2 Sheets—Sheet 1.

W. F. & H. SCHMOELE.

Electrical Musical Instrument.

No. 237,208. **Patented Feb. 1, 1881.**

Fig. 1.

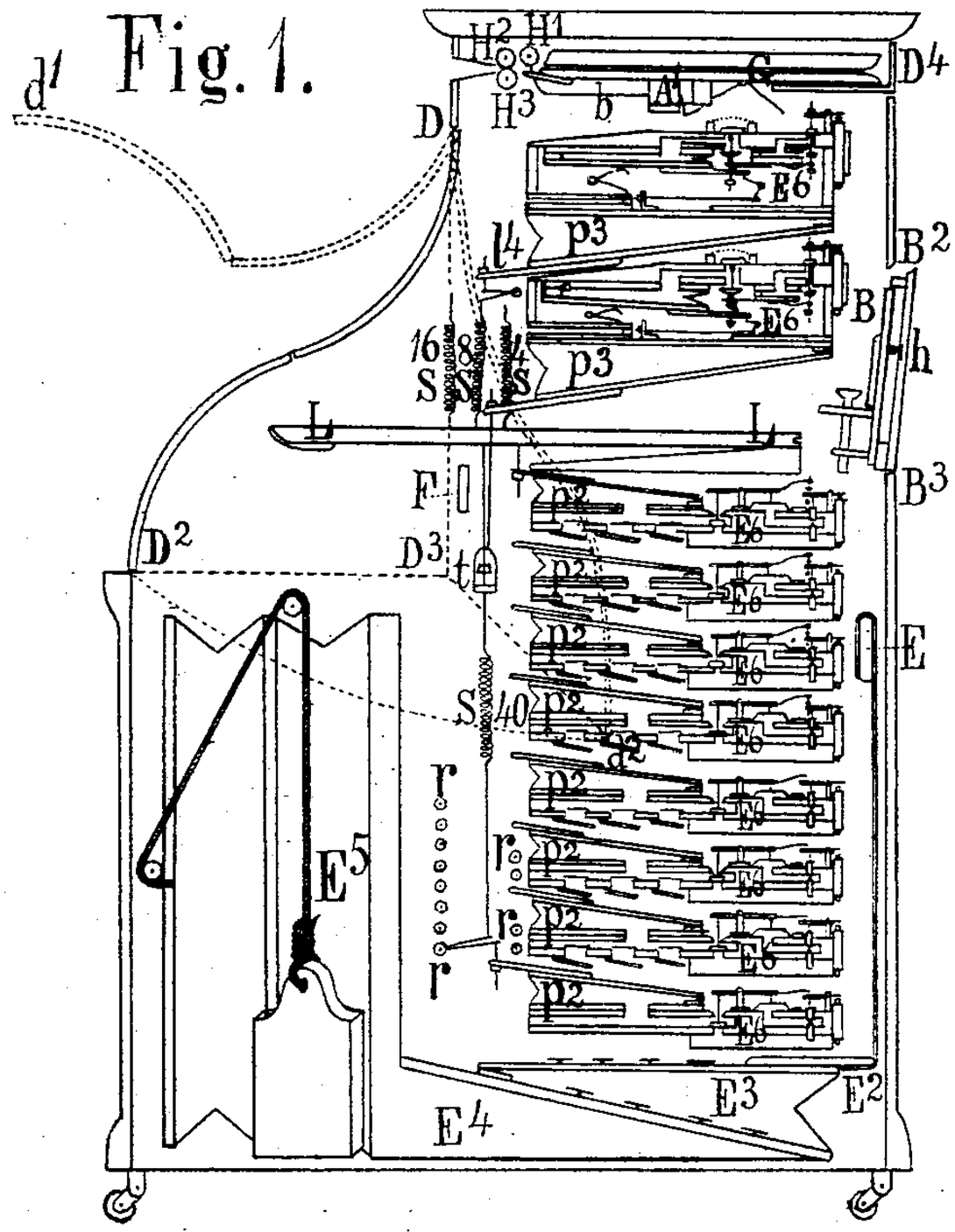

Fig. 2.

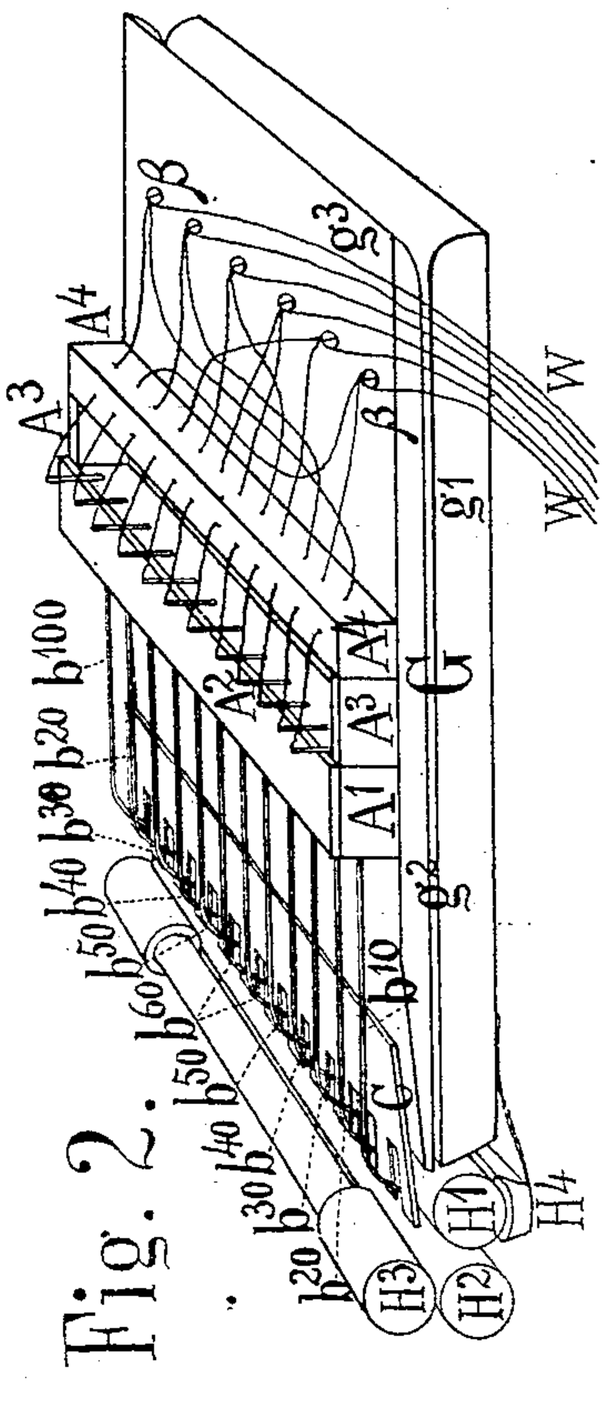

Fig. 4.

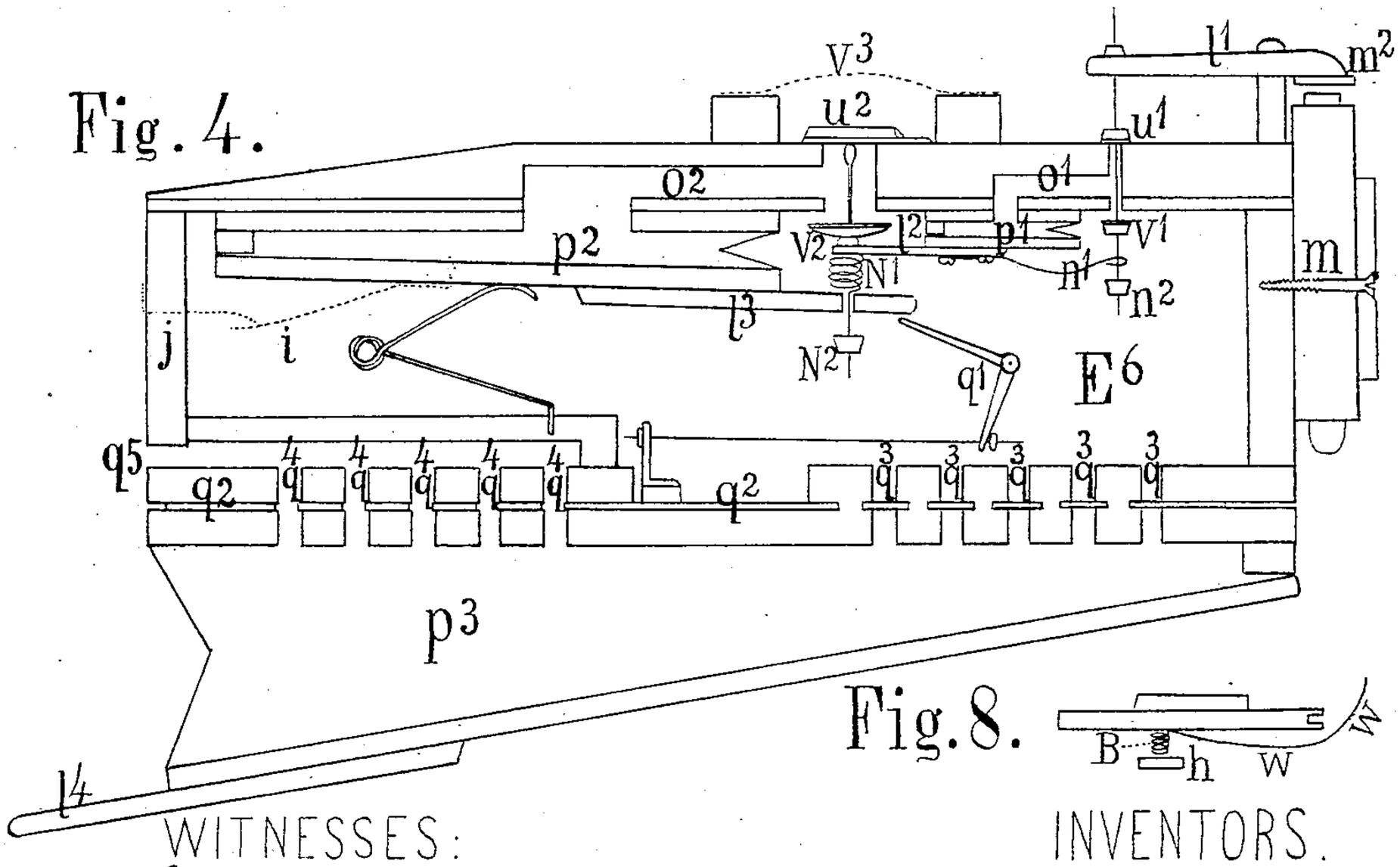

Fig. 8.

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2 Sheets—Sheet 2.

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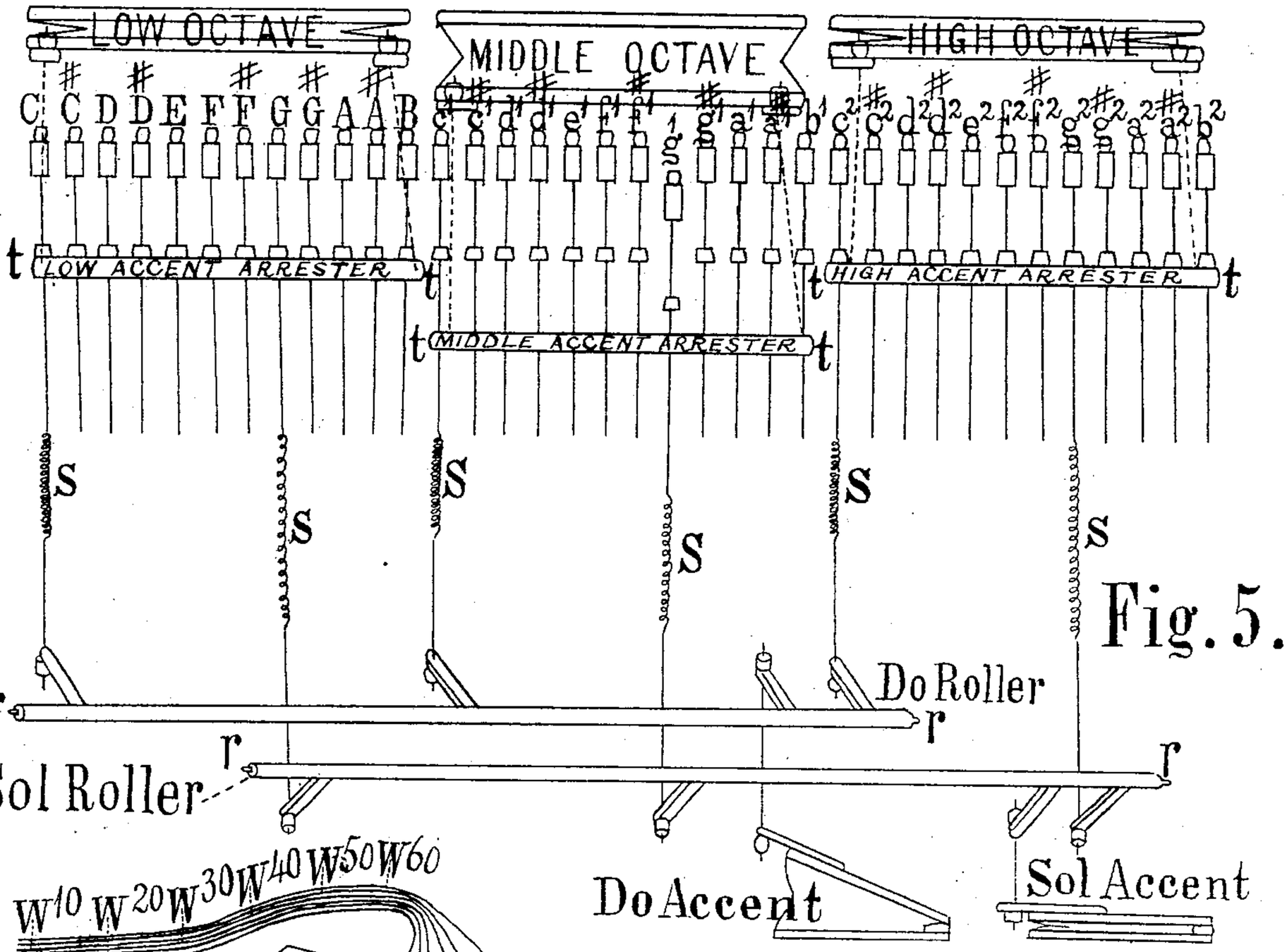


Fig. 5.

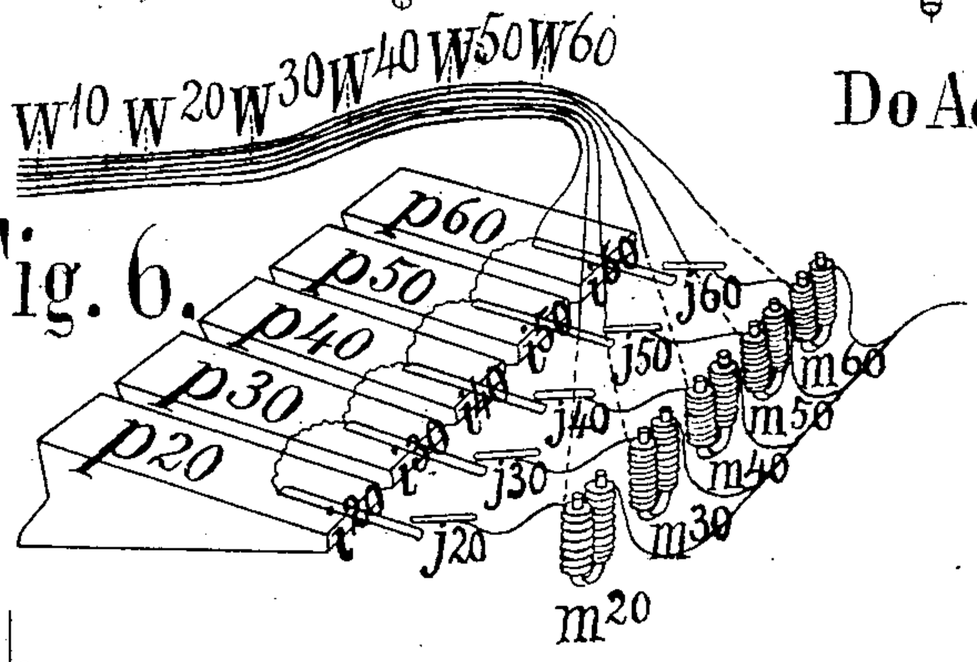


Fig. 6.

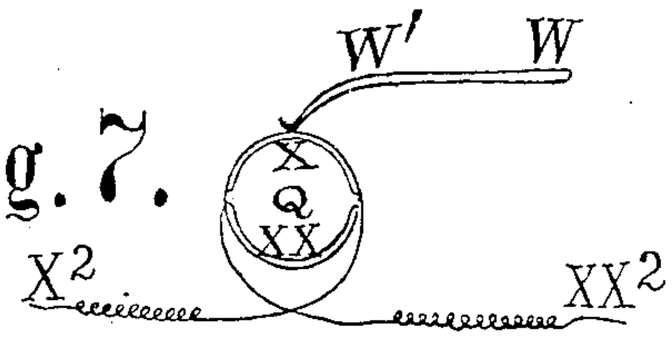
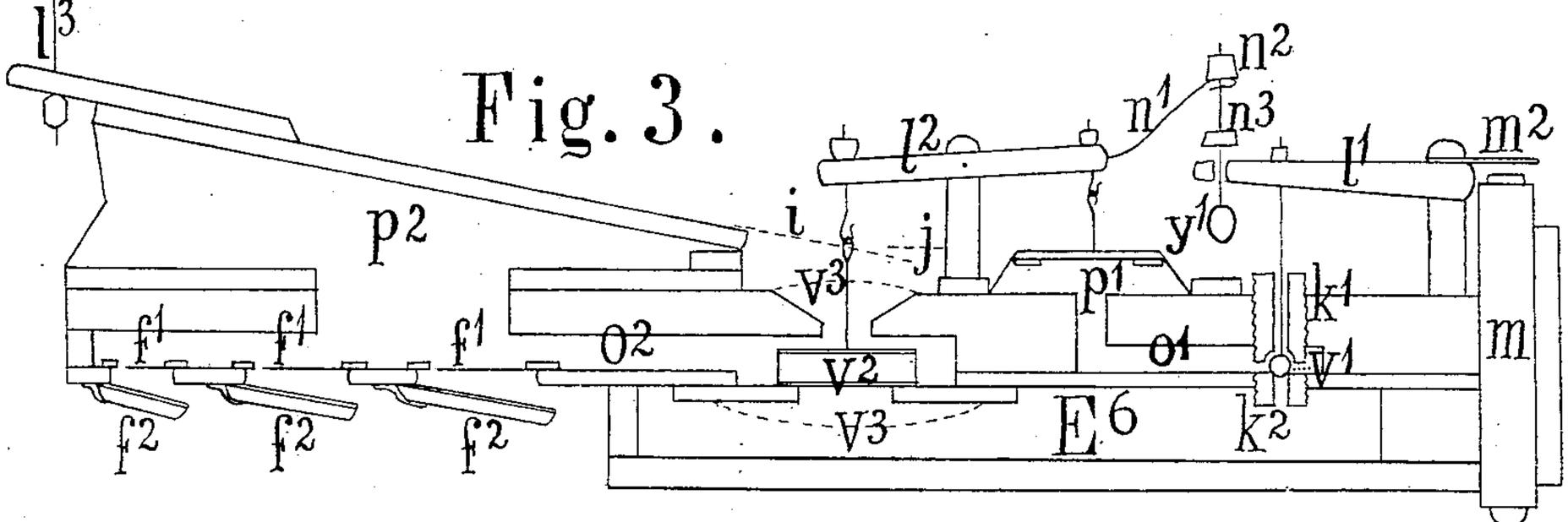


Fig. 7.

Fig. 3.



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UNITED STATES PATENT OFFICE.

WILLIAM F. SCHMOELE AND HENRY SCHMOELE, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNORS OF ONE-THIRD TO CHARLES SCHMOELE, OF SAME PLACE.

ELECTRICAL MUSICAL INSTRUMENT.

SPECIFICATION forming part of Letters Patent No. 237,208, dated February 1, 1881.

Application filed January 16, 1880.

To all whom it may concern:

Be it known that we, WILLIAM FORD SCHMOELE and HENRY SCHMOELE, both of the city and county of Philadelphia, State of Pennsylvania, have invented a Combined Pianista and Organ, operated automatically and by key-board by means of electricity and exhaust-air, of which the following is a specification.

The present invention consists of an instrument composed of electrical and pneumatic apparatus, designed to play, both automatically and by key-board, upon pianos and upon reeds, either jointly or separately, as desired. It is portable in form, and constitutes a reed-organ when disconnected from the piano, but is capable of playing the latter when brought into position in front of it. Both as an organ and as a pianista it is automatic as well as playable by hand.

Figure 1 is a sectional end view of the instrument. Fig. 2 shows the note-reading apparatus, seen inverted in the upper portion of Fig. 1. Fig. 3 is an enlarged sectional view of one of the note-performing actions of the middle and lower tiers of Fig. 1, and Fig. 4 is a similar enlarged view of one of the general-expression or other actions of the upper tiers of Fig. 1. Fig. 5 represents an outline of the accenting apparatus, most of the pockets belonging to which are in the lowest tier of Fig. 1. Fig. 5 gives a view of this apparatus as seen from that front of the instrument which stands toward the piano, and in Fig. 1 the position and an end view of the same are indicated by the twelve circles $r\ r\ r\ r$, showing the ends of the rollers, and by the spring s^{40} and accent-arrester t, all which letters refer to the same ones in Fig. 5. Figs. 6 and 7 are not seen in Fig. 1. Fig. 6 represents an electrical arrangement for holding or continuing notes started in any note-column of the music-sheet, and held by perforations made in another column or columns, known as "catch-note columns." Fig. 7 represents a shunter for shifting connections from one wire to another. Fig. 8 shows a spiral-spring circuit-closer on the under face of a key of the manual.

Similar letters in the various figures refer either to the same things—as, for instance, p^2 in Fig. 3, which is identical with any one of the p^2 of Fig. 1—or to co-ordinate or similar things in point of rank, as this p^2 of Fig. 3 and the p^2 of Fig. 4. Both these p^2, though differently circumstanced, are pockets of the same rank, each being a secondary pocket or second remove from the magnet, the two p' or primary pockets corresponding being the first removes. The same plan of notation is adhered to as regards other letters numbered with digits. The decimals, on the contrary, do not indicate rank, but the relationship of the parts of the several figures to their readers and their note-spaces on the music-sheet. Thus b^{30} of Fig. 2 communicates by the wire W^{30} of Fig. 6 with the magnet m^{30} and controls the final pocket p^{30} in Fig. 6, which pocket, in point of rank, may be either a p^2 or a p^3.

An end-view outline of the case when closed and not in use is shown in Fig. 1 by the solid outlying lines of the figure. The dotted line D d' shows the position of the lid D D^2 when the organ-pianista is in position in front of a piano, the point d' then resting on the music-rack of the piano, and the whole lid thus forms a pouch for the reception of the music-sheet as it issues from the opening above D, Fig. 1; and the dotted lines forming the dotted triangle D d^2 D^3 indicate the position of the triangular door D D^2 D^3 of the side of the instrument when opened out to allow the entrance of the body of the piano into that portion bounded by the lines D D^3 D^2. Thus, when in position to play, the portion of the pianista below the line D^2 D^3 stands under the body of the piano, extending almost to the pedal-harp of the same, and the felted ends of the striking-levers L then are over the piano-keys. The power for moving these levers and striking the piano-keys is atmospheric pressure brought to bear upon the various striking-pockets p^2, Fig. 1, by means of a suction or exhaust bellows, E^3 E^4 E^5. This bellows communicates with the airways E^6 by passages and wind-trunks at the sides of the organ-pianista, and the air within it and in these passages is exhausted by a pair of exhausters or suction-feeds, of which only one, E^3, is shown in the figure, and which are connected to the lever-arm E by strips of upholsterer's webbing

E E². This lever E is intended for hand-power; but the bellows may also be pumped by any other form of force, especially by means of water-rams or gas or caloric engines. Three or more suction-feeds geared to cranks on a revolving shaft are preferable when an engine or when clock-work is used. The whole case is mounted upon adjustable casters having long screw-threaded necks running through the end pilasters of the case, and by means of these the instrument can be adjusted to fit the height of any piano key-board.

The striking-levers L, Fig. 1, are a row of levers hinged at one end and free at the other, where they extend over the piano-keys when the pianista is in position. Those intended to bear upon the black keys are longer than the others, and in their normal position stand as much higher as the black keys are higher than the whites. All are felted on the lower or striking surface. Each lever of the three middlemost octaves has five attachments, as follows: First, one, l^3, to its striking-pocket proper—that is, to the final pocket p^2 of the electro-pneumatic train of the same note-name and octave; second, one to the roller-board r of the same note-name in the accenting apparatus; third, three to three resistance-springs, S^4, S^8, and S^{16}, belonging to pockets of the general-expression apparatus. The levers outside of the three octaves above named have similar attachments, except the attachment to the accenting apparatus, which is wanting. The object of these mechanisms and their method of working will be explained under the head of "expression."

The reading of the notes from the perforated music-sheet is done by a reading apparatus constructed as follows:

A guide, G, Fig. 2, for the passing music-sheet is formed by two boards, g' and g^3, of card-board, wood, or other porous substance whose expansibility under the influence of moisture is equal to that of paper. These boards are held apart at a distance about three or four times the thickness of the paper by two strips of metal, one at each side, which form the lateral boundaries g^2 of a slot whose width is exactly that of the music-sheet. Metal is preferred for these lateral walls, in order to resist the continuous sawing of the edges of the passing music-sheets; and if wood be used for the floor and roof it should be cross-pieced to prevent twist-warping, and should be left unvarnished to allow access of air through the pores, so that it may swell and contract in the same ratio as the paper.

On the end of the guide G toward the rollers is placed a rubber comb, C, fastened in short segments upon the board g^3, so that it may elongate and contract in unison therewith. The teeth of this comb are spaced to form slots, which fit accurately over the note-columns of the passing music-sheet, and in each of these slots, as in a stall, stands a reader, b^{10} b^{20} b^{30} b^{40}, &c.

To attain the maximum of durability under wear, the readers should be made of very hard metal, such as steel or phosphor-bronze, and the metallic surface on which they bear at their free ends should either be of the same metal or, better still, of a metal (such as zinc) electro-positive to the points or edges, to protect the same from rust by itself sustaining the action of the atmosphere; and, moreover, it should be in the form of a movable roller, H′, in order that it may be readily rotated and cleaned, and that its friction against the points of the readers may remove whatever rust may still affect them, or any accidentally passing dirt that may lodge beneath. The readers b are made of wire bent to the required shape and filed to an edge, and tempered very hard at the end. They are then ranged in line by being drawn through tightly-fitting holes in the support-board A′, previously perforated at the required distances apart for their reception. This support-board is screwed to the guide at each end, and can be made adjustable by lining up either in front or back of the screws, in order to tilt the board one way or another to insure more or less heavy contact of the reader-points with the roller H′, and bulging up of the central unsupported portions of the board A′ is prevented by means of a heavy stiff plate or stay, A^2, placed above. To the rear of the board A′ is another, A^4, parallel with it, and the space between these two is formed into a basin or trough by the two end pieces, A^3. Through the wall A′ of this basin the rear ends of the readers project, and are bent upward, so that their ends are above the level of the top. When the readers are all satisfactorily in position glue or other cement is run into the trough and allowed to harden and form a solid compact mass therein, in which the bent ends of the readers are inextricably and immovably embedded. Thus the readers are firmly secured; but before pouring in the liquid glue precaution against warping the parts should be taken by coating the interior of the basin with varnish, in order to prevent the entrance of the glue into the pores of the wood; and, moreover, the whole should be firmly held in jack-screws during the entire operation and until the glue has completely set and solidified. The addition of a little bichromate of potash to the glue makes a cement very dry and insoluble after hardening.

The readers are arranged upon the plan of the duplicate or twin column music-sheet patented November 23, 1875, in Patent No. 170,402, two or more readers at distances apart being assigned to each note. To the upright rear end of each is soldered a wire which passes through a closely-fitting hole in the board A^4, and thence to the screw B, where it meets the corresponding wire from the other reader belonging to the same note, and from this point a line-wire, W, Fig. 2, and W^{10} W^{20} W^{30} W^{40} W^{50} W^{60}, Fig. 6, passes to the proper magnet or other destination. The electrical currents enter, by a wire, the roller H′, whence they circulate through the readers uncovered

by the notes, and their line-wires, to the corresponding magnets, and thence to the battery by the common return-wire Z, Fig. 6.

The roller H′ should be solid, or, if tubular, should be packed with cotton to deaden the click of the reader-points. One journal has a screw-threaded neck projecting from it, the thread running in the reverse direction to that in which the roller ordinarily rotates. This arrangement is provided for cleaning the roller occasionally by running a piece of emery-paper into the guide until the rollers H^2 and H^3 seize upon and hold it, and then rotating the roller H′. Under H′ is also a strip of silk or felt, H^4, held in light contact with it, and placed there to wipe off the roller and keep it constantly clean. The rollers H^2 and H^3 are gum-covered, the upper one, however, only at its ends, where it bites upon and moves the music-sheet. One of them is geared to a suction wind-engine, which is the reverse of those used for pipe-organs or compression-wind, and the other turns by friction, and between them the music-sheet is drawn through the guide and under the readers and passes out into the pouch formed by the lid of the case, as shown in Fig. 1 in the dotted line D d'. On the opposite side of the case, where the music-roll enters, there is also a pouch formed from the case by a movable drawer, D^4, Fig. 1, which, when drawn out, supports the music-roll.

Fig. 3 gives an enlarged sectional view of one of the note-performing actions, as seen in the lower tiers of Fig. 1. The magnet m draws down the armature m^2 on the short arm of the lever l', from the other arm of which hangs the primary valve in the shape of a small spherical ball, v'. This valve works up and down in the interior of the chamber or groove o', and its working distance can be controlled and adjusted at pleasure by turning either the screw-threaded brass head k', which enters the groove from the outside, and through which passes the ingress-hole, or by turning the similarly-threaded valve-seat k^2, on which the valve rests. When the valve is at rest it closes the opening into the airway E^6 against the atmospheric pressure from without, but admits the outside air freely into the interior of the groove o' and the primary pocket p'. When the magnet draws down its armature m^2 the valve v' is raised, reversing thereby the air communications of the groove o' and pocket p' by shutting off the access of the external air and opening the passage to the exhaust-airway E^6. The air in o' and p' is at once sucked out and the pocket p' collapses by the pressure from without. This movement being communicated through the lever l^2 to the secondary valve v^2, this latter is likewise raised, thereby cutting off the pre-existing atmospheric communication with the groove o^2 and interior of the pocket p^2, and opening instead thereof the passage into the exhaust-airway E^6, so that the air in o^2 and p^2 is also instantly depleted. The resultant collapse of the pocket p^2 by the atmospheric pressure from without constitutes the stroke or impulse given to the striking-lever L, Fig. 1, to which the pocket p^2 is attached, and through which the impulse is transmitted to the piano-key, subject to and modified by the various expression and accent pressures which may be simultaneously acting upon the striking-lever, as hereinafter described. But at the same time that the secondary valve v^2 rises the opposite end of the lever l^2 and its prolongation n' falls. From this arm n' is suspended a weight, y', by the nut n^2, and at n^3 is another nut, adjusted at such a distance above the lever l', through which the suspensory wire of y' passes, that the lever l' shall be free to move when first actuated by the magnet without actually striking the nut n^3, though approaching very close thereto. The collapse of the pocket p' lowers the arm n', so that the weight y' is no longer supported by the nut n^2. Commencing to descend, the weight y' is caught by the nut n^3 engaging the magnet-lever l', then in a raised position, and thus the weight y' is transferred to the magnet-lever l' and opposes the magnet m, and continues to do so as long as the magnet holds its armature and the train continues in action. It is manifest that this transfer of the weight y' to the magnet-lever l' can take place only after the magnet has already succeeded in drawing the armature to close quarters upon its poles, for the collapse of the pocket p' and fall of the weight y' are conditioned upon and can only follow the antecedent action of the magnet-lever l' and the valve v'. The weight therefore comes down upon the magnet-lever exactly at the right instant after the magnet has its armature already close, in which position the magnetic force is exceedingly strong and the weight unable to overcome it; but as soon as the magnet drops its hold the weight is already in position to reverse the lever, and serves as a very efficient neutralizer of the retained magnetism, more or less of which always lurks in the magnet after its action has apparently ceased.

Secondly. Having reversed the valve v', which as soon as down is so retained by the atmospheric pressure, the weight is immediately snatched off the magnet-lever l' by the rise of the pocket p' and arm n', for the latter then engages the nut n^2 and thereby draws up the weight y'. Thus the magnet-lever is again entirely freed from the weight, and just at the time when it should so be—namely, when the armature is at a distance from the magnet, and consequently less powerfully under its influence than when close. This reciprocating resistance admits of a very close adjustment of the magnet to its armature without danger of retention, and effects thereby an immense saving in battery-power. The prolonged arm n', if made of spring-wire sufficiently thin and pliable and allowed during its movement to strike directly on the lever l', suffices, without the use of any weight at all, to exercise the reversing pressure directly on the magnet-lever l'. (See n', Fig. 4.) This arrangement is

cheaper than the weight, but is less exact and less economical of battery-power, for it is not easy to get a large number of such springs as perfectly even in their pressure as are the weights, whose perfect equality permits of the closest and most even adjustment of the magnets to their armatures, and obviates the tendency of the actions to roll when a very feeble battery is employed and heavy chords are played.

The pocket p', Fig. 3, is not made on the usual hinged plan, but is simply a circular or ellipsoidal disk of card-board, over which is stretched a flexible covering of kid or gum, and this covering is held down upon the floor on which the pocket is built by a ring of card-board tacked to the floor, sufficient play or gusset being allowed in the covering to enable the disk to move up and down. A ring of cloth or felt is fastened at the circumference of the disk, on its lower face, to prevent clapping noise against the floor. The groove o' opens into the interior of the pocket.

Fig. 4 shows an action similar to the foregoing, except that the pockets are placed inside the airways instead of outside, as in Fig. 3. Of course the valves must be reversed in order to meet the reversed conditions in the pockets. Fig. 4 also contains a terminal application not seen in Fig. 3—namely, the large tertiary pocket p^3, controlled by a set-slide, q^2, worked by the secondary pocket p^2 through the back fall, q'. The action of the pocket p^2, when set in motion by the magnet m, would be to draw the slide q^2 into the reverse position from that shown in the figure—namely, to close the holes q^4, which communicate with the passage q^5 opening into the open air, and to open the holes q^3 running between the pocket and the exhaust-airway E^6. The result of this would be the exhausting of the air within the tertiary pocket p^3 and its collapse under the outside atmospheric pressure, thereby drawing up and tightening all the resistance-springs S^4 or S^8 or S^{16}, Fig. 1, stretched between it and the various striking-levers L. There is another internal train belonging to this tertiary pocket and precisely similar to the one shown in the figure, whose function is to draw the slide in the reverse direction to that just described by a back fall turned the other way—that is to say, its function is to return the slide to the position shown in the figure, where communication with the exhaust-airway E^6, Fig. 4, by the holes q^3 is cut off, and the passages q^4 to the outside air are opened, thus admitting air again and allowing the leaf of the pocket to drop, its descent being further hastened by the pull of the resistance-springs S^8, Fig. 1. Such a pair of actions, being antagonistic the one to the other, work the set-slide q^2 in opposite directions, and the tertiary pocket p^3, common to both, will remain in the position in which the one last acting left it.

The object of the internal train p' and p^2, Fig. 4, inside the airways E^6 is to gain room in connection with the large outside tertiary pocket p^3, which latter must be of large size in order to be powerful enough to work several dozen springs, such as S^4, S^8, or S^{16}, Fig. 1, attached to as many striking-levers under its control. Similar letters in this train and in the external train shown in Fig. 3 indicate coordinate parts. There is also in Fig. 4 the letter u', which occurs in connection with the valves, and is equivalent to one-half of the v' in Fig. 3, where v' is undivided and equal to both u' and v' of Fig. 4.

The reciprocating valve-reverser in Fig. 4 is also a little different, and shows the application of a spring to this purpose in place of a weight, as in Fig. 3. The method of acting, however, is the same. The magnet at the start is free to act, closing v' and opening u', and raises the nut n^2 into contact with the eye of the spring n' without experiencing any pressure from it as yet. Then by the changed position of the valve the outside air rushes into the interior of p' and depresses it and forces the spring n' to press upon the nut n^2. The elasticity of the spring, being about equal to the force of the weight in Fig. 3, cannot reverse the valve u' v' and lever l' as long as the magnet holds on to m^2, but promptly does so as soon as the magnet ceases to act; and then the resultant collapse of the pocket draws up the spring n' and releases n^2, whereby the magnet is again free to act without resistance. At the secondary valve u^2 v^2 the same thing is repeated on a larger scale, the spiral spring N' and nut N^2 corresponding to n' and n^2 of the primary valve. Whatever the form of the reverser, whether spring or weight, and wherever applied on the train, as rendered most convenient by the relative situation of the other parts, to which it must accommodate itself, the principle of its reciprocating action remains always the same—namely, the application of temporary reversing pressure to an antecedent valve by a movement in a subsequent part of the train, so that the pressure arrives upon the valve only after the latter has assumed its working position, and the release of this pressure by the collapse of the train after the valve has reached or been returned to its position of rest.

In both Figs. 3 and 4 dotted lines v^3 over the secondary valves will be observed. These indicate the position of coverings of chamois-skin, felt, cloth, or other porous substance, which are there stretched across to intercept the blasts of air sucked through the valve-apertures directly from the outside atmosphere to the inside airways at the moment when the valves are shifting, in order to prevent the noisy puff of these blasts by breaking them up into innumerable fine currents whose movement is not audible. In the primary valves the apertures are so small that the noise is not perceptible.

Another arrangement peculiar to all striking-pockets is seen in the secondary valve-apertures of Fig. 3. The downward or striking stroke of the pocket p^2 must be accomplished

more rapidly and with more sudden vigor than is necessary in the upward movement or return of the pocket to the position of rest, in order to impart a shock or throw to the piano-hammer. Now, it is the opening of the lower aperture below v^2, establishing communication between o^2 and the exhaust-airway E^6, that collapses the pocket p^2; hence this lower aperture must be larger than the upper one above v^2, whose function is merely to refill p^2 with air when the valve v^2 returns to rest. The upper aperture is also made conical at its outer portion to allow for the impediment offered to the passage of air by the porous covering at the dotted line. The area of the hole at this line is much greater than at the entrance to the groove o^2, and yet the narrower free portion passes as much air as can filter through the much more extensive porous covering. And the same thing is accomplished in the lower aperture by allowing the covering to sag into a bag shape, as shown in the figure, the area of which bag is much greater than that of the hole at the valve-face.

The foregoing electro-pneumatic actions are the reverse of those patented in Patent No. 189,391 of 10th of April, 1877, and used by us in pipe organs with piano connection, in combination with compressed air. The reason why exhaust-air is preferred for the present instrument is that the reeds offer no obstacle to its use, and the great majority of the pockets being external ones, the gussets with exhaust-wind need not be lined with card-board, paper, or other stiffening, as is necessary with external pockets on compressed air. This work of lining being an exact and tedious operation, a considerable expense in manufacture is thereby saved.

Furthermore, it will be seen that the chamber-valve herein is used with exhaust-wind in connection with an external pocket, whereas with compressed wind it is employed with an internal pocket, as seen in Patent No. 189,391, and conversely as regards the other or double valves of Fig. 4. These are decidedly the best arrangements, as in all of them the wind-pressure moves with the valves to close these latter and holds them tight when at rest, without the use of spring-pressure to prevent leakage. But the essential feature of them all is the multiplication of the original slight magnetic impulse by a series of pneumatic trips progressively increasing in power until a relatively great force is disengaged by the final pocket of the train. Ordinarily we proportion the parts to increase the power twelvefold at each trip—that is to say, a secondary pocket, p^2, develops a drawing force one hundred and forty-four times greater than that of the magnet, and a tertiary pocket, p^3, gives seventeen hundred and twenty-eight (1,728) times the starting force. This is in the pressure alone. A similar though not equally rapid gain is made also in the stroke, so that many thousand times the power of the starting-magnet is developed by a tertiary pocket. Thus the battery-power which we require to play a piano is but the several thousandth part of what would be necessary to play by direct magnetic action.

So far provision has been made only for the reading and striking of the notes. Now comes the mechanism designed to lend expression to the strike of the pockets, without which their playing, though correct and accurate, would be mechanical and lifeless. The grace or expression of piano music depends on the changes that can be made in four things, to wit: first, variations in the time of rhythm, either of the whole *tempo*, as in change of movement, or of individual passages, as *accelerando* and *ritardando*; second, alterations in the note values, as *staccato*, *legato*, *arpeggio*, and similar effects; third, gradations in the animus or vigor or force of the sound, from the faintest *ppp*, through all grades of *p*, *mf*, and *f*, to the loudest *fff*; and, fourth, the accent or special prominence of the leading part. The first and second of these—that is, the time and note variations—are perfectly obtained on the music-sheet by a studied and careful representation of the exact lengths of notes and measures to correspond. The third, or animus or grades of touch, and the fourth, or accent, are produced by the parts now to be described.

Above the striking-levers L, Fig. 1, are a number of tertiary trains, like Fig. 4, called "resistance-trains," placed to control several series of springs of different tensions, whose functions are to resist with different degrees of force the impulses of the striking-pockets p^2. Each striking-lever has three such resistance-springs, S^4, S^8, S^{16}, Fig. 1, attached, representing different tensions—say four ounces, eight ounces, and sixteen ounces, respectively—and each series of springs of like tension is controlled by a pocket, p^3. The closing or collapsing of a pocket, p^3, by atmospheric pressure tightens all the springs in its series and causes them to resist the striking-levers, and its relaxation or letting down has the opposite effect of loosening them all, so that they no longer resist. The most convenient way of gearing the springs is to attach them to a roller and to work this roller by a pocket, p^3, the return of the pocket and roller being further hastened by a main counter-spring of greater tension. This main counter-spring returns the roller to a position beyond that to which the resistance-springs alone would pull it, and thus completely releases the tension of the latter on the levers.

A series of resistance-springs comprises and affects several octaves of notes. The whole number of striking-levers, considered with reference to the springs, is divided into three sets, each set having three co-ordinate series of springs of different grades, so that there are altogether nine series of resistance-springs. The first set comprises the bass-notes up to G below middle C. The second set governs the middle stretch from G, two octaves upward to G^2, inclusive, and the third set includes the balance, or the high treble. The object of this di-

vision into sets (which are, however, not necessarily arranged according to the above selection of limits) is to divide the expression mechanism into several sections, in order to be able to produce different effects simultaneously on different parts of the key-board by the resistance-trains alone, and independently of the further differences and grades produced by the accenters or re-enforcing pockets.

The accent or re-enforcing actions (lower tier of Fig. 1) are opponents of the resistance-actions, and are active in their mode of working, instead of passive, like the resistance-pockets—that is to say, they operate simultaneously with and assist the striking-pockets in the very act of striking, working for each note and every time it is repeated, whereas the resistance-pockets are passive in their functions, exerting while in play at all a continued pressure on the striking-levers, whether the latter are moving or not. Hence these accenting-trains have no slide mechanism to control, but are like striking-pocket actions, and are illustrated by Fig. 3. Their effect is not needed in more than three octaves—namely, the middle piano octave and the one next above and the one next below it. Each final pocket (p^2 of the lowest tier of Fig. 1 or p^2 of Fig. 3, also marked "do-pocket" and "sol-pocket" in Fig. 5) of an accent-action gears to a roller, *r*, Figs. 1 and 5, to which are fastened three springs, as in Fig. 5, one of which springs is seen in S^{40}, Fig. 1, all of the same tension—say about ten ounces each—and attached at their other ends to the three striking-levers L, Fig. 5, of the same note-name. Thus the pocket of the accent-action do, Fig. 5, gears to the roller having connection with the three do or C striking-levers—namely, the do below the middle do of the piano, written "C," the middle do, known as "C^1," and the do next above, called "C^2" in ordinary musical nomenclature. So, again, the accent-action do-sharp (C♯) gears to the roller connected with the three do-sharp striking-levers—viz., C♯, C♯^{1}, and C♯^{2}, and so on. (See also sol-pocket and connections, Fig. 5.) Hence there are twelve accenting or re-enforcing actions, one for each differently-named note, do, re, mi, fa, sol, la, si, and their sharps, and as each of these actions controls the three striking-levers of the same name in the three middle octaves, they control altogether the thirty-six middle notes of the piano from C to B^2, inclusive. The use of these resisting and re-enforcing actions in all their various combinations to vary the impulses delivered finally to the piano-keys imparts the most graceful shading to the touch, fully equal and even superior in variety to hand-playing, and more certain and reliable than it. Their effect is shown in the following table. The striking-pockets alone and unimpeded by the resistance-springs strike with a force of thirty-two ounces. If re-enforced by the simultaneous action of an accent-pocket of whose force ten ounces is transmitted through the spring to the striking-lever, the combined effective is forty-two ounces. The three resistance-springs combine with the unre-enforced striking-pockets to produce seven other grades of stroke, descending four ounces at a time to a very soft or four-ounce stroke, and they combine with the striking-pockets and the ten-ounce re-enforcement of an accent-pocket, as transmitted through springs gaged to this tension, to produce seven other grades of stroke, which fit in between the grades produced with the unre-enforced striking-pockets, so that the gradations go down but two ounces at a time, from thirty-four ounces downward to twelve ounces. Finally the re-enforcing or accent pockets alone strike with ten-ounce force, and when resisted by the four-ounce or the eight-ounce resistance-springs they strike with but six-ounce or two-ounce impulse respectively, thus filling up the last steps in the gradual descent, so that there is a successive rise of two ounces at a time, from two ounces up to thirty-four ounces, and from thence by steps of four ounces up to forty-two ounces—the maximum stroke.

Table of gradations of force of stroke.

	Ounces.		Ounces.
Striking-pocket alone	32	Re-enforced by accent-pocket.	42
Resisted by 4-oz. spring	28	" " " "	38
Resisted by 8-oz. spring	24	" " " "	34
Resisted by 4 & 8 oz. spring	20	" " " "	30
Resisted by 16-oz. spring	16	" " " "	26
Resisted by 4 & 16 oz. spring	12	" " " "	22
Resisted by 8 & 16 oz. spring	8	" " " "	18
Resisted by 4, 8, & 16 oz. spring	4	" " " "	14
		Re-enforcing pocket alone	10
		Resisted by 4-oz. spring	6
		" " 8-oz. "	2

Thus nineteen grades of touch or expression are produced, giving two shades of triple forte, (*fff*,) three of double forte, (*ff*,) three of forte, (*f*,) three of mezzo-forte, (*mf*,) three of piano, (*p*,) three of double-piano, (*pp*,) and two of pianissimo, (*ppp*,) so that the most effective shadings and the most perfect crescendo and diminuendo may be executed.

Apart from the function of the accenting-pockets to re-enforce the striking-pockets, and thus double the number of grades of touch produced by the latter in combination with the resistance-springs, they have another and important function to fulfill in the single accenting or salient accentuation of individual notes in chords, or in varied musical parts playing simultaneously. In other words, they are to bring out in relief, when required, louder than and above the other tones, that which is technically known as the *motif* of the music, be it the air, the second, the tenor, or any other part which is to be specially accented and prominent. This they do by the aid of three special pockets, one for each octave, known as the "high," the "middle," and the "low" octave accent-locators. These are situate above the striking-levers, (see Fig. 1,) and from them depend the accent-arresters *t*, Figs. 1 and 5. The latter are simply pieces of wood containing twelve perforations, through which the prolonged wires of the springs of the accent mechanism, Fig. 5, freely pass to the striking-levers L without rubbing or binding in the holes.

These prolonged wires have each a nut, t^2, Fig. 5, upon them above the arrester, in such position that when this latter is drawn up by its pocket the nuts bear upon it, and in this position any movement of a roller, r, below cannot affect the striking-levers above the arrester. This is seen in Fig. 5 in the sol pocket and roller, whose springs in the low and in the high octave are stretched by the resistance of their nuts, which are held by the raised arresters of those two octaves, whereas in the middle octave, whose arrester is represented as down, the nut has free play, and the spring, being stretched by the roller, has expended its force upon the key or striking lever.

To illustrate clearly the selecting power of the accent apparatus, suppose it were desired to strike the chord C E G in all three octaves simultaneously, and of these nine notes to bring out the E of the middle octave in special loudness or relief. In this event the whole chord would be struck by the corresponding nine striking-pockets, subject to whatever resistance-springs were acting at the time. The middle-octave accent-arrester would also have been lowered and the mi or E accent-pocket played, so that the E^1 striking-lever, and none of the other eight notes, would receive a special addition or re-enforcement of impulse or accentuation, rendering it prominent above the others. And then, as the music moved on and the accent progressed to other notes, the accent-pockets of the corresponding note-names would be played simultaneously with the striking-pockets, the arrester remaining down as long as the accented notes happened to be in the same octave, but shifting the instant that the accentuation went into another octave. Thus the stress follows the *motif* or leading strain from note to note and from octave to octave.

Fig. 6 shows the catch apparatus for holding notes. It is designed to save perforations in the music-sheet where chords or movements have to be held for a considerable time.

The reader b^{10} in Fig. 2 is supposed to be a catch-reader, and communicates by the wire W^{10}, Fig. 6, with the series of metal tails i^{20} i^{30} i^{40} i^{50} i^{60} on the pockets p^{20} p^{30} p^{40} p^{50} p^{60}, which are pockets like p^2 in Fig. 3 or p^2 in Fig. 4. These tails can be put on any other convenient moving part of the trains. Near them are other tails, j^{20} j^{30} j^{40} j^{50} j^{60}, which are stationary, and which communicate each with the magnet of the action to which it is attached. These also may be located in any convenient place—say on the flank of the post of the lever l^2, Fig. 3, or to the rear of p^2 in Fig. 4, as shown in dotted lines, provided they are near i, and that i, in moving, may come into contact with j.

When a pocket—p^{20}, for example—collapses it forces i^{20} against j^{20}, and so completes a circuit from the reader b^{10} to the magnet m^{20}, and so on for any other train whose final pocket is collapsed.

In Fig. 2, b^{100} is the duplicate reader of b^{10}, and communicates with the same wire W^{10} in Fig. 6. Now, when a note or chord is playing, and we desire to hold it without further perforations in the note-columns of the notes proper, we put a perforation in one of the catch-columns under either b^{10} or b^{100}, and the electricity is thus let in by what may be called a "side door" to the magnets whose pockets are down at the time, and these magnets and pockets can be held as long as perforations are continued in the catch-columns. This arrangement is specially useful in catching and holding temporary mechanical movements and bass-notes.

Fig. 7 shows the apparatus called the "shunter, for shifting the connections of the readers belonging to certain actions, arranged in pairs to communicate opposite movements to a common resistance, like the slide q^2 in Fig. 4, which is moved in one direction by the train therein shown, and then back in the opposite direction by an opposing train precisely similar. These two trains, taken together, constitute a pair of actions which move the slide on or off, and there are a number of such pairs in the instrument; but in order to save readers, and consequently width of paper in the music-sheet, each such pair has but one reader, which is made to do double duty by shifting the electric connection of its line-wire W, Fig. 7, either to the wire X^2, running to the on-magnet, or to the wire X X^2, running to the off-magnet of the pair. This shifting is done by the shunter Q, which is a roller having two opposite rows of plates, each half-encircling it and almost touching each other. Bearing upon the roller is a row of springs, of which there are as many in the row as there are pairs of plates on the roller, and there are as many pairs of plates as there are pairs of on and off magnets to be operated on. One row of plates communicates with the on-magnets and the opposite row with the off-magnets. Consequently currents arriving from a reader by a line-wire, W, Fig. 7, are sent either to an on or to an off magnet, according to the position of the roller. This latter is rotated in opposite directions by two opposing actions, each of which has a separate reader and note-space, and perforations in the latter move and set the shunting-roller as desired before a current is sent to an on or to an off magnet and action.

The lowest and next to lowest bass octaves share in common the same octave of readers, and are shifted in or out of connection as desired by a coupler for each octave.

The reeds $f' f' f'$, Fig. 3, serve to make the instrument available as an organ, and musical in itself, even without a piano to play upon, and, in connection with its piano performance, they give the effect of an imitation of violin and other prolonged sounds, and furnish an effectual adjunct to the music. Several sets or stops of them, $f' f' f'$, Fig. 3, are inserted in the grooves o^2 of the note-actions, as seen in Fig. 3, and are governed by shutters f^2 f^2 f^2, which are opened when the reeds are wanted to play and closed when they are to be silent.

Each set or stop of reeds is divided into several sections, each section having an independent shutter, the object being to limit the reed performance, when desired, to certain portions of the compass, and obtain only piano-sounds without reed accompaniment from the other portions of the instrument, or vice versa. Corresponding to these divisions or sections in the reed-stops are key-locks F, Fig. 1, likewise sectional, to lock the striking-levers L of the parts effected and prevent the pockets p^2 from working them when reed-solos without the concomitant piano-sounds are desired on the parts locked out. These key-locks are simply bars hanging under the striking-levers, and are out of reach when down; but when drawn up they bar the levers effected and prevent their movement.

The electric key-board or manual for hand performance on the instrument is mounted on a hinged door, B^2 B^3, Fig. 1, which, when closed, forms part of the wall of the case, and which opens down and out when the key-board is to be used. The only peculiarity about this manual is the circuit-closer for the keys. On depressing any key, Fig. 8, an electric connection with the proper magnet is made by a spiral spring, B, on the under surface of the key striking upon the common contact-plate *h*. On first touching the plate the spring has very little or no tension in it, and consequently easily gives way and makes no audible noise or click of contact; but as the key continues its downward movement the tension becomes stronger, and the resultant pressure thus gradually brought about without noise or scratching insures a firm contact and an easy passage for the electric current. This spiral-spring circuit-closer is much superior to the pin and mercury-cup device, as it is equally noiseless and there is nothing in it to spill or splash. It is also better than a sliding-spring arrangement, which produces a scratching noise between spring and contact-plate.

The battery-plates are automatically lowered into and raised from the exciting-liquid by a pocket and spring, as explained in Patent No. 189,391 of April 10, 1877.

The above-described instrument is light and portable, and is useful in many ways. By means of its key-board it serves, first, as a reed-organ for hand-playing; and by running it up in front of a piano it is available, second, for playing organ and piano simultaneously by the same person. Besides the above two functions, it may be used also, third, as an automatic pianista or piano-player alone, and, fourth, as an automatic reed-organ alone, and, fifth, as a part-player, or combined automatic pianista and organ, or cabinet parlor-orchestra.

We claim as our invention—

1. In a music-reading apparatus, the adjustable support-board A′, Fig. 2, and the method of fastening the readers therein, substantially as described, and for the purposes set forth.

2. The combination, in a music-reading apparatus, of an automatic roller-cleaner, H^4, Fig. 2, substantially as described.

3. The combination, with a row of metallic readers, of a metallic roller or roller-covering composed of a metal electro positive to that of the reader-points, for the purpose of protecting the reader-points from corrosion by itself sustaining all corrosion caused by the atmosphere when two dissimilar metals are in contact.

4. In an electrical music-playing apparatus, the combination of an electro-magnet and armature with one or more pneumatic trips whose parts progressively increase in size, for the purpose of augmenting the initial force of the magnet by the aid of the power of the exhaust-air.

5. The combination, Fig. 3, with an exhaust-air chamber, E^6, of an electro-magnet, *m*, armature m^2, pockets p' p^2, valves v' v^2, levers l' l^2 l^3, air-passages o' o^2, and valve-seats k' k^2, to form an external electro-pneumatic trip or train of pockets, substantially as described.

6. The internal or chamber valve used in this combination, which, when starting into action, moves against the atmospheric pressure to close the ingress-aperture, and when returning to rest moves with the atmospheric pressure to close the egress-aperture, substantially as described.

7. The combination, Fig. 4, with an exhaust-air chamber, E^6, of an electro-magnet, *m*, armature m^2, pockets p' p^2, valves u' u^2 v' v^2, levers l' l^2 l^3, and air-passages o' o^2, to form an internal electro-pneumatic trip or train of pockets, substantially as described.

8. The combination, Fig. 4, of an external pocket, p^3, and lever l^4 with an internal electro-pneumatic trip or train of pockets and an exhaust-air chamber, substantially as described.

9. The porous covering of the valve-apertures, to prevent the noise of the passage of air-currents at the instant of the shifting of the valves.

10. In an electro-pneumatic trip or train of pockets, the automatic application of reversing-power by weight y', Fig. 3, and by spring n', Fig. 4, or their equivalents, to the valves and armature by means of the movement of p' n' n^2, &c., Figs. 3 and 4, or their equivalents, subsequent to the movement of u' v', Fig. 4, and v', Fig. 3, and also subsequent to the movement of m^2, Figs. 3 and 4, and the automatic release of this reversing weight or pressure caused by y', Fig. 3, and n', Fig. 4, or their equivalents, by the collapse of the action-pockets p' and p^2, Figs. 3 and 4, substantially as described, and for the purposes set forth.

11. The specific forms of reverser herein described, consisting of the reversing weights or springs so arranged as to bear upon the valves while the actions act and to release said valves when the actions are at rest, substantially as described.

12. The combination, with the striking-pock-

ets, of one or more resistance-pockets and their appurtenant springs, or equivalent, of different tensions, where there are several series, to resist, either singly or jointly, the said striking-pockets, and thus vary the force of the impulses delivered to the piano-keys, substantially as described.

13. The combination of a set of re-enforcing or accenting pockets with their rollers and springs, or equivalents, to assist the striking-pockets, and, in connection with the resistance pockets and springs, to multiply the number of grades of impulse delivered to the piano-keys, substantially as described.

14. The combination, with the re-enforcing or accenting pockets and with their rollers and springs, of several accent-arresters, or their equivalent, to limit or curtail, when desired, the impulses of the accenting-pockets to a certain key or keys, substantially as described.

15. The combination of a shunter, consisting of roller Q, plates X XX, connections X^2 XX^2, and springs W′, with an electric note-reading apparatus, substantially as described, and for the purposes set forth.

16. The combination of reeds with the electro-pneumatic exhaust wind-actions hereinbefore described, substantially as set forth.

17. The combination of sectional shutters and key-locks, or their equivalents, with each other and with the reeds and striking-pockets, in order to allow of the execution of different musical parts separately, yet simultaneously, on organ and piano in different portions of their compass, substantially as described.

18. The combination of reeds and pockets on common grooves or air-passages, substantially as described, and for the purposes set forth.

19. The spiral-spring circuit-closer for the keys of the manual, substantially as described.

20. The combination of reeds and striking-pockets with electro-pneumatic actions, reading apparatus, and manual key-board, the whole to form a combined automatic and hand-playing organ-pianista, substantially as described, and for use in the several ways set forth.

21. The form or shape of the instrument, with opening sides and movable front lid to admit of the entrance of the piano-body under the striking-levers, and with the projecting base entering under the piano-body and extending toward its pedal-harp, substantially as shown.

22. A catch-reader, b^{10}, Fig. 2, and its various connections b^{100}, Fig. 2, and W^{10} i^{20} i^{30} i^{40}, &c., j^{20} j^{30} j^{40}, &c., Fig. 6, or their equivalents, substantially as described, and for the purposes set forth.

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