GUN COTTON—ITS HISTORY, MANUFACTURE, USE.

BY KARL ROHRER, U. S. N.

The explosive of this name was discovered in 1833 by Braconnot, who dissolved paper and starch in concentrated nitric acid, and recovered a powdery white substance, which burned with a flash when brought in contact with flame.

Pelouze, about the same time, observed that starch so treated gained in weight. He also noticed that by dipping cellulose matter in nitric acid of 1·5 sp. g. it became very inflammable.

In 1846, Schonbein announced the discovery of a new explosive, having four times the power of gun powder, and as being eminently suited to take its place as a propeller of projectiles and in explosive work generally.

Almost simultaneously, Bottger succeeded in producing what he called explosive cotton. He combined with Schonbein to practically utilize their joint discovery.

Otto succeeded in producing gun cotton independently of Schonbein and Bottger, working up from Pelouze's published experiments. Otto's product was weaker than Schonbein's, as he only used nitric acid in its preparation, and not mixed nitric and sulphuric acid, which the latter used. The publishing of Otto's experiments and their results led many expert and amateur chemists to investigating in this field.

Knop, Heeren, and Karmarsch discovered that the best gun cotton was produced by dipping cellulose in the mixed acids, nitric and sulphuric, a fact which was the secret of Schonbein and Bottger.

Publishing and discussing the various ways of producing gun cotton created great excitement in the scientific world of that day. As a humorous scientist put it, "The current literature breathes gun cotton, and the consumption of nitric acid is colossal."

In the meantime efforts were made in France, Russia, and England to introduce gun cotton, and substitute it for gun powder. But the processes of manufacture and the impurity of the raw materials used were such that the results were unsatisfactory. Fatal explosions occurred in France and England in 1848. The political revolutions of that time drew further public attention from the subject.

An Austrian officer, Captain Von Lenk, by study and investigation, succeeded in producing gun cotton which excelled all its predecessors in the regularity of its effect and in its keeping properties. Experiments with it from 1849 to 1853 tended to justify faith in its future, and the Austrian government bought the Schonbein-Bottger patents.

In 1853 the first gun cotton factory established and worked upon a rational plan was erected at Hirtenberg, near Vienna, under Von Lenk's superintendence. His method of manufacture was kept secret until 1862, when he gave it to the French and English, and patented it in the United States in 1864.

In 1865 the Austrian government abolished the use of gun cotton in its service because of two fearful explosions of magazines filled with it, the cause of which could not then be determined.

In this year Abel made the discovery which took gun cotton out of the realm of possibly useful explosives and placed it in that of the safe, practicable, effective, and useful ones. This consisted in pulping it, to admit of its proper purification, and in compressing it to increase its explosive effect. Upon the Von Lenk-Abel method all gun cotton is now produced. Essentially, this method is to dip good and thoroughly cleansed cop or weaver's waste in pure and strong mixed nitric and sulphuric acid—one part by weight of the former and three parts by weight of the latter; to wash, boil, pulp, and liberate the resulting gun cotton from all free acid; then to mould and compress it into the desired shapes and sizes for use.

For the manufacture of gun cotton in the factory established at the naval torpedo station and war college (Fort Wolcott) in 1883, the cotton used is cop or weavers' waste, which is received in bales of about 500 pounds each. (Fig. 2.) The bales are opened, and the cotton is picked over and placed in the cotton boiling tubs, about 200 pounds in each tub (Fig. 3), to which is added about 250 gallons of water and 35 pounds caustic soda. The cotton is boiled in this solution for eight hours, then drained overnight; it is then boiled for eight hours in clear water, again drained, and then thoroughly washed in a centrifugal wringer or extractor. It is thus freed from oil and other impurities.

It is then spread on the wire netting shelves of a suitably arranged dry room, through which hot air, at about 180° F., is circulated, and is sufficiently dried to be picked.

The cotton as received in the bales is full of knots and rolls, and the boiling adds to them. To prepare it for conversion into gun cotton, it is necessary to take them out, that the acid may penetrate easily and quickly through all parts of it. To accomplish this result, the cotton is passed through a picker, a machine common to all cotton factories (Fig. 5).

Having been opened out by the picker, it is dried as thoroughly as possible. This is done by placing it in the wire-netting-bottomed drawers of a specially constructed drier, which is closed when filled, through which, and its contents, hot air at about 225° F. is driven by a Sturtevant blower, which draws its air through a steam heater. In this drier it is left for eight hours, at the end of which time it is estimated that not more than ¼ to ½ of one per cent of moisture remains (Fig. 6). Water is liberated by the action of nitric acid upon cotton, and to avoid weakening the former any more than is absolutely necessary, and to prevent dangerous increase of temperature, the latter must be as dry as possible.

When dry the cotton is stowed away in powder tanks (Fig. 7), so that it may be conveniently handled, and also kept dry. It is now ready for the conversion process.

This is carried on in the dipping room, which is fitted with cast iron dipping troughs, located in a tank of running water, proper cooling troughs, and acid reservoirs. The acid used is received already mixed, contained in iron drums of about 1,200 lb. capacity. The mixture is, as nearly as possible, one part by weight of pure nitric acid of 1·5 specific gravity to three parts by weight of pure sulphuric acid of 1·85 specific gravity, and costs 3¼ cents a pound. As in the converting and the two succeeding steps of the purification process a great deal of acid fume is liberated, the dipping and two following pieces of apparatus are connected with a fan, to take it up and drive it out. The prepared cotton is brought to the dipping room on the railway running through the factory. The dipper fills the troughs with acid and arranges his tools for use. The helper weighs out a pound of dry cotton, with which he approaches the dipper, and pitching about a third of it into the acid (Fig. 8), the latter submerges it with a steel fork, made for the purpose, and so on, until the first trough is charged with the pound of cotton. The other three troughs are similarly charged. When about ten minutes have elapsed, the dipper returns to the first trough, and with the fork gathers the gun cotton out of the acid and puts it on a grating at its further end, and there squeezes the surplus acid out with a hand press (Figs. 9 and 10). By the time this is done, the helper has placed a stone jar, into which the two place the gun cotton from the first trough. The helper presses it down in the jar, puts a cover over, and sets it in a cooling trough. The dipper replenishes the acid, and the trough is charged with cotton as before, and so on, until the day's dipping, about 110 pounds, is finished. The jars are left in the cooling troughs overnight, so that their contents may thoroughly digest, and there remain no unconverted particles of cotton (Fig. 12).

From the cooling troughs, the gun cotton is taken to a centrifugal wringer, two jars at a time, in which the acid is extracted and caught in a drum (Fig. 13). This spent acid is sold to the acid manufacturers for three-quarters of a cent a pound. Extracting it is a delicate operation, and great care must be taken that no oil or water finds its way into the wringer, for, if it does, the gun cotton will be ignited, and, under such circumstances, it is very difficult to draw the line between a fire and an explosion.

The gun cotton, having been approximately freed from acid, is taken to the immersing tub, in which washing out the free acid is begun (Fig. 14). Immersing acid gun cotton in water is dangerous, and must be carefully and intelligently done. In this tub revolves a paddle wheel, over which is a hopper, which communicates with the wheel by a slot. The gun cotton is brought from the wringer in a tray, and placed in the hopper, from which it is fed by separate handfuls, down the slot, upon the revolving wheel, and into the flowing water in the tub. If it is otherwise fed down to the wheel, so much heat is developed in that part at the edge of the water that it may ignite, and burn the contents of the hopper, and do other damage.

The gun cotton is taken out of the immersing tub, and thoroughly washed in a centrifugal wringer, and then placed in a gun cotton boiling tub. These tubs are similar to the cotton boiling tubs, differing from them in having the steam enter through the top, going to the bottom, then through a coil, and out. The boiling space is insulated from the metal pipes by perforated boxing. Live steam does not come into contact with the gun cotton, nor does the metal of the steam pipe. In this tub it is boiled in fresh water, and 10 lb. of carbonate of soda, for eight hours. It is then drained, and thoroughly washed in a centrifugal wringer, and boiled again for eight hours, in fresh water, and again drained, and washed as before.

After the second boiling and washing, it is taken to the pulping machine (Fig. 15), which is similar to the machine used in paper mills, for pulping paper stock. In this machine, which is suitably filled with water, it circulates between the knives until pulped to about the fineness of corn meal.

From the pulping machine it is drawn off into a poacher, which is a large oval tub provided with a paddle wheel in the middle of one side, working just clear of a platform with inclined approaches (Fig. 16). The pulp and a sufficient quantity of water being in the poacher, its paddle wheel is made to revolve, which causes both pulp and water to circulate, and the latter to wash the former. After an hour's washing the paddle wheel is stopped, upon which the gun cotton settles to the bottom. The soiled wash water is drawn off by means of a telescopic pipe at one end of the poacher. Fresh water is added, and the cleansing continued until the washing water ceases to become soiled. The gun cotton is then supposed to be clean and without free acid.

A sample is taken from the bottom of the poacher, and submitted to the solubility test, to determine what percentage of soluble gun cotton it contains, which must be less than ten per cent. The lower orders of gun cotton are soluble in a solution of one part alcohol and two parts ether, and by means of this solution the test is made. It is then submitted to the heat test, to determine whether any free acid remains. To make this test, small quantities of the sample, thoroughly dried, are placed in test tubes which are filled in a hot water bath, carrying a suitable thermometer. The mouths of the test tubes are closed with corks, under which are suspended pieces of iodide starch paper, which has been very carefully prepared. The bath is heated to 150° Fah., and the gun cotton must bear this temperature for not less than fifteen minutes, without turning the test paper brown.

Having passed the tests, the next step is to prepare it for service use. To every poacher full of it there is added three pounds precipitated chalk, three pounds caustic soda, and three hundred gallons of lime water. So fortified with alkali, it is pumped into what is called the stuff chest, a round tank with a vertical shaft, carrying feathers to keep the pulp agitated and mixed with the water (Fig. 17).

The gun cotton being in the stuff chest is drawn thence and moulded, or pressed into shape for compressing, which is accomplished by means of a hydraulic press arranged for the purpose. Knowing the size of the compressed block desired, it is determined by experiment how much of the pulp is necessary to produce it, increasing or decreasing the length of stroke of the press pistons, then the moulding is proceeded with. The standard gun cotton block for naval use is 2·9 inches square and 2 inches high (Figs. 20 and 21), to produce which the moulded block must be 2·8 inches square and 5½ inches high (Fig. 19), moulding at a pressure of 100 pounds to the square inch.

From the moulding press the blocks are taken to the final press, which is one of Sellers hydraulic presses with an 18 inch ram (Fig. 18). In the receiver of this press the moulded blocks are placed between two perforated steel plates, a traveling block is then hauled over and the pump started, which forces up the ram and the pistons on top of it, which act on the gun cotton in the receiver. The naval service gun cotton is compressed at three tons to the square inch, and leaves the press with from 12 to 16 per cent of moisture, which is increased to about 35 per cent before issue to the service. It goes into the service packed in the standard tin exercise torpedoes and tinned sheet iron service torpedoes, which are capable of being made water and air tight, and have the necessary fitments for filling, fusing, and being attached to spars preparatory to explosion (Figs. 22 and 23).

The public owes much to the various experimenters with gun cotton, but owes most to Von Lenk and Abel. The former determined the facts that the strongest and best gun cotton is secured from the purest and best raw materials, and that to make it safe, its free acid must be extracted. The latter discovered how to make it safe, and how to increase its explosive effect. He also realized its true sphere of usefulness.

The filaments of cotton in the natural state are hollow, and all the spinning, weaving, and other processes to which it is subjected in the manufacturing and commercial worlds fail to destroy these tubes, as they may be called. Their existence caused the failure of the early gun cotton makers, because, upon dipping the cotton into acid, it permeated the hollows of the filaments, and no ordinary method of washing served to extract it. With free acid in gun cotton it is a question of short time for decomposition to begin, and explosion to follow.

Abel, by discovering the pulping process, enabled the gun cotton to be thoroughly purified of free acid; as by pulping the filaments are broken up, and the worker is able to wash it out. Again, by fortifying the purified pulp with a percentage of alkali to neutralize the nitrous exhalations which all nitrated bodies give off, sooner or later, and then compressing this purified product, he presented to the military world the ideal explosive for its purposes.

It is extensively manufactured in England, by government as well as by private individuals. In Germany, Italy, Austria, and other countries it is manufactured by private parties. It is used by the military services of the whole world, and is constantly growing in favor. The Chinese and Japanese are taking steps to establish their own factories, and thus free themselves from the European manufacturers.

The United States government should to-day have a half million tons of it, contained in torpedo and mine cases, distributed along the Atlantic, Gulf, Pacific, and lake coast, and at central distribution points along that line. It should also have a well drilled and organized naval militia, prepared to lay them out properly and put the life of death into them for those who attack us.

In these days, when the Monroe doctrine is expounded to embrace islands 2,000 miles and more from the continent; when interoceanic canals are to be controlled; and when it is the mode to twist the tails of the British and Spanish lions, to pull feathers from the Gallic cock and the eagles of Germany and Austria, it were well that many and rapid steps be taken to enable the country to maintain and prosecute a fight, if one should be developed. From the point of view of one to whom war means promotion, aggressive foreign policy might be very promising, other things being equal. Alas! other things are not equal; and while this country, in area, wealth, population, and latent defensive and offensive war strength, ranks among the highest of first class nations, yet in its immediately available defensive and offensive power, upon the sudden declaration of war, it ranks little, if any, higher than Denmark. Modern guns, forts, ships, torpedoes, mines, and gun cotton must be accumulated, and the fighting strength of the nation trained in their use.

Wet compressed gun cotton is the safest high explosive yet produced. It can be readily and safely transported by any conveyance whatever. It is eminently convenient and safe to handle, store, and work with. It can be sawed, turned, cut, and bored easily and with perfect safety; and the turnings, cuttings, and borings may be worked over, as may old, distorted, or obsolete shapes. It can be compressed in any shapes or sizes.

Dry compressed gun cotton is safer, in every way, than gun powder, and a very small percentage of the whole weight of any charge for explosive work need be dry.

In view of the daily accidents with the ordinary market high explosives, it is pertinent to ask what would happen if the work of lining our whole coast with mines and torpedoes charged therewith were attempted? Our defense would be as dangerous to ourselves as to our enemy. No man fights well who is afraid of his weapon.

The time has arrived for private enterprise to take hold of gun cotton. The processes and machinery for its manufacture can be greatly simplified and improved, and its sphere of usefulness much increased. It is certain that the overweening common sense of our naval and military ordnance authorities will, in the near future, cause it to be adopted as the normal high explosive for government use. Even now, reasonable inducement might be received for private parties to move in the matter.

As superintendent of the factory whose processes this paper describes, I have, in the past three years, made many tons of it, handling it under various circumstances, in both the wet and dry states, without injury to person or property.

That Ache in the Back.

An Albany physician, says a contemporary, declares that Americans suffer more generally from Bright's disease and nervous diseases than any other people, and he says the reason is that Americans sit down so persistently at their work. He says: "Americans are the greatest sitters I ever knew. While Englishmen, Germans, and Frenchmen walk and exercise, an American business man will go to his office, take his seat in his chair and sit there all day without giving any relief to the tension of the muscles of the back. The result is that these muscles surrounding the kidneys become soft and flabby. They lose their vitality. The kidneys themselves soon become weak and debilitated. If Americans would exercise more, if they would stand at their desks rather than sit, we would hear less of Bright's disease. I knew of a New York man who had suffered for some years from nervous prostration until it was recommended to him that he have a desk at which he could stand to do his work. Within a year he was one of the healthiest men you ever saw. His dyspepsia and kidney trouble had disappeared, and he had an appetite like a paver.'

A Mountain of Iron.

Dr. Noetling, of the Geological Survey of India, in a recent report on magnetic rock among the Shan Hills of Upper Burmah, describes a mountain or hill at Singaung which "consists of a huge mass of iron ore." Having, he says, noticed on the way numerous pieces of iron ore, which became still more frequent on the southern side of the hill, he examined the latter in several directions. He found the surface everywhere covered with large blocks of iron ore, originating evidently from superficial decomposition of lower beds. He concluded that the whole hill consisted of a large mass of iron ore. He was unable to ascertain the geological conditions under which this ore occurs, or its exact limits and extensions, on account of the dense jungle and the tremendous attraction, rendering his compass useless. He estimates, however, that the hill covers, at least, an area of about a square mile, and that it rises about 200 feet above the level of the Twiunge valley. The ore is hematite peroxide of iron.

Correspondence.

Wheat in Geranium Stalk.

To the Editor of the Scientific American:

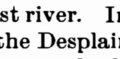
A peculiar growth has lately come to my notice, which may be of interest to some of your readers. About three weeks ago I was told, when about to plant some geranium cuttings, that if the lower end of a cutting was split and a grain of wheat inserted, it would much promote the growth, so I tried the experiment. It did not have the desired effect, as the cutting never grew at all; but when I pulled it up I found that the wheat grain had grown to the height of about 7 inches up through the pith of the cutting, and had two perfectly formed pale green leaves, closely folded up within. The only part of the wheat projecting from the geranium was about one inch of root. WM. H. P.

The Great Lakes.

To the Editor of the Scientific American:

I accidentally, a few weeks since, came in possession of the SCIENTIFIC AMERICAN of August 18, 1888, in which I read an article on the formation and changes of the level of the great lakes, by Mr. C. K. Gilbert. I was greatly interested in his theory and opinion of the changes of level of Lake Erie, of Lake Huron, of Lake Michigan, and Lake Superior. It is evident from the indications and marks on the south shore of Lake Erie that that body of water was, at some anterior date, many feet above the present level. Also, that Lake Huron's and Lake Michigan's present levels are many feet lower than they were at some anterior date.

In 1835 and 1836 I traveled on foot through the region of country from the southwest portion bordering on Lake Michigan in a southwest course to the Desplaines River, commencing some six miles south of Chicago, near or at the mouth of the Calumet River. The country at that time (1835) was a low, swampy region for some four or five miles in width, extending in a south by west direction toward the Desplaines River. Some ten or twelve miles from Lake Michigan, the low, swampy character of the land was contracted to about a mile in width, and from that point on to the Desplaines River was known as or called the sag. This sag was a wet, swampy piece of land, almost impassable, overgrown with long swamp grass and flags. This was the general character of the sag, or low ground, until it united with the Desplaines River, some six or eight miles above the town of Joliet. This low ground, commencing at Lake Michigan, and the sag, or valley, has every appearance of once being the bed of a large river. In June, 1835, I was at the town of Joliet, which had then but four or five buildings—but one house on the east side of the river (Desplaines) and three or four buildings on the west side of the river.

The valley of the Desplaines River, from the junction of this low, swampy sag, or valley, I should say is from one-half to three-quarters of a mile in width from thence to its union with the Kankakee River. From Joliet I traveled on foot down this valley, following an Indian trail most of the way to within a short distance of the town of Ottawa. The peculiar formation of the bottom, or land, of this valley, between the bluffs, was such that it led me to believe it was, at some ancient period of the world's history, washed by a large river. At Joliet, on the east side of the river, there was no soil of consequence. The valley was covered with round, coarse gravel and sand for from six to ten inches or more in depth; then the rock formation commenced; this extended down the valley for some two miles. This coarse gravel and small stones had every appearance of having been washed by water, they being so round and smooth. Some three or four miles below Joliet there is a mound, or mountain, as it was called at the time (1835) that I was looking at the country. This valley, on each side of the mound, had every appearance of having been washed by a large river. This mound is, I judge, some 60 or 80 feet in height, and the top of the mound is on a level with the country on either side of the valley. The top of this mound contains several acres of rich soil of the same character as the prairies in that vicinity. The upper end of this mound, at the base, is composed of a ledge of rock. There are also distributed throughout this valley, to its junction with the Fox River at the town of Ottawa, numerous small mounds, from 15 to 20 feet high. All of these had the appearance as if they were islands in the bed of a river. The formation of these mounds was precisely that of all islands in large rivers—broad and round at the upper end, and washed to a point at the lower end like this . From the town of Ottawa to the town of Peru, the head of navigation on the Illinois River, the bluffs on either side of the river have the appearance of having been washed by the waters of a vast river. In fact, the Illinois River, with its tributary, the Desplaines, to its union with the Mississippi, I have no doubt, was the channel through which the waters of the great lakes, Erie, Huron, Superior, and Michigan, once found their way to the Gulf of Mexico.

There is no question, in the minds of scientific men, as to the fact that the surface of these lakes was many feet higher than at the present time. From the formation of the surface of the country at the southwest end of Lake Michigan, some ten or twelve feet elevation of this lake would discharge the water through the channel above mentioned into the Illinois River. There is no doubt but the ridge of rock formation extending from Lockport to and across the Niagara River was, at some anterior age of the world, a barrier to the outlet of Lake Erie; hence the evidence from indications on the south shore of the lake shows that the water of the lake was from forty to fifty feet higher than at the present time. There is, according to engineering surveys, but twenty-two feet fall from Lake Huron to Lake Erie; hence this elevated ridge of land crossing the Niagara River would be a barrier to the outlet of Lake Erie into Lake Ontario. Therefore the waters of Lake Erie flowed into Lake Huron and through the Straits of Mackinac into Lake Michigan and thence through the Illinois River to the Gulf of Mexico.

C. T. S.

Creolin in the Local Preventive and Curative Treatment of Infectious Throat Diseases.

BY F. W. KOEHLER, M.D., LOUISVILLE, KY.

In Nos. 17, 18, and 19 of the current volume of the *Wiener Medizin. Wochenschrift*, Dr. James Eisenberg describes a series of experiments made with the new antiseptic creolin. He shows it to be an extremely powerful germicide, and yet, even in large doses, altogether harmless to man. These qualities made it appear to me an ideal remedy for the preventive and curative treatment of infectious throat troubles. Adults can use gargles of the ordinary poisonous antiseptics, like the bichloride of mercury, but for children something is needed which can be safely swallowed. Soon after I had read Dr. Eisenberg's article I procured a supply of the creolin, and have since used it to the exclusion of other local applications. My success with it has been very pleasing indeed. In treating infectious throat troubles, I now always put not only the patient, but also all the well members of the household, on the creolin treatment. Thus I have prevented, I think, diphtheroid sore throat from going through entire families of children, which it had previously, under other modes of treatment, always done.

But it is as a preventive of true diphtheria that I expect most from the creolin. Dr. Eisenberg's experiments show that no form of pathogenic germ can resist its action; and it is therefore reasonable to suppose that the germ of this disease will also succumb to it. Recently I was called to see an old lady, who, a day or two after exposure to a case of diphtheria (proved to be so by paralysis occurring several weeks afterward), was taken sick with rigors, fever, and sore throat. Almost simultaneously her daughter and son-in-law were taken in the same way; but her little grandchild, a boy of four years, showed no signs of the disease when I was called. I at once, however, put him, as well as the others, on the creolin treatment. The child, although always rather predisposed to throat and bronchial trouble, escaped an attack altogether, and his parents and grandmother recovered promptly.

Diphtheria is certainly one of the most dreadful diseases that confront us, and any treatment that might reasonably be expected to prevent its spread should be given a trial. I am inclined to believe that if the mouths, throats, and nasal passages of children were kept as clean as their faces, there would be much less of the disease. When diphtheria prevails, no child's toilet should be considered complete until the upper air passages have been thoroughly douched with some suitable antiseptic; and in the long list of such agents I know of none that fulfills the requirements so well as creolin.—*Medical Record.*

Good Counsel.

How true it is, as the *Practical Mechanic* says, thousands start well, but never finish one thing at a time. They have a dozen things on hand and no one completed. Time is wasted on unfinished work. Always finish what you begin. One thing finished is worth a hundred half done. The completion of an undertaking yields more pleasure and profit than dozens of plans. The man who is always planning or scheming is rarely, if ever, successful. He often furnishes ideas for others, who go persistently to work and finish what his ideas suggested. "That was my idea—my plan,' we frequently hear some one say, but the man who carried it out was the one who benefited himself and others. Do not begin what you cannot finish. What you undertake to do, *do*, and reap the reward of your own ideas and skill. This is good advice both in and out of the shop.

New Automatic Rifle.

A new automatic magazine rifle, invented by R. Dewhurst and H. A. Pitcher, has been brought out at Neillsville, Wisconsin, where it is making quite a sensation. Like the Maxim gun, the cartridges may be fired singly, by pulling the trigger for each desired discharge, or the gun may be set so as to fire itself off, with great rapidity, until all the cartridges in the magazine are used.

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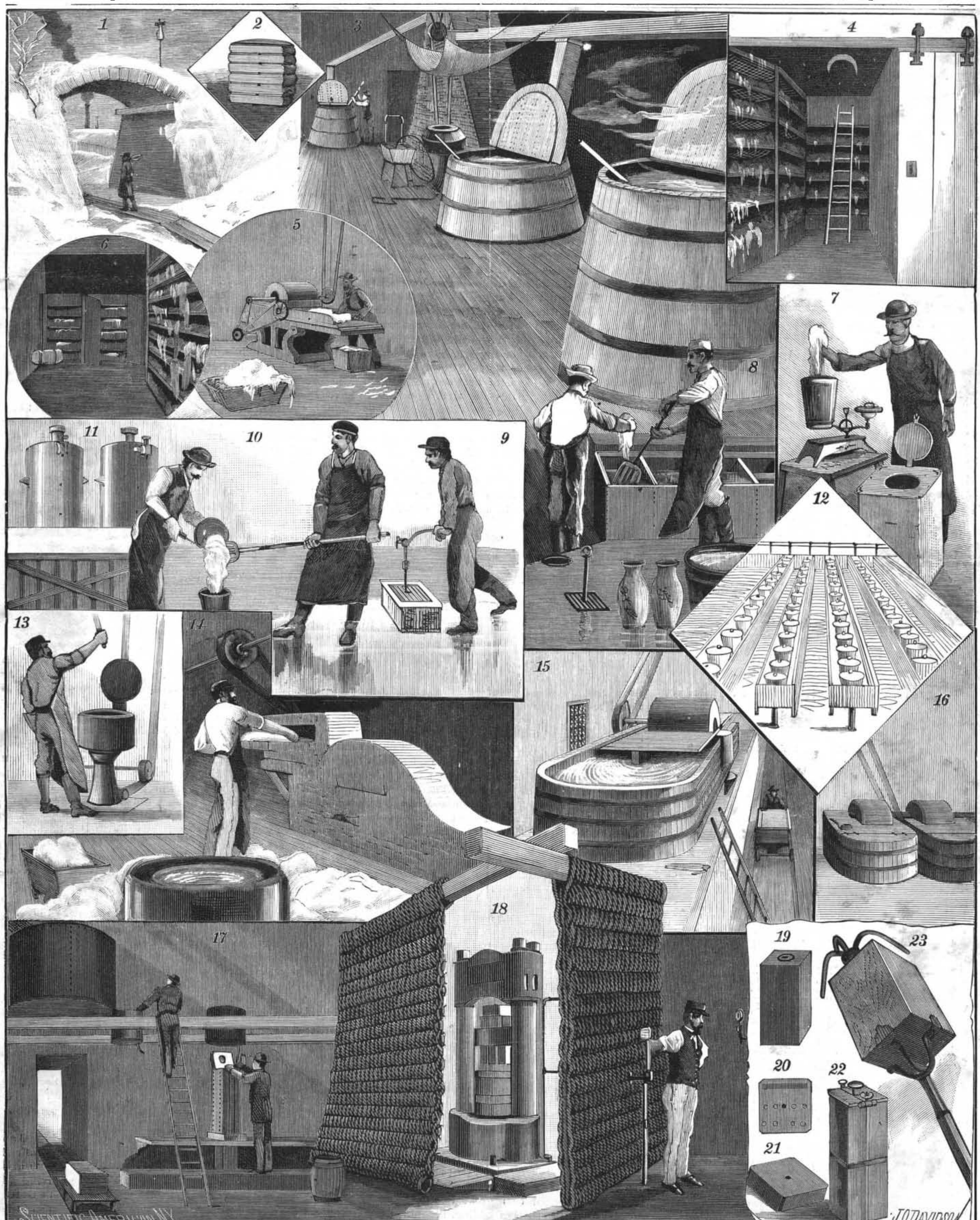

1. Entrance to Fort Wolcott, location of U. S. gun cotton factory. 2. Bale of cop, or weaver's waste. 3. Boiling room. 4. (1) Drying room, temperature 180° F. 5. Picking machine. 6. (2) Drying room, temperature 225° F. 7. Weighing before "dipping." 8. Dipping in mixed acid—sulphuric (3) and nitric (1). 9. Pressing out mixed acid. 10. Potting in digesting pots. 11. Earthenware acid holders, or reservoirs. 12. Digesting pots in cooling troughs. 13. Centrifugal acid extractor. 14. Immersing tub and wringer. 15. Pulping machine. 16. Poachers. 17. Stuff chest and moulding machine. 18. Hydraulic press. 19. Gun cotton block moulded. 20 and 21. Gun cotton block compressed for service use. 22. Exercise torpedo. 23. Service torpedo.

UNITED STATES GUN COTTON FACTORY AT TORPEDO STATION, NEWPORT.—[See page 116.]