FRANKLIN INSTITUTE

(*Stated Meeting held Wednesday, November 18, 1908.*)

THE DEVELOPMENT OF THE ELECTRIC PIANO PLAYER.

BY

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It is said that every good medical essay begins with Aristotle. I cannot with my subject to-night go back so far, but I go almost to the beginning of the electrical art.

The wonderful results obtained by the great masters of the art of piano playing ordinarily serve to disguise from us the simplicity of the means employed. This mechanical simplicity at an early date directed the attention of mechanicians towards seeking a substitute for the pianist's fingers. When a piano key is struck its hammer is thrown against the corresponding string, from which it immediately rebounds part way, and in this mid position it is caught and held until the key is released. The depression of the key simultaneously lifts the damper from the string. Both hammer and damper are therefore clear of the string while it is sounding. Nothing can be done to the key before the hammer is thrown, or after it is thrown and before the damper is returned, that can at all alter the tone produced. In any given instrument the pianist controls manually only the velocity with which the hammer strikes the string, and the return of the damper. The ordinary pedals add no new feature, they merely add to the ease of control. The wonderful art of piano playing is therefore built up by varying two simple elements.

Froment appears to have attacked the problem as early as 1850, but I have not been able to procure any accurate account of his work. In 1861 a patent for an electric player was taken out in Württemberg by Andre. In 1867 the celebrated mechanician Hipp exhibited an electrically operated piano which is worthy of some attention. It may be considered as the foundation of the work of the present day and indeed in some respects

it is in advance of much of the subsequent work. The Hipp apparatus consisted of two parts, a transmitter and a receiver. The latter consisted of a series of electro-magnets with armatures pivoted so as to swing towards and across the poles, and having the armatures connected by wooden rods with the jacks of the piano action. The transmitter employed a roll of perforated cardboard or cloth, similar apparently to the music rolls now so familiar, which was drawn by means of clock-work from one wooden roller to another. On its course it passed over a metallic roller and under a comb consisting of wires properly spaced and held in an insulating frame. The roller and the wires of the comb formed terminals of electric circuits including the magnets in the piano. The method of action is obvious. It is necessary to add that expression was controlled by the insertion of resistances in the common return. That he chose a type of magnet whose action could be modified in this manner is one of the evidences of Hipp's knowledge and careful work.

Another Swiss, Spiess, exhibited an electric player in Paris the following year, 1868. So far as the description goes this player seems to be substantially the same as Hipp's. We are more fortunate, however, in that we possess a contemporary statement as to the results obtained. The clearness and distinctness in rapid passages are the subject of special praise. It may be of interest to add that Hipp operated with ten Bunsen cells and Spiess with thirty-six Daniell. To a considerable extent Hipp and Spiess must be regarded as being too far in advance of their time. The lack of a cheap supply of electric energy and the relatively small number of pianos in use would have precluded commercial success in any event.

At much about the same time as Hipp and Spiess, Prof. J. B. Webb and Mr. Oberlin Smith were at work on the problem in this country. They sought to replace the perforated tape by one having the notes printed in metallic ink, and they tried also a conducting tape with the notes printed in insulating ink. Other work proved more attractive to both inventors and they abandoned the piano player in an unfinished condition.

In the late seventies and early eighties William F. and Henry Schmoele of Philadelphia took out a number of patents relating to piano players. One of the patents described a music roll with the notes printed in metallic ink. The Schmoeles, who

had on the whole a very clear idea of what a piano player ought to do, seem to have been deterred from the use of a straight electric action by the cost and unreliability of the supply of electricity at that time. They fell back on an electro-pneumatic action similar to that employed in playing organs from a distance, or, to compare their apparatus with what has now become more familiar, it resembled the present-day pneumatic action with the primary pneumatic replaced by an electric action.

At the electrical exposition of 1881 in Paris, Carpentier, the well-known instrument maker, exhibited a piano-playing apparatus which he called a repeating Melograph. The name Melograph had already been applied to an instrument exhibited at Vienna in 1873 designed to record piano playing. The complete Carpentier instrument was intended to cut a record of a composition played at the keyboard in the ordinary manner, and then to use this record as the music roll in the reproducer. In reproduction, which alone concerns us, Carpentier introduced a new idea. A shaft revolving at a fixed speed was placed under the keyboard. A number of brake shoes, corresponding to the keys to be operated and linked to them, were placed contiguous to the shaft, and pivoted so that a slight motion would apply them to it. When so applied the friction developed would pull down the piano keys with a force dependent on the speed of the shaft. The magnets controlled by the music roll instead of operating the piano action had only to throw the brake shoes against the rotating shaft. In this way it became possible to use smaller magnets and to economize in the use of electric energy, but unfortunately at the loss of control of expression.

Some dozen or more years later Carpentier's scheme was taken up by an American inventor, Mr. G. H. Davis, and embodied in a commercial machine. In the machine as now constructed Carpentier's cylindrical shaft has been replaced by one in the shape of the frustum of a cone with small apical angle. The chief improvement, however, is the addition of a hinged three-piece, soft-pedal bar, controlled by three levers. By means of this expression may be imparted manually to music which as controlled by the music sheet, alone would be perfectly flat.

Most inventors, however, have preferred to follow in the line marked out by Hipp, and in it personally I am most interested. I have called attention to the fact that Hipp inserted resistance in

the circuit with a view to varying the strength of the magnets and so the intensity of the blow of the hammers. Although du Moncel described Hipp as obtaining in this manner a satisfactory range from forte to piano, a little consideration will disclose an essential weakness in the scheme. For any given resistance introduced into the main circuit will have an effect the greater the more magnets in circuit, a very undesirable result. Yet it was not until some thirty years later that it was shown that the true method is to insert a separate resistance in each branch circuit. Before condemning too severely the electrical inventors occupied with piano players for their slowness in discovering this point, it might be well to take into consideration that an analogous fault still exists in some of the pneumatic players of to-day.

In order, however, that insertion of resistance may give effective control of the magnetic pull, and hence of the touch on the piano keys, it is necessary that the magnets should be peculiarly constructed. It is necessary that the attractive force should be near its maximum when the armature first begins to pull on the piano action. When a magnet is employed in which the attraction on the armature rapidly increases as the armature moves towards the poles, it is practically impossible to control the movement by the control of the current. In such a case the current that is required to start the armature from its initial position suffices for a violent blow at the end of the path. Hipp perceived this but it was overlooked by many of his successors.

Those who have had experience with pneumatic players know that one of the most serious difficulties with such instruments is the susceptibility of the paper music roll to atmospheric conditions. Naturally the same trouble is encountered when a paper roll is used in an electric player, and there are some new ones. The fact that the paper is pulled between a wire comb and a rotating cylinder instead of being drawn over a smooth tracker board does not make for better tracking. And again, if the electric pressure be high, there is a tendency to burn the paper where it acts as a circuit breaker; while if it be low there may easily be uncertainty as to contacts.

In a series of patents running from 1901 to 1904, T. B. Powers, partly in collaboration with M. R. Jewell, has shown a player combination designed to overcome these difficulties. Powers' direct contributions are more important than those of

any of his American predecessors, and he has also shown great talent in his utilization of the elements he took over from the prior act. His most important improvements are the substitution of thin metal tape for paper in the music roll, and the introduction of individual resistance coils in the branch circuits.

In 1905 I acquired the Powers patents and organized the Tel-electric Company to manufacture a player in accordance with them. Naturally in the course of manufacture a great many improvements in detail have been introduced and some of greater importance. It would be useless and wearisome to point all these out and I shall therefore content myself with describing the players now made, calling attention only to such changes as materially modify the musical results.

FIG. 1.

A, music-tape case; B, music tape; C, tracker roll; D, reading finger; E, ivory insulating block; F, contact bar; G, contact wire; H, resistance coil; J, comb wires; K, terminal; L, resistance coil frame; M, cradle casting; N, adjusting screws for contact bar; P, platinum strip and contact bar; Q, platinum bands on contact wires; R, swivel rod for reading fingers.

The apparatus in general plan recalls that of Hipp. The use of a metallic instead of a non-conducting roll has necessarily led, however, to a material change in the construction of the comb. In our apparatus each of the elements of the comb consists of two parts, a reading finger proper, and insulated from this a wire acting as a contact maker. The contact is made with a separate contact bar instead of with the tracker roll as in the Hipp apparatus. These elements, and a corresponding set of small resistance coils, are, in our standard sixty-five-note apparatus, set in a special frame, which, from its being pivoted in front to allow of a rocking motion, is usually called the cradle. The cradle is shown in Fig. 1, and its relation to the rest of the machine in the general view Fig. 2. In Fig. 3, the construction and relation of the

reading finger *D* with its contact wire *G*, to the contact bar *F* and the resistance coil *H*, is clearly indicated. The ivory block *E* serves to insulate the reading finger from the wire. It will be also clear from this figure that the metal music tape *B* when

FIG. 2.

A, music-tape case; *B*, music tape; *C*, cradle; *D*, swinging carriage; *E*, base; *F*, rubber belt drive; *G*, gears; *H*, starting switch; *I*, expression cut-out knob; *J*, trip switch; *K*, forte expression magnet; *L*, medium forte expression magnet; *M*, piano expression magnet; *N*, expression handle; *P*, tempo handle; *Q*, carriage latch; *R*, motor; *S*, governor; *T*, lifting lever; *U*, trip button; *V*, trip magnet; *W*, base subduing switch; *X*, sustaining pedal button; *Y*, soft pedal button; *Z*, treble subduing switch.

unperforated will lift the reading finger *D*, and so break the connection between the contact wire and the bar *F*. The wire *J* is one of a set forming a second comb serving to maintain connection between the resistance coils and the cable terminal *K*. When the cradle is rocked upwards the resistance coil is raised and, as an inspection of the figure will show, resistance is intro-

duced into each circuit. This rocking of the cradle may be effected either automatically by means of the magnets shown at *K*, *L* and *M* in Fig. 2, or manually by means of the handle shown at *N* in the same figure.

The winding and unwinding of the tape constituting the music roll is accomplished by means of an electric motor *R* provided with a governor *S*, Fig. 2. The transmission from the motor to the winding and rewinding rolls is through a pair of rubber belts and a set of gear wheels. The lifting of the tracker roller into place by means of the lever *T*, Fig. 2, puts the winding

FIG. 3.

A, music-tape case; *B*, music tape; *C*, tracker roll; *D*, reading finger; *E*, ivory insulating block; *F*, contact bar; *G*, contact wire; *H*, resistance wire; *J*, comb wire; *K*, terminal; *L*, resistance coil frame; *P*, platinum strip in contact bar; *Q*, platinum band on contact wire; *R*, swivel rod for reading finger.

gear in mesh, while the lowering of the same roller shifts to the rewinding gear. This shift may be effected by pressing the button *U*, but ordinarily it is effected automatically at the end of the selection by means of the trip magnet *V*, Fig. 2. At the end of the music tape an opening is cut which allows a special reading finger to close the circuit of this trip magnet, thus dropping the tracker roller and shifting the gear.

For our purpose a governor must not only maintain a steady speed, but it must maintain steady any speed the operator may choose. The simple make-and-break ball governor shown in Fig. 4 accomplishes this remarkably well. The speed is varied by shifting the position of the contact arm *A* by means of the

handle *P*, Fig. 4. This simple and absolute control is of especial value in accompaniments. Because of it, it becomes easy for any singer to accompany himself.

Fig. 5 shows two views of one of the actuating magnets and the means of attaching the armature to the piano key. It will be observed that the rotary armature is so shaped and set with reference to the poles as to ensure a strong initial attraction which, as before pointed out, is necessary in order that the touch on the piano keys may be effectively controlled by varying the current in the magnet winding. A small screw eye is put into the

FIG. 4.

GOVERNOR

A, contact arm; *B*, governor bracket; *C*, follow spring; *D*, point of break; *E*, platinum point on contact arm; *F*, platinum point on follow spring; *G*, governor spring; *H*, governor disc; *J*, hinges for governor spring; *K*, governor balls; *L*, insulation block; *M*, shunt coil; *P*, tempo handle; *R*, motor.

key, the connection between this and the armature being made by means of a flexible steel wire. The eye of the screw carries a small rubber cushion to prevent any clicking from being developed by the wire striking against the screw. It will be observed that this method of connecting leaves the keys entirely free at all times, so that, for instance, one may play a duet with the electric apparatus as a partner.

Magnets similar to the key magnets but larger are used for operating the pedal bars. These magnets are controlled by perforations made at suitable points in the music tape, or they may be operated at will by the buttons *X* and *Y* shown at the centres of the handles *P* and *N* in Fig. 2.

The music tape is a brass ribbon five inches wide and three-thousandths of an inch thick. The perforations for the notes are arranged in a similar manner to those on the paper rolls, but on a much smaller scale. The brass is only one-third as long as the paper for the same music. That the same proportion is not exactly preserved in width is due to the fact that our brass tapes carry other perforations than those corresponding to the notes. Perforations, as stated already, are provided for controlling the action of the pedals, for varying the resistance in the circuit and for shifting to the rewinding gear at the end of the selection.

FIG. 5.

A, armature; B, poles; C, armature shaft; D, brass yoke; E, swivel; F, armature return spring; G, pull-down wire; H, screw eye; J, piano key; K, rubber buffer.

The cutting of each selection is so arranged that the tempo of any selection will be normal for a fixed motor speed. This applies even to what may be called the normal variations from the standard tempo of the selection. Such variations are incorporated in the cutting. Variations in tempo to suit special tastes may be readily introduced by turning the handle *P*, Fig. 2, right or left as may be required.

Apart from the variation in tempo, the means of obtaining expression so far described consist in the variable touch on the piano keys obtained by the use of variable resistance, and the use of the pedals. If I have succeeded in making my meaning clear,

it will be evident that two distinct purposes have been kept in view in the building of the Teleelectric player. On the one hand we have attempted to build a machine which, when left to itself, will reproduce with perfect accuracy the music as written by the composer and with the proper interpretation. From this standpoint we have cut the music rolls, carefully avoiding all "adaptations" to make it easier for the player, and all the whimsies of interpretation of this or that virtuoso. For steady use and to meet the general cultivated taste we believe standard normal music is best. And we are also of the opinion that music so cut

FIG. 6.

W, bass subduing switch; Z, treble subduing switch.

forms the best basis for those who wish by manual control to obtain a personal interpretation. And on the other hand keeping in view this desire for a specialized or individualized interpretation, we have provided extremely simple means by which any one with special tastes may vary the expression to suit himself.

Still further control of expression is of course desirable. In many cases a much improved effect is produced by playing bass and treble with different force. I have accomplished this in a simple manner by dividing the magnets into two groups so that two different electromotive forces may be simultaneously used. The electromotive forces may be varied by means of the switches

W and *Z* in Figures 2 and 6. This improvement is incorporated in all our sixty-five-note standard players. If I were to use the language of the piano player advertising agent I should describe this change as causing the accenting of individual notes, and as bringing out the melody. This language is far too strong, and, like all exaggerated language, it is not only harmful in its direct untruth, but it leaves us without terms to describe further improvements when actually made. Of course when the notes are thus divided into two groups all notes occurring simultaneously in either group are struck with equal force.

The musical advantage of a distinct individual accent is so great, however, that for two years I have largely devoted my efforts to securing it, with the results that are shown in the eighty-eight-note player which I exhibit here to-night. The simplest way to get an individual accent would be to practically duplicate the tape using different electromotive forces on the parts. Imagine the music tape as made up of two parallel longitudinal bands, corresponding to a divided contact bar with a permanently maintained difference in potential. Imagine also the reading fingers, rheostats and other accessories duplicated in each section, *i.e.*, one wire from each section for each magnet and piano key. Then it will be clear that a note would be accented or not, according to which section carried the corresponding perforation. Unfortunately this system calls for music rolls nearly twice the width required for non-accenting rolls, greatly increases the cost of the rolls, and is otherwise clumsy.

To keep the roll within reasonable dimensions and at the same time obtain the requisite control over the force of the blow supplied to different keys was the subject of much thought. I became satisfied that some system of grouping the notes must be used, and I worked out several plans for the control of the groups. These plans with the exception of that now being introduced into practice it is unnecessary to describe. As to the grouping, the first idea that presented itself was, instead of simply dividing the scale into bass and treble, to cut it up into numerous sections. I should thus be able to confine the accent within a narrow section. Unfortunately, until the section is reduced to the compass of but a single note, it is always possible that it may contain a note which it would be undesirable to accent. Indeed the narrower the section the more important it is that it should not

contain a second accented note. The next idea that presented itself was to include in each group only notes of the same name; C's in one group, C sharps in another, and so on to the end of the scale. This is very much more satisfactory. Even if two notes should happen to be sounded in one group, as would occur sometimes, so that both might catch the accent, as the two are consonant, the effect would be substantially that of accenting the single note. Indeed with the old-fashioned player the accenting of a note can often be simulated by cutting its octave to sound

FIG. 7.

with it. I thought it desirable, however, to go further than this, and on this octave grouping I superimposed the division into bass and treble. In consequence of this double grouping it is possible to obtain four different strengths of blow on the piano keys simultaneously. This capability added to the power of control over expression already described ought to satisfy the most exacting requirements.

The arrangements for carrying out this method are clearly shown in the diagram Fig. 7. The key operating magnets are from one end of the circuit divided into two groups, and from the other end into twelve. The source of electromotive force has four terminals, ordinarily 0, 2, 10 and 14 volts. Switches

are so arranged that the wires leading to the magnets on the one side may be connected either to 0 or the 2-volt terminal, and on the other to either the 10 or the 14. These changes are independent of each other. We, therefore, have the power to supply any magnet with 8, 10, 12 or 14 volts at will. The switches are operated by quick acting electro-magnets, and these, in turn, are controlled, either by special perforations in the music roll, or at will by the operator through specially provided buttons. At the will of the operator also any one or more of the means of expression may be left music roll controlled while he manually controls the rest. He may pick out that portion of the expression in which he feels he can best express his individuality, leaving the rest to the machine, or he may take into his hands the whole control, and make the expression entirely his own.

A WORD AS TO THE FUTURE.

I fear the idea is still prevalent that a piano player must be necessarily inartistic. Logically those who hold this idea should condemn the piano also, for piano playing is but mechanized harp playing. In all arts and crafts alike there is and always will be a place for hand work. Pioneer work falls to the hand, and in the arts especially there is a peculiar grace arising from the flexibility of the instrument. But power, accuracy and precision are the feature of the machine. The grace of the harp, the fact that it allows of a more highly individualized playing, has in nowise prevented the more mechanical piano from becoming a hundred times more common, and the favorite instrument of great artists. And while, as in passing from the harp to the piano so in passing from the simple piano to the piano and player, there may be in some respects a loss, I am fully satisfied that for this loss there is a more than equivalent compensation. And in speaking of compensation I have in mind not only that thousands are reached by the player who otherwise would be deprived of all good music, but I have also in view to some extent direct artistic compensation. While the piano mechanism restricted the performer in some directions as compared with that of the harp, in others it opened out to him a wider field. And the player in turn will again widen the field. The composer will no longer have to think of the limitations of ten fingers on two hands. Consider what this

may mean in transcriptions of orchestral music, or, if we have the daring, let us even dream of what it may mean in original piano music.

There is another reason why our ultra-artistic piano lovers should take a more generous attitude towards the player. The growth of the piano trade, if it did not actually hinder the making of harps, at least did nothing to advance that art. The piano playing business on the other hand tends to enormously increase the number of pianos in use, and each of these pianos should be recognized as the possible means of development of a future artist. And surely the struggling musician will be none the less likely to develop into an artist because he has at his disposal a machine which will make it possible for him to hear the great music of the world. As well might we say that it would be harmful to a young painter to be placed in possession of a set of photographs of the world's masterpieces in painting.

As for myself I am simply glad that I have been in any way able to contribute towards placing culture and refinement within the reach of all.

WATER-RESOURCES INVESTIGATIONS BY THE GEOLOGICAL SURVEY.

WORK ADVOCATED BY PROMINENT ENGINEERS.

The necessity for determining the extent and character of the water resources of the country, if such resources are to be wisely utilized, is emphasized by the Director of the United States Geological Survey in his annual report, now in press. It is pointed out that prominent engineers have long advocated the extension of Government investigations of water resources, and that the work in the United States is not commensurate with that done in many European countries. If the United States were to provide for the prosecution of water-resources investigations on a scale of thoroughness equal to that of Switzerland, for example, it would appropriate \$11,000,000 annually, a sum 110 times greater than the present annual appropriation for similar work in this country.

A brief statement of a few of the industrial and social problems of the present day in which the utilization of water is the controlling factor is made in the report, as follows:

FLOODS.

The average annual damage by floods in the United States has never been accurately determined, but such investigations as have been made indicate that the loss must be at least \$100,000,000 annually. It appears that in many parts of the United States the proper expenditure of an amount equal to one year's flood loss would prevent future floods; in other parts of the country the cost would probably equal the losses of two or more years; but in every locality prevention could be accomplished by an expenditure equivalent to the losses from the floods of a few years.