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Contents:

(Illustrated articles are marked with an asterisk.)

PETROLEUM FOR FUEL.

Some of the best inventive talent of the world has recently been employed zealously and hopefully on devices for using petroleum as fuel. Experiments have been conducted on the most liberal scale and the projectors have received the encouragement and applause of the public. Governments also have come to the assistance of private enterprise. In the United States, two independent series of experiments, lasting many months, are going on night and day, quite regardless of cost, under the patronage of the Naval Department. When the authentic records of these labors are brought together and studied, it will be found that the subject has been very thoroughly explored.

We are right, then, in assuming that the practical difficulties pertaining to the construction and management of petroleum furnaces, are fairly met and obviated. We assume that petroleum fuel is safe, that the petroleum furnace may be automatic. For the moment, we admit, all the conveniences fairly claimed for petroleum fuel in order that we may more directly fix attention on a single other consideration which is generally overlooked or misrepresented. We allude to the cost of the heat which petroleum can produce.

The question of the cost of petroleum heat seems to us vital and fundamental. The answer to this modifies every other consideration; it should be the starting point of all our reasoning. When we know precisely what can come out of petroleum, we are ready to discuss, intelligently what may be done with it.

Fortunately the question can have no doubtful answer. The methods of estimating the heat of combustion are constantly subjected to the scrutiny of scientific and practical observers. The figures which are agreed upon are known to be so accurate that no error can ever be discoverable when they are adopted as a guide in practice. The total heating power of petroleum may be variously stated according to the standards of measurement adopted, but for our purpose it is most convenient to reckon it in terms of pounds of water at 212° it can evaporate by its complete combustion. It has been ascertained that the heat from the combustion of one pound of petroleum can evaporate from twenty to twenty-two pounds of water, the water being taken at 212°. The variation of 20 to 22 is due to the fact that the composition of petroleum is not constant; for convenience we take 21 to represent the heating power. For comparison it is necessary to understand that the heating power of pure carbon is the evaporation of fifteen pounds of water at 212°. The heat-values of petroleum and carbon are therefore as 21 is to 15.

The petroleum and coal of commerce are, however, not the pure substances on which the above figures are based. The ratio of 21 to 14 or 3 to 2, probably, very nearly represents the relative heating power of the petroleum and coal which are actually in use. Petroleum then gives fifty per cent more heating power than coal, and taking nothing else into the question, we can afford to give in money fifty per cent more for petroleum than for coal. If we go into the market to-day we find that we can buy crude petroleum for 21 cents per gallon, and coal for $6 per tun. Reducing to cost per pound we find that a pound of petroleum costs three cents and a pound of coal one third of a cent. Weight for weight petroleum costs nine times more than coal; and taking into account that the petroleum has a fifty per cent greater value, we find that the relative costs of the heat of petroleum and coal are as six to one. We repeat: petroleum heat costs six times more than coal heat.

There are objections, however, to such a putting of the case. It is said, for example, that the ratio of 21 to 14 is not shown to be true in actual practice; instead of a pound of coal evaporating fourteen pounds of water, the number of pounds in actual good practice is seven, and with our improved petroleum burners we hope to reach twenty-one. Let the ratio of 21 to 7 or 3 to 1 be assumed as possible, and then at the prices—21 cents per gallon and $6 per tun—petroleum heat would cost three times more than coal heat. But there is no ground for the hope that one pound of petroleum will ever, in practice, evaporate twenty-one pounds of water; in fact, the most authentic experiments thus far indicate that the ratio of 3 to 2 is sufficiently generous towards petroleum. We need more data than are at present at our command to determine precisely the most truthful expression for the ratio of practice; but we are quite willing to believe that it will be somewhat more favorable to petroleum than 3 to 2.

It is objected that our prices are not a criterion for other times and places. It is quite true that the relative prices are often more favorable to petroleum. At the oil wells, petroleum has been sold at a lower rate by weight than coal. If the ratio 3 to 2, representing the relative heat values, be kept in mind, it will be a simple thing to compute any question of cost. For example: If coal cost $6 per tun, what must be the price per gallon of petroleum, to furnish heat at the same rate as the coal? Answer: Three and one-half cents.

It is our purpose in future, taking the above as a starting point, to show where petroleum fuel is economical and practicable.

ORIGINAL INVENTORS AND MECHANICAL IMPROVERS.

Comparing the present style of inventions for which patents are granted, with some of those in the past whose use and reputation are universal, the superficial observer may conclude that either the period for great inventions is gone, or that the race of inventors has deteriorated. A little consideration will probably show that this view of the situation is erroneous; and to arrive at this conclusion it is not necessary to belittle the work of those who have gone before us. In many instances their success seems to have been achieved by inspiration rather than reached by persevering and patient effort.

Take the greatest of Watt's inventions—the steam engine. While it cannot be disputed that many very useful improvements have been made in the tools for its manufacture and in the perfection of its parts, consequently in its value as a motor, the steam engine of Watt is in all essential respects the steam engine of the present day. Indeed, engines of his manufacture are still running in England and doing good service. So with the forming lathe of Blanchard; it has received no really radical improvement since his first successful machine went into operation. Whitney's cotton gin is the gin now built, altered, perhaps, in form, proportion of parts, and rapidity and perfection of execution, but still Whitney's gin in all essential points. The tack and nail-cutting machine of Read remains nearly the same as when first invented. Howe still receives a royalty from the various manufacturers of sewing machines.

But while these facts are incontrovertible, it is no less true that, although the principle of the primary invention may remain the same, improvements have been made in its application which wonderfully enhance the value of the machine to which they are applied. If an inventor improves a machine which, in its crude state, was itself only an improvement on the hand labor it was intended to supersede, and makes it doubly or trebly valuable, shall he not have the credit and reward as well as the original projector? There are cases where the value of these improvements has alone popularized and made remunerative the original invention. Let the machinist of twenty-five years' experience remember the rude lathe with wooden shears and slide rest for screw cutting, and then look upon the perfect specimens of the machine as turned out by the best makers at the present day, and he will be convinced that the inventor of improvements is worthy a place among the discoverers in mechanics. Surely if Sterne's aphorism, "he who makes two blades of grass grow where only one grew before, is a benefactor of his race" is correct, the inventor of improvements can fairly claim that honor.

DO METALS GROW.

It is supposed by some that the metals were formed or deposited in some past age of the world by the agency either of heat or water, during some great convulsions of nature such as have not been witnessed in the period embraced by written history or tradition. There are reasons for doubting the reliability of this opinion. That various mineral substances are now in process of formation or development is certain. For instance, the formation of stone is as apparent as its disintegration. On the beach at Lynn, Mass., may be seen a conglomerate of clay and silicious sand impregnated with ferrous oxide, in all stages, from the separated particles to the layers of hardened rock. These rocks are merely the particles of sand, cohered and agglutinated by means of the clay and the oxide of iron, the salt water acting as a solvent of the softer particles and the sun's rays compacting and baking all together in one mass. So, also, we know that coal is being formed from peat. The intermediate stage is lignite or "brown coal" which in turn becomes coal.

It is morally certain that gold, silver, copper, and some other metals are now in process of formation or deposition. Abandoned silver mines in Peru have been found rich in arborescent deposits of the metal on the walls of galleries unused for many years. A gold-bearing region after having been cleaned of the precious metal gives good results after the lapse of only a few years. So with copper. In the Siberian mines not only the precious carbonate known as malachite but the metal itself, in a state of almost absolute purity is deposited on the walls, roofs, and floors of galleries run under the earth's surface. In some places it appears in masses and in others as tree-like formations, with trunk and branches similar to a delicate moss.

What becomes of all the gold and silver unavoidably wasted in the process of manufacture and the wear of transmission from hand to hand as currency? It is well known that with all the care exercised in the manufacture of these precious metals, and notwithstanding their specific gravity, an appreciable portion of them is utterly wasted; at least so distributed as to be incapable of being collected and used again. Is it annihilated? The teachings of science prove this to be impossible. Nothing is ever wasted. If the particles are thrown into the atmosphere they must in time seek the earth's surface. Are they attracted by some unknown power to certain localities, and if not, why should not the streets of a busy city become in time deposits of the precious metals?

Perhaps, after all, the old alchemists had an inspiration of what may yet become *un fait accompli*. When we understand the wonderful processes of nature's laboratory we may possibly imitate her and grow our own metals as we now do our own vegetables; or we may find the philosopher's stone and actually collect the particles of metals, if we cannot transmute a base mineral into one of the precious metals.

A GREAT NEWSPAPER ESTABLISHMENT.

Although the rich white marble front of the new *Herald* building had towered over Broadway as one of its most striking landmarks for the best part of a year, it was not until about the middle of May, that the machinery of the new establishment commenced turning out newspapers, nor is it even yet at its mature complement.

The top and bottom extremes of this building, devoted to the mechanical departments, are its most extraordinary and interesting parts. Each of these—the basement and the Mansard upper story—is a magnificent hall, twenty-four feet in hight, one hundred feet long, and from fifty to sixty feet wide: the rear end of the upper story, however, being partitioned off for the stereotyping department. Probably there is nothing like this establishment devoted to printing a newspaper, elsewhere in the world. Few princes and great men do their work, such as it is, in halls so lofty, airy, and salubrious as that occupied by the *Herald's* compositors. Both light and air, on that unobstructed hight, far above the city chimneys, have all the freshness and amplitude of open day, yet agreeably tempered to every variation of weather by capacious ventilators in the iron roof and sides, steam coils, lofty windows, and the glass bulls eyes that thickly stud the roof. The stands in use accommodate 70 compositors, and hundreds of gas burners stand ready, with intervals of only a few inches, to illuminate instantly any spot upon which light is wanted. Of course the conveniences for making up the forms, for the accommodation of standing type, etc., are very ample and perfect. In the stereotyping room stand the heavy presses for stamping the type forms into sheets of soft paper; the melting furnace, surrounded by iron flasks in which the paper molds are placed for casting, hung by trunions on iron carriages; and cutting machines that gage and trim the edges of the plates instantly and to a hair. On one side is the minor elevator, with its donkey engine a hundred feet below, by which the plates descend to the press room and return. Near this is the great elevator, with its more powerful engine and machinery in the basement, which a person on any floor of the building may operate by a cord, ascending or descending at will, with the heaviest loads.

The machinery hall in the basement—of which a fine view is presented in the engraving—has its imposing appearance somewhat broken up by a broad gallery running all around and between the printing machines for the accommodation of the pressmen and feeders, and almost dividing it into two stories. Two rows of tall iron columns support the floor above, and massive piers of masonry sustain the walls at the sides on Broadway, Park Row, and Ann street. Beyond these piers, beneath the sidewalks, are arranged the boiler rooms, coal and paper storage, and vats for dampening the huge piles of paper required for every day's edition. The coal chute from the street conducts to a boiler iron reservoir balanced on a platform scale which shows the weight of the load as soon as dumped, and a hinged bottom in the reservoir then opens and drops the fuel at the feet of the fireman below.

The engines, of 60-horse power each, are of the favorite style known as the "beam engine," built by R. Hoe & Co., the builders also of the immense presses, and are models of strength and beauty, combined with simplicity, compactness and good workmanship. They are connected one at either end of the fly-wheel shaft, so that they can be run together if required, although ordinarily run separately. The cylinders are fitted with the simple long-lap slide-valve, arranged to cut off the admission of the steam at two-thirds of the stroke. The governor is of the well-known Judson patent, and regulates the speed to perfection. The shafting consists of a single line placed beneath the floor and runs along by, and drives, each press.

The publication office, on the street floor, is the most sumptuously furnished room we have ever seen opened to the public for business; the counters being composed of fine variegated marble, polished and paneled, and surmounted with desks and railings of carved and inlaid walnut, with plate glass windows and doors for transacting business, in the fashion of first class banking houses.

The editorial establishment is mainly on the second floor, and has its peculiar features of mark, among which may be mentioned the handsome "council chamber" wherein the managing editor daily meets his staff to confer upon the affairs of the day, determine the course to be taken, and assign to each his *rôle* in the next morning's editorial demonstration. Near to this is the manager's private office, and connected with it an inner sanctum where a Wheatstone's telegraph communicates with the senior proprietor's residence on Washington Heights, eight or ten miles distant, by a private line of wires erected expressly for the purpose. The library is a large apartment not yet fitted up, designed for shelves from floor to ceiling, accessible by stairs and balconies, and to contain thousands of books of reference on the innumerable subjects constantly arising in a daily paper. The numerous editors and editorial writers have their separate apartments on this floor, and the reporters' room has accommodations for more than a dozen at once. There is also a reception room furnished with files of the daily papers, and a doorkeeper always in attendance at the entrance, to admit or exclude. The proof-reading room is a good-sized apartment on the floor beneath the compositors', connected with the latter—like the editorial and publication offices—by small hand elevators and pipes. One of the excellent features of the system is the index office, where every event and subject noticed in the paper is indexed daily, and may be referred to in a moment, many years back. For system, completeness, and extent, the now *Herald* establishment, editorial, mechanical, and commercial, is probably without a rival.

For the Scientific American.

THE FIFTEEN-INCH BALL VS. ARMOR PLATES.

The fifteen-inch cast-iron navy smooth bore cast by Alger, of Boston and sent to England for the British ordnance officers and iron plate commissioners to experiment with, underwent its preliminary trials for "velocity, range, and accuracy," at Shoeburyness, on the 27th June last. Fifteen rounds were fired with cast iron balls averaging a little more than 450 pounds each.

The first three rounds were fired with 35 pounds of the "mammoth grain" powder. Elevation 2 degrees; range, 711, 740, 737 yards respectively; velocity of ball averaged 920 feet per second; deviation of shot, $\frac{6}{10}$ of a yard to the right.

Next three rounds with 50 pounds "mammoth grain." Elevation as before; range averaged 987 yards. Velocity of ball, 1,110, 1,120, 1,133 feet per second respectively; deviation from 2 to 3·2 yards to the right.

Next round, 60 pounds of "mammoth grain" powder—elevation the same. Range, 1,138 yards; velocity of ball, 1,210 feet per second; deviation of shot, 1·4 yards.

Next three rounds with 35 pounds of English powder of the following character and composition: Number of grains to an ounce, 500; niter, 75·3 per cent; sulphur, 10·3; charcoal, 14·4; moisture, 1·07; density, 1·74. Elevation the same; average range, 873(?) yards; velocity, 1,044 feet per second; deviation of shot, ninth round "flew absolutely straight;" greatest deviation of the other two, 1 yard.

Next three rounds with 50 pounds of the same powder—elevation as before. Last round gave a range of 1,140 yards, with a velocity of 1,214 feet per second. Deviation—one round "flew straight to the mark;" last round deviated 2·4 yards.

Two rounds were then fired with 60 pounds of the "mammoth grain" powder, with about the same results as the other rounds with the same powder.

These preliminary trials seem to have astonished the British artillerists not a little, with respect to both velocity, range, and accuracy. *Engineering* remarks: "After Thursday's experiments we trust we shall hear little more of this parrot cry about *low velocity*;" and "As regards accuracy, we fancy the results must have surprised some of the judges not a little." Not only were the British artillerists astonished, but it was shown that one of the most distinguished of this fraternity, Captain Noble, of the Royal Engineers, who wrote the elaborate report to the Ordnance Select Committee, did not understand certain elements which should be regarded in computing the effect of large spherical shot. This officer, in the report alluded to, after extolling the power of the 9-inch wrought-iron Woolwich rifle, the favorite English gun, made a calculation which seemed to prove that the 15-inch American smooth bore was a mighty poor concern. These calculations, together with the termination of the gallant Captain's report, in which he pooh-poohed the American gun, seem to have been extremely gratifying to the British journalists. Ponderous leaders were written, and Lord Elcho was for the time pretty well put down for his Parliamentary attacks on the extravagance and inefficiency of the Ordnance Department of the government. He was for the time looked upon pretty much as our artillerists and engineers regard Mr. Wiard.

On page 30 of his report, Captain Noble sets forth as the result of his calculations on the American smooth bore, that with 50 pounds charge of English powder and a 484-pound spherical shot, a velocity of 1,070 feet per second will be the result. This is equivalent to a dynamic force represented by 8,658,760 foot-pounds, and 8,658,760÷50=173,175 foot-pounds to each pound of powder.

Now on the trials for range, velocity, etc., which are given above, it is seen that Captain Noble himself propelled the 450-pound 15-inch ball with 50 pounds of English powder with the velocity of no less than 1,214 feet per second. The dynamic force of this ball was therefore represented by 10,328,400 foot-pounds, or 10,328,400÷50=206,570 foot-pounds to each pound of powder, that is, 206,570—173,175=33,395 foot-pounds *more* energy per pound of powder than stated in his calculation on which he based his erroneous opinion of the power of the gun.

In no case which has fallen under the observation of the writer has a pound of powder in the English 9-inch rifle developed a greater energy than 175,000 foot-pounds; this with a 250-pound cylinder will give a velocity of about 1,490 feet per second.

Having thus shown that Captain Noble made a mistake of 1,569,634 foot-pounds in his calculations based on a charge of but 50 pounds, let us turn to the trials which took place at Shoeburyness in July last with the 15-inch gun against armor. The target was constructed of John Brown's celebrated solid iron slabs, 8 inches thick, laid on a teak backing 18 inches thick, placed on the ¾-inch iron skin of the ship, to which were secured "a double number of supporting ribs." It is almost unnecessary to remark that such a cuirass as this is not carried by any French or English iron-clad, and that the *Warrior*, with her 4½-inch plates and 18 inch teak backing, represents the average impregnability of the iron-clads of the powers alluded to; and bearing in mind that the shot-resisting power of solid slabs varies as the square of their thickness, the immense difference between such a protection and the target fired at will be seen.

Against this target three rounds were fired from the 15-inch gun, as follows:

First Round—Range, 70 yards; American cast-iron spherical shot, weight 453 pounds, diameter 14·895 inches; charge 60 pounds of "mammoth grain" powder; velocity, 1,174 feet per second. The effect, according to the London *Mechanics' Magazine*, was as follows:—"The shot struck the target near the horizontal junction of the armor plates, nipping about two inches only of the lower one, and smashing a deep indent of four inches into the plate, rebounded nearly entire—the striking face being flattened and a few largish fragments splintered off—twelve feet back from the front of the target. The armor plates were separated from each other vertically at the left edge about two inches, the space tapering along the whole plate to the right. The buckling from the indent extended over forty-one inches of area, and at the striking point (three feet from the left edge of the target) was inward to the extent of five inches," and the effect on the rear of the target was to bend the six supporting ribs "some inches," and to "slightly crack" them, and six butt-joints of the skin plates were opened along their entire length.

Second Round—Range the same. Pontypool No. 6 cast-iron spherical shot, weight 452·5 pounds, diameter 14·89 inches; charge same as before. According to the same authority, the effect was that the ball "struck about two feet six inches from the right end of the armor plate on the median line. Half the shot stuck in the indent (seven inches), the other half splintering off to a ragged, nearly flat face. Buckle on the vertical line; three inches at the middle of the width of the plate, and on the horizontal line, 1·6 inches, extending over a surface of five feet."

Third Round—Firth's steel spherical shot, tempered in oil, weight 498 pounds; charge same as before; velocity 1,134 feet per second; it pierced the plate 8·2 inches. The *Mechanics' Magazine* says: "It struck about five feet from the left end and a foot from the top edge of the lower armor plate, and stood out from its front perfectly entire (except six or eight radiating narrow fissures) for about eight inches, the remainder being buried in the indent it had made in the plate."

Now in order that the reader may have a correct idea of the relation between the power of the 15-inch gun and the resisting capability of this tremendous target, it will be enough to state that about 40 per cent less than the real power of the gun was employed in these trials, and as an examination of the results show, a slight increase in the velocity of the big balls would have put them through the target. In short, as a cotemporary remarked, "what the effect of ten pounds more powder would have been, was drearily confessed by all the spectators of the trial." "The *Hercules*," says the *London Herald*, "ought to keep these missiles out; but she is not yet afloat. But it is something essential to know that henceforth no English man-of-war could be laid broadside against an American ship carrying guns of this caliber."

The English journals, both scientific and popular, have made a curious mistake with regard to the strength and quantity of the powder employed by us in the 15-inch gun. They call the "mammoth grain" powder used in these trials "American" powder, in contradistinction to their own, and state that sixty pounds of the "mammoth" is the maximum charge. The following extract from the instructions of the Naval Ordnance Bureau, issued during the war—April 1, 1864—while the experiments for endurance with the 15-inch gun were progressing, will show how very much less than the real power of the piece was used on the late trial: "Sixty pounds may be used for twenty rounds of solid shot. Cannon powder only should be used, as 35 pounds of this kind gives a greater range than 50 pounds mammoth powder."

Thus it is seen that the weight of the charge of "mammoth grain" used on the trial against the English target was equal to less than 42 pounds of such powder as is always used in the 15-inch navy gun, and 60 pounds of our powder gives a velocity of over 1,400 feet, against less than 1,200 obtained on the English trial ground against their target. Remembering that the power varies as the square of the speed, it cannot fail to be seen that the proper charge would have pierced and smashed this tremendous target. Seventy pounds of our cannon powder has been frequently employed on the trial ground, and a few months since a velocity of nearly 1,600 feet per second was achieved with the 15-inch gun with 100 pounds of "mammoth grain."

Perhaps the natural delicacy of John Bull has made him fearful of injuring the Yankee gun, but it is much more likely that his great care of the gun is due to his fear, not of bursting the piece, but of bursting his target and his reputation at the same time. N.

GUNPOWDER—ITS MATERIAL AND MANUFACTURE.

The origin of this composition, which may be considered, next to steam, as the most influential agent in human progress, is involved in hopeless obscurity. It certainly was known to the Chinese and Hindoos at a very early period. The Chinese histories make repeated mention of it at a time when European nations were sunk in semi-barbarism, and Philostratus in his life of Apollonius Tyanæus speaks of the Oxydracæ, a people living between the Hyphasis and the Ganges, whom Alexander declined to attack because "they come not out to fight those who attack them, but those holy men, beloved of the gods, overthrow their enemies with tempests and thunderbolts shot from their walls." Hercules and Bacchus, who from Egypt overran India, were repulsed by these people "with storms of thunderbolts and lightnings hurled from above." The invention of gunpowder has been attributed to a German monk and alchemist of the 14th century, named Schwartz, and also to Roger Bacon, commonly known as Friar Bacon, who lived in the 13th century. But it is certain the latter referred to it as a composition already known as a scientific toy or means of amusement, and if so the claims of Schwartz who lived years afterward are of no value. It is somewhat remarkable that to ministers of the gospel of peace should be attributed the credit of inventing such an agent for the destruction of human life. It is singular, also, that the composition and the proportions of the constituents of gunpowder should remain radically unchanged from the earliest period to the present time.

Gunpowder is composed of niter, charcoal, and sulphur; according to Benton the proportions used by the United States government are niter, 76; charcoal, 14, and sulphur 10. According to the same authority the parts performed by these iugredients are shown by the following table:

COMPOSITION OF GUNPOWDER.

BEFORE COMBUSTION.		AFTER COMBUSTION.
3 parts of carbon,	3 carbon,	3 carbonic acid (gas).
1 part of nitrate of potassa,	6 oxygen,	
	1 nitrogen,	1 nitrogen (gas).
	1 potassium,	1 sulphide of potassium (solid).
1 part of sulphur,	1 sulphur,	

A gunpowder can be made of niter and charcoal alone; but it is not so strong as when sulphur is present; beside, the substance of the grain is friable, has considerable affinity for moisture, and rapidly fouls the arms in which it is used. Theoretically, sulphur does not contribute directly to the explosive force of gunpowder by furnishing materials for gas, but by uniting with the niter it affords a large amount of heat, and prevents the carbonic acid from uniting with the nitrate of potassa, or niter, and forming a solid compound, the carbonate of potassa. It is to the heat and carbonic acid thus formed that gunpowder mainly owes its explosive force.

Niter does not absorb moisture from the ordinary atmosphere, a very important quality in the principal ingredient of gunpowder; it is decomposed when strongly heated and oxygen is evolved at first; finally nitrogen is given off, and peroxide of potassium remains. When heated with combustible materials it is completely deprived of its oxygen; this is the part it plays in gunpowder. Charcoal is an absorbent of oxygen and very combustible. In burning, a large amount of carbonic acid is evolved. When first prepared by heating in a closed iron retort, it will, if pulverized, absorb so much of the oxygen of the atmosphere and so rapidly, as sometimes to ignite by spontaneous combustion. The properties of sulphur in gunpowder have been already described.

The explosion of gunpowder is a deflagration in which the combination of the ingredients is completed at once, the whole, or most, passing almost instantly into a gaseous condition by the influence of heat. The gases are combinations of the carbon of the charcoal with the oxygen of the niter; the sulphur serving to decompose the nitrate of potash by combining with its metallic base and thus setting free another atom of oxygen for producing more carbonic acid. The accession of heat thus engendered, also greatly adds to the effect. The sulphur and niter are refined to a point of almost absolute purity, and great care is exercised in the preparation of the charcoal and in the selection of the material from which it is produced. It is usually made from the twigs of the black dogwood, black alder, or the willow, the latter being exclusively used in this country. It is charred in closed retorts of cast iron at a low temperture, as it is found that the lower the heat by which the change is effected the greater the combustibility of the charcoal. Each of the ingredients is ground to impalpable powder and bolted. They are then weighed in proportions and sifted into a trough or cylinder in which are revolving fans which intimately mix the constituents.

They are then taken to a mill similar to that known as the Chilean mill for grinding gold-bearing quartz, which is simply a vertical shaft, having on two projecting horizontal arms immensely heavy rollers of cast iron which revolve on a circular cast iron bed having wooden sides. From forty to fifty pounds are put into the mill, moistened with water, and ground by revolving rollers. It is in this grinding process that those fearful accidents occur which occasionally horrify the public. The mill is isolated and at a distance from others, which are protected by trees or earth traverses. It requires from three to five hours to complete the grinding process. If a particle of grit gets into the mill during the process the result is almost unavoidably an explosion.

When taken out it is dried and presents the appearance of grayish black cakes called mill cake. It is then sprinkled with water and spread on brass plates in a press and subjected to immense pressure. This press is a hydraulic press, as the flying dust of the powder might become ignited by the friction of a screw. It comes out in thin, hard cakes, and is broken and granulated by being passed between fluted rollers, one series after another, being passed from one to the other over sieves which have a reciprocating or shaking motion.