J. W. DARLEY, JR.

MUSICAL INSTRUMENT.

APPLICATION FILED APR. 3, 1907.

1,155,299.

Patented Sept. 28, 1915.

6 SHEETS—SHEET 1.

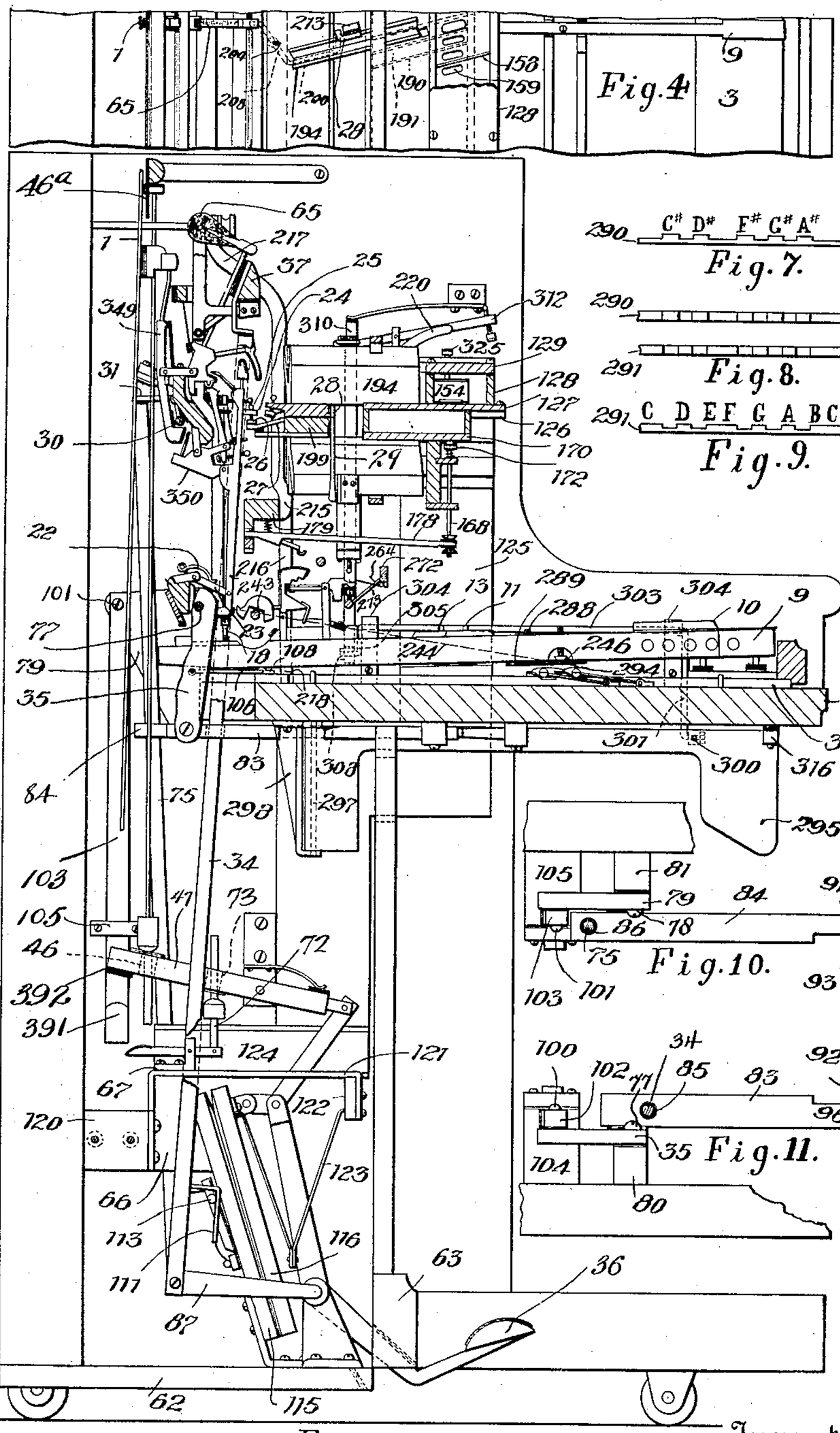

Fig. 1.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Witnesses

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6 SHEETS—SHEET 2.

Fig. 1a

Fig. 1b

Fig. 3a

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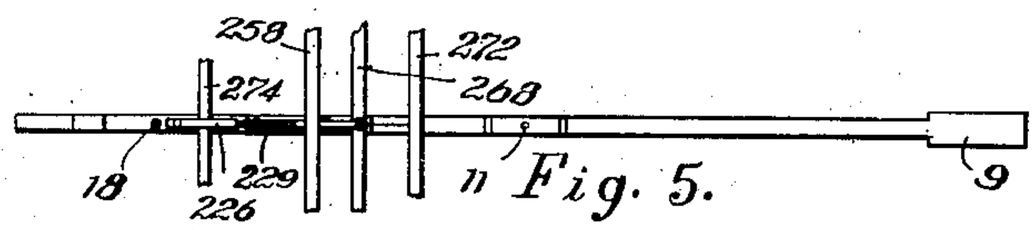

Fig. 5.

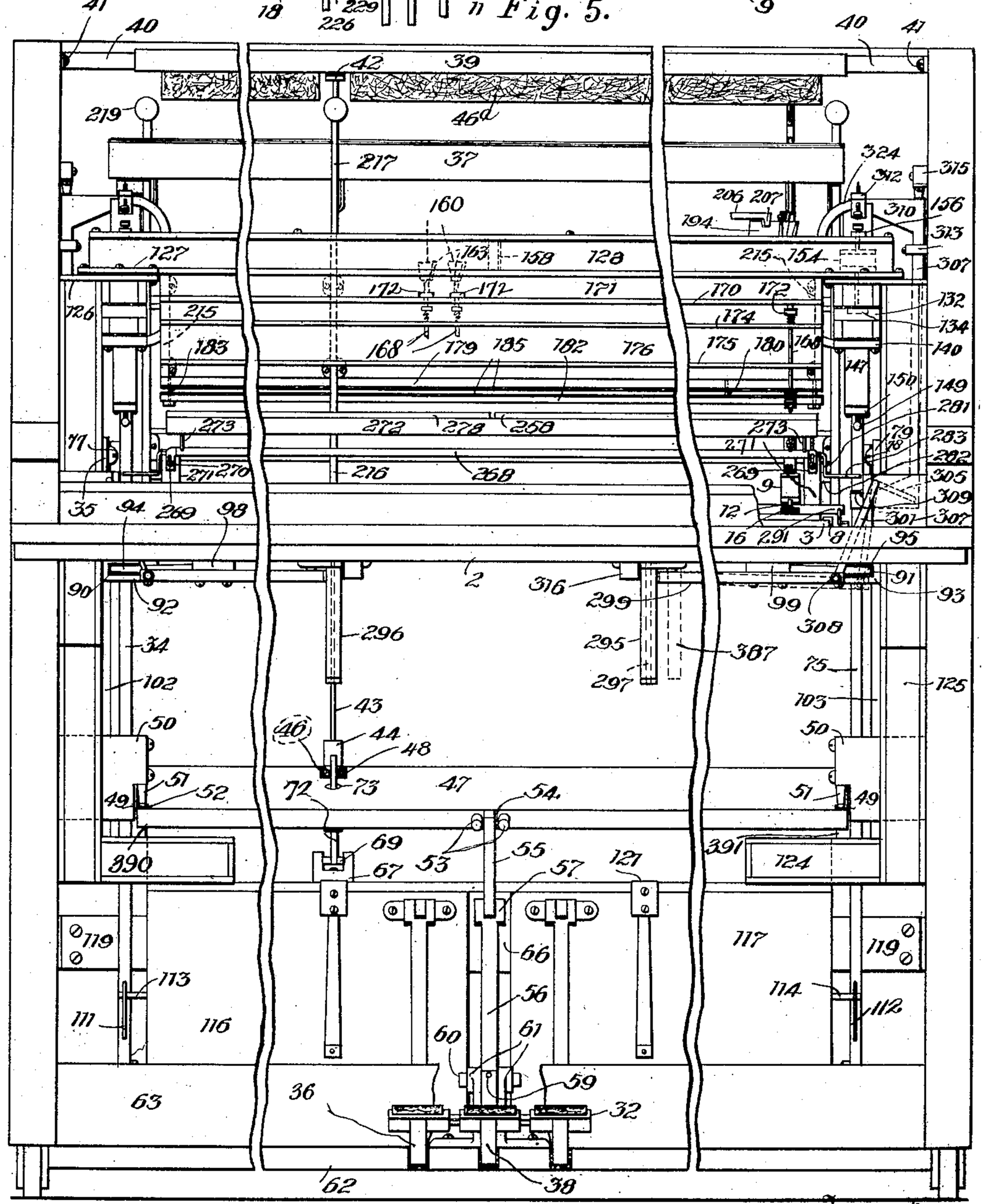

Fig. 2.

Witnesses

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6 SHEETS—SHEET 4.

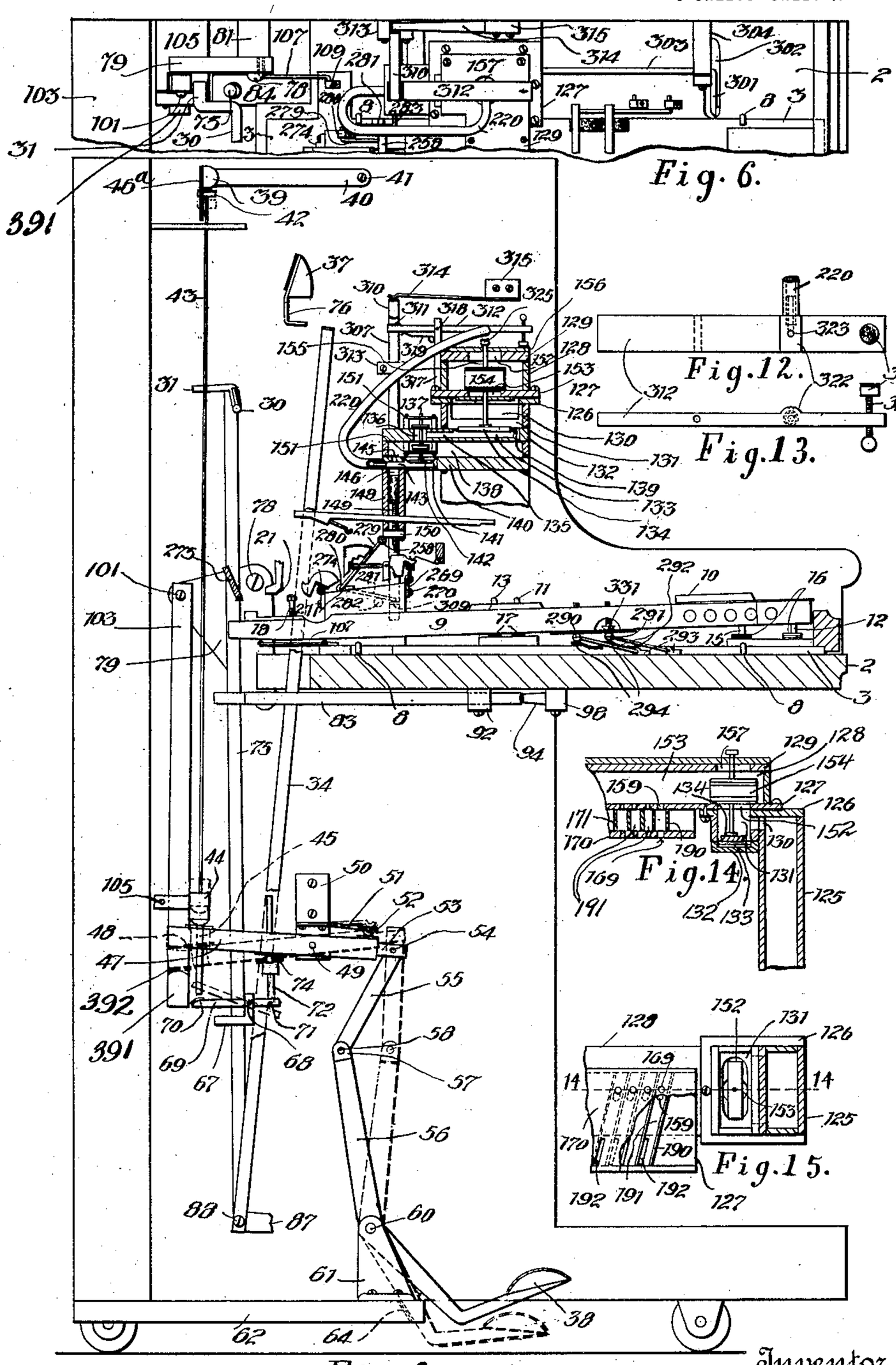

Fig. 6.

Fig. 12.

Fig. 14.

Fig. 15.

Fig. 3.

Witnesses

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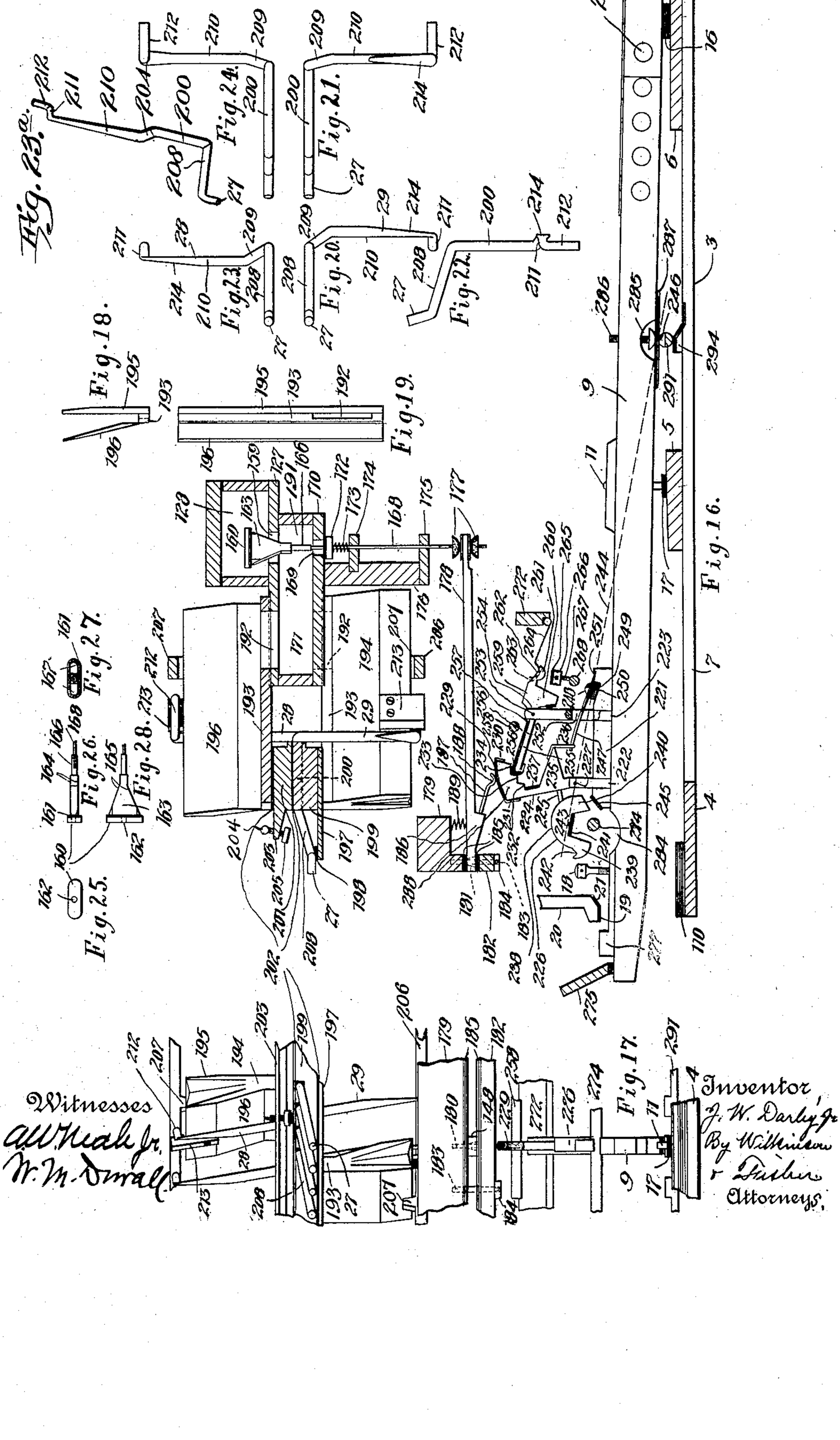
6 SHEETS—SHEET 5.



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6 SHEETS—SHEET 6.

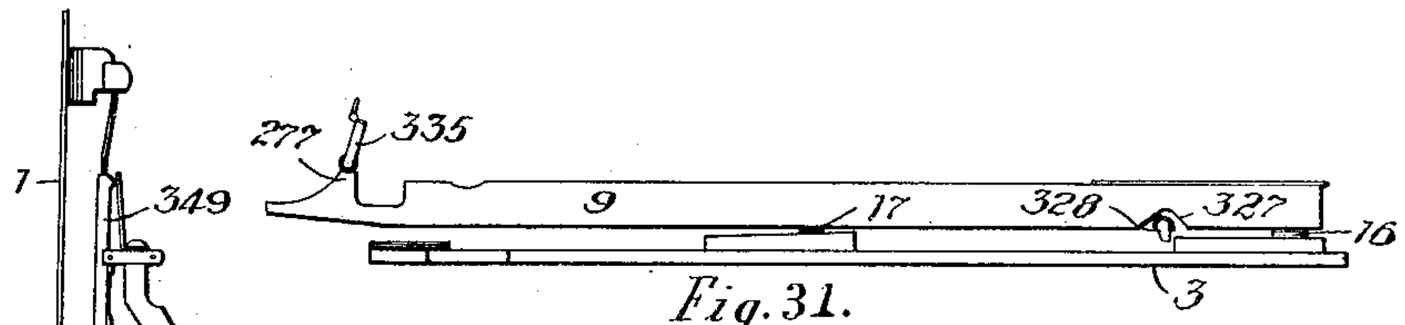

Fig. 31.

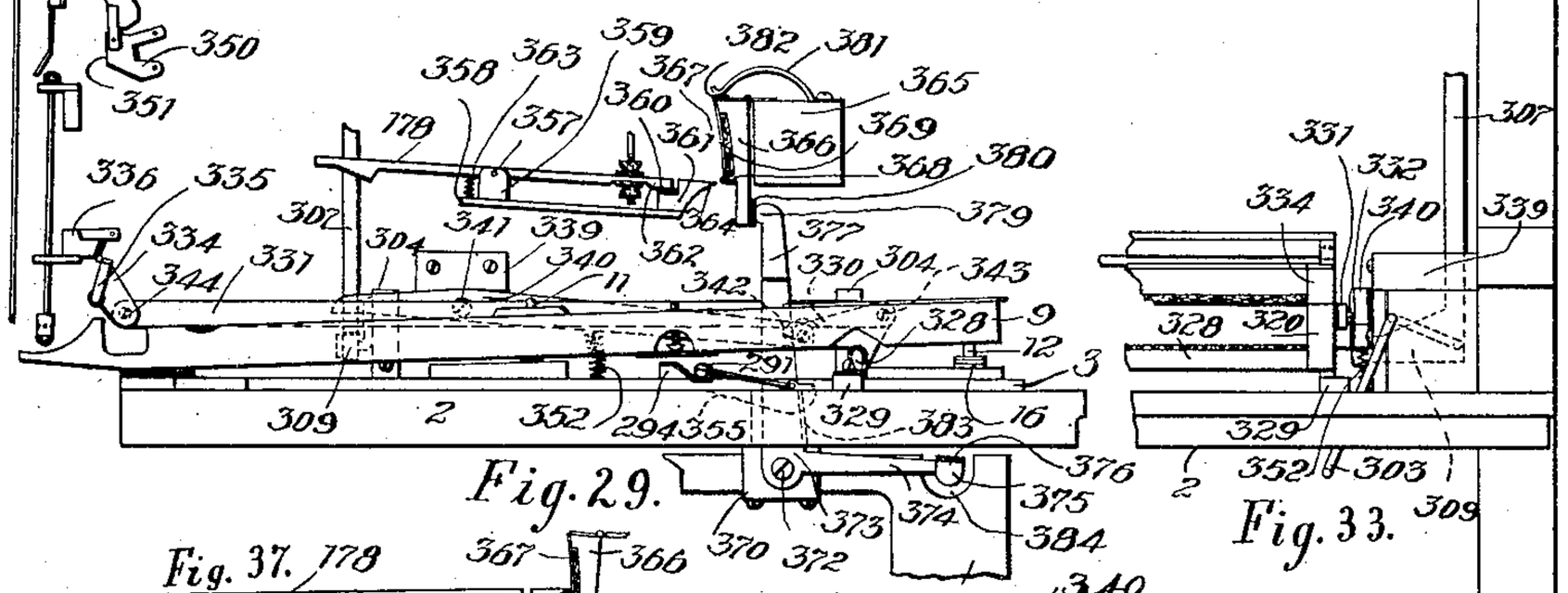

Fig. 29.

Fig. 33.

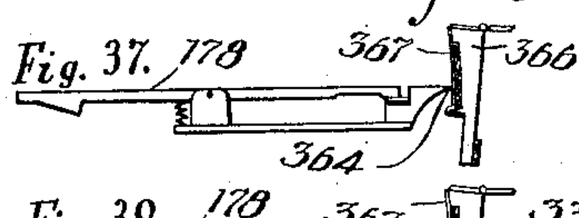

Fig. 37.

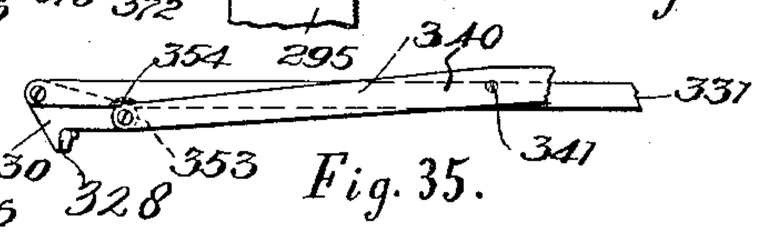

Fig. 35.

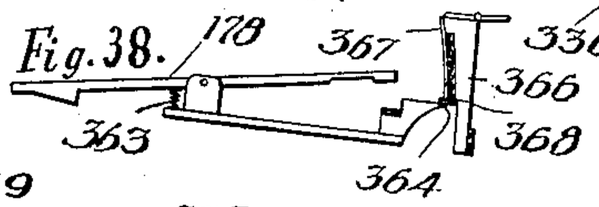

Fig. 38.

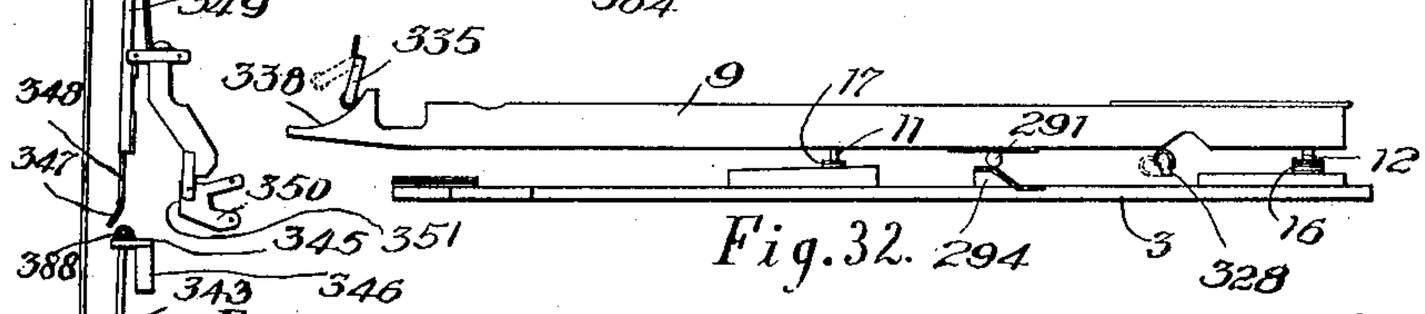

Fig. 30.

Fig. 32.

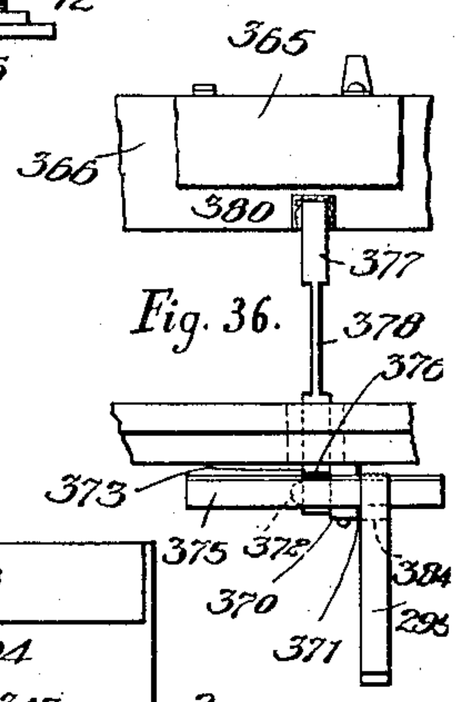

Fig. 36.

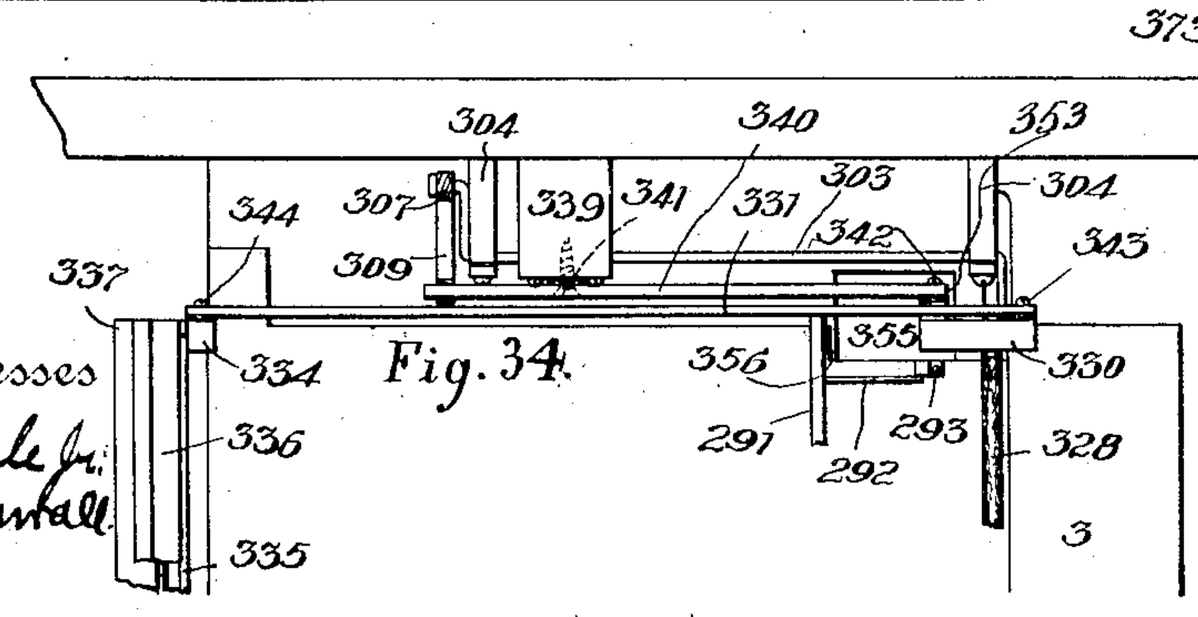

Fig. 34.

Witnesses

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MUSICAL INSTRUMENT.

1,155,299. Specification of Letters Patent. Patented Sept. 28, 1915.

Application filed April 3, 1907. Serial No. 366,213.

To all whom it may concern:

Be it known that I, JOHN W. DARLEY, JR., a citizen of the United States, residing at Baltimore city, in the State of Maryland, have invented certain new and useful Improvements in Musical Instruments; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in musical instruments, and it is intended to provide a source of power controlled by a key or its equivalent, whereby sound-producing means may be sounded by a single movement of the key, the loudness of the tone produced by said sound producing means being dependent upon the speed impressed upon the key: to provide a source of power extraneous to said key for producing an evanescent vibration of said sound-producing means for each depression of the key, or for continuously vibrating, at the will of the performer, said sound-producing means as long as the key is held in the operated position, said extraneous source of power maintaining the tone continuously at the loudness determined by the speed communicated to the key: to provide means whereby, when the tone is being continuously emitted by the sounding means, a general crescendo or diminuendo of the loudness may be obtained, or a crescendo or diminuendo of the tone of any one or number of a plurality of sounding means that may be continuously sounding, or a crescendo or diminuendo of the tone of any one or number of said plurality simultaneous with a diminuendo or crescendo, respectively, of the tone of any one or number of the remainder of said plurality, while at the same time there may be either a general crescendo or diminuendo in all tones: and to provide means whereby these features may be introduced into musical instruments of ordinary type, such, for instance, as the piano, so that the same may be used in the ordinary manner or the features herein described used at the will of the operator.

My invention includes other capacities of smaller import, for producing expression which can be better pointed out in the specification.

Heretofore attempts have been made to produce a key-board instrument having a sustained tone and a capacity for expression by adapting to the ordinary piano a means for continuously vibrating the strings after the initial blow of the hammer was delivered, but I am aware of none that made the tone continue at the same loudness as the tone produced by the initial hammer blow, or that gave the other capacities for expression hereinafter enumerated.

While I have shown the invention as applied to a piano, many of the features may be used in organs, self-playing musical instruments, etc.

Reference is had to the accompanying drawings, whereon the same reference letters and figures are used throughout the several views.

Figure 1 is a side elevation of the interior of a piano containing my improvement, certain of the parts being omitted, others being broken away, and others being shown in section, the key-board being in position for ordinary playing; Fig. 1ª is an enlarged view of the upper portion of Fig. 1; Fig. 2 is a front view of the same, the front panels of the piano being removed, and the mechanism for one key only being shown; Fig. 3 is a view similar to Fig. 1, the piano action, part of the pneumatic mechanism for operating same, and the ordinary loud and soft pedals being removed, the remaining pedal being shown in one of its operated positions, and certain of the parts being shown in section, the key-board being in position to operate the improved devices hereinafter described; Fig. 3ª is an enlarged view of the upper portion of Fig. 3; Fig. 4 is a top view of the key, piano action and pneumatic mechanism for operating same; Fig. 5 is a top view of the key and the rails which coöperate with the parts carried thereby; Fig. 6 is a top view of the parts shown at the right of Fig. 2; Figs. 7, 8 and 9 are, respectively, rear, top, and front views of an octave in length of the rods used as secondary fulcrums for the keys. In these views the letters C to C and C sharp to C sharp refer to the notes of the distonic scale; Figs. 10 and 11 are top views of the mechanisms for guiding the top ends of the rods for operating the damper lifter bar and hammer-rest-rail, respectively; Figs. 12 and 13 are bottom and inverted side views, respectively, of the lever whose position determines whether the piano shall produce an evanescent tone for

each depression of the key, or a sustained tone as long as the key is held depressed; Figs. 14 and 15 are section and bottom views, respectively, of the junction of the vertical and horizontal air trunks, Fig. 14 being a section along the line 14—14 of Fig. 15; Figs. 16 and 17 are side and rear views, respectively, on an enlarged scale of the key, its connected parts, the pneumatic mechanism for operating the piano action, and the air trunks, the parts being shown in the operated position; Figs. 18 and 19 are front and bottom views, respectively, of the wood portions of the bellows which are used to operate the piano action; Figs. 20, 21 and 22 are rear, side and bottom views of the wire levers for transmitting motion from each of the bottom row of bellows to its corresponding element of the piano action; Figs. 23 and 24 are rear and side views, respectively, of similar wires for the top row of bellows; Fig. 23[a] is a perspective view of the wire shown in Fig. 23; Figs. 25, 26, 27 and 28 are top, front, bottom and side views of the valve for controlling the bellows which operate the piano action elements; Figs. 29 to 38 inclusive show modifications of the device shown in the preceding figures. Fig. 29 is a side view of the key and cooperating mechanism for allowing individual crescendos or diminuendos for each note independently of all others that may be sounding, the parts being set for manual operation of the piano action element by said key; Fig. 30 is a view similar to view Fig. 29, but the parts are set for pneumatic operation of the piano action under manual control of the key; Fig. 31 is a view of the key depressed, the parts being set as shown in Fig. 29; Fig. 32 is a view of the key depressed, the parts being set as shown in Fig. 30; Fig. 33 is a front view of some of the parts shown in Fig. 29; Fig. 34 is a top view of the parts shown in Fig. 33; Fig. 35 is a view of the lever 340 and some of its coöperating parts as they would appear if viewed from the right of Fig. 33; Fig. 36 is a front view of some of the parts shown in Fig. 29; and Figs. 37 and 38 are views of some of the parts shown in Fig. 29, when in the operated position.

The arrangement of the action and keys will now be described. In Figs. 1, 2, 3 and 4, 1 designates the strings for each element of the action, there being either one or a plurality of strings, depending on the position in the scale, the number varying from one in the bass to three in the treble. 2 designates the key bottom upon which the key frame 3, consisting of the rails 4, 5 and 6, united by the cross pieces 7, is mounted. The key frame is held down upon the key bottom by screw hooks 8, 8, 8, 8, which also serve as guides for said key frame, when it is shifted in a direction transverse to the rails 4, 5 and 6 for a purpose hereinafter explained. 9 represents one of the natural keys, and 10 one of the sharp keys, fulcrumed in the usual manner on balance pins 11, 13, respectively, and having their front ends guided by pins 12, 15, respectively, in the usual manner, the pins 11, 13, 12 and 15 having thereon the usual felt washers 17 and 17 for deadening the noises produced by the key movement. The key is provided with recesses, projections, etc., for purposes hereinafter explained and has a capstan screw 18, on which rests the foot 19 of the abstract 20; all parts of the piano action are the same as shown in my U. S. Letters Patent #810,920, January 30, 1906, excepting that an incline 21 is provided on the lower front corner of the abstract 20, a spring 22 is added, the link 23 being grooved for same, and a projection 24 is inserted near the top of said abstract; said projection having mounted therein an adjusting screw 25 on the end of which is a button with padded lower surface 26. The pad 26 is arranged to just touch the end 27 of the cranked wires 28 and 29 when the foot 19 is resting on the capstan screw 18.

The piano action is operated by the key in the manner specified in said patent, this type of action being preferable for this work on account of its ability to strike an extremely rapid succession of blows, which may vary from the lightest pianissimo to the heaviest fortissimo, while if the loudness is to remain constant for a long tone, this action will strike each one of the rapid succession of blows with practically the same force, giving rise to the sensation of a sustained tone.

The piano is provided with the usual damper lifter bar 30, having the projection 31, by which it is operated by the pedal, and the usual hammer rest rail 37, which is operated by the pedal 36. The bar 30, rail 37 and pedals 36 and 32 are arranged and operate in the same manner as is shown in my U. S. Patent No. 936,763.

In Fig. 1[a] the frame 219, shown in Fig. 2, is broken away to shown interior parts. The lever 35 is shown broken away in Fig. 1. The stick 34 is shown broken away in Fig. 3. These parts are broken away to show the interior parts.

When the parts are as arranged in Figs. 1, 1[a] and 2, the keys 9, 10 work on the washers 17 as fulcrums, being guided by the pins 11, 12 and 13, 15, and having their downward movements limited by the washers 16, these parts working in the usual manner; and the tone emitted will have the usual characteristics, namely the tone evoked by the percussion of the hammer on the strings, followed by (should the key be held depressed) the rapidly fading tone due to the vibrations of the strings caused by the energy they ac-

quired from the hammer blow, hence the duration of tone is not under the control of the performer except in a minor degree. It is to overcome this defect and make the duration of tone variable at the will of the performer that I have devised the additions to the features already described.

The arrangement of the pedals will now be described. While the parts are in the position shown in Figs. 1 and 1ª, the pedals 36 and 32 operate the hammer rest rail 37, and the damper lift bar 30 in the manner described in the U. S. patent above mentioned, and the pedal 38 operates the apron pianissimo rail 39 by the following instrumentalities. To the rail 39 the arms 40 are attached and these arms are revolubly mounted on the screws 41 secured in the sides of the piano. The rail 39 rests by its own weight on the padded button 42 secured to the top of the rod 43, which slides loosely in a bushing provided in the usual frame supporting post. The rod 43 extends downwardly, and is provided at its lower end with the boss 44 having the reduced portion 45 which passes loosely through a hole 46 in the board 47. A pad 48 located between the board 47 and boss 44 serves to prevent noise. The board 47 extends nearly from side to side of the piano, and is provided with pivots 49 which are revolubly mounted in the blocks 50 secured to the sides of the piano; springs 51 are secured to these blocks and the free ends of the springs bear against pads 52 secured to the board 47, and serve to press the front end of the said board downwardly. In the front edge of the board 47 are secured bosses 53, which support the pivot 54 on which the upper end of the link 55 is mounted. The upper end 56 of the pedal 38 is provided with a fork 57 supporting the pivot 58 on which the lower end of the link 55 is mounted. The pedal 38 is secured by the pin 59 to the shaft 60 which is revolubly mounted in the supports 61 secured to the bottom 62. Hence it is evident that when the parts are as arranged as shown in Figs. 1, 1ª and 2, a slight depression of the pedal 38 will move its upper end 56 toward the right in Fig. 3, and when it has been moved far enough to occupy the position shown by dotted lines in said figure, the link 55 will have moved the board 47 to the dotted position; this will allow the boss 44 and button 42 to fall to the dotted positions in Figs. 3, 3ª, consequently the rail 39 will fall and its attached curtain 46ª will come into the path of the hammers, and produce the well known softening of the hammer blow on the strings. When pressure is removed from the pedal 38, after it has been forced to the position shown dotted in Fig. 3, the springs 51 will force the board 47 to the position shown in Figs. 1 and 2, which, acting through the link 55, forces the pedal 38 to the position shown in said figures, with its lower lever portion resting against a pad in the pedal strip 63 similar to the pad against which the lower lever portion of the pedal 36 rests. Hence the three pedals 36, 38 and 32, so far as their functions have been described, perform the functions of the pedals ordinarily used on a piano. When, however, it is desired to have the piano produce tones which are sustained as long as the corresponding keys are depressed, the performer presses the pedal 38 to the position shown by full lines in Fig. 3, where its lower lever portion rests against the pad 64 in the bottom 62; this will force the link 55 and board 47 to the position shown by full lines in Fig. 3, and it will be noted that during this movement of the pedal 38, the center of the pivot 58 will pass to the right of a line joining the center of the shaft 60 and center of the pivot 54, as shown in Fig. 3, hence the tension of the springs 51 will keep the lower lever portion of the pedal 38 against the pad 64, until the pedal 38 is moved slightly upward by the toe of the performer sufficiently to bring the center of the pivot 58 to the left of a line joining the centers of the shaft 60 and pivot 54, as shown in Fig. 3, when the springs 51 return the board 47, link 55 and pedal 38 to the position shown in Fig. 1.

During the movement of the pedal 38 from the position shown in Fig. 1 to that shown by full lines in Fig. 3, the curtain 46 will be dropped into the path of the hammer 65 when the pedal 38 arrives at the position shown dotted in Fig. 3, and the further depression of the pedal 38 removes the curtain 46ª from the path of the hammers 65 by the following instrumentalities.

Secured to the air trunk 66, is the slotted bearing block 67, supporting the pivot 68; in the slot and on the pivot 68 is revolubly mounted the lever 69, having a curved end provided with a pad 70, and carrying near its other end the pivot 71. This end of the lever 69 is provided with a slot in which, and on the pivot 71, is revolubly mounted the lower reduced end of the pitman 72; the upper reduced end of the pitman 72 passes loosely through a hole 73 in the board 47, a pad 74 being secured on the board 47 to obviate noise. The pad 70 rests just below the reduced lower portion 45 of the boss 44, and when the pedal 38 is forced from the position shown in full lines in Fig. 3, to the position shown by dotted lines in said figure, the pad 74 strikes the curved top of the enlarged portion of the pitman 72 and forces it and the lever 69 from the positions shown by full lines in Fig. 1 to those shown by dotted lines in Fig. 3, and during this upward movement of the pad 70, it strikes the end of the reduced portion 45, thus raising the button 42 from the position shown dotted

to that shown by full lines in Figs. 3, 3ª, and removing the curtain 46ª from the path of the hammer 65. This movement of the pedal 38 also shifts the key frame, keys, etc., toward the front of the piano, shifts the sticks 34 and 75 to positions in which they will clear the parts 76 and 31, respectively, and otherwise modifies the apparatus so that the movement of the pedals 36 and 32, instead of operating the hammer rest rail 37 and damper lifter bar 30, will produce a wind current in the trunk 66; in other words shifts the parts from the positions shown in Figs. 1, 1ª, 2, 4, 10 and 11, to those shown in Figs. 3 and 6. The means for effecting these changes of position will now be described.

The arrangement for shifting the keyboard will now be described. Revolubly mounted on the sides of the piano, (see Figs. 1, 2, 3, 6, 10 and 11) on the screws 77, 78, are the bell crank levers 35, 79; distance pieces 80, 81 being interposed between said levers and the sides of the piano. The lower arm of the lever 35 is connected by the screw 82 to the bar 83, and the lever 79 is connected by a similar screw, not shown, to the bar 84. The bars 83 and 84 are provided with bushed holes 85, 86 for guiding the upper ends of the sticks 34, 75, the lower end of the stick 34 being pivoted by the screw 88 to the lever 87 which is formed integral with the shaft 89 on which the pedal 36 is rigidly mounted. The lower end of the stick 75 is a lever, similar to the lever 87. The lever to which the stick 75 is pivoted is formed integral with a shaft, (similar to 89), and upon this shaft the pedal 32 is rigidly mounted.

The bars 83, 84 are provided near their outer ends with reduced portions which slide freely in bushings 90, 91, provided in the slotted bearing blocks 92, 93, which are secured by screws to the under side of the key bottom. Springs 94, 95, bear against the pads on the outer ends of the bars 83 and 84, and tend to keep them in the position shown in Figs. 1, 2, 10 and 11. Pads 96, 97, attached to the bars 83, 84, and bearing against the blocks 92, 93, serve to limit the inner movement of said bars. The springs 94, 95, are secured to blocks 98, 99, which are secured to the under side of the key bottom.

Near the extremities of the horizontal arms of the bell crank levers 35, 79, are revolubly mounted on the screws 100, 101, the downwardly extending bars 102, 103, guided near their lower ends by the slotted and bushed bearing blocks 104, 105, which are secured to the sides of the piano. The bar 102 is provided with a projection 390 and the bar 103 with a projection 391. The projections 390 and 391 are in all respects similar and they extend inwardly under the board 47. A side view of the projection 391 is shown in Figs. 1 and 3. The tops of said projections are curved in order to coact with pads on the board 47, one of which is shown at 392. Intermediate between the screws 77, 78 and the screw 82 and its similar, bushed holes are provided in the levers 35, 79, in which are revolubly mounted the bent ends of links 106, 107; the other ends of said links being also bent and revolubly mounted in bushed bearing blocks 108, 109, secured to the key frame 3. In Fig. 3, the pad 110 is omitted in order to better show the link 107. Hence it is evident that a movement of the pedal 38 from the dotted line to the full line position in Fig. 3, will remove the curtain 46ª from the path of the hammer, as before explained, and will cause the board 47 to pull the bars 102, 103, downwardly, thus shifting the levers 35, 79, from the position shown in Fig. 1 to that shown in Fig. 3. This will move the bars 83 and 84 outwardly against the tension of the springs 94, 95; at the same time the sticks 34, 75, will be shifted from the position shown in Fig. 1 to that shown in Fig. 3, in which position they cannot operate the hammer rest rail 37 and damper lifter bar 30. The wires 111, 112, will release the valve wires 113, 114, and the operation of the pedals 36, 32 will produce a wind current in the air trunk 66, by the action of the pumpers formed by the back board 115, front boards 116, 117 and suitable webbing. See the U. S. patent above noted. The back board is united with the wind chest and both are supported in the piano by the braces 118, 119, 119, the latter of which are secured to blocks, one of which is shown at 120, which are secured to the sides of the piano. Braces, such as 121, support blocks 122, which form outward abutments for the springs 123 which return the pumper boards 116, 117 to the position shown in Fig. 1 after each displacement therefrom.

When the bars 102, 103 are moved downwardly, the links 106 and 107 move the key frame from the position shown in Fig. 1 to that shown in Fig. 3. When the pedal 38 is pressed upward by the toe of the operator, the springs 94, 95, restore the bars 83, 84, 102, 103, levers 35, 79, sticks 34, 75, and key frame 3 to the positions shown in Fig. 1, and the springs 51 restore the board 47 and coöperating parts to the positions shown in said figure.

For purposes of controlling the expression of bass tones of the piano separately from the expression of the treble tones, there are two sets of controlling means, one for each of the just-mentioned portions of the piano, and there are two sets of air trunks, controlling valves, etc., both of which receive air from the air trunk 66; as the two parts are duplicates, that for the treble side only will be described. Secured to and in pneu-

matic connection with the air trunk 66 is the horizontally extending air trunk 124, which connects with the upwardly extending air trunk 125, which is provided with cap 126 at its upper end for closing same. See Figs. 1, 2, 3, 14 and 15. Secured to the cap 126 by screws is the flanged bottom 127 of the air chamber 128; a leather packing being interposed. This latter air trunk has a removable lid 129 secured thereto, by the screws shown; a leather packing being interposed.

The air trunk 125 communicates through the passage 130 with the chamber 131, the bottom of which is closed by a pneumatic mechanism constructed in the following manner. 132 represents a block in which a recess 133 is formed, which is covered loosely by a piece of leather in the usual manner, on the top of which and secured thereto near its center, rests the block 134; the recess 133 communicates by the passage 135 with the valve port 136, which is controlled in the usual manner by the double flanged valve 137. The port 136 communicates with the chamber 138, when the parts are as shown in Figs. 3 and 3ª, and this chamber is also in communication with the chamber 131 through the passage 139; the chamber 138 is closed at the bottom by the block 140 in which is the recess 141, covered loosely at the top by a piece of leather in the usual manner, on the top of which and secured thereto near its center rests the block 142. The recess 141 communicates by the passage 143 with the flexible tube 220, the usual bleed 145 and the chamber 146 formed in the block 147, which is secured to the block 140. The chamber 146, which is cylindrical, is closed at the bottom by a cylindrical block covered with leather 148, and this block is secured to the screw 149, which threading through the cover 150 attached to the lower end of the block 147 affords a means for varying the vertical position of the leather covered block 148, for a purpose hereinafter explained. The valve 137 is formed in the usual manner by two flanges united to a central cylindrical stem which is guided by the guides 151 attached to the upper and lower sides of the block 132, and the lower end of the stem rests upon a pad on the block 142.

The chamber 131 communicates through the passage 152 with the port 153, which is covered by the valve 154. The valve 154 is rigidly mounted on a central cylindrical stem 155 which fits loosely in guides 156 secured to the top and bottom of the air chamber 128; the air trunk 128 communicates with the external air through the port 157. The air trunk 128 extends nearly from side to side of the piano, but is divided into two sections by the septum 158, shown in Figs. 2 and 4, so that the characteristics of the air in each side may be separately controlled.

In the bottom 127 of the air chamber 128, a series of ports are pierced, one port 159 for each element of the piano action, (see Figs. 4, 14, 15, 16, 25, 26, 27 and 28) and each of the ports is controlled by a valve consisting of the flange 160, having a padded under surface 161. The flange 160 is secured on the stem 164 formed integrally with the body of the valve 163, which has two parallel flat sides 164, two flat sides 165 tapering from the padded surface of the flange to the stem 166. At the broadest part of the valve body 163 the corners are rounded, as at 167, to conform to the shape of the port 159. A wire 168 is threaded in the end of the stem 166 and extends downwardly through the port 169 in the bottom 170 of the channel box 171. A valve 172 slides loosely on the wire 168 and when the valve 163 is raised, as shown in Fig. 16, the spring 173 forces the valve 172 against the bottom 170, thus closing the port 169. The wire 168 passes through bushed holes in the rails 174, 175, which are secured to the large rail 176, the latter being secured to the bottom 170 of the channel box. The wire 168 is threaded at its lower end and leather nuts 177 are mounted thereon, between which is the reduced end of the lever 178, a suitable bushed hole being provided therein for the passage of the wire 168. There is one lever 178 for each element of the piano action, and they are fulcrumed on the rail 179 in the following manner.

The rail 179 extends nearly from side to side of the piano and is provided with pins, one of which is shown at 180 (see Figs. 16 and 17), upon which the inner ends of the levers 178 are mounted; tapered holes 181 being provided near the inner end of the lever 178 to permit of its free vertical movement. To prevent the levers 178 from dropping from the pins 180, a rail 182 is secured below the levers on the pins 183 by the nuts 184. Suitable pads 185 are provided on the rails 179, 182 to prevent noise, and the nuts 184 press the lower pads against the ends of the pins 180, which are sufficiently long to insure the free movement of the levers 178. The pins 183, of which there may be as many as desired, also serve as fulcrums for their corresponding lever 178.

The lever 178 is provided with an offset 186, in which is mounted the forwardly and downwardly extending wire 187, provided with a curved end 188. Springs 189, placed between the offset portion of the rail 179 and levers 178, serve to depress said levers to the position shown in Figs. 1, 1ª and 2. The springs 189 are made sufficiently strong that when the stem 168 of the valve 163 strikes the valve 172 it will be depressed

against the force of the spring 173, thus opening the port 169.

The channel box 171 is divided by septums 190 into channels 191 (see Figs. 4, 14, 15 and 16), there being one channel for each port 159, the channels being air tight with reference to each other and the external air, excepting through the ports 159 and 169. The passages 192 extend alternately through the top 127 and the bottom 170 of the channel box 171, and thence through the passage 192 in the hinge strips 193 of the top and bottom rows of striker bellows 194. In Fig. 16, the top bellows is shown with one board 195 and the webbing removed, and the strip 193 shown in section. The striker bellows 194 (see Figs. 16, 17, 18 and 19) are formed of two side boards 196 and 195, to the latter of which the strip 193 containing the passage 192 is glued. The side 196 is brought to a feather edge near the strip 193, and a leather hinge is secured between them in the usual manner; webbing being placed around the top and end edges of the boards 196 and 195, and the ends of the strip 193, the striker bellows 194 are formed. The hinge strips 193 are then glued alternately on the top 127 and bottom 170 of the channel box 171, so that the passage 192 in the strips 193 shall register with the passages 192 in the top 127 and bottom 170 of the channel box 171, the bellows being glued on at an oblique angle to the channel box 171, as shown in plan in Fig. 4, in order to bring the valve wire 168 and the ends 27 of the levers 28 and 29 in a line at right angles to said channel box.

To the bottom row of striker bellows 194 there is glued a rail 197 having a pad 198 which serves as a bottom stop for the ends 27 of the levers 28 and 29. To the rail 197 there is glued the rail 199, provided with bushed bearings extending at an oblique angle thereto, as shown in Fig. 4, for the bearing portions 200 of the levers 28 and 29. Secured to the rail 199 by screws (not shown) is the rail 201 which carries pads 202 on its upper and lower faces, the lower pad serving to noiselessly retain the bearings 200 in position, and the top pad forming a stay for the strips 193 of the upper row of striker bellows 194. The rail 201 is provided with an inwardly extending rib 203 in which is mounted, an adjusting screw 204 for each of the cranked wires 28 and 29, each screw 204 having on its lower end a padded button 205 for limiting the upward movement of the end 27 of said cranked wires. Rails 206, having projections 207, extend above the top and below the bottom row of striker bellows 194, and each projection 207, is glued to one of the fixed boards 195, the whole construction is stiffened, while allowing freedom of movement of the board 196.

The cranked wires 28 and 29 (see Figs. 20 to 24 inclusive) are formed with the ends 27, the horizontal portion 208 (see Fig. 23) forming an oblique angle to the end 27 and bearing portion 200, as shown in Fig. 22, the inclined portion 209 to provide clearance around the strip 193 of the striker bellows and the approximatelv vertical portion 210. The portions 209 and 210 (see Fig. 23) of the cranked wires 28 and 29 extend upwardly and downwardly for the top and bottom rows of striker bellows, respectively. At the end of the portion 210 the cranked wires 28 and 29 are bent at right angles to form the portion 211, and are again bent at right angles thereto to form the portion 212 which extends over the pad on the block 213, one of which is secured by screws and glue to each of the striker bellows boards 196, and serves to apply the power of the striker bellows to its cranked wires 28 and 29. The cranked wires 28 and 29 are flattened as at 214 to provide clearance with reference to the adjacent striker bellows board 195.

The rails 179 and 199 are secured together at their ends by the brackets 215 (see Figs. 1 and 2), and by intermediate brackets, one of which is shown at 216. The intermediate brackets 216 are provided with upward extensions 217 which are secured under the screws 219, and with feet 218 resting upon the key bottom. Hence by removing the screws clamping the flanges 127, 126, the tubes 220 and the screws 219, the chamber 128, box 171, rail 179, and their connected parts, may be removed independently of the piano action. The tube 220 is flexible and connects from the passage 143 to the lever 312.

The construction of the key, its attached and coöperating parts will now be described. To the key 9 there is secured a block 221 (see Fig. 16), having grooves in the side thereof in which are glued the uprights 222, 223. The upright 222 is slotted at its upper end, and in this slot on the pin 227 is pivoted in the usual manner a lever, which consists of the wood portion 224, in which is screwed the wire 225, on the outer end of which is secured the metallic portion 226. This lever is used as a means for determining the amount of power applied to the sounding means, and it is herein referred to as an inertia-controlled means for the following reasons. It will be noted, by a reference to Fig. 16, that the spring 247 keeps the lever 224 in the position shown in Fig. 1, and tends to return it to that position after each displacement therefrom, and the tension of the spring 247, which is applied to the lever 224 on the right of the pivot 227 is great enough

to overcome the effect of gravity on the weight 226 which is attached to the lever 224 on the right of the pivot 227. Hence gravity cannot move the lever 224, but when there is a quick depression of the front end of the key 9 the inertia of the weight 226 causes the lever 224 to turn around its center of mass against the tension of the spring 247, and since only the inertia of the weight causes this movement of the lever 224 from its initial position to another of its effective positions the term "inertia-controlled means" is applied to the lever 224.

The wood portion 224 is provided with the eccentric upper portion 228 provided with a pad 229, which extends downwardly, as at 230, 231, with the three steps 232, 233 and 234 and the horn 235 to which is secured the silk cord 236. A pad 237 is secured between the step 232 and horn 235. The metallic portion 226 is formed with a curved top 238, two depending lugs 239 and 240 between which is a straight portion provided with a pad 241. In the outside of the lug 239 a V-shaped depression 242 is formed. The metallic portion 226 is shaped so that the center of gravity of it and the wood portion 224 shall be approximately at the point 243, which is so placed that a full movement of the parts 224 and 226 on the pin 227 shall move the point 243 from a point just above the line 244, as shown in Fig. 1, to an equal distance below said line. The line 244 is drawn through the point 246 which is the fulcrum when the inertia controlled means is being used and the center of the pin 227. A pad 245 on the block 221 limits the downward movement of the inertia controlled means.

The spring 247 has one end secured in the cord 236, and its other end is secured to block 221 by the screw 248, a felt washer 249 being interposed between the spring and block to prevent rattling. The block 221 is cut away, as at 250, 251, for the reception of the washer 249 and end of the spring 247, respectively. A slot 252 is provided in the upright 223 for the passage of the spring 247.

The wood part 224 is shaped to perform its necessary functions, and the metallic part 226 is shaped to bring the center of gravity of the two parts combined at a point 243, which is placed with reference to the line through 246, 227, as before noted, and at such a distance from the point 227, that if it (the point 243) were considered to remain stationary while the inner end of the key moves upward, the inertia controlled means would turn sufficiently on its pivot before the pad 229 strikes the wire 187, as to allow the pad 256 to abut on the face of the step 234, as before explained with reference to the hardest blow struck by the performer.

The spring 247 is to be adjusted by the screw 248, so that the lightest blow used by the performer will cause the valve 163 to be moved to the position corresponding to the pad 256 resting against the pad 237; and the spring 247 is to be so shaped, that its tension will increase in such a degree as it is flexed that the heaviest blow struck by the performer will cause the pad 256 to abut on the face of the step 234, as before explained. It is evident from the preceding that the power necessary to move the inertia-controlled means or lever 224 bodily with the key is communicated to the said means through the pivot 227 and spring 247. It is also evident that the said lever 224 turns around its center of gravity at 243 when its pivot 227 is moved rapidly upward by the key, thus flexing the spring 247 until the force of said spring acting on said lever 224 is sufficient to cause it to move through space bodily with the key. When this happens the pad 256 rests in the appropriate notch between the steps on the part 226; thus preventing the spring 247 from retracting the lever 224, the rest of the key stroke is completed and the valve 163 is moved an amount corresponding to the amount the lever 224 has moved on its pivot 227, which amount varies with the speed of the key.

In order to insure regularity of adjustment of the springs 247, the notch 242 is provided in the part 226 and a light and a heavy weight each having hooks adapted to hang in said notch 242 are to be used, the light weight first being hooked in the notch 242; the spring 247 is to be adjusted so that the pad 237 will just leave the pad 256, then this weight being removed and a heavy one substituted, the lever 224 should be moved so that the pad 256 will just abut on the face of the step 234. The first test insures a proper initial adjustment of the spring 247, the last test insures that the spring 247 increases its tension at the proper rate. While I have indicated means for assuring the correct relative tensions of the spring 247, I have not specified the absolute amounts, as these can be made any amount desirable.

While I have shown three steps 232, 233 and 234, on the part 224, giving four working positions of same, this number of steps and consequent working positions may be increased or diminished at will. The length of the steps, in a line at right angles to the line drawn through their corners and the pivot 227 may also be increased or diminished at will, to increase or diminish the speed required on the key to produce the corresponding movement of the inertia controlled means.

The upright 223 has a recess at its top, in which, and on the pivot 253, is arranged in the usual manner the lever 254, which consists of the portion 255, padded as at 256,

to coact with the pad 237, and steps 233, 234 and 235, and as at 257 to coact with the rail 258; at the rear of the portion 255 of the lever 254 there are upwardly and downwardly extending parts 259, 260, terminating at their right hand junction in Fig. 16 in the extension having the downwardly extending convex portion 261 and the concave top 262 in which is a slot 263 for the reception of the spring 264. The parts 259, 260 are shaped to approximately balance the lever 254 on the pivot 253, and the convex portion 261 is arranged to contact with the pad 265 on the button 266, adjustably mounted on the stud 267, which is secured in the rail 268, the rail 268 extending from side to side of the key board, as shown in Fig. 2, and there being a stud 267 and button 266, one of which is shown in said figure, for each element of the piano action. The rail 268 is provided with downwardly extending lugs 269 having slots through which pass the screws 270 by which the rail 268 is adjustably secured to blocks 271 mounted on the key frame 3.

The springs 264 are secured in the rail 272, which is supported from the rail 268 by the wires 273, shown in Figs. 1, 1[a] and 2, of which there may be as many as desired. The rail 274 is provided with lugs similar to 269, by which it is adjustably mounted on the block 271 (see Fig. 3). The rails 272 and 274 may be supported in the positions shown in any approved manner. The rail 275 is adjustably secured to the lower rail 276 of the piano action, as explained in the patent above referred to, and when the parts are in the position shown in Figs. 1 and 1[a] the pad on the rail 275 is struck by the block 277 secured to the key 9, thus limiting the upward movement of the inner end of the key; and when the parts are in the position shown in Figs. 3, 3[a] and 16, the pad is struck by the key 9; hence the upward movement of the inner end of the key 9 is greater in the latter case than in the former by the thickness of the block 277.

The rail 258 (see Figs. 1, 2, 3, 5, 16 and 17) extends across the levers 254 which correspond to the elements of the piano action from the extreme treble of the piano, to the element immediately to the right of the septum 158, inclusive, and a similar rail 278 extends across the remaining levers 254. The rails 258 and 278 being similarly mounted and controlled, the parts pertaining to rail 258 only will be described. The rail 258 is carried by arms 279, see Figs. 3 and 3[a], which extend downwardly toward the left, are bent at right angles and pass through the bushed bearing blocks similar to 280, secured to the block 271, and one of these arms extends forwardly to form the lever arm 281, which rests against the stop 282 in the block 271. The lever arm 281 is bent at its outer end to form the horizontal extension 283. The duplication of the arms 279 being familiar in the art has not been illustrated. The keys are recessed, as at 284, to provide clearance for the metallic part 226 of the inertia-controlled means when it is in its lowest position, and the white keys 2 are recessed as at 285, to provide clearance around the head of the adjusting screw 286 which is threaded through the key 9 and serves to adjust the pad 287 on the underside thereof. A similar recess is provided in the black keys 10 for clearance around the screw 288, which serves to adjust the pad 289 on the underside thereof.

Fulcrum rails 290, 291 extend immediately under the keys and slightly beyond the sides of the key frame 3. Near the extremities of the fulcrum rails 290, 291, they are provided with arms 292 having bent ends which work loosely in the bushed bearing blocks 293 secured to the key bottom. Inclines 294, of which there may be as many as desired, are secured to the key frame 3. An octave in length of the fulcrum rails 290 and 291 is shown in Figs. 7, 8 and 9. 290 is shown as having projections marked C sharp to C sharp which are adapted to contact with the pads 289 on the corresponding black keys when the parts are in the position shown in Figs. 3 and 3[a]. The cut away portions of the rail 290 between the raised portions marked C sharp to C sharp are to provide clearance around the white keys. The projections on the rail 291 marked C to C and the cut away portions between same perform similar functions to the white and black keys, respectively.

The white and black keys are to be balanced in the usual manner by lead weights, as at 294[a] in the white key 9, so that when resting on the bars 290 and 291, there shall be the proper resistance to the downward movement of the front end of the key, and as this amount of balancing would be too great when the keys are working on the washers 17 as fulcrums, the spring 22 is arranged to bear downwardly upon the link 23 of the piano action, and thus make the resistance to movement of the front end of the key the same whether the parts are in the positions shown in Figs. 1, 1[a], or 3, 3[a]. The spring 22 also serves to cause a rapid expansion of the bellows 194.

To control the air in the air chamber 128, the following means are provided, which being the same for the bass and treble sections will be described only with reference to the latter. 295 (see Figs. 1, 2, 6, 29 and 34) represents a knee lever placed adjacent the right knee of the performer, a similar lever 296 being placed adjacent the left knee of the performer. The lever 295 is pivoted on a vertical pin 297 secured in the casting 298, which is fastened to the underside of

the key bottom. A stick 299 is provided with a pin 300 which fits loosely in a hole in the lever 295 between which and the stick 299 a felt washer is placed. The stick 299 is provided with a hole in its right hand end which is journaled on the bent end of the lever 301, which extends upwardly, through a hole 302 in the key bottom, toward the right, and is bent at right angles to form the bearing portion 303, which is journaled in the bushed bearing block 304 attached to the side of the piano. The bearing portion 303 extends inwardly and is bent at right angles to itself and the lever 301 to form the lever 305, upon the bent end of which the connecting rod 307 is journaled. Leather nuts 308 retain the stick 299 and rod 307 in place on their respective levers. The rod 307 is provided with padded extension 309 which rests under the horizontal extension 283 of the lever 281 and at its top end with a similar extension 310 having a pad which normally rests on the pad 311 of the lever 312 the pad upon the extension 310 holding the lever 312 in the position shown in Fig. 1. The top end of the rod 307 is guided by the bushed bearing block 313, secured to the side of the piano. A spring 314 having one end secured to the block 315, which is fastened to the side of the piano, and having its other end bearing on a pad on the top of the rod 307 serves to return this rod, and its connected parts to the positions shown in Figs. 1, 1ª and 2 after each displacement therefrom. A block 316 stops the lever 295 at the limit of its movement toward the left in Fig. 2.

The upright 317 (see Figs. 1, 1ª, 2, 3, 3ª, 6, 12 and 13) is secured to the air trunk 128, and is provided with a recess in its top, in which, and on the pivot 318, is mounted the lever 312. A spring 319 normally tends to press the left hand end of the lever 312 in Fig. 3 upwardly. Near the right hand end of the lever 312 there is threaded through the same the adjusting screw 320, having on its outer end the padded button 321. Between the screw 320 and the pivot 318 there is a semicylindrical offset 322 on the lever 312, in which is the hole 323, which communicates with the tube 220. The offset 322 is provided to present a good contacting surface to the padded button 325 mounted on the stem 155 of the valve 154.

Figs. 29 to 38, inclusive, show a variation from the construction heretofore explained. These variations are intended to provide means for obtaining independent crescendos with each key, and also to provide means for sustaining notes at will, even though the corresponding keys are released. In these figures, only the variations from the preceding construction and sufficient of the preceding construction to show the relation of same to the variations are shown, the rest of the construction remaining unaltered, except that the rails 258, 278, and their appurtenances, are dispensed with.

The incline 294 in Figs. 29, 30 and 32 is made higher than the incline 294 shown in Fig. 16, to raise the white key 9 from the washer 17, as shown in Fig. 30, thus raising the front end of the key 9 in order to permit of a greater depth of movement, before the key strikes the washer 16. The black key 10 and its fulcrum rail 290 are not shown in Figs. 29, 30 and 32, but they are similar in construction to the construction of the white key 9 and its fulcrum rail 291, and the latter construction only will be described.

In order to permit of the greater upward movement of the inner end of the key occasioned by this greater depth of movement of the front end of same, the rail 268 in Fig. 16 is replaced by the flat strip 326 in Fig. 30, the block 221 is made thinner, and a recess 289 is provided in the inner end of the key to provide clearance around the foot 19, of the abstract 20. A recess 327 is also provided in the bottom side of the key to provide clearance around the rail 328, when the parts are in the position shown in Figs. 29 and 31. The rail 328 is padded on its upper edge and extends under all the white keys 9, and black keys 10, of the piano from the last treble key of the piano, to the key inclusive which operates the valve 163 immediately to the right of the septum 158 (see Fig. 2), and a similar rail, not shown, extends under all the white keys 9, and black keys 10, from the key which operates the valve 163 immediately to the left of the septum 158 to the first bass key inclusive. The rail 328 is hinged to a series of blocks secured to the key bottom, one of these blocks being shown at 329, and at its right hand end is provided with a lever 330 affixed thereto and connected as at 332, by the rod 331, with the lever 334, as at 333, which lever is affixed to the rail 335, which extends over the rear ends of the same keys that the rail 328 extends under the front end of. The rail 335 is padded on its lower edge and is hinged to the rail 336 which serves the same purpose as the rail 276 in Figs. 1 and 1ª, but is made approximately rectangular in section, so that the rail 337 may be secured to the underside thereof. The inner end of the key 9 is curved as at 338 to cooperate with the rail 335. A block 339 is secured to the side of the piano, and a lever 340 is fulcrumed thereon, as at 341. The inner end of the lever 340 extends over the extension 309 of the bar 307. The outer end of the lever 340 is connected to the lever 330, as at 342.

A rod 343, having an adjustable button 344 for contacting with the curved portion 338 of the key, slides loosely through a bushed hole in the rail 337, and a similar hole in the rail 345, affixed to the rail 346,

which is secured to the frame of the piano action. The rod 343 carries at its top the padded button 388, which rests against the rail 345, and serves to limit the downward movement of the rod 343. The button 388 is arranged to strike the incline 347 on the wire 348, secured in the damper lever 349. The lever 350 is cut off, as at 351, since the damper lever is operated directely from the key and not from said lever, as in Figs. 1 and 1ª.

A compression spring 352, placed between the lever 340 and key bottom 2, serves to keep the lever 340 in the position shown in Figs. 29, 33, 34 and 35, and to restore it to this position after the knee lever 295 has been moved toward the left and then released.

The upward movement of the end of the lever 340 which is connected to the lever 330, beyond the position shown in Figs. 29 and 35, is prevented by the washer 353 between said lever and the lever 330 coming into contact with the pad 354 in the curved recess on the underside of the bar 331, see Fig. 35, which is a view of these parts, as shown in Fig. 33, taken from the right.

A recess 355, shown in Figs. 29 and 34, is provided in the key bottom for clearance around the levers 340 and 330, when their junction is in the lowest position, and the wires 292 near the ends of the rods 290 and 291 are moved toward the center of the piano, so that they and the bearing 293 for same shall clear the recess 355. The key frame 3 is notched, as at 356, to clear the wires 292 and bearing 293.

To the lever 178 there is pivoted, as by the pin 357, a lever consisting of a thin strip 358, to which are glued the block 359, which is slotted at its top and revolubly mounted on the pin 357 in the usual manner, and the block 361, which is notched and provided with a pad 360 adapted to normally rest against the forward extension 362 of the lever 178 under tension from the spring 363. The outer end of the block 361 is curved to a point 364.

A rail 365 extends from side to side of the piano, being supported on the sides of the piano, in any approved manner, and rails, one of which is shown at 366, are hinged to the rail 365. The rail 366 is to control the levers 178 which are operated by the same keys as are controlled by the rails 328 and 335, and the rail similar to 366, above noted, is to control the remaining levers 178. The rail 366 is provided on its inner face with a leather covering 367, which also extends around the pointed rib 368. Behind the covering 367, in a suitable recess in the rail 366, is a resilient felt pad 369. This recess is so shaped that when the rail 366 is in the operated position, as shown in Figs. 37 and 38, the working face of the covering 367 shall be substantially a cylindrical surface, having the center of motion of the lever 178 for a center.

In the construction shown in Figs. 29 to 36, the block 316, heretofore described, is replaced by a block 370, having a pad 371 for limiting the movement toward the left of the knee lever 295. Secured to the under side of the key bottom, and fulcrumed thereto, as on the screw 372 is the bell crank 373 which has a horizontally extending arm 374 terminating in a laterally extending knee bar 375 provided on its top with the pad 376. The upwardly extending arm 377 of the bell crank 373 is made thin, as at 378, to pass between the keys, and is provided at its top with the nose 379, which bears against the pad 380 on the rail 366. A spring 381 is secured to the rail 365, and bearing on a pad 382 secured to the rail 366 serves to keep the pad 380 against the nose 379, and press the arm 377 of the bell crank 373 against the pad 383, which is secured in a slot in the key bottom, and serves to limit the outer movement of the arm 377. A slot 384 is cut in the knee lever 295 to afford clearance around the knee bar 375. A knee bar similar to 375 is placed adjacent to the knee lever 296 and controls the rail similar to 366 above noted.

The adjustment and operation of my improved device as illustrated in Figs. 1 to 28 inclusive, are as follows:—When the parts are set, as is shown in Figs. 1, 1ª, 2, 4, 10 and 11, the performer can play upon the keys and operate the piano action in the usual manner, the keys working on the washers 17 as fulcrums, and the inner ends of the keys only having sufficient upward movement to operate the piano action, which movement is not sufficient to cause the pad 229 to strike the curved portion 188 of the valve operating wire 187, as shown in Fig. 16. The performer can also operate the pedal 36 to actuate the hammer rest rail for producing a soft expression; he can operate the pedal 32 to actuate the damper lifter rail 30; and he can operate the pedal 38, which being depressed only to the position shown dotted in Fig. 3, operates the pianissimo rail 39. The tones produced, during the setting of the parts as shown in Figs. 1, 1ª, 2, 4, 10 and 11, will have the usual characteristic of piano tone, that is the rapid fading of same in loudness. When, however, it is desired to set the parts so that the piano may produce a fading or sustained tone at will, the performer presses the pedal 38 to the position shown in full lines in Fig. 3. This brings the sticks 34 and 75 out of the path of their coöperating parts on the rail 37 and rod 30, releases the valve wires 113 and 114, thus releasing the corresponding valves and enabling the wind-inducing mechanism to produce a par-

tial vacuum in the air trunk 66, as explained in my U. S. Patent No. 936,763 before referred to, and the parts 102, 103, 35, 79, 106 and 107 move the key frame 3 to the position shown in Fig. 3. The pedal 38 is automatically held in the position shown by the full lines in Fig. 3, when the performer removes his foot from same, as before explained. When the key-board 3 is in the position shown in Figs. 3 and 3ª, the piano action cannot be directly actuated by the keys, for the capstan screw 18 passes from under the foot 19 of the abstract 20, which is prevented from dropping by the contact of the button 26 with the ends 27 of the cranked wires 28 and 29 see Figs. 1ª and 16; and the lever 224 is in such a position that the curved portion 188 of the wire 187 will be struck by the curved pad 229 near its junction with the straight portion 231.

The movement of the key frame 3 from the position shown in Figs. 1 and 1ª, to that shown in Figs. 3 and 3ª, moves the inclines 294 under the rods 290 and 291; the effect being the same with reference to both rods will be described with reference to the latter only. The screw 286 is to be so adjusted that the pad 287 will just touch the bar 291 when the parts are in the position shown in Figs. 3 and 3ª, when it is evident that the point 246 of contact between the pad 287 and 291 will be the fulcrum of the key 9, instead of the washer 17, which is the fulcrum of the key when the parts are in the position shown in Figs. 1 and 1ª, and as the point 246 is closer to the front of the key 9 than the washer 17, it follows that the inner end of the key will have a greater upward movement when the parts are in the position shown in Figs. 1 and 1ª, since the depth of movement of the front end of the key is the same in both cases. This greater movement of the inner end of the key is provided to give sufficient space for the full operation of the inertia-controlled means on its pivot 227 before the pad 229 strikes the wire 187.

The parts being in the position shown in Fig. 3, with the exception of the lever 312 which is to be considered as being in the position shown in Figs. 1 and 1ª until moved therefrom, as hereinafter explained, the performer places his feet upon the pedals 36, 32, depresses and releases them alternately in the manner customary with organs, player pianos, etc. During release the springs 123 restore the pedals 36 and 32 to the position shown in Fig. 1. This operation of the pedals 36 and 32 produces a partial vacuum in the air trunks 66, 124, 125. There are two air trunks corresponding to the air trunks 124 and 125 situated on the left side of the piano as shown in Fig. 2. Since the adjustment and operation of the piano are the same for the treble and bass sections, the adjustment and operation will be described with reference to the treble section only.

Since the chamber 138 communicates through the passage 139 with the chamber 131, and the latter communicates through the passage 130 with the air trunk 125, it follows that a partial vacuum also exists in the chambers 131 and 138, passage 135 and recess 133; and the external air coming into the recess 141 through the passage 143, tube 220 and hole 323, raises the leather over the recess 141, raises the block 142 and valve 137, thus terminating the connection of the passage 135 and recess 133 with the partial vacuum and placing them in communication with the external air, which raises the leather over the recess 133, and raises the block 134 and valve 154, thus terminating the connection of the air chamber 128 with the external air through the port 157, and placing it in communication with the partial vacuum through the port 153, hence a partial vacuum is maintained in the chamber 128. It will be noted that although the valve 154 is in its highest position, the button 325 on the end of its stem will not close the hole 323 in the lever 312, as this is in the position shown in Figs. 1 and 1ª.

A gentle upward movement of the inner end of the key causes the pad 229, near its junction with 231, to strike the curved portion 188 of the wire 187. This raises the valve 163 slightly through the lever 178 and wire 168, thus putting the corresponding channel 191 in communication with the partial vacuum through the port 159. The rise of the valve 163 allows the valve 172 to close the port 169 in the bottom board 170 of the channel box 171, thus terminating the connection of the same with the external air.

The slight opening of the port 159 by the valve 163 permits the air in the corresponding striker bellows 194 to be slowly exhausted, and a feeble blow is struck by the hammer 65, and the damper being held off the string in the usual manner, the string vibrates producing the ordinary fading tone as long as it is able to, should the front end of the key be held down, or as long as the key is held down should it be released before the tone has died away. When the striker bellows 194 is exhausted, the board 196 approaches the board 195, see Fig. 17, the block 213 pulls the top 212 of the wire 28 toward the right, thus raising its end 27, the button 26 and the abstract 20, thus causing the hammer 65 to strike the blow. When the key 9 is released the valve 163 closes the port 159 and the valve 172 opens the port 169, thus terminating the connection of the channel 191 with the vacuum and placing it in communication with the external air, the striker bellows 194 expands and the ac-

tion parts return to the position shown in Figs. 1 and 1ª, ready to strike another blow. While the key 9 is reurning to its initial position the part 261 of the lever 254 strikes the pad 264, and the lever 254 is forced into the position shown in Figs. 1 and 1ª, and the spring 247 returns the inertia-controlled means to the positions shown in said figures. In order to prevent the inertia of the metallic part 226 from moving same downward, when the inner end of the key terminates its downward movement by striking the pad 110, the rail 274 is adjusted to just touch the pad 241 on the metallic part 226.

Should the performer strike a blow somewhat harder than that above noted, the inner end of the key will rise much faster than before, and this increased velocity being communicated to the inertia-controlled means, formed by the wood part 224 and the metallic part 226, through the pivot 227 whose locus is a circle having 246 for a center during the early part of the key movement, causes the inertia-controlled means to turn on its pivot 227 to the position shown in Fig. 16; at the same time the spring 264 causes the lever 254 to turn on its pivot 253 and brings the pad 256 into the notch between the steps 233 and 234, thus preventing the return by the spring 247 of the inertia-controlled means to the position shown in Figs. 1 and 1ª. During the remaining part of the key movement, the pad 229 is brought into contact with the wire 187, the port 169 closed, and the valve 163 lifted a greater amount than before, since the part 228 is eccentric to the pivot 227 and the portion of the pad 229 near 230, which portion strikes the wire 187 is farther from the pivot 227 than the portion of the pad 229 near 231, which struck the wire 187 in the preceding instance. This greater lift of the valve 163, by reason of its tapered sides 165, opens a greater area of the port 159, the air is more rapidly exhausted from the bellows 194, and a harder blow is struck by the hammer 65, the tone produced having the characteristics before noted, and when the key is released the operation is as before. Thus it will be seen that the lift of the valve 163 and the force of the blow struck by the hammer 65, are functions of the speed impressed by the performer upon the key 9, the degree of vacuum maintained in the air chamber 128 remaining constant.

Heretofore there has been but a single blow of the hammer 65 on the strings for a single depression of the front end of the key, the force of the blow being a function of the speed impressed upon the key. I will now explain how the performer can change instantly from this setting of the instrument, to one in which the hammer 65 vibrates rapidly (the damper being lifted before the hammer strikes the string), striking the strings a rapid succession of blows as long as the front end of the key is held down the force of each blow being a function of the speed impressed upon the key. To do this the performer presses the knee lever 295 to the position shown dotted at 387; this pushes the stick 299 and lever 301 to the position shown dotted in Fig. 2; this raises the arm 305, and this movement of the arm 305 raises the bar 307 to the position shown in Figs. 3 and 3ª. During this movement of the bar 307 the extension 310 releases the lever 311, and the spring 319 forces said lever toward the position shown in Figs. 3 and 3ª until the offset 322 strikes the button 325, thus closing the hole 323 and cutting off the external air from the tube 220, passage 143, chamber 146, and recess 141, in all of which a partial vacuum is created, since the air therein is partially removed through the usual vent hole 145; this causes the valve 137 to drop, terminating the connection of the port 136, passage 135 and recess 133 with the atmospheric air, and placing them in communication with the partial vacuum in the chamber 138; this causes the valve 154 to drop, terminating the connection of the chamber 128 with the partial vacuum, and placing it in communication with the external air. While the valve 154 is dropping, the offset 322 follows the button 325 until the button 321 strikes the guide 156, when further downward movement of the lever 312 being prevented, the button 325, during the further downward movement of the valve 154, leaves the offset 322, thus opening the hole 323, when the atmospheric air rushing through the hole 323 raises the valve 137, as before explained, which causes the valve 154 to be raised which again closes the port from 128 to the external air and opens the port 153 to the partial vacuum. During the raising of the valve 154, the button 325 closes the hole 323, causing the valve 137 to again drop, which causes the valve 154 to again drop and again change the air chamber 128 from partial vacuum to plenum, and this cycle is repeated indefinitely. Thus as long as the knee lever 295 is held in the position 387, the valve 154 will continue to vibrate rapidly and change the air chamber 128 rapidly from plenum to vacuum to plenum, and the rapidity with which these changes occur is controlled in a measure by the adjustment of the screw 320 which on being screwed farther down through the lever 312 makes the button 325 contact with the offset 322 later in the rise of the valve 154 and defers the dropping of same, as it takes an appreciable time for the air to be removed through the vent 145 from the passages, etc., in communication with the hole 323; on the screw 320 being moved in the opposite direction the valve 154 drops

earlier. The rapidity of the changes is also regulated by regulating the size of the chamber 146 by the screw 149, for it is evident that the larger said chamber, the slower it will fill with air when the hole 323 is open and the slower it will empty when said hole is closed. Hence by regulating the screws 320 and 149 the most suitable speed of vibration of the valve 154 may be obtained, and the valve corresponding to 154 on the other side of the piano may be brought to vibrate at the same speed.

Bearing in mind that the air chamber 128 is rapidly changing from plenum to partial vacuum to plenum, should the performer strike the key a soft blow the valve 163 will be slightly opened, as before explained, and the corresponding bellows 194 will change from plenum to vacuum to plenum. In other words, the bellows board 196 will vibrate, causing the hammer 65 to strike a succession of soft blows, giving a soft sustained tone. Should the performer strike the key slightly harder, the valve 163 will open, slightly more, and the hammer 65 will strike a succession of slightly harder blows, giving a slightly louder sustained blow, and so on for the remaining two positions of the inertia controlled means.

While the piano is emitting a sustained tone, the key or keys being held down, the tone of the note or notes sounding may be increased in loudness by pressing the knee lever 295 from the position 387 still farther toward the right in Fig. 2, which causes the bar 307 to rise higher than the position shown in Figs. 3 and 3ª; this causes the extension 309 to press upwardly the extension 283 of the lever 281, thus moving the wire 279 and rail 258 to the left, see Figs. 3, 3ª and 16. During this movement the rail 258 passes over the top of the levers 224 belonging to the keys which have not been operated, strikes the pads 230 on the levers 224 belonging to the keys which have been operated, and moves said levers on their pivots 227, thus raising the valve 163, since the top of the lever 224 is eccentric.

The rail 258 may be moved until the valve 163 is fully raised, or it may be stopped at any intermediate point, thus giving a crescendo which may be sudden or gradual, depending on the speed with which the knee lever 295 is moved. Should the performer, either before or after the knee lever 295 is moved, desire to produce a diminuendo of any of or a plurality of the tones sounding, this can be accomplished by allowing the key or keys corresponding thereto to rise slightly, either gradually or suddenly, depending on whether a gradual or sudden diminuendo is desired.

It is evident that the bass rail 278 can be operated by the knee swell 296 independently of the treble rail 258, so that notes may be sounded with a crescendo in the bass section independently of the notes sounding in the treble; also, that there may be single blows for each depression of the keys in either the bass or treble section, while the other section is producing sustained tones.

For a general crescendo or diminuendo of all the sustained tones sounding, it is only necessary to pump harder or softer on the pedals 36, 32, which produces a greater or less degree of partial vacuum in the air trunk 128.

I have not shown the usual equalizer in communication with the pumping means, but this can be used if desired.

When it is desired to produce single blows of the hammer for each depression of the key in either section, the corresponding knee lever is allowed to come to the position shown by full lines in Fig. 2. When it is desired to restore the parts to the positions shown in Fig. 1, so that the piano can be played as an ordinary one, the performer places his toe under the pedal 38, and presses it up until the center of the pivot 58 is to the left of the line joining the center of the pivots 60 and 54, when the springs before noted accomplish the rest of the movements of the parts to the positions shown in Fig. 1.

The construction whose operation has just been described can produce the following effects. The keys in all cases are to be played upon with different speeds of attack for producing the loud or soft effects, and in case B and the following cases the parts are as shown in Fig. 3, and the pedals 36, 32 are to be pumped as before noted.

A. Parts in position shown in Fig. 1. Tone evanescent.

B. Knee levers in positions shown at 295, 296. Tone evanescent.

C. Knee lever 295 in position shown at 387. Tone evanescent in bass. Tone sustained in treble. General crescendo or diminuendo possible in treble, by a brisk or slow operation, respectively, of the pedals 36, 32. Diminuendo of any note in treble possible by simply allowing the finger end of the corresponding key to rise slightly.

D. Knee lever 296 in position corresponding to 387. Tone sustained in bass. Tone evanescent in treble. General crescendo or diminuendo, possible in bass, by a brisk or slow operation, respectively, of the pedals 36, 32. Diminuendo of any note in bass possible, by simply allowing the finger end of the corresponding key to rise slightly.

E. Knee lever 295 in position 387, and knee lever 296 in position corresponding to 387. Tone sustained in bass and treble. General crescendo or diminuendo possible in bass and treble by a brisk or slow operation, respectively, of the pedals 36, 32. Dimin-

uendo of any note in bass or treble possible by simply allowing the finger end of the corresponding key to rise slightly.

F. Knee lever same as in case E, and other conditions same. If 295 be moved farther to the right than 387, crescendo of all notes sounding in treble.

G. Same as F with reference to bass section.

H. Knee levers same as in case E, and other conditions same. 295 and 296 move as specified in cases F and G, crescendo of notes sounding in bass and treble.

In cases F, G and H, no crescendo is possible for any note whose valve 163 is in its highest position, excepting the crescendo obtainable by a brisker operation of the pedals 36, 32.

I will now explain the operation of my improved musical instrument when the variations shown in Figs. 29 to 38, inclusive, are used. When the parts are in the position shown in Figs. 29 and 31, which correspond to those shown in Fig. 1, the piano is played like an ordinary one. The key 9 works on the washer 7 as a fulcrum. When the key is depressed its motion is stopped at its front end by its washer 16 and at the rear end by the pad on the bottom edge of the rail 339, which strikes the offset 277 on the key 9, and during the depression of the key the recess 327 affords clearance around the rail 328. During the early part of the movement of the key 9, the portion 338 strikes the button 344, lifts same and the button 388 which, striking the incline 347, lifts the damper from the string. When the parts are in this position the effects marked A, above, are produced.

When the key frame 3 is moved from the position shown in Figs. 29 and 31, to that shown in Figs. 30 and 32, which movement is the same as that which takes place when the key frame is moved from the position shown in Fig. 1 to that shown in Fig. 3, the rods 290 and 291, only one of which, 291, is shown, slide up the inclines 294, which are made somewhat higher than those shown in the preceding figures, lifting the key 9 from the washer 17, as shown in Fig. 30. The movement of the key frame 3 also brings the key 9 forward, so that when it is depressed, its bottom will strike the rail 328, as shown in Fig. 32, the incline 294 and rails 328 and 335 being so arranged that the movement of the key will be the same as that of the key shown in Fig. 3, and the keys can be played and the effects produced as explained above in B to E inclusive. It is evident that the damper will be lifted as long as the key is held down independently of the movement of the lever 350, while the rapid succession of blows is struck. Should the performer desire to produce a crescendo of any note or notes in the treble, which are sounding without producing a crescendo independently of the remaining notes in the treble which may be sounding steadily or sounding diminuendo, he presses the knee lever 295 shown in Figs. 29 and 36 toward the right beyond a position corresponding to 387 in Fig. 2; this moves the rails 328 and 335 toward the dotted position shown in Fig. 32; then the performer can push the key whose tone he desires to increase farther down than the position shown in Fig. 32, consequently raising the valve 163 higher and increasing the tone. This additional movement of the key is determined in extent by the position to which the rails 328 and 335 are moved. The rail 328 is of such a height, with reference to the washer 16, that should the initial blow on the key be the softest possible, (the rail 38 being in the position shown by full lines in Fig. 32), this additional movement will be sufficient to lift the valve 163 to its highest position, thus affording means for a crescendo on any key in the treble from the softest to the loudest tone. The bass section is also controlled in a similar manner by a knee lever similar to 295 in Figs. 29 and 36; hence a crescendo can be played on any note independently of all the other notes, and explained with reference to the construction shown in Figs. 1 to 28, inclusive, a diminuendo can be played on any note. It will also be noted that if the performer desires to make any note or notes increase gradually from the softest to the loudest tone, he presses the appropriate knee lever to the limit of its movement, thus moving the rails 328 and 335 to the positions shown dotted in Fig. 32, when the key or keys being slowly depressed until the tone begins, there will result a gradual or sudden crescendo, depending on the speed with which the key is depressed after the tone begins.

Should the performer desire to sustain a note, or notes, in the treble, and the composition he is rendering requires him to use both hands in playing other notes, while the first-mentioned notes are sounding, he first sounds the first-mentioned notes at the loudness he desires, say at such a loudness as would correspond to the position of the lever 178 shown in Fig. 37. Then while holding the keys down, he presses upward on the knee bar 375, which moves the rail 366 to the position shown in Figs. 37 and 38; then the point 364 is caught by the leather covering 367, and the levers 178, corresponding to the note or notes sounding, are prevented from returning to their initial positions, even though the performer's fingers are removed from the corresponding keys. Thus the performer can retain these notes sounding indefinitely, while he is playing other notes, and the points 364 belonging to these last-named notes are prevented by the rib 368 from moving into a position where they

would be caught by the covering 367; hence when the corresponding keys are released these last-mentioned notes will cease. When the performer desires the first-mentioned notes to cease, he releases the knee bar 375, the levers 178 drop to their initial positions and the notes cease.

A knee bar similar to 375 being used to control the bass section, it follows that tones may be sustained in the bass section independently of those in the treble. Hence when the variations shown in Figs. 29 to 38 are used, the following forms of expression may be obtained, which are in addition to those specified in cases A to E:

I. Knee levers same as in case E, and other conditions same, if 295 be moved farther to the right than 387, possible crescendo of any notes sounding in the treble, depending upon which keys are depressed.

J. Same as I, with reference to bass section.

K. Knee levers same as in case E, and other conditions same, 295 and 296 moved as specified in cases I and J, crescendo of any notes sounding in bass and treble, depending upon which keys are depressed.

L. Same as B, but with either or both knee bars used and desired tones held sostenuto.

M. Same as C. Knee bars used as in L.
N. Same as D. Knee bar used as in L.
O. Same as E. Knee bar used as in L.
P. Same as I. Knee bar used as in L.
Q. Same as J. Knee bar used as in L.
R. Same as K. Knee bar used as in L.

In addition to the above, in which the keys were supposed to be struck a blow of the appropriate force and then the crescendo or diminuendo effects afterward obtained, there are three other effects obtainable as follows, by pressing the appropriate knee lever over to its fullest extent first, and then slowly depressing the key, a crescendo can be obtained from the softest to the loudest tone, and the diminuendo by allowing the key to come back slowly:

S. 295 pressed fully over, keys in treble slowly depressed, loudness of tone in treble varies with depth of key touch.

T. 296 pressed fully over, same as S with reference to bass.

U. 295 and 296 pressed fully over. Same as S and T simultaneous. In S and T the knee lever not specified may be operated in any of the modes before explained.

Thus I am enabled to build a key-board musical instrument having many capacities for expression over those heretofore in use, as for instance a change of tone color of a chord while sounding, obtained by making a crescendo or diminuendo on a certain note or notes of the chord. An inspection of the recess 327 and curve 338 will render it evident that the key frame 3 can be moved from the position shown in Fig. 29 to that shown in Fig. 30, even though the keys may have been struck and held down when the parts were as shown in Fig. 29, for it is evident that when the key frame 3 is moved, the key 9 will readily move with reference to its controlling rails from the position shown in Fig. 31 to that shown in Fig. 32.

While the construction shown has many capacities for expression many of these capacities may be dispensed with in making commercial instruments and the same rendered favorably comparable as regards simplicity with the pianos and organs in general use. These elisions being of a nature readily discernible to those skilled in the art to which this invention relates, will not be described.

While a musical instrument of this type, equipped with the variations shown in Figs. 29 to 38, would appear to entail an inordinate amount of labor on the performer, the reverse is the case, for the instrument sustains its own tone, and the performer, being relieved from the necessity of making the trills, rapid succession of chords, etc., which are necessary in playing the ordinary piano to cover up the defects of the instrument and keep the ear filled with music, can devote his attention exclusively to the expression of the composition he is rendering.

While I have shown the tone-producing means divided into but two sections for purposes of control, more sections may be made if desired, the number of controlling means being correspondingly increased.

I have shown the pedals 36, 32 as a means of controlling the degree of vacuum in the air trunk 128, but I consider any means of producing a partial vacuum in the trunk 128, the degree of which is under the control of the performer, to be within the scope of my invention.

While I have shown a rapidly vibrating hammer for sustaining the tone of the strings, I do not desire to be limited to this means, any stringed instrument having a source of power for maintaining the vibrations of the strings, and in which the loudness of tone is a function of the speed impressed upon the controlling means by the performer, or other means, the intensity of the source of energy, or both, I consider to be within the scope of my invention. It is evident that the amplitude of vibration of the strings may depend upon the speed of operation of the key, upon the depth of movement of the key or on both.

I claim as new:—

1. In a musical instrument, the combination of selecting means, strings, a source of energy for vibrating said strings, and means

for applying power from said source to said strings, the amount of power depending upon the speed of the selecting means and being uniform at will during any part of the time said means is held in the operative position, substantially as described.

2. In a musical instrument the combination of selecting means, strings, a source of energy for vibrating said strings, and means for varying the force derived from said source and applied to said strings, the force applied depending upon the speed of the selecting means and continuing uniform at will during any part of the operation of the selecting means, substantially as described.

3. In a musical instrument, the combination of selecting means, strings, and means for applying power to said strings, the amount of power depending upon the speed of the selecting means and being uniform at will during any part of the time said means is held in the operative position, substantially as described.

4. In a musical instrument the combination of selecting means, strings, a source of power and mechanism operated thereby for continuously vibrating said strings, and means for varying the amplitude of vibration depending upon the speed of the selecting means, substantially as described.

5. In a musical instrument the combination of selecting means, strings, means for continuously vibrating said strings with an amplitude of vibration depending upon the speed of the selecting means, and for increasing said amplitude at the will of the operator, substantially as described.

6. In a musical instrument the combination of selecting means, strings, means for continuously vibrating said strings with an amplitude of vibration depending upon the speed of the selecting means, and for decreasing said amplitude at the will of the operator, substantially as described.

7. In a musical instrument the combination of strings, keys, a lever carried by each of said keys, and means for sounding said strings loudly or softly depending on the extent of movement of said lever with reference to said key, substantially as described.

8. In a musical instrument the combination of selecting means, strings, a hammer, a source of power for operating said hammer, and means for causing said hammer to strike said strings a plurality of blows for each operation of the selecting means, the force of each blow being dependent upon the speed of the selecting means, substantially as described.

9. In a musical instrument the combination of selecting means, strings, and means for continuously vibrating said strings with an amplitude of vibration, depending first upon the speed and afterward upon the position of the selecting means, substantially as described.

10. In a musical instrument the combination of selecting means, strings, a hammer, and means for causing said hammer to strike said strings at will, either a single blow or a plurality of blows, for each operation of the selecting means, and independent of the duration of said operation, the force of each blow being dependent upon the speed communicated to the selecting means, substantially as described.

11. In a musical instrument the combination of selecting means, strings, a hammer, and means for causing said hammer to strike said strings at will, either a single blow or a plurality of blows for each operation of the selecting means, the force of each blow being dependent upon the speed and extent of movement of the selecting means, substantially as described.

12. In a musical instrument the combination of selecting means, strings, a source of energy for vibrating said strings, and means for applying power from said source to said strings, the amount of power depending upon the speed and extent of movement of the selecting means and the length of time said means is held in the operated position, substantially as described.

13. In a musical instrument the combination of selecting means, a string, a hammer, a source of power for operating said hammer, and means for causing said hammer to strike said string at will either a single blow or a plurality of blows for each operation of the selecting means, the force of each blow being dependent upon the extent of movement of the selecting means, substantially as described.

14. In a musical instrument the combination of longitudinally shiftable keys, pedals, tone-producing means operated by said keys, tone-modifying means operated by said pedals, and means for simultaneously shifting said keys in the direction of their length, and for terminating the operative relation between said modifying means and said pedals, substantially as described.

15. In a musical instrument the combination of sound producing means, a source of energy for sounding said sound producing means, keys and means operated thereby to sound said sound producing means, means operated by said key to control the sounding of said sound producing means by said source of energy, and means for either modifying the operation of said sound producing means by said keys, for transmitting energy to said source of energy at will, substantially as described.

16. In a musical instrument the combination of selecting means, strings, a source of

energy for vibrating said strings, and means for varying the quantity of energy applied per unit of time to said strings, the quantity depending upon the speed and extent of movement of the selecting means, substantially as described.

17. In a musical instrument the combination of selecting means, strings, and means for applying power to said strings, the amount of power depending upon the speed and extent of movement of the selecting means and the length of time said means is held in the operated position, substantially as described.

18. In a musical instrument the combination of selecting means, strings, and means for continuously vibrating said strings with an amplitude of vibration depending upon the speed and extent of movement of the selecting means, substantially as described.

19. In a musical instrument the combination of selecting means, strings, means for continuously vibrating said strings with an initial amplitude of vibration depending upon the speed and extent of movement of the selecting means, and for increasing said amplitude at the will of the operator, substantially as described.

20. In a musical instrument the combination of selecting means, strings, means for continuously vibrating said strings with an initial amplitude of vibration, depending first upon the speed and afterward upon the extent of movement of the selecting means, and for decreasing said amplitude at the will of the operator, substantially as described.

21. In a musical instrument the combination of strings, selecting means, a pneumatic mechanism for vibrating said strings, a source of air pressure, an air trunk, a port between said air trunk and said pneumatic mechanism, a valve to vary the effective area of said port, and means for moving said valve a variable distance by said selecting means, the distance depending upon the speed of said selecting means, substantially as described.

22. In a musical instrument the combination of strings, selecting means, a pneumatic mechanism for vibrating said strings, a source of air pressure, an air trunk, a port between said air trunk and said pneumatic mechanism, a valve to vary the effective area of said port, and means for moving said valve a variable distance by said selecting means, the distance varying first with the speed and afterward with the extent of movement of said selecting means, substantially as described.

23. In a musical instrument the combination of selecting means, strings, a hammer, and means for causing said hammer to strike said strings a plurality of blows for each operation of the selecting means, the force of each of the blows being first dependent upon the speed communicated to and afterward upon the extent of movement of the selecting means, substantially as described.

24. In a musical instrument the combination of pumpers, strings, pneumatic mechanisms for vibrating said strings, an air trunk connected to said pumpers, an air chamber connected to a plurality of said pneumatic mechanisms, a port between said air trunk and air chamber, a valve governing said port, and means for vibrating said valve by a source of power at will, substantially as described.

25. In a musical instrument the combination of pumpers, strings, pneumatic mechanisms for vibrating said strings, an air chamber connected to said pumpers, an air trunk connected to a plurality of said pneumatic mechanisms, a port between said air trunk and air chamber, a valve governing said port, means for vibrating said valve by a source of power at will, and means for adjusting the period of vibration of said valve, substantially as described.

26. In a musical instrument the combination of a sound producing means, a key and connections for manually operating said sound producing means, a source of energy for also operating said sound producing means, means for interrupting the connection between said key and said sound producing means and means for establishing a controlling relation between the said source of energy and said key, whereby the application of energy from said source to said sounding means is controlled.

27. In a musical instrument the combination of selecting means, sound producing means, a source of energy, means for operating said sound producing means either by said selecting means, or by said source of energy and means for shifting said selecting means from the position in which it operates the sound-producing means to that in which it controls the operation of said sound producing means by said source of energy, substantially as described.

28. In a musical instrument the combination of a key, sound producing means operated and controlled by said key, separate fulcrums for said key for use during its operating and controlling functions, respectively, and means for shifting said key into operative relation with either fulcrum at will, substantially as described.

29. In a musical instrument, the combination of a key, sound producing means operated or controlled by said key at will, means for causing said key to perform either the operating or controlling function, a stop for limiting the movement of the said key when said sound producing means is

operated by said key, a second stop for limiting the movement of the said key when said sound producing means is being controlled by said key, and means for varying the position of said last-named stop at will, substantially as described.

30. In a musical instrument the combination of a key, sound producing means, a hammer controlled by said key, a source of power for operating said hammer, means for determining at will whether a single operation of said key shall produce a single blow or a plurality of blows by said hammer, said determination being independent of the duration of said operation of said key, said key having an initial downward movement for sounding said single blow and the first of said plurality of blows, and means for decreasing the force of the remainder of said plurality of blows by an upward movement of said key after said initial downward movement, and for increasing the force of the remainder of said plurality of blows by a further downward movement of said key after said initial downward movement.

31. In a musical instrument the combination with a key, and means for producing a tone varying in loudness with the extent of movement of the key, of means for continuing the tone at the loudness determined by the extent of said movement after the full release of said key by the hand of the operator, substantially as described.

32. In a musical instrument the combination with a key, and means for producing a tone varying in loudness with the speed of movement of the key, of means for continuing the tone at the loudness determined by the speed of said movement after the full release of said key by the hand of the operator, substantially as described.

33. In a musical instrument the combination with a key, and means for producing a tone varying in loudness with the speed and extent of movement of the key, of means for continuing the tone at the loudness determined by the speed and extent of said movement after the full release of said key by the hand of the operator, substantially as described.

34. In a musical instrument the combination with a key, and with means for producing a tone varying in loudness with the extent of movement of the key, of means for continuing the tone at the loudness determined by the extent of said movement after the full release of said key by the hand of the operator, and for increasing said loudness at will, substantially as described.

35. In a musical instrument, a plurality of strings, a single selecting means for the strings of each note, means for communicating to said strings either a single impulse or a plurality of impulses for a single operation of said selecting means, and means for acting on said communicating means for changing at will from the communicating of a single impulse to the communicating of a plurality of impulses to any predetermined strings and vice versa.

36. In a musical instrument, the combination with a hammer, of a key, a plurality of devices separately operated or controlled by said key for operating said hammer, and means for limiting the movement of said key at will to the movement required to operate or control each of said devices separately.

37. In a musical instrument the combination of strings, a plurality of pneumatic mechanisms for vibrating said strings, an air chamber connected to said pneumatic mechanisms, and means operable at will to either pulsate the air in said air chamber, or to maintain a steady air pressure in said air chamber, substantially as described.

38. In a musical instrument the combination of strings, a plurality of hammers for vibrating said strings, pneumatic mechanisms for operating said hammers, an air chamber connected to said pneumatic mechanisms, and means operable at will to either pulsate the air in said air chamber, or to maintain a steady air pressure in said air chamber, substantially as described.

39. In a musical instrument the combination of strings, a plurality of pneumatic mechanisms and means operated thereby for vibrating said strings, an air chamber, means for pulsating the air in said air chamber, a valve between said air chamber and each of said pneumatic mechanisms, a selecting means for each valve and means for opening said valve a distance depending upon the speed of said selecting means, substantially as described.

40. In a musical instrument the combination of a spring, a pneumatic mechanism and means operated thereby for vibrating said string, and means for determining at will the degree of pressure communicated to said pneumatic mechanism, the degree varying with the speed of the determining means, substantially as described.

41. In a musical instrument the combination of strings, a plurality of pneumatic mechanisms and means operated thereby for vibrating said strings, an air chamber, means for pulsating the air in said air chamber, selecting means, valves between said air chamber and said pneumatic mechanisms, and means for opening said valves a distance depending upon the speed and extent of movement of the corresponding selecting means, substantially as described.

42. In a musical instrument, the combination of strings, pneumatic mechanisms and means operated thereby for vibrating said

strings, an air trunk containing air under a steady pressure, an air chamber connected to said pneumatic mechanisms and to said air trunk, means between said trunk and chamber for periodically varying the pressure of air in said chamber, and means for adjusting the period of the vibrations at will, substantially as described.

43. In a musical instrument the combination with a key and strings, of means controlled by said key for continuously sounding said strings with different degrees of force, the degree of force being determined by the velocity of said key, said degree of force continuing constant while said key is held down, substantially as described.

44. In a musical instrument the combination with a key, a string, and a source of power for sounding said string, of a moving member having a movement with reference to said key which varies with the velocity of said key, and means controlled by said member for applying said power to said string with varying degrees of force, the degree depending upon the extent of movement of said member, substantially as described.

45. In a musical instrument the combination with a key, a string, and a source of power for sounding said string, of a moving member having a movement with reference to said key which varies with the velocity of said key, and means controlled by said member for applying said power to said string continuously with varying degrees of force, the degree depending upon the extent of movement of said member, substantially as described.

46. In a musical instrument the combination with a key, a string, and a source of power for sounding said string, of a moving member having a movement with reference to said key which varies with the velocity of said key, means controlled by said member for applying said power to said string with varying degrees of force, the degree depending upon the extent of movement of said member, and a spring for regulating the movement of said member, substantially as described.

47. In a musical instrument the combination with a key, a string, and a source of power for sounding said string, of a moving member having a movement with reference to said key which varies with the velocity of said key, means for supporting said member near the limit of its movement, and means controlled by said member for applying said power to said string with varying degrees of force, the degree depending upon the extent of movement of said member, substantially as described.

48. The combination with a key, a pneumatic, a channel for said pneumatic and an air chamber, of a valve opening said channel to the external air, and a valve opening said channel to the air chamber and means operated by said key for moving said valves, the extent of movement of said last-named valve varying with the speed of the key, substantially as described.

49. The combination with a key, a pneumatic, a channel for said pneumatic and an air chamber, of a valve opening said channel to the external air, and a valve opening said channel to the air chamber and means operated by said key for moving said valve, the extent of movement of said last-named valve varying with the speed and extent of movement of the key, substantially as described.

50. In a musical instrument, the combination of strings, pneumatic mechanism for vibrating said strings, selecting means, a source of air pressure, and means for varying the degree of pressure communicated to said pneumatic mechanism, the degree varying with the speed and extent of movement of the selecting means, substantially as described.

51. The combination of sound-producing means and means for applying power thereto with a key, a lever carried by said key, a spring acting on said lever and counteracting all static forces tending to move said lever, said lever having an eccentric face and means controlled by said face to govern the application of power to said sound producing means, substantially as described.

52. The combination of sound producing means and means for applying power thereto with a key, a lever carried by said key, a spring acting on said lever and counteracting all static forces tending to move said lever, a detent for supporting said lever near the limit of its movement, said lever having an eccentric face and means controlled by said face to govern the application of power to said sound producing means, substantially as described.

53. The combination of sound producing means and means for applying power thereto with a key, a lever carried by said key, a spring acting on said lever and counteracting all static forces tending to move said lever, and a detent for supporting said lever near the limit of its movement by inertia, said lever having an eccentric face, and means controlled by said face to govern the application of power to said sound producing means, substantially as described.

54. In a musical instrument, the combination with a key, a string and a source of power for sounding said string, of a moving member having a movement with reference to said key which varies with the velocity of said key, means controlled by said member for applying said power to said

string with varying degrees of force, the degree depending upon the extent of movement of said member, and means for supporting said member near the limit of its movement, so that while supported it can be moved by said key.

In testimony whereof I affix my signature, in presence of two witnesses.

JOHN W. DARLEY, JR.

Witnesses:

RICHARD BLUE,

ELLA H. DARLEY.