

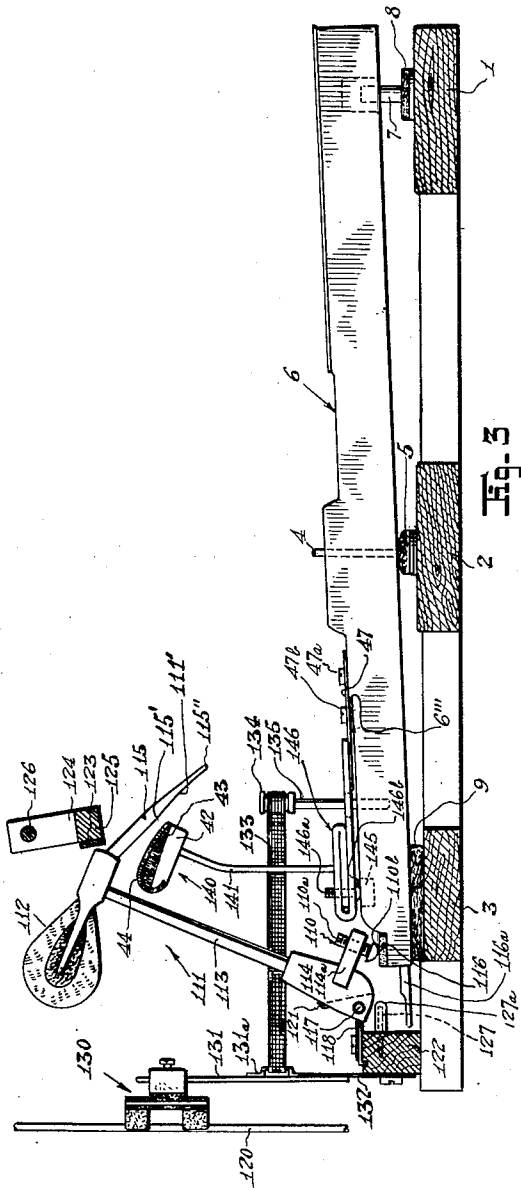
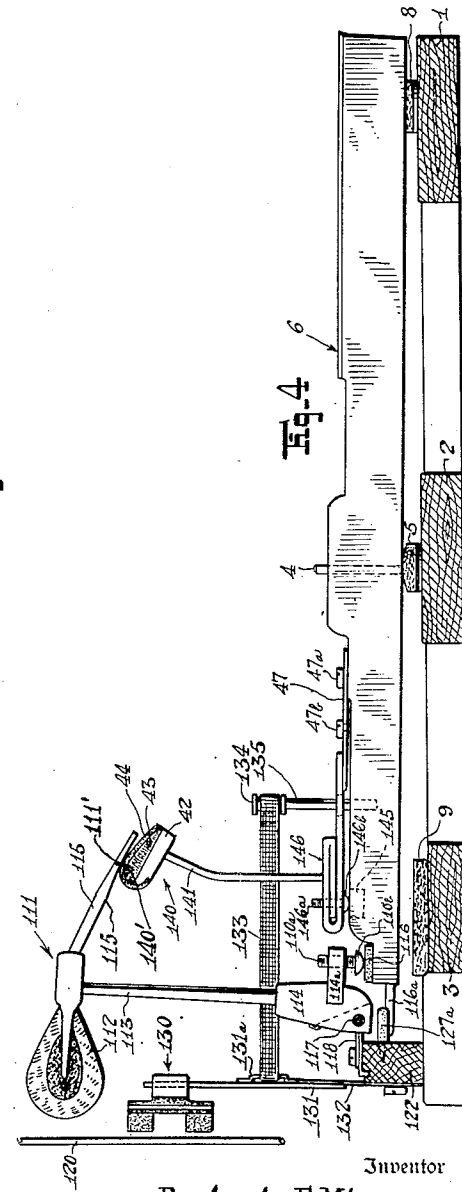
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VIBRATOR-EXCITING ACTION

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1

This invention relates to actions for the excitation of vibrators, such as the vibrators employed in musical instruments. The invention contemplates especially, though not in all aspects limitatively, instruments of the piano type, wherein tuned strings or other vibrators are percussively excited by hammers under the control of a keyboard. The description will accordingly be presented largely with relation to pianos.

In United States Patent No. 2,271,460 issued January 27, 1942, on an application of mine, I pointed out the relatively great complexity of a modern piano action of conventional design; and I disclosed and claimed a greatly simplified action from which there were eliminated the usual escapement mechanism (e. g., jack), checking mechanism (e. g., back-check), and repetition-aiding mechanism (e. g., repetition lever)—yet by which excellent and in some respects improved performance was achieved. In certain subsequent patent applications (Serial No. 556,166, filed September 28, 1944, now abandoned; Serial No. 566,979, filed December 7, 1944, now matured into U. S. Patent No. 2,469,568, dated May 10, 1949; and Serial No. 707,879, filed November 5, 1946) I disclosed and claimed modifications of and improvements on the actions disclosed in that patent.

In a more recent patent application (Serial No. 760,795, filed July 14, 1947) I disclosed a piano action having certain features in common with the actions of the patent and applications above-mentioned, but specifically different therefrom in that it retained the checking mechanism, or back-check, of conventional actions—still eliminating, however, the escapement and repetition mechanisms. In the action disclosed in that application the underlying requirement of a satisfactory action—that the hammer or other vibrator-exciting member be precluded, upon rebounding from the vibrator after its initial excitation thereof, from re-rebounding or “bouncing” back into a further contact (or series of further contacts) with the vibrator—was accomplished by a braking effect exerted on the hammer. For the exerting of that braking effect there was employed a back-check, or means of a generally similar nature—though of course in an arrangement wherein it performed functions further than and different from its functions in a conventional action. The back-check was effectively employed to exert the requisite braking effect without entailing the result which tends to occur from effective back-checking in a conventional action—the exertion of a detrimental effect on repetition. Further, the braking effect was caused to be a dynamic one—i. e., proportional to the need therefor.

2

It is an object of the present invention to provide a modified action characterized by the general functional features just outlined.

It is an object of the invention to provide an improved action characterized by those functional features.

In the action disclosed in the last mentioned co-pending application the elements which came into impingement with each other to exert the braking effect were the hammer and the back-check. It is an object of the present invention to provide alternative arrangements of those elements, wherein they will still, however, come into impingement with each other to exert the braking effect.

In the action disclosed in the last mentioned co-pending application the impingement between the elements above referred to occurred as a result of an oscillatory “swing” of one of those elements from its normal or slow-motion path. It is an object of the present invention to provide an arrangement in which the impingement between the elements required for the braking effect is not dependent on an oscillatory nature of swing of either element (though such a swing is permissible), but may be caused by a simple unilateral displacement of one of the elements.

In the action disclosed in the last mentioned co-pending application the digression of one of the elements from normal or slow-motion path to occasion the braking effect was a lateral displacement. It is an object of the present invention to utilize a terminal overshooting of the normal or slow-motion path as the digression causing the braking effect.

In the action disclosed in the last mentioned co-pending application the element arranged to digress significantly from its normal path to cause the braking effect was the hammer. It is an object of the present invention to effectively utilize the back-check as the digressing one of the elements.

In an action embodying the broad principles disclosed in the last mentioned co-pending application there may be associated with one of the elements, to cause and control its digression, both a resilient means and a mass. It is an object of the present invention to associate such a resilient means and mass with the back-check in a particularly convenient and effective manner.

Other and allied objects will more fully appear from the following description and the appended claims.

In the description of my invention hereinafter set forth, reference is had to the accompanying drawings, of which

Figure 1 is an elevational view of one embodiment of my invention, incorporated in an action of the grand-piano type;

Figure 2 is an elevational view of a portion of the apparatus of Figure 1 but illustrating the same with the components in positions which they occupy at a certain stage during operation;

Figure 3 is an elevational view of another embodiment of my invention, incorporated in an action of the upright-piano type; and

Figure 4 is an elevational view of a portion of the apparatus of Figure 3 but illustrating the same with the components in positions which they occupy at a certain stage during operation.

In Figure 1 the numerals 1, 2 and 3 respectively designate the front, intermediate and rear rails of the key-assembly portion of a piano action. Extending upwardly from the rail 2 is shown a pin 4, encircled by a bushing or pad 5; and a key 6 is shown pivotally assembled on that pin and resting on that pad. The front end of the key extends over the rail 1, which is provided with the guide pin 7 extending upwardly and freely into the key, that pin being encircled by the bushing or pad 8 underneath the key. The rear end of the key is shown in its normal position of rest against the top surface of the strip or pad 9, which in turn is secured on the top surface of the rear rail 3. Between the pivot pin 4 and the rear extremity of the key, the key 6 is provided with the upwardly extending capstan screw 10. The key assembly as so described will be recognized as well known.

Driven by the capstan screw 10, upon operation of the key 6 (i. e., downstroke of its forward extremity), is the hammer 11. This may be considered as comprising the hammer head 12; the hammer stem 13, at the rear end of which the hammer head 12 is attached; the hammer butt 14, in which the forward end of the hammer stem 13 is secured; and the pad 16 secured to the lower surface of the hammer butt 14. The butt 14, and thereby the entire hammer 11, is pivoted at 17 to a flange 18, which in turn is secured to a suitable rail 19 in the action.

The hammer 11 is coupled to the capstan screw 10, so as to be driven by the key 6, through a suitable coupling member such as 57. This may be in the form of a cylinder, for example of metal, with each of its end portions spun over into end-closing formation excepting for a relatively small central aperture—as shown in Figure 1 for the upper end of the member 57. In and extending downwardly from the hammer butt 14 through the pad 16, a short distance rearwardly from the pivot 17, there is secured a small pin 53; and in and extending upwardly from the capstan screw 10 there is secured a small pin 54. The parts are so positioned that the pin 53 is disposed approximately above the pin 54. The coupling member 57 may extend from the pad 16 to the capstan screw 10, excepting that a pad 58 of thin felt or the like may intervene between the top of the capstan screw and the bottom of the coupling member. The pins 53 and 54 respectively extend freely through the apertured ends of the coupling member.

The string which the hammer 11 is to strike is shown as 20, horizontally disposed above and in the path of movement of the hammer head 12 when the hammer pivots about 17. It will be understood that upon operation of the key 6 the attendant upward movement of the coupling member 57 will rock the butt 14 upwardly about

the pivot 17, carrying the hammer head 12 toward the string.

The capstan screw 10 may be so adjusted that at the conclusion of an abnormally slow operation of the key—i. e., one so slow that the coupling member remains in contact (through 53) with the capstan screw and the pad 16 remains in contact with the coupling member—the active (top) end of the hammer head 12 will have brought to a small distance from the string 20; this distance may be comparable, for example, to that to which in a conventional action the hammer head has been brought at the time of "tripping."

The normal position of the hammer will be fixed by the resting of the butt 14, through pad 16 and coupling member 57, against the capstan screw 10, and the resting of the rear end of the key through pad 9 on the rear rail 3. The downward displacement of this normal hammer position from the position occupied by the hammer at the conclusion of key operation (e. g., the key operation mentioned in the preceding paragraph) will of course be determined by the distance through which the capstan screw 10 moves during key operation—and this distance of capstan-screw travel is in turn established, as conventionally, by adjustments of the effective thicknesses of pads 8 and 5 (as by choice of the thicknesses of stacks 8a and 5a of paper or cardboard washers with which the fixed-thickness pads 8 and 5 may be supplemented), which adjustments of course fix the length of keystroke (as well as the normal key level).

Though not indispensable, it may be desired to provide some form of stop against "overshooting" of the hammer downwardly up key release (due to momentary yieldings of various parts such as pads 16, 9, etc.). Purely by way of example there has been shown under the hammer stem 12 a pad 23 of soft felt or the like, secured to the top of a removable rail 24. The positioning of the rail 24 and the thickness of the pad 23 will be such that on downward hammer movement to slightly below normal hammer position the hammer stem 12 will impinge against the pad 23—from which it will, however, normally have a slight spacing.

Simply by way of simplification of illustration, there has been omitted from Figure 1 any showing of the usual damper for the string 20; this may, however, be provided in any conventional manner.

When the key 6 is operated the hammer will be propelled toward the string, until the forward end of the key bottoms on the pad 8. At this point the movement of the key and of the coupling member 57 will be essentially stopped; in the case of stronger blows administered to the key, however, the key and coupling member will continue their movements for a small further distance with the pad 8 is being compressed to a slight degree, but any such continuance is at sharply reduced velocity. (Key and coupling member may execute a still further excursion, though only momentarily, while the upward inertia of the rear portion of the key momentarily causes a slight lifting of the key from its resting on pad 8; any such excursion will be relatively minute, however, and if troublesome in any degree may be precluded by means such, for example, as are shown in connection with a later embodiment of my invention herein.)

The hammer has been propelled by the coupling member up to the time of key impingement

on pad 8, and has acquired an upward inertia of its own. At this time, being free to continue its movement, it ceases to be propelled by the now-stopped or much-slowed coupling member, and moves on without discontinuity of velocity to strike the string. It produces an initial upward deflection of the string; it then moves downwardly with the string as the latter accelerates from its deflected position back toward its normal position, thus starting a rebound from the string.

As the string passes through its normal position and decelerates in its downward movement, the hammer under its own inertia (as well as gravity) leaves contact with the string and continues its rebound downwardly through the small distance required to bring it into impingement against the coupling member 57—assuming the key to have remained in operated position since the propulsion of the hammer by it. Of course if the key has not remained in operated position (i. e., if it has been released promptly after being struck) the downward passage of the hammer will continue through the very substantial distance required to restore it to its normal (Figure 1) position. While it will tend to overshoot that position, there have already been described means (i. e., pad 23) for relieving any resulting strains—and the hammer will be so far from the string that any re-rebounding toward the string is quite harmless.

If, however, the key has remained in operated position the hammer, upon passing through the small distance required to bring it into impingement against the coupling member 57, will come into such impingement and will then, by its inertia, cause a temporary compression of various compliant members in the system, including the hammer stem 13, the pad 16, the pad 5, the pad 58, and various other compliances (including the equivalent compliance of the pad 8 if that is then being compressed by pressure on the key, in that there will be occasioned a temporary de-compression of that pad), the hammer moving downwardly at decreasing velocity while yielding up its energy to those compliances. The hammer will then be moved upwardly, by the release of the energy acquired by those compliances, at a velocity which increases until the hammer has reached the point at which it began the compression of those compliances, by which time all the energy it delivered to those compliances (reduced only by dissipation therein) will have reappeared in the hammer in the form of upward inertia.

The foregoing outlines the action of the hammer in the absence of appropriate counteractive measures. And it will be understood that if such counteractive measures are not applied, the hammer will respond to its own inertia by continuing on toward the string, and will re-strike the string excepting in the special case of a relatively weak original striking. Upon rebounding from the string after the re-striking, or dropping down again without re-striking in the special case just mentioned, the hammer will enter the second cycle of an oscillation to and from the coupling member 57 which oscillation may be considered to have begun when the hammer first rebounded from the string after the original, intended striking. The only limitation of the number of cycles of this oscillation, in the absence of counteractive measures, is provided by the gradual dissipation of energy in the system—and the hammer may re-strike the string in as many as several of the early cycles of the oscillation. It was to prevent

such tonally ruinous occurrences that the escapement mechanisms of conventional actions were resorted to and are still employed.

According to the principles employed both in the disclosure of the last abovementioned copending application and in the instant invention, I apply a braking force to the hammer during its attempted oscillation to and from the coupling member 57; by such application I limit the oscillation to a harmlessly low magnitude and rapid attenuation. I apply this braking force in progressively greater degree the higher the velocity of key operation, with the results not only that the braking parts are saved from needless wear, but also that full reliability of operation is insured. And I limit the application of braking force to the period of attempted oscillation of the hammer, not only avoiding interference with the prior propulsion of hammer to string, but also leaving the hammer quite unbraked by the time it concludes its attempted oscillation—with the result that there is no interference whatsoever (such as occasioned in a conventional grand-piano action by a tight engagement of hammer tail with back-check) with immediate repetition.

Both in the prior disclosure and in that of the instant application the braking means is typically formed by the hammer as one element; by a second element with which the hammer may enter into impingement at proper times, to result in the frictional relative movement which is characteristic of a braking action; and by means for causing impingement between the two elements, or in other words rendering the braking means effective, at the proper times. As in the prior disclosure, I may again conveniently utilize for the second element a checking mechanism or back-check of which the hammer-engaging portion may be formed in general similarly to that of a conventional grand-piano back-check. According to the illustrated embodiments of the present invention, however, it is in the back-check or non-hammer element of the braking means that I incorporate the means for rendering the braking means effective.

In Figure 1 the back-check is designated generally as 40. Its portion arranged for immediate cooperation with the hammer may be formed by a block 42 of wood or other relatively hard material; a pad 43 of relatively soft felt or similar material secured against the upper forward surface of the block 42; and a facing 44 of leather or the like secured to the rear-top and forward-bottom portions of the block 42 and encircling the pad 43. The block 42 may be secured on the top extremity of a rod 41, the bottom end of which is fastened in a weight 46. This weight may be disposed within a recess 6' in the top of the rear portion of the key 6 and may normally rest, for example, on the bottom of that recess through a pad 45 of fairly hard felt or other slightly yieldable material. Secured to the top of the weight 46 is the rear extremity of a flat spring 47, the forward extremity of which is secured (as by screw 47a) to the top of the key 6 slightly forwardly of the recess 6'.

The front surface of the back-check is preferably arranged so that, progressing upwardly from the bottom, it gradually accomplishes a very slight reduction of its separation from the hammer pivot 17. The top surface of the back-check may be a convex one, progressing from the front surface along an arc of relatively small radius centered within the upper portion of the back-check. The result of this preferred construc-

tion is to provide, near the top elevational level of the back-check, a horizontal line or narrow region 40' whose separation from the hammer pivot 17 is less than that of any other part of the hammer-cooperating portion of the back-check.

The part of the hammer against which the back-check exerts its braking effect may be a hammer tail 15, generally similar to that conventionally provided in grand-piano actions. Such a hammer tail has been illustrated as 15, formed for example in the usual manner by a downward extension of the wooden core of the hammer head 12. While it is not indispensable, I prefer to incorporate in the hammer tail 15, to form its rear surface, a facing 15a of leather or similar material. The hammer tail 15 is desirably so shaped that the bottommost portion of the rear surface is rounded off downwardly and forwardly from the immediately higher portion, which latter may be approximately arcuately shaped about the hammer pivot 17, the two portions merging smoothly at the horizontal line or narrow region 11'.

The relative elevations of the regions 40' on the back-check and 11' on the hammer are preferably so established, by appropriate design of those two elements, that these regions are approximately opposite each other when the key, having been depressed very slowly, is being pressed against the pad 8 with force equal to that with which it is so pressed at the conclusion of a relatively strong blow on the key. The relative fore-and-aft positions of the back-check and hammer are preferably so established (and, for example, finely adjusted by bending of the rod 41) that the path of the back-check region 40' (which during the slow key motion has pivoted about the top of the pad 5) will just have arrived at an intersection with the path of the hammer region 11' (which of course pivots about 17) under the same conditions. These conditions are those under which the parts assume substantially the positions illustrated in Figure 2.

The designations 11' and 40' may be assigned to regions, on the surfaces of the hammer and back-check, respectively, each of which embraces the respective region 11' or 40' abovementioned and additionally includes a small surface portion immediately thereabove. It is between these regions 11' and 40' that impingement occurs at appropriate times between the hammer and the back-check.

The means which causes this impingement at those times is comprised in the back-check. It typically includes the weight 46 and the spring 47 already mentioned. It will be understood that the spring 47 constitutes a resilient or flexible portion; further, that this together with the mass of the weight 46 (augmented by the effective mass of the portions 41—42—43—44 of the back-check fastened to the weight) forms a unilateral mechanical oscillating or "swinging" system. The term "unilateral" is employed in view of the fact that swings in one direction (i. e., of the weight toward the key therebelow) are precluded by the normal resting of the weight through the pad 45 on the key. Swings in the opposite direction, however, are not precluded, and it is upon these swings that dependence is placed for bringing the regions 11' and 40' into impingement with each other to occasion the braking of the hammer.

Thus when the key 6 is depressed at any substantial velocity the mass, mentioned above, of the back-check acquires substantial kinetic

energy. When the key impinges on the pad 8 and the key velocity executes a rapid reduction to zero, the kinetic energy of the weight will cause the back-check to execute an excursion from its normal relationship to the key. The very first part of this excursion will comprise the release of such compression as the pad 45 may normally be subjected to; but the excursion will continue, with the weight 46 rising for a distance away from the pad. The upward velocity of the weight will of course be reducing and will eventually reach zero—at an interval after the beginning of the excursion determined by the mass abovementioned and the stiffness of the spring 47—whereupon the weight will start downwardly toward the key and will come back into impingement against the pad 45. The weight will then tend to temporarily compress the pad to a greater-than-normal degree, then to move upwardly again, and so on, oscillatorily; but the relative incompressibility of the pad 45 will prevent any very substantial displacement of the weight toward the key beyond its normal position relative to the key, while the inherent damping action of the pad 45 will preclude any very appreciable continuance of the oscillatory tendencies. It may be mentioned that this damping action may, if desired, be increased by the employment, instead of felt or the like for the pad 45, of a more viscous (i. e., energy-absorptive) material such, for example, as Butyl rubber.

So long as the weight 46 moves with the key, the back-check movement is a pivotal one about the top of pad 5—thus being very nearly vertical, its path forming a relatively oblique angle with the path of movement of the hammer region 11'. The continued movement of the back-check just described, however, becomes a pivotal one about the effective point of its securing (i. e., the securing of the spring 47) to the key. It will readily be appreciated that this latter movement, as felt at the region 40', has a large forward component (e. g., of the same order of magnitude as the vertical component) and that it is therefore much more nearly at right angles to the path of the hammer region 11'. In the absence of any screw through the spring 47 other than the screw 47a which secures that spring to the key, the effective pivoting point for the continued back-check movement would be substantially at that screw. I prefer, however, to employ another screw 47b a little to the rear of screw 47a, passing the screw 47b freely through the spring and on down into the key, which I provide with a slight recess 6'' (merging into the larger recess 6' to the rear of it) underneath the spring at this fore-and-aft position. By turning the screw 47b I am able to adjust the pressure with which the weight 46 normally rests on the pad 45, and to some extent the effective stiffness of the spring 47. The presence of the screw 47b of course causes some rearward displacement of the effective pivoting center for the continued back-check movement.

When key depression has been carried to the point where the key first touches the top of the pad 8, the hammer will have reached a position a trifle lower, and the back-check a position a trifle lower and more rearward, than the positions typically illustrated in Figure 2. The key movement then being rapidly slowed to zero, the two elements just mentioned will nevertheless continue their respective movements. In view of its many-times greater velocity, and assuming an

appropriate establishment of the mass and stiffness of the back-check elements, the hammer will have passed its Figure 2 position sooner than—typically, it will have reached the string when—the back-check has reached its Figure 2 position.

As the back-check passes its Figure 2 position its region 40' intersects the path of movement of the hammer region 11'. If at this time the hammer has already rebounded somewhat from the string, impingement of the region 40' and the region 11' will occur substantially forthwith. If the hammer has not yet significantly rebounded, its region 11' will be above the back-check region 40', but still elevationally opposite and close to some higher part of the region 40'—and the first small interval of hammer rebound will be sufficient for the movements of back-check and hammer to occasion impingement of the region 40' and the region 11'. In any case the region 40' and the region 11' will come into impingement with each other, and the hammer will drive down for an interval in contact with the back-check—the parts (especially the pad 43 in the back-check) yielding while that contact continues.

This contact, since it depends on the unilateral swing of the back-check out of normal relationship to the key, is of course temporary only—and, since it is influenced by the magnitude of the swing, its duration will be less with low than with high key velocities. Its duration is ample, however, for the resulting frictional energy dissipation to attenuate the energy of the rebounding hammer amply to preclude its reaching the string on any re-rebound from the coupling member 57, if not to preclude any such re-rebound altogether—and the shorter duration with lower key velocities is entirely permissible since the braking requirements are inherently less with those lower key velocities. It will further be understood that the temporary nature of the contact leaves the hammer free of any continued restraint by the back-check, so that perfection of repetition is assured.

The choice of mass of the weight 46 and stiffness of the spring 47, while important, is in no sense critical. And with any given values of those parameters a considerable latitude for adjustment is provided by the screw 47b above-mentioned.

In Figures 3 and 4 I have illustrated an embodiment of my invention in an action for use in an upright piano. Herein there appear, as in earlier figures, the rails 1, 2 and 3; the pivot pin 4; the pad 5; the key 6; the guide pin 7; the pad 8; and the strip 9. The key at its rear extremity may carry the pad 116 of relatively hard felt or, if desired, of more viscous material such for example as butyl rubber. On this pad may normally rest the round head 110b of an adjusting screw 110 hereinafter mentioned.

The hammer appears as 111, and includes a rearwardly directed head 112, a stem 113 at the top of which the head 112 is carried, and a butt 114 from which the stem 113 extends upwardly. The butt 114 is pivoted at 117 to a flange 118 which extends rearwardly from the pivot to be secured to the top of a suitable rail 122. The butt 114 is provided with a forwardly extending "shoe" 114a through which, at a little distance from the main body of the butt, there passes the adjusting screw 110 above-mentioned. The top of this screw may be provided with a screw-driver slot 110a for adjusting purposes, while the bottom of the screw may be formed into the

round head 110b already seen to rest normally on the pad 116. A spring 121, one extremity of which appears in Figure 3, may be employed in association with the pivot 117 to lightly urge the hammer forwardly about the pivot.

The string which the hammer 111 is to strike is shown as 120, vertically disposed behind and in the path of movement of the hammer head 112. It will be understood that upon depression of the key the upward movement of the pad 116 will rock upwardly the screw 110, thus rocking the entire hammer and carrying the head 112 toward the string. The screw 110 may be so adjusted that at the conclusion of an abnormally slow depression of the key the hammer head 112 will have been brought to a relatively small distance from the string. The normal position of the hammer will be fixed by the resting of the screw 110 on the pad 116 and the resting of the rear end of the key on pad 9—all in analogy to the fixing of the normal position of the hammer in the earlier-described embodiment of my invention, and subject to similar comments as to adjustments.

As a stop against "overshooting" of the hammer forwardly upon key release (due to momentary yieldings of various compliant parts), with consequent strain on the hammer stem 112, there may be provided a rail 124 carrying a strip 123 of soft felt or the like on its rear surface, in such a position that on forward hammer motion to slightly beyond normal hammer position the front end of the hammer head 112 will impinge against the strip 123—from which it will, however, normally have a slight spacing. If it be desired that the hammer at times have a reduced spacing from the string 120, the rail 124 may be moved rearwardly—for which purpose it has been shown as forming the cross-arm of a bail one of whose side-arms appears as 125, pivoted at 126 to permit the just-mentioned rearward movement (which may be effected by the usual "soft pedal," not shown). As usual under conditions of less-than-normal hammer-to-string spacing, the key-hammer contact (at 116—110b) will be opened up until some initial portion of key depression has been completed.

As a stop against momentary overshooting upwardly by the rear end of the key—which may tend to occur as a result of the key momentarily rising out of contact with the pad 5 at the conclusion of a depression of its forward end—I have shown a stop member 127 extending forwardly from the rail 122; the surface of this stop member may be provided with a covering 127a of slightly compressible and preferably viscous material such, for example, as butyl rubber. A shoe 116a may extend rearwardly from the rear end of the key under the stop member 127, at such an elevation that upon key depression it will essentially exhaust the compressibility of the covering 127a when pressure on the front end of the key has essentially exhausted the compressibility of the pad 5. The use of such a stop member, which is of course not limited to the presently described embodiment, will be understood simply to insure that behaviour of the rear end of the key which is to be expected from the manipulation of the front end of the key.

It will be understood that, with the pad 116 considered as replacing the coupling member 57 of the earlier-described embodiment, the same general organization of elements is present as in that embodiment; that the manner of basic operation, subject only to the obvious interchange

of rearward for upward hammer movement, is similar; and that similar hammer-oscillation problems are encountered and must be dealt with. In this embodiment I employ essentially similar means for solving those problems, but with variations appropriate to the altered arrangement of the hammer relative to the key. Thus I again employ a back-check carried by the key, and a hammer tail with which the back-check may come into impingement; but whereas in the earlier-described embodiment the back-check was arranged to cooperate with the outer face of the hammer tail (i. e., the face more remote from the hammer pivot), I reverse that arrangement in the instant embodiment and place the back-check so as to cooperate with the inner (or pivot-ward) face of the hammer tail.

By way of optional variations not necessarily peculiar to the present embodiment, I omit from the active surface of the hammer tail therein any covering such as the leather or similar facing 15a of the earlier embodiment; and I continue the active hammer-tail surface smoothly to beyond the outermost point or region thereon where the back-check could impinge, thus eliminating any such feature as the rounded-off bottom extremity of the hammer tail of the earlier embodiment.

The hammer tail in Figures 3-4 is designated as 115; while no limitation thereto is intended, it is shown formed as an attachment to the core of the hammer head 112, rather than as an integral piece therewith. From its secure attachment to that core the tail 115 extends diagonally downwardly and forwardly. Starting at a point 115' part-way out along the tail from the hammer head proper (which point is closer to the hammer pivot 117 than is any part of the tail nearer the stem 113), and continuing on to the end 115'' of the tail, the inner (pivot-ward) surface of the tail 115 is approximately arcuately formed, typically with a radius of the order of magnitude of the separation between point 115' and pivot 117, but about a center forwardly displaced from that pivot the end and outer surfaces of the tail may be of any convenient configuration.

The back-check in Figures 3-4 is designated generally as 140. It may comprise a block 42, pad 43 and facing 44 respectively similar to the corresponding parts of the back-check earlier described; the rod 141 extending generally downwardly from the block 42 which is secured thereon, in this instance however from the longer-dimension (rather than the end) face of that block; the weight 146, from which the rod 141 extends upwardly, and which is conveniently formed of a flat strip of heavy metal twice folded back upon itself and clamped in its folded state by the screw 146a threaded through its several folds; and the spring 47 at the rear end of which the weight 146 is secured, and the front end of which is secured to the top of the key by the screw 47a. Beginning just behind the screw 47a the key may be slightly reduced in height, as indicated at the slight shoulder 6''; and the screw 47b may be passed freely through the spring 47 and into the reduced-height portion of the key—for the same function as the screw 47b of the earlier embodiment. The pad 45 of that embodiment may be replaced in this by a plug-shaped pad 145 inset into the top of the key underneath the screw 146a and normally borne on by the downwardly directed head 146b of that screw.

The back-check 140 is arranged with its fac-

ing 44 disposed toward the hammer stem 113 and tail 115; with the key in rest position the back-check may have only a slight spacing from that stem. Its portion 42-43-44 may be oriented so as to cause its portion furthest from the hammer pivot 117 to be a horizontal line or narrow region 140' generally corresponding to 40' of the earlier embodiment; such orientation is readily accomplished by a bending of the rod 141 at a point a little below 42.

When the key, having been depressed very slowly, is being pressed against the pad 8 with force equal to that with which it is so pressed at the conclusion of a relatively strong blow on the key—the conditions approximately illustrated in Figure 4—the hammer and hammer tail will have been moved rearwardly about 117 (bringing the hammer head to a small separation from the string), and the back-check will have been moved a smaller distance upwardly and forwardly about the top of pad 5. The parts may be so adjusted (final adjustment being, for example, by turning of the screw 146a to lower or raise its head 146b) that then the back-check region 140' is opposite (below) an intermediate portion of the inner surface of the hammer tail lying between 115' and 115'' (which surface portion is conveniently designated as 111'), and is just out of frictional contact therewith.

It will be apparent that the back-check—spring 47 together with the weight 146 augmented by the effective mass of the portions 141-42-43-44 fastened to the weight—forms a unilateral mechanical swinging system analogous to the one described in connection with the earlier embodiment. As in that embodiment, when the key is depressed at any substantial velocity the mass of the back-check acquires substantial kinetic energy, and that when the key impinges on the pad 8 this kinetic energy will cause the back-check to execute an excursion from its normal relationship to the key. As in the earlier embodiment, this further excursion will involve an upward and forward movement of the back-check about the screw 47b as an approximate pivot. And, in correspondence with the earlier embodiment, the hammer will have passed its Figure 4 position slightly sooner than the back-check reaches its Figure 4 position, and will strike the string without interference from the back-check.

But as the back-check passes its Figure 4 position its region 140' nearest the hammer tail will have intersected the path of movement of the hammer-tail surface portion 111'. If at this time the hammer has rebounded sufficiently from the string to bring the hammer-tail portion 111' above the back-check portion 140', impingement between the two portions will occur substantially forthwith. If the hammer has not yet rebounded that far, the back-check will continue its excursion for a minute further distance, and there will then occur an impingement between the back-check portion 140' and a hammer-tail surface portion slightly forward of the portion 111'—the radial formation of the inner surface of the tail 115 about a center forwardly displaced from 117 causing it to act against the back-check as a cam, thus rendering especially non-critical the exact region along that surface at which the impingement may occur.

Again, of course, the contact of hammer-tail and back-check is temporary only, is of duration dependent on key velocity, is ample in duration for the resulting frictional energy dissipa-

tion to sufficiently attenuate the energy of the rebounding hammer, and very promptly leaves the hammer in condition for effective repetition.

In Figures 3-4 I have shown a damper 130, secured on a vertical rod 131 near the top of the latter. The bottom portion of the rod 131 may be secured to the vertical part of a small spring bracket 132, the horizontal part of which may be secured to the rail 122; the spring bracket 132 may bias the damper against the string. At an intermediate point on the rod 131 there may be welded to its forward surface the extremities of a small stirrup 131a, and through this stirrup there may be passed a loop forming the rear extremity of a flexible tape 133. This tape may extend forwardly, passing alongside the hammer stem 13, and may terminate in a loop encircling a small spool 134. This spool may surround and frictionally engage a rod 135 extending upwardly from the key 6 between the key-pivoting rod 4 and the rear extremity of the key. The tape 133 will be of such a length that normally it will be a trifle slack; upon key depression, however, the spool 134 will be moved upwardly and forwardly in an arc about the top of pad 5, and the tape will be pulled forwardly by the forward component of the spool movement, taking the slack out of the tape and pulling the damper out of contact with the string. The distance of movement of the damper effected by key depression may of course be varied by sliding the spool up and down along the rod 135.

While I have disclosed my invention in terms of particular embodiments thereof, and with reference to a piano as a typical instrument and to a string as a typical vibrator, I intend thereby no unnecessary limitations. Modifications in many respects will be suggested by my disclosure to those skilled in the art, and such modifications will not necessarily constitute departures from the spirit of my invention or from its scope, which I undertake to define in the following claims.

I claim:

1. In a key-operated action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; means, continuously retained in a hammer-propelling path and moved by key operation to a limiting position in that path, for propelling the hammer toward the vibrator, to and from which means while in that position the hammer attempts to oscillate after striking the vibrator; and means, comprising a mass carried by and placed in motion by the key and a flexible member interposed between said mass and the key, for braking the hammer during such attempted oscillation only.

2. In a key-operated action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; means, moved by the key in a hammer-propelling path and retained in a limiting position in that path while the key remains operated, for propelling the hammer toward the vibrator, to and from which means while in that position the hammer attempts to oscillate after striking the vibrator; and inertia-controlled means, carried by the key and responsive to the velocity of operation thereof, for applying to the hammer in such attempted oscillation thereof a braking force variable in accordance with such velocity.

3. In a key-operated action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; means, moved by the key in a hammer-propelling path and retained

in a limiting position in that path while the key remains operated, for propelling the hammer toward the vibrator, to and from which means while in that position the hammer attempts to oscillate after striking the vibrator; normally inoperative means carried by the key for braking the hammer; a flexible member included in said braking means to permit its establishment in operative condition; and inertia means included in said braking means and cooperating with said flexible member to maintain the braking means in inoperative condition during hammer propulsion but to place the braking means in operative condition during such attempted hammer oscillation.

4. In a key-operated action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; means, moved by the key in a hammer-propelling path and retained in a limiting position in that path while the key remains operated, for propelling the hammer toward the vibrator, to and from which means while in that position the hammer attempts to oscillate after striking the vibrator; a back-check moved by the key, free of interference with the hammer element when the key is operated at very low velocity; and means, included in the back-check and rendered effective by inertia upon operation of the key at higher velocities, for causing impingement between the back-check and the hammer during such attempted hammer oscillation.

5. In a key-operated action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; means, moved by the key in a hammer-propelling path and retained in a limiting position in that path while the key remains operated, for propelling the hammer toward the vibrator, to and from which means while in that position the hammer attempts to oscillate after striking the vibrator; a back-check moved, normally free of interference with the hammer, by the key; a flexible member included in said back-check to permit impingement between the back-check and the hammer; and inertia means included in the back-check and cooperating with said flexible member to maintain the back-check free of the hammer during hammer propulsion but to cause impingement between the back-check and the hammer during such attempted hammer oscillation.

6. In an action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator, from which after such striking the hammer rebounds; a movable key for propelling the hammer toward the vibrator; and means, moved by the key during key movement and rendered effective only by its own kinetic energy acquired during such movement by the key, for frictionally engaging the rebounding hammer.

7. In an action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator, from which after such striking the hammer rebounds; a limitedly movable key for propelling the hammer toward the vibrator; and means, flexibly carried by the key and responsive to the abrupt stoppage of key movement, for braking the rebounding hammer.

8. In an action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator, from which after such striking the hammer rebounds; a movable key for propelling the hammer toward the vibrator, and stop means against which the moving key impinges; and means for braking the rebounding hammer, com-

15

prising a unilateral mechanical swinging system energized by key movement and swingingly responsive to the impingement of the key against said stop means.

9. In an action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator; a movable key for propelling the hammer toward the vibrator; and a back-check moved by the key during key movement and thereafter subjected to movement by its own kinetic energy acquired during such movement by the key, the back-check being positioned to be engaged by the hammer during such further movement only.

10. In an action for exciting the vibrator of a musical instrument, a hammer movable to strike the vibrator, from which after such striking the hammer rebounds; a movable key for propelling the hammer toward the vibrator; and a back-

16

check for the hammer moved by the key through a range free of interference with the hammer, both during propulsion and rebound thereof when the key is very slowly operated, and means comprised in the back-check for extending its range of movement in response to key operation at higher velocities.

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