Sept. 8, 1931. M. TROUTON 1,822,465

ELECTRICAL VIBRATORY DEVICE SUCH, FOR EXAMPLE, AS A LOUD SPEAKER

Filed Aug. 7, 1929 2 Sheets-Sheet 1

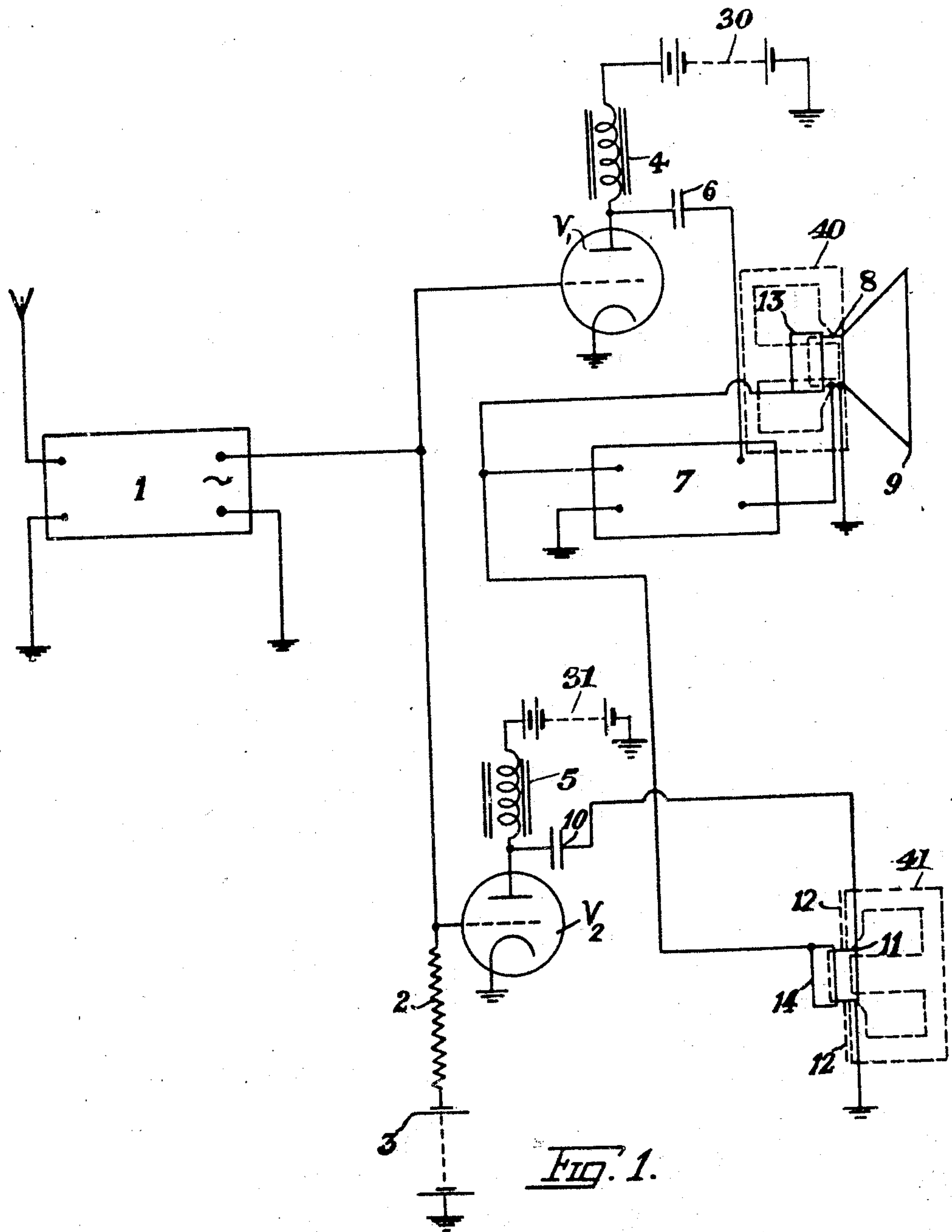

Fig. 1.

Inventor
Maurice Trouton
By Cushman, Bryant & Darby
atty

ELECTRICAL VIBRATORY DEVICE SUCH, FOR EXAMPLE, AS A LOUD SPEAKER

Filed Aug. 7, 1929 2 Sheets-Sheet 2

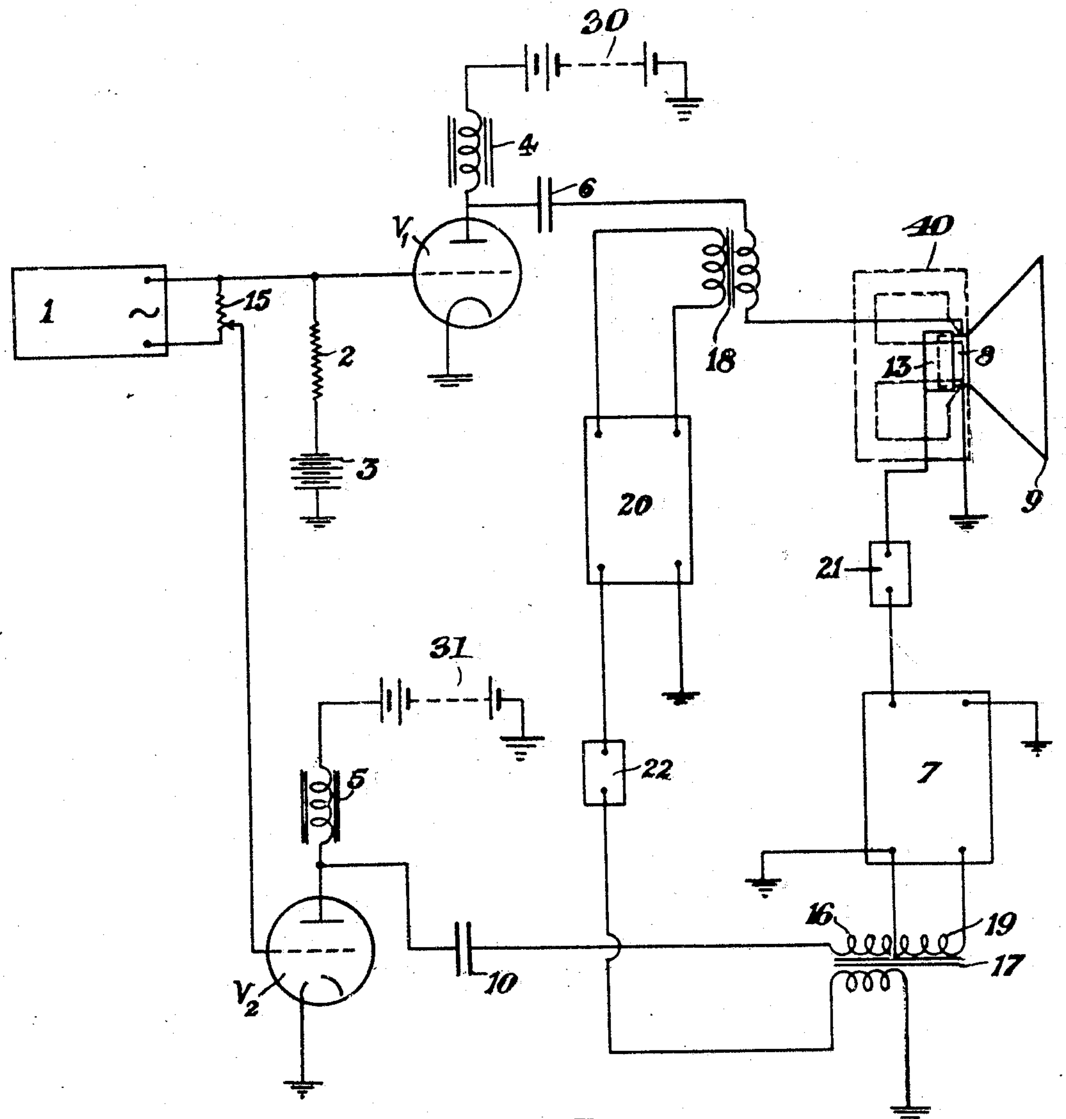

Fig. 2.

Inventor
Maurice Trouton
By Cushman, Bryant & Darby
Attys

Patented Sept. 8, 1931 1,822,465

UNITED STATES PATENT OFFICE

MAURICE TROUTON, OF CUDDINGTON, ENGLAND, ASSIGNOR TO WIRELESS MUSIC LIMITED, A COMPANY OF GREAT BRITAIN

ELECTRICAL VIBRATORY DEVICE SUCH, FOR EXAMPLE, AS A LOUD SPEAKER

Application filed August 7, 1929, Serial No. 384,212, and in Great Britain August 10, 1928.

The present invention relates to electrical vibratory devices such for example as loud speakers.

It is an object of the present invention to provide a vibratory device for the interconversion of electrical and mechanical oscillatory energy which shall respond more faithfully than devices hitherto known to "transients".

It is a further object of the present invention to provide a vibratory device for the interconversion of electrical and mechanical oscillatory energy in which the ill effects arising due to the fact that the mechanical oscillator has appreciable mass and an effective mass which changes with frequency and is called upon to do work are reduced.

If an alternating electromotive force of constant frequency be suddenly impressed upon a loud speaker, it is known that a certain time elapses before the mechanical vibrations of the diaphragm of the loud speaker correspond in wave form with the applied oscillations. This time lag is inherent in any device in which a mass has to be set in vibration.

Efforts have been made to reduce the time lag by making the vibrating parts exceedingly light but it will be clear that, since considerable rigidity is necessary in order that a diaphragm may communicate its vibrations to the surrounding air, there are practical limits to the extent to which the mass of the vibrating parts can be reduced.

Further, the fact that a loud speaker is required to do work in radiating sound tends to impair the faithfulness with which the electrical oscillations fed to it are translated into sounds.

According to the present invention a corrective effect dependent upon the disconformity between the applied and the generated wave forms is applied to the oscillatory system in such a manner as to reduce the disconformity.

It is to be understood that when comparing the wave form of generating and generated oscillations of different natures it is intended in this specification that the appropriate characteristics of the two oscillations be taken according to circumstances. For example, if it is desired, in converting electrical oscillations into mechanical oscillations, to produce a mechanical oscillation having a velicity proportional to the applied current then it is the wave forms of current and velocity which must be compared.

Two forms of the invention will be described by way of example with reference to the accompanying diagrammatic drawings, in which

Figure 1 shows an arrangement in which corrective electrical oscillations are derived with the aid of a freely movable auxiliary coil, and

Figure 2 shows an arrangement in which correction is effected purely electrically.

Referring to Fig. 1, one of the output terminals of a wireless receiver 1 or other source of electrical oscillations to be converted into sound, is connected to earth and the other terminal is connected to the grid of the valve V_1 and to the grid of the valve V_2', the grids being connected to earth through a grid leak resistance 2 and through a source of grid bias potential 3. The anodes of the valves V_1 and V_2 are connected through the chokes 4 and 5 respectively to the positive terminal of a source of high tension supply 30, 31. The anode of the valve V_1 is also connected, through a condenser 6 and through the output circuit (which may for example be the secondary winding of a transformer) of an amplifier represented diagrammatically by the rectangle 7, to one terminal of the moving coil 8 of a loudspeaker. This coil 8 is mounted, in known manner, for vibration in the annular air gap of a magnet (represented in dotted lines at 40) and is secured to a conical diaphragm 9 which is also mounted in known manner. The detail arrangement of the loud speaker is not illustrated since it is well known. The other terminal of the coil 8 is connected to earth. The anode of the valve V_2 is connected through a condenser 10 to one terminal of a second moving coil 11, the other terminal of which is earthed. The coil 11 is also mounted for vibration in the annular air gap of a magnet (shown in dotted lines at 41) and is suspended, for example, by means of ligaments shown dotted at 12, so as to be subjected to the minimum of elastic restraint. Since the coil 11 has to do no appreciable work it can be made very light and it should be made with as little radiating area as possible. The coils 8 and 11 together with their magnets 40, 41 may be regarded as working and idler motors respectively.

Parts of the coils 8 and 11, (which may if desired be wound on metal formers) or metallic projections therefrom are arranged to vibrate within and close to the fixed cylindrical electrodes 13 and 14 respectively which are connected together and to one of the input terminals of the amplifier 7, the other input terminal of the amplifier 7 being earthed. The amplifier 7 is of the known type suitable for use with a so-called condenser microphone. That is to say variations in the capacity shunted across the input terminals of the amplifier give rise to electrical oscillations in the output circuit of the amplifier. The coils 8 and 11 are so connected that they vibrate in phase opposition.

In operation, when electrical oscillations, corresponding to sounds, are impressed by the receiver 1 upon the grids of the valves V_1 and V_2, the coils 8 and 11 are set in vibration in opposite phase. If therefore coil 8 moves in the same manner as coil 11, a decrease in capacity between coil 8 and the electrode 13 is compensated for by a corresponding increase in the capacity between the coil 11 and the electrode 14 and the value of the capacity shunted across the input of the amplifier 7 remains constant. If, on the other hand, the motion of the coil 8 does not correspond with the motion of the coil 11, a change in the capacity across the input of the amplifier 7, corresponding to the difference between the motions of the two coils, will take place and corrective electrical oscillations will accordingly be superposed upon the oscillations fed to the coil 8, the corrective oscillations tending to bring the oscillations of coil 8 more into correspondence with those of coil 11.

Since coil 11 is called upon to do a negligible amount of work and since it is light and has very little elastic restraint, its vibrations may correspond more closely to the input electrical oscillations than the vibrations of the coil 8 and the corrective electrical effect above described, therefore tends to cause the coil 8 to follow the input electrical oscillations more closely than it would without such corrective effect.

The circuit of the amplifier 7 is of course such as to produce negligible phase shift in the oscillations passing through it or at least a phase shift, of known amount or of an amount which is substantially constant for all frequencies concerned so that the phase shift can be corrected in known manner. The connections are also of course arranged so as to produce the effects above described, that is to say when the coil 8 is lagging behind coil 11, the corrective effect must add to and assist the oscillations from the valve V_1 and vice versa. Suitable phase adjusting means may be included in the circuit for this purpose.

The coil 11 may, if desired, be provided with damping but if so, the damping should preferably be non-reactive. Eddy current damping may, for example, be used and in that case the cylindrical electrode 14 may be in the form of a continuous ring. If minimum damping is desired the electrode should be split.

Any desired number of stages of amplification may of course be used in the amplifiers represented by the valves V_1 and V_2 and volume controlling means may be provided for the amplifier V_2 to permit of adjustment of the amplitude of vibration of the idler coil 11.

The air space between the electrode 14 and the coil 11 may be made smaller than the air space between the electrode 13 and the coil 8 in order that a smaller displacement of the former is required to produce a given change in capacity than in the latter. By keeping the amplitude of vibration of the idler coil small, the wave form of its movement may be made to correspond very closely with that of the applied electrical oscillations.

To prevent undesirable effects due to the vibration of the idler coil in the small air space betwen the magnet poles, the idler coil and its magnet may, if desired, be placed in vacuo.

A further form of the invention is illustrated in Fig. 2 wherein like components are given the same references as in Fig. 1. The source of oscillations 1 is shunted by a potentiometer 15, a tapping point of which is connected to the grid of the valve V_2. The output of the valve V_2 is connected to one primary winding 16 of a transformer 17. The output of the valve V_1 is connected to the coil 8 of the loud speaker through the secondary winding of a transformer 18. The capacity of the condenser formed by the coil 8 and the fixed electrode 13 is connected across the input of the amplifier 7, the output of which is connected to a second primary winding 19 of the transformer 17. The secondary winding of the transformer 17 is connected to the input of an amplifier 20, the output of which is connected to the primary winding of the transformer 18. The connections are so arranged that when the electrical oscillations generated by the condenser 8, 13, amplified by the amplifier 7 and applied to the winding 19 are of the same wave form as the oscillations derived from the potentiometer 15 and fed to the winding 16, no electromotive force is generated in the secondary winding of the transformer 17. When, however, there is a difference between these wave forms, a corective electromotive force is applied to the input of the amplifier 20 and a corrective effort is impressed upon the coil 8 through the transformer 18. It will be evident that potential differences developed across the amplifier 7 are proportional to the displacement of the coil 8 relatively to the electrode 13 and if it is desired that the voltage in coil 19 should be proportional to the acceleration of the coil 8, a circuit for differentiating twice the potential differences from the condenser 8, 13 will be required. The rectangles 21 and 22 represent differentiating or integrating circuits of any known or suitable type in which may be included suitable phase correcting devices.

To insure the correct working of the system as described, it is evident that the corrective oscillations must be prevented from feeding back to the original source of the oscillations. In the circuits shown, the corrective oscillations are effectively localized, in the arrangement of Fig. 1, by the valve V_1, and in the arrangement of Fig. 2, by the valves V_1 and V_2.

The corrective effect may of course be derived from some point on this vibratory system other than the coil or other driving element. The capacity between the diaphragm (which is rendered conducting) and a fixed electrode may, for example, be used.

Although in the arrangements above described the corrective effect is derived by change in capacity, it will be evident that any other known or suitable means may be used for this purpose. For example inductive effects arising from the difference in displacement of the vibrating elements of the working and idler motors may be utilized.

I claim:

1. An electro-mechanical vibratory system comprising a first circuit adapted to be energized from a source of electrical oscillations, a device for converting electrical oscillatory energy into mechanical vibratory energy, a second circuit associated electrically with said first circuit and with said device, means for preventing feed back of electrical oscillatory energy from said second circuit to said first circuit, means for deriving corrective electrical oscillations corresponding substantially to the difference between the wave forms of said mechanical vibratory energy and the electrical oscillations in said first circuit, and means for applying said corrective oscillations to said second circuit.

2. An electro-acoustic system comprising a sound reproducing device adapted to be actuated from a source of electrical oscillations, a vibratory device which is lightly loaded in comparison with said sound reproducing device and which is adapted to be set in vibration by the electrical oscillations from said source, means for deriving corrective electrical oscillations corresponding substantially to the difference between the mechanical oscillations of said sound reproducing device and said vibratory device, and means for applying said corrective oscillations to said sound reproducing device.

3. An electro-acoustic system as claimed in claim 2 wherein means are provided for preventing said corrective oscillations from affecting the vibrations of said vibratory device.

4. A sound reproducing system comprising an electrical sound reproducing device, a vibratory device which is slightly loaded compared with said sound reproducing device, and means for actuating said sound reproducing device and said vibratory device from a common source of electrical oscillations.

In testimony whereof I have signed my name to this specification.

MAURICE TROUTON.