In the same manner the following distilled waters are produced : Violet, lily and lily of the valley, fresh flowering tops of the hyssop, lavender, ivy, melilot, balm mint, sage, thyme, etc. Also the following: Orange, bitter almond, apricot, cherries, peaches, prunes, anise, Chinese anise, caraway, fennel, juniper, etc.

Anise Water.
Eau Distillée d'Aneth.

Dry anise seeds........ .... 1 k.
Salt .... 50 grm.
Water........ .. .. 8 l.

Pr duct, 4 l.

In the same manner are prepared the distilled waters of angelica, coriander, parsley, etc.

Coffee Water.
Eau Distillée de Café.

Browned coffee .... 1 k.
ater................ .... 13 l.

Cinnamon Water.

For the bark of cinnamon and for roots and woods in general, take :

Material..................... ..... 1 k.
Salt.. .... 400 grm.
Water .... 16 l.

Distill twice, so as to obtain 8 l.

Water of Lemon Peel.
Eau Distillée de Zestes de Citron.

For distilled water from the skins of lemons, oranges, bergamot, etc., take :

Material .... 1 k.
Salt .... 100 grm.
Water................... .... 20 l.

Product, 10 l.

Distilled Water from the Pulp of Fruits.
Eau Distillée de Fruits Pulpeux.

Pulp of fruits .... 1 k.
Water .. .., ... 4 l.

Product, 2 l.

Cherry Laurel Water.
Eau Distillée de Laurier-Cerise.

Leaves of the cherry laurel cut fine ... 1 k.
Salt........ .... 50 grm.
ater. ....,............ .... 1 l.

Product, 1 l.

In the same manner distilled waters are prepared from the leaves of the apricot, cherry and peach trees.

Distilled Water of Tea.
Eau Distillée de Thé.

T a .... 1 k.
Water.... .... 20 l.

Product, 10 l.

(To be continued.)

ABSTRACT OF MUNROE'S LECTURES ON CHEMISTRY AND EXPLOSIVES.

By Lieut.-Col. J. P. FARLEY, Ordnance Dept., U. S. A.

DURING the summer of 1888 a very interesting and instructive course of lectures was delivered to the class of that year by Prof. C. E. Munroe, S.B., F.C.S., etc., at the Torpedo Station. Newport, R. I.

The series appears in Torpedo Station print for the same year as a volume of 400 pages, and in view of its limited circulation it is thought that a brief *resume* of the same may prove of interest to the readers of the *Journal.*

An attempt has been made to follow the general sequence of arraugement under the various headings of "chemistry," "combustion," "gunpowder," "chlorates and nitro-substitntion compounds," etc., etc., but the form of expression and preseutation of facts are materially altered from the original in the condensed shape required.

COMBUSTION.

Combustion, we are informed, is the result of chemical union between atoms of combustible substances and supporters of combustion ; beat and light result from the impact of the atoms ; mechanical energy is converted into heat, and the potential energy is lowered.

Oxygen and hydrogen in water proportions when ignited are followed by rapid combustion; the mixture itself constitutes detonating gas, which is produced by electrolysis and has been suggested for use for torpedo charges.

Gases and volatile liquids when mixed with air in certain proportions and ignited give rise to explosions.

Finely pulverized solids, such as coal dust, saw dust, starch, flour, and fine zinc dust, mixed in certain proportions with air, undergo rapid chemical change on ignition.

Solids disappear during combustion and the volume of gases generated increases in bulk with the heat developed. Gaseous compounds of carbon (C), hydrogen (H), and sulphur (S), form with oxygen CO_2, H_2O and SO_2. The coefficient of expansion of a gas for 1° C. is $\frac{1}{273} = 0.003665$, and from this we may determine pressures for a constant volume and varying temperature.

Radiation, conduction and convection reduce the heat of combustion, but the heat evolved during the re ction is compensating. The materials of explosives should be pure, and the mixtures intimate. Oxygen may be supplied either in the free state to the carbon (C) or else combined, as in $KClO_3$. A mixture of charcoal and potassium nitrate is best adapted for use in ordinary guns, and to this sulphur is added in order to lower the point of ignition.

EXPLOSIVES—GUNPOWDER.

Gunpowder, a mixture of KNO_3 75 per cent., C 15 per cent., S 10 per cent., is nervous, sensitive and susceptible to the slightest change of temperature—to mist, sunshine and dew; whereas, many of the explosive compounds are stored for preservation in water, and are but slightly affected by variations of temperature within reasonable limits.

Col. Rains (Confederate service) incorporated gunpowder by steaming the powder and afterward rolling it. The Russian Wiener powder has its moisture eliminated at the melting point of sulphur (240° F.), and although of uniform deusity, the grain is porous and absorbs moisture.

Fossano or Progressive powder is an agglomeration of powders of two densities, fine and coarse grain.

The composition of cocoa powder is a trade secret, but from analysis it is thought to be made with under-burnt "clubmoss" charcoal. Its ash contains alumina in quantities not found in the ash of woods usually used for gunpowder charcoal.

Dupont's brown powder consists of saltpeter 78 per cent., sulphur 2·8 to 3 per cent., a carbohydrate (such as sugar) 3 to 4 per cent., and baked woods (underburnt) 12 to 12·5 per cent., which latter retain their fibrous structure. This powder gives high initial velocity with a low maximum pressure and possesses advantages over black powders, owing to the form, size, density and hardness of grain, which features, combined with a lesser proportion of sulphur, reduce the readiness of ignition. After the initial movement of the projectile the grains are somewhat broken up, which new eondition, added to the greater inflammability of the underburnt charcoal and carbohydrates, promotes chemical reaction and maintains the pressure.

Loss of velocity in gunpowder during storage is thought to be due to action of the oxygen condensed in the pores of the charcoal, which oxidizes the sulphur to SO_2, which by union with the water present is transformed into H_2SO_4, which then decomposes the KNO_3, forming K_2SO_4 and HNO_3. This HNO_3 induces further oxidation, and the cycle of changes proceeds again and again, its rapidity being increased with time. It is this inert K_2SO_4, therefore, which serves to retard the velocity of combustion.

During explosion of gunpowder the following chemical changes take place. The oxygen of the niter converts the charcoal chiefly into CO_2, part of which assumes the gaseous state, while the remainder is converted to K_2CO_3. The greater part of the sulphur is converted into K_2SO_4, and the chief part of the nitrogen contained in the niter is evolved uncombined. Potassium carbonate, potassium sulphate, carbon dioxide and nitrogen result, the last two being gases, which are expanded by the heat of combustion.

CHLORATES AND NITRO-SUBSTITUTION COMPOUNDS.

$NaNO_3$ (sodium nitrate) can be substituted for KNO_3, for blasting and other powders. Ammonium, barium or lead nitrates have been used with considerable success, but the latter gives off poisonous fumes. The chlorates contain less oxygen than the nitrates, but give all of it up during the reaction, whereas with the nitrates some of the oxygen remains attached to the acid radical.

Chlorates are decomposed at 352° (C.). while oxygen is not evolved from the KNO_3 until red heat is reached, and combustion of bodies in contact with chlorates results in developing very high temperature ; greater by one-half than that of the nitrate powders; therefore, they possess greater force.

Chlorate powders are sensitive to friction and percussion, explode with sharpness, erode the walls of the gun to a greater extent than the nitrates, and the chlorine gas liberated after firing is deleterious to those who are exposed to its action. The manufacture and handling of the powders is attended with risk and is comparatively costly.

The chlorate powders have been used in fulminating primers and percussion caps. Siemens takes saltpeter, chlorate of potash and a solid hydrocarbon, and, mixing the same, he treats the product with a liquid volatile hydrocarbon as a solvent for the solid hydrocarbon. The mass is plastic, and after passing through rollers is rendered hard by evaporating the solvent. The cakes are then broken up and converted into grains. This powder has the same density, greater hardness, and double the force of ordinary gunpowder.

Mellard's paper powder consists of—

|		
Potassium chlorate		9
" nitrate		4·5
" ferrocyanide		3·25
" chromate....................		1/16
Charcoal		3·25
Starch		1/21

Porous paper, when dipped into the liquid, is rolled into cartridges, dried and coated with xyloidine.

This powder is cheaper than other chlorate powders, fairly safe and easy to make; it gives off very little smoke, leaves but little residue, is only slightly erosive and is more powerful than gunpowder.

A chlorate powder termed "White powder," being very erosive in its action on iron and steel, its use was restricted principally to bronze guns and shell charges. The shells contain the "White powder" and glass bulbs filled with sulphuric acid, which latter break on impact. This principle of explosion by *admixture* has been applied in the use of certain contact torpedoes ; the charge, consisting of black powders, being fired by means of sulphuric acid and "White powder." It has also been applied in pile driving; the explosion not only drives the hammer back, as intended, but also drives the pile forward an additional amount and accelerates the work.

Explosive substances before referred to, such as nitrate and chlorate mixtures, have been produced by mixing combustible matter and oxidizing salts. The next step is the introduction of oxidizing agents into chemical molecules by chemical means, these molecules being composed chiefly of atoms which have a strong affinity for oxygen and form with it under suitable circumstances very stable and permanent substances whereby a great degree of intimacy is obtained. This combination with hydrocarbons may be effected through the agency of the oxides of nitrogen, and it may result in the formation of two classes of compounds, viz., nitro-substitution compounds, in which the nitrogen oxide is directly attached to the carbon atoms, and nitric ethers or *esters*, in which the nitrogen oxide is connected to the c rbon atoms, through the interposition of oxygen atoms. The best example of the first class is picric acid, which is made by the action of nitric acid on indigo, or of nitric acid on phenol (carbolic acid). The latter reaction is expressed by the formula :

$C_6H_5OH + 3HNO_3 = C_6H_2(NO_2)_3OH + 3H_2O.$
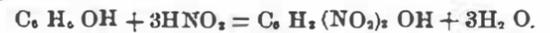
Picric acid was discovered by Hausemann in 1788, resulting from the action of nitric acid on indigo. By Weller, in 1795, nitric acid on silk ; but the best and cheapest method and the one used for making commercial picric acid is derived by the action of nitric acid on phenol (carbolic acid).

The reaction is thus expressed :
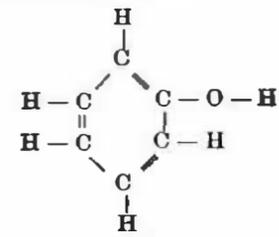
PHENOL.

Below it is seen that three atoms of hydrogen have been replaced by three atoms of nitrogen oxide.

TRI-NITRO-PHENOL OR PICRIC ACID.

$C_6H_5OH + 3HNO_3 = C_6H_2(NO_2)_3OH + 3H_2O.$
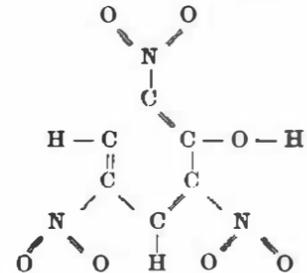
Phenol is a product of coal tar, and the picric acid thus produced is an important article of commerce; in fact, one of the cheapest and most brilliant of the yellow dyes.

It can be prepared experimentally by putting two teaspoonfuls of fuming nitric acid in a glass flask of 150 cm. capacity and adding cautiously and in small portions half a teaspoonful of crystallized phenol. The reaction is very violent and is attended by copious development of nitrous fumes. When the action has subsided and the flask becomes cold, yellow crystals of picric acid will be found in the liquid. Picric acid is made commercially by melting carbolic acid, mixing it with strong sulphuric acid and then diluting the sulpho-carbolic (or "phenol sulphuric acid") with water, after which it is run into a tank containing nitric acid. The mixture is llowed to cool and the crude picric acid crystallizes out.

The crystals are again dissolved in water by the aid of steam, cooled and crystallized and a third time dissolved, this time in hot water, then cooled and allowed to crystallize, after which any excess of wat r is removed by a centrifugal machine. Great differences of opinion exist respecting the explosiveness of picric acid. No one is prepared to say, however, that under no circumstances unconfined picric acid can be exploded by action of fire, but when mixed with metallic nitrates explosion will then surely result. It can when unmixed be exploded by detonation or blow, and when mixed with the metallic nitrates, if detonated, it is highly explosive. In 1873 Sprengel stated that picric acid, without help of foreign oxidizers, is a powerful explosive, even when fired without a detonator, and that such explosion is not accompanied by smoke. Turpin, in 1885, exploded picric acid by employing a powerful fulminate detonator, or by an intermediate priming of picric acid in powder primed with a fulminat ; also by employing a large charge of ordinary brown powder inclosed in a strong tube and made to burn *inside* of the picric acid charge.

Picric acid may be perfectly detonated by means of a five grain fulm ate detonator.

Detonating a small quantity of picric acid will detonate a quantity of the same acid at a distance from it, and detonating a charge of picric acid placed alongside of another charge of the same acid containing 17 per cent. of water, the former will also cause the detonation of the latter.

When picric acid is near its melting point (240° F.) one pound falling 14' will explode it. When cold and in thin sheets (dry or powdered) one pound falling 26" will explode it.

Berthelot, confirming Desortiaux, states that should a nitro compound (nitro-benzine or naphthalene) such as picric acid, while burning in large masses, by chance, heat the containing inclosure or vessel sufficient to induce incipient deflagration, this deflagration may combine to further increase the temperature of the inclosure, and detonation will result.

The large number of compounds denominated picrates (of which ammonium and potassium picrates are the principal ones) are, with the exception of the ammonium picrate, easily exploded by heat or blows. The ammonium picrate, although containing the most oxygen, requires a large addition of oxygen to insur complete combustion, and is therefore the least sensitive of the picrates; whereas the barium picrate, which, although it contains the least oxygen, requires the least amount of oxygen of all the picrates for combustion, is, in consequence, the most sensitive of the picrates. Potassium picrate, $C_6H_2(NO_2)_3OK$, is one of the most violent of all the picrates in its action. It is made by mixing potassium carbonate, warm, with a solution of picric acid in water. On cooling, the liquid deposits small crystalline needles of a golden yellow color, which show green and red by reflected light. Its explosive qualities increase much by oxidizing agents and especially with potassium chlorate, and almost equal those of nitroglycerine and gun cotton in violence, but owing to its sensitiveness to friction and percussion it is perfectly useless.

The Designolle cannon powder consists of potassium picrate 16, potassium nitr te 74, and cha coal 9. A

shell charged with this powder will be broken into six times as many fragments as when charged with gunpowder. It does not erode the piece, gives scarcely any fumes, and its ballistic properties are much superior to those of gunpowder—notwithstanding this powder is the more *brisant* of the two.

Spontaneous decomposition is not anticipated, such as sometimes occurs with nitro-glycerine and other nitric esters, owing to the definite composition and known reactions of this, as well as of the whole series of crystalline bodies denominated picrates.

Ammonium picrate, $C_6 H_2 (NO_2)_3 ONH_4$, is prepared by saturating warm picric acid with concentrated ammonia water. After this operation has been repeated with slight modification several times, the liquid is allowed to stand and the salt crystallizes out in transparent orange-colored prisms. It may also be obtained in citron yellow needles by treating picric acid with ammonium carbonate.

Abel's picric powder is composed of ammonium picrate 42·18, potassium nitrate 53·93, charcoal 3·85.

Its force is greater than that of gunpowder in the ratio of 1·75 to 1. It can be moistened, worked, and granulated, as is the case with ordinary gunpowder. Its color is yellow green and it gives off the same colored smoke. This powder, it is said, does not contain a sufficient quantity of saltpeter.

Ammonium picrate and potassium nitrate solutions undergo mutual decomposition when mixed, but it is singular that no such change takes place when they are simply moistened. For this reason the manufacture of this Abel's powder is rendered quite safe.

S. H. Emmens dissolves an excess of commercial picric acid by aid of gentle heat, in fuming nitric acid, the mixture being a refrigerating one. When evaporated, three grades of crystals at different stages are deposited approximating in composition $C_6 H_7 (NO_2)_3 O_2$.

This material, when mixed with metallic salts, is explosive, and in making emmensite this body, which is called " Emmens' acid," is mixed with both picric acid and a nitrate, preferably ammonium nitrate, and the whole fused together and cast in moulds. The result is a solid mass of bright yellow color, bitter taste, nearly inodorous and with porous structure. It is claimed to be insensitive to shock, blow, or fire, but more powerful than nitro-glycerine when detonated, and when used in the granulated form for a projecting charge it produces but little smoke and does not foul the bore of the gun.

Nitro-substitution compounds may be formed from hydrocarbons, such as benzene and naphthalene. When one atom of hydrogen is replaced by NO_2, there results mono-nitro-benzene. This, when mixed with potassium chlorate in the ratio of 21 to 79, gives Rack-a-rock, 204,400 pounds of which were used in blasting Flood Rock. This mixture is made either by pouring the liquid on the solid or by immersing the solid (potassium chlorate) in the liquid, the solid being held in wire baskets. A 24 grain fulminate fuse scarcely suffices to explode this compound when not confined or but slightly confined, which is its chief objection.

In phenol (carbolic acid) the substitution of $3NO_2$ for three atoms of H gives the tri-nitro-phenol or picric acid as before shown. Bellite, discovered by Carl Lamm, of Sweden, consists usually of meta-di-nitro-benzene with ammonium nitrate, which are melted together at 160° F. and mixed with saltpeter. When pressed warm it has a specific gravity of 1·2 to 1·4 and a gravimetric density of 0·8 to 0·875. When heated in an open vessel to 360° F., separation results and evaporation takes place. It burns if heated suddenly, but ceases to burn when the source of heat is removed. It absorbs but very little moisture from the air after it has been pressed.

Under powerful blows it heats, but neither ignites nor explodes; in fact, it may be said to withstand blows, friction and vibration, and can be stored or transported with perfect safety. It is the opinion of those best qualified to judge that it is as well adapted for military purposes as for mining and blasting, and bids fair to become of great importance.

Securite is one of the varieties of bellite, and consists of a nitrated hydrocarbon mixed with an oxidizing agent, such as potassium chlorate, and with some organic salt, which renders it flameless. Its power is said to be equal to dynamite, and it is exploded only by the detonating cap.

Hellhoffite is a solution of a nitrated organic compound (naphthalene, phenol, benzene and the like) in fuming nitric acid. It has the same advantages as bellite, but the disadvantage of being liquid. The fuming nitric acid contained in it requires that it shall be stored in closed vessels. As it is rendered completely inexplosive by being mixed with water, it cannot be employed for work under water.

Gruson's explosive of 1881 appears to be especially adapted to all military purposes, whenever a safe but violent explosive is required. It is a secret compound made by dissolving certain crystals in nitric acid, and is probably similar to Hellhoffite. Its ingredients are transported separately and mixed only for use. It requires twice as powerful a detonator as that which explodes dynamite, and when mixed may be neutralized by adding water, the crystals separating out. These crystals burn like sealing wax, but neither the crystals nor the mixture can be frozen at 0° F. The crystalline ingredients are some well-known substance which is freely transported, but what it is we are not informed; this is Gruson's secret. The ingredient is not soluble in water, does not absorb moisture and therefore never becomes damp. The solid components of Gruson's explosive look like brown sugar, the crystals are needle-like, and nearly an eighth of an inch in length.

They burn in the flame of a Bunsen burner with much smoke. If dissolved in nitric acid a drop of the same when placed on an anvil and hammered will not explode. Paper dipped in the solution serves the purpose of a wick when ignited, and burns with increased flame, but without igniting the solution. Water poured on the solution causes recrystallization, but this change is not attended with material reduction of temperature. The crystals may then be separated from the nitric acid.

In a tube, exploded by a primer three times as strong as that required for dynamite, its force or energy is estimated as 1·3 to 1 of that of nitro-glycerine.

Hellhoff made an explosive from crude coal tar, but found that the treatment of coal tar with strong nitric acid was a very dangerous operation. Acid of 1·33 to 1·45 specific gravity was used and liquid coal tar gradually stirred into it, the surface of the acid at first becoming covered with the coal tar, which gradually settled to the bottom. The substance thus obtained when washed and purified was mixed with oxidizing bodies (alkaline nitrates, chlorate of potash and the strongest nitric acid being used for this purpose).

Two to five parts of concentrated nitric acid or four to six parts of salts were sufficient for one part of the nitro-derivative.

It was found in the course of experiment that either pulverized coal or peat after treatment with nitric and sulphuric acids, when soaked in a solution of chlorate of potash and dried, forms a powerful explosive, and all nitro derivatives from either of the above ingredients are stronger and better when mixed with oxygenated bodies.

The Sprengel class of explosives of 1873 consists of two liquids, or one liquid and one solid, kept separate until needed for use. Among the oxidizing agents were the nitrates and chlorates, which are solid, and nitric acid and nitrogen tetroxide, which are liquid.

FULMINATES.

The class of fulminates include the salts of fulminic acid and other substances, which under normal conditions undergo detonating explosion only.

Nitrogen chloride is one of the most unstable of the class of fulminates, and although sensitive and dangerous, and its local action is marked, due to detonating reaction, yet its explosive force (Sarrau) is but slightly greater than that of gunpowder. It was discovered by Dulong in 1812, and resulted from the action of chlorine on ammonium chloride. Some chemists regard it as NCl_3 (trichloramide), that is ammonia NH_3, in which all the hydrogen has been replaced by chlorine NCl_3.

Berthelot discovered (1788) silver amine, a powerful fulminating compound produced by the action of ammonia upon silver oxide. It may also be produced by precipitating silver nitrate with sodium hydroxide and washing the silver oxide by decantation. This body explodes by the slightest concussion when dry and requires the greatest caution in handling even when moist. It is claimed to have been the detonating agent used in the bomb that killed the Czar.

The " fulminating gold " is formed as a buff precipitate by adding ammonia to a solution of auric chloride, a violent explosive resulting.

Cupricamine is formed by passing a current of dry gaseous ammonia over finely powdered cupric oxide heated to 250° C. Water and nitrogen gas are evolved, and the nitrate is left as a dark green powder, which, when heated to 310° C., explodes freely.

Mercury amine may be made by passing gaseous ammonia over the dry yellow mercury oxide, which is precipitated from mercury salts by an alkali. This may be continued so long as the gas is absorbed, and by heating the resulting black brown mass constantly (at a temperature not exceeding 150° C.), so long as water is given off, an anhydrous brown powder is produced, which detonates powerfully when heated or struck, and which is decomposed by acids with salts of ammonium and mercury.

Fulminating platinum is produced as an insoluble black powder by dissolving ammonium platinic chloride in a solution of sodium hydroxide and adding an excess of acetic acid. It detonates violently when heated to 200° C.

Nitrogen Sulphide.—This body detonates powerfully under percussion, but is less sensitive than diazo-benzene nitrate or mercury fulminate. It deflagrates at 270° C., but more slowly than mercury fulminate. It is made by passing dry ammonia gas through a solution of sulphur dichloride in ten or twelve times the volume of carbon bisulphide.

Howard, an English chemist, discovered mercury fulminate in 1800, and with this substance began our knowledge of what are chemically known as fulminates. The discovery was made while acting on mercury oxide with alcohol and nitric acid. A whitish salt was produced, which crystallized in acicular needles possessing a saline taste, and which, when dried, exploded with extreme violence when a drop of sulphuric acid was poured upon them. This compound gives extremely low velocity as a propellant, but bursts the gun by the violence of its action. In 1863 Nobel employed fulminate of mercury to detonate nitro-glycerine. It is a salt of an organic acid having the probable proportions $C_2 N_2 O_2 H_2$, and which is known as fulminic acid.

This fulminate is now made by taking 10 parts by weight of mercury and dissolving it by gentle heat in 120 parts by weight of nitric acid s. g. 1·4. It is then poured into a glass containing 100 parts of alcohol (95 per cent.), the flask holding six times the volume of the alcohol. At a temperature of 60° F. action begins, the mixture becomes turbid and generally continues so until the reaction is completed. From 11 to 12 parts of mercury fulminate result from every ten parts of mercury. The fulminate will be found as a pasty mass of fine gray crystals of uniform color, and if different colors are exhibited or globules of metallic mercury are seen, it indicates that the operation has not been properly carried out, and the charge is then known to be unfit for service.

Dry fulminate explodes violently when struck or compressed, or when rubbed between hard surfaces; when heated to 186° C.; when touched with strong sulphuric or nitric acid; when in contact with sparks from flint and steel or from the electric spark. If wet with thirty per cent. of water, it is inexplosive except when dry fulminate is detonated in contact with it. Its density is 4·42 and the reaction attending decomposition is thus expressed: $Hg C_2 N_2 O_2 = Ho_3 + 2CO + N_2$.

The superiority of the fulminate of mercury over all other fulminates is due to its nearly instantaneous decomposition by simple inflammation, to the absence of dissociation products and finally to its great density. Definite products of combustion form at once before even the matter has time to take a volume notably superior to that of the primitive solid. Hence if exploded in a vessel and in contact with its sides, it will develop an instantaneous pressure, incommensurately greater than its mean pressure, which latter is controlled by the capacity of the receptacle. Mercury fulminate, with an absolute density 4·42, in contact develops a pressure of 48,000 atmospheres, while compressed gun cotton in contact develops a pressure of not more than 24,000 atmospheres, and no other substance in contact will give a pressure at all comparable with that of the fulminate of mercury. This circumstance, joined with that of the absence of dissociation, makes the compound perfectly irresistible.

The composition for percussion caps consists of 100 parts dry fulminate, 30 water, 50 saltpeter and 29 sulphur, the whole being mixed by rubbing with a wooden pestle on a marble slab. It is dried sufficiently to be granulated, is forced into copper caps and when perfectly dried is varnished or covered with tinfoil to protect it from dampness. The caps are finally dried by a gentle heat and packed in boxes.

The detonators employed in the navy consist of a copper case made in two parts. The lower part is a No. 36 metallic cartridge case and is 1 1-8 long and 11-32 inches in diameter. The upper part is a copper tube 5-8 inches long and 12-32 inches in diameter, open at both ends, which has been cut from a No. 38 metallic cartridge case. A 3-16 inch thread is cut on each of these parts, so that the upper part or cap screws nicely into the lower part. The lower part is fitted with fulminate of mercury up to the lowest thread of the screw. The top part is fitted with a plug made of sulphur and glass, through which the detonator legs pass to connect the bridge with the wires leading to the battery. When the fulminate is dry the spaces in the lower case and the cap are fitted with pulverulent dry gun cotton and the parts are screwed together.

The different grades of detonators, known as blasting caps, are known as single, double, triple, quadruple and quintuple force caps. The single contain three grains of fulminate, the others increase by three, and hence the quintuple contains fifteen grains. They usually consist of 75 per cent. of mercury fulminate and 25 per cent. of potassium chlorate, pressed into the caps under high pressure, and a little gum is added to make it more coherent. The presence of chlorates, nitrates, sulphur, etc., give rise to flame and incandescent particles, whereas mercury fulminate *per se* does not produce either.

In silver fulminate the acid hydrogen is replaced by silver instead of mercury. Certain precautions are to be used in its manufacture. Large vessels are employed to prevent boiling over, which latter would permit the salt to dry on the outside of the vessel and lead to accidental explosion. All flame must be kept away, lest the vapors should take fire and explode. The mixture should be stirred with wooden rods and not hard ones of glass or metal. Paper shovels should be used in removing it, and the fulminate must be kept in pasteboard or paper boxes to avoid the friction of glass stoppers. Finally the vessels holding it must be loosely covered to prevent explosion due to pressing the cover of the box to fit it. The silver fulminate is very poisonous; it consists of white opaque shining needles with bitter metallic taste; dissolves in hot water and separates on cooling. It explodes much more violently than mercury fulminate by heat, the electric spark, friction, percussion or by contact with oil of vitriol.

It explodes at 130° C. when dry or when rubbed by hard substances such as glass dust, sand, or even the edge of a card. It may be rubbed to powder in a porcelain mortar either with a cork or by the finger. If well washed and dried by exposure to the sun, it explodes by the slightest touch. It is used very largely for crackers and detonating toys.

Besides those mentioned, a large number of salts of fulminic acid are known, all of which are unstable and explosive.—*Journal of the Military Service Institution.*

CHEMICAL ARTS IN BIBLE TIMES.*

By Dr. H. CARRINGTON BOLTON.

CHEMISTRY, considered as an art, dates its origin from prehistoric times; considered as a science, it is little more than one hundred years old. The attempts of man to improve his surroundings as respects diet, clothing, and domestic economy familiarized him with certain phenomena now recognized as chemical. The necessity of securing weapons for war and for the chase, and the attempts to alleviate disease, stimulated the application of chemistry to metallurgy and medicine. Among the sources of information concerning the very earliest period is the Holy Bible, which contains a surprising number of facts and allusions to chemical arts.

The ancients were acquainted with seven metals, of which six are mentioned by Moses in a single verse (Numbers xxxi. 22): " Only the gold and the silver, the brass [*i. e.*, copper], the iron, the tin, and the lead," are to be purified by fire when captured as spoil from heathen nations.

Tubal-cain, the seventh from Adam, seems to have excelled in metallurgy, and apparently aided his brother's musical taste by his skill. The remarkable passage in Job xxviii. 1, describing the occurrences of ores and their metallurgic treatment, is well known. With this can be compared Ezekiel xxii. 18. Jeremiah, in chap. vi. 28, seems to describe the process of cupellation of gold and silver.

Of the seven metals, gold is the most attractive, and, occurring native, was early known to men. It is named among the attractions of the Garden of Eden (Gen. ii. 12), and was manufactured into ornaments for personal decoration at a very early period. Of its abundance in King Solomon's reign, testimony is striking. (I. Kings x. 21 and II. Chron. i. 15.)

Silver was early used in currency (Isaiah xlvi. 6), and, as the pieces were not stamped, " wicked balances " and " deceitful weights " were unhappily too common. (Micah vi. 11.)

Copper, commonly called brass, is named by Moses as occurring in the Promised Land (Deut. vii. 9), and is compared in value to gold by Ezra (Ezra viii. 25). Its alloys were in common use.

Tin and lead were frequently confounded in early times, the latter being called " soft tin." The use of leaden tablets for inscriptions is graphically described by Job (Job xix. 23). Solder was known to the Israelites (Isaiah xli. 7) for repairing metallic trinkets.

Iron was much used in Bible times. Among the many articles manufactured of iron are "chariots" (Judges iv. 8), " spear heads " (I. Sam. xvii. 7), " axes "