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2,690,091

TONE GENERATOR

Filed Dec. 4, 1950

2 Sheets-Sheet 1

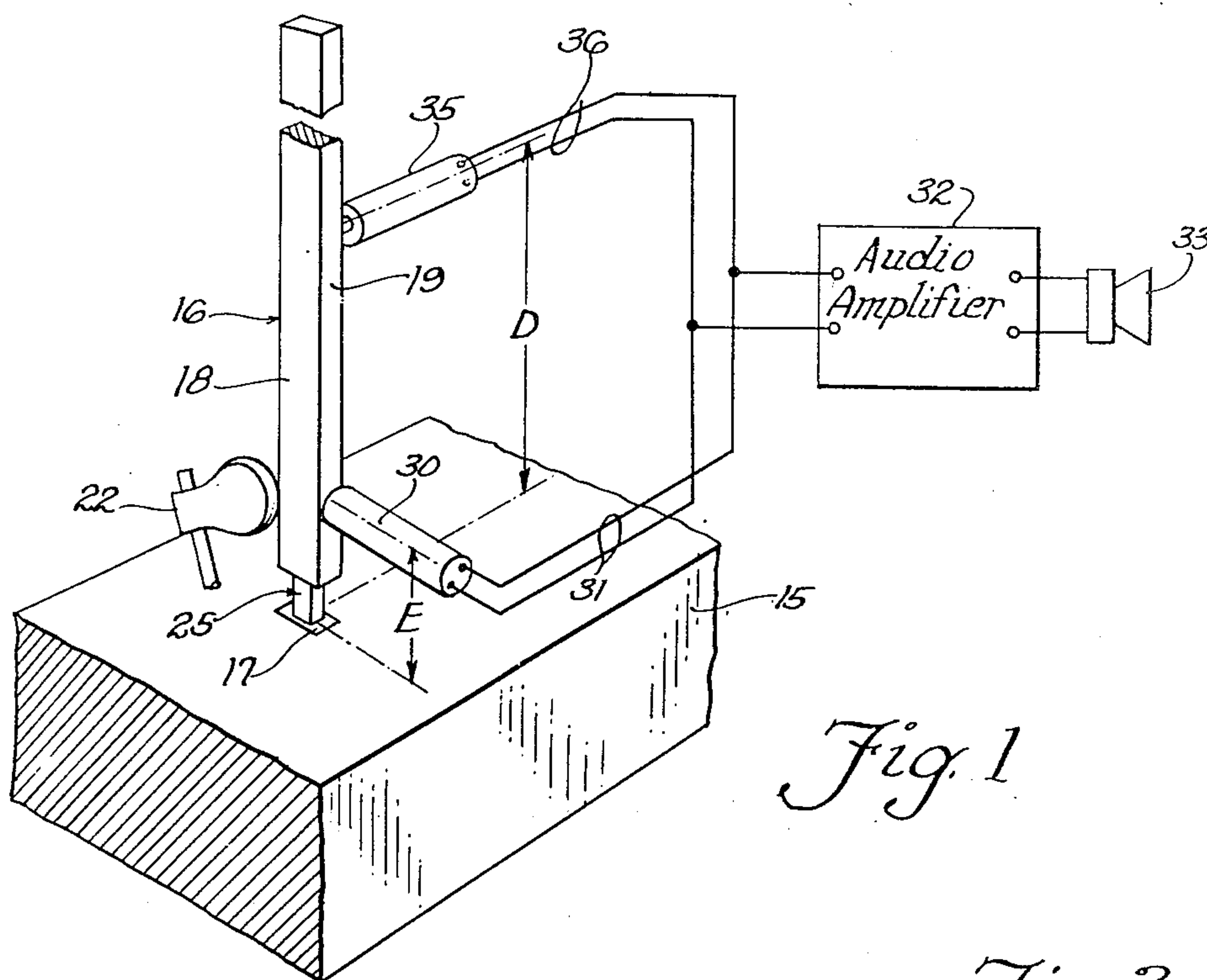


Fig. 1

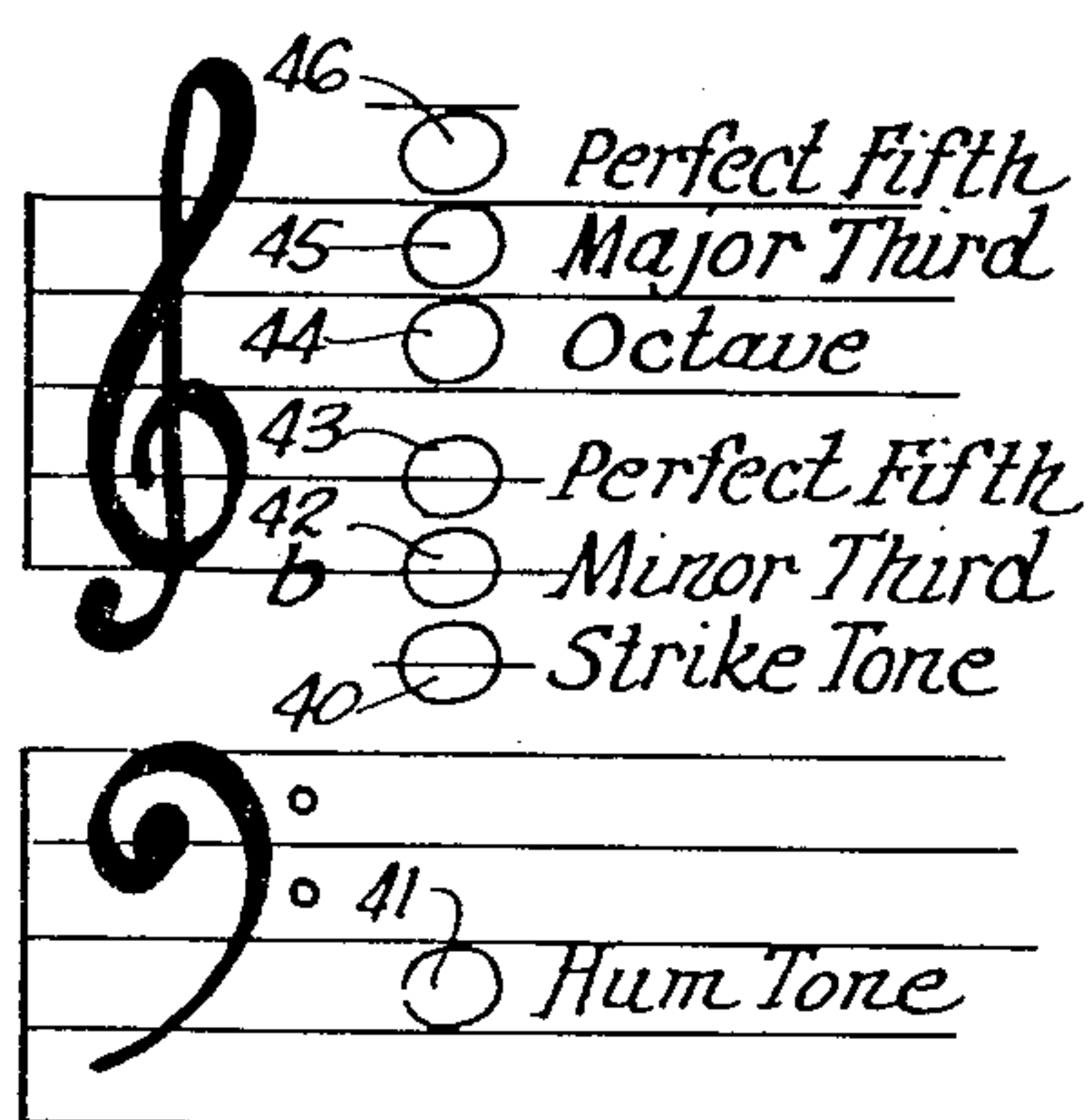


Fig. 2

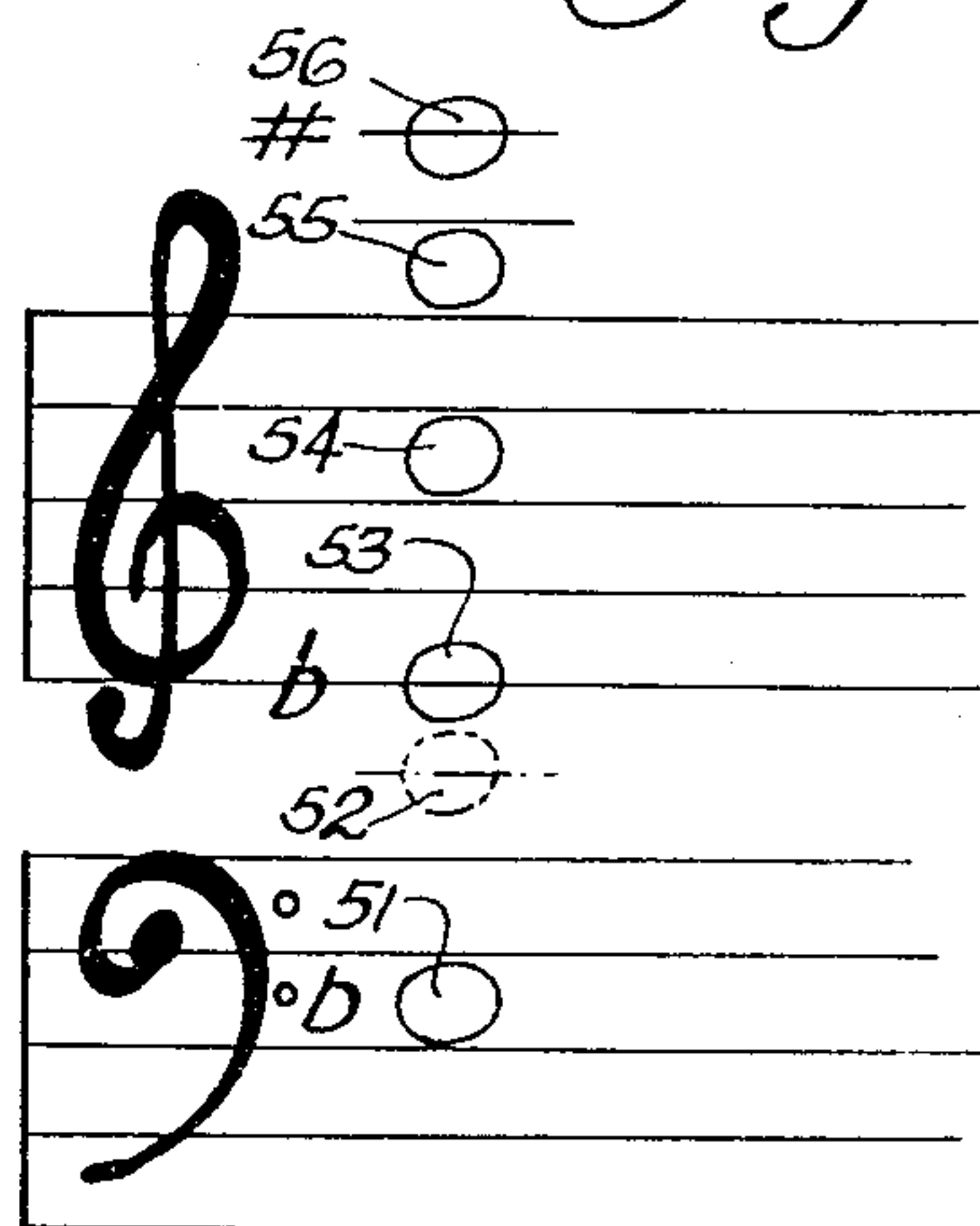


Fig. 3

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Fig. 4

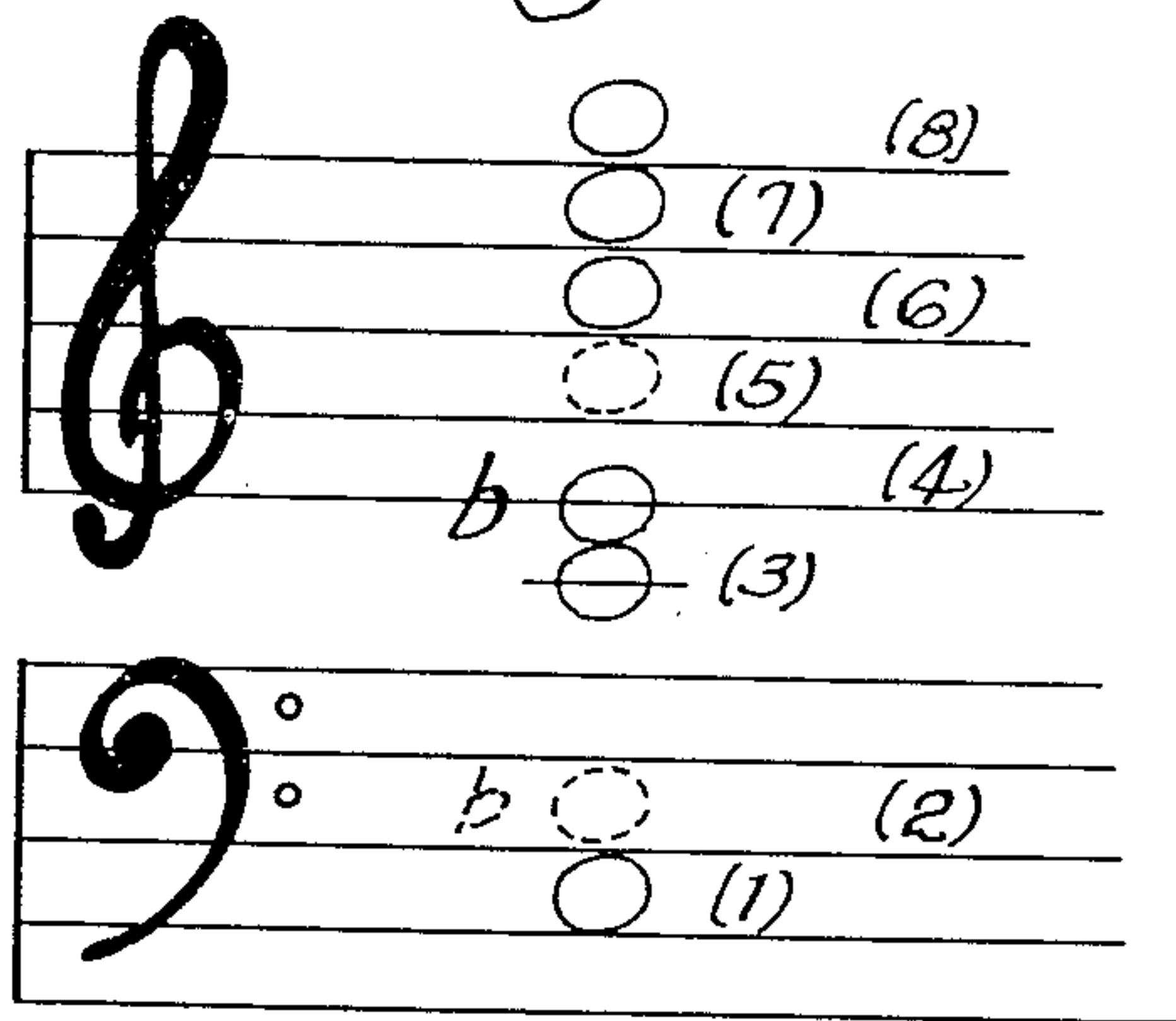


Fig. 5

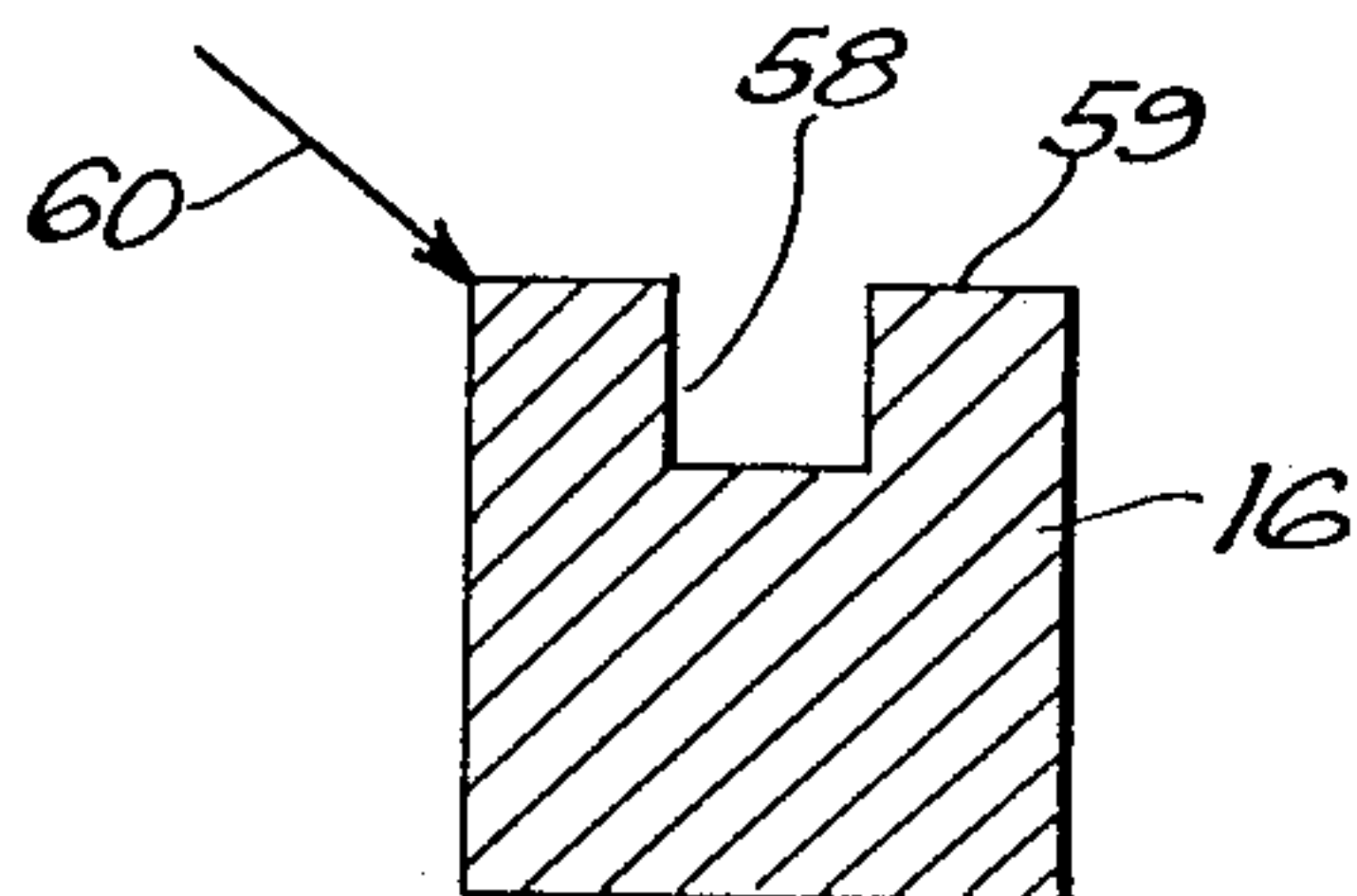


Fig. 6

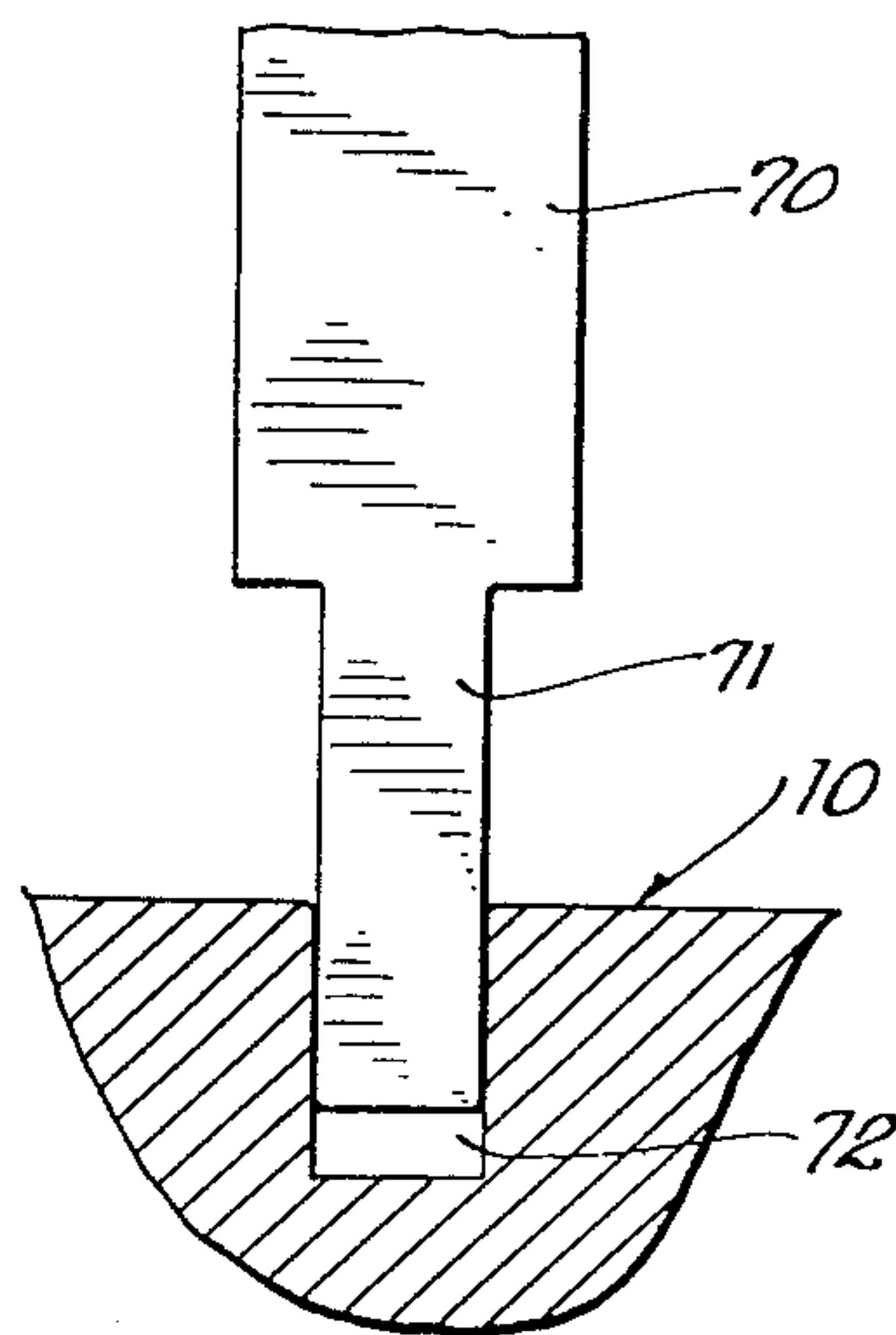
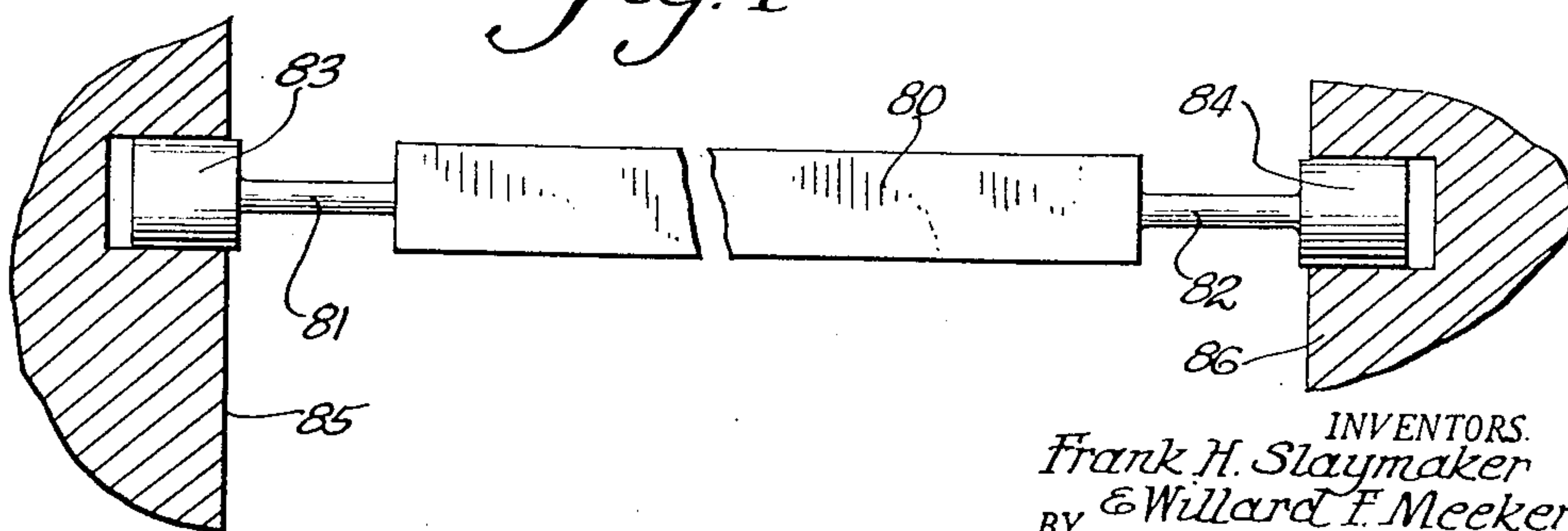


Fig. 7



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TONE GENERATOR

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12 Claims. (Cl. 84—1.15)

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The present invention relates to tone generators and, more particularly, to tone generators of the type employing a tuned metal bar which is struck to produce tone vibrations therein corresponding to a predetermined musical note.

Certain musical instruments, such as the electronic or so-called amplified carillon, employ a plurality of tone bars of different lengths and striker means for striking the bars either individually or in groups to play musical selections. The tone vibrations set up in the bar are picked up by a transducer device which converts the low level tone vibrations of the bar into electrical waves which are then amplified and reconverted into high intensity sound waves through suitable loud speakers. Electronic carillons of this type are fast replacing the conventional carillon using traditional or campaniform church bells because they will do everything the campaniform bells can do, and they are much lighter and cheaper. Furthermore, an electronic carillon can be installed where campaniform bells, by virtue of their weight and cost, are entirely out of the question.

In the main, the tone generator employed in most electronic carillons comprises an elongated tone bar, usually cylindrical, which is clamped at one end and has the other end free to vibrate when the bar is struck by any suitable striker means. Such a tone bar is commonly called a clamped-free type of tone generator. While tone generators of the above-described type do provide a tone which is basically pleasing to the ear, the tone from such a generator nevertheless sounds like a vibrating bar and not like the campaniform bells used in true carillons.

Certain attempts have been made to improve the tone of a clamped-free tone generator by varying the spacing of the tone partials so that they coincide more exactly with musical notes. Other prior art arrangements contemplate the use of various combinations of tone bars which are struck simultaneously to provide a fuller tone with more tone partials. However, it is almost impossible to strike several bars at exactly the same time, with the result that the overall effect is that of several bars being struck at once instead of a single bell being struck.

Accordingly, it is a primary object of the present invention to provide a new and improved tone generator.

It is another object of the present invention to provide a new and improved tone generator of the tone bar type in which a tone partial distribution of predetermined configuration is produced.

It is a further object of the present invention to provide a new and improved tone generator

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of the tone bar type wherein a tone substantially identical with that of a campaniform bell is produced.

It is a still further object of the present invention to provide a new and improved tone generator of the tone bar type wherein the spacing of the tone partials produced by the generator may be varied to correspond with the tone partial spacing of a chime or bell.

It is another object of the present invention to provide a new and improved tone generator in which a single tone bar is made to produce a group of related tone partials which correspond almost exactly with the tone partials produced in a campaniform bell.

It is still another object of the present invention to provide a new and improved tone generator in which a single tone bar is made to produce tone partials corresponding to all of the important tone partials of a campaniform bell-tone.

In accordance with one aspect of the invention, the tone generator comprises an elongated tone bar of rectangular cross-section which is struck on one corner thereof to produce two groups of related tone components, the pitch of the first group of tone components being spaced a minor third above the pitch of the second group of tone components. One of the tone components of the first group is suppressed by positioning a first electrical pickup near one end of the tone bar and opposite a narrow face of the bar, and a tone component of the second group is suppressed by positioning a second electrical pickup opposite a wide face of the bar and at a nodal point for the undesired component. With this arrangement, the composite tone produced by the two groups of related tone components corresponds almost exactly to a true campaniform bell tone. In accordance with a further aspect of the invention, the tone bar is provided with a reduced neck portion at the clamped end thereof and the tone component spacing of each of the two groups may be independently varied by changing the width of the neck portion in a direction perpendicular to the face of the tone bar which generates that group of tone components.

The invention, both as to its organization and method of operation together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of an electronic carillon employing tone generators constructed in accordance with the present invention;

Fig. 2 illustrates the musical tone components of a true campaniform bell-tone;

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Fig. 3 illustrates the musical tone components of a tone produced by a conventional clamped-free tone bar;

Fig. 4 illustrates the musical tone components of a tone produced in accordance with the present invention; and

Figs. 5-7, inclusive, illustrate alternative embodiments of the invention.

Referring now more particularly to the drawings, there is illustrated in Fig. 1 thereof a portion of an electronic carillon employing a tone generator constructed in accordance with the principles of the present invention. In general, the electronic carillon shown in Fig. 1 comprises a base member 15, which carries a plurality of tone bars of different lengths, one of which is illustrated at 16. The tone bar 16 is clamped at the lower end thereof in the base member 15 by any suitable means. For example, the tone bar 16 may be inserted into a socket type clamp 17 so that the lower end of the bar 16 is prevented from vibrating.

In accordance with the present invention and as will be described in more detail hereinafter, the tone bar 16 is of rectangular cross-section and is provided with a relatively broad face 18 and a somewhat narrower face 19. In order to produce tone vibrations in the bar 16, the bar is struck by any suitable striker means, as for example by the hammer 22, at a point intermediate the length thereof. However, in accordance with the present invention the hammer 22 is made to strike the tone bar on a corner thereof to produce two groups of related tone components, as will be described in more detail hereinafter. The bar 16 is provided at its lower end with a reduced neck portion 25 which is somewhat narrower in both dimensions than the corresponding faces 18 and 19 of the main portion of the tone bar 16.

When the bar 16 is struck by the hammer 22, a group of related tone vibrations, or tone partials, are set up in the bar which collectively produce a composite tone having a pitch which is determined by the physical dimensions of the bar. The vibrations of the bar may be picked up by any suitable pickup device, converted into corresponding electrical waves, and amplified and reconverted into sound waves of high intensity which simulate the high intensity sound waves produced by the traditional church bell. While a single pickup device may be employed to reproduce in electrical form the tone vibrations of the bar 16, in order to suppress certain undesired tone components two electrical pickup devices are provided which are positioned at spaced points along the bar as described in more detail hereinafter. Thus, a first electrical pickup device 30 is positioned opposite the narrow face 19 of the tone bar and picks up the vibrations which are radiated from this face. The electrical output of the pickup 30 is supplied over the conductors 31 to an audio amplifier 32 wherein the electrical waves are amplified to a suitable level and supplied to a loud speaker system indicated at 33. A second electrical pickup device 35 is positioned opposite the broad face 18 of the tone bar and picks up vibrations emanating from the face 18 and converts these vibrations into corresponding electrical waves which are supplied over the conductors 36 to the input of the amplifier 32 in parallel with the output from the pickup 30. For reasons to be discussed in more detail hereinafter, the pickup device 30 is positioned a distance E away from the clamped end of the tone bar 16

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and the pickup device 35 is positioned a greater distance D away from the clamped end of the tone bar.

In considering the operation of the above-described electronic carillon tone generator, it will be evident that if the electronic carillon is to be used to simulate the tone produced by a true campaniform bell, the tone components or partials which go to make up the composite tone produced by the bar 16 must correspond almost exactly with the tone components of a campaniform bell-tone. The human ear is quite sensitive to the omission of a tone partial or the dissonant grouping thereof and readily detects the tone of a conventional clamped-free tone bar as that of a vibrating rod and not a true campaniform bell. The differences in tone structure of the clamped-free bar tone and the campaniform bell-tone are readily apparent when a comparison of the tone component spacing of the two tones is made. In Fig. 2 there is illustrated the tone components present in the tone of a true campaniform bell. As there shown, the important components of a true campaniform bell-tone comprise the strike tone 40, which in the example illustrated is at middle C, a hum tone 41, which is an octave below the strike tone, a minor third component 42, a perfect fifth component 43 above the strike tone, an octave component 44 above the strike tone, a major third component 45 above the octave 44 and a perfect fifth component 46 above the octave 44. In the tone component arrangement of the campaniform bell shown in Fig. 2 the perfect fifth 43 above the strike tone is relatively weak as compared to the other tone components and is not too important in determining the overall pitch of the tone.

In contradistinction to the above-described tone partial grouping which obtains in a true campaniform bell, the tone components of a conventional clamped-free tone bar which is tuned to a nominal pitch of middle C are illustrated in Fig. 3. Referring to this figure, the notes 50-56 inclusive represent the second through the seventh tone components in a clamped-free rod to the nearest musical note. It will be understood that the note 52 which corresponds to the strike tone of the campaniform bell is not physically present as a tone component but is reconstructed by the human ear, due to the tone relation of the tone partials so that the listener appears to hear the component 52.

In considering the tone components in the conventional clamped-free rod shown in Fig. 3 it is evident that these components are spaced much farther apart than the tone partials of the campaniform bell-tone shown in Fig. 2. The second and seventh components 50 and 56 are so far removed from the nominal pitch that they may be neglected in an analysis of the tone partial arrangement of the bar. However, the third through sixth components, 51-55 inclusive, neglecting the imaginary strike tone 52, are sufficiently close to the musical notes shown in Fig. 3 to appear to the ear to be in tune. It is further evident from a comparison of Figs. 2 and 3 that even though the spacing of the tone components 51-55 inclusive can be varied, there still remain certain tone components of the campaniform bell tone which are missing. Thus the campaniform bell tone has seven tone components whereas the conventional clamped-free bar has only four tone components falling within the same range.

In order to provide additional tone components which correspond to the missing tone components

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of the true campaniform bell-tone of Fig. 2, there is provided in accordance with the present invention a second series of tone components corresponding to the third through sixth tone components of the bar and this second series of components is spaced a minor third below the components 51, 53, 54 and 55. To accomplish this, the tone bar 16 of the present invention is provided with a rectangular cross-section and the sides thereof are of different widths. The bar is struck on one corner thereof to produce double tones so that for each of the third through sixth components of the conventional clamped-free tone bar two tone components are produced which are spaced apart by a minor third. The tone partial distribution obtained with the rectangular tone bar of Fig. 1 is shown in Fig. 4 and comprises a first set of tones (1), (3), (5), and (7) which are produced at the broad face 18 of the tone bar and a second group of related tone components (2), (4), (6), and (8) which are produced at the narrow face 19 of the tone bar. By comparing the notes of Fig. 2 and Fig. 4 it becomes evident that the tone components of the rectangular tone bar shown in Fig. 4 correspond to the tone components of the true campaniform bell with the exception that a major sixth tone component (5) above the strike tone is present in the tone pattern of Fig. 4 and a false hum tone component (2) above the lower octave (1) is not present in the campaniform bell tone. However, it will be understood that the components (1), (3), (4), (6), (7) and (8) of the rectangular tone bar correspond to the tone components 41, 40, 42, 44, 45 and 46 of the campaniform bell-tone.

To provide a tone from the tone bar 16 which sounds like a true campaniform bell tone, it is necessary to suppress the major sixth component (5) and the false hum tone (2) of Fig. 4. In accordance with the present invention the major sixth component (5) is suppressed by positioning the pickup device 35 at a point along the bar 16 which corresponds to a node of the component (5). With this arrangement, the major sixth component vibrations are not present at the nodal point and hence are not picked up by the device 35 and do not appear in the audio output from the loud speaker 33. It has been found that the device 35 should be positioned a distance D away from the clamped end of the rod which is approximately equal to .28 times the length of the rod to effect suppression of the tone component (5).

In order to suppress the false hum tone (2), the pickup device 30 which is opposite the narrow face 19 of the tone bar, is placed near the clamped end of the tone bar, and, more specifically, is spaced a distance E away from the clamped end of the tone bar such that the device 30 discriminates against all low frequency components. With this arrangement, the false hum tone (2) is greatly attenuated. If insufficient discrimination is thus provided, a filter (not shown) individual to pick-up 30 may be employed.

While there is no perfect fifth component above the strike tone in the tone partial combination of Fig. 4, corresponding to the tone component 43 of the true campaniform bell tone of Fig. 2, the component 43 is so weak in a real bell tone that it is not necessary to introduce a fifth component by other means.

The individual tone components which go to make up the two series of tone components (1), (3), (5) and (7) and (2), (4), (6) and (8), may not correspond exactly to the musical notes

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shown in Fig. 4. Accordingly, it is necessary to vary the relative spacing of these components. For example, it may be necessary to vary the spacing of the components (1), (3), (5) and (7), or on the other hand, it may be necessary to vary the relative spacing of the components (2), (4), (6) and (8). In this connection it will be understood that the spacing between the two groups of tone components is determined by the relative widths of the broad and narrow faces 18 and 19 of the tone bar. Preferably the ratio of the widths of the broad and narrow faces of the tone bar is such that the two groups of tone components are spaced a minor third apart to give the composite tone shown in Fig. 4. Thus, the component (2) is spaced a minor third above the component (1), the component (4) is spaced a minor third above the component (3), the component (6) is a minor third above the component (5) and the component (8) is a minor third above the component (7).

The tone components of a rectangular tone bar of uniform cross-section, which is not provided with the reduced neck portion 25, are too closely spaced to simulate the musical notes shown in Fig. 4. However, the relative spacing of the tone components which go to make up a particular group may be varied in accordance with the present invention by varying the width of the corresponding dimensions of the reduced neck portion 25 of the tone bar. Thus, the tone components (1), (3), (5), and (7) may be spread out by reducing the width of the neck portion 25 in the direction perpendicular to the broad face 18 of the tone bar so as to make the tone bar more flexible in a direction perpendicular to the face 18. In a like manner the other group of tone components (2), (4), (6), and (8) may be spread out by reducing the width of the neck portion 25 in a direction perpendicular to the narrow face 19 so that the bar is more flexible in that direction. The above described reduction in width of the sides of the neck 25 may conveniently be accomplished by filing the neck portion to reduce the width in the desired direction. Alternatively, the length of the neck portion 25 may be changed by moving the bar into or out of the socket 17 so as to change the flexibility of the bar in both directions at once.

Thus, it may be seen that this invention provides for controlling the frequency spread of components by means of a neck portion having a cross-sectional area extending about a major and a minor axis. Any change in the dimensions of either one of the axes of the cross-sectional area without change in the other axis changes the spacing between components in a first group of components without affecting the spacing of components in the other group of components.

In changing the spacing between the tone components of each group as described above, the pitch of the tone components is also lowered so that it is necessary to choose the correct ratio of the sides of the rectangular tone bar to obtain the tone component spacing shown in Fig. 4. It should be noted that the frequency ratio of the two groups of tone components is approximately equal to the ratio of the widths of the sides of the rectangular tone bar, and it has been found that a ratio of 1.2 to 1 will satisfactorily provide the above described minor third separation.

The amount by which the tone component spacing can be varied by making the neck portion 25 more flexible is limited to the normal

frequencies of a tone bar having one end fixed in position, but not clamped, and the other end free. Such a tone bar has been called a fixed-free tone bar and the spacing of the normal tone components of such a fixed-free bar has been calculated by Rayleigh in his volume, "Theory of Sound," volume 1, page 286. According to Rayleigh, the tone components of a fixed-free bar are further apart than the corresponding components of the tone shown in Fig. 4, whereas the components in a clamped-free bar of uniform cross-section are too close together. Accordingly, by varying the width of the neck portion 25 an intermediate point may be found at which the spacing between the individual tone components closely corresponds to the musical notes shown in Fig. 4 thereby simulating the true bell tone of Fig. 2. It should be noted that the two sets of components may be adjusted independently of one another by varying the flexibility of the tone bar in a direction perpendicular to either the broad face 18 or the narrow face 19.

While the present invention has been described in connection with a tone generator employing a clamped-free type of tone bar, it will be evident that a useful grouping of the tone components may be obtained by employing free-free or clamped-clamped tone bars of rectangular cross-section in which the tone bar is struck on one corner and electrical pickup means are employed in a manner similar to that described in connection with Fig. 1. Additionally, it will be evident that tone bars of other unsymmetrical cross-sections may be employed as well as the rectangular cross-section bar shown in Fig. 1. For example, the tone bar may be of the cross-section illustrated in Fig. 5. Referring to this figure, the tone bar 16 is square and is provided with a groove or spline 58 in one side thereof. The tone bar is struck on one corner thereof as indicated by the arrow 60 to produce two related groups of tone components, and the width of the side 59 of the tone bar is effectively increased by the groove 58 so as to produce the lower frequency group of tone components (1), (3), (5) and (7) shown in Fig. 4. A pickup device is positioned opposite the face 59 to pick up the lower frequency group of tone components and another pickup device is positioned opposite one of the other faces of the bar to pick up the higher frequency group of tone components. In the alternative, other unsymmetrical cross-sections such as a T-section, H-section or L-section may be employed to produce the composite tone described above.

The spacing of the tone components of the tone bar may also be varied by means of the alternative arrangement shown in Fig. 6. As shown in this figure, a tone bar 70 is provided which may have any unsymmetrical cross-section, and is provided with a reduced neck portion 71 of cylindrical cross-section. The neck portion 71 is arranged to be clamped in the base member 10 by any suitable means, and the spacing of the tone components is varied by changing the clamping point. With this arrangement, the bar may be moved up and down within the clamping well 72 in the base member 10 to provide the correct flexibility of the neck portion 71 so as to produce the desired tone component spacing.

In the event that tubular chimes are to be simulated by an electronic instrument similar to that shown in Fig. 1, it is customary to employ a clamped-clamped type of tone bar in preference to the clamped-free type of tone bar shown in

Fig. 1. However, the tone components of a clamped-clamped bar are too close together frequency-wise. In a fixed-fixed tone bar, i. e., a tone bar in which both ends are fixed in position but are not clamped, the tone components are too far apart as described above in connection with the fixed-free tone bar. However, the correct spacing of the tone components of a clamped-clamped tone bar may be obtained by employing the alternative embodiment shown in Fig. 7. Thus, referring to this figure, the clamped-clamped tone bar 80 is provided with reduced neck portions 81 and 82 at either end thereof, the neck portions being preferably of cylindrical cross-section, and the extremities 83 and 84 of the tone bar 80 are clamped in the base members 85 and 86. With this arrangement it is possible to tune the several tone components of the clamped-clamped tone bar 80 simultaneously in the manner described in connection with the clamped-free bar of Fig. 6 by merely varying the length, and hence the flexibility of the neck portions 80 and 81. Alternatively, the flexibility of the neck portions 81 and 82 may be varied by changing the cross-section thereof by any suitable means, such as by filing or the like.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention as defined in the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In an electronic carillon or similar device, the combination of, an elongated tone bar having at least two sides of different widths, means for striking said tone bar on a corner thereof to produce two related groups of tone components therefrom, and two pickup means, one of said pickup means being positioned adjacent one of said sides in such a manner as to be excited by vibrations radiated therefrom, and the other of said pickup means being positioned adjacent another of said sides in such a manner as to be excited by vibrations radiating therefrom.

2. The electronic carillon of claim 1 in which said elongated tone bar has a rectangular cross-section in which the sides are of different widths, each of one of oppositely disposed set of said sides being substantially 1.2 times as wide as each of the other oppositely disposed set of said sides.

3. The electronic carillon of claim 1 in which said elongated tone bar comprises a neck portion, said neck portion having a major and a minor axis of cross-section positioned such that any change in the dimensions of either one of said axes changes the spacing between components in a first of said groups of tone components without affecting the spacing of components in the other of said groups of tone components.

4. The electronic carillon of claim 1 in which the relative widths of said sides are of such dimensions as to make the pitch of one of said groups of tone components a minor third above the pitch of others of said groups.

5. The electronic carillon of claim 1 in which said elongated tone bar comprises a neck portion having an elongated cross-section of dimensions which are selectively reduced with respect to each of said sides such that the tone components of said first and second group substantially coincide with the corresponding tone components of a campaniform bell-tone of the same pitch.

6. The electronic carillon of claim 1 in which the relative widths of said sides are of such dimensions as to make the pitch of one of said groups of tone components a predetermined musical interval above the pitch of the other of said groups of said tone components.

7. In an electronic carillon or similar device, the combination of, an elongated tone bar having at least two sides of different widths, means for striking said tone bar on a corner thereof to produce two related groups of tone components therefrom, said tone bar having a neck portion, said neck portion having a major and a minor axis of cross-section positioned such that any change in the dimensions of either one of said axes changes the spacing between components in a first of said groups of tone components without affecting the spacing of components in the other of said groups of tone components, and two pickup means, one of said pickup means being positioned adjacent one of said sides and the other of said pickup means being positioned adjacent another of said sides.

8. In an electronic carillon or similar device, the combination of, an elongated tone bar having at least two sides of different widths and having one end clamped and the other end free to vibrate, means for striking said tone bar in a direction having a substantial component which is in a plane at an acute angle to one of said sides, said plane also being substantially parallel to the length of said bar, said strike producing two related groups of tone components from said bar, two pickup means, one of said pickup means being positioned adjacent one of said sides and the other of said pickup means being positioned adjacent another of said sides, said tone bar having a neck portion of reduced cross-section adjacent the clamped end thereof, and means for varying the length of said neck portion, thereby to adjust the spacing of the tone components of said groups.

9. In an electronic carillon or similar device, the combination of, a rectangular tone bar clamped at one end and having the other end thereof free to vibrate, means for striking said bar on a corner thereof to produce two related groups of tone components, the pitch of said second group of tone components being a minor third above the pitch of said first group of tone components, a first pickup device positioned opposite a wide face of said bar for converting said first group of tone components into corresponding electrical waves, a second pickup device positioned opposite a narrow face of said bar for converting said second group of tone components into corresponding electrical waves, and means utilizing the outputs of said first and second pickup devices for producing a true campaniform bell-tone when said bar is struck.

10. In an electronic carillon or similar device, the combination of, an elongated rectangular tone bar clamped at one end and having the other end thereof free to vibrate, means for striking said bar on a corner thereof to produce first and second groups of tone components, the pitch of said second group of tone components being a minor third above the pitch of said first group of tone components, a first pickup device positioned opposite a wide face of said bar for converting said first group of tone components into corresponding electrical waves, said first pickup device being positioned at a point along said rod which is a node for the major sixth tone

component of said first group, thereby to suppress said major sixth tone component of said first group, a second pickup device positioned opposite a narrow face of said bar for converting said second group of tone components into corresponding electrical waves, said second pickup device being positioned near the clamped end of said bar, thereby to suppress the hum tone component of said second group, and means utilizing the outputs of said first and second devices for producing a true campaniform bell-tone when said bar is struck.

11. In an electronic carillon or similar device, the combination of, a clamped-free tone bar of rectangular cross-section and having a neck portion of reduced cross-section at the clamped end thereof, means for striking said bar on a corner thereof to produce first and second related groups of tone components therefrom, the pitch of said second group of tone components being a minor third above the pitch of said first group of tone components, said neck portion having a cross-section such that the tone components of said first and second groups substantially coincide with the corresponding tone components of a campaniform bell-tone of the same pitch, a first pickup device positioned opposite a wide face of said bar for converting said first group of tone components into corresponding electrical waves, said first pickup device being positioned at a point along said rod which is a node for the major sixth tone component of said first group, a second pickup device positioned opposite a narrow face of said bar for converting said second group of tone components into corresponding electrical waves, said second device being positioned near the clamped end of said bar thereby to suppress the hum tone component of said second group, and means utilizing the outputs of said first and second devices for producing a true campaniform bell-tone when said bar is struck.

12. In an electronic carillon or similar device, the combination of an elongated tone bar having two mutually perpendicular dimensions of different length lying in a cross-sectional area of said bar, means for clamping one end of said bar, the other end being free to vibrate, means for striking said tone bar in a direction having a substantial component which is in a plane at an acute angle to one of said dimensions, said plane also being substantially parallel to the length of said bar, said strike producing two related groups of tone components from said tone bar, two pickup means, one of said pickup means being positioned substantially in line with one of said dimensions and the other of said pickup means being positioned substantially in line with the other of said dimensions, said tone bar having a neck portion of reduced cross-section adjacent the clamped end thereof, and means for varying the length of said neck portion, thereby to adjust the spacing of the tone components of said groups.

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