THE MANUFACTURE OF SMOKELESS POWDER.

FROM THE RAW MATERIAL TO THE FINISHED PRODUCT.

BY DAY ALLEN WILLEY.

Not so long ago the battleship "Iena," one of the finest of the French navy, was lying in the Toulon drydock, being overhauled for service. Officers and crew aboard were as unconscious of danger as the men of the "Maine" before the death blow came to them. There was an explosion—not very heavy—then followed another that shook the ship from stem to stern. A volcano of flame, as the spectators put it, burst from her interior. More and more explosions followed, so rapidly that they could not be counted. The "Iena" had been attacked from within. Luckily, a shell from another vessel knocked away the gate of the drydock, and the water rushing in partly filled her hull and extinguished the raging fires, but not before over a hundred men had perished and the craft was a wreck—destroyed by her own missiles.

What caused the catastrophe? Smokeless powder.

The destruction of the "Maine" was a mystery, as Capt. Sigsbee and his officers admit. The French government at first endeavored to veil the Toulon tragedy in mystery; but it was unsuccessful, and it is now generally admitted that the disaster was caused by a chemical change in the powder so simple that any child could perform it with his school apparatus—a change which may occur wherever the same kind of ammunition which was aboard the "Iena" is kept in the magazines—the ammunition we call smokeless powder.

What is smokeless powder? Principally guncotton mixed with two or three chemicals. What is guncotton? Just cotton soaked in acid.

Most of the stuff composing it is grown in the fields of the South, and the schoolboy chemist can make the acids; but it is the way in which he prepares his ingredients and mixes them together that shows the skill of the powder maker. Here is something that must be made with the utmost care if it is to be used with safety.

A trivial error may change it from an explosive that can be handled and kept without harm into a fearful instrument of death and disaster—more dangerous because the element it may contain is unseen and unknown, and may not show its power until years after the powder has been pressed into its strips and cylinders, and stored in the ship. Out of a million or so of these cylinders perhaps a few hundred are not pure. There comes a day when they begin to give off fumes. Should the gunner or storekeeper enter the magazine, he will quickly know something is wrong, for they are fumes of nitrous gas, pungent and disagreeable. But the powder room may not be opened for weeks—only the temperature noted by the thermometer at its entrance—so the gas rapidly increases its rate of generation, and a greater and greater volume arises. The impure powder changes from the hard shiny pieces of gutta percha it resembles into a pasty yellow mass. If the chemist is called to investigate, he says that the nasty-smelling gas is due to the formation of oxide of nitrogen, while in the yellow paste formic acid and acetic acid are now at work. In short, the powder is no longer powder. It has decomposed.

If the gas has any crack or crevice through which it can escape in sufficient quantities, ship and sailors may keep afloat; but suppose the magazine is air-tight or nearly so. It is astonishing how much gas even one cylinder of powder will generate; and if the chamber is nearly full of ammunition, very little of the decomposing stuff is sufficient to fill the space with the fumes. As they grow thicker, they quickly raise the temperature. Here is where the danger point is set; for if the air becomes heated above a certain degree, it means combustion of the yellow paste, which will ignite much more quickly than the powder itself. The fact is that the gas, if confined in sufficient volume, will so heat the air that the paste will ignite.

What happens then is what happened to the "Iena," what happened to the "Mikasa" as she went under the waters at Sasebo with the banner of the sunflower flying and her hundreds of seamen crying "Banzai" as the sea closed above their heads.

If we look into the making of guncotton, we realize how much truth lies in this theory. Yes, it consists simply of fiber which we strip from the cotton boll of the southland, soaked in acid; but to do this and do it right is not the simple thing it seems. If you should enter one of the few factories where it is made, you would see an imposing variety of machinery used for nothing else. The same kind of waste with which the engineer wipes his valves and levers—the refuse cotton which is thought too dirty or poor to be spun or woven—is now used mainly for the explosive. First it is treated to a bath of hot water and caustic soda, in which it stays eight hours, to be then dumped into another vat of clear cold water, after the other liquid has been drained from it. This cleansing ought to remove the grease and dirt which may be in it; but it is subsequently picked to shreds by hand and examined for any bits of sand, gravel, or other foreign substances. Then it is washed a third time; being whirled round and round for eight minutes while a jet of cold water is played upon it. The whirling is done in what is called a centrifugal washer, which is driven by steam power at the rate of 1,400 revolutions a minute. This partly dries the cotton, just as one can dry his handkerchief in a minute or so by letting it flutter in the breeze. But the cotton has to be almost absolutely dry if the acid is to do its work; so it is laid on racks in a heating chamber where the temperature is 187 degrees, and stays there from three to five days. The cotton, however, usually becomes so tangled and twisted during its baths, that even this exposure does not dry all of it; so it is run through a picking machine, which combs the fiber straight and separates the tangles. It is then once more exposed to the heat for at least eight hours.

Thus far the cotton is the pure staple and nothing else. Now begins the change from a harmless lint into one of war's most powerful instruments. Bits of it weighing about a pound are taken and dipped in troughs filled with acid, about one-fourth of the mixture being sulphuric acid and the balance nitric acid. After each dip, the workman squeezes and kneads the wad of cotton to mix the acids with it. The dipping continues about ten minutes, when the stuff is "digested"—not as we digest our food, but left in a pot of hot water, where it steeps, so to speak, and the acid more thoroughly assimilates with the fiber. Following a bath of cool water, it is passed through a machine that squeezes out the water as a clothes wringer aids in drying the laundry.

This, however, is only the beginning of a series of washings and dryings, the reason for which will be made clearer by what follows. A vat called the immersion tub is partly filled with caustic soda and hot water. Into this the nitro-cellulose, as the chemist calls it, is placed in handfuls, so that it will be as thoroughly saturated as possible. For eight hours it is boiled, to next be placed in clear cold water, which rinses it for the same length of time. Now it is turned over to the pulping machine, where revolving knives cut the fiber into such small pieces that it becomes pulp in appearance. Again it is washed in a vat of water, where the particles of pulp are kept in motion by revolving feathers. After being mixed in this way for two days it is put in the "stuffing chest," where it receives another stirring. It is then taken to the first molding press. Here the water it contains is partially squeezed out; but the creation of the guncotton is not complete until it is further dried by pressure under the enormous pressure of 6,000 pounds to each square inch of its surface.

Why all these washings and dryings and sortings? Because the cotton, before it receives its acid bath, must be entirely free from any foreign substance if the wonderful chemical change it undergoes is to be successfully and safely accomplished. And the acid must impregnate every particle of the fiber. Look at a bit of cotton under a powerful microscope, and you may note that each tiny filament, or hair if you will, is twisted. Its surface is not smooth. The acid must not merely cover each hair, but must permeate it—become a part of the new substance which is created by this union. So it is that the cotton is not only cleaned but combed, and is soaked a handful or so at a time, to be squeezed and soaked again and again.

Now, to make the smokeless powder that goes into the magazines of our warships and our forts, the makers simply dissolve the guncotton and dry the paste that is left until it looks like sheets of shellac or caramels before they are cut into morsels. It is no more powder than is macaroni; although the long slim tubes into which the "powder" is molded before being sliced into flakes and compressed into gun charges feel hard and smooth like macaroni. It is now of a dark brown color. These flakes are no more powerful than the guncotton, but are more convenient to handle, and take up less space. Most of the American powder, however, is made by putting the cotton into a combination of ethyl alcohol and ethylic ether, to which are added some barium nitrate, a little potassium, and a trace of calcium carbide. In this solution the cotton literally melts away, and the paste takes its place. But the creation of the paste is a work that no man sees; for after the cotton and the solution are placed in the "kneading machine," and the machine started, every one leaves the building. The kneading is done by a set of revolving paddles that keep the mixture thoroughly stirred up while it is in the kneading vat; but the vat is covered with a heavy iron jacket to check the force of explosions, for though few accidents of the kind have so far occurred, no one knows when one may happen. During this process, which lasts about four hours, the paste is partly dried. It is then forced between steam-heated rollers; but the transparent shellac-like sheets are completely freed from moisture in a drying room, where they are exposed to a high temperature. Then they can be cut by machinery to be used for gun charges.

Suppose merely one of these many processes which create the smokeless powder is omitted or carried out too hastily. Suppose the cotton is not thoroughly freed from impurities or the acids are not strong enough. The chemist says that the mixture will not be stable. What does he mean by that? Simply that it is liable to decompose, especially in a warm climate. It is not merely unsafe, but highly dangerous. The nitric acid and sulphuric acid must be very strong and pure. Their test of strength is their specific gravity. Our grade of smokeless powder is supposed to be made from guncotton which has been soaked in nitric acid whose gravity is at least 1.49 and sulphuric acid of a gravity of 1.835. Much of the acid made in the chemical plants, however, is weaker than this. If the acid is even five per cent weaker, it is not fit to be used; so say the few government experts who inspect the making of this ammunition. Here is something else they say: If even a trace of the acid is left in the guncotton, which has not impregnated it and is still in the acid form, it will, to use the proper scientific term, cause progressive decomposition. Just an atom of this acid which may have escaped the many washings and steepings and wringings is like a yellow-fever microbe in the human body. It may so leaven the compound that the change of a half degree in temperature will cause it to take fire by spontaneous combustion.

NATURAL AND ARTIFICIAL ASPHALT.

Natural asphalt can be distinguished without difficulty from substitutes made of coal tar pitch, but it has hitherto been impossible to separate natural asphalt and petroleum residues, because the two substances are very similar in composition. Marcusson and Eickmann have recently succeeded in distinguishing between natural and petroleum asphalt by means of their oily constituents. Natural asphalt contains from 1.4 to 31 per cent of oil, which becomes completely liquid at 64 deg. F., at which temperature the larger quantity of oil, from 26 to 58 per cent, contained in petroleum asphalt still retains the consistency of soft lard.

A still better means of discrimination is afforded by the respective quantities of paraffin contained in the two substances. Natural asphalt, on distillation, yields little or no paraffin, while the distillate obtained from petroleum asphalt consists chiefly of paraffin.

The following process is recommended for the determination of the proportion of petroleum products in asphalt. The specimen is distilled, and the distillate is dissolved in benzol, precipitated with petroleum ether and further purified with suphuric acid and soda lye. The proportion of oil is then determined, and from this a conclusion is drawn in regard to the presence and quantity of petroleum products. The result may be confirmed by distilling the oil and determining the percentage of paraffin in the distillate by means of alcohol and ether, by Holde's method. If the paraffin amounts to more than 2 per cent of the weight of the oil, before distillation, an admixture of petroleum asphalt may be regarded as probable.

Cement for Vessels to Hold Acids.—Damaged porcelain, glass and other vessels that are used to contain acids, can best be cemented with a mixture consisting of 1 part each of asbestos and fine floor sand and 3 to 4 parts of soda water glass (30 deg. Bé.). The mass can be molded, hardens in the air and is fire-resistant. After being exposed to the action of the acids in these vessels, the cement becomes water-resistant, although before it would be softened by water.

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