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W. D. BUCKINGHAM

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TUNING FORK DRIVE

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FIG. 1

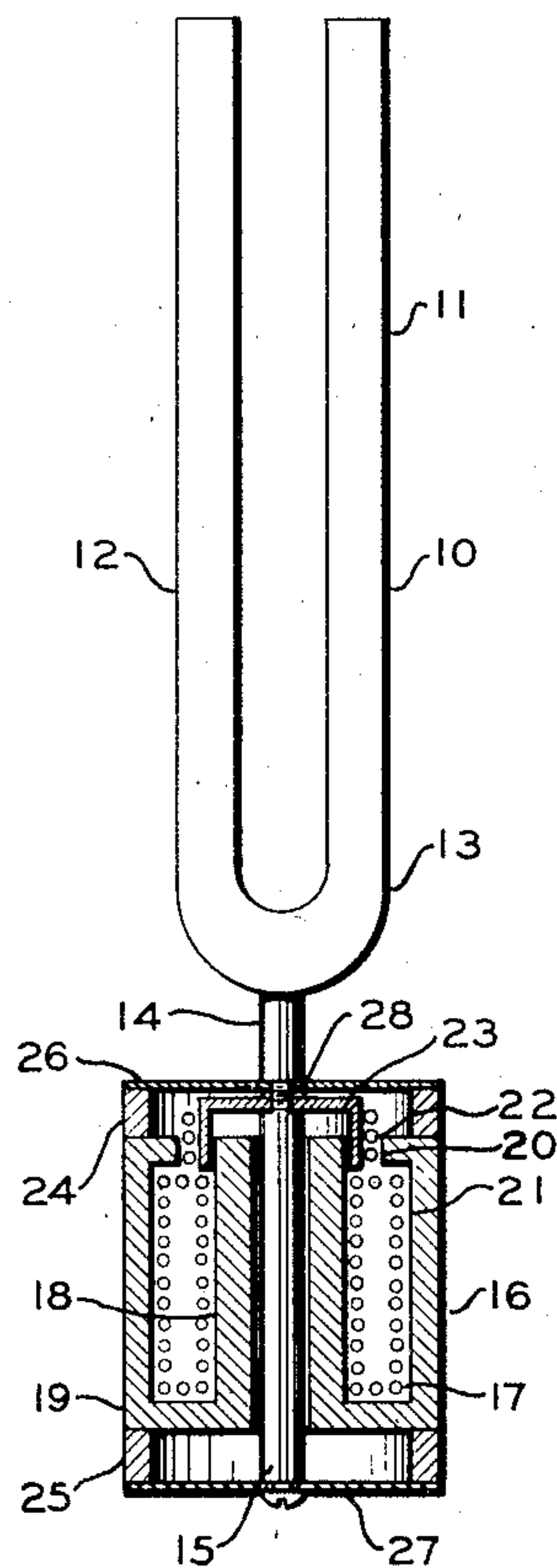


FIG. 2

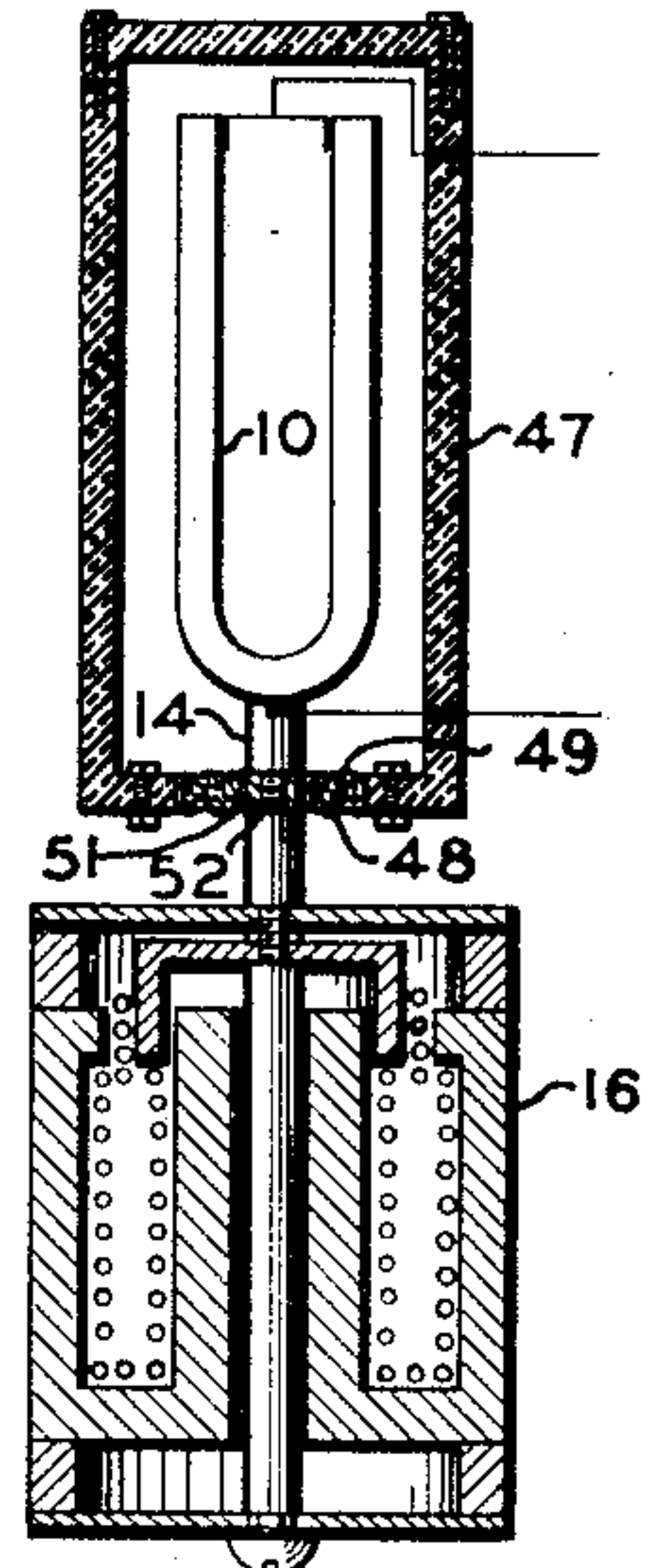
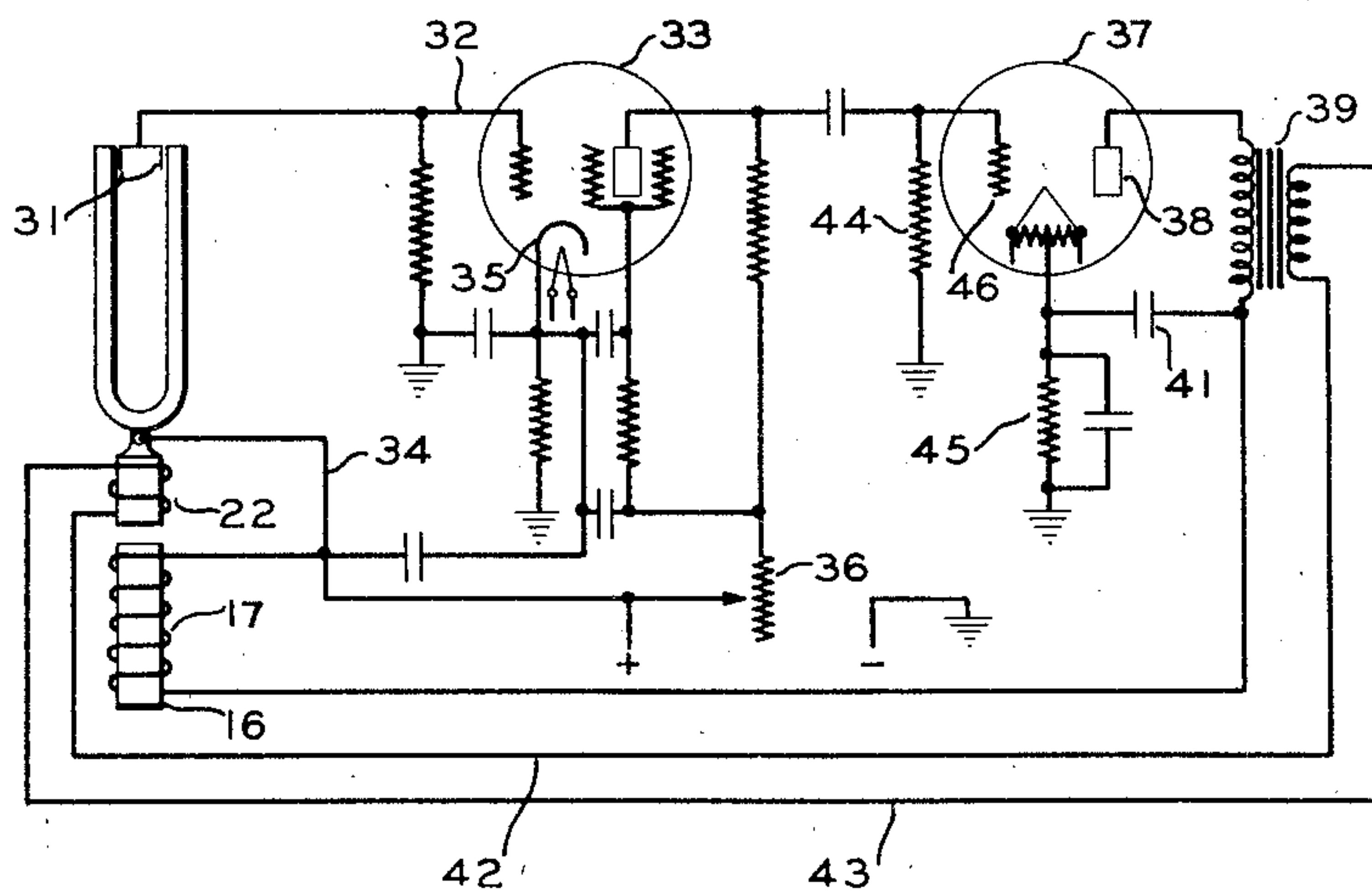


FIG. 3



INVENTOR
W. D. BUCKINGHAM

BY

Engel C. Brown
ATTORNEY

UNITED STATES PATENT OFFICE

WILLIAM D. BUCKINGHAM, OF SOUTHAMPTON, NEW YORK, ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TUNING FORK DRIVE

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This invention relates to tuning forks or vibrating bodies and particularly to a method and apparatus for driving or maintaining the fork or body in vibration.

This invention has for an object to provide for driving a tuning fork by imparting a longitudinal movement to the stem of the fork.

It has for another object to provide supporting means for the fork secured to its stem and arranged to permit longitudinal movement thereof, in combination with a simple form of motor disposed to impart a driving movement to the fork longitudinally of the stem.

Still another object is to provide a driving means for a tuning fork or other vibrating body spaced from the body and connected therewith through an extension member, such as the stem in the case of a fork, so that the vibrating body may be separated from the motor by a heat insulation member in order to minimize the effect of the heat dissipated in the motor.

A still further object of this invention is to provide a type of regenerative amplifier adapted to supply power to the fork driving motor provided with means to compensate for variations in the potential of the current supplied to said amplifier.

A still further object is to provide both a drive means for the fork and a regenerative amplifier means operated from the tines of the fork which will leave the tines free to vibrate undamped and unrestrained by any mechanical connections made therewith or magnetic fields embracing the same.

It is known to those skilled in the art that a tuning fork in vibration sets up a longitudinal vibratory movement in the stem of the fork. In view of this, it has been proposed heretofore to maintain tuning forks in vibration by applying a vibratory motion to the fork longitudinally of the stem. Such a method of driving tuning forks has proven effective but the means for applying the driving force to the stem of the fork has been somewhat complicated and unsatisfactory due to the fact that the stem of a tuning fork must also serve as a means to support the fork. Ac-

ording to this invention it is proposed to employ what is commonly known in the art as a moving coil or "dynamic" coil motor for driving the fork. With such a driving mechanism an opening can be provided through the central portion of the field coil of said motor through which the stem of the fork or an extension thereof may extend and diaphragms may be secured to the stem of the fork at points spaced from the opposite ends of said opening. This provides a comparatively rigid support for the fork transversely of the stem and at the same time provides a very flexible support longitudinally thereof depending upon the rigidity of the diaphragms employed. Such an arrangement leaves the tines of the fork unimpeded by the usual method of applying driving force directly thereto. The tines are further left free or unimpeded in their vibratory movement by providing a capacity pick-up arrangement for driving the regenerative amplifier instead of the usual inductive pick-up.

One of the greatest difficulties usually encountered in the operation of tuning forks is due to the fact that the voltage or potential of the current supplied to the amplifier cannot easily be maintained uniform. Any change of potential in said current causes the amplifier to apply more or less power to the driving motor which in turn has its effect upon the frequency of the fork. According to this invention means is provided for compensating for variations in the current to the amplifier instead of depending solely upon maintaining the amplifier current uniform.

The variations in input to the driving motor also result in changes in the amount of heat dissipated from the motor which in arrangements heretofore employed produce appreciable temperature changes in the fork. However, the arrangement of the parts according to this invention permit the motor to be segregated from the fork by heat insulation.

Other features and advantages of this invention will be apparent from the following description and claims taken in connection with the drawings.

tion with the accompanying drawing, in which:

Fig. 1 shows a plan view of the tuning fork with the driving motor in section;

Fig. 2 is a view showing the fork insulated from the motor; and

Fig. 3 is a diagrammatic view of the tuning fork and motor circuits together with the circuits of the amplifier employed for driving the motor.

Referring to Fig. 1 the arrangement comprises a tuning fork 10 having a pair of tines 11 and 12 connected together by a yoke section 13 from the center of which extends a stem 14. The tuning fork and the stem 14 may be of steel or other suitable material. For the purposes of heat insulation the stem 14 or a section of the same may be formed of bakelite or similar material. The stem 14 is relatively short and provided with an extension 15 preferably of non-magnetic material.

The driving motor 16 comprises a field magnet having a winding 17 disposed between a central core 18 and an annular casing 19. The core 18 and the shell 19 comprise the pole pieces of the field magnet. An annular slot 20 is provided at the top of the pole pieces in which is disposed a moving coil 22 supported on an annular drum or cup member 23. At the upper and lower ends of the field magnet annular extension rings 24 and 25 preferably of non-magnetic material are provided upon the outer ends of which are secured diaphragms 26 and 27. The stem of the fork is supported at the centers of the diaphragms, the upper diaphragm 26 being pierced to admit a threaded projection 28 of the extension stem 15. The lower end of the extension 15 is secured to the center of the lower diaphragm 27. The cup member 23 supporting the moving coil is also secured about the projection at the upper end of the extension stem. The threaded projection 28 extends through the bottom of the cup member 23 and through the diaphragm 26 into a tapped opening in the stem 14 and in this manner provides for carrying the tuning fork by supports secured to its stem. The bottom of the cup 23 is preferably spaced from the diaphragm 26 by a spacing member inserted therebetween. This prevents interference with the free movement of the diaphragm 26. It will be apparent to those skilled in the art that the foregoing elements may be assembled in different relationship to each other without modifying the cooperation between them.

It will be observed that the foregoing arrangement, as described, provides, among other things, for mounting a tuning fork by means of diaphragms secured at spaced points along the stem of the fork. Such an arrangement supports the tuning fork substantially rigid transversely of the stem and

at the same time with a decided resiliency longitudinally of the stem. In other words the stem is permitted to have a substantially free longitudinal movement within certain limits. Heretofore it has been regarded as extremely essential that the stem of the fork shall be supported rigidly in a base member having substantial mass for the best conditions of operation. However, I have found that with diaphragm supports the effect of mass in a direction transversely of the stem of the fork is retained and further that the rigidity supplied by a large mass is not required in a direction longitudinally of the stem. In a vibrating fork there is a component of motion transmitted to the stem as is well recognized by those skilled in the art. Taking this into consideration it has been found that a better operating characteristic of the tuning fork is obtained if resiliency in the support is provided longitudinally of the stem so as not to restrain this longitudinal vibration in the stem, imposing a damping effect to some extent upon the fork.

According to this invention further use is made of the fact that a motion is set up in the stem of a vibrating fork by imparting an additional motion to the stem corresponding to the fork frequency for driving or maintaining the fork in vibration. Further, an extremely compact driving means for the fork has been provided in the form of the moving coil motor disposed between the supporting diaphragms 26 and 27 with the moving coil secured to a portion of the stem of the fork extending through an opening in the drive motor. Such an arrangement permits the motor to serve as a support for the diaphragms providing a unit which, when supported on a suitable base or mounting, provides both the supporting and driving means for the fork encompassed in a very compact space.

Referring to Fig. 2 a drive arrangement similar to that shown in Fig. 1 is illustrated, showing the fork enclosed in a heat insulating chamber or compartment. The arrangement comprises the fork 10 and a drive motor 16 comprising a field magnet and the other parts, as already described and illustrated in Fig. 1, connecting the motor and the fork. A heat insulating chamber or compartment 47 is arranged to enclose the fork 10 and is provided with means for permitting the stem 14 of the fork to extend through one side of the chamber to connect with the drive motor. The ordinary fork oven or heat chamber within which the fork is enclosed for temperature control may be employed as the chamber 47 when provided with suitable means for connecting the drive motor located outside of the chamber to the tuning fork within the chamber. The side of the chamber through which the stem extends is arranged to embody flexible members 48 and 49

which are pierced at the center to permit the stem of the fork to extend therethrough. The members 48 and 49 may be made of a light flexible heat insulating material such as chamois skin or similar material with light felt incorporated between the same. The outer edges of these elements are secured by suitable means to the side of the compartment 47 and may be secured at the center between the shoulders of threaded interfitting portions of the stem 14 with a spacing collar 51 disposed about the extension 52 of the stem. The lower section of the stem may be connected with the drive motor in a manner similar to that described in connection with Fig. 1.

With the above arrangement the vibratory movement imparted to the stem by the driving motor may be readily transmitted through one side of the compartment without any appreciable interference or damping of its movement. At the same time the heat radiating from the driving motor due to the energy dissipated therein is effectively insulated from the body of the fork or vibrating member. In this manner, variations in the heat radiation from the motor will not have any appreciable effect on the temperature of the fork enabling the temperature to be more easily maintained at a substantially constant value.

Referring now to Fig. 3 the preferred arrangement of the regenerative amplifier and the connection with the driving motor and fork will now be described. In this diagram the fork is illustrated with the moving coil 22 secured to a short section of the stem and the field magnet 16 in line therewith. A capacitative pick-up is provided for operating the regenerative amplifier by a pair of plates 31 disposed preferably between the outer ends of the tines of the fork. These plates are connected together so that as the tines of the fork move inwardly and outwardly the capacity between the plates and the fork is varied in accordance with the frequency of the fork. This capacitative pick-up is connected with the grid 32 of an amplifying tube 33. The circuit is completed through a conductor 34 connected between the base of the fork and the cathode 35 of the first amplifying tube. Any suitable type of amplifying tube may be employed at this point but I prefer the four element or screen grid type of tube due to its high amplification factor and stability in operation.

The characteristics of the external circuits for the first tube 33 are such that the tube will operate under the normal amplifying conditions. The gain of the amplifier may be regulated by varying the voltage applied to the plate and the screen grid of the tube 33 through a resistance 36 in series with the source of positive potential supplied to this tube.

The tube 33 is suitably connected in cascade with a second tube 37 having preferably a high output capacity. The regulation of the amplifier is accomplished through special operating characteristics employed in connection with this tube. The current to the plate of this tube is fed through the field coil 17 of the motor for energizing the field of the motor. From the field coil 17 the current is fed through the primary of an audio transformer 39 to the plate 38 of the tube. The usual by-pass condenser 41 is provided between the conductor leading to the primary of the transformer 39 and the cathode of the tube. The secondary of the transformer 39 is coupled in series with the moving coil 22 of the drive motor through suitable conductors 42 and 43.

With this arrangement the current passed by the tube 37 may be said to be divided into two components, namely, an alternating component and a pulsating uni-directional component. From the diagram it can readily be understood that the uni-directional component must pass through the field coil 17 and the primary of the transformer. The inductance of this circuit tends to smooth out the effect of the pulsating current and produce a more or less steady field in the drive motor. The alternating component passes through the transformer and is impressed upon the coil 22 disposed in a highly concentrated field of the motor magnet producing a movement of the coil in a well-known manner. This movement is longitudinally of the stem 14 and is transmitted thereto through the cup member 23. The frequency of this alternating component will correspond to the frequency impressed upon the amplifier from the fork to the pick-up means 31, the net result being a regenerative action which maintains the fork in vibration.

In order to produce a compensating effect, this tube is preferably operated with a grid bias lower than normal and is provided with a grid leak 44 of a relatively large value. The biasing resistance 45 and the grid leak 44 are of such value that when an alternating current is fed to the grid 46 of this tube, the grid will draw current from the cathode which will tend to accumulate on the grid due to the slow leak off through the higher resistance 44 in proportion to the amplitude of the applied alternating current. In other words, with a varying input to the tube 37, as the input rises current accumulates on the grid 46 increasing the bias of the grid which results in a decrease of the uni-directional component of the current passed by the tube whereas the alternating component will be increased somewhat due to the increase of its input to the tube. This action results in decreasing the field current of the driving motor at the same time that the current through the moving coil is increased. By employing suitable

values in the external circuits for the tube 37 and the driving motor 16, the change in the gain of the amplifier due to any cause such as a variation of the potential of the current supplied to the amplifier will be substantially compensated for and will result in substantially the same driving effort being applied to the stem of the fork.

It will be apparent to those skilled in the art that the same type of compensation may be employed to correct frequency variations in the fork due to various other causes such as temperature changes, etc., where such conditions would produce a change in the characteristics of the amplifier or the energy supplied to the pick-up mechanism 31 connecting the fork and the amplifier.

From the foregoing, it will be seen that a method and means for mounting and driving a tuning fork or other vibrating body has been provided which leaves the vibrating body free and unrestrained by the damping action of a driving and pick-up means operated by direct mechanical or magnetic connection with the tines of the fork or vibrating element. A further advantage will appear from the fact that the driving mechanism is placed on the stem of the fork in which position it may be insulated from the body of the fork in such a manner that variations in input current to the driving motor which naturally result in a variation of the temperature of the driving motor due to power losses therein will not appreciably effect a temperature of change in the fork itself. These and any other advantages will appear to those skilled in the art.

While this invention has been shown in but one form, it will be apparent to those skilled in the art that it is not so limited but is susceptible to various changes and modifications without departing from the spirit thereof and it is desired, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. A vibrating system having in combination a tuning fork comprising a stem and tines, and a moving coil motor for imparting a longitudinal vibratory motion to the stem.

2. A vibrating system having in combination a tuning fork comprising a stem and tines, and a motor of the moving coil type, the moving coil of said motor being secured to the stem of the fork in such a manner that when the fork is driven by the motor, the coil and the stem of the fork vibrate together as a unit.

3. A vibrating system comprising in combination a vibratory body and a moving coil motor for vibrating the body, the moving coil of said motor being secured to said body

in such a manner that the coil and the body vibrate together as a unit.

4. A vibrating system having in combination a tuning fork comprising a stem and tines, and a motor of the moving coil type, the moving coil of said motor being secured to the stem of the fork in such a manner that when the fork is driven by the motor, the coil and the stem of the fork vibrate together as a unit, and means secured to the stem for supporting the fork, said means being arranged to provide for limited substantially free longitudinal movement of the stem.

5. A vibrating system having in combination a tuning fork comprising a stem and tines, and a motor of the moving coil type, the moving coil of said motor being secured to the stem of the fork in such a manner that when the fork is driven by the motor the coil and the stem of the fork vibrate together as a unit, and resilient members secured to the stem at spaced points therealong for supporting the fork, said members being substantially rigid transversely of the stem and freely yieldable within a limited distance longitudinally of the stem.

6. The combination of a tuning fork and means for mounting the fork comprising means secured to the stem and arranged to provide a limited substantially free movement longitudinally of the stem of the fork.

7. The combination of a tuning fork and means for mounting the fork in such a manner as to provide for movement longitudinally of the stem, said means comprising a pair of members yieldable longitudinally of the stem of the fork and secured to said stem at spaced points therealong.

8. The combination of a tuning fork and means for mounting the fork in such a manner as to provide for longitudinal movement of the stem, said means comprising a pair of diaphragms secured around the stem at spaced points therealong.

9. The combination of a tuning fork and means for mounting the fork in such a manner as to provide for longitudinal movement of the stem, said means comprising a pair of members yieldable longitudinally of the stem and secured at spaced points therealong, and means for driving the fork comprising a moving coil motor disposed with the moving coil secured to the stem of the fork so as to impart motion to said stem longitudinally thereof.

10. The combination of a tuning fork and means for supporting and driving the tuning fork comprising diaphragms secured to the stem of the fork at spaced points therealong, and drive means disposed about the stem of the fork and positioned between said diaphragms, said diaphragms and drive means being secured together as a single unit.

11. The combination of a moving coil motor comprising a field magnet having an

armature provided with a central core embodying an opening extending longitudinally through the center of the core and a moving coil suspended in the field of said magnet, with a fork comprising a stem and tines, the fork being disposed with its stem passing through the opening in the core of said magnet, and means adjacent the opposite ends of the core of said magnet for supporting the stem of the fork and arranged to provide for longitudinal movement thereof, the moving coil of the motor being secured to the stem of said fork for setting up vibrations in the fork by imparting a vibratory movement thereto.

12. The combination of a moving coil motor comprising a field magnet having an armature provided with a central core embodying an opening extending longitudinally through the center of the core and a moving coil suspended in the field of said magnet, with a fork comprising a stem and tines, said fork being disposed with its stem passing through the opening in the core of said magnet, and means adjacent the opposite ends of the core for supporting the stem of the fork comprising diaphragms supported at the opposite ends of the motor and secured about said stem and providing for longitudinal movement thereof, the moving coil of the motor being secured to the stem of said fork for setting up vibrations in the fork by imparting a vibratory movement thereto.

13. In combination a tuning fork comprising a stem and tines, a support secured to said stem and yieldable longitudinally thereof, said support comprising a diaphragm, and a moving coil motor for driving said fork, said motor being disposed below said diaphragm, the moving coil of said motor being secured to said diaphragm in such a manner that the stem of the fork, the area of the diaphragm upon which the fork is supported and said moving coil vibrate as a unit.

14. In combination a tuning fork comprising a stem and tines, a support secured to said stem and yieldable longitudinally thereof, said support comprising a diaphragm, a moving coil motor for driving said fork, said motor being provided with a field magnet having a core embodying a longitudinal opening, said motor being disposed above said diaphragm and arranged to permit the stem of the fork to extend through said opening for engaging the diaphragm, the moving coil of said motor being secured to said stem in such a manner that the stem, the area of the diaphragm engaging the said stem, and said moving coil vibrate as a unit.

15. In combination a tuning fork, an amplifier for driving said tuning fork, and a capacitive pick-up means for coupling the input of the amplifier to the tuning fork.

16. In combination a tuning fork, an amplifier for driving the tuning fork, and a

capacitive pick-up means for connecting the input of the amplifier to the tuning fork comprising a fixed plate secured adjacent a vibrating portion of a tine of the fork in such a manner that the plate provides one element of a condenser and the tine of the fork provides the other element thereof.

17. In combination a moving coil motor comprising a field coil and a moving coil, an electron tube including a grid for supplying energy to said motor, means associated with the output of said tube for separating the output into a first component of unidirectional current and a second component of alternating current, means for passing the unidirectional component through the field coil of the motor, and means for passing the alternating component through the moving coil, said electron tube being provided with a grid leak of high resistance of suitable value, such that as amplitude of the input to the tube increases, the grid bias is increased, resulting in a decrease of the unidirectional component passed by the tube at the same time that the alternating component passed by the tube increases.

18. The combination of a tuning fork, a motor for driving said fork embodying a stationary field coil and a moving drive coil, an electron tube amplifier having a grid controlled output tube for supplying energy to the motor, means in the output circuit of said tube for separating the output into a first component of unidirectional current and a second component of alternating current, means for passing the unidirectional component through the field coil and means for passing the alternating component through the moving coil of said motor, means to bias the grid of said output tube below normal, including a resistance of high value being provided as a leak for the grid, said bias means and leak being so correlated that, as the amplitude of input to the tube varies, the unidirectional component of the current passed by the tube is varied in inverse proportion while the alternating component is varied in direct proportion thereto, thereby producing a compensating effect on the energy supplied to the motor.

19. The combination of a tuning fork, a motor for driving the fork, said motor comprising a stationary field coil and a moving drive coil, said drive coil being secured to the stem of the fork, supporting means also secured to the stem of the fork and yieldable longitudinally thereof, an electron tube amplifier having a grid controlled output tube for supplying energy to the motor, means in the output circuit of said tube for separating the output into a first component of unidirectional current and a second component of alternating current, means for passing the unidirectional component through the field coil and means for passing the alternating

component through the moving coil of said motor, grid bias and leak means associated with said tube of such value as to impose operating characteristics upon the tube such that the alternating component of the current passed by the tube flows in direct proportion to the input while the unidirectional component of the current passed by the tube flows in inverse proportion to the input of the
10 tube.

20. The combination of a vibrating body and a drive motor for maintaining said body in vibration, said vibrating body and said motor being spaced apart, a member extending
15 between and connecting the body and the motor for transmitting vibratory movement to the body, a heat insulating element disposed between the vibrating body and the motor for insulating said body against heat
20 radiated from the motor due to energy dissipation therein, and means embodied in the heat insulating element through which said connecting member may extend to transmit the vibratory movement.

25 In testimony whereof, I affix my signature.
WILLIAM D. BUCKINGHAM.

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