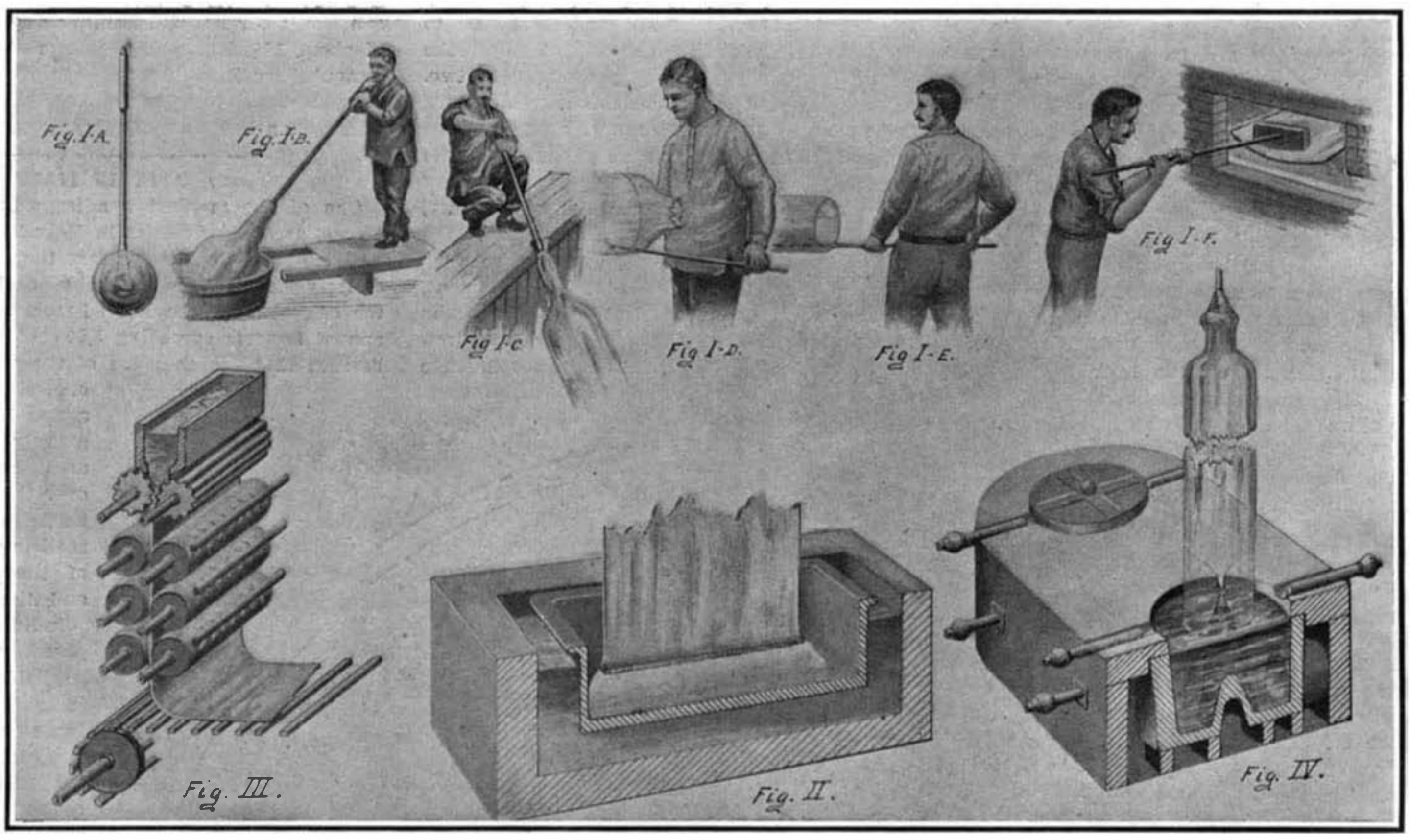
THE FIRST MACHINE FOR THE COMMERCIAL PRODUCTION OF WINDOW GLASS BY THE SHEET PROCESS.

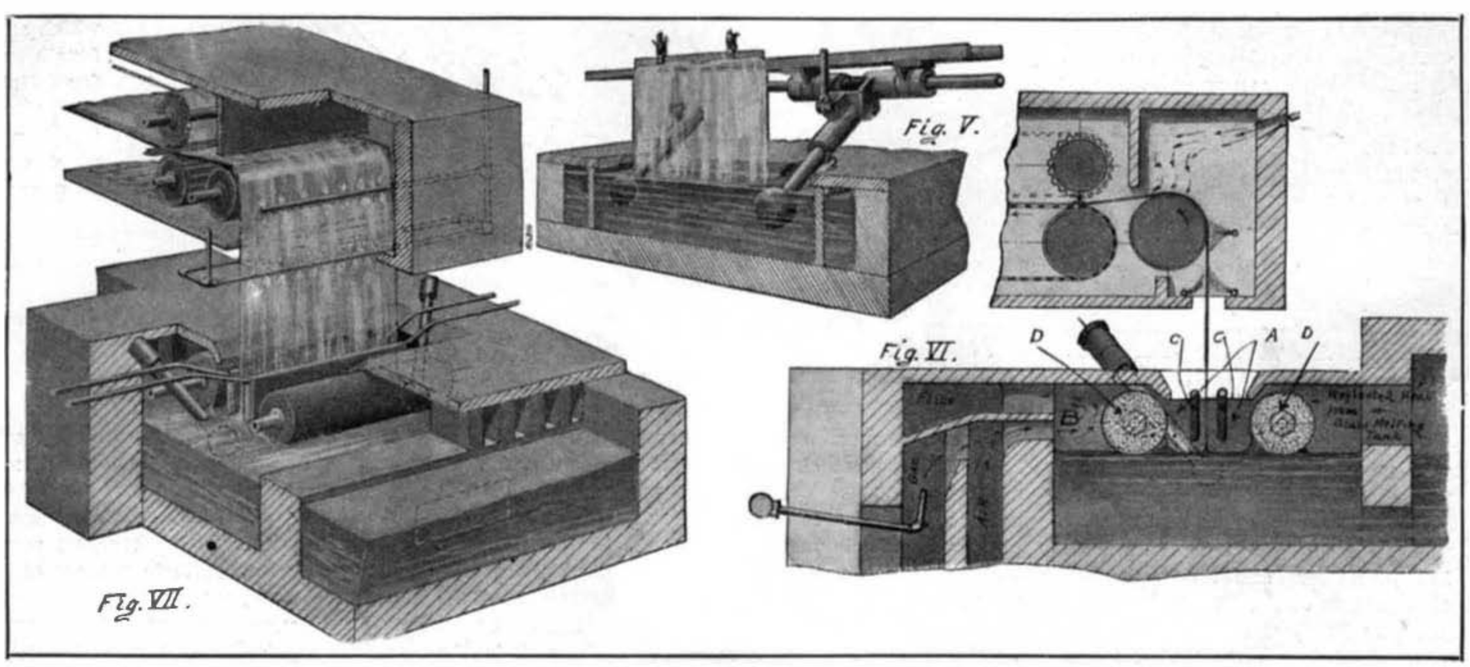
The manufacturing of window glass is one of the few arts which seems to have resisted all efforts of the keenest mechanical intellects to raise it above a handicraft which involves much costly and cumbrous human labor, to the dignity of an automatic process. Ever since panes of glass have been used in buildings, but three manufacturing methods have been employed, viz., the crown process, the hand-blown cylinder process which displaced it, and the machine-blown cylinder process. The hand-blown cylinder method, by which the bulk of window glass is made at the present time, is not only simple, but almost primitive in its crudeness, notwithstanding that it requires considerable skill and strength on the part of the workmen. The wages paid such skilled workmen are higher than those for almost any other class of labor. By repeated gatherings a workman, technically known as a gatherer, collects a ball of plastic glass on the end of a blowpipe, as shown in Fig. 1*a*. The gatherers pass the balls to workmen known as blowers and snappers, who block and shape the mass. By the sheer force of his lungs, the blower inflates and shapes the glass until it forms a sphere of some size (Fig. 1*b*); and then elongates the bubble while swinging it in the swing hole (Fig. 1*c*) until it has chilled. This partially completed cylinder is now reheated, and by repeated blowing and manipulation is finally brought to its desired shape and length. The lower end of the cylinder is then warmed and blown open. Thus a ball of glass is inflated to a cylinder, which is usually from four to eight feet in length, according to the desired dimensions of the finished sheet. In order to produce the ordinary flat window glass, the cylinder is cracked from the blowpipe, and the neck severed from the cylinder proper with a thread of red-hot glass (Fig. 1*d*). The cylinder is next cracked lengthwise with a hot iron (Fig. 1*e*) and placed in an oven where it is heated, flattened (Fig. 1*f*), and annealed. It is then washed and cut.



These Illustrations Show the Old and New Cylinder Processes, and Partially Successful Attempts to Produce Glass by the Sheet Process.

The only successful effort which has been made to improve on this ancient process is recorded in the introduction of machinery for drawing and blowing the cylinders. As a matter of fact, the only machine-made window glass produced to-day is made by this means. The process simply substitutes men known as ladlers, machine blowers, and tenders for the gatherers, blowers, and snappers. A high degree of skill is required to manipulate and control the blowing and drawing apparatus properly. The other operations are identical with those of the hand-blown process. There is, however, a small saving in the cost of production by the machine over the hand cylinder process. Although it substituted a method, mechanical in some of its stages, for the production of cylinders, it is not considered an important advance in the art.

It must not be inferred that the proprietors of the large works have not been alive to the deficiencies of the older methods of making glass; for ever since machinery became a potent factor in modern industries, they have endeavored to create a practical process for drawing glass sheetwise from the molten material. Numerous costly experiments have been made in this direction, but up to this time all have ended unsuccessfully. Apparently the supreme obstacle was the difficulty of maintaining the width of the sheet as it was drawn from the pot or working chamber. Molten glass like all viscous substances tends to narrow down to a thread as it is drawn, and all attempts to maintain the width by gripping the edges of the glass with clamps or pincers as it emerged from the mass proved impracticable. Somewhat more ingenious so far as holding the width of the sheet is concerned, but unsuccessful as a whole, is the scheme which is roughly illustrated in Fig. 2. It consists in forcing the glass through a slit in the bottom of a fireclay vessel and drawing it upward. Whenever the surface of the glass touches any substance directly, it can never be drawn into sheet glass free from surface marks, such as is required in marketable window glass.



THE COLBURN MACHINE FOR MAKING WINDOW GLASS BY THE SHEET PROCESS.

By far the most systematic and painstaking study which has been made of the whole problem we owe to Mr. Irving W. Colburn, of Franklin, Pa. He has attacked it on every conceivable side, expended large sums in experimenting, built and destroyed machine after machine, and after eight years has produced the first commercially successful apparatus for drawing sheet glass of any reasonable width and of desired thickness, surface, and polish. Naturally, his first thought when assailing the problem was to pass the plastic glass between heated rollers (Fig. 3), but it was soon found that while it was possible thus to produce sheets of desired width and thickness, the glass was not marketable because its surface chilled on coming in contact with even the most fervid rollers, so that instead of exhibiting the limpid transparency and high fire polish so much desired, it resembled frosted glass in appearance. The effect was produced by infinitesimal surface marks, or cracks. Obviously, the sheet might have been ground to transparency, but the additional expense was prohibitive.

After a series of failures along these lines Mr. Colburn directed his attention to the manufacture of window glass by machine cylinder processes, and after expending considerable effort in this direction he finally succeeded in constructing a machine which produces marketable glass of uniform strength, which machine is probably the best cylinder machine thus far invented. This statement is made because the cylinder can be removed from the pot of molten glass without contaminating the contents of the pot with fragments of chilled glass. The machine has a double drawing pot, so that the machine blower is enabled to draw successive cylinders, the surface of the glass in the idle pot being reheated while its companion pot is producing a cylinder. This design of apparatus dispenses with the ladler, the glass being kept at a constant level in the drawing pot, by being continuously fed from the melting furnace. How this is accomplished may be seen in Fig. 4. The pot is formed with a central cone of fireclay, upon the apex of which the tapering end of a cylinder is ultimately held. By means of a blast flame the comparatively thin glass bond that ties the cylinder to the cone is melted away, and thus the pollution of the molten glass in the working pot by fragments of glass is avoided, making it possible to continue the drawing of successive cylinders from the same pot—a feat which has not been heretofore accomplished.

Efficient as this method of producing cylinder glass is, it falls far short of a machine by means of which glass can be drawn out in continuous sheets. Returning to the task of producing a machine which would produce glass without first blowing it into cylinder form, Mr. Colburn hit upon the method illustrated in Fig. 5. In this plan spheres of fireclay are employed, carried on the ends of long arms which are immersed in the glass and which are made to revolve upwardly and outwardly, and away from the two edges of the sheet. These spheres impart an outward motion to that portion of the surface of the

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tion at an even tension; otherwise, the music sheet would be run slowly when the bellows were being pumped softly, and too fast when they were being pumped vigorously. The governor which has been devised for this purpose is one of the most ingenious of the devices controlled by the makers of this player. It is a self-choking device of the same principle of action as that used in the two expression control chokers, above described. It consists of a pneumatic, which is interposed between the bellows and the motor, and serves automatically to throttle the flow of air through the motor, closing when the tension is high, and opening when it is low. The equilibrium thus automatically secured causes the motor to run evenly at the desired tempo, whether the instrument is being played loudly or softly.

PHRASING LEVER.—Another important device, peculiar to this instrument, which assists greatly in allowing the operator to impress his personality on the music, is a little rocking lever placed on the ledge just below the piano keyboard on which the tempo and the choker box levers are also arranged, which acts directly upon the tempo governor pneumatic, and enables the player, by depressing one end of the lever, to instantly close the governor valve to any extent he desires, and slow down the music, proportionately, even to a full stop. By depressing the other end of the lever the tempo may be accelerated. It is claimed that the interposition of this direct control through the phrasing lever has done more than anything else to break up the mechanical effect, and bring the operator as nearly as possible into the position of having his hands directly upon the keyboard itself.

The sustaining or "loud" pedal is operated through the member *a* and the levers *b* and *C*, by a lever placed conveniently to hand among the various operating levers on the ledge below the piano keyboard.

In concluding our description of this interesting device, it should be noted that this player was the first to be installed within the piano case itself. In fact, the first player was of this character. Subsequently, in order to enable existing pianos to be played, the instrument was set up in a separate cabinet case. To-day, however, the obvious advantages of having a piano which is available for use either by those who play by hand, or those who play by the music roll, are likely to render the company's first style of player the prevailing and permanent type.

THE FIRST MACHINE FOR THE COMMERCIAL PRODUCTION OF WINDOW GLASS BY THE SHEET PROCESS.

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molten mass lying adjacent to the edges of the sheet, thereby counteracting that tendency to shrink and draw to a thread which is the property of all such materials, and which has rendered the problem of devising a sheet machine so difficult of solution. By this means he was enabled to draw continuously sheet glass of any desired width and of a thickness varying at the will of the operator from 1-16 to ¼ of an inch. Complete success was not, however, immediate. Ribs or wave-like lines or striæ were formed upon the surface of the finished product in some unaccountable way. These were very minute, but still perceptible enough to distort the visual rays and to produce unpleasant refraction. Although the use of the spheres had overcome the difficulty of maintaining the width of the sheet, still the presence of the wave lines was so serious a defect that it became absolutely necessary to remedy it. An elaborate study of the conditions which caused these formations was now undertaken. After observations and experiments extending over a year, it was discovered that the defect was due to several causes, among which was the tendency of the glass to receive on its surface impressions from the rough side walls of the pot, particularly if the point at which the glass left the walls was only a few inches from the point at which the glass entered the sheet. Moreover, the chilling influence of the atmosphere on the surface of the glass, while molten in the working chamber, caused it to lie dormant in spots and also to wrinkle slightly. These defects were hardly perceptible to the eye, but existed nevertheless, and were bound to cause the disastrous wave lines when the glass entered the sheet form. Dust particles dropping into the working chamber were also a source of serious trouble. It seems that such particles, however minute, adhering to the surface of the molten mass, are gradually incorporated in the sheet, and the blemish made by them is elongated so as to produce a wave, line, or cord. Mr. Colburn found that by placing near and on each side of the sheet a rotating fireclay cylinder *D*, slightly immersed in the molten mass (Figs. 6 and 7), and at the same time superheating remote portions of the glass, the difficulties were overcome. These rollers are rotated in opposite directions during the operation of drawing the sheet of glass, and serve not only to impart movement to a portion of the surface of the molten mass away from the faces of the sheet during the drawing operation, but also to determine the area of the surface in the working chamber or pot, which is more or less exposed to the cooling influences of the atmosphere, the superheating occurring on that portion of the surface of the molten mass to the rear of the rollers. These rollers make but one revolution in from ten to thirty minutes, depending upon existing conditions, and serve also as a most perfect equalizer of temperature of the molten glass in the working chamber, which is an absolutely necessary factor in drawing an even thickness of sheet glass. A film of plastic glass adheres to these rollers and is carried upward and over the rollers, chilling slightly in the chamber *A*, because of the presence of the water jackets *C C*, which are inserted, one on each side of the emerging sheet of glass. These jackets are not designed to chill or thicken the sheet, but merely to screen off the heat radiating from the revolving white-hot clay rolls. The plastic film of glass on the rollers melts off entirely in the superheating chambers *B B*.

As the sheet of glass is drawn from the mass of glass lying between the rollers, and as the spheres impart an outward movement to that portion of the surface of the mass lying immediately adjacent to the edges of the sheet, the following effects are observed: The molten glass at and just beneath the surface adjacent to the edges of the sheet moves outwardly and away from the central line of the sheet, thus serving to hold the sheet to its full width. As the sheet moves upward there is drawn into it some of the surface portion of the molten mass immediately adjacent to its two faces, and also some of the molten glass beneath the surface. The skin or surface portion of the glass in the working chamber adjacent to the sides of the sheet being drawn, becomes the skin or surface of the finished drawn sheet. Simultaneously the two rollers on opposite sides of the sheet of glass skim some of the surface portion of the molten glass lying between the rollers and the sheet of glass away from the sheet. The result of the combined action of the drawing of the sheet and the movement of the rollers is a constant skimming of the molten glass lying between the two rollers, so that a fresh portion or a new surface is constantly being exposed to the cooling effect of the atmosphere, which has not time to form wave lines on its surface before it has passed into the drawn sheet or over the revolving rollers. Furthermore, the rollers serve to bring a supply of fresh and uniformly heated molten glass into the area lying between the rollers and the sheet. The glass which is skimmed from the surface by the rollers and carried over them is subjected to the superheating action in the chambers *B B*, as already explained, and is melted down so as to free the rollers from the adhering film, and restore the film itself to a proper working condition. Simple as the expedient of the rollers may seem, it meant months of painstaking observation and experimenting before they were conceived.

Operated by three shifts of men, of eight hours each, three men to a shift (one man filling in the batch to the continuous glass-melting tank furnace, one man watching the operation of the sheet-drawing apparatus, and one man cutting off the glass into sheets and removing them as the sheet emerges from the end of the annealing leer) this machine will produce sheet glass continuously, month in and month out, twenty-four hours a day, stopping only for repairs. The glass leaves the machine at an approximate rate of from fourteen to twenty-eight inches a minute (depending upon whether thick or thin glass is being drawn), and uniform quality of glass is maintained regardless of the speed at which the glass is drawn. Glass much thicker than the heaviest double-strength window glass, as well as the single-strength, can be produced with perfect ease, the quality being midway between the best hand-blown and plate glass. The surface presents a most beautiful fire polish.

After the sheet has been formed it passes from a vertical to a horizontal travel over an idler or bending roller into an annealing leer, which bending roller receives the power necessary to start and keep it in motion from frictional power mechanism acting in conjunction with the frictional contact of the traveling sheet of glass. This combined application of power to the bending roller prevents it from marking or scratching the finished sheet. The glass is rendered sufficiently flexible at the bending point by a series of gas flames, as illustrated in Fig. 7.

The Rumored Wireless Merger.

John W. Griggs, president of the Marconi Wireless Telegraph Company of America, denies published reports of the entrance of the Marconi companies into a merger of English and American wireless telegraph companies.

A 3⅛-inch rock drill, at full work, has been found to require 28 to 32 indicated horse-power at the compressor, but the actual power used against the rock was determined in a certain case to be only 1.7 horse-power. On the basis of 28 horse-power at the compressor, consequently, the efficiency of power at the drill bit was only 6 per cent.

PRESENT CONDITIONS AT PANAMA.

President Roosevelt could not have chosen a more opportune time for his recent visit of inspection to the Panama Canal; for that great enterprise has now been carried forward to the point at which the country is at last prepared to launch itself actively upon the work of construction. Hitherto, as we have shown in our editorial columns, the work has been almost entirely that of preparation. As far as the engineering staff was concerned, such excavation as has been done has been mainly of a tentative and experimental character, and directed, first, to the ascertaining of the actual value for future construction of the plant which was purchased from the French company, with a view to determining what must be sent to scrap and what could be used to advantage; and secondly, with a view to determining the unit cost of construction and the best forms of excavating machinery to be installed. The cost of excavation is greatly affected by the weather conditions, being of course higher in the rainy season than in the dry. It is found generally to vary in the Culebra cut from 50 to 75 cents per cubic yard.

ORGANIZATION: Under a recent executive order, the plan of administration has been simplified so as to concentrate the executive staff upon the Isthmus and render its work more simple and direct. The Isthmian Canal Commission will hold quarterly sessions on the Isthmus of Panama during the first week of February, May, August, and November of each year, and under the supervision of the Secretary of War, and subject to the approval of the President, it is charged with the general duty of the adoption of plans for the work of construction; the purchase of supplies; the employment of officers and laborers; the operation of the Panama railroad and the steamship lines; the government and sanitation of the canal zone; the making of all contracts for construction; and with all other matters necessary for the construction of the canal as provided for by the Act of June 28, 1902. The old Executive Committee is abolished, and in order to promote harmony and secure results by the most direct methods, a new organization has been created, consisting of a chairman and seven heads of departments. The chairman, to whom supreme authority is thus given, is T. P. Shonts; and under him are seven departments. The First Department will be presided over by the Chief Engineer, who will have absolute charge of all engineering and construction work; the operation of the Panama railroad as far as it affects canal construction; and the custody of all supplies and plant. In the absence of the Chairman from the Isthmus, the Chief Engineer will act for him in all matters requiring prompt attention. The Second Department, presided over by General Counsel Richard Reed Rogers, will be concerned with the administration of civil government within the canal zone, and he will exercise through a local administrator the authority heretofore vested in the Governor of the Canal Zone. The Third Department, presided over by the Chief Sanitary Officer, Gen. Gorgas, will be concerned with all matters of sanitation within the canal zone, in the cities of Panama and Colon, and in the terminal harbors. The Fourth Department, presided over by the General Purchasing Officer, will be concerned with the purchase and delivery of all supplies, machinery, and necessary plant. In the Fifth Department, the General Auditor will have charge of general bookkeeping, property accounts, statistics, etc., and the audit of the government of the canal zone. In the Sixth Department, the Disbursing Officer will have charge of timekeeping and the preparation of payrolls and vouchers; and lastly the Manager of Labor and Quarters will have charge of the employment of all necessary labor; of the general personal record of all employees; of all quarters provided for the same; and of the operation of commissary hotels and mess houses.

Thus we find that the government has at length adopted what is practically the carefully elaborated and long-tested system used by our great railroad corporations in carrying out important works of construction and maintenance.

THE CONTRACT: Originally it was the intention of the Commission to build the canal with its own organization and labor. But because of the present unprecedented and greatly extended industrial activity, and the consequent violent competition for all classes of superintendents, foremen, sub-contractors, skilled mechanics, and even ordinary laborers, it became apparent that it would take the Commission several years to secure men and build up organizations for construction, which would equal in efficiency those which are now controlled by the leading contractors of the United States. The Commission came to the conclusion that by gathering together a trained corps of its own engineers and administrators of the highest experience and efficiency, and then calling in one or more of the largest contracting firms to do the actual work of construction under their guidance, it would be possible to complete the canal in shorter time and for less money than by day labor. Of the different forms of contract considered, it was decided that the best proposition would be to let the actual work of construction to an associ-