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TUNING FORK IN VACUUM

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FIG. 1

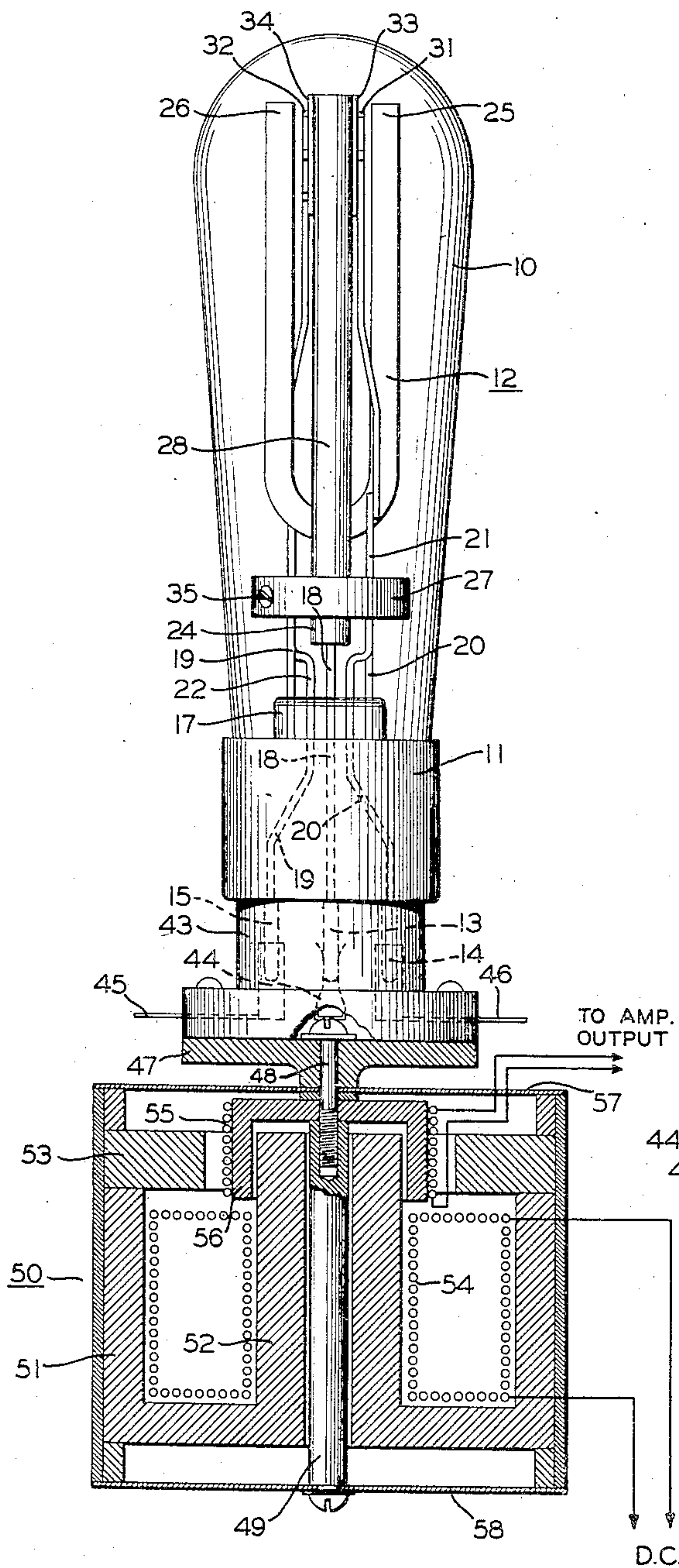


FIG. 2

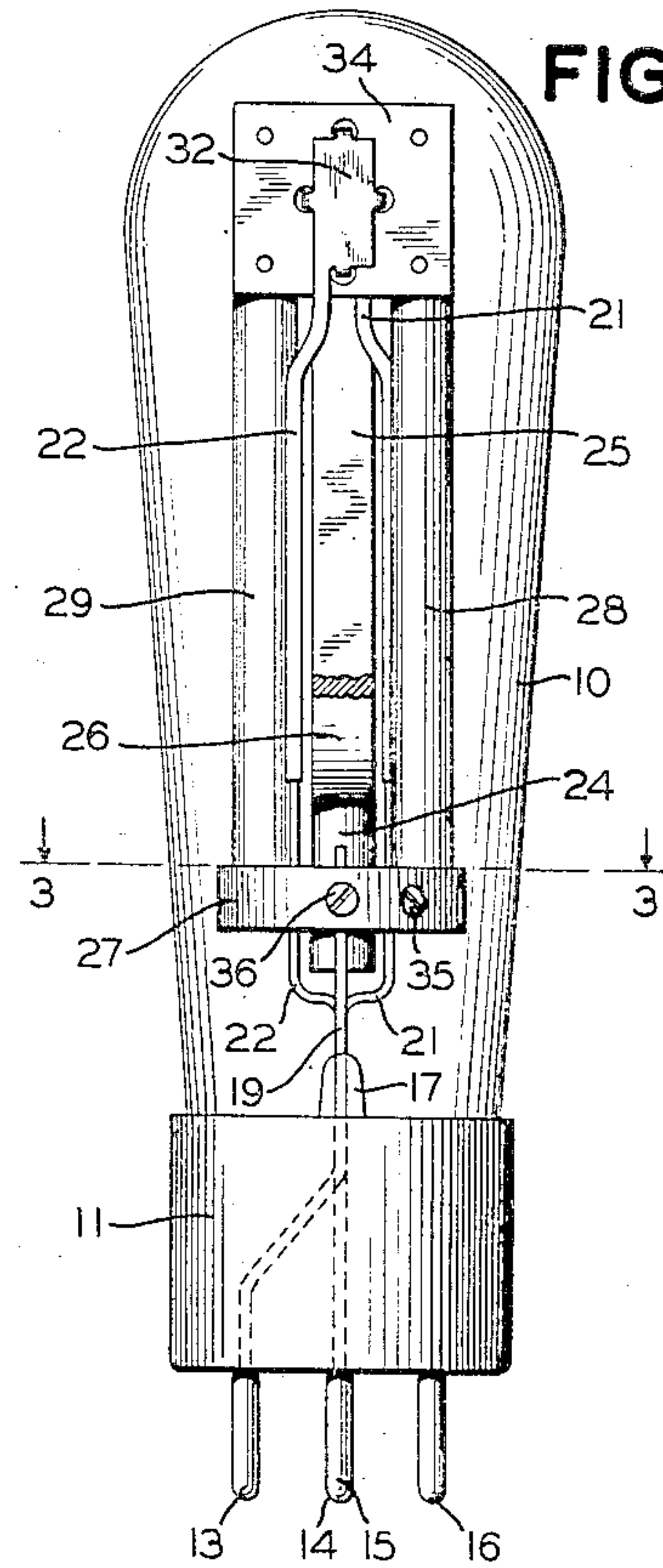
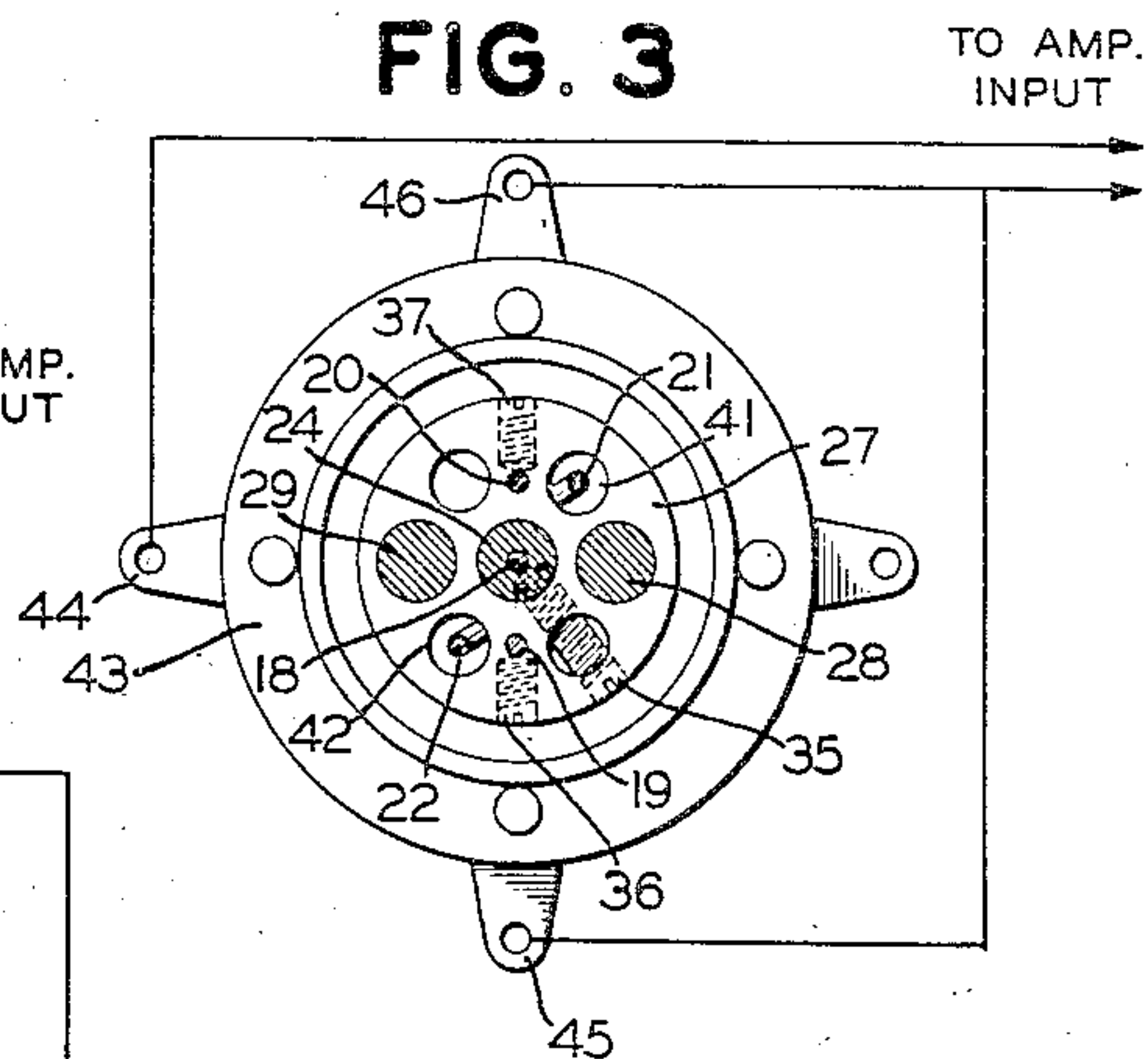


FIG. 3



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TUNING FORK IN VACUUM

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This invention relates to tuning forks, more particularly to mounting tuning forks in an evacuated vessel and operating the forks so mounted.

It is well known in the art that the atmosphere normally surrounding a tuning fork causes considerable damping of the fork. It is also well known that if a tuning fork is operated in a vacuum this damping effect is eliminated in accordance with the degree of vacuum. Other advantages will flow from vacuum enclosed forks as will more fully appear.

The principal object of this invention is to provide an improved type of envelope or evacuated vessel in which the fork is mounted.

Another object of this invention is to eliminate the difficulty of maintaining the vessel evacuated by employing a sealed envelope.

A further object is to provide improved means for driving a fork mounted in a permanently sealed envelope and for making electrical connection with the fork for picking up and amplifying the vibrations.

A still further object is to insulate a tuning fork from temperature change due to variation in the temperature of the surrounding atmosphere by enclosing the fork in an evacuated vessel.

Still another object is to provide a tuning fork unit enclosed in an evacuated vessel which will not tend to destroy the vacuum due to the release of occluded gases from the elements of the fork unit by employing only metallic elements for forming the unit.

These and other objects will appear from the following description and claims taken in connection with the accompanying drawing in which:

Fig. 1 is a view in front elevation of a fork mounted in an evacuated glass envelope and end section of the means of driving the fork;

Fig. 2 is a view in side elevation of the fork and vessel with one of the tines of the fork broken away, and,

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2.

According to this invention a tuning fork is enclosed in an evacuated vessel and mounted therein upon means extending inwardly from the base of the vessel in such a manner as to support the fork and transmit vibrating force thereto for the purpose of driving the fork. The envelope may assume any suitable form and may be mounted in any suitable manner.

In its preferred form a glass envelope is employed which is mounted upon a base. The enve-

lope embodies a stem upon which the tuning fork is supported. The envelope and base unit together are preferably of the type ordinarily employed in the manufacture of electron or vacuum tubes or incandescent lamps.

For a more complete description reference will now be had to the drawing. The principal elements comprising the fork and evacuated envelope assembly, as shown in Figs. 1 and 2, are an envelope 10 supported in a base 11 and a fork 12 disposed within the envelope and supported therein, as will presently be more fully described.

The remaining description of the apparatus will be taken up in the order of the normal assembly of the parts. In this manner both the description of the parts and the method of assembly may be readily set forth at the same time.

The base 11 may be prepared in the well known manner followed in the preparation of similar bases in commercial vacuum tube art. The base is provided with pins arranged to be inserted in a standard vacuum tube socket. In the illustration the base is provided with four pins 13, 14, 15 and 16.

A stem 17 of the vacuum tube type is prepared with a suitable number of relatively heavy wires sealed in the pinch. In the present instance there are five wires 18, 19, 20, 21, and 22. Of the five wires three are employed to act both as support members and conductors, while two act only as support members.

The fork 12 embodies a stem 24 and tines 25 and 26. The fork assembly includes a disk or plate 27 in the center of which the stem of the fork is secured and which also carries upright bars 28 and 29 for supporting small metal plates 31 and 32 adjacent the upper inside face of the tines 25 and 26 respectively. The portion of the fork tines adjacent the plates form one side of a condenser, while the plates themselves form the other. As will be readily understood the capacity of the condensers vary with the movement of the fork tines as they vibrate and in this manner provide a capacity pick-up of the vibrations of the fork, such as described in Patent 1,913,331, granted June 6, 1933, to the present inventor. The plates 31 and 32 are electrically insulated from the supporting columns 28 and 29 by being mounted respectively on plates 33 and 34 of insulating material, such as mica. When the fork and the plates are connected in an electrical circuit they will cause a current to flow which may be amplified through a suitable amplifier such as described in the foregoing patent.

The columns 28 and 29, together with the plate

27, are preferably comprised of aluminum or some suitable light alloy. The columns are suitably secured to the plate by being driven or screwed into holes provided in the plate. The columns are positioned so that the tines of the fork extend transversely between them and have an upper end of such size as to hold the plates at a suitable distance from the upper ends of the tines when the supporting plates 33 and 34 of insulating material are assembled on the columns.

This assembly is supported by the wires passing through the pinch by the same being secured to the fork and the plates, as will now be described. The central wire 18 is connected with the stem 24 of the fork by being inserted into a hole provided longitudinally of the stem. The outside wires 19 and 20 are secured directly to the plate 27 by being inserted into holes provided in the plate or by other suitable means. As illustrated most clearly in Fig. 3 the wires 18, 19, and 20 are secured in position by suitable set screws 35, 36, and 37. The wires may be secured in place by soldering, welding, or other suitable means. The set screw 35 is arranged to engage the central wire 18 by passing through a suitable hole provided in the side of the stem 24 of the fork to a point where it may be set directly against the wire 18. In this manner it binds the wire 18 against the side of its hole in the stem of the fork and likewise binds the stem in the hole provided in the plate 27. The screws 36 and 37 are merely set against the wires 19 and 20 respectively. The two remaining wires 21 and 22 pass through enlarged holes 41 and 42 in a position central of these holes and connect with the pick-up plates 31 and 32 respectively. At the pinch the conductor wires 21 and 22 pass down and are connected to base pins 14 and 15. The central wire 18 likewise passes down through the pinch and is connected to the pin 13. Referring to Fig. 3, the pins 13, 14, and 15 connect with the socket tabs 44, 45, and 46 respectively, by passing into holes or receptacles of the socket 43. By connecting the tabs 44 and 45 either singly or parallel in one side of a circuit and the tab 46 to the other side of the circuit, a pick-up connection is made, which may be connected with a suitable amplifier for impressing the vibrations of the fork on the amplifier.

After the fork and pick-up element assembly has been properly secured to the stem 17, the envelope 10 is then inserted over the assembly and fused to the stem as in the well known method of manufacturing vacuum tubes. The envelope is then evacuated as a vacuum tube by employing a vacuum pump or the like for the preliminary evacuation and "getter" for completely evacuating the envelope. The envelope and fork assembly is then secured to the base and the connections properly made with the base pins as already described.

As is well known to those skilled in the art, a tuning fork may be driven or caused to vibrate by imparting a vibratory motion to the stem of the fork in a direction longitudinal thereof. Such a method of driving is explained in the patent referred to above. In the present case the same method of driving is employed except that the whole envelope is caused to vibrate in a direction longitudinally thereof and this vibratory motion is transmitted to the fork through the supporting wires 18, 19, and 20, all three of which have considerable longitudinal rigidity which they exert in a plane parallel to the stem of the fork, as

may be understood from the foregoing description.

The vibratory motion to be imparted to the envelope is secured by mounting it upon a suitable socket, such as a vacuum tube socket having the required number of pin receptacles, which has been secured to any suitable type of vibration motor which when actuated by the fork pick-up amplifier will cause the socket to vibrate at a suitable frequency in a direction longitudinally of a fork-envelope assembly. The vibration motor may be any of the well known types such as the vibrating armature type or the vibrating or moving coil type. Only the latter type is illustrated for the purposes of the present invention. The application of other types will be obvious in view of the form illustrated.

The moving coil motor is illustrated in Fig. 1 as set up to drive the fork by vibrating the whole assembly. A socket 43 is mounted upon a disk or base plate 47 which is secured by means of a suitable screw 48 to stem 49 of the vibration motor 50. The motor has means for creating an intensive magnetic field across an air gap comprising a cup 51 of magnetic material embodying a central core member 52 and a plate 53 mounted upon the rim of the cup and spaced from the upper end of the core so as to form an air gap in the magnetic path. The core assembly is energized by a suitable coil 54 supplied with direct current from a suitable source. In the core air gap is mounted the moving coil 55. The coil is supported at the upper end of the stem 49 by being mounted on a suitable cup member 56 of sufficient rigidity to transmit the driving force generated in a well known manner by the coil when alternating current of a suitable frequency is passed therethrough. The source of the alternating current of proper frequency is the output of an amplifier employed to amplify the current vibrations created by the fork through a pick-up mechanism already described. A suitable amplifier is described in the patent hereinbefore referred to. The moving coil 55, the socket base plate 47, the stem 49 and the other portions of the vibration assembly are secured in place in a manner which will prevent transverse motion, but permit a substantially free longitudinal motion by being attached to the center of flexible diaphragm members 57 and 58 located respectively at the top and bottom of the motor field cup 51 and suitably secured in spaced relation therefrom by being made fast at their peripheries to rings, collars, or the like attached to the opposite ends of the motor body.

From the foregoing description it will be seen that vibrations generated by the motor will be readily transmitted to the fork and envelope assembly in a direction longitudinally thereof through the socket 43 which must vibrate in accordance with the vibrations of the moving coil 55. In other words, if the pick-up of the fork vibrations by means of the current generated by the varying capacity of the pick-up condensers formed at the outer ends of the fork tines is connected through the socket tips or otherwise to the input of a suitable vacuum tube amplifier, electrical vibrations of substantially the same frequency as generated by the fork will be impressed upon the moving coil which in turn imparts a vibratory motion to the fork and envelope assembly in such a manner as to maintain the fork in constant vibration.

The system thus produced provides a frequency control which is substantially constant due to the

fact that substantially all means which heretofore have caused damping of the fork vibrations have been removed. Most important of these is the damping effect of atmosphere normally surrounding the tines of a fork. The second of these is the provision of a capacity type pick-up which has a minimum amount of damping reaction upon the fork. Another important item is the employment of the method driving the fork by imparting a motion longitudinally of the stem which substantially eliminates the possibility of damping from the driving means. Thus it will be seen that a tuning fork mounted and driven according to this invention will operate substantially as a free vibrating body, maintaining the highly desirable characteristics of such a body.

In addition to the foregoing, effective means is provided by the heat insulating characteristics of the vacuum surrounding the fork for aiding in maintaining the fork or vibrating body at a uniform temperature.

Moreover the removal of the air, a sound conducting medium, from the fork enclosing chamber substantially eliminates the possibility of unfavorable reaction upon the fork of sound reflected from the wall of the enclosing structure.

The type of evacuated envelope illustrated and described is particularly adaptable for use in connection with forks of small size such as forks vibrating at around 1000 cycles or more. An envelope and assemblage for this size fork corresponds closely in dimensions to that of the most widely used vacuum tubes. However, the same principles are readily adaptable to forks of larger sizes and no correspondingly greater difficulty is experienced with the largest sized fork assemblies than with the construction of envelopes for other devices such as lamps, vacuum tubes, X-ray tubes, etc., requiring larger sizes of envelopes.

The particular advantages of a permanently sealed envelope over previous types of envelopes in which tuning forks were enclosed in vacuum are due to the fact that the problem of maintaining the vacuum is eliminated and the possibility of a varying vacuum is minimized. This is made possible largely because the necessity for employing solenoids or electro-magnetic for driving the fork and for picking up the fork vibrations has been eliminated and a simplified fork drive and pick-up means has been provided. According to this invention the driving means is disposed entirely outside of the envelope and the pick-up means comprising a simple condenser arrangement is readily mounted in the envelope. Another important factor is that the pick-up means and other elements necessary, according to this invention, to be located within the envelope, may be constructed of bare elements not requiring the type of insulation which it would be necessary to provide in connection with a solenoid or magnetic relay and thus eliminate or at least minimize to a high degree the possibility of the release of gases within the envelope after a vacuum has been established. Of course, it is recognized that the problem of occluded gases in the elements remains but that may be met by the ordinary methods of driving out occluded gases in connection with the manufacture of vacuum tubes.

Although the embodiment of the invention herein described is arranged to drive the fork by the impartation of motion to the fork longitudinally of the stem, the fork may be driven by other means such as imparting a motion to the envelope in a direction transversely of the tines.

This method may be employed in connection with the present embodiment. For example, the supporting wires 18, 19, and 20 are disposed in the same plane as the tines of the fork. Therefore, a motion transversely of the tines in this plane when imparted to the envelope will be transmitted to the fork due to the rigidity of the supporting wires by virtue of their being arranged in this plane. Other methods of transmitting the driving force to the fork by vibrating the envelope will occur to those skilled in the art.

Various modifications and embodiments other than that shown will occur to those skilled in the art to be within the spirit of this invention, and it is desired to place thereupon only such limitations as are imposed by the prior art or as set forth in the appended claims.

What I claim is:

1. In combination, an evacuated vessel comprising a glass envelope of the vacuum tube type, a tuning fork disposed to be enclosed in the envelope, said envelope embodying an inwardly extending stem portion having a pinch and a plurality of rods extending through the stem and sealed in said pinch, said fork being supported from the stem by having the inner end of one or more of said rods joined to the fork, others of said rods connecting with means for establishing in cooperation with the fork an electrical circuit, the current flow in which is responsive to the vibrations of the fork, a base of the vacuum tube type upon which the envelope is mounted, said base having depending pins at least one of which is connected to one of the rods which is joined to the fork and at least one to one of the rods connecting with the circuit means, whereby the pins may serve to connect the internal circuit elements with external elements for completing the fork responsive circuit.

2. A tuning fork assembly comprising a longitudinally extending envelope embodying support means at one end, a tuning fork embodying a stem and tines disposed longitudinally of the envelope and attached by its stem to said support means, and impelling means for imparting a vibratory motion to the envelope in a direction to transmit through said support means a vibratory motion to the fork in a direction longitudinally of its stem.

3. The combination of a tuning fork, a sealed evacuated envelope embodying internal support means upon which the fork is mounted, a vibration generator arranged to impart a vibratory motion to the fork-envelope assembly for vibrating the fork, and means for detachably securing said assembly in a vibratory relation to the generator.

4. The combination of a tuning fork, a sealed evacuated envelope embodying means internally thereof upon which the fork is mounted, said envelope embodying a base having connector means and a driving motor embodying cooperating means for detachably receiving the connector means of the envelope base to connect the envelope with the driving motor.

5. The combination of a tuning fork and a sealed envelope for enclosing the fork, support means in the envelope upon which the fork is so mounted that vibratory movements imparted to the envelope are transmitted to the fork, means to suspend the envelope so that it may vibrate freely in one direction, and means to impart a vibrating movement to the envelope in this direction to set up vibrations in the fork.

6. The combination of an enclosure vessel,

means for imparting a vibratory motion to said vessel, a tuning fork enclosed within the vessel, and support means within the vessel forming an integral part thereof upon which the fork is fixed
5 whereby vibratory movements imparted to the vessel are transmitted to the fork.

7. The combination of a tuning fork and en-

closure for the fork, means for mounting said fork within the enclosure, means for imparting vibrations to the enclosure and a vibration transmitting element connecting the enclosure and the fork so that vibrations imparted to the enclosure 5 are transmitted to the fork.

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