March 4, 1952 P. H. ROWE 2,588,295

APPARATUS FOR PRODUCING CHIME TONES AND METHOD OF TUNING MUSICAL BARS

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Fig. 1.

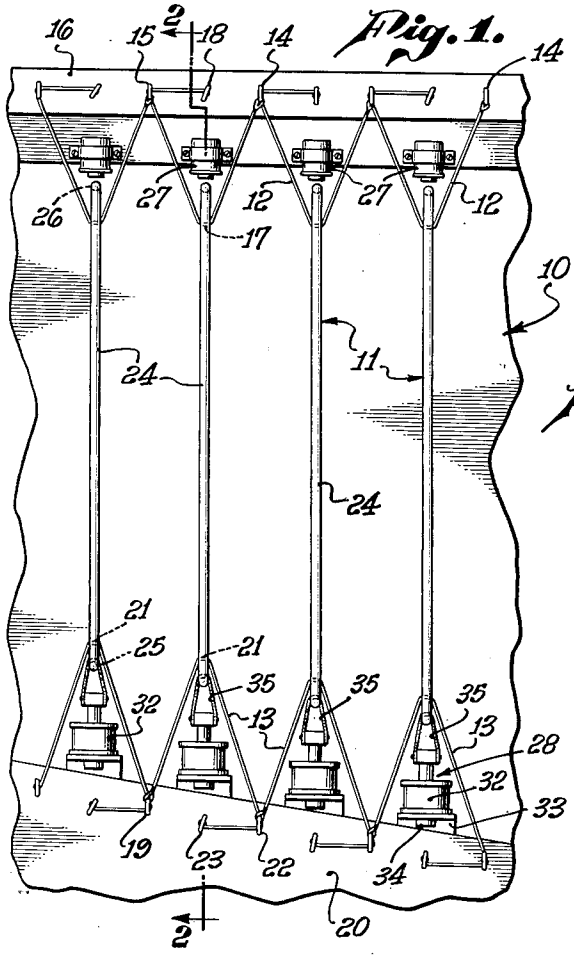


Fig. 2.

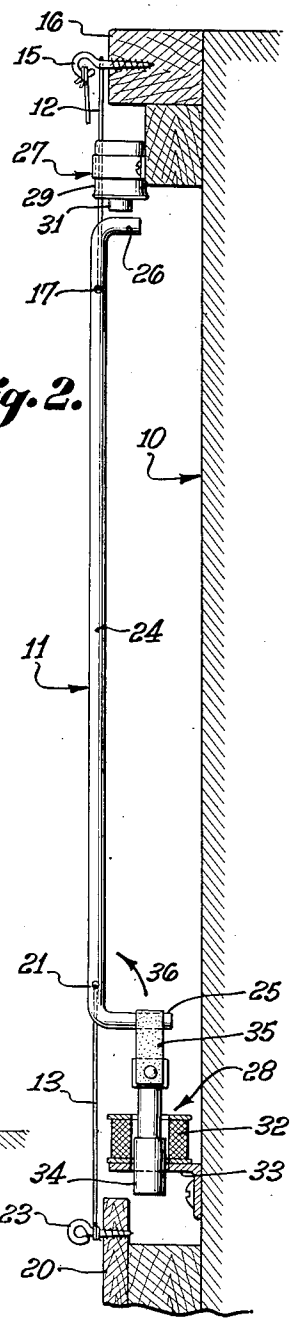


Fig. 3.

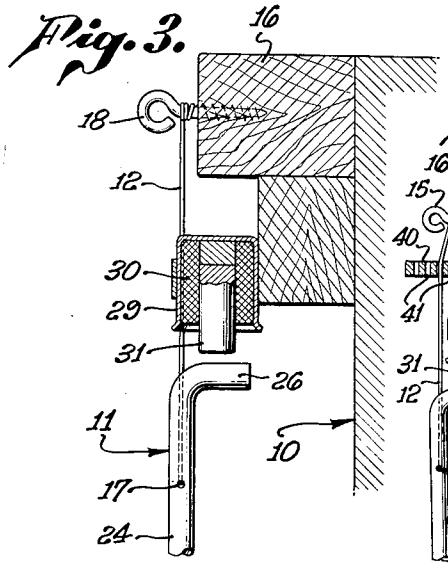
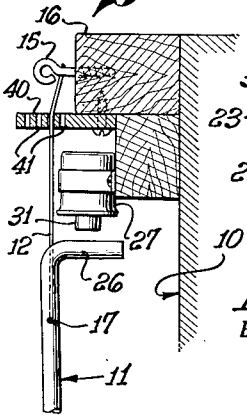


Fig. 4.



INVENTOR.
PAUL H. ROWE
BY
John Flam
ATTORNEY.

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APPARATUS FOR PRODUCING CHIME TONES AND METHOD OF TUNING MUSICAL BARS

Paul H. Rowe, Los Angeles, Calif., assignor to Maas-Rowe Electromusic Corporation, Los Angeles, Calif., a corporation of California

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21 Claims. (Cl. 84—1.04)

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The present invention relates to the generation of musical tones, and more particularly to the generation of chime and bell tones.

The partials of a freely suspended member, such as a metallic bar, rod or tube, in transverse flexural vibration are of identical frequencies relative to the fundamental or first mode, regardless of the diameter of the vibrating member. Accordingly, the same sound effect should be obtainable from a small diameter rod type generator as from a large diameter tubular chime.

In using a small diameter rod or tube and amplifying its sound by an electronic pick-up device, considerable difficulty has been encountered in producing a chime having a tone corresponding to a large tubular chime. The small diameter member is capable of storing only a small amount of energy, as compared to a massive chime tube, and is therefore extremely sensitive to any damping action of its supports. Reduction of this damping action to a permissible value requires the use of very delicate supports, but these enable the small diameter member to be shifted bodily when struck, displacing it as a whole with respect to the pick-up and varying the air gap therebetween. This introduces undesirable variations in the amplified tone from that intended.

An object of the present invention is to provide a percussion musical instrument having one or more suspended bars or tubes that can be flexed by a striking mechanism without substantially laterally displacing the bar or tube as a whole.

Another object of the present invention is to arrange the pick-up of an amplifier and the resonant bar or tube in such manner as to maintain their relative spacing substantially constant when the bar or tube is struck, despite the use of a delicate suspension for the resonant member.

A further object of the invention is to relate the pick-up of an amplifier to a resonant bar or tube in such manner that the lateral vibration of the bar or tube results in the addition of harmonics to the amplified tone.

Still another object of the invention is to provide an apparatus employing a small diameter bar or tube and an amplifier, which results in the production of a sound of the same tonality as a large diameter tubular chime.

Heretofore, attempts have been made to improve the quality or timbre of a chime tone by bringing the frequencies of the partials of the chime bar or tube into accurate harmonic relation. Actually, the resultant tone of such a harmonically tuned chime is not necessarily as pleasing as a chime having the normal inharmonic partials of a struck bar or tube, in which the relative intensities of the partials are pleasing.

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It is, therefore, another object of this invention to improve the quality or timbre of a chime tone by correcting some of its larger harmonic discrepancies, while retaining the relative intensities of the partials producing the tone. In this connection, I have determined that the timbre of the chime tone depends largely upon the relative intensities of the partials producing the tone. Such relative intensities and their rate of decay appear to influence the timbre more than the relative frequencies of the partials.

Still another object of the invention is to effect a ready tuning of a resonant bar or tube to flatten or sharpen its partials.

Yet another object of the invention is to provide a chime apparatus including a resonant bar having its partials spaced one octave and two octaves above the pitch tone, and in which the relative intensities of these partials are such as to be characteristic of a large tubular chime.

A further object of the invention is to provide a damping arrangement for a resonant bar or tube of comparatively small cross-sectional area, which is capable of performing its damping functions properly without the necessity for its precise arrangement and fine adjustment with respect to the bar or tube.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a method and the apparatus shown in the drawings accompanying and forming part of the present specification. This method and apparatus will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a front elevation of an apparatus embodying the invention;

Fig. 2 is an enlarged vertical section, taken generally along the line 2—2 on Fig. 1;

Fig. 3 is a further enlarged partial vertical section of the amplifier end of the apparatus; and

Fig. 4 is a partial vertical section through a modified form of the invention.

A percussion type musical instrument is disclosed in the drawings, including a suitable frame

10 from which are supported spaced parallel resonant bars 11, that may be made from metallic material. Each bar is suspended vertically by an upper hanging cord 12 made of elastic material, such as "Nylon." It is also restrained from movement by a lower elastic cord 13 of the same material.

Each upper cord extends downwardly from spaced anchor screws 14, 15 threaded into the upper portion 16 of the supporting frame and displaced transversely on opposite sides from the central plane of the bar 11. One end of the upper cord 12 is anchored to the eye of one of the anchor screws 14, from which it extends obliquely in a downward direction for passage through a transverse hole 17 drilled through the bar at a point near the pitch tone node. From this point, the cord passes obliquely in an upward direction over the shank of the other anchor screw 15 and is then wound upon a tightening screw 18 threaded into the upper portion 16 of the frame. This screw 18 is preferably placed immediately above the bar 11, in order to definitely indicate that such tightening screw is operative upon that particular bar.

The lower cord 13 for the bar is arranged in a similar, although opposite, manner to the upper cord. One end of the lower cord is anchored to the eye of a screw 19 secured in the lower portion 20 of the supporting frame 10, the cord extending obliquely upwardly for passage through a transverse hole 21 drilled through the bar at a point near its pitch tone node. This cord then extends obliquely downwardly for passage around the shank of another screw 22 and onto a tightening element 23 threaded into the lower portion of the supporting frame. This latter screw 23 preferably lies in the same plane as the resonant bar 11, in order to readily indicate the bar with which it is associated.

As is apparent from Fig. 1, the anchor 14 or 19 to which the end of one cord is secured serves as a guide around which the cord for an adjacent bar may extend for passage onto its tightening screw 18 or 23.

The upper and lower ends of each vertically hung bar 11 are bent at an angle to the main portion 24 of the bar, these bent end portions or arms 25, 26 preferably being coplanar. A magnetic pick-up 27 is placed above the upper arm 26, whereas a striking device 28 is disposed below the lower arm 25. The magnetic pick-up may be of a known type, including an outer shell 29 secured to the upper portion 16 of the frame. This shell contains a coil 30 disposed around the magnetic core 31, which has its axis disposed generally parallel to the direction in which the main portion 24 of the resonant bar extends.

The striking device 28 includes a solenoid 32 suitably supported on a bracket 33, and adapted to actuate a plunger or striker 34, in order to shift it in a direction parallel to the length of the main portion 24 of the rod 11. The striker preferably engages the lower bent arm 25 near its end, in order to cause transverse flexural excitation of the bar 11 in a plane including both of the bar arms 25, 26. When the solenoid 32 is de-energized, the striker drops and is suspended from the arm 25 by a loop of felt 35, to which it is suitably secured. The felt 35 is adapted to engage the lower arm and damp the resonant bar 11.

It is apparent that the striker 34 will direct a blow on the bar in a direction generally parallel to the length of its main portion 24, or in a vertical direction. The weight of the bar tends to resist its upward displacement under the action of the striker and also prevents its upward displacement by the pull of the magnetic pick-up 27. Such upward displacements are also resisted by the lower cord 13. When the striker is actuated, a bending moment, indicated by the arrow 36 in Fig. 2, is imparted to the bar against its inertia, causing its lateral flexural excitation. However, the bar itself is not displaced laterally, so as to change its position bodily with respect to the pick-up device 27. The lack of any substantial lateral bodily displacement of the bar allows the upper and lower cords 12, 13 to be made comparatively delicate, avoiding the imparting of any appreciable damping action on the bar during its flexural excitation.

Since the damping felt 35 acts upon the arm 25, and engages it upon moving in a direction generally parallel to the main portion 24 of the bar 11, the force of the damping action need not be as carefully controlled as in the use of a damping device moving laterally into engagement with a bar, and particularly a bar of small cross-sectional area. The damping action is resisted by the top cord 12 and does not tend to shift the bar laterally to any appreciable extent; nor does it change the amplitude of vibration of the bar in a sudden manner, as might occur upon use of a laterally movable damping device. Instead, the damping action gradually decreases the amplitude of vibration of the bar, achieving the same effects as have heretofore been obtainable in damping a large tubular chime possessing a comparatively large quantity of energy as a result of being set in vibration.

The difficulties in properly damping small diameter bars are also avoided to a large extend because of the manner of striking the bar in a direction generally parallel to the direction of the length of its main portion. As above noted, this manner of striking substantially obviates bodily lateral displacement of the bar, and minimizes the need for the damper to arrest such displacement.

The striking of the bar 11 generally longitudinally of the length of its main portion 24 also causes the pick-up magnet and coil to act in a unique manner. The variation in the air gap causing the voltage in the pick-up coil 30 is due to two different directions of vibration of the upper arm 26 of the bar. The tip of this arm has a comparatively large component of movement in a direction toward and away from the pick-up device (as in a vertical direction), and at the same time the entire arm vibrates back and forth in a direction of its length. When the resonant bar 11 is at rest relative to the magnet, it naturally assumes a position corresponding to the maximum flux through the magnetic circuit, insofar as the lateral position of the bar is concerned. Since lateral displacement of the bar as a result of its vibration causes the arm 26 to be displaced on opposite sides of its natural position, such displacements of the arm causes a drop in the total flux twice for each vibration. Consequently, the induced voltage is largely a second harmonic of this lateral vibration.

The up and down vibration of the tip of the bar does not induce any appreciable second harmonic because of the fact that the bar is not in a neutral position in the up and down direction.

It is apparent that a very rich tone can be obtained by appropriate location of the pick-up magnet 27 with respect to the arm 26, in order to

control the proportion of second harmonics added to each chime tone. When the pick-up system 27 is moved laterally relative to the bar away from the position which the bar normally seeks, the bar will be restrained to some degree by its upper supporting cord 12, and the proportion of second harmonics is correspondingly reduced. Conversely, location of the pick-up device 27 toward the position which the bar normally seeks correspondingly increases the proportion of second harmonics.

The relative lateral position between pick-up magnet 27 and its associated resonant bar, just referred to, can be selected in various ways. The magnet and bar can be mounted and supported in the desired predetermined relative location by their various supporting elements, such as shown in Figs. 1, 2 and 3. With the arrangement disclosed in Fig. 4, their relative positions can be selected and varied, as desired. Intermediate guides 40 are secured to the upper and lower portions 16, 20 of the frame 10, each guide being provided with sets of laterally spaced vertical holes 41. There are two sets of holes for each cord 12 and 13 on opposite sides of the plane of the bar. The diagonal portions of a cord may pass through selected holes 41 in a guide on opposite sides of a bar to determine the position of the bar with respect to the pick-up device 27. It is apparent that the relocation of an upper cord through holes to the left of the position of the cord shown in Fig. 4 will correspondingly relocate the bar 11 and its arm 26 to the left with respect to the pick-up magnet 27. Conversely, passing of the cord through holes to the right of the cord position shown in Fig. 4 will correspondingly shift the bar 11 and its arm 26 to the right with respect to the pick-up magnet 27. By selecting various vertical holes in the guides, the relative location of each pick-up device 27 and the resonant bar can be determined, to obtain the desired proportion of second harmonics added to each chime tone.

Not only does the bending of the bar 11, to provide one or more arms 25, 26, permit a striker arrangement 28 to be used that produces only a minimum of lateral bodily displacement of the bar, but each arm, if appropriately proportioned, and the angle of its bend to the main portion 24 of the arm, can determine the partials of the bar, their relative intensities, and their harmonic concordance.

When one arm, as the lower arm 25, is made approximately 0.06 times the length of the bar before bending, and the other arm, as the upper arm 26, is made approximately 0.03 times the length of the bar before bending, the bar will have two partials spaced one octave and two octaves above its pitch tone, and the octave tuning of these particles will be found to be quite accurate and in harmonic concord. Where necessary, the partials can be further tuned to a slight degree. Reducing the length of the longer arm 25, as by filing, causes the partial, which is one octave above the pitch tone, to be sharpened more rapidly than either the pitch tones or the double octave partial. If the higher partial is flat, it can be sharpened by shortening the shorter arm 26. Such shortening of the shorter arm will sharpen this double octave partial at a much faster rate than either the fundamental or the octave partial.

Although the arms 25, 26 are disclosed in the drawings as bent at an angle of ninety degrees to the main portion 24 of the bar, the angle of the bend of each arm can be varied, in order to achieve a flattening or sharpening of the partials. For example, as the angle of the bend of the longer arm 25 is increased from zero to ninety degrees, that mode of vibration, which is approximately two octaves above the pitch tone, is flattened as a direct function of the angle, and the octave partial is also flattened, although to a smaller degree. Even after the angle of bending passes ninety degrees, the octave partial is still flattened to a further extent, but the double octave partial becomes slightly sharp.

As the angle of the bend is increased, it is found that the pitch tone of the bar is sharpened.

Accordingly, the degree of bend affords control over the double octave partial with respect to the pitch tone. As explained above, shortening the longer arm 25 sharpens the octave mode approximately twice as much as it sharpens the pitch tone. On the other hand, the angle of bend of this same longer arm has more effect upon the partial two octaves above the pitch tone, particularly in the range around ninety degrees. Furthermore, the effect of the angle of bend on the pitch tone is opposite to its effect on the double octave partial, since, as above stated, the double octave partial is flattened, whereas the pitch tone of the bar is sharpened.

A bar tuned in the above manner has a very pleasing chime tone, which is more musical than the tone of a straight free-free bar. This appears to be due to the emphasis placed on the pitch tone by the two octavely spaced overtones. In addition, the angle of bend of the arms 25, 26 of the bar and the lengths of these arms can vary the chime tone by introducing the several flattening and sharpening effects above noted. Moreover, a bar bent in the manner described retains the relative intensities of the partials, which is characteristic of a large tubular chime.

When the pitch tone and its upper partials are tuned by bending the bar in the manner described above, it is found that the first sub-tone, which, in a chime is a flat diminished sixth below the pitch tone, will be a sharp major sixth below the pitch tone. Comparison tests have shown that there is little noticeable difference between a bar in which the sub-tone is tuned to a harmonious relation with the pitch tone and one in which it is left sharp, provided the two octavely spaced overtones of the pitch tone are accurately tuned. Since the two octavely spaced overtones are in harmonic concord, by virtue of the present tuning method, the sub-tone can be left sharp, in order to add to the pleasing quality of the chime tone produced.

From the foregoing description, it is apparent that a musical percussion instrument has been provided in which relatively small diameter bars (as, for example, of the order of one-eighth of an inch) can be used, tuned, and vibrated in such manner as to produce tones which closely approximate the chime tones obtained from a large diameter tube. The suspensions of such small diameter bars can be delicate; bodily lateral displacement of the small diameter bars is avoided; the pick-up devices retain their proper relationship relative to the bar, avoiding variations in the air gap that would be caused by bodily displacement of the bar; and the partials can be tuned into harmonic concord.

As used in this specification, it is to be understood that the term "bar" includes a rod or tubular member as well.

The inventor claims:

1. In apparatus for producing sound: a resonant bar having an integral end portion disposed at an angle to the main portion of the bar; a pick-up adjacent the bar for translating the bar vibrations into electrical impulses; and means for striking said end portion; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

2. In apparatus for producing sound: a resonant bar having an integral end portion disposed at an angle to the main portion of the bar; a pick-up adjacent the bar for translating the bar vibrations into electrical impulses; and means for striking said end portion in a direction generally longitudinally of the main portion of the bar; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

3. In apparatus of the character described: a resonant bar having one or more end portions bent at an angle to the main portion of the bar, the length of each of said end portions being about 0.06 divided by X times the length of said bar before it is bent, in which X represents the number of octaves above the pitch tone to which a partial is to be tuned.

4. In apparatus of the character described: a resonant bar having its opposed end portions bent with respect to the main portion of the bar, said end portions being coplanar; the length of said end portions being, respectively, about 0.06 and about 0.03 times the length of said bar before it is bent.

5. The method of tuning a musical bar of substantial length, which comprises bending a portion of said bar at an angle to the remainder of the bar, the length of its bent portion and its angle relative to the main portion of the bar being proportioned and arranged to bring a plurality of tone partials of the bar into harmonic concord.

6. The method of tuning a musical bar of substantial length, which comprises bending opposed portions of said bar in a single plane and at one or more angles to the main portion of the bar, the lengths of the bent portions and their angles to the main portion of the bar being individually chosen to impart a plurality of tone partials to the bar that are in harmonic concord.

7. The method of changing the timbre or tone color of a resonant bar by changing the ratio of the vibration frequency of one of the partials of the bar to the vibration frequency of another partial of the bar, which comprises bending a portion of the bar at an angle to the remainder of the bar at a point selected to produce a proportionately greater effect on one partial than on the other partial.

8. The method of changing the timbre or tone color of a resonant bar by changing the ratio of the vibration frequency of one of the partials of the bar to the vibration frequency of another partial of the bar, which comprises bending a portion of the bar at an angle to the remainder of the bar at a point selected to increase the frequency of one partial while decreasing the frequency of the other partial.

9. In apparatus for producing sound: a resonant bar having an integral portion bent at an angle to the main portion of the bar; a pick-up for translating the bar vibrations into electrical impulses adjacent said bent portion; means for vibrating said bar; and means for selecting the lateral positions of said bent portion and pick-up with respect to each other when said bar is at rest.

10. In apparatus for producing sound: a resonant bar having an end portion bent at an angle to the main portion of the bar, the length of said bent portion relative to said main portion and the angle of said bent portion relative to said main portion being such as to produce harmonic concord between a plurality of tone partials of the bar.

11. In apparatus for producing sound: a resonant bar having an integral end portion bent at an angle to the main portion of the bar; a pick-up adjacent said end portion for translating the bar vibrations into electrical impulses; and means means for vibrating said bar in a plane including said end and main portions of said bar; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

12. In apparatus for producing sound: a resonant bar having its opposed end portions bent with respect to the main portion of the bar; a pick-up adjacent one of said end portions for translating the bar vibrations into electrical impulses; and means for striking the other of said end portions for vibrating said bar in a plane including the end and main portions of the bar; the end portions being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

13. In apparatus for producing sound: a resonant bar having an end portion bent at an angle to the main portion of the bar; damping means movable into and out of engagement with said end portion in a direction generally longitudinally of the main portion of the bar; and means for striking said bar and moving said damping means out of engagement therewith.

14. In apparatus for producing sound: a resonant bar having its opposed end portions bent with respect to the main portion of the bar, said end portions being coplanar; a pick-up adjacent one of said end portions for translating the bar vibrations into electrical impulses; and means for striking said other end portion in a direction generally longitudinally of the main portion of the bar; the end portions being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

15. In apparatus for producing sound: a resonant bar having an end portion disposed at an angle to the main portion of the bar; supporting means; means secured to said supporting means engaging the bar and permitting substantially free vibration thereof; and means for striking said end portion in a direction predominantly corresponding to the length of the bar; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

16. In apparatus for producing sound: a resonant bar having end portions bent with respect to the main portion of the bar, said end portions being coplanar; supporting means; means secured to said supporting means engaging the bar and permitting substantially free vibration thereof; a pick-up adjacent one of said end portions for translating the bar vibrations into electrical impulses; and means for striking the other end portion in a direction predominantly corresponding to the length of the bar; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

17. In apparatus for producing sound: a vertically disposed resonant bar having upper and lower end portions bent with respect to the main portion of the bar, said end portions being coplanar; supporting means, means secured to said supporting means engaging the bar at its upper and lower parts and permitting substantially free vibration thereof; a pick-up adjacent said upper end portion for translating the bar vibration into electrical impulses; and means for striking said lower end portion in a predominantly vertical direction; the end portions being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

18. In apparatus for producing sound: a resonant bar having an end portion bent at an angle to the main portion of the bar; a pliant suspension for the bar; a magnetic pick-up having a core located adjacent said end portion for translating the bar vibrations into electrical impulses; and means for setting said bar into vibration transversely of said pick-up core axis; the end portion being structurally proportioned to tune tone partials of the bar into substantial harmonic concord.

19. In apparatus for producing sound: a resonant bar having end portions bent with respect to the main portion to extend transversely of said main portion, said end portions being coplanar; supporting means; means secured to said supporting means engaging the bar and permitting substantially free vibration thereof; and means for striking one of said end portions in a direction predominantly corresponding to the length of the bar; the end portions being structurally proportioned to true tone partials of the bar into substantial harmonic concord.

20. A chime bar having a pitch tone, the bar also having bent end portions imparting to the bar a partial one octave and another partial two octaves above the pitch tone.

21. In apparatus for producing sound; a resonant bar having an end portion bent at an angle to the main portion of the bar; damping means movable into and out of engagement with said bar; and means for striking said end portion in a direction generally longitudinally of the main portion of the bar and for moving said damping means out of engagement with the bar.

PAUL H. ROWE.

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