March 8, 1955 P. H. ROWE 2,703,504

TONE ADJUSTMENT FOR VIBRANT BARS

Filed Sept. 13, 1949 3 Sheets-Sheet 1

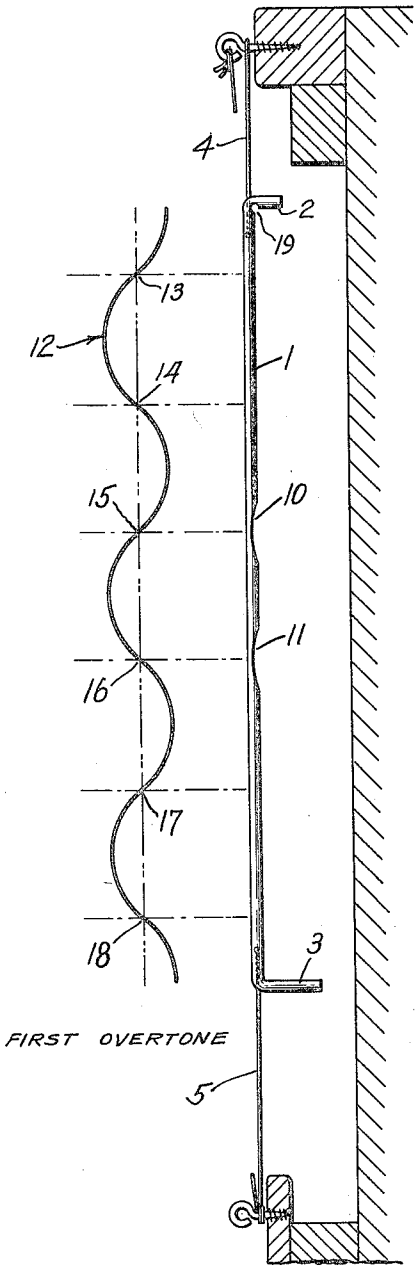


Fig. 1.

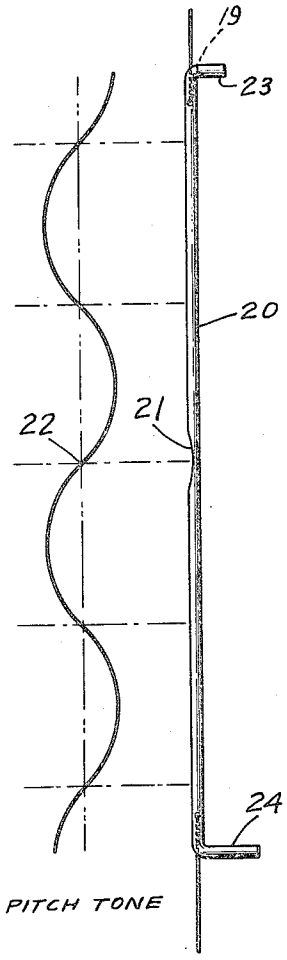


Fig. 2.

INVENTOR.
Paul H. Rowe
BY
John Flam
ATTORNEY

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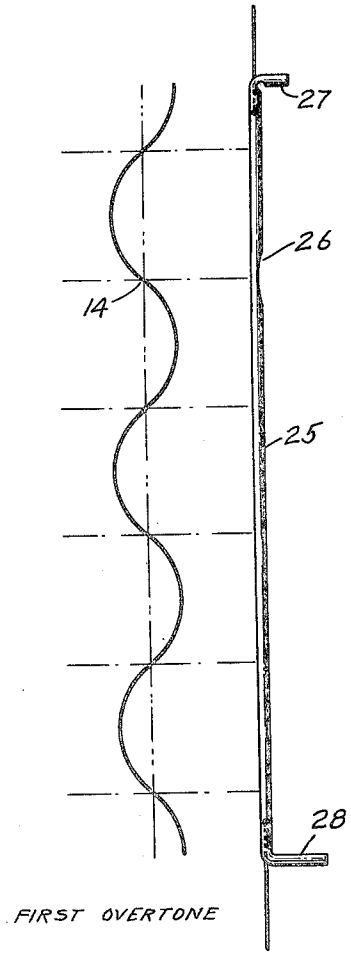


Fig. 3.

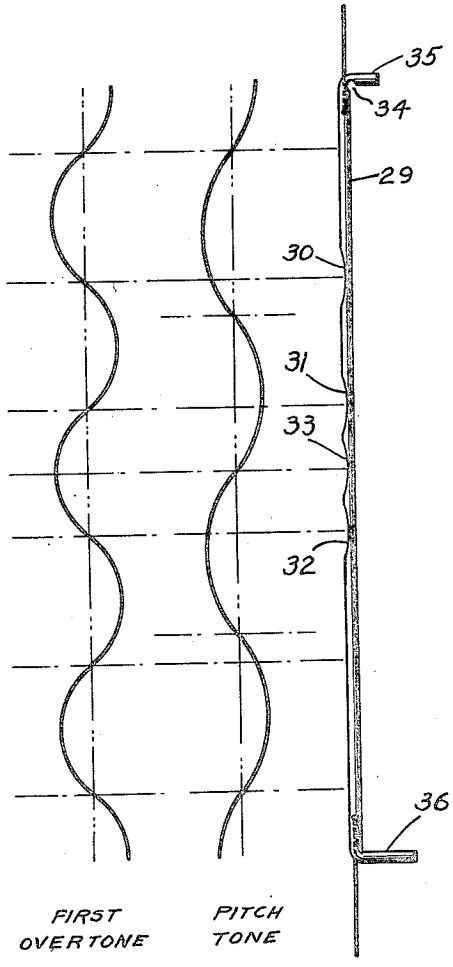


Fig. 4.

INVENTOR.
Paul H. Rowe
BY
John Flam
ATTORNEY

March 8, 1955 P. H. ROWE 2,703,504

TONE ADJUSTMENT FOR VIBRANT BARS

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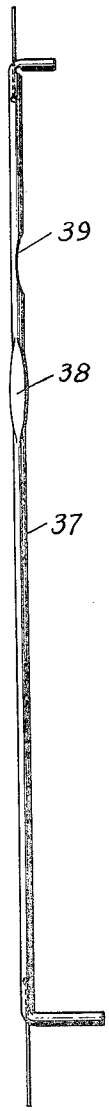


Fig. 5.

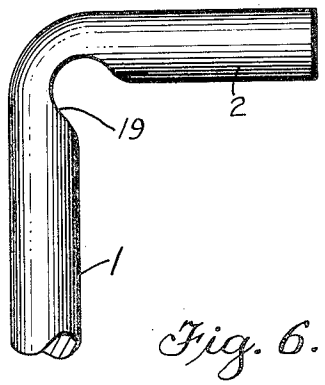


Fig. 6.

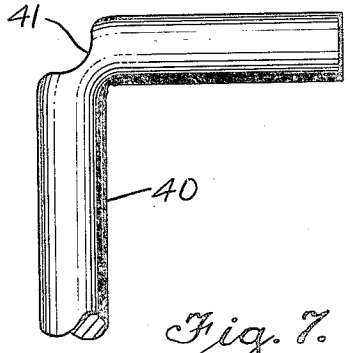


Fig. 7.

INVENTOR.
Paul H. Rowe
BY John Flam
ATTORNEY

United States Patent Office 2,703,504 Patented Mar. 8, 1955

2,703,504

TONE ADJUSTMENT FOR VIBRANT BARS

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

Application September 13, 1949, Serial No. 115,350

10 Claims. (Cl. 84—402)

This invention relates to vibrant bars, such, for example, as disclosed in an application filed in the name of Paul H. Rowe on January 7, 1949, under Serial No. 69,658, and entitled: Apparatus for Producing Chime Tones and Method of Tuning Musical Bars. This application is a continuation in part of said prior application.

In the prior application, the bar therein disclosed is made of relatively small cross section, such as one-eighth of an inch in diameter, and the ends of the bar were bent so as to extend transversely of the main body of the bar. The principles disclosed in this application and the prior one, apply to any bar regardless of diameter. The one-eighth inch size was chosen for convenience only. Anyone skilled in the art can apply the teachings of these inventions to bars of other diameters. It is therein pointed out that by proportioning the lengths of the bent ends, it is possible to obtain desirable tone effects, especially to produce accurate octave and double octave tones above the pitch tone of the bar.

It is well known that it is possible to lower the pitch of one mode of a bar in relation to other partials by thinning the bar near an antinode of the mode to be flattened. Such an arrangement, for example, is shown in the patent Winterhoff, No. 1,632,751 of June 14, 1927.

Generally, the present invention utilizes the principle of altering the compliance of the bar with bent ends, either by thinning or stiffening; and such a combination of a bent bar with either an increase or decrease in compliance makes it possible to bring the bar readily into substantially complete consonance.

It is accordingly an object of this invention to enlarge the scope of tuning the bar to the desired pitch tone or partial tones without materially adversely affecting the other modes of vibration.

It is another object of the invention to improve the tonal quality of a bar of this character by tuning partials other than the first and second octaves, such for example as the subtone which is usually approximately a major sixth below the pitch tone.

It is another object of this invention to provide a simple and inexpensive method and means for substantially accurately tuning the important partials of a resonant bar.

In the usual resonant chime bar or tube, there are five important tones that are to be tuned together. There are (1) a pitch tone, which is the most prominent; (2) a subtone intended to be eight semitones below the pitch tone; (3) a first overtone intended to be seven semitones above the pitch tone; (4) an octave tone above the pitch tone; and (5) a double octave above the pitch tone.

By the aid of the present invention, all five modes of vibration can be brought into substantially accurate tune by first proportioning the bends in a definite manner and then by altering the compliance of the bar either by increasing or decreasing the degree of flexibility of the bar at one or more points in the direction of flexure during vibration.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, 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 side view of a resonant bar which is intended to be excited (by plucking or striking) to vibrate in a plane parallel to the surface of the drawing;

Figs. 2, 3, 4, and 5 are views, similar to Fig. 1 of modified forms of the invention, parts of the suspension system being omitted;

Fig. 6 is an enlarged fragmentary view of the upper part of the bar; and

Fig. 7 is an enlarged fragmentary view, similar to Fig. 6, of another modification.

In Fig. 1, a bar **1** is illustrated made, for example, of metal such as cold rolled steel, and having a short bend **2** at one end and a longer bend **3** at the other end. The bar **1** may be suspended by the aid of resilient strings **4** and **5** respectively at each end.

When the bar **1** is struck by a force substantially parallel to the plane of the drawing, the bar vibrates in this plane. A pitch tone is produced, as well as one or more subtones and several overtones. Usually for a chime tone, the essential tones are (1) the pitch tone; (2) a sub-tone, eight semi-tones below the pitch tone; (3) the first overtone, which is seven semi-tones above the pitch tone; (4) the octave of the pitch tone; and (5) the double octave above the pitch tone.

These relationship are not accurate in the ordinary chime tube or bar. By the aid of processes to be described, the pitch tone and these four partials can be accurately brought into consonance.

As described in the prior application, the relative lengths of the bent ends **2** and **3** with respect to the overall length of the bar **1** before it is bent can be such that the pitch tone and the first and second octaves are in tune. The present process includes as a first step, forming the bar **1** with its ends **2** and **3** in such proportion that the first overtone above the pitch tone is in tune with the desired pitch tone. However, in that case, it is found that the first sub-tone, the pitch tone, and the first and second octaves above the pitch tone are too sharp.

For example, with a pitch tone of A–440, a bar made of one-eighth inch diameter round cold rolled steel can be made as follows: the lower bend **3** is .0685 times the unbent length of the bar, and the short upper bend **2** is made .039 times the unbent length of the bar. This proportion is subject to minor variations for bars of different length, and may be affected, to some extent, by different materials and different diameters.

In order to compensate for the sharpness of the pitch tone, the sub-tone, and the first and second octaves above the pitch tone, one or more grooves **10** and **11** are cut in the bar **1**. These grooves thin the bar, and are so located as to increase the flexibility of the bar at these points in the direction of flexure of the vibrations. Such thinning generally has the effect of flattening those tones that do not have nodal points at the grooves. The grooves are accordingly so placed that they are aligned with the bent ends **2** and **3**. These grooves are located near the third and fourth nodal points of the first overtone and not necessarily exactly at these nodal points. The mode of vibration, corresponding to the first overtone, is represented by the sinuous line **12** to the left of the bar **1**. This first overtone has six nodal points **13**, **14**, **15**, **16**, **17**, and **18**. At these points, the bar does not vibrate in the first overtone mode. Accordingly, these grooves **10** and **11** have little effect on the pitch of the first overtone, which is purposely made to be quite closely consonant with relation to the desired pitch.

However, since these grooves **10** and **11** fall at points corresponding to points of vibration for the first sub-tone, pitch tone, and the first and second octaves, these four modes of vibration are flattened. Sufficient flattening can be obtained by cutting the groove **10** at the third nodal point **15**. If desired, the groove **11** may be near the third nodal point **16** from the bottom of the bar. The dimensions given below apply to a bar with a single groove.

It has been found that the groove may be cut on a radius of one and one-half inches and to a depth corre-

sponding to approximately one-half the diameter of the bar 1.

In a specific example, after bending, but before the groove 10 is cut, the pitch tone was found to be 6 8/100 of a semi-tone sharp. The first octave above the pitch tone was found to be 2 9/100 of a semi-tone sharp. The second octave above the pitch tone was found to be 4 3/100 of a semi-tone sharp. The first sub-tone, which is to be placed eight semi-tones below the pitch tone, was found to be 1 1/100 of a semi-tone sharp. The first overtone, intended to be seven semi-tones above the pitch tone, was, in this instance, 2/100 of a semi-tone sharp. After the groove 10 was cut, it was found that all of the overtones were in substantially perfect concordance.

The length of the bar was chosen to make the first overtone slightly sharp (2/100 of a semi-tone) because it was experimentally determined that the best consonance of all partials is obtained when the groove is cut at a point slightly toward the end of the bar from the actual nodal point. Accordingly, a very slight flattening of the first overtone is effected by the groove.

Additional fine tuning can be accomplished by other steps in the process. Thus, if the longer bend 3 is shortened by filing, the first octave of the pitch tone is sharpened; the pitch tone and the second octave above the pitch tone are sharpened substantially equally but to a less extent than the first octave. The sub-tone eight semi-tones below the pitch tone is sharpened only to a slight degree. The first overtone seven semi-tones above the pitch tone is sharpened least of all.

By reducing the length of the bend 2 by filing, the pitch tone is sharpened, the octave above the pitch tone is sharpened to approximately the same degree, and the second octave is sharpened to a greater degree. The overtone is sharpened to a lesser degree than the pitch tone, and the first subtone is sharpened least of all.

It has also been found that the various partials of the bar 1 can be flattened in relation to each other to a small degree by filing a groove 19 on the inside corner of the bar. In this way, the pitch tone is very slightly flattened, the double octave partial is flattened to a greater degree, and the first octave is flattened about the same as the pitch tone. The first overtone is flattened to a degree slightly more than the pitch tone but considerably less than the second octave. The sub-tone is barely affected.

The groove in the bar may be located at other of the points in order to produce tuning effects by increasing the flexibility. Thus, in the form shown in Fig. 2, the bar 20 is shown as having a groove 21 of about the same proportion as grooves 10 and 11 located at or near the central node 22 of the pitch tone. When this is done, the first sub-tone will be flattened and the pitch tone will remain relatively constant. The first overtone will be flattened; and by this means, the sub-tone can be brought, if desired, to nine semi-tones below the pitch tone, and, by proper adjustment of the length of the bent portions 23 and 24, the double octave partials can be kept in tune with the pitch tone. The pitch tone and the first octave are flattened but slightly by the groove 21, since these partials have a node at this point. The double octave partial is flattened somewhat, but kept sharp by reducing the length of the short bend 23. A filed groove 19 in the corner of the short bend may be provided if desired for fine tuning (see Fig. 6). If desired, the groove can be placed at the outside corner, as at 41 of bar 40, as shown in Fig. 7.

In the form shown in Fig. 3, the bar 25 is similar to the bar 1 shown in Fig. 1, but the groove 26 is now cut in the bar at the second nodal bend 14 of the first overtone. In this way, the sub-tone can be lowered to a point nine semi-tones below the pitch tone. The bar 25 must be made somewhat sharp before grooving, since the pitch tone is likewise flattened by the groove 26, but to a slighter degree. Groove 26 improves the relationship of the first overtone to the pitch tone, since the first overtone is not flattened, while the pitch tone is flattened to a considerable degree. Accordingly, the effect is the same as if the first overtone were sharpened with respect to the pitch tone. In this manner, the first sub-tone, the pitch tone, and the first and second octaves above the pitch tone can be brought into accurate concordance by this method.

The first octave is flattened to the same degree as the pitch tone, whereas the second octave is affected very little. Accordingly, the length of the bar 25 and the bends 27 and 28 are such as to provide a sharp pitch tone and first octave, so that, when flattened by the grooving operation, these partials will be in tune.

In the form shown in Fig. 4, the resonant bar 29 can be provided with grooves 30, 31, and 32, corresponding substantially to the second, third, and fourth nodal points of the first overtone. The groove 33 is cut at or near the central nodal point of the pitch tone. In this form, all of the effects hereinafter noted may be obtained to a considerable degree. The filed corner 34, as well as the filing of the ends of the bends 35 and 36, may be utilized to provide finer tuning.

In the forms illustrated in Figs. 1 to 4, the compliance of the resonant bar is affected solely by thinning the bar at spaced points to increase flexibility in the direction of vibration. The same effects, however, can be substantially realized by decreasing the flexibility at one or more definite points. If the stiffness of a vibrating bar is increased at a given point, the frequencies of all partials requiring the bar to flex at this point will be increased. The degree of frequency increase is a direct function of the proximity of an antinode of the particular mode of vibration to the point of increased stiffness. On the contrary, if the stiffness is decreased (as illustrated in Figs. 1 to 4) to increase the compliance the same rule holds good except that now the frequency is decreased as a direct function of the proximity of an antinode of that particular mode of vibration to the point of increased compliance.

In Fig. 5, stiffening of the bar 37 at or near a node of the pitch tone is effected by increasing that dimension of the bar which is in the plane of vibration. This stiffening may complement the use of thinning at other places such as at 39, in the manner theretofore described. Stiffening can be effected, for example, by a forging operation flattening the bar at place 38 in a direction transverse to the plane of the bent ends. This flattening process increases the rigidity (or reduces the compliance) of the bar at the locality 38. Accordingly, all those partials are sharpened in pitch which have no nodes falling at or near the locality 38. On the other hand, the groove 39 lowers the pitch of those partials that do not have nodes falling at or near the groove 39.

Since the bars illustrated in each of the figures are provided with bends at the ends falling in a common plane, these bends serve to confine vibration substantially entirely to such a plane. In a straight bar, such a stiffening would be impractical since such a straight bar vibrates indiscriminately in all planes, and such stiffening would produce undesired beats.

The inventor claims:

1. A resonant bar having bends at each end, and forming end portions beyond the bends that extend transversely of the bar, one end portion being shorter than the other end portion, said bar having a groove in the corner of one of the bends, for flattening at least some of the tone partials of the bar.

2. A resonant bar having end portions bent transversely to the bar; one end portion being substantially twice as long as the other end portion; said bar having a stiffened portion intermediate the ends, the stiffened portion being such as to decrease flexibility in the plane of vibration.

3. A resonant bar having end portions bent transversely to the bar; one end portion being substantially .068 of the total length of the bar, and the other end portion being substantially .039 of the total length of the bar; said bar having a stiffened portion near a nodal point of one of the modes of vibration of the bar.

4. A resonant bar having a bend near one end thereof forming an end portion extending transversely of the bar, and having a groove in a corner of the bend.

5. A resonant bar having a bend at one end, forming a portion extending transversely of the bar; said bar having a thin portion intermediate the ends of the bar, there being a minimum thickness dimension transverse to the bar at said thin portion that is substantially in the direction of said end portion, to provide flexibility in said direction.

6. A resonant bar having bends at each end, and forming end portions extending in the same direction transversely of the bar; said bar having a thin portion intermediate the ends of the bar, there being a minimum thickness dimension transverse to the bar at said thin portion that is substantially in the direction of said end portions, to provide flexibility in said directon.

7. A resonant bar having a bend at one end, forming a portion extending transversely of the bar; said bar havhaving a thin portion intermediate the ends of the bar, the thin portion serving to reduce the thickness of the bar, there being a minimum dimension transverse to the bar at said reduced thickness that is substantially in the direction of said end portion, to provide flexibility in said direction.

8. A resonant bar having a bend at one end, forming a portion extending transversely of the bar; said bar having a thin portion intermediate the ends of the bar, the thin portion serving to reduce the thickness of the bar, the dimension of reduced thickness being substantially in the direction of the end portion.

9. A resonant bar having a bend at one end, forming a portion extending transversely of the bar; said bar having a plurality of thin portions intermediate the ends of the bar, there being, for each thin portion, a minimum thickness dimension transverse to the bar at said thin portion that is substantially in the direction of said end portion, to provide flexibility in said direction.

10. A resonant bar having a bend at one end, forming a portion extending transversely of the bar; said bar

having a plurality of thin portions intermediate the ends of the bar, the thin portions serving to reduce the thickness of the bar, the dimension of reduced thickness for each of the thin portions being substantially in the direction of the end portion.

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