

Nov. 25, 1924.

L. J. BEINDORF
TUNING DEVICE

Filed Sept. 8, 1922

1,516,947

2 Sheets-Sheet 1

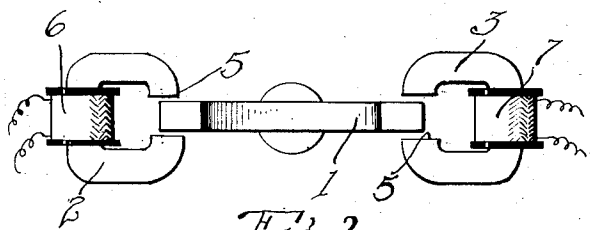


Fig. 2.

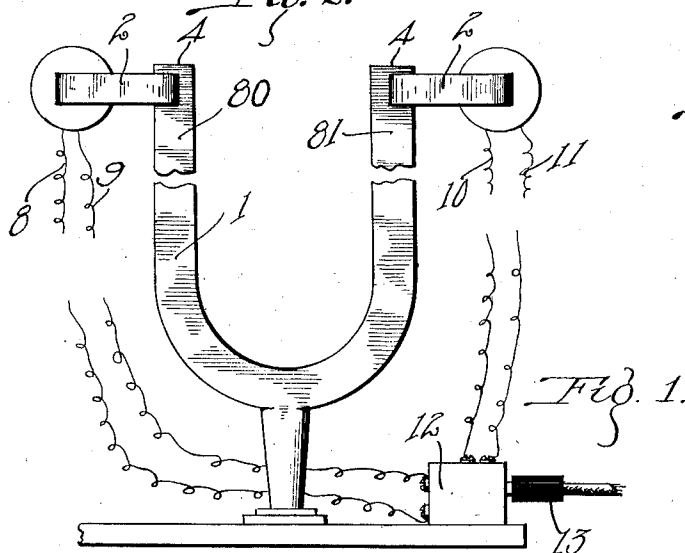


Fig. 1.

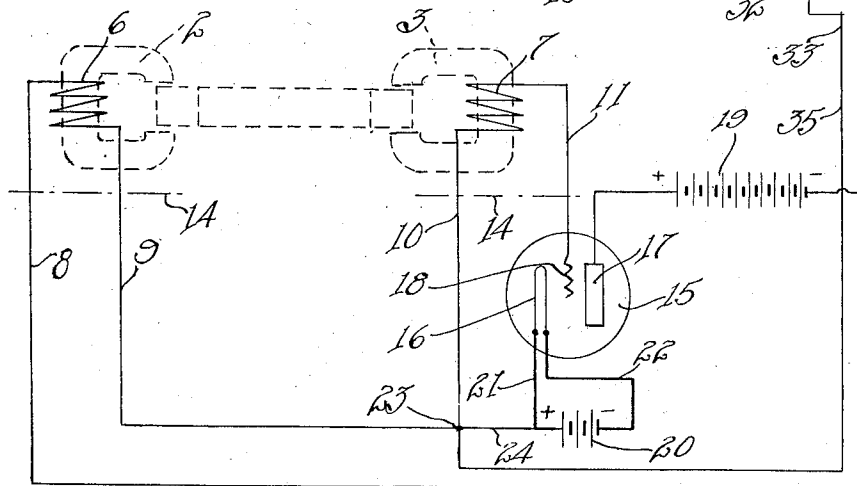


Fig. 3.

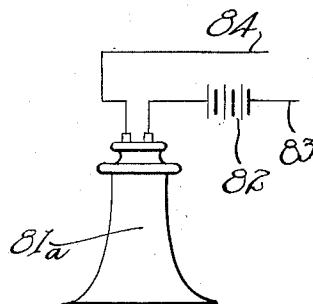
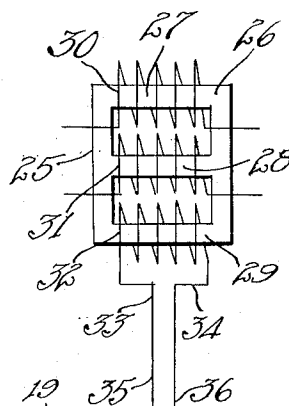


Fig. 7.



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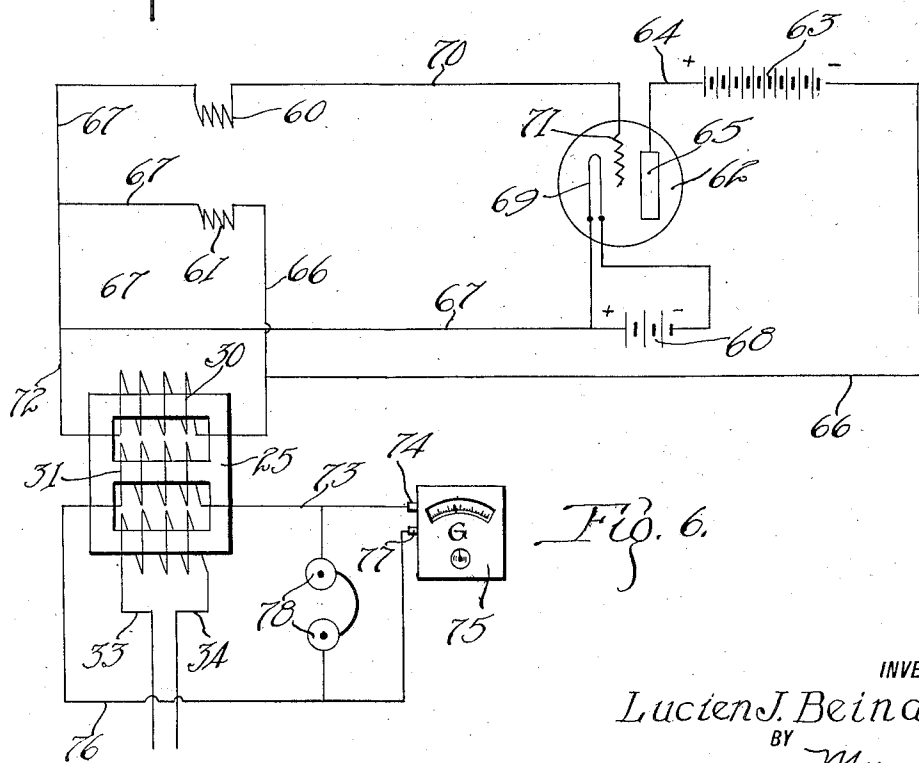
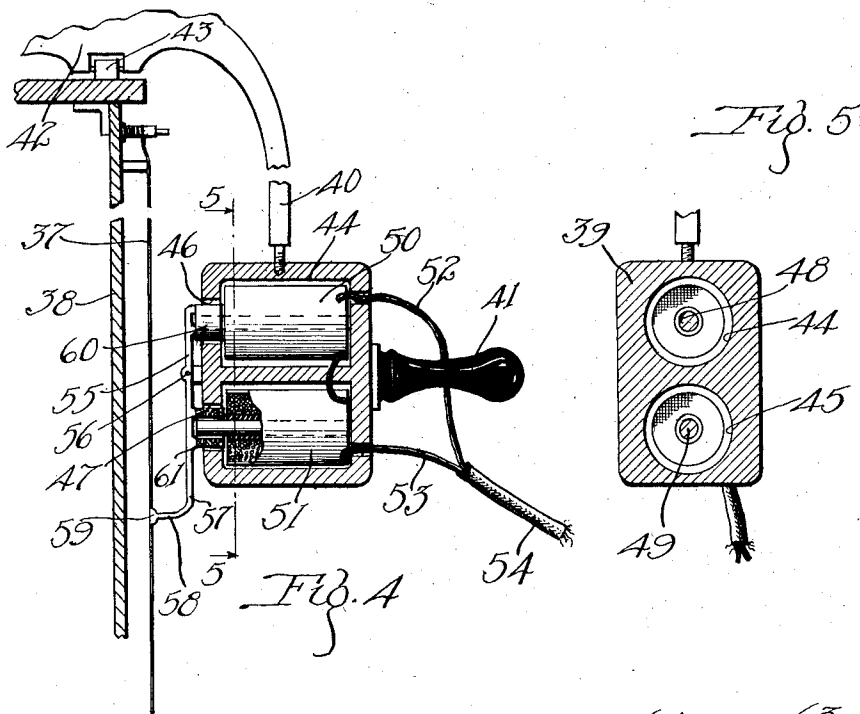
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UNITED STATES PATENT OFFICE.

LUCIEN J. BEINDORF, OF CHICAGO, ILLINOIS.

TUNING DEVICE.

Application filed September 8, 1922. Serial No. 586,906.

To all whom it may concern:

Be it known that I, LUCIEN J. BEINDORF, a citizen of the United States, and a resident of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Tuning Devices, of which the following is a full, clear, and exact description.

My invention relates to improvements in tuning devices, and it consists in the combinations, constructions, and arrangements herein described and claimed.

An object of my invention is to provide a device of the character described in which means is provided for comparing the frequency of vibration of a standard tuning fork and a piano string to determine whether or not the piano string is in tune.

Another object of my invention is to provide a device of the character described which does not rely upon a comparison of audible waves as the ordinary tuning done by ear, but instead, by the comparison of mechanically reproduced pulsating electric current.

A further object of my invention is to provide a device of the character described which may be used to advantage where more than one instrument is tuned in the same room and audible tuning would occur.

Another object of my invention is to provide a device of the character described which is compact in form, which is easy to operate, and which is thoroughly practical commercially.

Other objects and advantages will appear in the following specification and the novel features of the invention will be particularly pointed out in the appended claims.

My invention is illustrated in the accompanying drawings, forming part of this application, in which—

Figure 1 is a side elevation of one of the standard tuning forks and a portion of the mechanism for operating the fork,

Figure 2 is a top plan view of the mechanism illustrated in Figure 1,

Figure 3 is a diagrammatic view of the electrical connections of a portion of the tuning device,

Figure 4 is a sectional view of a portion of the tuning device,

Figure 5 is a sectional view along the line 5—5 of Figure 4,

Figure 6 is a diagrammatic view of the

electrical connections of the tuning device, and

Figure 7 is a side elevation of a modified form of the mechanism illustrated in Figures 4 and 6.

In carrying out my invention, I make use of a plurality of tuning forks 1. I provide one tuning fork for each of the cords or strings of the instrument to be tuned, and the forks each produce a sound wave that may be a standard. I have shown only one of the forks and the mechanism for operating the fork for the purpose of simplicity.

The fork 1 is mounted upon a suitable base as shown. A pair of split ring magnet cores 2 and 3 are mounted adjacent to the upper ends 4 of the fork 1 so that the ends 4 of the fork may lie slightly in front of the gap 5 between the adjacent ends of the cores 2 and 3. Each of the cores 2 and 3 is provided with a magnet winding 6 and 7 respectively. The terminals 8 and 9 of the magnet winding 6, and the terminals 10 and 11 of the magnet winding 7 are connected by means of a jack 12 to the ordinary type of switch board plug 13 having four lead wires, one for each of the terminals 8 to 11 inclusive. The broken line 14 in Figure 3 represents the relative position of the jack and plug 12—13 in the circuit.

A vacuum valve 15 of the ordinary type having a filament 16, a plate 17 and a grid 18 is provided and secured on a suitable mounting, together with a B battery 19 for the plate circuit, and a filament battery 20. In describing the electrical connections for this portion of the device, I shall consider that the plug 13 is inserted in the jack 12 and therefore describe the completed circuit. The filament battery 20 is connected in the usual manner by feed wires 21 and 22 to the filament 16. The plus pole of the B battery 19 is connected to the plate 17 and the negative pole of the battery 19 is connected to the terminal 8 of the magnet winding 6. The terminals 9 and 10 of the magnet windings 6 and 7 are connected to one another at 23 and to the filament circuit 20, 21, and 22 between the battery and filament by a connector 24. The terminal 11 of the magnet winding 7 is connected to the grid 18 of the valve 15. The mechanism and circuit described above constitutes the mechanism for generating a

pulsating current having a frequency that is perfectly synchronized with the natural period of vibration of the tuning fork 1. The operation thereof will be hereinafter described.

A transformer 25 which I choose to call a differential transformer, is provided, and is constructed of a closed core 26 having three branches 27, 28, and 29. The three branches 27 to 29 inclusive, are provided with windings 30 to 32 respectively, the winding 31 being on the intermediate or central branch 28. The terminals 33 and 34 of the winding 32 are shunted across the plate circuit of the generator at 23 and at the negative pole of the battery 19 by means of connectors 35 and 36, respectively. This connection therefore permits a portion of the current in the secondary or plate circuit of the valve 15 to flow through the coil 32.

The means for generating a pulsating current having a frequency synchronous with the period of vibration of the piano cord or string as shown at 37 on the piano sound pole 30 is provided as follows. A shell of iron 39 is supported upon the supporting arm 40 and is provided with a handle 41 for guiding the movement thereof. The supporting arm 40 forms a portion of a carriage 42 having a roller 43 which may be moved longitudinally of the piano sound board 38 so that the shell 39 may be brought into registration with any of the various cords or strings of the piano. The shell 39 is provided with a pair of compartments 44 and 45, each having a restricted opening 46 and 47, respectively, at the forward end of the shell 39. Round iron core pieces 48 and 49 are centrally located in the compartments 44 and 45, respectively, and arranged to project through the restricted openings 46 and 47.

A pair of magnet coils 50 and 51 are disposed in the compartments 44 and 45 concentric the cores 48 and 49. The coils 50 and 51 are connected in series with one another and are provided with terminals 52 and 53 which terminals are connected by means of a feed cable 54 to a low voltage battery (not shown) which may be, if desired, the filament battery 20. When current is flowing through the coils 50 and 51, a strong magnetic flux is built up about the cores and the outer ends of the core pieces 48 and 49 form one pole of the magnet, and the forward end of the shell 39 forms the opposite pole, so that a strong field is built up on the annular space between the restricted openings 46 and 47 and their respective pole pieces 48 and 49.

A delicately constructed lever 55 is pivotally mounted intermediate its length, as shown at 56, upon the shell 39, one portion 57 of the lever extending downwardly below the lower side of the shell 39 and bent lat-

erally adjacent to its end at 58 so that the tip 59 thereof, which is slightly enlarged, may rest upon the cord or string 37 of the piano. A pair of armature coils 60 and 61 are supported upon either side of the pivotal point 56 so that the coil 60 may lie in the space intermediate the opening 46 in the pole 48, and the coil 61 may lie in the space between the opening 47 in the pole piece 49. It will be apparent at this time that movement of the lever 55 as by vibration of the string 37 will cause simultaneous movement of the coils 60 and 61. If current is flowing through the magnet coils 50 and 51, the coils 60 and 61 will cut the magnetic field previously described and the current will be generated therein.

The connections for this portion of the mechanism are clearly shown in Figure 6 and consist in a vacuum valve 62 identical to the valve 15. A "B" or plate battery 63 is connected with its positive pole and joined by a line 64 to the plate 65. The negative pole of the battery 63 is connected by means of a line 66 to one terminal of the coil 61 and to one terminal of the winding 30 upon the transformer 25. The other terminal of the coil 61 is connected by means of a line 67 to the filament intermediate the filament battery 68 and the filament 69 and also to one terminal of the coil 60. The opposite terminal of the coil 60 is connected by means of a wire 70 to the grid 71 of the vacuum valve 62. A line 72 connects the line 67 to the opposite terminal of the coil 30 of the transformer 25. The coil 31 of the transformer 25 is connected with one of its terminals 73 to one post 74 of a galvanometer 75. The opposite terminal of the coil 31 is connected by means of a line 76 to the remaining post 77 of the galvanometer 75. A pair of head phones 78 are shunted across the terminal 73 in the line 76, i. e., across the galvanometer 75.

From the foregoing description of the various parts of the device, the operation thereof may be readily understood. Let us assume that the G string of the piano is out of tune. The operator would first insert the plug 13 into the jack 12 adjacent the fork 1, which fork was constructed to produce a wave having the period of vibration of the true G. It should be understood that in this device there are a plurality of the forks, one for each of the strings, and that the connections with the plug 12 are the same in each of the forks, i. e., each of the forks is provided with a magnet 6 and 7, and cores 2 and 3.

It is understood by those experienced in the handling of vacuum tube circuits that the proper normal negative potential is maintained on the grid 18 by an adjustable resistance shunted across the filament battery 20 so as to operate the tube on the desired

portion of its characteristic curve which in this case will be the center of the straight portion, thereby allowing a fixed amount of current to flow through the windings 6 and 32 from the "B" battery 19 contained in the plate circuit of the valve 15, this current will flow all the time the plug 13 is in position and the prong 81 of the fork 1 is at rest.

As the plug 13 is inserted in the jack 12, the filament 16 of the valve 15 which is already incandescent, will permit a flow of current from the plate 17 to the filament and this current will flow through the magnet winding 6 in its course from the plug terminal of the battery 19 to the negative terminal. The property of the vacuum valve to conduct current from the plate to the filament is a well established fact. The plug 13 in feeding the jack, makes a connection very quickly and as current flows through the magnet 6, the leg 80 of the fork 1 will be drawn toward the end of the walls 5 of the core 2.

This will cause the opposite leg or prong 81 of the fork 1 to move towards the walls 5 of the core 3. It should be here noted that the core 3 possesses a slight residual magnetism.

Movement of the prong 81 towards the end of the walls 5 of the core 3 will cause a change in the flux through the coil 7, and a feeble current will be induced in the coil 7. Since the coil 7 is in series with the filament and the grid of the valve 15, the movement of the prong 81 towards the coil 7 will cause the grid 18 to receive a slight positive charge, whereupon the flow of current in the magnet 6 will increase (another well established property of the vacuum valve). As current in the plate circuit which includes the coil 6 is increased, the magnetic field about the core 2 will attract the prong 80 still further which will also cause the prong 81 to move still further towards the magnet 7, making the grid more positive, increasing the flow of current through the magnet 6 still more which attracts the prong 80 further. This action takes place until the prongs 80 and 81 reach their outward limit of vibration.

As the prong 81 reaches its limit of vibration, thereby coming to a rest, the generation of current in the coil 7 ceases, the positive charge that was on the grid 18 now falls to normal which is slightly negative, due to the inherent action of the valve. The current flowing through the plate circuit and the coil 6 decreases to normal lowering the magnetic field about the prong 80, which released it somewhat letting it move back away from the coil 6; the prong 81 therefore also moves away from the coil 7 which generates a current in the coil 7 in the opposite direction to the last; the grid already

having a negative charge (normal) is now made more negative by the increased flow of current from the filament 16 to the grid 18 from the coil 7; the current through the plate circuit and coil 6 decreases still more, releasing the prong 80 from the magnetic field almost entirely and it moves to its limit of vibration inward, the prong 81 also moves inward to its limit of vibration. The prongs 80 and 81 tending to move back to their normal position, starts the second cycle of its oscillatory or vibratory movements. It can be readily seen at this time that as the fork is moving to one extent of its oscillatory or vibratory paths, the grid will be charged either negative or positive and the plate current decreases or increases, thus maintaining the fork 1 in constant vibrations of equal amplitude and the plate circuit will have a pulsating direct current flowing therethrough, which current will have a frequency that is perfectly synchronized with the movements of the fork 1.

We will assume therefore that the fork 1 is in operation and that the frequency of the current in the plate circuit, of which a small amount is flowing through the coil 32 of the transformer 25, has a frequency that is synchronous with the standard musical tone G. The operator will then move the shell 39 by means of the handle 41, so that the enlarged tip 59 of the lever 55 will contact the G cord 37 of the piano, which cord is to be adjusted and tuned.

As the operator touches the string 37 with the tip portion 59, the contact therewith will set the string into vibration, and the lever 55 will vibrate with the cord. As the lever 55 vibrates, the coil 60 supported thereon will move in the magnetic field heretofore described between the opening 46 and the core piece 48. This movement will generate a current in the coil 60, one terminal of which is connected to the filament 69 by means of the connector 67, and the other terminal to the grid 71. The grid 71 will thereupon receive alternately positive and negative charges and the current which is normally flowing from the plate 65 to the filament 69 when the coil 60 is at rest, will either be increased or decreased in the coil 61, thereupon forcing the string 37 inward or permitting the string to move outward following in contact with the tip 59; owing to the vibration of the string 37 and the gradual increase and relaxation of the tension against the string 37 by the lever 55 the coil 60 will oscillate in the magnetic field generating a smooth alternating current wave therein. The coil 61 will receive instantaneously a pulsating direct current of the identical wave form, although of greater amplitude which keeps the string 37 in constant vibrations of equal amplitude.

The normal flow of current through the

plate circuit and coil 61 while the coil 60 is at rest, would tend to keep the coil 61 at its outward limit of movement, but when the tip 59 is pushed against the string 37, the coil 61 is forced back to the center of the magnetic field. Therefore a pulsating direct current in the coil 61 will cause a relaxation or increase of tension on the string, causing a smooth to and fro movement of the coils 60 and 61, string 37, and lever 55. As the current flows through the coil 61, the coil 61 and the electromagnet 51 would virtually constitute a motor which would serve to force a movement of the lever 55. The current in the coil 61 would cease when the lever had moved to the opposite end of its oscillatory movement and the operation heretofore described would repeat itself, so that it may be readily seen that the lever 55 would be propelled in an oscillatory movement upon its pivotal point 56 with a frequency synchronous with the unadjusted or untuned frequency of the string or cord 37.

A portion of the current from the central or plate circuit of this portion of the device is arranged to flow through the coil 30 of the transformer 25, and therefore the frequency of pulsations of this current would also be present in the coil 30.

It has been found that where a transformer of the character shown at 25 has been used, and the end branches provided with coils in which current of different frequencies are passed, that the difference between the frequency of the pulsations of the current is registered in an induced current in a coil, such as the coil 31 upon the intermediate or central branch. The operator therefore observes the galvanometer 75 and if the indicating hand oscillates, he has knowledge that there is a difference in the frequency of the current in the plate circuit of the valve 16 and the plate circuit of the valve 62 and therefore the string 37 is not tuned with the fork 1. If this difference is so great, i. e., more than could be registered by use of the galvanometer 75, then the difference may be observed by use of the phones 78 which will buzz. The operator thereupon adjusts the string 37 until the galvanometer shows some movement. He can then complete the adjustment by watching the galvanometer and when the needle does not move but stands perfectly still, the string 37 is in tune with the fork 1 and the plate circuits of the valves 16 and 62 each have pulsating current of identical frequencies.

In Figure 7 I have shown a modified form of the mechanism illustrated in Figure 6, in which in place of using the vacuum valve and the mechanism shown in Figures 4 and 5, I employ the ordinary type of telephone transmitter 81^a and a battery 82 in series therewith. One terminal 83 of the

battery of the opposite pole and transmitter 81, as shown at 84, is connected directly to the coil 30 of the transformer 25. This modified form of the device is particularly well adapted for organs, and it would be impossible to use the device shown in Figure 4 for this purpose. The operation of the modified form is quite simple in that as the waves strike the transmitter 81^a, a pulsating current is permitted to flow through the coil 30 simply because the resistance of the transmitter increases and decreases as the waves strike the transmitter and the frequency of these waves may be compared in precisely the same manner as the frequency of the current in the plate circuit of the valve 62 of the tuning fork 1.

I claim:

1. A tuning device of the character described comprising a differential transformer having three windings thereon, means for generating a pulsating current having a predetermined frequency, said current being directed through one of the windings on said transformer, means for producing a pulsating current having an uncertain frequency, said last named current being directed to flow through the second winding on said transformer, and means electrically connected with the third winding on said transformer for detecting any difference in frequency between the current of predetermined and uncertain frequency.

2. A tuning device of the character described comprising a differential transformer having three windings thereon, means for generating a pulsating current having a predetermined frequency, said current being directed through one of the windings in said transformer, means for producing a pulsating current having an uncertain frequency, said last named current being directed to flow through the second winding on said transformer, and a galvanometer connected with the third winding on said transformer whereby any difference in frequency between the current of predetermined and uncertain frequency may be visually indicated.

3. A tuning device of the character described comprising a differential transformer having three windings thereon, means for generating a pulsating current having a predetermined frequency, said current being directed through one of the windings in said transformer, means for producing a pulsating current having an uncertain frequency, said last named current being directed to flow through the second winding on said transformer, and a telephone receiving mechanism connected with the third winding on said transformer whereby any difference in frequency between the current of predetermined and uncertain frequency may be audibly indicated.

4. In a device of the character described, a vacuum valve having a plate battery, a filament battery, a plate circuit, and a grid circuit, a lever pivotally mounted intermediate its length and adapted for engagement with the string of a piano or the like, a pair of armature coils on said lever, and means for maintaining the electromagnetic field about said armature coils, one of said armature coils being connected in series with said plate circuit and the other being connected in series with said grid circuit.

5. In a device of the character described, an electromagnetic field unit, a lever pivotally mounted intermediate its length on said field unit, a pair of armature coils in operative registration with the poles of said field piece, said lever being provided with a laterally bent portion fashioned to engage the string of a piano or the like, and electrically operated means associated with said armature coils for maintaining said lever in oscillatory motion on its pivotal support at a frequency synchronous with the natural period of vibration of said piano string when said lever is placed in engagement with said string.

6. In a device of the character described,

a tuning fork, a pair of electromagnets, one in registration with each of the prongs of said tuning fork, a vacuum valve having a plate battery, a filament battery, a plate circuit, and a grid circuit, one of said electric magnets being connected in series with said plate circuit, and the other of said magnets being connected in series with said grid circuit, whereby said tuning fork may be kept in constant vibration and the plate circuit may carry a pulsating current having a frequency synchronous with the frequency of the sound waves emitted by the tuning fork.

7. A tuning device of the character described comprising means for generating a pulsating current having a predetermined frequency synchronous with a known audible vibration, means for generating a pulsating current having a frequency synchronous with an unknown audible vibration, and electrical means associated with said first and last named means for detecting any difference in frequency in the current of known frequency and the current of unknown frequency.

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