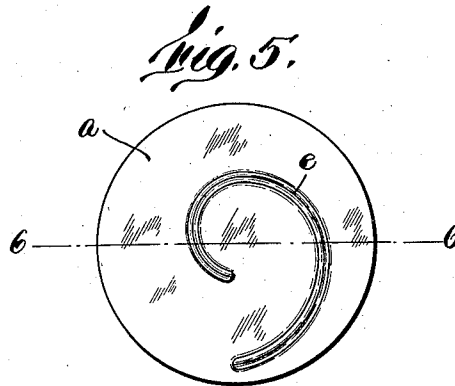
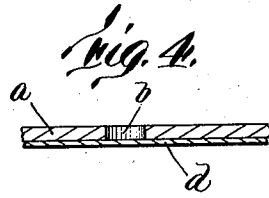
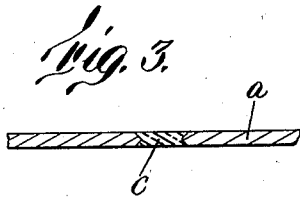
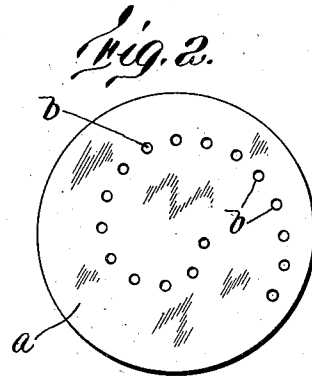
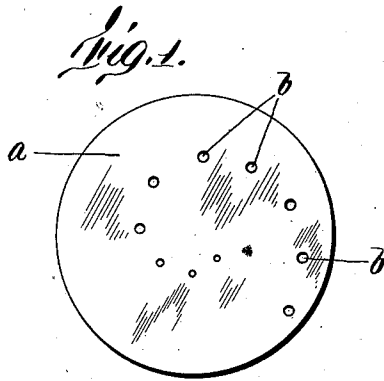


May 6, 1930.

N. CRANE
MEANS FOR SUPPRESSING SECONDARY VIBRATIONS
IN DIAPHRAGMS AND THE LIKE
Filed Feb. 15, 1926

1,757,451



Inventor:
Newton Crane

By Wright, Brown, Quincy & May
Attys.

UNITED STATES PATENT OFFICE

NEWTON CRANE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO CRANEWAY DIAPHRAGM COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

MEANS FOR SUPPRESSING SECONDARY VIBRATIONS IN DIAPHRAGMS AND THE LIKE

Application filed February 15, 1926. Serial No. 38,456.

The present invention relates to devices used for transmission, propagation, or intensification of sound waves, and the conversion of electrical effects into sound waves, and vice versa. More specifically, it relates to diaphragms, such as are used in telephonic receivers for converting electrical undulations or vibrations in the telephone line into sound vibrations and propagating them, in telephonic transmitters for effecting the transformation of sound vibrations into electrical impulses or currents of varying strength, in phonographs or talking machines for transforming mechanical vibrations and undulations into sound waves, in radio loud speakers for securing analogous effects to those above stated, and in other equivalent or analogous situations where similar actions and effects are to be obtained.

It is well known and recognized by all who have used machines and apparatus employing vibratory diaphragms for obtaining and transforming sound effects, that a considerable variation takes place between the sounds originally made, and those which emerge from the receiving or delivering diaphragm. For example, in the use of a telephone, the tone quality of the speaker's voice is more or less modified at the receiving instrument in circuit with the speaker's transmitter, and the word sounds transmitted over the line are often distorted so as to be incomprehensible or recognizable only with difficulty, and extraneous sounds are often heard by the person at the receiving end; in the use of radio apparatus very commonly a large distortion occurs between the sounds broadcast and those delivered by the receiving sets; and the sounds emitted by the reproducing diaphragms of talking machines or phonographs also frequently vary more or less widely from those originally emitted for impression on the record. In the reproduced sounds, whether of speech or of musical tones, some tones are suppressed and others are amplified in great-

er or less degree, and upon some tones there is impressed a disagreeable harsh or rasping quality. These defects apply to all of the types of instrument and apparatus here referred to, and their correction has been an object long sought by many investigators.

My object is to overcome or remove the defects above stated, and the present invention consists in a new means by which that object has been accomplished and a more faithful reproduction of the original sounds has been effected than has been obtainable heretofore. This effect is accomplished by improvements in the diaphragms adapted to be used in the transmitting or broadcasting or recording instruments or apparatus, as well as in the receiving or reproducing or amplifying instruments of such systems and apparatus as are hereinbefore referred to and contemplated. In brief, the invention comprises such modification in the structure of such diaphragms as will interrupt or prevent the occurrence of objectionable secondary vibrations in the diaphragm when vibrated by the impingement of sound waves, or by the application of magnetic, electrical or mechanical force to vibrate the diaphragms when they are used for the propagation of sound.

Investigations have been made of sound producing and receiving diaphragms, from which it has been demonstrated that such diaphragms when vibrated with the frequencies of audible vibrations, whether by impingement of sound waves, or by other means, also set up secondary or subsidiary vibrations of their own, which produce harmonics or overtones of the diaphragm itself; some of such harmonics acting in opposition and others in amplification of the fundamental vibrations imposed on the diaphragm as a whole. The occurrence and characteristics of such secondary vibrations have been illustrated by the Chladni sand figures. We find that on sprinkling fine sand on a horizontally supported diaphragm, and setting the dia-

phragm into vibration by a sustained tone, the sand divides itself on lines, showing the existence of definite nodes in the diaphragm between which the areas of the diaphragm vibrate with frequencies which are multiples of the frequency of the vibration of the diaphragm as a whole. In a majority of instances, the sand figures form in one or more concentric circles, showing the existence of circular nodes at the lines where the sand collects, and the occurrence of secondary vibrations in the areas of the diaphragm between these nodes. In other instances, the sand arranges itself in parallel lines on opposite sides of, and equidistant from the center of the diaphragm, across the diameter of the diaphragm and a parallel line on each side of the diametral line may be formed; and in still other instances the lines form the outline of a square with sides equidistant from the center and concave toward the circumference.

Undoubtedly such secondary vibrations occur whenever a diaphragm is vibrated by musical sounds or spoken words, and whenever it is so vibrated as to reproduce or propagate such sounds or words; and in the course of receiving or emitting a succession of sounds of various pitches, intensities and tone qualities, the secondary vibrations and the locations of the nodal lines rapidly change and shift in number, form and position. It is to these secondary vibrations, and to their changing character that I ascribe the objectionable effects in sound reproduction and emission above referred to and well recognized in instruments and apparatus of the character referred to.

Those diaphragms which are vibrated by magnetic flux, as in telephonic receivers, are subject to still another disturbing influence, due to the formation of eddy currents in the diaphragm induced by the electromagnet which causes its vibration.

I have discovered that if the continuity or integrity of the diaphragm is interrupted at suitable points, the secondary vibrations in all diaphragms of the types noted, and the setting up of eddy currents in magnetically vibrated metal diaphragms, may be prevented or minimized, and the objectionable effects hereinbefore noted so far diminished as to be unnoticeable; and that, by making suitable provisions in the construction of the diaphragm, hereinafter described, greatly improved effects in clearness of spoken words, and in faithful reproduction of tonal qualities may be secured without sensible or substantial sacrifice of desired loudness and volume of sound.

The principles of the invention may be embodied in various forms in diaphragms for various purposes. The drawings herewith furnished, and with reference to which the following detailed description is given,

show some of the possible constructions or forms of the invention applied to a diaphragm suitable for a telephonic receiver.

In the drawings,—

Fig. 1 represents a plan view of such a diaphragm, pierced with holes having a prescribed arrangement effective for the purpose;

Fig. 2 is a similar view of a diaphragm having a different arrangement of holes;

Fig. 3 is a fragmentary sectional view of the diaphragm on an enlarged scale, showing one form of means for closing such holes;

Fig. 4 is a similar view showing another means for closing the holes in the diaphragm;

Fig. 5 is a view similar to Figs. 1 and 2, but showing a different construction of means for interrupting the continuity of the diaphragm;

Fig. 6 is an enlarged sectional view taken on line 6—6 of Fig. 5.

Like reference characters designate the same parts wherever they occur in all the figures.

In all the figures, the diaphragm is designated by the letter *a*. Fig. 1 shows such a diaphragm pierced with holes *b* in an arrangement which at present I prefer to other possible arrangements of holes. It will be noted that the holes are separated from one another by integral parts of the diaphragm and that they are arranged at intervals along a curved line. The curve on which the holes in Fig. 1 are arranged is a logarithmic curve, the character of which is well known and understood in mathematics, and the location of which on the diaphragm is established by plotting on different radii of the diaphragm, taking an arbitrary distance from the center on one of the radii as unity and plotting the points of the curve on other radii in accordance with the formula for the logarithmic curve. The holes may be spaced on this curve as far apart from one another as desired and may be of any diameter desired. Preferably they are so spaced and of such widths that one or another of the holes will intersect any circular line concentric with the diaphragm, except in the area immediately surrounding its center, and at least one of the related lines of any other symmetrical figure in which nodes tend to occur. Thus the holes interrupt the continuity or destroy the integrity of the diaphragm at some point in any line on which secondary vibrations or harmonic vibrations can occur, except a small area at the center of the diaphragm, which is negligible, because such harmonic vibrations as can occur in that area are so rapid that the sound waves propagated thereby are inaudible and do not affect the quality of audible vibrations transformed or propagated by the agency of the diaphragm.

I have found in practice that the interruption of the diaphragm in this manner sub-

stantially eliminates all extraneous sounds and sound interferences which cause the objectionable effects before described in instruments and apparatus of the character referred to, with the result that much greater clearness and fidelity to the original sounds (including spoken words and musical tones) is obtained with the use of my improved diaphragm than has been heretofore obtainable with diaphragms.

It is preferable to arrange the holes and give them such diameters or widths, within the limits above indicated, as will leave intact as much as possible of the integral diaphragm. The holes may be of any shape and cut or otherwise formed in any desired manner, but preferably they are circular and are formed by punching.

In another arrangement, shown in Fig. 2, the holes are located on an involute curve generated from a circle of short diameter at or near the center of the diaphragm as the base circle. In this form also the holes are spaced along the curve and made of such diameters or widths as will cause interruption or cutting of the lines on which harmonic vibrations could occur. I have found, however that the arrangement in a logarithmic curve gives superior results to other arrangements of holes.

In order that the vibrations of the diaphragm may not be diminished in amplitude when caused by impinging sound waves, or the intensity of sound vibrations transmitted into the air by the diaphragm may not be diminished, on account of the holes, I may close these holes as by stopping or covering them by a substance which will prevent passage of air through them, but will not restore to the diaphragm the ability to vibrate in the objectionable manner. For example, I may fill the holes with rubber, as shown at *c* in Fig. 3, plugs of vulcanizable rubber composition being molded in the holes, and preferably interlocked therewith, as there shown, and vulcanized. Instead of rubber, I may use other material, which either has no ability in itself to vibrate or of which the vibrational qualities are different from those of the diaphragm. Or, instead of filling the holes with plugs, I may cover them with a sheet, or patches, of suitable material secured to the face of the diaphragm, as indicated at *d* in Fig. 4. Rubber, or other material suitably different from the substance of which the diaphragm is made, may be used for the cover sheet or patches *d*.

Another mode of interrupting the continuity of the diaphragm is shown in Figs. 5 and 6, where the continuity or homogeneity of the diaphragm is interrupted without interrupting or destroying its integrity. In this case the diaphragm is impressed and offset so as to form a rib *e*, disposed, according to the principles before explained, so as to

intersect and interrupt all lines on which vibrations can occur or nodes be formed. Such rib may be designed to follow a curve of any character, which will cause it to interrupt nodal lines, but preferably it is formed according to the logarithmic curve. Instead of making a continuous rib, discontinuous offsets or humps may be formed in the diaphragm, spaced apart from one another along a given curve, substantially as are the holes in the forms of the invention first described.

The holes or equivalent humps hereinbefore described have sensible areas in order collectively to interrupt all possible nodal lines and at the same time to be spaced far enough apart so that they will not sensibly weaken the diaphragm. The portions of the area within the circumference of the diaphragm occupied by such holes or humps are defined herein as discontinuous areas interrupting the continuity of the diaphragm.

While I have shown for illustration a diaphragm designed for a specific instrument, i. e., a telephonic receiver, I have endeavored to make it clear that the principles of this invention, and the protection which I claim, are applicable and extend to any diaphragm in any apparatus used for the conversion, recording, propagation, or amplification of sound, or the conversion of other vibrations or impulses into sound waves, and to equivalent vibratory surfaces.

What I claim and desire to secure by Letters Patent is:

1. A diaphragm for the purpose described, pierced with separated holes so spaced and having such dimensions that they interrupt substantially all circular lines concentric with the diaphragm, and at least one of the related lines of any other symmetrical figure, on which audible secondary or harmonic vibrations of the diaphragm may occur, the diaphragm being elsewhere intact.

2. A diaphragm for the purpose set forth, pierced with discontinuous holes, each substantially equal in length and breadth, following a logarithmic curve between points near the circumference and center, respectively, of the diaphragm, the diaphragm being otherwise intact between said holes and its center.

3. A diaphragm of the character described, pierced with holes spaced apart along a logarithmic curve plotted on lines radial to a central point in the diaphragm, and being otherwise intact at all points between its center and said curve.

4. A diaphragm for the purpose set forth, pierced with discontinuous holes following a logarithmic curve from a point near the circumference to a point near the center of the diaphragm, said holes being of such widths as collectively to intersect all concentric circular lines outside of a narrow cen-

tral area of the diaphragm, and the diaphragm being otherwise intact.

5. A diaphragm of the character described, having holes spaced and proportioned to interrupt lines on which harmonic vibrations of the diaphragm may occur and non-vibratory material carried by the diaphragm and closing said holes.

In testimony whereof I have affixed my signature.

NEWTON CRANE.

15

20

25

30

35

40

45

50

55

60