April 30, 1935. A. N. CURTISS 1,999,355

MUSICAL INSTRUMENT

Filed Dec. 16, 1933

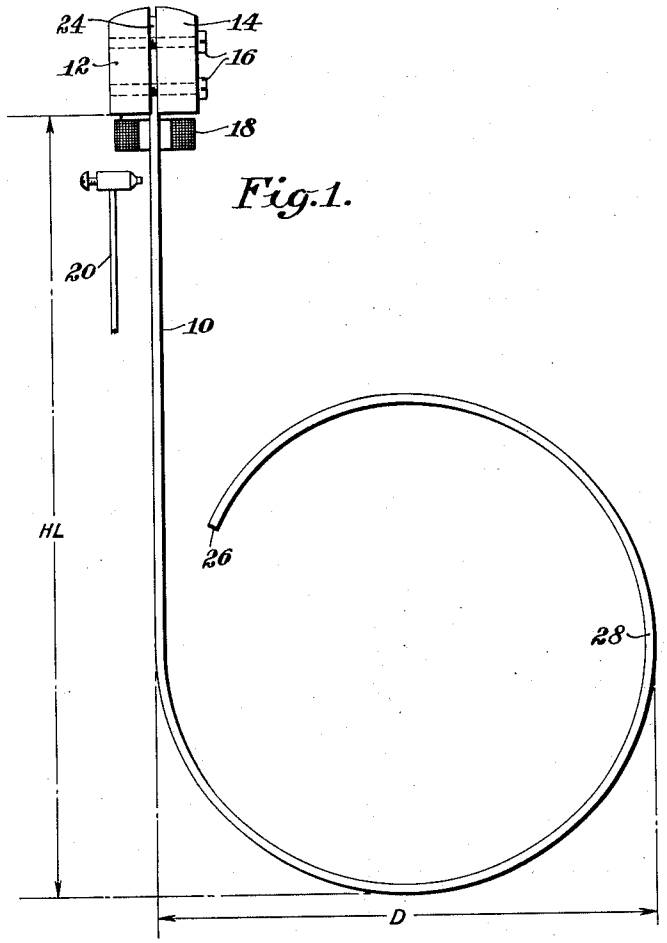


Fig.1.

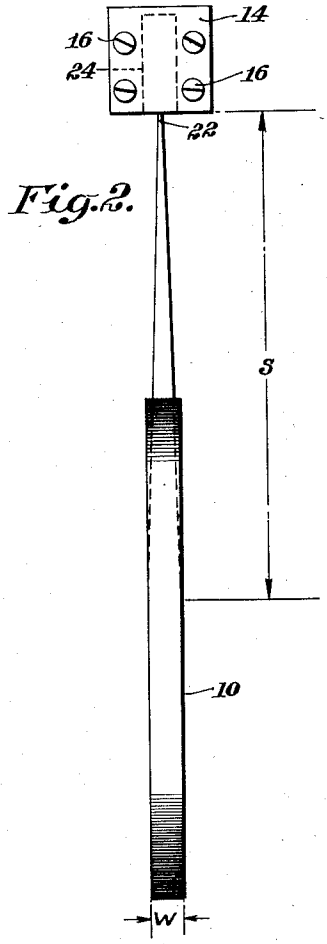


Fig.2.

Fig.3.

NOTE	PITCH FREQUENCY (X)	HANGING LENGTH(HL)	TOTAL LENGTH(L)	OUTSIDE DIAMETER (D)	WIDTH (W)	SLOPE (S)
C'	517.3∾	6.48"	18.16"	4.17"	.25"	5.21"
D_b'	548.∾	6.32"	17.7"	4.06"	.25"	5.08"
D'	580.7∾	6.15"	17.24"	3.96"	.25"	4.95"
E_b'	615.2∾	6."	16.81"	3.86"	.25"	4.83"
E'	651.8∾	5.85"	16.38"	3.76"	.25"	4.7"
F'	690.5∾	5.7"	15.97"	3.66"	.25"	4.58"
G_b'	731.6∾	5.55"	15.56"	3.57"	.25"	4.47"
G'	775.1∾	5.41"	15.17"	3.48"	.25"	4.35"
A_b'	821.2∾	5.27"	14.78"	3.39"	.25"	4.24"
A'	870 ∾	5.14"	14.41"	3.3"	.25"	4.14"
B_b'	921.7∾	5.01"	14.04"	3.22"	.25"	4.03"
B'	976.5∾	4.88"	13.68"	3.14"	.25"	3.93"
C^2	1034.1∾	4.75"	13.32"	3.06"	.25"	3.82"

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MUSICAL INSTRUMENT

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10 Claims. (Cl. 84—408)

My invention relates to improvements in musical instruments of the type wherein a vibratory element in the form of a coiled spring or reed is struck and thereby caused to vibrate to produce a musical note and, more particularly, to the construction of the vibratory element per se.

Development work on musical instruments of the character referred to has been carried on with the object of obtaining an instrument, commonly referred to as an electric carillon, which faithfully reproduces the sounds of chimes and/or bells. In this connection, it has been found that the capability of the instrument to exactly reproduce the sound of a chime or a bell depends upon a number of structural and physical characteristics of the vibratory element. The various constructions of vibratory elements proposed heretofore have been capable of reproducing the sounds of chimes and bells with some degree of fidelity, but there has often been a very noticeable distortion of some kind. For example, the vibratory elements proposed heretofore have been too rich in undesirable harmonics to be entirely satisfactory for exactly reproducing the sounds of bells and chimes and, furthermore, these elements have lacked the characteristic harmonics of bells.

In Patent No. 1,907,936 issued to me May 9, 1933, an improved construction of a vibratory element of the character referred to is disclosed. While this construction makes possible satisfactory reproduction of a musical note of a chime or bell, there is some perceptible distortion of the reproduction.

With the foregoing in mind, it is one of the objects of my invention to provide an improved construction of vibratory element of the character referred to which is capable of a more faithful reproducing action than has been possible with the various constructions proposed heretofore, and which has advantages over the prior constructions in the way of a substantial decrease in the attenuation or rate of decay of the vibrations in the reeds, a substantial reduction of the quantity of undesirable undertones (subharmonics), and a substantial increase in the number and quantity of desirable upper harmonics.

Other objects and advantages will hereinafter appear.

For the purpose of illustrating my invention, an embodiment thereof is shown in the drawing, wherein

Figure 1 is a front elevational view of a portion of a musical instrument constructed and set up in accordance with my invention;

Fig. 2 is an end elevational view, looking toward the left in Fig. 1; and

Fig. 3 is a table of dimensions for a vibratory element constructed in accordance with my invention, and capable of faithfully reproducing the notes of chimes or bells.

In Figs. 1 and 2, the vibratory element **10** is capable of reproducing a musical note having a definite pitch frequency, and may be considered as being one of a number of such elements mounted in bank formation and constructed and adjusted to reproduce the respective notes in the musical scale. One manner of supporting and operating the various elements is disclosed in the copending application of Carroll D. Kentner, Serial No. 574,961, filed November 14, 1931, and assigned to the Radio Corporation of America.

As shown, the end of the straight portion of the element **10** is clamped between suitable blocks **12** and **14** by screws **16** which pass loosely through the block **14** and thread into the block **12**.

For the purpose of transforming the physical vibrations of the element **10** into electrical pulsations, the element is supported with its straight portion extending through an air gap in a magnetic circuit which may be provided by a permanent magnet of suitable form (not shown). A pick-up coil **18** is so disposed in the magnetic circuit that, as the element **10** vibrates in the air gap, a current is induced in this coil at a frequency corresponding to the frequency of vibration. This current is then amplified and supplied to a loud speaker or other acoustic device (not shown).

A striker, which may be in the form of a hammer **20**, is suitably supported for manual or electrical operation to strike the element **10** to set it into vibration.

The advantages of my improved construction over those proposed heretofore is attributed to the characteristic shape of the supported end of the element, as shown in Fig. 2. The essential characteristic, particularly over the construction disclosed in Patent No. 1,907,936, resides in the taper of the supported end of the element to a neck **22** which is very narrow as compared with the width W of that part of the element which is not tapered. More specifically, the relation of the width of the neck **22**, or that part of the element **10** directly at the point of support, to the width W of the part which is not tapered, is less

than one-fourth. In the disclosed embodiment of my invention, this relation is one-tenth.

Immediately at the neck 22 or smaller end of the taper, the width of the element increases abruptly to W or at least to several times the width of the neck to form the end portion 24 by which the element is supported.

It has been found that by reason solely of the characteristic construction or shape of the supported end of the element that the latter has important advantages over the prior constructions in the way of a substantial decrease in the attenuation or rate of decay of the vibrations in the reed, a substantial reduction of the quantity of undesirable undertones (sub-harmonics), and a substantial increase in the number and quantity of desirable upper harmonics.

Any particular element for reproducing a musical note of a definite pitch frequency has characteristic relations between certain dimensions of this element and the pitch frequency. These relations, in my improved device, are different from those in the construction disclosed in Patent No. 1,907,936, on account of the characteristic taper of the supported end of the element.

One of these dimensions I refer to as the total vibrating length L of the element, and measure this along the element, from the neck 22, at the edge of the clamping blocks 12 and 14, to the free vibrating end 26 of the element. In my improved construction, $L=Ax^a$, wherein x is the pitch frequency, L is the total vibrating length of the element in inches, A is a factor within the range of 290 to 300, and a is an exponent of x within the range of $-.44$ to $-.45$. Very satisfactory results have been obtained by making A substantially equal to 294.3 and by making the exponent a substantially equal to $-.4456$.

Another important dimension in my improved construction is the hanging length HL, which is measured, as shown in Fig. 1, from the neck 22, at the edge of the clamping blocks 12 and 14, to a line tangent to the spiral portion 28 of the vibratory element and perpendicular to the straight portion of the latter. In my improved construction, $HL=Bx^b$, wherein HL is the hanging length of the vibratory element in inches, B is a factor within the range of 100 to 110, and b is an exponent of x within the range of $-.44$ to $-.45$. Very satisfactory results have been obtained by making B substantially equal to 104.9, and by making b substantially equal to $-.4456$.

Another important dimension in my improved construction is the outside diameter D of the spiral portion 28, the relation being $D=Cx^c$, wherein D is the outside diameter in inches, C is a factor within the range of 63 to 73, and c is an exponent of x within the range of $-.44$ to $-.45$. Satisfactory results have been obtained by making C substantially equal to 67.46, and by making c substantially equal to $-.4456$.

Another structural characteristic of my improved vibratory element resides in the number of degrees through which the spiral portion 28 extends. In the particular embodiment of my invention disclosed, the spiral portion 28 extends through substantially 330 degrees. In vibratory elements constructed in accordance with my invention, the number of degrees through which the spiral extends may be within the range of from 270 to 450 degrees, as might be desired. I have found that if the spiral extends beyond this range, the tone reproduced is too rich in harmonics and that if the spiral does not come within this range the vibratory element lacks the characteristic harmonics of a bell of the corresponding note.

The tapered end of the element 10 I refer to as the "slope" (S), the relation being $S=Ex^e$, wherein E is a factor within the range of 80 to 90, and e is an exponent of x within the range of $-.44$ to $-.45$. Satisfactory results have been obtained by making E substantially equal to 84.4 and by making e substantially equal to $-.4456$.

I propose to make the elements 10 from a very high grade tempered steel, the steel being tempered to between 1400 and 1500 degrees Fahrenheit, the material being $\frac{1}{16}$'' gauge. Any other magnetically permeable material, or combination of materials having the required characteristics, may be used to make the elements 10. The width W of the material preferably is from $\frac{1}{8}$'' to $\frac{1}{2}$''. The width of the element does not affect the tone color, and is selected only to provide the desired stiffness.

For the purpose of preventing rusting of the elements, I propose to give the same a very light coat of cadmium. This is done without raising the temperature or subjecting the device to other conditions which might change the tonal qualities of the instrument.

The various dimensions given in Fig. 3 have been found to be satisfactory for a set of vibratory elements covering the various notes in the musical scale from the "C" one octave above "middle C" to "high C".

I claim as my invention:

1. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support, and being characterized by the existence of the following relations between the structural dimensions of said element and the pitch frequency: $L=Ax^a$; $HL=Bx^b$; $D=Cx^c$; and $S=Ex^e$; wherein x is the pitch frequency, L is the total vibrating length in inches of said element, A is a factor within the range of 290 to 300, a is an exponent of x within the range of $-.44$ to $-.45$, HL is the hanging length in inches of said element, B is a factor within the range of 100 to 110, b is an exponent of x within the range of $-.44$ to $-.45$, D is the outside diameter in inches of the coiled portion of said element, C is a factor within the range of 63 to 73, c is an exponent of x within the range of $-.44$ to $-.45$, S is the length in inches of said tapered end measured from the beginning to the end of the taper, E is a factor within the range of 80 to 90, and e is an exponent of x within the range of $-.44$ to $-.45$.

2. A vibratory element as claimed by claim 1, further characterized by the fact that the coiled portion of said element is in the form of a spiral wherein the number of degrees through which the spiral extends is within the range of from 270 to 450 degrees.

3. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support, and being characterized by the existence of substantially the following relations between the structural dimensions of said element and the pitch frequency: $L=294.3x^{-.4456}$; $HL=104.9x^{-.4456}$; $D=67.46x^{-.4456}$; and $S=84.4x^{-.4456}$; wherein x is the pitch frequency, L is the total vibrating length in inches of said element, HL is the hanging length in inches of said element, D is the outside diameter in inches of the coiled portion of

said element, and S is the length in inches of said tapered end.

4. A vibratory element as claimed in claim 3, further characterized by the fact that the coil portion of said element extends through substantially three hundred and thirty degrees.

5. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support, and characterized by the fact that at the narrow end of the taper the width of said element increases abruptly to provide a relatively wide portion by which it can be supported for free vibratory movement from the point of support.

6. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support and characterized by the fact that the relation of the width of said element directly at the point of support to the width of the untapered portion of said element is less than one-fourth.

7. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support and characterized by the fact that the relation of the width of said element directly at the point of support to the width of the untapered portion of said element is of the order of one-tenth.

8. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support and characterized by the fact that the length of said tapered end measured from the beginning to the end of the taper is within the range from 3 to 6 inches and by the fact that the relation of the width of said element at the smaller end of the taper to the width at the larger end of the taper is of the order of one-tenth.

9. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, said element having its supported end tapered toward the point of support and characterized by the fact that immediately at the smaller end of the taper the width of said element is at least several times the width of the smaller end of the taper to form an end portion by which said element can be supported.

10. A vibratory element of the coiled-spring type for producing a musical note having a definite pitch frequency, the supported end of said element being tapered to a neck whose width is relatively small as compared to the width of the untapered part of said element, the width of the extreme end portion of said element beyond the neck being relatively large as compared to the width of the neck, said extreme end portion constituting the means by which said element can be supported for free vibratory movement from the neck to its other end.

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