, so as not to leave any O behind, this precaution being necessary in the production of good gunpowder; since if any O remains combined with H, so as to form water, such a large amount of heat will be absorbed by the water during the ignition of the powder that very little force will be given to the ball or shot. The coarse wood, mixed with the poplar, gives charcoal for blasting powder; since, though some of it be imperfectly charred, sufficient time is allowed such powder to undergo complete combustion before the expansion of the gases bursts the rock. A coarse-grained wood, as willow, is selected, because it requires but three or four hours to char it, while oak would consume a much longer time. All wood should be thoroughly dried before being charred.

In the coal house near by were five or six cast iron cylindrical vessels containing the wood which was being charred. These retorts are sunk in an iron platform to such a depth that their lids are about five inches above the floor. The retorts are about four feet in diameter. Each one has a copper pipe in the lid for carrying off the pyroigneous acid, etc., formed during the process. The fire is kindled under these vessels. Up to about 150° F. the product of distillation tastes quite like distilled water; as the heat increases it begins to assume the taste of burned wood. The H is not entirely driven off unless the wood is subjected to a very high temperature. The presence of H is an advantage in powder used in shotguns, as rapid combustion and the production of a high temperature are required. When the explosion takes place, the heat, produced by the combination of this H with the O of the niter, is very great. Hence the temperature for the charcoal for shotgun powder is raised to only 480° F., and kept at that point for three and a half hours. For cannon or blasting powder it is raised to 600° F.

When the wood is sufficiently charred, it is taken out of the retorts and placed in a room to be sorted. Here it is separated into three classes, one consisting of that which, from being in contact with the sides of the retort, has been too much charred. This class is distinguished by the very black, glossy surface. Another class, which has not been sufficiently charred, is of a light brown color. The third class, which is selected for shotgun powder, is of a reddish brown. It is, however, entirely unfit for rifle powder, since it would produce too rapid combustion.

Next is the saltpeter department. Here the saltpeter in the crude state is separated from its impurities. Common salt and chloride of potassium, on account of their property of absorbing moisture, must, as far as possible, be gotten rid of. In order to do this, about 20 tons of saltpeter are placed in a vat standing about 15 feet high, in which it is subjected to the action of a constant stream of water. In cold water the chlorides dissolve first and escape through a pipe at the bottom of the vat. After several such washings the saltpeter is, to a great extent, freed from the common salt. The vat is shaped like the inverted frustum of a cone, and revolves about an axis. Six or eight feet from the vat is a large tank, so placed that about four feet of it stand above the level of the floor. When the salt has been separated, the contents of the wooden vat are emptied into this copper tank and dissolved in hot water. About two pounds of glue are dissolved in 200 pounds of cold water. This solution also is thrown into the tank. By stirring with a long rod the contents of the tank are thoroughly mixed. The cold solution of glue, chilling the niter, causes it to settle, while the glue rises to the surface, clearing the niter of mechanical impurities. It may be necessary to repeat this operation. If so, a weaker solution of glue must be used, since the niter, being partly crystallized, would have a tendency to adhere to a strong solution. When this operation is completed, the niter is removed from the tank to a long wooden trough and dissolved in hot water. The solution is kept stirred so as to cause the niter to subside in minute crystals, thus avoiding the presence of the mother liquor, which, were large crystals formed, would, by capillary attraction, remain in their seams.

The niter, when deposited, is removed from the mother liquor and placed on a platform to drain. It is then washed to rid it of all the mother liquor. For this purpose it is placed in perforated wooden boxes, and distilled water is poured upon it. This water soaks through the mass and escapes through the bottoms of the boxes. At this point the purification, as far as chemical impurities are concerned, is ended. From the boxes it is removed to the drying mill. It is spread on a circular floor about 20 feet in diameter, and over it passes a large number of rollers. Alternate with these rollers are plows or scrapers which keep the niter stirred. The water is evaporated by heat, communicated to the bottom of the floor. When

thoroughly dried, which requires several hours, the niter is passed through fine sieves.

The charcoal and sulphur are ground together. The two substances are placed in barrels in proper proportions. These barrels have horizontal shafts passing through them from end to end, about which they revolve. There are about a dozen of these barrels on one shaft, and in each barrel is a number of malleable iron balls. As the barrels revolve, the balls, falling about, crush the charcoal and sulphur to the proper degree of fineness. The pulverized mixture is passed through a sieve to remove the coarse pieces of charcoal.

From this mill the powdered charcoal and sulphur are taken to the incorporating mill, where they are mixed with the proper proportion of the prepared saltpeter. The mixture, together with a number of zinc balls, is then placed in barrels made of buckskin stretched on frames. These barrels are driven in a manner similar to that in which those used in crushing the charcoal are driven. Since there is a small amount of moisture in the ingredients, it is necessary, while the barrels are revolving, that care should be taken that the powder does not adhere to the sides. If it should, the accumulation of the powder might hold the balls in its mass, forming, as it were, a fly wheel. In order to prevent this accumulation, the sides of the barrel are struck with a wooden mallet. The operation going on in the barrels is for the purpose of producing a homogeneous mixture of the three ingredients.

When thoroughly incorporated, the powder is taken to a building where it is mixed with water—in winter  $3\frac{1}{2}$  per cent., in summer 4 per cent.

The powder is then ground. It is so spread over the bed of the mill as to cover it to the depth of two or three inches. There are two large cast iron edge wheels, each weighing eight tons. These, which are driven by an upright shaft, move over the powder, grinding it to a high degree of fineness. There are at one time only about 100 pounds of powder in each of these grinding mills, so that if an explosion should occur in one of them, injury to the neighboring mills would be avoided.

After being ground, the powder is removed to the pressing mill, where it is subjected to a pressure of 2,000 pounds to the square inch. After being pressed it is very hard, and in the form of square cakes about two feet square and one inch thick. These are passed between rollers upon which are cogs of bell metal. This is merely preparatory to the granulating operation, which consists in passing the broken cake through rollers. These rollers are placed at a distance from each other varying according to the size of the grain to be prepared. As the powder passes between them it falls upon a series of sieves. The part which passes through the first sieve falls upon another, which retains the proper sized grains, allowing the rest to pass through. That portion not sufficiently fine is again passed through the rollers. That which is too fine is returned to the mill to be again pressed.

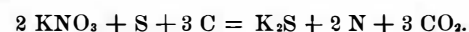
The next operation is the glazing of the grains. The powder is placed in barrels. As the barrels revolve upon horizontal axes, the friction of the grains against each other leaves the powder glazed and ready to be dried. For this purpose it is placed in bags and taken to the drying house. In a room is a framework, upon which the sieves containing the powder to be dried are placed. After remaining here about eleven hours, it is removed to another building, where it is packed, and from which it is shipped to the various markets.

### DISCUSSION.

The following summary of results concerning the explosion of powder and the chemical reaction which occurs during the process was presented by Mr. J. W. Redway.

The explosion of powder is nothing more than the ordinary phenomenon of combustion—that is, the combination of carbon with oxygen to form carbon dioxide. The only difference is that in ordinary combustion the oxygen occurs diluted with four times its volume of nitrogen. In the combustion of gunpowder, not only is the oxygen undiluted, but it is chemically compressed to about one three-hundredth part of its normal volume. This is the secret of the dynamics of a gunpowder explosion. This is why a gunpowder explosion develops a force so much greater than one of carbon "dust" or of coal gas.

The average gunpowder consists of about 75 parts of potassium nitrate, 12 of sulphur, and 13 of charcoal. This corresponds nearly to the chemical formula:



This has long been considered the chemical reaction of the explosion. The real reaction, however, is far more complex.

A number of analyses of the residues of explosion or combustion, made in part by the writer, he having undertaken the investigation of the solids, showed the following average results in round numbers. These analyses closely confirmed the results obtained by Abel and Noble.

SOLIDS.	
Potassium carbonate.....	0.55
do. sulphate.....	0.15
do. hyposulphite.....	0.20
do. sulphide.....	0.07
Ammoniacal and other products.....	0.03
	1.00
GASEOUS.	
Carbon dioxide.....	0.49
Carbon monoxide.....	0.09
Nitrogen.....	0.36
Hydrogen sulphide.....	0.04
Other products.....	0.02
	1.00

There is much variation in the composition of the solid residues, even when the powder is ignited in a vacuum, but inasmuch as powder is composed of elements of strong affinities, a low uniformity of the percentage of products might be expected. The composition of the gaseous products is more uniform than that of the solids.

The volume of the permanent gases reduced to normal tension (one atmosphere) and temperature is from 275 to 290 times the volume of the powder. If the cham-



ber containing the powder is entirely filled, the tension of the liberated gases varies from 31 to 37 tons per square inch, the theoretical pressure being about 42 tons per square inch, with the gases reduced to normal tension and temperature.

But the temperature of the elements at the time of explosion may be safely estimated at 2,200° C., and therefore the volume of the liberated gases will exceed the values already noted, being nearly eight times as great theoretically.

Practically all of these values must be taken with more or less allowance, as all analyses, physical, chemical, and dynamic, demonstrated that inconstancy of result was one of the most noticeable factors.

The explosion of nitro-glycerine is wholly unlike that of gunpowder. The latter is reaction and combination; the former, molecular disintegration.

A molecule of glycerine, a very stable substance, may be represented by the formula  $C_3H_5O_3$ . If, however, we allow a fine stream of glycerine to trickle into a vessel containing red, fuming nitric acid, it undergoes a remarkable change. The atoms of hydrogen are dropped, and in their place the glycerine takes up three molecules of a nitrogen compound having the composition  $NO_2$ . The glycerine, in other words, has become nitro-glycerine, and has the formula  $C_3H_5(NO_2)_3O_3$ , and it is marked by extreme instability. It is like a boiler with a pressure the merest trifle below the bursting point—a slight percussion, and the bands are broken. There is no combination of atoms in the nitro-glycerine explosion. The molecule merely falls to pieces. It does so *instantly*, and nine hundred volumes of gaseous products, chiefly carbon dioxide and nitrogen tetroxide, resume their normal condition. In other words, the gaseous products have nine hundred times the volume of the nitro-glycerine. This, together with the instantaneity of the explosion, may explain why nitro-glycerine is so much more destructive in its effects than black powder.—*Proceedings of the Engineers' Club of Philadelphia.*

#### HIGH EXPLOSIVES AND HIGH EXPLOSIVE PROJECTILES.

In the last volume that has been issued by the U. S. Office of Naval Intelligence (General Information Series, No. VII.) is a paper on the above subject by Lieutenant C. E. Vreeland, of the U. S. N.

Melenite, so Lieutenant Vreeland says, is believed to be a mixture of fused picric acid, in granules, with trinitro-cellulose dissolved in ether. It was originally invented by M. Turpin; but the French government is declared to have so much improved upon M. Turpin's compound that the inventor would scarcely recognize the substance that is now used in France. The original secret is purchasable by any government that may choose to buy it, and it is reported to have been already acquired by the Elswick Ordnance Company. According to "Le Manuel du Dynamiteur," by M. Max Dumas-Guilin, the explosive force of melenite is only three times that of gunpowder. Less authoritative statements set it down as from five to seven times that of gunpowder, but the recent French experiments with the old iron-clad *Belliqueuse* seem to conclusively establish the approximate correctness of M. Dumas-Guilin's estimate. The effect of a shell charged with melenite striking against the armored part of the ship was inconsiderable. On the other hand, shells that struck the unprotected parts are said to have caused terrible havoc. These results, so far as is known, agree with the results which have been obtained at Portsmouth during the experiments on her Majesty's ship *Resistance*. Many French naval experts are now, in consequence, advocating a reversion to the old system of giving a battle ship something like complete armor; and it is now no secret that the construction of the battle ship *Brennus* and the cruiser *Dupuy de Lome* has been modified in accordance with their views. The French have succeeded in safely firing melenite shells from guns that give a muzzle velocity as high as 2,000 ft. per second, and shells containing 70 lb. of melenite have repeatedly and without accident been thrown from an 8½ in. mortar with a muzzle velocity of over 1,300 ft. per second.

Roburite, the new German high explosive, belongs, says Mr. Vreeland, to what is known as the Sprengel class—that is, to the class of explosive mixtures of two substances, neither of which by itself possesses explosive qualities. In the case of roburite both these compounds are solids, and the resulting mixture has a sandy, granular appearance somewhat resembling common yellow sugar. It has been experimented with at Chatham under the direction of Major Sale, R. E., and these experiments have substantiated some, at least, of the claims which its inventor, Dr. Carl Roth, makes on behalf of it. He claims (1) that the two components are perfectly harmless and inert separately; (2) that even when mixed or ground together in an ordinary coffee, cement, or flour mill, the mixture cannot be exploded by friction, percussion, or the application of flame; (3) that, when detonated, roburite produces neither spark nor flame; (4) that it produces very little noxious gas; and (5) that it is not subject to deterioration through climatic variations of temperature. It should be kept dry, but even if it become damp its strength can be safely and perfectly restored by the application of heat. Experiment proves that it is stronger than any known picric powder, that in some respects it is more powerful than dynamite, and that, owing to the safety with which it may be handled, it is eminently fitted for use as a bursting charge for shells. But it does not seem to be as yet established that it is adapted for submarine mining. A roburite factory has been founded under government sanction in Germany, and the establishment is at present capable of turning out about two tons a day.

Bellite, a new Swedish high explosive, owes its discovery to Mr. Carl Lamm, managing director of the Rotebro Explosives Manufactory, near Stockholm. It is stated to consist of ammonium nitrate and di-nitro-benzol, which, when melted together at a temperature of from 176° to 194° Fahr., are mixed with saltpeter, and form a compound of which each molecule is explosive. It is in a granulated state that it appears to be best adapted for military purposes. It then has a specific gravity of from 1.2 to 1.4, and may be fully exploded by the aid of a small quantity of fulminating mercury, even if it be confined only by the pressure of a thin sheet of tin. When pressed into hard cakes, it

needs a stronger impulse and stronger confinement; and the covering, whatever it may be, must, moreover, adhere to the cake. Heated gradually in an open vessel, bellite begins to evaporate at a temperature of 302° Fahr., and the rapidity of evaporation increases as the temperature rises, but no explosion occurs. Heated suddenly, bellite burns with a sooty flame; but, if the source of heat be removed, combustion ceases, and the substance assumes a caramel-like structure, the composition remaining as before, save that the proportion of saltpeter is somewhat reduced. Bellite can withstand blows, fire, friction, and vibration without being exposed to the slightest risk of explosion, and it may be stored without danger of spontaneous combustion. Exploded in a submarine mine, it gives, at a distance of 17 ft., a blow 10.4 per cent. greater in force than is given by gun cotton under similar conditions. At a distance of 12 ft. 6 in. the superiority of bellite increases to 15.2 per cent. This seems to specially fit it for use not only in mines, but also in torpedoes.

Carbo-dynamite is a recent British invention which owes its origin to Messrs. W. D. Borland and W. F. Reid. The base is nitro-glycerine and the absorbent is carbon. It is as cheap as ordinary dynamite, but it is alleged to possess several advantages over it. For example, it has much greater explosive force, seeing that 90 per cent. of the compound is pure nitro-glycerine, and that the absorbent itself is highly combustible. In addition, it is claimed that, when the dynamite is wet, no exudation of nitro-glycerine takes place from the absorbent. It is even declared that some carbo-dynamite which had lain for eight months in water presented at the end of that period the same appearance as when first immersed, and had suffered no deterioration of its explosive qualities.

Graydonite is the invention of Lieutenant James Weir Graydon, late of the U. S. N., who in 1886-87 conducted, first in California and afterward in Russia, a series of experiments with the Graydon dynamite shell. This he succeeded in firing, with some degree of success, from a 6 in. rifled gun that was loaded with a mixture of 11 lb. of dynamite to 37 lb. of powder. Mr. Graydon claims for graydonite absolute freedom from danger in handling and transportation, a destructive power from 400 to 700 per cent. greater than that of No. 1 dynamite, and suitability for military and naval uses. Particulars of its composition have not been made public. Since the conclusion of the experiments in Russia, the Ordnance Board of the United States Army has assisted at further experiments with the Graydon dynamite shell at Sandy Hook. The Graydon method of charging the shell consists in subdividing the bursting charge of dynamite into small pellets, each of which is inclosed in a separate envelope and treated with paraffin. The interior of the shell is previously lined with asbestos. Explosion is secured by means of a detonator, which acts upon impact. The great advantage of the shell is alleged to be that it can be fired from any service gun with the ordinary service charge of powder. At the Sandy Hook experiments a 7 in. Ames wrought iron muzzle-loading rifled gun was used, with a powder charge of 23 lb., and with a steel service shell that weighed, with its charge of 2.3 lb. of No. 2 dynamite, about 122 lb. The target was a section of wrought iron turret, made up of two 7 in. plates, so as to give a total thickness of 14 in. The target was, however, not a new one. It had been indented by previous practice, and several cracks in its surface were noticeable. Three shells were fired at, and burst on, the surface of this target. The third round penetrated the first plate, seriously bulged and cracked the second, and had a generally disruptive effect upon the turret. Next day four rounds were fired, two at a wooden target a mile away, and two seaward. All the shells were fired. The first shell burst prematurely 300 yards from the gun, the second burst at or beyond the object, the third did not burst, the fourth burst prematurely at 1,000 yards. These results were not satisfactory. Later in the day the liability or otherwise of the dynamite to explode on being fired into with small arm projectiles was tested. This experiment was also unsatisfactory. The compound exploded on being struck at 50 yards by a Springfield rifle bullet. Yet it was something to have shown that the dynamite shells could be successfully fired from an ordinary gun, and were capable of inflicting serious damage upon a somewhat heavily armored target.

The Smolianinoff explosive has also been experimented with in America during the past twelve months. The composition consists of 80 per cent. of nitro-glycerine combined with a certain fluid, the nature of which is a secret. The target was similar to that which was used in the Sandy Hook Graydon experiments. A 100 pounder Parrott gun was employed, and three shells were fired, the first two weighing 69 lb., carrying 4.6 lb. of Smolianinoff explosive, and the third weighing 82 lb., and having a 4.1 lb. bursting charge. The firing charge in each case was 18 lb. of Du Pont powder, the range was 101 yards, and the muzzle velocity was about 1,490 ft. The first shell was not fired. It struck the target and broke up with a low explosion, doing only superficial damage. The second shell was fitted with a detonating percussion fuse. It struck the target, exploded with much more force than had been developed by the unfused shell, did some surface damage, and badly injured the target's foundations. The third shell produced much the same results. No damage was done to the gun, and the weakness of the cast iron shells which were used, as well as the shape of the heads, which were suitable only for a nose fuse, was held to be mainly responsible for the unsatisfactory nature of the experiments. These, we hear from other sources, are to be repeated under more favorable conditions.

The Snyder explosive has recently been tested, with very successful results, in Turkey. It consists of 94 per cent. of nitro-glycerine and 6 per cent. of a compound of collodion, gun cotton, camphor, and ether; and it is exploded by mere percussion against any hard body. It is, nevertheless, said to be safe to handle. The gun employed was a 6 in. rifled piece. The target, 220 yards away, was composed of twelve 1 in. steel plates, welded together and backed with 12 in. and 14 in. oaken beams. It measured 14½ ft. by 4½ ft., and weighed more than 20 tons. The charge of Snyder explosive was 10 lb. The target was utterly destroyed at the first shot, and nine other shots were fired without accident of any kind. This explosive, which is the invention of Mr. F. H. A. Snyder, of New York, appears to have an important future.

Gun cotton shells have, since 1885, been extensively

experimented with in Germany. In 1883 Herren Von Forster and Wolff, of the Walsrode gun cotton factory, in Hanover, took out two patents—one for a process of preserving gun cotton, the other for the construction of a shell to be charged with that explosive. Preservation is attained by steeping either wet or dry gun cotton in ether or nitro-benzol for from 15 to 20 seconds. This causes a hard, impervious film to form on the surface of the cotton. The film does not interfere with the explosive properties; but it prevents decomposition and loss of consistency and humidity. The shell was never tried; but in 1885 a new patent was taken out for a system of filling which could be applied to shell of service pattern. Wet gun cotton compressed disks are cut up into prismatic grains, and to these are added about 200 grammes per charge of dry gun cotton. Space being reserved for the fuse and detonator, melted paraffin is poured over the charge, which is protected by the preservative film, and the whole, as it cools, forms a solid mass. The fuse is similar to the German service percussion fuse of 1873. The fulminate capsule is immediately surrounded by ten grammes of dry gun cotton, and is protected from shock by India-rubber rings. The shells are stored filled, but not fused. Early experiments were not satisfactory, and certain changes were made, especially in the arrangement of the capsule. Since then more than 200 shells have been fired without accident, and with complete explosion, from the 3.4 in. gun; and 35 lb. charges have also been fired from the 5.8 in. gun and 100 lb. charges from the 10.9 in. mortar, with equally satisfactory results. Quite recently Mr. Von Forster has further improved his fuse, and experiments have been continued with an 8.1 inch Krupp gun, a 48 lb. charge of powder, and a projectile weighing 220 lb., and filled with 2 lb. 3 oz. of gun cotton. The initial velocity was about 1,410 ft. per second. The target was a compound 4.6 in. plate, measuring about 39 in. by 78 in., backed by 20 in. of oak. Four yards in rear of the target was a palisade of pine stocks supporting an earthen wall over three yards thick. The shell perforated the plate, backing, and palisade, and burst only after entering the wall of earth. The performance was, therefore, very satisfactory, for the weak point in many high explosive shells is that they have a tendency to burst too soon after impact.

The general effect of the dynamite shells which were fired toward the end of last year from the Zalinski pneumatic gun at Fort Lafayette, in New York harbor, was made public at the time. The details did not appear. They are now given at length. The shells used were each charged with 50 lb. of blasting gelatine and 5 lb. of No. 1 dynamite, and their gross weights varied from 136 lb. to 137 lb. The target was the old government schooner *Silliman*, which was moored with her stern toward the firing point, and distant 1,864 yards therefrom. The schooner was 79 ft. long and 22 ft. in breadth, and had a depth of 8 ft. 6 in. A trial sand-loaded projectile was first fired in order to get the range. It struck 24 yards to the right and 27 yards short of the vessel. The second shot entered the water 8 yards to the left and 10 yards short, but for some unexplained reason did not explode. The third struck a little astern and on the starboard quarter of the schooner, and exploded under water, breaking off the mainmast just above deck, throwing down bulkheads, breaching the planking under the quarter, and letting about 2 ft. of water into the vessel. The fourth shot struck the water close to and abreast of the starboard quarter, and must have exploded very nearly under the schooner's center. The underwater fuse acted perfectly. The vessel's back was broken, and she fell back a complete wreck. On this occasion the high trajectory of the gun was much objected to by the experts who were present. The projectiles fell into the water at as great an angle as 18 deg. or 19 deg. On the other hand, the high trajectory prevented ricochet, and insured a proper entry into the water for torpedo action. The United States Navy Pneumatic Dynamite Gun Board subsequently witnessed experiments to test the rapidity of fire, accuracy, and extreme range of Lieutenant Zalinski's weapon. The board reported (1) that the dynamite gun is a new instrument which has its own functions in time of war; that it cannot replace any existing weapon; and that its place cannot be wholly taken by any other; (2) that the value of compressed air as a means of throwing projectiles from a gun is chiefly apparent in the ability which it gives to the gunner of exactly reproducing any shot, and of accurately increasing or decreasing range at will; (3) that the machinery employed in connection with the control of air under great pressure is very effective; (4) that the gun is remarkably accurate; (5) that the extreme range is probably about two miles, the effective range from 1,400 to 1,800 yards; (6) that the power of the projectile has not yet been thoroughly tested; (7) that the gun appears to be trustworthy in its action; (8) that the system is a simple and not expensive one, and that the gun might be made in any large town where there are foundries and machine shops; (9) that the weapon is valuable for harbor defense; (10) that it is adapted to naval warfare whenever mortar fire can be advantageously used; (11) that a modification of it might be adapted to the projection of torpedoes from ships; (12) that, until after the gun has been properly tested on board the dynamite cruiser which is now under construction, it will be inexpedient to adopt it as part of the battery of ships of war. The dynamite cruiser, it may be mentioned in passing, was built by Messrs. Cramp, of Philadelphia, but is not yet ready for sea. Instead of the 10.5 in. pneumatic guns for which she was originally designed, she is to have three 15 in. tubes, which will be able to throw up to 600 lb. of explosive gelatine. The length of her guns, which was excessive, has also been shortened to 55 ft. In the meantime a Zalinski gun, with a caliber of 15 in. and a length of only 40 ft., has been constructed for the Italian government.

Another pneumatic gun has, according to the *Temps*, been tried this year in Germany, under the supervision of the German Admiralty. The instrument is of 11.7 in. caliber, and is 73.8 ft. long. The shell was 81.5 in. long, and contained 66 lb. of nitro-glycerine. The target was a wooden vessel moored 2,080 yards away from the firing point. Two rounds of shell completely destroyed the craft. Of Mr. Hiram Maxim's dynamite gun little of a practical nature is yet known. It is a pneumatic tube; but the tube is comparatively short, and, according to the specification of the patent, a very high muzzle velocity is attained. The peculiarity of