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THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.

There is probably no industry among the many that have been benefited by the utilization of natural gas in which the results have been so marked as in the manufacture of glass. For a number of years past, American glass has been undoubtedly inferior to the product of European factories, and has consequently occupied but a secondary position in the estimation of American builders and architects. The foreign manufacturers, and particularly those of France and Belgium, have hitherto manifested a superior dexterity in the handling of their materials. They seem to have held the secret of either neutralizing the effect of impurities in their fuel, or of burning it in such a manner as to get the minimum disadvantage from their presence. This has been due partly to greater experience in the industry and partly to a better construction of furnaces. In some of the more perfect plants, crude fuel has been abandoned and manufactured gas used instead, thus giving them in advance the advantages of natural gas, with the important exception, however, of its cheapness and almost total freedom from sulphur. These circumstances made imported glass synonymous with best quality.

That these conditions have now so far changed that our own glassmakers can compete with the best foreign producers, and can even honestly claim certain points of superiority for the home product, is a subject for hearty congratulation. The improvement has been effected, in a measure, by the more complete mechanical appliances now at our command, but the most potent influence must be ascribed to the use of natural gas. In the manufacture of window glass, the results have been particularly gratifying, many important buildings being now fitted with American glass which but a few years ago would have demanded the imported. The metamorphosis of the crude material into a clear and brilliant pane of glass involves so many interesting points that we have illustrated the process, choosing the works of Messrs. S. McKee & Co., at Pittsburg, as a typical establishment.

The manufacture of sheet glass depends for its success upon the closest attention to details, and its history is therefore one of delicate manipulations. It is a very easy matter simply to make glass, for it is nothing more than a double silicate of soda or potash and an

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THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.—BLOWING.

THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.

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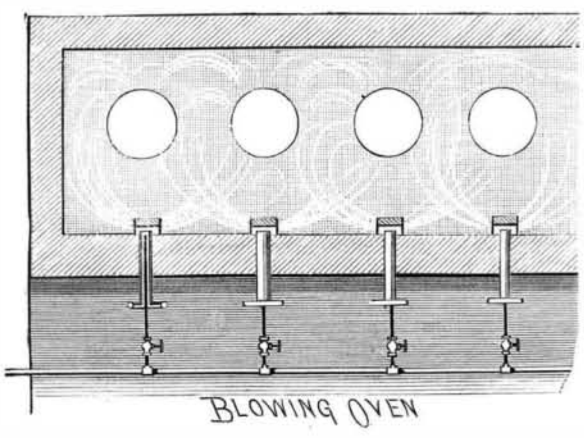
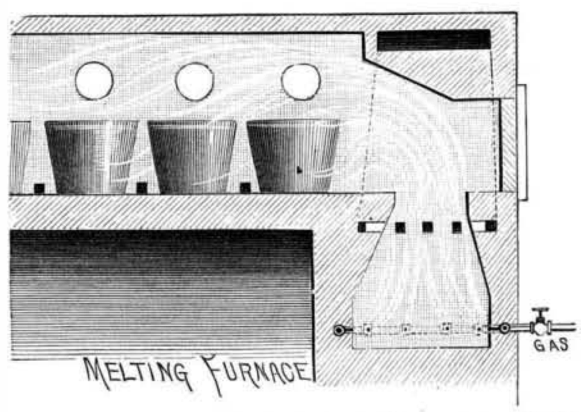
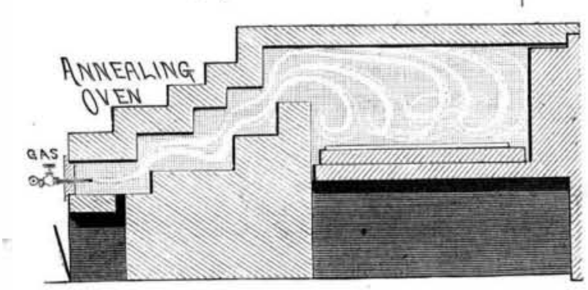
alkaline earth. The iron-master gets rid of the silica in his ores by making it into a fusible silicate of lime—an opaque glass. The assayer frees his metal from the accompanying gangue by adding suitable fluxes until







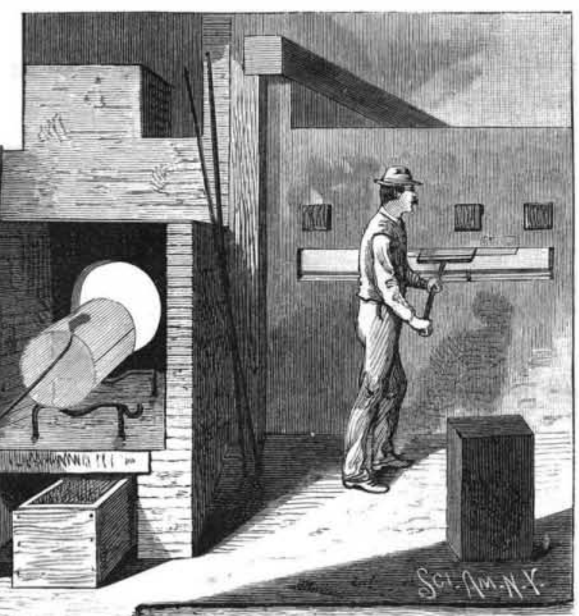
all the earthy matter is gathered into a fusible slag, and floats above the metal button as a molten glass. And even nature, when her interior caldron bubbles over in a volcano, shows that she, too, is a giant glass-maker. But to make good glass, clear, transparent, colorless, to simulate the purest water of a mountain stream, this requires skill and patience.

These two qualities are demanded in all stages of the operation. The first step is the manufacture of the crucible pots, and in this the glassmaker has a good opportunity to display these qualifications. The pots are made up of a mixture of about 2 parts raw fire clay, 2 parts burned clay, and 1 part ground pot shells, and require the greatest amount of care. The mixture is ground and thoroughly worked in a long trough, where it is turned once a day for a period of about four weeks. The workman kneads the plastic mass with his bare feet to make it tough and free from air. If the treatment is imperfect or careless, the entire subsequent work of the crucible will be unsatisfactory. The pots are formed entirely by hand, and in a room the temperature and humidity of which are kept as nearly constant as possible. They are all of one size, 33½ in. deep and 42½ in. across the top. The thickness varies from 3½ inches at the base to 3 inches on top, while the bottom of the pot is about 4 inches. The bottom having been first formed, the sides are gradually built up from day to day, the entire process requiring about six weeks. The capacity of the pots is from fourteen to sixteen hundred pounds of molten glass. When quite dry, they are placed in small heating furnaces, where the temperature is gradually raised to that of the melting furnace, and when this point is reached they are quickly transferred, and are then ready to receive the raw materials.

At the McKee works there are three melting furnaces, having a total capacity of 26 pots. These stand two abreast, one of the furnaces having 10 pots and the other two, 8 each. Round openings in each side of the furnace permit free access to each pot. The fuel, as everywhere else throughout the works, is natural gas. This is admitted at each end of the furnace, and is mixed with air which has been heated by passing through chambers in the fire-brick arch. A well is built under each furnace to collect the molten glass, should a pot break, and thus prevent loss of material or stoppage of the furnaces. The raw material, or "batch," introduced into the pot consists of: sand, 100 parts, lime, 30 parts; alkali, 40 parts; and a small but varying amount of pulverized charcoal. Some manufacturers make their alkali all sulphate of soda, while others employ a mixture of sulphate and carbonate, in the proportions shown by their experience to be the best.

These are thoroughly ground and mixed together. One-third of the full charge is placed in the pots, and after an interval of four hours a similar amount is added. With the last charge, introduced still four hours later, about two pounds of arsenious acid are added. This acts as a bleaching agent, and by converting the iron present into a higher oxide, removes the color to a large extent. At some establishments peroxide of manganese is used for this purpose, but a slight excess will give a pinkish color, and it also has the further disadvantage of making the transparency of the glass less durable. When the contents of the pots are quite liquid, and have settled down to a constant level, enough broken glass is added to fill the pots completely. This is known as the "capping." The entire melting occupies about 16 hours. During the latter part of this time, the heat is somewhat reduced in order to make the glass less liquid, and prepare it for gathering.

LAYING IN.



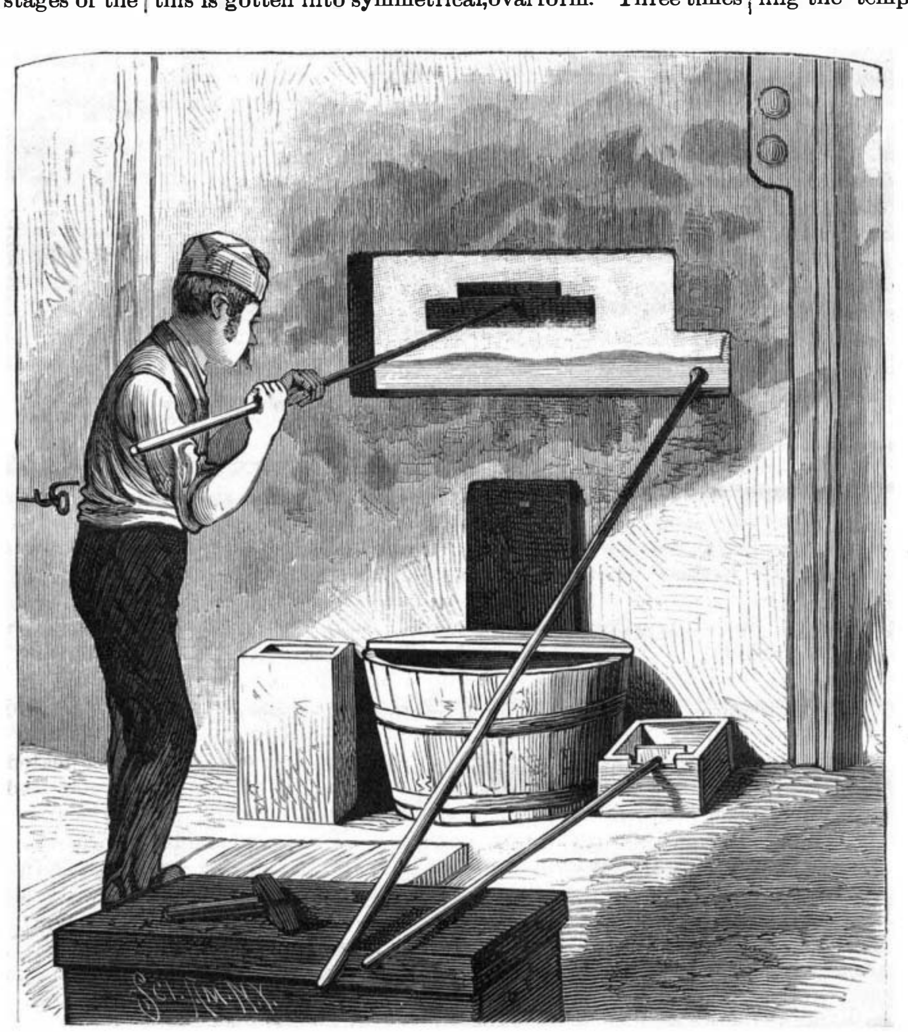
ANNEALING OVEN.

When the fusing period is completed, the surface of the molten "metal" must be freed from all impurities by skimming. For this purpose a fire-clay ring, introduced when the pot is first put into the furnace, floats upon the surface of the bath, and the gatherer, by removing all the scum from the interior of this ring, always has a clear surface from which to draw.

The gathering is done with a wrought iron pipe, about five feet long, the end of which is decidedly flared. Toward the mouthpiece, the pipe is surrounded with a wooden handle. The first dip brings out but a small lump of glass. By careful turning of the pipe, this is gotten into symmetrical, oval form. Three times the gatherer dips his pipe into the molten bath, each time getting a little more glass, until at the end he has a mass weighing from 15 to 20 pounds. If, however, window glass of double thickness is to be made, the metal must be gathered four or five times, and the resulting ball will weigh from 30 to 40 pounds.

It is at the final dip that the gatherer's greatest skill is called into requisition. The mass of red hot plastic glass must be gotten into symmetrical shape, and must be thoroughly homogeneous before it can be handed over to the blower. The pipe is therefore placed on a convenient fulcrum, the end carrying the ball of glass being in the furnace, and by depressing the handle and revolving the pipe the last glass added is made to completely overlap the former ball. The entire mass is brought to a uniform temperature but little short of liquidity, and by a further revolution of the pipe the fold of glass formed by these manipulations is turned into a spiral and worked to the end of the mass. The ball of glass, red hot, and, if properly gathered, without flaw or blemish, is now taken to a wooden mould, shown at the right in our illustration of the blowing furnace, and by dexterous turnings is formed into a pear-shaped ball. The wood is kept from burning by being continually moistened with water, which, in contact with the red hot glass, assumes a speroidal condition, and looks like so many globules of mercury. The gatherer's duty is now ended, and he hands pipe and glass over to the blower.

Formerly, the melting and blowing furnaces were combined in one, but it has been found more economical to have them separate. The blowing furnace has the same side openings as the melting furnace, and simply provides an intensely hot chamber for controlling the temperature of the glass while being blown.



THE MANUFACTURE OF WINDOW GLASS WITH NATURAL GAS.—FLATTENING.

The first act of the blower is to grasp the pipe, and with the ball of glass still resting in the mould, blow through the mouthpiece until a large bubble of air is formed in the mass of glass. Then, with alternate blowing and manipulating, he increases the bubble until the mass takes the shape of a large carboy, such as one uses for transporting acids.

The blower now transfers his operations to the platform in front of the blowing furnace, where long openings permit him to swing his pipe and globe of glass in a pit beneath. Blowing and swinging and reheating, he extends the bubble at the pipe's end, until, in place of the ungainly carboy, with its disproportionately thick bottom, he has a beautifully symmetrical figure, the shape of an enormous test tube. But during these operations it happens from time to time that the glass flows a little too freely, and the sides of the tube are in danger of becoming too thin. So the blower must occasionally throw his tube into the air and let the glass settle back upon itself. As the tube by this time is about 5 ft. long and from 15 to 18 inches in diameter, one can readily fancy that this apparently playful toss requires great skill and a large amount of muscle. In our illustration we have shown an even larger cylinder, one that when finished will furnish a pane 66 by 54 inches. The foremost figure of the group, who has thrown his heavy and bulky cylinder into the air with seemingly so little effort, is the only man in the works who can manage so large a burden, for, in addition to its extra size, it is also double thickness.

When the tube is formed to the satisfaction of the blower, he permits it to become comparatively cool, thrusts the end into the furnace, blows into his pipe, and quickly covers the opening with his hand. A slight report is speedily heard. The confined air, expanding with the heat, has blown a small hole in the end of the tube. Resting his pipe on a suitable support, he gradually turns it around, while the hole grows larger and larger, until he no longer has a test tube, but a complete cylinder. Quickly he withdraws his pipe from the furnace, and allows the cylinder to depend into the pit below until the plastic edge passes to cherry red, and it can be taken away without danger of getting out of shape.

The blower has now finished his part, and he stands before you dripping with perspiration and apparently exhausted. But it takes him only a moment to recover his breath. Already another pipe is in his hand, and he is repeating his heavy labor.

A string of red hot glass adroitly drawn around the cylinder end causes an even crack to separate the neck and attached blowpipe from the cylinder proper. Then a hot iron is passed along the interior surface from end to end, and makes a longitudinal crack. As a cylinder, the glass looks as if it were pretty well ruined, with a crack running its entire length, but the process is only another step in its transformation into a window pane.

The cylinder is now ready for the laying-in furnace. This is in a separate building, and of late years has been made one of the most complete parts of the entire plant. The hearth of the furnace is circular, and is divided into several sectors, separated from each other by fire-clay bridges. As the hearth revolves, these sections pass through a corresponding number of compartments, in which the temperature may be varied at pleasure. The first compartment is only moderately heated, and is known as the laying-in oven. In this the cylinder becomes gradually warmed. A partial revolution of the hearth then carries it to the next compartment, the laying-out oven, where the heat is sufficient to make the glass plastic. On the floor of each section of the hearth a large flat stone, made of fire-clay and prepared with the greatest care, so as to be perfectly smooth, is adapted to receive the cylinder. While in the laying-in oven, the cylinder is supported by two brackets at the side of the stone; but as soon as it reaches the laying-out oven, it is removed to the stone, and, the crack being uppermost, is allowed to unfold until it lies open like a sheet of rumpled paper. It is then carried by the revolution of the hearth to the flattening oven, where a workman, as shown, irons out the plastic sheet until it lies perfectly smooth and flat. Further revolutions of the hearth carry the glass, now in a smooth sheet, to the dumb oven, where it slowly cools, and then to the entrance of the annealing oven, next door to the laying-in oven, making the circuit finally complete.

When the comparatively cool sheet of glass reaches this stage of its journey, it is picked up with a large two-pronged fork and placed upon a rod or bar projecting from the annealing oven. These rods are found an immense improvement over the car formerly used. They handle each sheet separately, and with the receipt of each fresh sheet they move the entire contents of the annealing oven toward the outer end, discharging a finished sheet at that end. The glass remains in the oven from 30 to 40 minutes. When discharged, the sheets are cut into proper sizes and stored in suitable frames.

The process is completed. The surface of the glass, just as it comes from the annealing furnace, is remarkably brilliant and as beautifully clean as if it had been washed in hot water and dried with linen. In all stages of the process the advantages of natural gas become each day more evident. The more intense heat of the new fuel gives a better fusion, while the contamination of the "metal," from particles of coal and cinder, is entirely avoided. It is, however, in the blowing furnace and flattening oven that the most marked advantages are obtained. With coal, the sheets of glass formerly came from the ovens coated with smoke, and, what was infinitely worse, with a white deposit of sulphur. As these impurities had been gathered while the glass was in a semi-plastic condition, no subsequent washing or acid bath could entirely restore the brilliant surface.

A comparison between new and old glass will make these differences very plain. But perhaps one can best appreciate the influence of gas upon the industry by glancing at the history of those establishments which are not so fortunate as to possess it. So radical, indeed, has been the change wrought by the new fuel, that several important glassworks in other parts of the country have admitted that the competition is too unequal, and have either suspended business or transferred themselves to the shadow of the nearest gas derrick. A number of such migrations have been reported during the past few months. It is a gratification to examine the products of such firms as the Messrs. McKee and others who have done so much to advance this industry, and to feel that our architects can now honestly recommend the use of American glass.

The Relations of the Government to Chemistry.

In a presidential address before the Chemical Society of Washington, Prof. F. W. Clarke recently reviewed the connection between the laboratory and the Government. While he finds a most encouraging growth in chemistry during the past twelve years, and an increasing disposition on the part of the Government to avail itself of chemical assistance, he also points out certain tendencies which at present menace the highest development of the science.

Nearly all of the departments of the Government are now provided with their own special laboratories, and in some cases it has been found necessary to devote several to the work of one department. With the increasing demands of a large industry, and the growing spirit of investigation, more laboratories will be needed. The development which these necessities involve requires, however, the advantage of a discriminating supervision if it is to afford the highest usefulness. The present chemical "plant" of the Government has not been the result of any definite plan. It is simply the outcome of every-day necessities, and, as such, it is without the organization needed for the prosecution of a great work. Much important apparatus is still wanting, while the scattered nature of the work has made the duplication of other portions necessary. In addition to this serious want of proper equipment, the Government chemists are severally called upon to do a greater variety of work than is compatible with excellence.

To uninformed officials, a chemist is simply a chemist; and as a consequence, problems of the most varied character are distributed among the different workers with an impartiality which would do great credit under other circumstances, but which in the present instance is nothing less than disastrous. The science is already so large that specialization becomes essential to success. With this scattering of effort and multiplication of poorly equipped laboratories, excellence will hardly be possible, for the range of work will be too broad and the appliances too meager. Prof. Clarke, therefore, strongly recommends a concentration of forces in one complete and thoroughly equipped national laboratory, divided into the proper number of departments, and presided over by a corps of skilled specialists. He also favors the union of the chemical and physical laboratories in one building and under one director, with facilities in both for scientific research as well as practical work.

Lanoline or Cholesterine Fat.

At a recent meeting of the Physiological Society, Berlin, Professor Liebreich gave a short sketch of a series of investigations which had engaged him for some years, and had led to the introduction of a new substance into the pharmacopœia. He premised that the denomination "fats" would have to cover more than it had hitherto done, and not merely such substances as were capable of decomposition into fatty acids and glycerine. All substances, on the contrary, would have to be conceived of as neutral fats which contained sebacic acids, no matter with what organic base these were combined. Such a neutral fat was discovered by Herr E. Schulze, in 1869, in the yolk of the fleece of sheep, and which consisted of a sebacic acid and cholesterine. This cholesterine fat of sheep's wool, or "lanoline," had been studied by Professor Liebreich, as to the method of obtaining it, on account of its excellent qualities in the way of a salve constituent. It was now being extracted from woolen hairs by means of a centrifugal machine, and had become an article of trade. Professor Liebreich had next investigated the origin of this cholesterine fat, and, with the help of the uncommonly sensitive cholestol reaction of Professor Liebermann, had come to the conclusion that the cholesterine fat contained in the yolk of sheep was derived neither from the sudorific glands nor from the sebaceous glands, nor from the sebaceous texture of the under skin, but was seated exclusively in the hairs and in the epidermis cells. This fact led, on the one hand, to the production of the substance as a kind of manufacture, while on the other hand it induced a very extensive series of experiments respecting the distribution of cholesterine fat in the animal kingdom. The speaker found it in the epidermis, the hairs, and nails of men, in the hairs of all mammalia he had examined, in the hoofs of horses, in the paws of swine, in the horns of cattle, in the prickles of the hedgehog, in the feathers of fowls, geese, and a large number of other birds, in the plated sheaths of the tortoise; in short, in all horned textures which, with long and toilsome labor, he had examined. The speaker had, in addition, found the cholesterine fat in the kidneys and the liver of mammalia; yet it was not beyond question that in these organs the cholesterine fat did not proceed from the blood, in which it was always present in small quantities. It might be conjectured that it would likewise be found in the intestinal canal, and generally wherever epithelial cells occurred. The constant presence in all epithelial formations of a particular fat, which was there formed in the keratine cells, rendered it highly probable that the hairs of the mammalia and the feathers of birds owed their elasticity and pliancy not, or at all events not exclusively, to the secretion of the sebaceous or caudal glands, but to the cholesterine fat generated in the horn cells themselves. The quality possessed by cholesterine fat of not oxidizing, or oxidizing only under very rare conditions, rendered it, as was very readily conceivable, most peculiarly adapted for lubricating the skin and feathers. Beyond the property of not becoming rancid, lanoline possessed a whole series of other advantages distinguishing it quite peculiarly as a salve constituent. It absorbed, for example, 100 per cent of water, and by so doing became a soft substance easy to the touch, penetrating the skin with altogether extraordinary facility, and, after but a short rubbing into the cutis, disappeared from view. Professor Liebreich had already prepared into salves a great number of medicamental stuffs by means of "lanoline," and had made experiments with them which yielded entirely satisfactory results. Lanoline, dark brown in a dry state, grew pale like wax in light, and showed other qualities besides, assigning it a place between the ordinary glycerine fats and the wax kind of fats.

Unconstitutional Tax on "Drummers."

In the case of Walling *vs.* the People of the State of Michigan, decided by the Supreme Court of the United States, on Jan. 18th, it appeared that the plaintiff in error was prosecuted in the police court of Grand Rapids, Mich., under a Michigan law imposing a tax upon persons engaged in the business of selling in that State liquor to be shipped from any other State. The plaintiff in error was a "drummer" for a Chicago firm, and was charged in one court with selling liquor at wholesale without a license, and in another with soliciting and taking orders for its sale without a license. He was convicted, sentenced to pay a fine, and imprisoned in default of payment. Upon appeal the conviction was affirmed by the Supreme Court of Michigan. The decision of the Michigan court has just been reversed by the Supreme Court of the United States, which holds that a discriminating tax imposed by a State operating to the disadvantage of the products of other States when introduced into the first-mentioned State is in effect a regulation in restraint of commerce among the States, and as such is a usurpation of the power conferred by the Constitution upon the Congress of the United States. The Supreme Court of Michigan held that the tax imposed by the act was an exercise of the police power of the State for the discouragement of the use of intoxicating liquors and the preservation of the health and morals of the people. The Supreme Court of the United States declares that this would be a perfect justification of the act if it did not discriminate against the citizens and the products of other States, and thus usurp one of the prerogatives of the national legislature. The court sums up its opinion as follows: "We think that the act in question operates as a regulation of commerce among the States in a matter within the exclusive power of Congress, and that it is for this reason repugnant to the Constitution of the United States and void."

Gresham's Injector.

Among the most interesting features of the machinery department of the recent Inventors' Exhibition, held in London, was the new automatic restarting injector, exhibited by the well known engineer and inventor, James Gresham, of Manchester. It received the first premium, and was selected by the managers to supply the boilers which furnished the steam for the motive power used in the exhibition. Among its most valuable points were its wide steam range, the injector working equally well and reliable at high and low pressures; its instantaneous and perfectly automatic performance, as soon as steam and water were turned on; and its restarting quality, which enabled it to take up the feed water at once, and without any handling of valves, after the supply had been withdrawn or interrupted from any cause whatsoever. This last feature seems to make the Gresham injector peculiarly adapted for the feed of boilers or traction and farm engines, and on tug boats and steam craft generally, where the supply of feed water is so liable to interruption from traveling over rough surfaces on the one hand, and from the motion of the waves on the other.

THE value of the hardware produced in the United States each year is now about $60,000,000, and half of it is made in Connecticut. This does not include firearms, agricultural implements, cut nails, or ornamental ironwork. These, with other articles which may be regarded by some as belonging to the list of hardware, would swell the total to far above $100,000,000. The manufacturers of England, France, and Germany send us about $2,000,000 worth annually.