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W. HAHNEMANN

VIBRATION APPARATUS, PARTICULARLY FOR RECEIVING AND PRODUCING SOUND WAVES

Filed Feb. 4, 1921

Fig. 1.

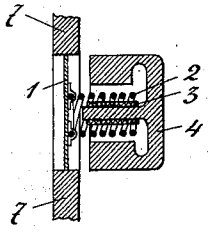
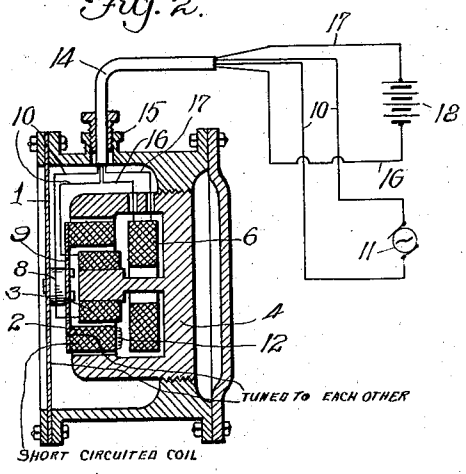


Fig. 2.



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VIBRATION APPARATUS, PARTICULARLY FOR RECEIVING AND PRODUCING SOUND WAVES.

Application filed February 4, 1921. Serial No. 442,578.

To all whom it may concern:

Be it known that I, WALTER HAHNEMANN, citizen of the German Republic, and residing at Kitzeberg, near Kiel, county of Schleswig-Holstein, State of Prussia, Germany, have invented certain new and useful Improvements in Vibration Apparatus, Particularly for Receiving and Producing Sound Waves, of which the following is a specification.

For the purpose of producing reciprocating motion with the aid of alternating or pulsating electric currents, devices have been constructed in which an electrical conductor, arranged in a constant magnetic field, is moved to and fro across the lines of force of this field, through the effect of electrical currents sent through the conductor. In these known arrangements the current is either led into the movable electrical conductor directly by means of brushes or flexible wires or the current is produced in the movable conductor by induction with the aid of auxiliary windings. This movable conductor itself is—if it is a question of producing sound vibrations by a diaphragm for example—held by a supporting means in such a manner that it is always returned to a middle normal position. The electrical conductor is attached, either directly or by means of rigid rods or the like, to the point to which the work which it performs is to be applied. For this reason the amplitude of the motion at this point is the same as that of the motion of the moving conductor itself. It is, however, hardly ever possible to obtain the greatest possible efficiency of the apparatus with an arrangement of this kind, for in order to obtain the most favorable efficiency, there should be a possibility of transforming the amplitude of the exciting part (the moving electrical conductor) up or down in some way or another, so as to be able to obtain a different amplitude of motion at the operated point of the apparatus.

If sound is to be produced with the aid of a vibrator of this kind, it is necessary, if the sound waves are to be set up in air, to produce larger amplitudes, and if the sound waves are to be emitted into water, to produce smaller amplitudes than those executed by the moving electrical conductor itself. This also applies to the reception of sound waves, when the amplitude of the motion of the diaphragm abutting against the sound propagating medium must generally be transformed down when the said medium is air, and up if the medium is water, in order to be converted into electric energy at a good efficiency.

An object of the present invention is to provide means for obtaining the transformations of amplitude necessary for a high efficiency. This is accomplished by so constructing the electrical conductor which is moved in the magnetic field that it acts as a vibratory structure or as a part of such a structure. If an amplitude is desired at the diaphragm, smaller than that which the coil itself performs, for instance when it forms a rigidly connected element of a vibratory structure coupled with the diaphragm (for submarine use) then the mass (weight) of the coil must be smaller than the sum of the diaphragm mass and the medium mass which vibrates with the diaphragm. For the reversed transformation (use in air) the reverse proportion must be used. By this means it is possible to obtain any desired ratio of the amplitude of the motion of the moving electrical conductor to the amplitude of the motion executed at or by the effective part, i. e. the part that produces the desired effect, this ratio being determined by the shape of the vibratory structure, and by the distribution or relative sizes of its masses or the masses attached to it.

The preferred arrangement consists in making the moving electrical conductor in the form of a rigid structure and in connecting it by an elastic member or members to the effective part of the apparatus, which, in the case of a sound producing or receiving device, is a sound-radiating or collecting diaphragm. In sound apparatus it will sometimes be found advantageous to place a special weight or mass, in addition to the mass of the diaphragm and the sound propagating medium, at the point where the said elastic member is connected to the diaphragm. This special mass must then be conceived as belonging partly to the vibratory structure of which the moving conductor forms a part, and partly to the vibratory structure that is formed by the diaphragm. This special weight or mass may consist of

the fastening devices (such as bolts, screws etc.) at the diaphragm. By varying the ratio of the sum of these masses to the free or unrestrained mass formed by the moving electrical conductor, it is possible to regulate in any desired manner, not only the closeness of the coupling between the two structures, but also the ratio of transformation of the amplitudes of the motions executed by the excited and exciting parts of the apparatus. A regulation of this ratio may also be accomplished, if the mass of the vibratory structure is adequately distributed in it, by shaping the vibratory structure itself in a certain way, this being particularly important in cases in which the entire moving electrical conductor forms the vibratory structure.

If the moving conductor, or this conductor together with its supporting member, is made in the shape of a vibratory structure which compels the diaphragm, which is assumed to be untuned, to execute the same motions as it carries out itself, the result will be a single tone or mono-resonant device whose frequency of resonance is determined by the natural frequency of the vibratory structure.

Very appreciable improvements of the efficiency of such vibration apparatus may be obtained by utilizing the known principle of mutual tuning. If a moving conductor which is adapted to act as a vibratory structure, or as part of such, cooperates with a second elastic member, as for example a diaphragm used in producing or receiving sound, the preferred arrangement will be one in which the two vibratory structures (i. e. the moving conductor and the diaphragm) are mutually tuned to one another with due regard to the effect which either of them produces on the other. In this way apparatus of the described kinds are converted into multi-resonant devices, i. e. devices which have as many frequencies of resonance as tuned vibratory structures are coupled to each other, and these frequencies are made to correspond to the tone used in sound signalling, it being thus possible to make the number of different signalling tones equal to the number of coupled tuned frequencies. In order to make the range of frequencies covered, or the wave spectrum, as broad as possible, the coupling between the vibratory structures should not be made too close. The signalling frequency is then preferably made to lie between the coupled frequencies of resonance.

Constructional forms of the invention illustrating how the idea involved may be applied to sound apparatus are diagrammatically shown in the drawing in which Fig. 1 shows a vibration apparatus in which a movable or flexible electrical conductor as a whole together with a certain amount of the mass of the diaphragm and the sound propagating medium represents a vibratory structure.

Fig. 2 shows a sound signalling apparatus with two coupled tuned vibratory structures, the one structure being formed of the moving electrical conductor, a weight attached to the diaphragm and a flexible connecting diaphragm, and the other vibratory structure consisting of the mass at the middle of diaphragm, the radiating diaphragm, and the casing of the apparatus.

The apparatus of Fig. 1 comprises a sound radiating diaphragm 1 fixed in a support 7. Extending at right angles to the diaphragm, 1, and fixed to the same, is an electric coil conductor 2 which is preferably made of copper-bronze or a similar material of good elastic properties. The two ends of the coil are electrically connected to each other. The coil extends along the air-gap between the poles of a permanent magnet 4. Alternating currents are induced in the coil 2 with the aid of an alternating current coil 3.

If alternating currents flow through coil 2, its windings move in the field of magnet 3. The coil commences to oscillate and transmit these oscillations to the diaphragm 1 coupled with it.

In Fig. 2 the oscillating conductor 2 consists of a coil as in Fig. 1 which contrary to Fig. 1 is not flexible. It vibrates in a gap between the poles of an electromagnet whose iron circuit consists of a shell 4 and a core that is magnetized by a continuous current winding 6. The alternating current that gives rise to the oscillations is induced in the coil 2 by an alternating current flowing through the primary coil 3. This alternating current is produced by a suitable generator 11 at a remote place and conducted through leads 10, 10, embodied in a cable 14, to coil 3. The energizing direct current for polarizing coil 6 is lead from its also remote source 18 through leads 16, 17, likewise embodied in cable 14, to coil 6. In suitable manner, well known in this art, cable 14 is lead into the apparatus casing, for instance by means of a stuffing box 15, so that the apparatus may be safely submerged in water. The coil 2, short circuited in itself by wire 12, is mounted upon an elastic plate 9, which in turn is attached to a weight 8 which forms the second mass of the vibratory structure composed of 2, 9 and 8. The weight 8 is mounted on the sound radiating diaphragm 1 which forms a second vibratory structure. The mode of operation of coil 2 in Fig. 2 is similar to that described with reference to Fig. 1. The difference in this case is, however, that in Fig. 2 all windings of the coil oscillate at the same amplitude and in phase with each other, because the entire coil 2 is constructed as a solid mass.

If apparatus according to this invention is to be used only for the purpose of receiving sound waves it should preferably be designed in small dimensions. In this case, however, the vibrating coil conductor should constitute a coil with many windings, because it is not possible to connect a coil of low resistance to an indicating apparatus of higher resistance (telephone receiver) without impairing the efficiency of the receiving set.

I claim:

1. A vibration apparatus comprising a magnetic field, an electrical coil adapted to vibrate in the magnetic field and two coupled vibratory structures of substantially the same natural frequency and means for coupling said structures with each other, one of the vibratory structures being adapted to act as a sound radiating member, the electrical coil representing a part of the vibratory structure which is coupled to the sound radiating member, the degree of coupling between the structures being suitably chosen so that the desired vibration frequency of the combined system is located within the range of the coupling frequencies of the system.

2. A vibration apparatus comprising a magnetic field, an electrical coil adapted to vibrate in the magnetic field and two vibratory structures of substantially the same natural frequency, coupled together, one of the vibratory structures being adapted to act as a sound radiating member and the other consisting of a mass concentrated at the sound radiating member, a second freely vibrating mass smaller than the other mass and containing the electrical coil, and an elastic member connecting the two masses, the degree of coupling between said structures being suitably chosen so that the desired vibration frequency of the combined system is located within the range of the coupling frequencies of the system.

In testimony whereof I have affixed my signature.

WALTER HAHNEMANN.