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VII. MEDICINE AND HYGIENE.—The Remains of William Harvey, the discoverer of the circulation of the blood. An interesting account of the death of Harvey Hempstead Church, his burial place, with 2 illustrations, the memorial tablet and bust, with 1 illustration, and a portrait. View of the interior of the Harvey vault, showing the sarcophagus of Harvey as it now exists.
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THE TRANSMUTATION OF ELEMENTS.

Not a little nonsense has been written with regard to Mr. Lockyer's recent assertions concerning the probable composite nature of several, possibly all, of the substances hitherto accounted elementary, and the probability that all the elements so-called are but varying phases of some fundamental matter-stuff.

It has been commonly assumed that if these assertions should be verified, the dreams of the alchemists would come true, and chemists would be able to change one form of matter into another, as lead into gold or silver. This assumption is altogether gratuitous. In his studies of the spectra of different substances under varying conditions of heat and pressure, Mr. Lockyer has indeed come to doubt the integrity of the elements as commonly understood; and to believe that substances as unlike as calcium, lithium, iron, and hydrogen, may be not only not fundamentally distinct, but that they may be merely different aspects of some basic matter-stuff, of which hydrogen is the simplest form at command. As yet, however, the evidence he has offered is far from convincing; and able chemists who listened to his paper before the Royal Society, among them Professors Roscoe, Williamson, Frankland, and Gladstone, are of the opinion that he has merely demonstrated the presence of impurities in elements supposed to be perfectly pure.

But supposing these gentlemen to be wrong, and Mr. Lockyer right; supposing it true that all matter is fundamentally one—would we be any nearer to the practical realization of the alchemist's dream?

If matter be at bottom only hydrogen or some still simpler substance, the existence of strongly marked phases of matter, like oxygen, iron, gold, and so on, can be explained only by supposing them to be the result of a process of natural selection operating through past ages, under conditions about which we can have but the vaguest knowledge.

We know that life in all its phases is fundamentally the same, yet those phases are in the main, so far as we are concerned, unchangeable, certainly not transmutable. Even if the common origin of the horse and the zebra should be demonstrated beyond the possibility of a doubt, we should be no better able to transmute zebras into horses than we are now. So if it be demonstrably true that two phases of one matter-stuff, like silver and lead, have resulted from the cosmical processes of material evolution, acting through the cycles of the past, the probability of our being able to change the one into the other would be scarcely greater than if they were fundamentally distinct. The chemical behavior of the different sorts of matter is quite independent of any theoretical notions with regard to the ultimate constitution of such substances; and chemistry will remain substantially what it is, whatever may be the outcome of the investigations of Mr. Lockyer and those engaged in similar work. By this we do not mean that the prevailing theories and practices of chemists may not be materially changed—such changes are the necessary result of increasing knowledge—but simply that the popular talk about the radical overturning of the science, as the result of Mr. Lockyer's alleged discoveries, is sheer nonsense, even if his utmost expectation should be realized.

THE FOURTH STATE OF MATTER.

That the three states of matter, the solid, the liquid, and the gaseous, though widely different in their properties, are yet only so many stages in an unbroken chain of physical continuity, has been amply demonstrated. The solid passes into the liquid, the liquid into the gaseous form of matter, by insensible gradations; and there is nothing any more improbable in the supposition that these three states do not exhaust the possibilities of material condition, than in supposing the possibilities of sound to extend to aerial undulations to which our organs of hearing are insensible, or the possibilities of vision to ethereal undulations too rapid or too slow to affect our eyes as light.

Indeed, while Pictet and others have been converting into liquids and solids the most tenuous of gases, by successively shortening the range of their molecular movements, Prof. Crookes has, on the other hand, succeeded in refining gases to a condition so ethereal as to reach a state of matter fairly describable as ultra-gaseous, and exhibiting an entirely novel set of properties.

The means by which this remarkable result was achieved were exhibited and described by Prof. Crookes at a meeting of the British Royal Society early last December; and the processes by which the discovery was made were discussed at length in a paper unfortunately too long even to be summarized here. It may be possible, however, to give an idea of their character and drift without the aid either of graphic illustrations or abstrusely scientific terms.

Our readers need not be told that the physical properties of gases are due to their molecular condition; in other words, to the swing and impact of their molecules, and the average length of flight of the molecules between collisions. As the number of molecules in a given space is reduced by mechanical exhaustion, the frequency of molecules collision is of necessity reduced, and the mean molecular flight is correspondingly extended. Now it is obvious that if the tenuity of the gas is very greatly increased, as in the most perfect vacua attainable, the number of molecules may be so diminished that their collisions under favorable conditions may become so few, in comparison with the number of misses, that they will cease to have a determining effect upon the physical character of the matter under observation. In other words, the free flying molecules, if left to obey the laws of kinetic force without mutual interference, will cease to exhibit the properties characteristic of the gaseous state, and take on an entirely new set of properties. That this is a matter of fact, and not of theoretic speculation, is demonstrated by the researches of Prof. Crookes.

In his previous studies of molecular activity in connection with the radiometer, the molecules were set in motion by means of radiations producing heating effects. In the present series of experiments the molecular motion was determined or increased by the induced current from an induction coil. The investigation began by a study of the dark space which surrounds the negative pole when an induction spark is passed through rarefied gas. The width of this dark space was found to vary with the degree of exhaustion of the tube; with the kind of gas employed; with the temperature of the negative pole; and in a slight degree with the intensity of the spark. For the study of these phenomena Prof. Crookes devised a very ingenious instrument, which he calls an electrical radiometer, and a variety of other apparatus, of wonderful delicacy and power, by means of which he was able to illuminate lines of molecular pressure; to converge streams of molecules upon a focus, with the evolution of light and heat and mechanical action; to deflect streams of molecules by means of magnets; to study the laws of magnetic deflection; to observe molecular shadows, so called, and other novel and extremely interesting phenomena.

The nature of the dark space around the negative pole Prof. Crookes interprets as follows: The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited pole keeps back the more slowly-moving molecules which are advancing toward the pole. The fight occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions of the molecules. When the exhaustion is sufficiently high for the mean length of the path between successive collisions to be greater than the distance between the electrode and the glass, the swiftly-rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. When streams of molecular discharge are focused upon a strip of platinum wire or foil, the metal becomes not only luminous but highly heated by the severity of the bombardment; so, too, the molecular impact upon the side of the inclosing glass may be sufficient to make the spot too hot to be borne by the finger.

The limits of our space forbid any attempt to describe at length the phenomena of magnetic deflection or the ingenious apparatus by means of which the action of the magnet upon the trajectory of molecules was made visible. Under the influence of a magnet the behavior of a stream of molecules is likened to that of a stream of cannon balls under the influence of gravitation. In Prof. Crookes' words:

"Comparing the free molecules to cannon balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and curved when under the influence of gravitation. It is, also, much curved when the balls pass through a dense resisting medium; it is less curved when the resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and, therefore, flattens the trajectory. The parallelism is still closer when we compare the evolution of light seen when the shot strikes the target with the phosphorescence on the glass screen from molecular impacts." Applied to a stream of molecules the magnet twists the trajectory of the molecules round in a direction at an angle to their free path, and to a greater extent as they are nearer the magnet, the direction of the twist being that of the electric current passing round the electro-magnet. The two poles of the magnet, we may add, twist the stream in opposite directions.

Prof. Crookes, very improperly, we think, speaks of the stream of molecules thus brought under observation as rays of molecular light. True, light is evolved by their impact under suitable conditions; so it may be by the impact of a stream of cannon balls. The impact of the flying molecules raises the temperature of any body interposed to arrest their flight, just as the impact of a stream of cold cannon balls would heat a resisting body arresting their flight; but we cannot call the one stream a ray of light or heat any more properly than the other. With this reservation, we may assent to Prof. Crookes' assertion that the phenomena he has investigated in his exhausted tubes reveal to physical science a new field for exploration, a new world—"a world wherein matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line, but where we can never enter, and in which we must be content to observe and experiment from without."

AMERICAN INDUSTRIES.—No. 3.

BY HAMILTON S. WICKS.

REFINING SUGAR.

One of the best thermometers of a nation's prosperity is the sugar it consumes. In epochs of great financial depression and commercial stagnation the consumption is small as compared with periods of general prosperity. Indeed the proportionate consumption of sugar is so accurately distributed with respect to national prosperity or depression that it really constitutes a true gauge of both. It is also a good test of civilization and cultured taste—the more civilized nations consuming the most, and the consumption decreasing in regular ratio through the less cultured and semi-civilized nations to the barbaric. This ratio of consumption is explained on the principle that a luxury follows the means to procure it, and that with increased means there ensues an increased use. Sugar, although classed as a luxury when compared with breadstuffs, meats, and vegetables, has yet become essential to modern civilization through the multiplex uses it has been put to. The sugar industry ranks about seventh among American industries. Following close in importance on such leading national industries as flour and grist milling, lumber, the manufacture of boots and shoes, clothing, cotton and woolen goods, and forged and rolled iron, as determined by the amount and value of their products, it stands next to tobacco and spirits as a special governmental resource, paying into the national treasury, in conjunction with molasses and melada, fully one sixth the total annual revenue levied as import duties.

In the United States the sugar business is both an agricultural pursuit and a manufacturing industry. Louisiana is the largest grower of sugar cane among any of the Southern States, though Texas and Florida swell the aggregate annual yield considerably. These three States during the year 1861 produced more than 191,000 tons of sugar. The pursuit of cane-growing was abandoned during the war of the Rebellion, but after its close was taken up with renewed energy, Louisiana alone producing from 1869 to 1873, 61,863 tons. The principal foreign supply of sugar is derived from Cuba. In fact, the importation from all other foreign countries together amounts to less than half of that imported from the Great Antilles. None of our other imports, excepting bullion, can approach sugar in value or quantity. In the year 1877 the quantity aggregated over a billion and a half of pounds, and had all of it been carried in American bottoms it would have greatly assisted our shipping interests. The large bulk of this trade should be commanded by American ships, because Cuba, Brazil, and Porto Rico, countries which grow nearly two thirds of the world's sugar production, are eager for improved commercial relations with the United States.

The quality of all sugar is determined by the amount of saccharine it contains. The yield of saccharine from sugar cane is much superior to the yield from any other fruit or vegetable. The amount obtained from sugar beets is next to that obtained from the cane, and hardly distinguishable from it when refined. Besides these two sources sugar is derived from dates, sorghum, maple trees, and corn. The latter is called grape sugar or glucose, of which the public has lately heard so much in connection with adulteration. It is produced by the chemical change of the starch in the Indian corn, through the action of sulphuric acid. It contains less saccharine, and is much cheaper than other sugars. There are three varieties of sugar known to commerce and readily determined by experts; *i. e.*, the Muscovado, the clayed, and the centrifugal. The first two are made according to old methods, the last is the modern improvement.

It is the purpose of this article chiefly to consider sugar as a manufacturing industry. Coming as it does in a very crude state from the plantations, intermixed with dirt, sand, bits of cane, fungus, and animalcula infinitely more repulsive than those of our midsummer croton, it has to undergo a thorough refining to throw off all these impurities and yield an article fit for commercial and domestic use. This industry utilizes the services of an army of 15,000 men; profitably employs $25,000,000 capital; and dispenses in wages $9,000,000 annually.

To illustrate the methods of sugar refining the establishment of Havemeyers & Elder, in Williamsburg, L. I., has been selected. It is not only the largest, but has the most approved methods of any refinery in operation, although most of the machinery is the same as that adopted by the largest refineries the world over.

The illustrations on the first page, if carefully studied, will impart to the reader as general a knowledge of these methods as though he himself were shown through the mammoth works by the superintendent, as the writer of this article was. It is not intended to portray every little detail of mechanism; that would require a volume. Only the most important machinery is given, such as is essential to the different processes of refining, and illustrating the important steps in these processes.

Such a refinery as Havemeyers & Elder is a world of activity in itself. Each of the many departments has its separate force of laborers, with well defined duties, working toward a common result. One becomes bewildered in the intricacies of their vast buildings. The investigator is taken two stories underground, and eight above. He walks under the street, and traverses in the departments above, 16 acres of flooring. The machines and apparatus illustrated are distributed in various parts of the refinery. Most of these are duplicated many times, and all of them only indicate the magnitude of the rooms in which they are operated.

This refinery, in common with all others, takes the "raw sugar," in all its varieties, and first of all, dissolves this crude article in large mixing vats, one of which is shown in the illustration, entitled "Melting Pan." These vats each hold 2,500 gallons. About 46 parts of water is added at a temperature of 110°, and the small engine, also seen in the illustration, performs the mixing. The raw sugar is pumped up eight stories into the heating tanks, where it is partly clarified by the introduction of an albumen, and 210° Fah. is applied to it by steam pipes running through the bottom of the tanks. If from any cause the sugar is sour, this is corrected by the use of lime water. The heated liquor is run from the tanks, and received into filter bags, arranged underneath, which strain out all dirt, sticks, and coarse impurities. The strained liquor is then run into the boneblack filter, where it comes in contact with the boneblack, and is entirely decolorized. The illustration entitled "Bone-Black Kiln" shows the vastness of the retorts necessary to reburn the large quantities of boneblack used. At this point the processes diverge for the production of Soft and Hard sugars. In the former the decolorized sugar is taken to the Vacuum Pan, shown in the center of the illustration, and is cold-boiled to a grain from 2 to 6 hours, according to the quality. Valves on the bottom of the Vacuum Pan discharge the grained liquor into large receptacles over the centrifugal machines.

These machines are among the most wonderful modern inventions for expediting the manufacture of Soft sugar. The illustration gives a good idea of them. They consist of a strong steel basket, holding 230 pounds, inside of which is a sieve, and a plate, as finely perforated as one of Edison's phonograph foils. The sieve is between the basket and the plate, to protect the latter. The whole is protected by a solid wrought iron Curb, within which the basket revolves with its contents at the rate of 1,000 revolutions per minute, and the centrifugal action forces the sirup through the perforations, which are too small for the passage of the sugar grain, into the Curb. Havemeyers & Elder have 32 of these machines in operation. The sugar after undergoing this process is emptied into wagons underneath the centrifugal machine, and dumped into bucket elevators, which run up over a powerful fan, that throws the sugar against a partition near by, and cools and mixes it at the same time, after which the sugar is ready for barreling. The cooling and barreling will be seen in the illustration.

The processes for manufacturing Hard sugar are the same up to the time the raw liquor goes into the Vacuum Pans. It is boiled in a slightly different manner. After running into a receiver from the Vacuum Pans the mass is filled into conical iron moulds, 4 feet in height and 12 inches in diameter across mouth. Each has a hole in the bottom like a flower-pot. The moulds are allowed to stand in the filling room downstairs for 12 hours, with the holes plugged up, so as to allow the sugar to cool a little, and "set." They are then hoisted up into the drying rooms, and the plugs are taken out of the bottoms. They are placed on "bedsteads" and drain. After all the sirup runs off that will, the top of the moulds are brushed smooth, and a saturated solution of white sugar and water is poured on top and percolates through the Titlers (as the contents of the moulds are called), carrying off the remaining sirup. The discolored tips are now cut off, and they are placed into large ovens, heated by steam to 110°, where they remain one week, coming out ready for the crushing, pulverizing, and sawing processes. In the former the Titlers are crushed into irregular shape; in the second, it is finely pulverized; in the saw mill the titlers, which are like columns of granite, are sawed through horizontally into wheels, laterally into strips, and then are chipped into cubes. Illustrations of these processes are shown, and sufficiently indicate the manner in which the titlers are worked up for the market.

Soft sugar, by the use of the centrifugal machine, is refined in twenty-four hours, while hard sugar requires a fortnight.

The establishment of Havemeyers & Elder has an existence of half a century. It employs 1,000 hands, and turns out a million and a quarter pounds of sugar daily. The accusation of adulteration made by certain parties against several of our largest refiners of sugar has, according to Mr. Wells' recent report on the subject, no foundation in fact. Careful tests have been made by the highest chemical authorities, which seem to verify his statement. Furthermore, the establishment described in this article invites the most thorough investigation by any competent authority.

THE BILL TO DISCOURAGE INVENTIONS.

It is doubtful whether any section of the proposed amendment of the patent law (Senate bill 300) was so generally approved by those who appeared before the Congressional Committee on Patents last winter, as section 11; a marvelous illustration, it seems to us, of the proneness of men to clutch at the nearest remedy for a present evil, without stopping to think whether the remedy may not in the end be worse than the disease.

Our readers will remember that this section introduces the principle of cumulative fees, a radical innovation in the working of the American patent system. As we have shown in previous issues of the SCIENTIFIC AMERICAN, the principle is entirely at variance with the spirit of the patent law as it has been interpreted hitherto, and one calculated to work no little harm to inventors and purchasers of patents.

A careful examination of the reasons offered, in Congress and in the Committee room, for making this change, proves them to be in reality but varying statements of one complaint, which was succinctly expressed by Mr. Christy in these words:

"After a patent has got established and become successful, it is a common thing to hunt up similar prior issues, purchase the patents, and, under the facilities afforded by law as reissues, obtain a reissue patent covering what somebody else has invented, and then sue the real inventor. This (section 11) will wipe out at least 75 per cent of that class, and then we will have a great deal less trouble from that law."

The class of patents which Mr. Christy had been speaking of were those which Mr. Raymond had described as "trivial, impractical, and invalid patents," and "those which become of value late in their existence, and then only for the purpose of infringement suits and speculations."

The advantage to be derived from officially killing "trivial, impracticable, and invalid patents," is not very apparent. Such patents must, by their very nature, be dead to begin with, so far as their possible influence is concerned. No inventor of anything that is not trivial, impractical, or invalid, is likely to be worried about them or by them. There remain a small number of patents which become, rightly or wrongly, the occasion of infringement suits and other forms of litigation, the majority of which are reissues of the sort described by Mr. Christy. These are indeed the occasion of much trouble, the desire to get rid of which furnishes the only excuse for the proposed alteration of the law.

How large is the number of such mischief-making patents?

From the noise made in certain quarters one might suppose that a patent was little else than a summons to appear in court to begin or defend an infringement suit. In reality there is no species of property about which there is proportionally so little litigation.

It was shown in the Committee room, by an advocate of section 11, Mr. Chauncy Smith, that 60 per cent of the patent litigation of the country arises upon reissued patents, while the number of patents reissued is not over 4 per cent of the whole number of patents. How enormous, then, is the proportion of patents about which there is no litigation!

There is an old and pertinent story about the killing of a fly with a sledge hammer. The fly was an annoyance, truly; the sledge hammer most effectually smashed the fly. But the avenger had no further use for his nose. Improperly reissued patents, misused for speculative purposes, are flies on the face of the patent system. Section 11 is a sledge hammer, which may hit them. Is it a fit means for accomplishing the desired end?

Mr. Christy and others say that the section will enable us to get rid of 75 per cent of the obnoxious reissues; in other words, three of the four patents in the hundred, which occasion three fifths of the patent litigation. Mr. Raymond says that a similar provision in the English patent laws annuls 75 per cent of all the patents issued. That would be a terrible blow for so small a fly!

An amendment preventing the reissue of patents "covering what somebody else has invented," in other words, more than the original patent included, would seem to be a more suitable as well as more effective remedy.

It is claimed for the proposed amendment that, at its best, or worst, it will do away with not more than three fourths of the vicious reissues; this, at the cost of, let us say, one half of all the patents issued, as the proposed section is not quite so severe in its operation as the corresponding provision of the English law.

Consider the probable effect of annulling, in their early years, one half the patents issued in this country. The majority of inventors are poor men. The majority of those who make important and valuable inventions are poor men. The majority of important and valuable inventions require more than four years, or eight years, wherein to become firmly established and commercially successful. The proposed amendment would therefore discriminate against valuable inventions quite as surely as against the trivial. The nose would be hit severely, though the fly escaped.

Consider the injustice of imposing upon all inventors heavy penalties in the form of fees, which are uncalled for in all cases, and which, in many cases, must be equivalent to the practical confiscation of the inventor's rights, simply because he happens to be poor as well as meritorious. How often it happens that an inventor dies before his invention is financially developed! Shall the United States rob his family of their only inheritance because they are not able to work it up at once, or redeem it by the payment of special taxes?

Consider the impolicy of adding to the discouragements of inventors (toiling, it may be, under privation to develop and persuade the community to use improvements which may be of enormous public benefit) by compelling them to meet such arbitrary and needless demands on pain of forfeiture of their rights.

Consider, too, the door that would be opened by this section for injury to purchasers of limited patent rights, since it would make the permanence of their rights contingent upon the payment of successive fees by the inventor. As the law stands it is safe to purchase a manufacturer's or user's right under a patent for any State or locality, because a patent once issued and approved is unconditionally good for its whole period, and the buyer can estimate its value accordingly. Under the proposed amendment it would not be safe, for the inventor might, through willfulness, carelessness, or inability, neglect or fail to complete his title. The change proposed would, therefore, very seriously diminish the market value of all patented inventions the manufacture or use of which could not be monopolized by one firm, to the serious injury of a large number, perhaps the larger number, of patentees. And it would needlessly increase the risk of all who should undertake a new industry resting on such a precarious footing. Such a law might thus be fairly styled a law for the discouragement of progress in the arts.

Surely it would seem possible for Congressional wisdom to devise some plan for preventing or punishing the evil aimed at with greater certainty and with vastly less cost to the entire community.

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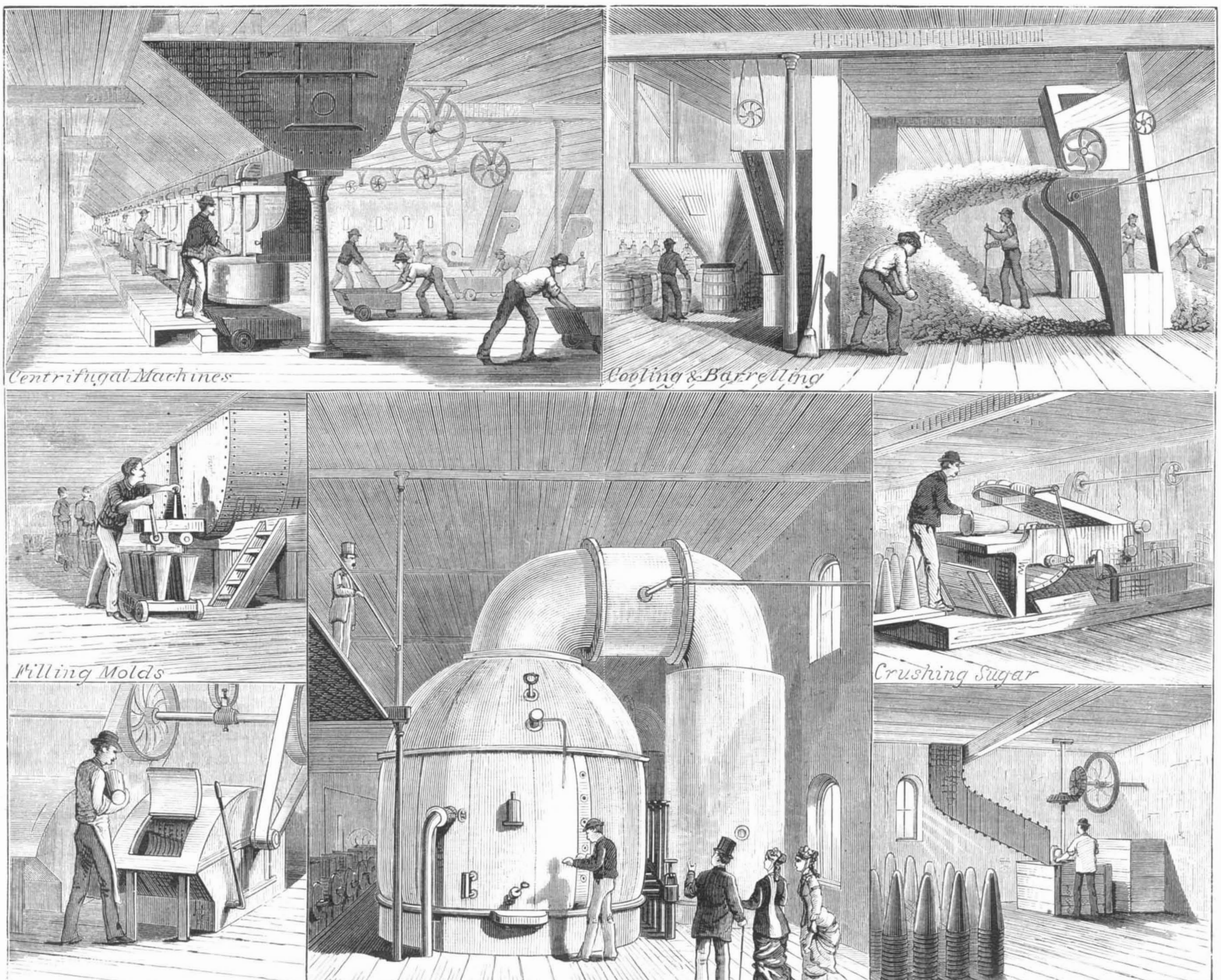

HAVEMEYERS & ELDER'S SUGAR REFINERY.—(See page 48.)