THE INTERIOR CONSTRUCTION OF A PIANO PLAYER.

It is not stating the case too strongly to say that the introduction of the first successful piano player, which event occurred about a dozen years ago, was, in its educational effects, the most important development in the musical world of the last century. For the average lover of music who may be desirous of becoming himself a performer, it will not be disputed that the piano is the most available and popular instrument. And yet the amount of laborious preparation that is necessary before anyone can become even passably proficient as a pianist is so great, and before one can become reasonably expert is so enormous, that the majority of the workaday people of this world have at their disposal neither the time nor the funds that are necessary. For the average amateur, by far the greater part of the labor entailed in learning to play the piano is spent in acquiring the manual dexterity which is necessary merely to strike the notes in their proper consecutive order and time; that is to say, to acquire the mere mechanical technique, irrespective of those shadings of time and expression which give life and color to the work of the finished pianist.

With the production of the first successful piano player, it became possible for anybody, whether he possessed any musical taste or not, to play any musical composition with absolute fidelity to the written score, at least as far as the striking of the notes in their proper order and time is concerned. Because of this extremely clever mechanical invention, it was no longer necessary to spend the years of time and the not inconsiderable sum of money that must formerly be spent to acquire even the most elementary technique. That the production of the mechanical player had filled a long-felt need was proved by the world-wide popularity which it instantly achieved; and even the musical critics and the virtuosos themselves, who at first looked with contempt upon this mechanical contrivance, have now come to realize and freely admit that it is one of the most powerful educational forces to be found in the world of music at the present day. That it had its limitations was not denied, even by the various makers themselves; but it is claimed, and not to be disputed, that these imperfections have been very largely eliminated. When we remember that, in point of years, the mechanical player is yet in its infancy, it is reasonable to expect that, when the interpretative devices shall have been perfected, the instrument in the hands of a musician will rival the playing of any but the most skilled performers by hand.

In view of its present remarkable popularity and the enormous industry which it has produced, there is food for thought in the fact that the piano player has had but a little over a single decade of commercial life. The United States Census Report says: "In 1895 Messrs. Wilcox & White, of Meriden, Conn., began manufacturing an interior attachment, and in February, 1897, built their first Angelus cabinet piano player. This instrument, the invention of E. H. White, may be regarded as the pioneer of various similar attachments which have since been placed on the market." Because of its priority, we have chosen this instrument to form the basis of the present article, in which we shall endeavor to show the interior construction and operation of this most interesting device.

Interior Construction.—Turning then to the accompanying transverse sectional view (Fig. 1), taken through the player, we find that it consists broadly of a pair of foot bellows for exhausting the air, a series

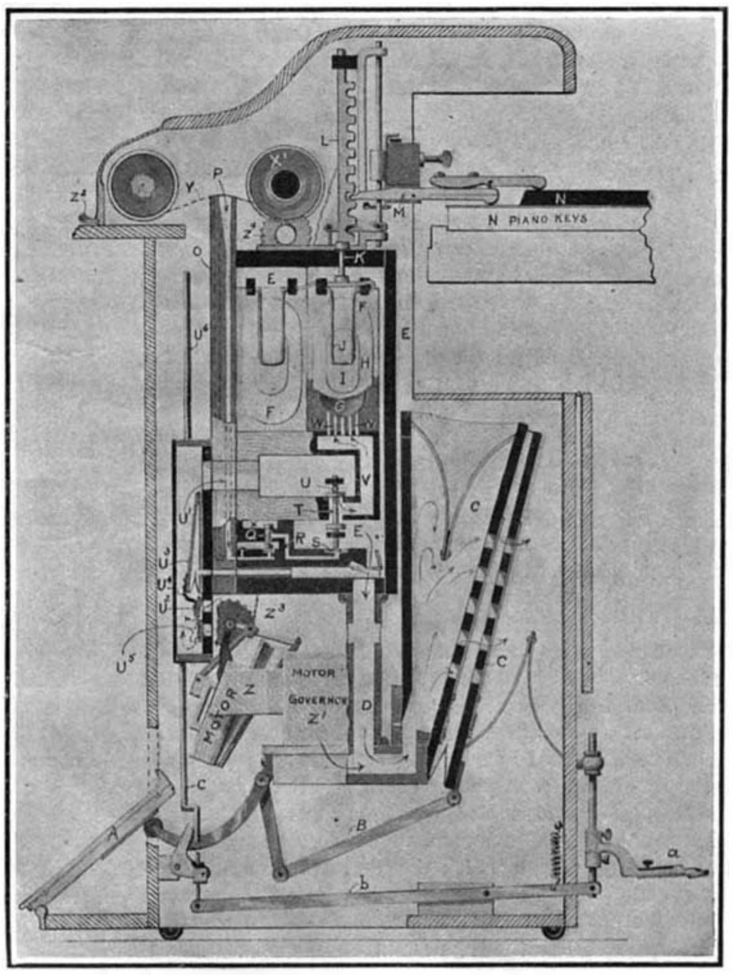


Fig. 1.—Transverse Section, Showing the Mechanism and Operation of the Player.

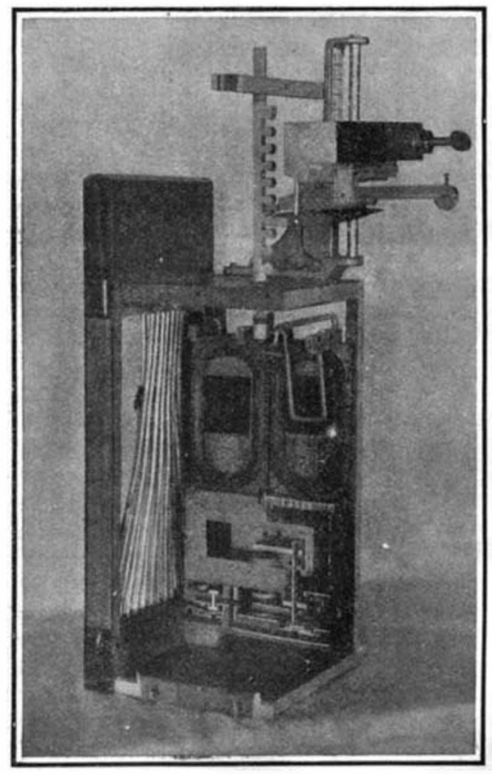
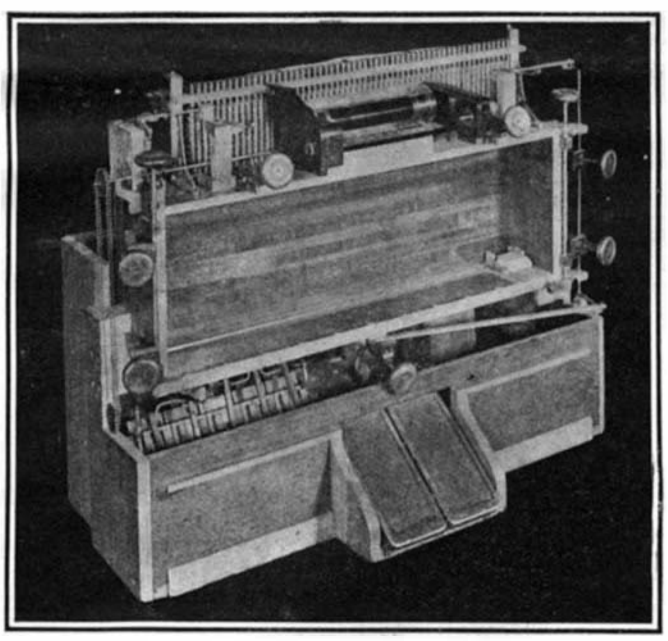
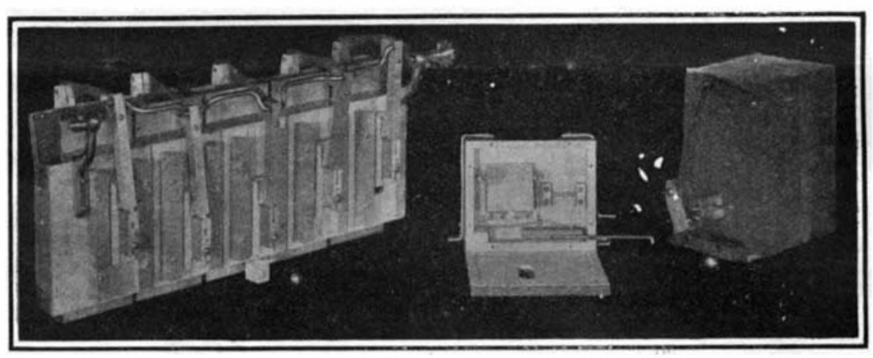


Fig. 2.—Sectional Model, Showing Tracker Board, Tubes, Primaries, Secondaries, Diaphragm Pneumatics and Striking Fingers.



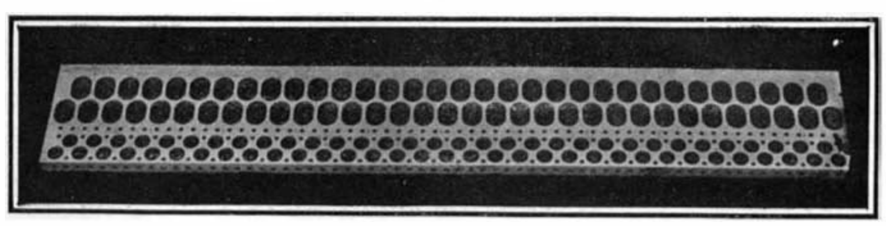
The complete action is placed in the central air-tight chest, and tested until it is perfectly satisfactory.

Fig. 4.—Jack for Testing Player Actions.



The motor. The gate box for tempo control. The governor.

Fig. 3.—The Tempo-Control Mechanism.



This shows the 130 pockets for the primary and secondary pneumatics.

Fig. 5.—The Well-Board.

Fig. 6.—Press for Glueing Sheepskin Diaphragms on the Power Pneumatics.

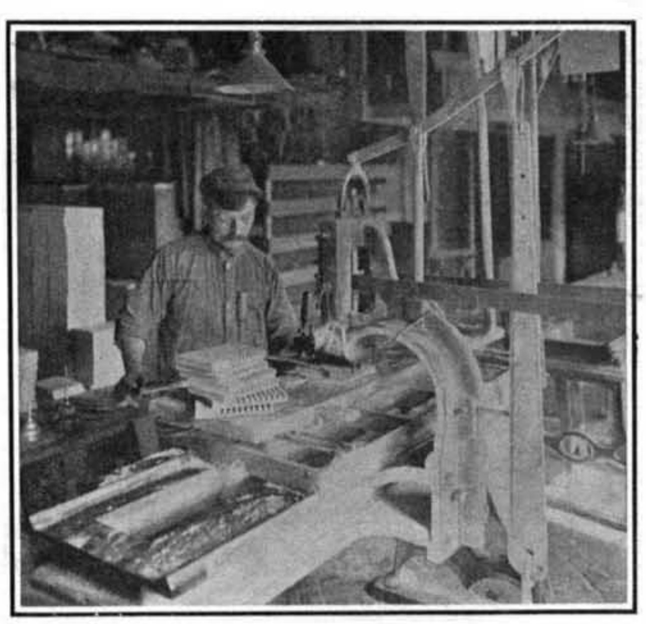


Fig. 7.—Milling Out the Teeth in a Set of Plungers.

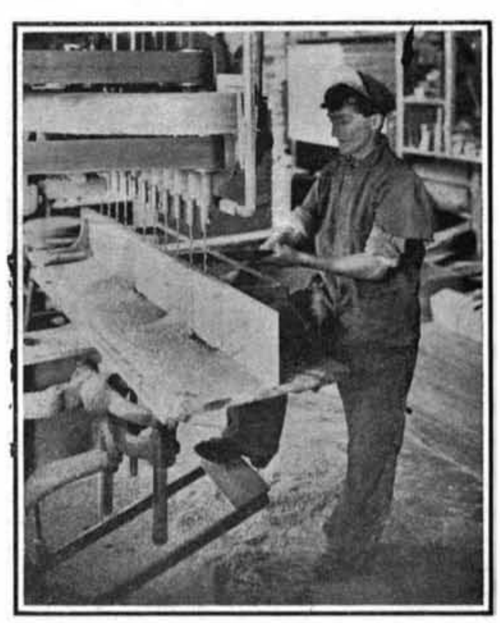


Fig. 8.—One of Several 11-Gang Drills, Boring Air Ducts in Edge of Well-Board.

THE INTERIOR CONSTRUCTION OF A PIANO PLAYER.

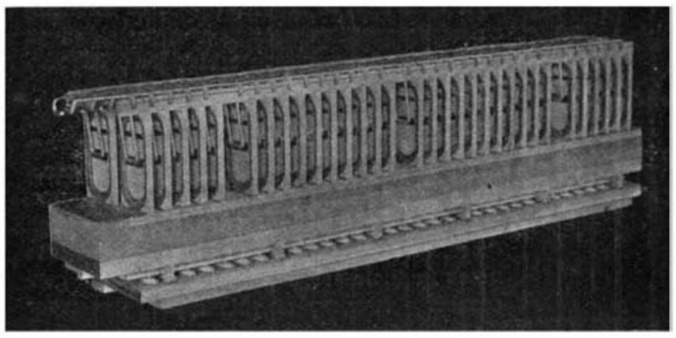
of delicately-balanced poppet valves for regulating the flow of air, a series of small bellows governed by these valves, one to each key of the piano keyboard, and a set of fingers operated by these bellows (or pneumatics, as they are technically known), for striking the piano keys. And just here it should be explained that the power which strikes the keys is produced by suction and not by pressure, the object of the foot bellows being to produce the vacuum, which is utilized in operating the little striking bellows in their proper order.

The foot bellows *A* operate, by means of the levers *B*, two large exhaust bellows *C*, which exhaust the air, as indicated by the arrows, through the passage *D*, from an air-tight chest *E E*. This chest extends across the full width of the player, and it contains within it the whole of the "action" (Fig. 5). The action consists of sixty-five complete sets of mechanism of the kind shown in our sectional view and in Fig. 2, there being a complete set to each key of the piano that is to be played. Each set consists, as we stated above, of certain little poppet valves regulating the flow of the air, and a power pneumatic which, by its inflation and deflation, serves through connecting levers to operate the striking fingers, which do the playing on the keyboard.

The front face of the air-tight action chest *E E* is closed by a board *O*, which is pierced at its upper edge by sixty-five air ducts *P*, each of which provides an independent passage from the outside air down to its own set of poppet valves, or pneumatics, as they are called. Normally, these ducts are closed by a sheet of music *Y*, which is adapted to be drawn across the tracker board, as it is unrolled from one and rolled on to the other of two spools carried on opposite sides of the tracker board.

Operation of the Pneumatics.—When a piece of music is to be played, the air is exhausted by means of the foot pedals, and the vacuum produced causes the little motor *Z* to operate the spool *X'* and draw the music sheet from left to right over the tracker board. In the normal condition, that is, before the perforations in the music sheet reach the holes in the tracker board, the whole of the action chest is subject to partial vacuum, proportionate to the strength of the pumping, and all of the power pneumatics, *H F*, are in the deflated condition, and the corresponding striking fingers are in the raised position. The instant, however, that a perforation in the sheet reaches the duct *P*, there is a rush of air down this duct to the under side of a little flexible and air-tight piece of thin leather, known as the primary pneumatic, which rises and lifts a little poppet valve *Q*. The button on the bottom of this valve closes against the vacuum, and the button at the top of it rises, opening a channel *X*, which is in connection with the outside air, and allowing said air to rush through channel *R* to the under side of a larger or secondary pneumatic *S*. This, in turn, rises; closes the bottom button of the poppet valve *T* against the vacuum; lifts the upper button and puts the channel *U*, which is open to the outside air, in communication with the passage *V*. The air rushes in through this passage and up through a series of ducts *W* into the interior *G* of the large diaphragm power pneumatic, or striking pneumatic, *H*. Now, this pneumatic being in the vacuum action box *E*, the entrance of the air causes it to expand suddenly, driving the wooden disk *I* forward, or outward, and operating the lever *J*. The horizontal arm of this lever lifts a poppet button *K*, which in turn raises the notched plunger *L*. This plunger engages the inner end of a pivoted striking finger *M*, causing the outer end to descend sharply and strike the piano key *N*. The piano key will remain depressed until the perforation in the music roll has passed the duct *P*, and the latter is closed again by the paper. Closing the duct *P* causes the primary and secondary valves and the whole of the action to resume their normal positions, ready for another blow. From this description it will readily be apparent that, by cutting perforations in the music roll to correspond in position and in length with the particular keys to be struck, and with the time during which they are to be held down, the music of the piano score can be reproduced with mechanical accuracy, as far as the striking of the proper notes, and the time during which they are to be depressed, is concerned.

The Diaphragm Pneumatics.—It will be seen from the above description that the whole of the action is inclosed in a vacuum chest, where the delicate little valves are entirely protected from dust, and the irritating rattling of these valves in their rapid movements, which is noticeable in some forms of players, is so completely muffled as to be inaudible. Furthermore, the fact that the action operates in a partial vacuum assists not a little in that rapidity of action which is of such vital importance where rapid repetition of a note is necessary. The peculiar construction of the diaphragm pneumatic, which, as we explained above, does the actual striking of the keys, is one of the distinctive and most important features in this style of player. In other players the power pneumatics are of the hinged-bellows type similar in form to the large pumping bellows, *C C*, as shown in the drawing; and under the heavy duty that is required of them, the leathers, because of their sharp folding and unfolding, are liable to crack at the edges, and cause a leakage of air. The form of pneumatic here shown has been designed to obviate this difficulty, and also to provide greater sensitiveness and speed of action. It consists of a block of quartered poplar wood 2¾ inches wide by 5½ inches high and ⅜ of an inch thick. It contains a recessed pocket *G*, provided with five ports, *W*, for the admission of air. The recessed chamber is closed by a diaphragm of specially tanned and very thin and flexible sheepskin, which is glued down upon the face of the block in such a way as to provide an air-tight inclosure, but yet allow the sheepskin to be sucked into the cavity, or distended above it, by the alternate admission or expulsion of the air into the pneumatic. By this arrangement the sheepskin is not subjected to any sharp creasing or folding, and its life is indefinitely prolonged. On the outside of the sheepskin is a thin disk of wood *I*, which bears against the lever *J*. The flexibility of this skin and its small inertia render the action of the pneumatic also very sensitive; and acting as it does in a vacuum, it is capable of a rapidity of repetition which is really remarkable. By way of testing the rapidity and durability of the diaphragm pneumatic, an Angelus player was recently installed in an exhibition room of this city, and run continuously ten hours a day for several months, during which period each of a dozen of the diaphragm pneumatics was operated 70,000,000 times at an average speed of 600 strokes per minute, without showing, at the end of that time, any appreciable evidence of wear.



These are the pneumatics which do the striking. Below them are seen the secondary pneumatics by which they are operated.

Fig. 9.—A Complete Bank of 65 Diaphragm Power Pneumatics.

Interpretative Control.—The mechanism of the instrument as thus described, has to do with the mere striking of the notes independently both of the force with which they are struck and of the tempo. If the capabilities of the instrument stopped at this point, the playing would be entirely automatic, mechanical, and uninteresting. To bring the instrument up to the point at which the operator can impress upon it his own individuality in controlling the tempo and the tone according to his interpretation of the music, was the most difficult task confronting the inventor, and in proportion as this interpretative control is secured, is an instrument entitled to rank in the first class.

Expression, or Volume of Tone.—The expression, or volume of tone, is dependent upon the degree of strength with which the notes are struck, and this should vary from the softest pianissimo to the strongest fortissimo. It is secured by the use of two so-called melody pistons operating upon the choking boxes, one for the bass, the other for the treble, through which the air must pass as it enters to inflate the diaphragm pneumatics. The entrance of the air to these boxes is controlled by two valves, U^2 and U^5. When the music is being played softly, valve U^5, which is controlled by hand, is kept closed, and the air flows through valve U^2. The degree of opening of U^2 is controlled through a bent rod U^4, attached to and operated by a choker pneumatic U^3, the degree of closure of this pneumatic being determined by the suction of the main bellows, with which it is connected. The object of this choker is to render the flow of air to the diaphragm pneumatics independent of the strength with which the main bellows are being worked; for if the operator is pumping hard and the suction is strong, the choker pneumatic will be sucked down upon the inlet valve U^2, throttling it, and maintaining the moderate inflow of air which is necessary when playing softly. When it is desired to play more loudly, the operator, by releasing the rod U^5, opens the valve U^5 and allows the outside air to flow directly to the diaphragm pneumatics, independently of the choker pneumatic U^3. The air chamber *U* is divided at its center by a transverse diaphragm, and a choker is provided for each half of the chamber. This enables the player to strike the keys on either the lower or upper half of the register with greater emphasis, and give to the theme or melody a stronger accent according as it happens to lie in the upper or lower half of the keyboard.

This instrument can be played by hand or by the music roll. Here shown with the pedals drawn out ready for use with the piano player. Note the control levers below keyboard.

Fig. 10.—Piano Player and Piano-Front Removed.

THE INTERIOR CONSTRUCTION OF A PIANO PLAYER.

Tempo Control.—The control of the tempo depends upon the speed with which the music sheet is drawn by the rotating spool across the top edge of the tracker board, and the speed of the spool is determined by the speed of the little five-crank suction motor *Z*, which drives the spool by means of chain and sprockets. The speed of the motor is controlled by a small slide valve, which is set by the operator at the tempo indicated on the roll. Now, it will be evident that since the speed of the motor will depend upon the strength of the air suction, it is necessary to provide some form of governor which will maintain that suction 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.

(*Continued from page 400.*)

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-