Feb. 28, 1961 H. B. RHODES 2,972,922

ELECTRICAL MUSICAL INSTRUMENT IN THE NATURE OF A PIANO

Filed March 9, 1959 2 Sheets-Sheet 1

Fig. 1.

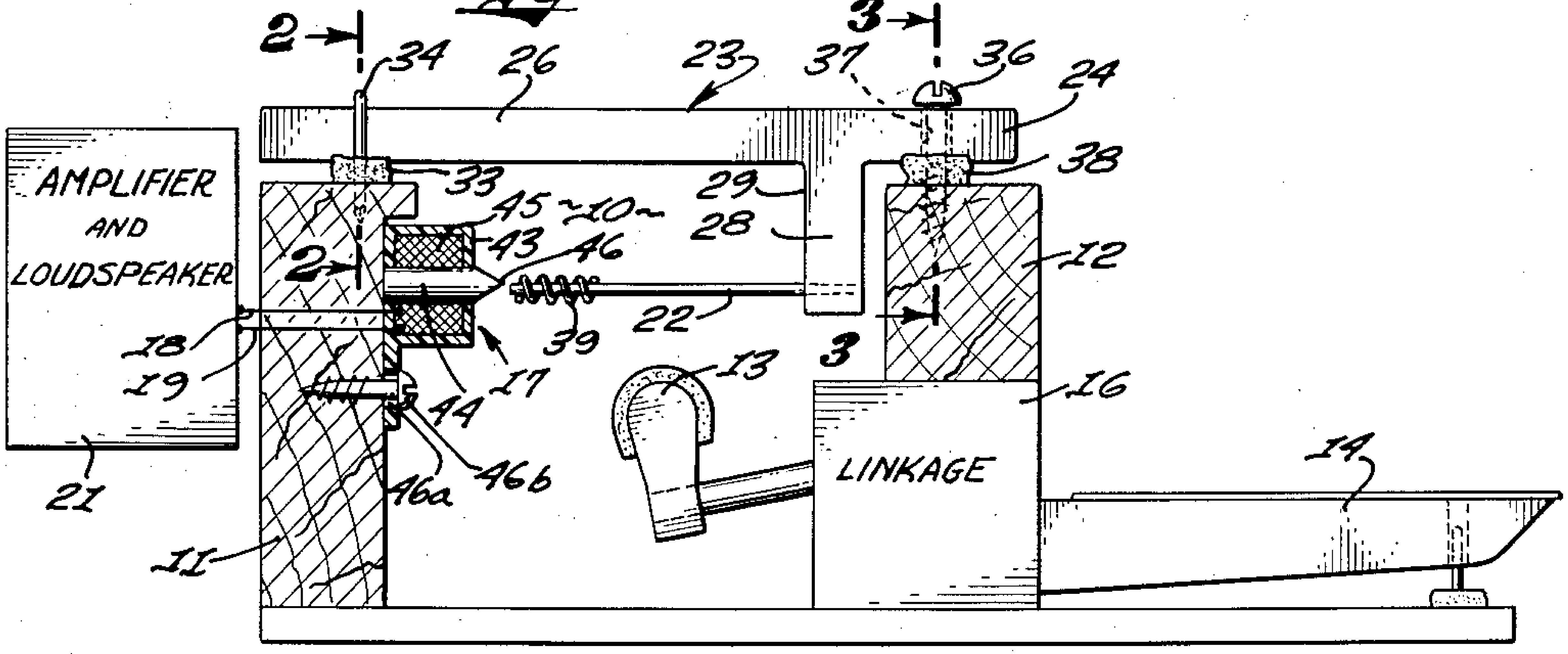


Fig. 2.

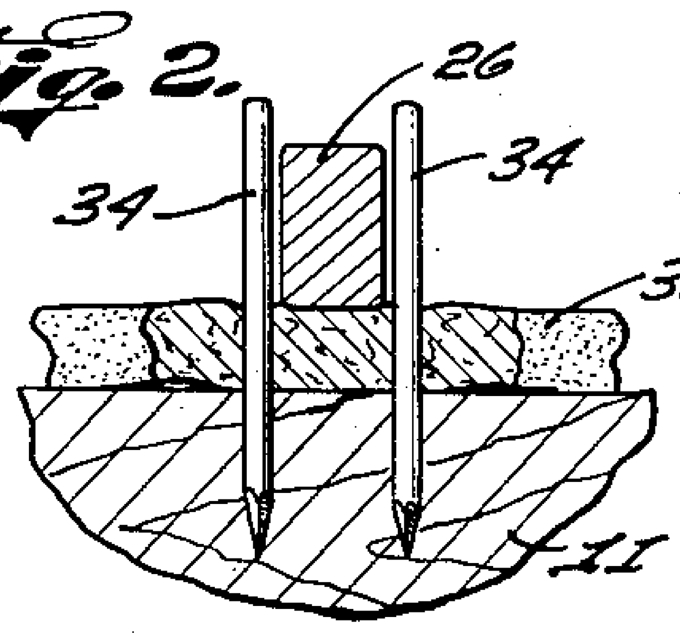


Fig. 3.

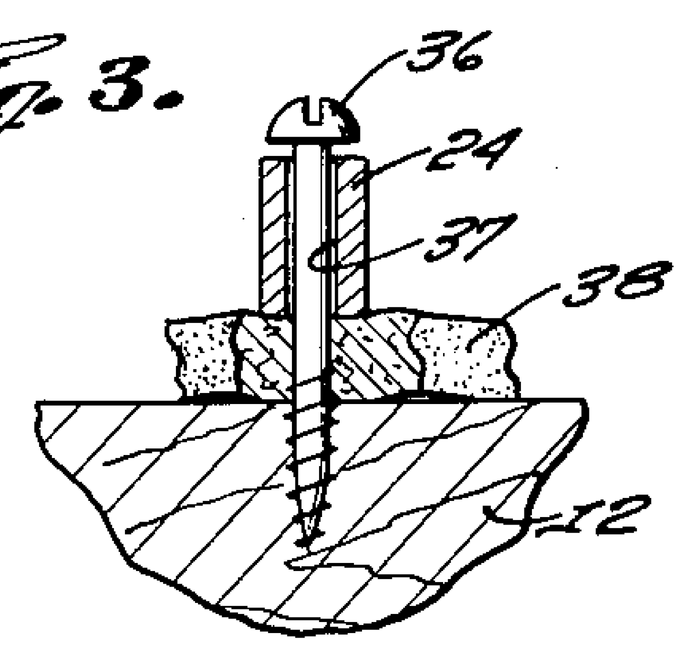


Fig. 4.

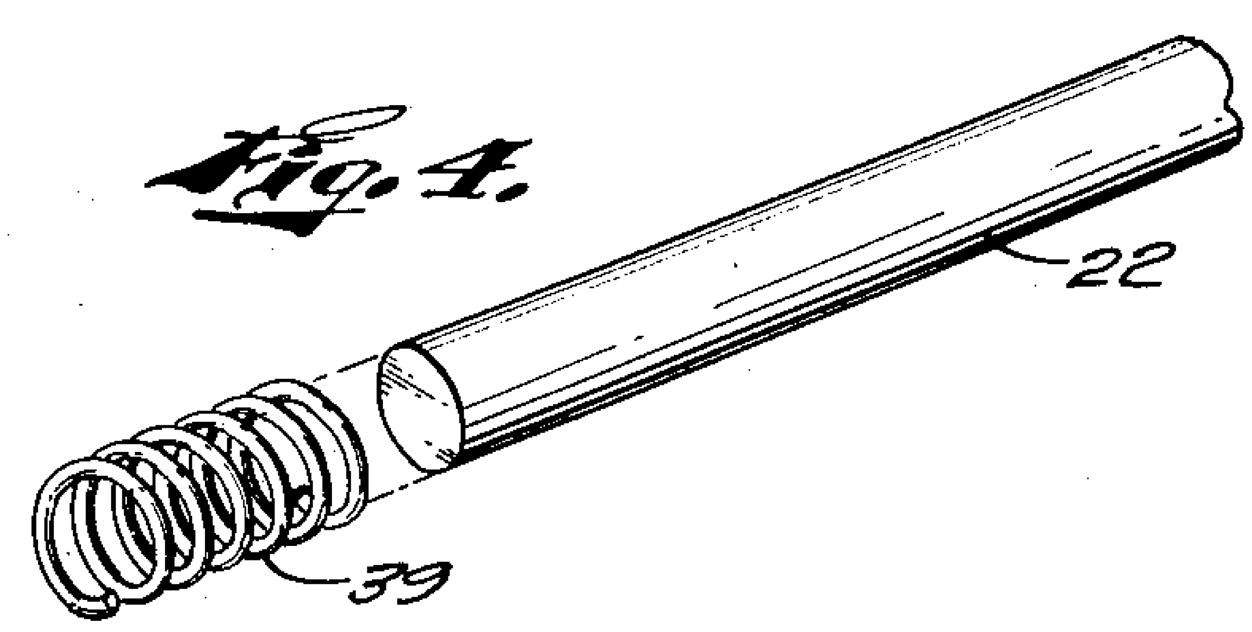
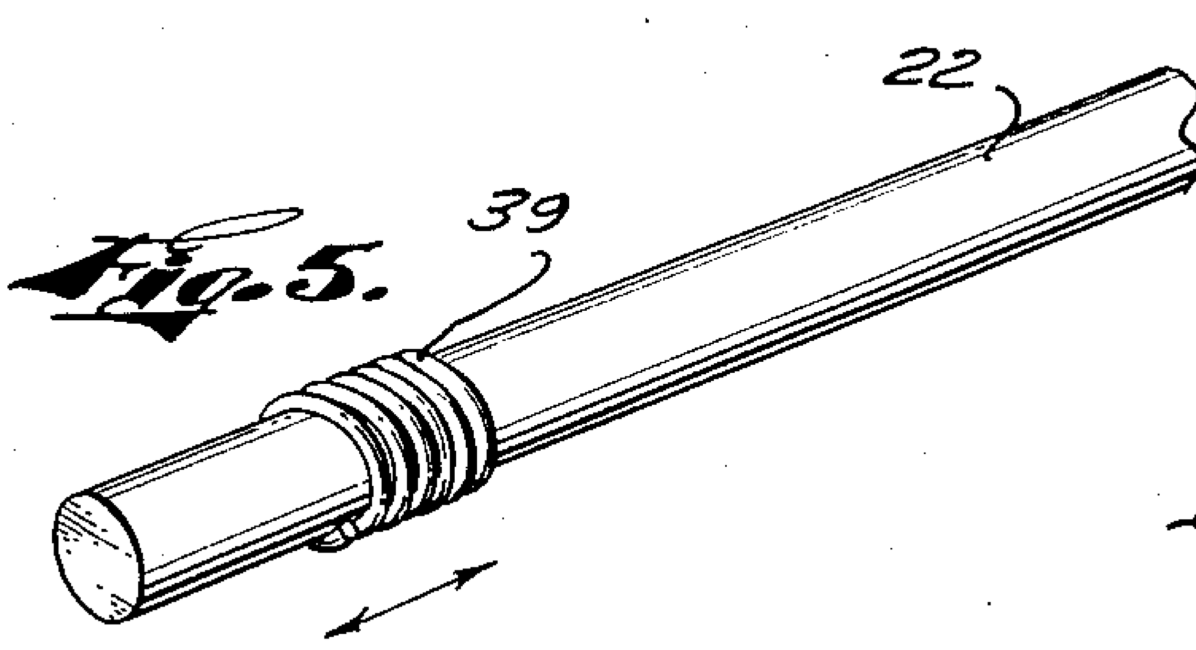


Fig. 5.



INVENTOR.
HAROLD B. RHODES
BY Richard [signature]
ATTORNEY

Feb. 28, 1961 H. B. RHODES 2,972,922

ELECTRICAL MUSICAL INSTRUMENT IN THE NATURE OF A PIANO

Filed March 9, 1959 2 Sheets-Sheet 2

Fig. 6.

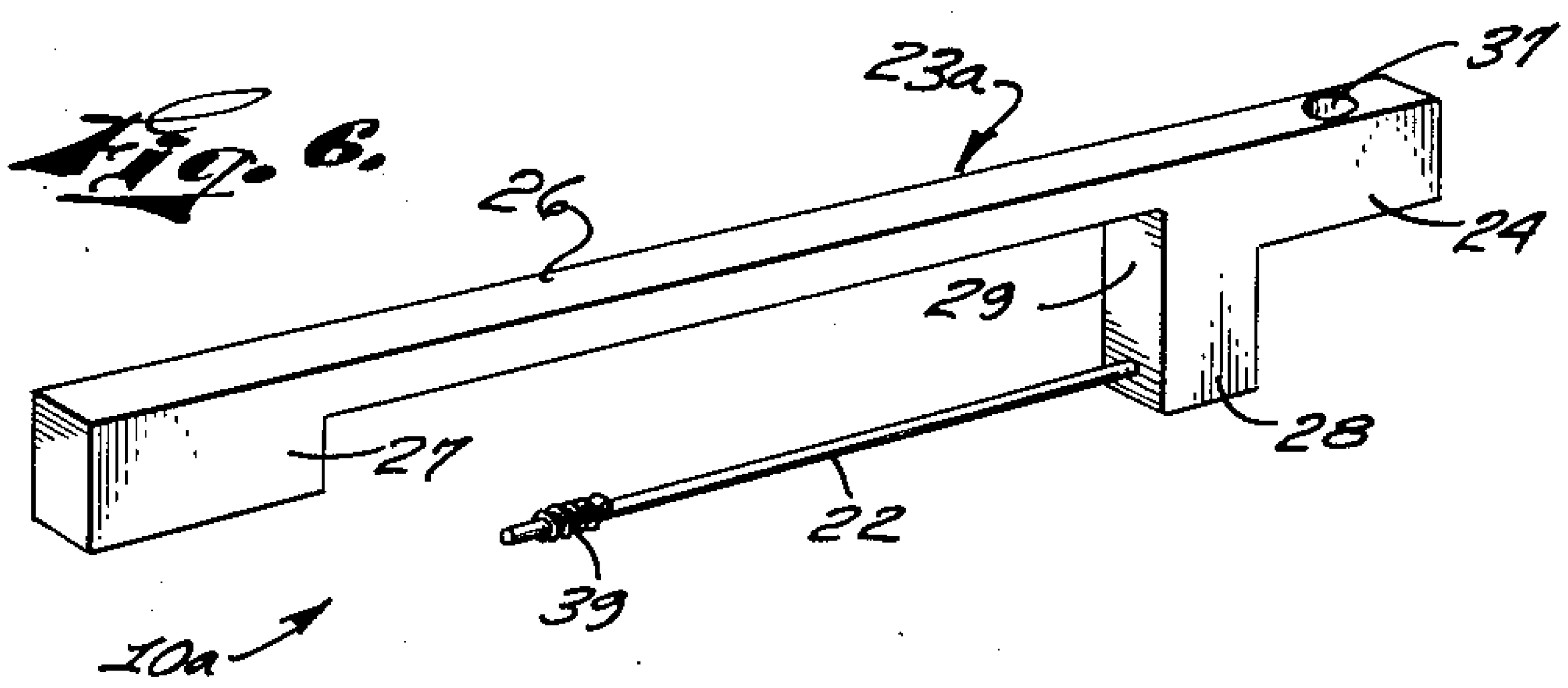


Fig. 7.

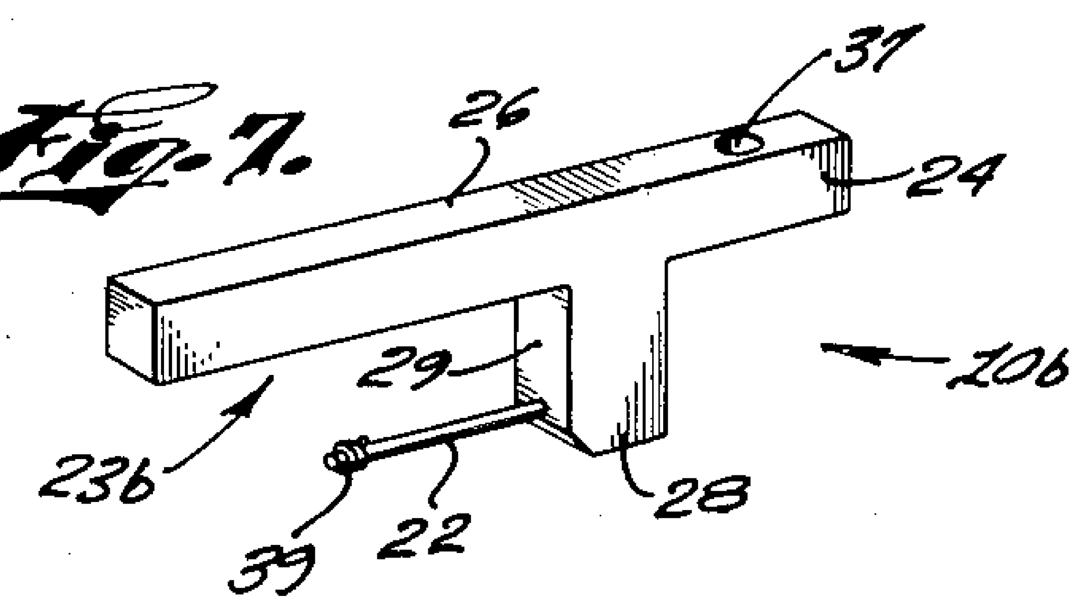


Fig. 10.

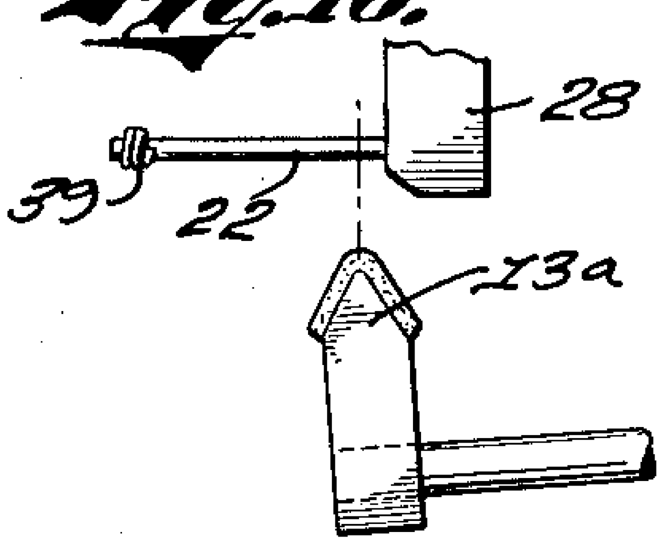


Fig. 8.

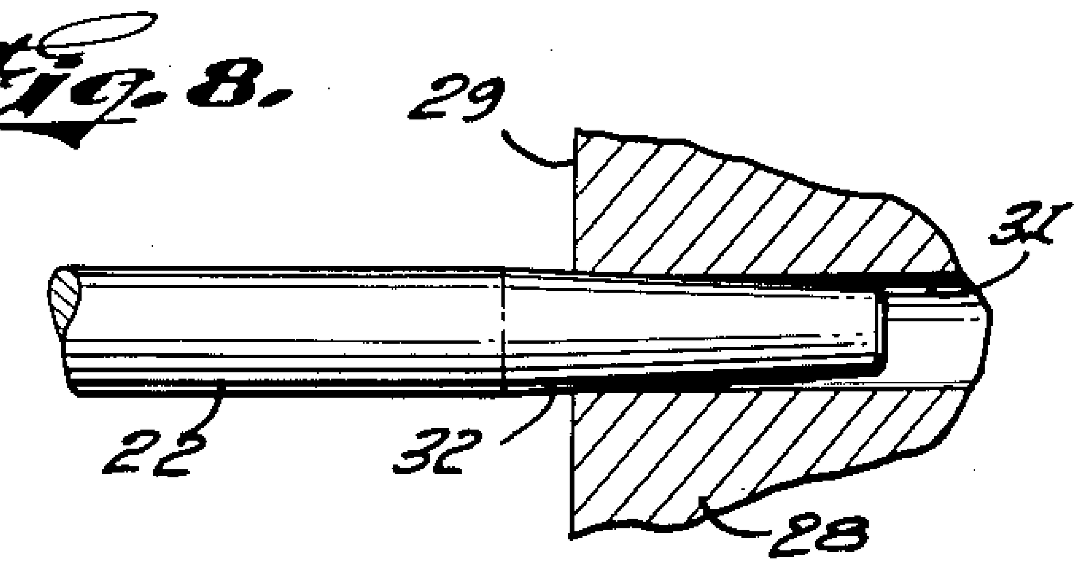
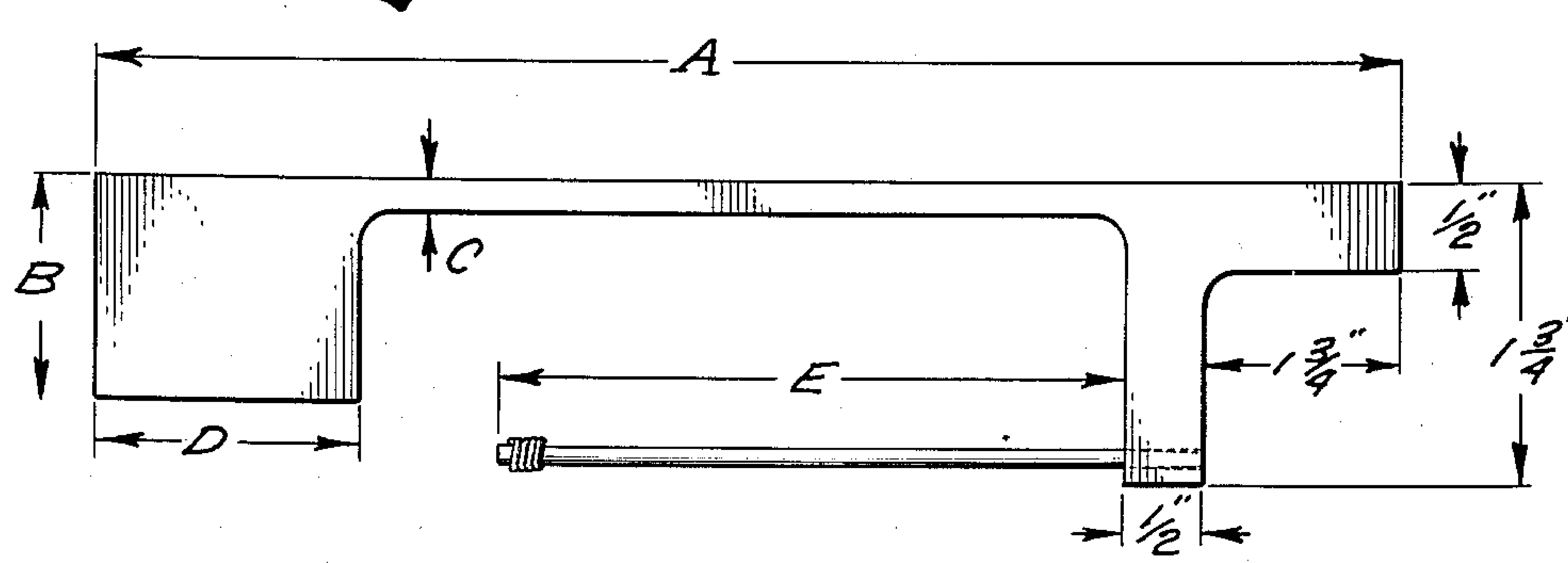


Fig. 9.



INVENTOR.
HAROLD B. RHODES

BY [signature]

ATTORNEY

United States Patent Office

2,972,922
Patented Feb. 28, 1961

2,972,922

ELECTRICAL MUSICAL INSTRUMENT IN THE NATURE OF A PIANO

Harold B. Rhodes, 1003 N. Lido, Anaheim, Calif.

Filed Mar. 9, 1959, Ser. No. 798,097
16 Claims. (Cl. 84—1.15)

This invention relates to an electrical musical instrument.

The problem of mass producing a musically excellent, yet low cost and light weight, electrical piano has been the subject of a large amount of prior-art activity but has not been solved heretofore. One prior-art approach was to mount a large number of vibrating reeds on a single large support, and to strike such reeds in order to produce vibrations which were electronically amplified and transmitted to a loudspeaker. Such arrangements worked within limited pitch ranges, but were unsatisfactory over large ranges such as the full piano keyboard. This is because a supporting mass which was proper for certain ranges of pitch would not be proper for others, and would result in the generation of notes which were musically undesirable with respect to dwell, overtones, etc.

Another prior-art approach to the problem was to employ a large number of conventional tuning forks, but this was undesriable since conventional tuning forks have excessively long dwells, do not produce an initial percussive effect simulating an actual non-electrical piano, and are expensive and critical to manufacture. It is emphasized that a satisfactory electrical piano should produce an initial percussive effect followed by a relatively rapid decay and then by a limited dwell which is longer at the lower pitches than at the higher ones.

The above and other prior-art systems were also characterized by many deficiencies relative to such factors as the necessity for many stages of amplification, the necessity that relatively expensive materials be employed, the necessity that manufacture be carried on in a manner which was so cirtical as to greatly increase the cost of the instrument, and others. A particularly important defect of the above-mentioned systems of the vibrating reed type was that such systems did not satisfactorily employ a reed having a small diameter and a generally cylindrical shape, such a reed being highly desirable because of its musical characteristics and its low cost of manufacture and assembly. The impracticality or impossibility of satisfactorily employing such a reed resulted from the fact that, in prior-art systems, the plane of vibration of the reed would rotate erratically and result in highly undesirable beating noises.

In view of the above and other factors with relation to prior-art electrical pianos and the like, it is an object of the present invention to provide a musically-excellent electrical piano characterized by extremely low cost of mass production, and relatively light weight.

A further object is to provide an electrical musical instrument incorporating a number of substantially-isolated tone generators each of which is adapted upon being struck to produce a strong initial percussive effect followed by a dwell which may be either long or short as required by the particular instrument.

A further object is to provide an electrical musical instrument incorporating tone generators which not only produce an initial percussive effect immediately followed by first rapid and then gradual decay, as in a piano or guitar, but also produce tones characterized by a strong preponderance of the fundamental so that undesirable harmonics are not heard by the listener.

An additional object is to provide an electrical musical instrument employing a multiplicity of fixed-free reeds

yet characterized by very weak and unobtrusive reed-like overtones.

A further object is to provide an electrical musical instrument incorporating tone generators which produce high-power tones requiring relatively little amplification, yet characterized by the complete absence of beating effects.

A further object is to provide an eletcrical musical instrument incorporating tone generators which produce pleasing sounds having pitches and overtones which may be varied in a simple manner during mass manufacture, yet which do not change subsequent to manufacture.

A further object is to provide an electrical musical instrument constructed of small amounts of extremely cheap materials, such as cast iron and piano wire, yet which produces musically-desirable sounds the pitches and characteristics of which may be regulated at the factory in a simple manner.

A further object is to provide a tone generator characterized by high power and the absence of beating, yet which may be economically manufactured with a small-diameter tine of cylindrical shape.

These and other objects and advantages of the invention will be set forth more fully in the following specification and claims, considered in connection with the attached drawings to which they relate.

In the drawings:

Figure 1 is a transverse sectional view schematically illustrating an electrical musical instrument constructed in accordance with the present invention, it being understood that the illustrated tone generator and associated hammer, pickup, etc., is but one of many corresponding assemblies which produce tones of different pitches, and it being further understood that the differently-pitched tone generators may be differently shaped in the manner illustrated in Figures 6 and 7 as will be described hereinafter;

Figure 2 is an enlarged fragmentary section taken on line 2—2 of Figure 1;

Figure 3 is an enlarged fragmentary section taken on line 3—3 of Figure 1;

Figure 4 is an enlarged fragmentary exploded perspective view illustrating the manner of mounting the pitch-regulating means on a tine;

Figure 5 corresponds to Figure 4 but illustrates the conditions of the parts after such mounting;

Figure 6 illustrates a tone generator corresponding to the one illustrated in Figure 1 but incorporating a resonated inertia bar of different shape, such as to produce a relatively low-pitched note;

Figure 7 illustrates a tone generator also corresponding to the one illustrated in Figure 1, but adapted to produce a note of higher pitch;

Figure 8 is a fragmentary section illustrating the manner of mounting the fixed end of a tine in the inertia bar and in acoustically-integral relationship;

Figure 9 is a side elevational view of a tone generator, such view being adapted to be employed in conjunction with the table set forth hereinafter to teach specific examples of tone generators for large numbers of pitches; and

Figure 10 is a schematic fragmentary elevation showing a hammer for one of the higher-pitched tone generators.

Referring to the drawings, and particularly to Figure 1, the electrical musical instrument is illustrated schematically to comprise a large number of tone generators **10** which are mounted on support means **11** and **12** in isolated relationship as will be set forth in detail subsequently. Each tone generator **10** has associated therewith a hammer **13** which is actuated in response to pressing of a piano key **14** to impart a hammer blow to the tine of the tone generator. Each piano key is associated with its corresponding hammer through a suitable linkage which may be of conventional variety and is illustrated schematically at **16**. The tine portion of each tone generator has associated therewith a suitable pickup **17** (or mechanical-electrical tranducer) which is preferably of the electromagnetic variety. Pickup **17** is illustrated as being mounted on one of the support means, number **11**, and as being connected through wires **18** and **19** with suitable amplifier and loudspeaker means schematically represented at **21**.

It is to be understood that the elements are the same for the remaining pitches or notes of the instrument as for the note generated with the apparatus shown in Figure 1, except that the tone generators are adapted to produce different pitches and characteristics. Thus, tone generators **10*a*** and **10*b*** illustrated in Figures 6 and 7 are adapted to produce, respectively, lower and higher pitches than the tone generator **10** illustrated in Figure 1. However, the associated supports, hammer, piano key, linkage, pickup, etc., may be substantially the same for each of the tone generators **10*a*** and **10*b***, etc., as for the tone generator **10**, except insofar as will be stated hereinafter.

Proceeding next to a description of tone generators **10**, **10*a***, **10*b***, etc., each comprises a tine **22** which is mounted in acoustically-integral relationship on a resonated inertia bar **23**. The tine **22** comprises an elongated, resilient, low-mass, fixed-free vibrating element having a predetermined natural frequency or pitch. Preferably, the tine **22** is a small-diameter generally-cylindrical element, instead of a flattened element, since such an element has a superior tone and greatly facilitates assembly and adjustment. As an illustration, the tine **22** may comprise a cylindrical piano wire formed of high carbon steel.

The resonated inertia bar **23** comprises a rigid, high-mass, fixed-free, elongated vibrating element. Such vibrating element has, when it is associated with another and corresponding (identical) element in a conventional tuning-fork relationship, a predetermined natural pitch which is audible when one prong of the tuning fork is struck. However, when such a bar **23** is employed alone (as in the present invention but with no tine **22**), without another and corresponding bar mounted in conventional tuning-fork relationship relative thereto, there is little or no audible sound produced when the bar is struck except for a very brief ringing noise representing higher harmonics.

The inertia bar **23** should be composed of a material having a relatively flat resonance curve, corresponding to a resonant electrical circuit having a low Q. A preferred material is cast iron since this material is extremely inexpensive, has a flat resonance curve, and does not produce any substantial sound—all sound instead being produced by the tine **22** associated therewith. The reason for employing a low-Q material is to make the manufacturing operation much less critical, and to facilitate adjustments by the pitch-regulating means which is slidably mounted on the tine **22** as will be described. However, where lightness is important it may be desired to employ aluminum in the less-critical low-pitch generators, even though most aluminum is a high-Q material.

In the illustrated embodiments, each inertia bar **23** has a base portion **24** adapted to be mounted on one of the support means, numbered **12**. Such base portion **24** is integral and coaxial with the working portion **26** of the bar, such portion **26** extending from the base **24** to a free or distal end which is associated with the other support means **11**. In the tone generators **10** and **10*b*** (Figures 1 and 7), the working portion **26** is illustrated as having a uniform cross-sectional shape throughout. However, in the tone generator **10*a*** of Figure 6, the outer or free end of the working portion **26** is integrally associated with an added mass portion **27** to result in a lower vibrational frequency without unduly increasing the length of the bar. The use of an added mass **27** is preferred to greatly increasing the length of the bar, particularly since an excessive increase in bar length may produce undesirable overtones.

A leg **28** is integrally formed on each inertia bar **23** at the junction between the base portion **24** and the working portion **26**, and perpendicular thereto. It is to be understood that the working portion **26** of the bar, and also the operating portion of the tine **22**, comprise such portions of those elements which are to the left (Figures 1, 6 and 7) of a plane containing the surface **29** of leg **28**. Both the tine **22** and the inertia bar **23** are referred to as "fixed-free" elements since they have fixed end portions at the leg **28**, and free or distal end portions remote therefrom.

If the tine **22** of any tone generator were replaced by a bar corresponding exactly to working portion **26** and integrally associated with leg **28**, a conventional tuning fork would result. The tone produced by such a hypothetical tuning fork would have a certain pitch or frequency. Such frequency is hereby defined as the natural frequency of vibration of inertia bar **23**. The frequency thus defined, and the frequency mentioned at various places herein with relation to tine **22**, is the fundamental unless harmonics are specifically recited.

As previously indicated, means are provided to fix the ends of the tine and the inertia bar in acoustically integral relationship, and comprise a cylindrical hole **31** (Figure 8) formed through leg **28** in spaced parallel relationship relative to the working and base portions **26** and **24** of the inertia bar. Such means further comprise a tapered (frustoconical) end portion **32** (Figure 8) of the tine, such end portion being hammered into the hole **31** to provide a galling and locking action closely adjacent the surface **29**. Preferably, the end portion **32** is formed on a centerless grinder and has a taper of approximately 1°. The diameter of the hole **31** is slightly undersized relative to the diameter of the main body of tine 22, for example 0.005 to 0.01 inch smaller in diameter. The described means for associating the tine with the inertia bar is very simple and economical to employ, yet produces results which are much better than produced by set screws, for example. This is because set screws tend to produce a damping action which undesirably reduces the length of the dwell of the vibrating tine.

It is pointed out that the location of the hole **31** is such that the tine **22** and all portions of inertia bar **23** lie in a single plane, with the tine **22** disposed generally parallel to the working portion **26** of the inertia bar.

The means to mount each inertia bar loosely on the support means **11** and **12** in isolated, non-damping relationship will next be described. Referring first to Figure 2, the free or distal end portion of each inertia bar is shown as resting on a strip of felt **33** disposed on the upper surface of support means **11** which may comprise an elongated block of wood. In order to prevent undesired lateral movement of the inertia bar, a pair of pins **34** may be driven through the felt and into the upper surface of the wood, in spaced relationship relative to the inertia bar so as not to provide any substantial damping action. Referring next to Figure 3, a screw **36** is shown as being inserted downwardly through an oversize hole **37** in the base portion **24** of the inertia bar and into the support means **12** which may also comprise an elongated block of wood. The base portion **24** thus rests freely on a strip **38** of felt, through which the screw is also inserted. The substantial isolation of each tone generator relative to the common support for the tone generators is important.

The previously-indicated pitch-regulating means is indicated generally at **39** and comprises a weight adapted to slide to various longitudinal positions on the tine **22** and to remain at any desired position until an adjustment is made intentionally, such as at the factory. More specifically, and with particular reference to Figure 4, the pitch-regulating means comprises an open-coiled helical spring the inner diameter of which, when the spring is at free length as shown in Figure 4, is slightly undersize with respect to the diameter of tine **22**. To permit mounting of the spring on the tine, the spring is first compressed to increase the inner diameter thereof until it is greater than that of the tine. After the compressed spring has been mounted over the tine to the desired position, it is released and permitted to spring back toward its free or relatively long condition as shown in Figure 5. This effects a decrease in the inner diameter of the spring to lock it firmly in position on the tine, as shown in Figure 5, until an adjustment is subsequently and intentionally made.

The helical spring comprises an extremely simple means for adjusting the exact pitch of the tine **22**, it being understood that the longitudinal position of the weight on the tine varies the frequency of vibration of the tine after the latter is struck by hammer **13**.

Preferably, the springs **39** for the lower-pitched tone generators are heavier than for the higher ones. Thus the springs for the high-pitched tines shown in Figures 7 and 10 may have only a few turns. The springs are located relatively close to the free ends of the tines, in order that variations in spring locations will alter the fundamental frequencies and not the harmonics.

The pickup **17** is illustrated in Figure 1 to comprise a casing **43** which is mounted on one surface of the block **11** and serves to fixedly support an elongated permanent magnet **44**. The magnet **44** is generally coaxial with tine **22** and has one end disposed closely adjacent the free or distal end of the tine when at its neutral position. A coil **45** is wound around the magnet **44** and is connected, as previously described, through wires **18** and **19** to the amplifier and loudspeaker means **21**. Since the tine is formed of magnetizable material, its vibration alters the field of the magnet **44** and results in the generation of a voltage in the coil, which voltage corresponds to the tine vibration and may be amplified and then converted into sound by the loudspeaker. It is to be understood that the exact pickup construction may vary with the pitch of the associated tone generator.

Magnet **44** is formed with a chisel edge **46** which is perpendicular to the common plane of elements **22** and **23**. The exact position of the chisel edge **46** may be adjusted by loosening the mounting screw **46*b*** for casing **43** and sliding the casing upwardly or downwardly a slight distance, such sliding being permitted because of the presence of a vertical slot **46*a*** in the casing. As illustrated, the adjustment is such that the edge **46** is somewhat off-center relative to the axis of tine **22** when the tine is in neutral (stationary) condition. The described adjustable off-center relationship permits accurate adjustment of the fundamental-overtone relationships sensed by the pickup and converted into sound by the loudspeaker. This is highly important to the musical characteristics of the instrument.

It is pointed out that the hammer **13**, when operated through the linkage **16** by key **14**, should strike the tine **22** at an intermediate portion thereof and perpendicular thereto. Thus, the movement of the hammer is in the same plane as the inertia bar **23** and tine **22**, and is generally perpendicular to the tine. The hammers for the lower-pitched tone generators are relatively large and are thickly felted, in order to damp out harmonics. The hammers are reduced progressively both in size and in thickness of felt as the higher-pitched tone generators are approached. Thus, hammer **13*a*** for the higher-pitched tone generator shown in Figure 10 is relatively sharp, and is only thinly felted.

Detailed description of certain important relationships and factors

A first important relationship is that the inertia bar **23** is so constructed as to resonate to the connected tine **22**, which accounts for its being termed a "resonated" inertia bar. The resonance point may be defined as occurring when the frequency of vibration (fundamental) of the tine is the same as the previously-defined natural frequency (fundamental) of the inertia bar associated therewith.

Stated otherwise, the inertia bar **23** and the connected tine **22** are tuned to each other.

It is emphasized that the pitch produced by each tone generator is determined solely by the tine **22** and the associated weight **39**, and not by the inertia bar **23**. Thus, when the pitch of the tine is changed by shifting the position of weight **39** thereon, the resulting pitch of the tone generator is raised or lowered depending on the direction the weight is moved. The vibrational frequency of the inertia bar **23** is correspondingly varied, being the same as that of the tine **22**. However, when the frequency of vibration of the tine **22** is varied on either side of the above-defined natural frequency of the inertia bar **23**, the dwell period of the generated tone is reduced. Stated otherwise, the tone generator has a maximum dwell when the tine **22** and the weight **39** are such that the frequency of vibration of the tine is the same as the natural frequency of the inertia bar.

When the tone generators are employed in a piano-like instrument, as in the present illustration, it is preferred that the tone generators adapted to produce the lower pitches (such as number **10*a*** in Figure 6) be somewhat off resonance (that is to say off the peak of the resonance curve) in order that the dwell period will be reduced. For example, it is desired that the dwell period of such low-pitched notes be about 17 seconds. However, at the higher pitches, achieved with tone generators such as the one **10*b*** shown in Figure 7, it is preferred that the tine **22** and the inertia bar be substantially at the peak of the resonance curve in order that the maximum dwell will be achieved, for example 3 to 5 seconds. Of course, the low-pitched notes normally dwell much longer than the high-pitched ones.

As previously stated, the inertia bar **23** is constructed of a material, such as cast iron, having a flat resonance curve, or low Q. With such a material the pitch of the tine **22** may be varied for as much as half an octave without completely departing from resonance with the inertia bar. The weight **39** may therefore be shifted on the tine **22** to vary the pitch in a practical and simple manner, such adjustment being normally accomplished at the factory. If the inertia bar **23** were formed of high-Q material, such as aluminum, the point of adjustment of the weight **39** would be much more critical than in the present situation since a relatively small departure from the resonance peak would greatly alter the dwell and pitch characteristics. This would make the manufacture and adjustment of the tone generators more expensive.

Proceeding next to a description of a further important relationship, it is emphasized that the working portion **26** of the inertia bar should have many times the combined mass of the tine **22** and weight **39** thereon. This applies, as previously stated, to the portions of the tine and the inertia bar to the left (Figures 1, 6 and 7) of the plane containing surface **29** of leg **28**. The mass of the working portion **26** should be at least ten times the mass of the tine and weight **39**, and preferably at least twenty-five times the mass thereof.

Assuming that the working portion **26** of the inertia bar has (in each instance) such a length and shape as to resonate to the associated tine, increasing the mass of the working portion **26** increases the amplitude of vibration of the tine **22** for a hammer blow of given strength. Such an increase in the amplitude of vibration has beneficial results in that it increases the strength of the signal generated in coil **45**, and decreases the number of stages which must be incorporated in the amplification means. Furthermore, it is emphasized that, in a piano-like instrument, it is desired that the initial vibration be very strong to thereby simulate the hammer sound which is produced when a conventional piano string is struck by a hammer.

To illustrate the above, let it again be assumed that the tine **22** is removed and replaced by a bar integrally associated with the leg **28** and corresponding to, and parallel with, the working portion **26**, so that a conventional tuning fork results. Upon being struck by the hammer **13**, the tuning fork would not produce any substantial initial percussive effect and would not be piano-like in action. Furthermore, the generated tone would have a very long dwell, much longer than a conventional piano, it being assumed that the hypothetical tuning fork is composed of a conventional tuning-fork material instead of cast iron or the like. Because of the small amplitude of vibration of the arms of the tuning fork, the signal generated in an associated pickup would be relatively weak and require much amplification, which is not only expensive but frequently has the effect of introducing distortion.

To continue the illustration, let it next be assumed that the working portion **26** of the illustrated inertia bar **23** is cut off and replaced by a second tine corresponding to the tine **22** which is illustrated. Such a device would also be a conventional tuning fork, but having small-diameter resilient prongs. This would be highly undesirable in that the amplitude of vibration of the tine struck by the hammer **13** would be small in comparison to the amplitude of vibration (for a hammer blow of the same strength) of a tine associated with an inertia bar as shown in Figure 1. The number of stages of amplification required would be increased, the piano-like percussive action would be greatly reduced, and the dwell would be undesirably shortened. Furthermore, in both the large-mass and small-mass conventional tuning fork situations, the musical characteristics of the generated tones would be greatly inferior, in regard to overtones and the like, than the musical characteristics of the tones generated by the tone generators of the present invention.

The present tone generator may also be characterized as a tuning fork but, in contrast to the illustrations presented in the two preceding paragraphs, of unconventional construction for reasons including the fact that the legs **22** and **26** of the fork have greatly unequal masses.

A further important relationship is that the inertia bar **23** should have relatively little mass, and preferably no mass, outside of the common plane containing the inertia bar and the tine **22**. When all portions of the elements **22** and **23** lie in a single plane, and when the inertia bar is isolated from the common support as described heretofore with reference to Figures 2 and 3, the plane of vibration of the tine **22** will always lie in the above-mentioned plane of the inertia bar and the tine, and will not rotate to provide an undesirable beating noise in the loudspeaker. To illustrate this, let it be assumed that the tine **22** is struck in a direction 90° from the direction illustrated in Figure 1, i.e. in a direction perpendicular to the plane containing elements **22** and **23**. Upon such a striking action, the tine **22** will vibrate little, if any, and any vibration will be in the same plane as the elements **22** and **23**. In summary, therefore, the inertia bar **23** is so constructed and mounted as to be incapable of supporting any substantial vibration of the associated tine in a plane other than the common plane in which the hammer moves, and which contains the inertia bar and the tine. Thus, the free end of the tine moves closely adjacent, and perpendicular to, chisel edge **46**.

Because of the above-indicated relationship by which the plane of vibration of the tine may not rotate, and because of other factors, the tine need not be flat but may be constructed with a cylindrical shape, preferably a piano wire or the like. This produces, as previously stated, a superior tone (with much more desirable overtones) and with less expense than in a situation where the tine must be flat. Furthermore, the cylindrical tine may be mounted in the leg **28** in the above-described highly simple manner (Figure 8), and the weight **39** may comprise the spring which is adjusted in a very simple manner as previously described with relation to Figures 4 and 5.

In summary, therefore, the end product is a piano-like musical instrument which produces the desired initial percussive action, and the desired long or short dwell at various pitches, yet without beating and with such high power that relatively little amplification is required. The generated tone is musically excellent and highly pleasing, yet the instrument is constructed cheaply and light in weight for economical mass production. No tuning of the instrument is required once it has been adjusted at the factory.

Specific example

In order to provide, without limitation but merely for purposes of illustration, a specific example of one piano-like instrument constructed in accoradnce with the present inveniton, the following table is presented. This table is to be read in connection with Figure 9 which illustrates, along with certain fixed dimensions, the variable dimensions recited in the table. The dimensions are all given in inches.

It is to be understood that the table relates to an instrument incorporating the pitch-regulating means **39**, and having inertia bars constructed of cast iron and having cylindrical tines **22** formed of piano wire (high carbon steel). The tines in each instance are 0.075 inch in diameter. Each of the inertia bars is uniformly 3/8 inch in its dimension perpendicular to the showing of Figure 9.

Bar No.	Dimension A	Dimension B	Dimension C	Dimension D	Dimension E
1	10.32	1 3/8	3/16	1 51/64	6.365
2	10.07	1 5/16	3/16	1 3/4	6.225
3	9.82	1 1/4	3/16	1 21/32	6.065
4	9.61	1 3/16	3/16	1 41/64	5.857
5	9.44	1 1/8	3/16	1 19/32	5.688
6	9.28	1 1/16	3/16	1 9/16	5.533
7	9.13	1 3/64	3/16	1 15/32	5.375
8	8.95	1 3/64	3/16	1 7/16	5.195
9	8.78	1 1/32	3/16	1 13/32	5.029
10	8.65	1 1/64	3/16	1 25/64	4.903
11	8.50	1 1/64	3/16	1 11/32	4.750
12	8.38	1	3/16	1 21/64	4.632
13	8.29	59/64	3/16	1 5/16	4.545
14	8.19	29/32	3/16	1 17/64	4.435
15	8.06	57/64	3/16	1 1/4	4.307
16	7.93	7/8	3/16	1 7/32	4.183
17	7.82	55/64	3/16	1 13/64	4.074
18	7.68	13/16	3/16	1 3/16	3.932
19	7.55	3/4	3/16	1 11/64	3.795
20	7.42	11/16	3/16	1 1/8	3.668
21	7.32	5/8	3/16	1 7/64	3.565
22	7.23	9/16	3/16	1 3/32	3.475
23	7.14	35/64	3/16	1 5/64	3.386
24	7.03	1/2	3/16	1 1/16	3.283
25	6.95	15/32	3/16	1 3/64	3.202
26	6.86	7/16	3/16	1 1/32	3.114
27	6.77	3/8	3/16	1 1/32	2.994
28	6 68	5/16	3/16	1 1/64	2.932
29	6.59	9/32	3/16	1 1/64	2.841
30	6.48	1/4	3/16	1	2.734
31	6.39	7/32	3/16	1	2.642
32	6.31	7/32	7/32	0	2.563
33	6.24	1/4	1/4	0	2.479
34	6.16	1/4	1/4	0	2.412
35	6.10	1/4	1/4	0	2.352
36	6.05	1/4	1/4	0	2.299
37	5.98	1/4	1/4	0	2.231
38	5.90	1/4	1/4	0	2.148
39	5.80	11/32	11/32	0	2.052
40	5.77	11/32	11/32	0	2.027
41	5.70	11/32	11/32	0	1.947
42	5.63	11/32	11/32	0	1.882
43	5.57	11/32	11/32	0	1.821
44	5.53	11/32	11/32	0	1.777
45	5.47	13/32	13/32	0	1.720
46	5.44	13/32	13/32	0	1.688
47	5.38	13/32	13/32	0	1.625
48	5.35	13/32	13/32	0	1.595
49	5.28	13/32	13/32	0	1.532
50	5.23	13/32	13/32	0	1.483
51	5.20	1/2	1/2	0	1.445
52	5.17	1/2	1/2	0	1.423
53	5.12	1/2	1/2	0	1.369
54	5.08	1/2	1/2	0	1.328
55	5.03	1/2	1/2	0	1.276
56	4.99	1/2	1/2	0	1.241
57	4.95	9/16	9/16	0	1.195
58	4.90	9/16	9/16	0	1.145
59	4.86	9/16	9/16	0	1.106
60	4.85	9/16	9/16	0	1.097
61	4.80	19/32	19/32	0	1.045

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

I claim:

1. An electrical musical instrument, comprising a tuning fork having a first leg of high mass and a second leg of low mass, said legs being in tune with each other, a pick-up means operatively associated with said low-mass leg to produce an electrical signal which is determined at least substantially entirely by vibration of said low-mass leg only, and exciting means operatively associated with said low-mass leg only.

2. The invention as claimed in claim 1, in which means are provided to mount said pick-up means in fixed relationship on a support, said support being independent of both of said legs.

3. The invention as claimed in claim 1, in which said low-mass leg and high-mass leg are spaced a sufficient distance from each other, to prevent contact therebetween at all times, including during operation of said exciting means.

4. The invention as claimed in claim 1, in which the mass of said high-mass leg is many times that of said low-mass leg.

5. The invention as claimed in claim 1, in which the mass of said high-mass leg is at least ten times that of said low-mass leg.

6. The invention as claimed in claim 1, in which means are provided to mount said tuning fork on a support in substantial isolation relative thereto.

7. The invention as claimed in claim 1, in which said high-mass leg comprises a relatively rigid elongated metal element having a mass many times that of said low-mass leg, and in which said low-mass leg comprises a relatively resilient elongated metal element extending generally parallel to said high-mass leg in overlapping relationship relative thereto, said low-mass leg being connected to said high-mass leg in acoustically-integral fixed-free relationship.

8. The invention as claimed in claim 7, in which said low-mass leg comprises a relatively small-diameter cylindrical wire.

9. The invention as claimed in claim 7, in which said exciting means comprises a piano action having a hammer portion disposed to strike said low-mass leg, said hammer portion being adapted to move in the plane of said legs.

10. The invention as claimed in claim 7, in which said low-mass leg is formed of magnetizable material, in which said pick-up means comprises an electromagnetic pickup mounted adjacent the free end of said low-mass leg to sense the vibrations thereof, and in which amplifier and loudspeaker means are connected to said pickup.

11. The invention as claimed in claim 10, in which said pickup incorporates an elongated magnetizable core one end of which is disposed near the free end of said low-mass leg, said one core end converging to a relatively sharp edge located closely adjacent said free end of said low-mass leg when said low-mass leg is in rest position, said sharp edge extending generally transversely to the common plane of said legs, and in which means are provided to adjust the location of said sharp edge in a direction transversely thereof to various locations off-center relative to said free end.

12. The invention as claimed in claim 1, in which said low-mass leg is adapted to vibrate at a predetermined frequency, and in which said high-mass leg is identical to one leg only of a tuning fork having legs identical to each other and adapted to vibrate at substantially said predetermined frequency.

13. The invention as claimed in claim 1, in which said high-mass leg is a metal bar having a metal base portion rigidly associated therewith, said base portion having a cylindrical recess therein extending generally parallel to said high-mass leg, and in which said low-mass leg is a cylindrical metal wire having a diameter slightly greater than that of said recess, said wire having a frustoconical end portion driven into said recess.

14. The invention as claimed in claim 1, in which said high-mass leg is formed of a metal having a relatively flat resonance curve, and in which weight means are movably mounted on said low-mass leg to adjust the pitch thereof upon being moved to different longitudinal positions thereon.

15. The invention as claimed in claim 1, in which means are provided to mount said tuning fork in substantially isolated relationship relative to a support, in which amplifier and loudspeaker means are connected to said pick-up means to reproduce the movements of said low-mass leg in the form of sound, and in which said exciting means comprises a piano action having a hammer portion disposed to strike said low-mass leg.

16. The invention as claimed in claim 1, in which said high-mass leg comprises an elongated cast iron bar having a laterally-extending base at one end portion thereof, in which said low-mass leg comprises an elongated cylindrical piano wire rigidly connected to said base, said wire extending generally parallel to said cast iron bar in overlapping relationship, in which means are provided to mount said bar and wire on a common support in substantial isolation relative thereto, in which said pick-up means comprises an electromagnetic pickup mounted adjacent the free end of said wire to sense the vibrations thereof, in which amplifier and loudspeaker means are connected to said electromagnetic pickup to convert the currents generated therein into sound, and in which said exciting means comprises a piano action having a hammer portion movable in the plane of said bar and wire to strike said wire and initiate vibration thereof in said plane.

References Cited in the file of this patent

UNITED STATES PATENTS

1,269,511	Roberge	June 11, 1918
1,963,719	Schelkunoff	June 19, 1934
2,155,741	Severy	Apr. 25, 1939
2,318,936	Fisher	May 11, 1943
2,492,919	Hings	Dec. 27, 1949
2,510,094	Fluery	June 6, 1950
2,647,949	Burns	Aug. 4, 1953
2,755,697	Miessner	July 24, 1956
2,765,693	Link	Oct. 9, 1956