

Nov. 14, 1939.

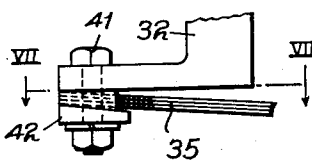
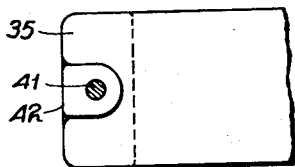
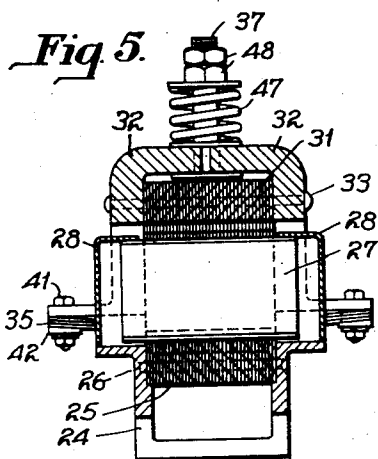
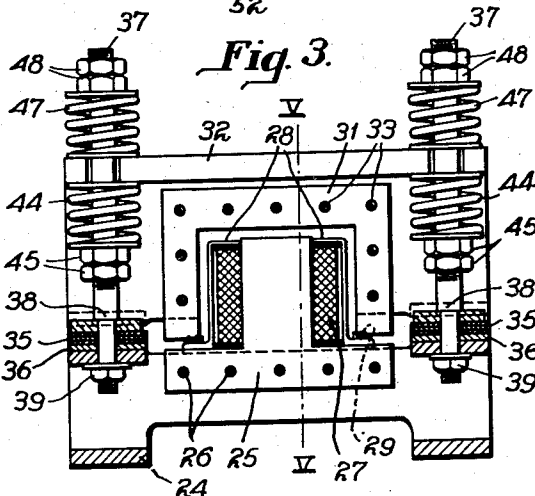
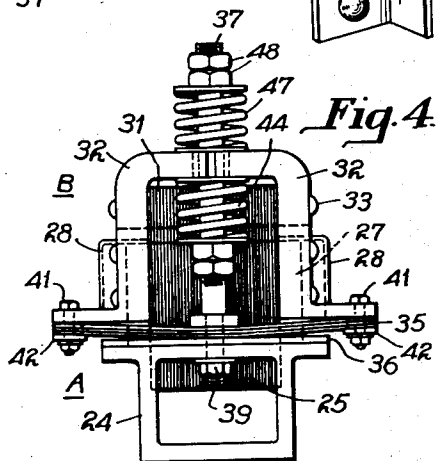
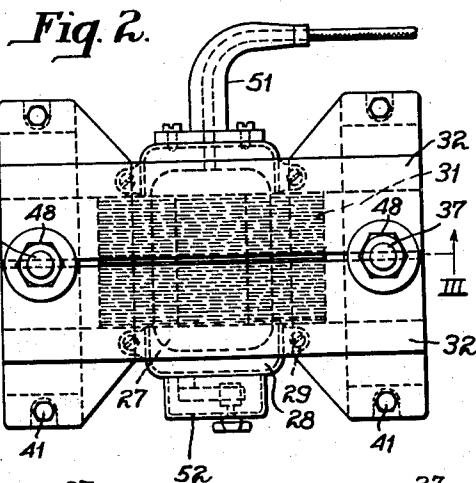
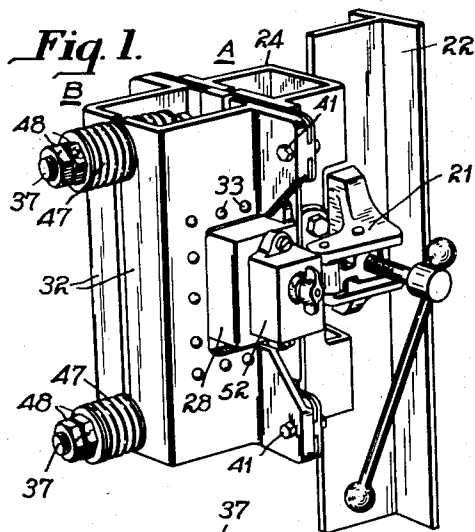
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2,180,189

VIBRATOR

Filed Oct. 13, 1934

4 Sheets-Sheet 1



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VIBRATOR

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4 Sheets-Sheet 2

Fig. 12.

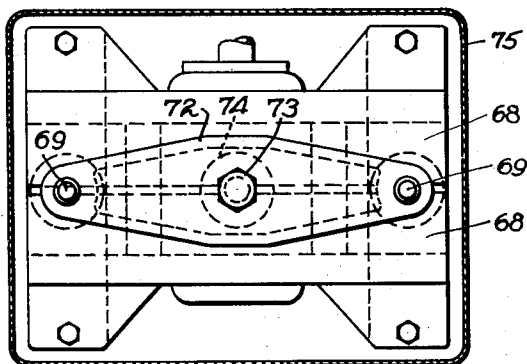


Fig. 8.

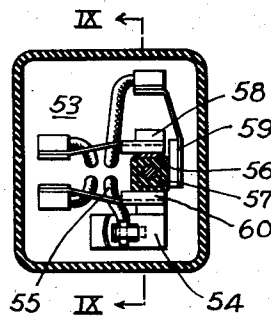


Fig. 13.

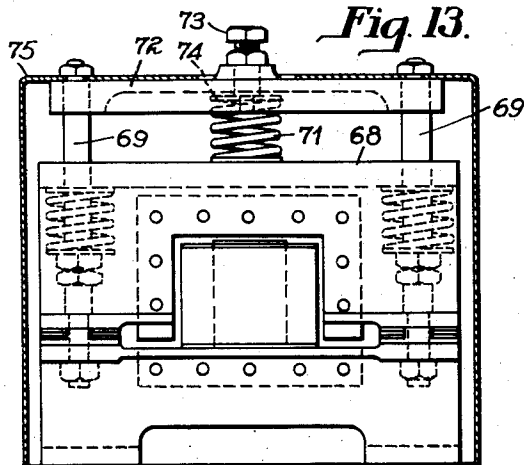


Fig. 10.

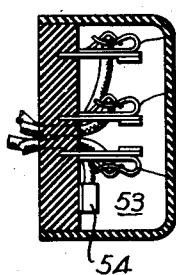


Fig. 9.

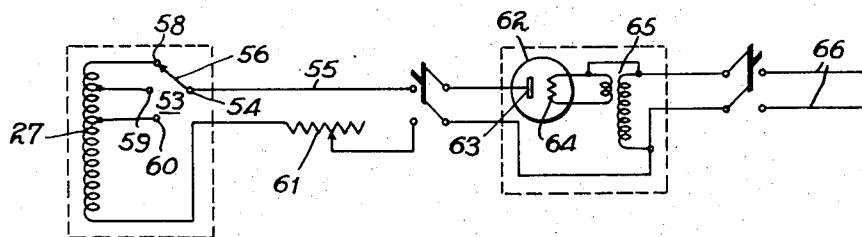
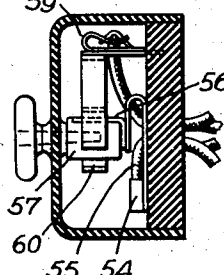


Fig. 11.

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4 Sheets-Sheet 3

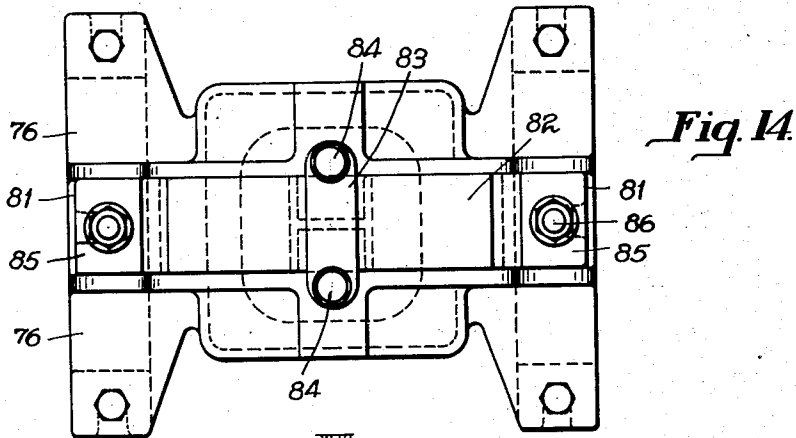


Fig. 14.

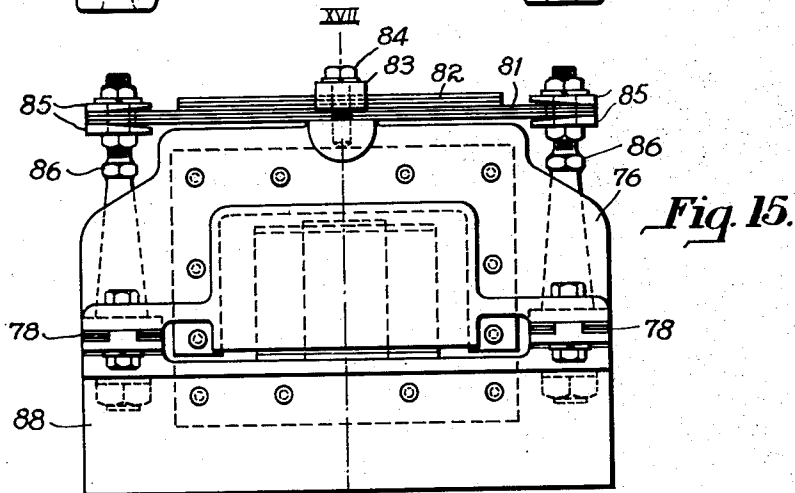


Fig. 15.

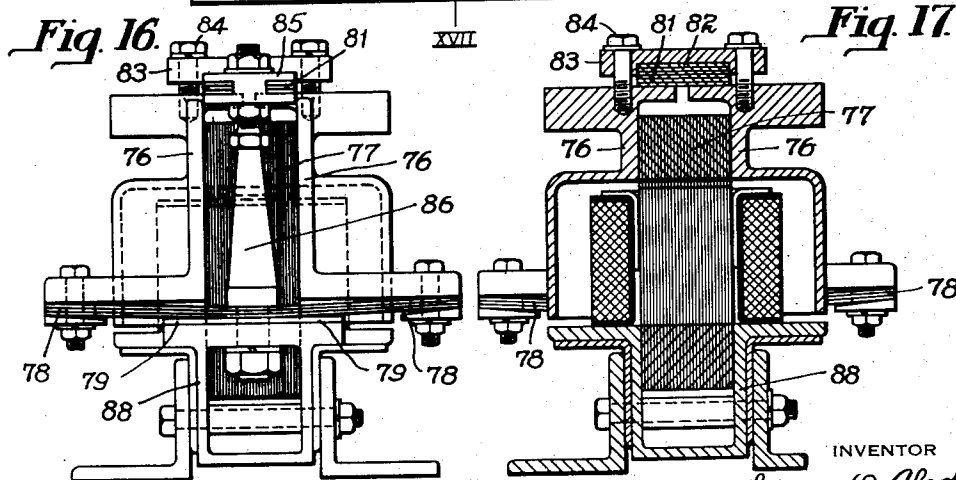


Fig. 16.

Fig. 17

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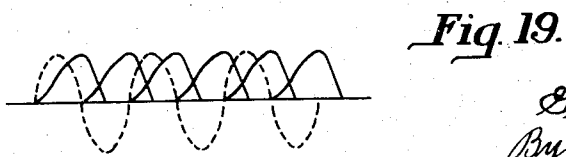
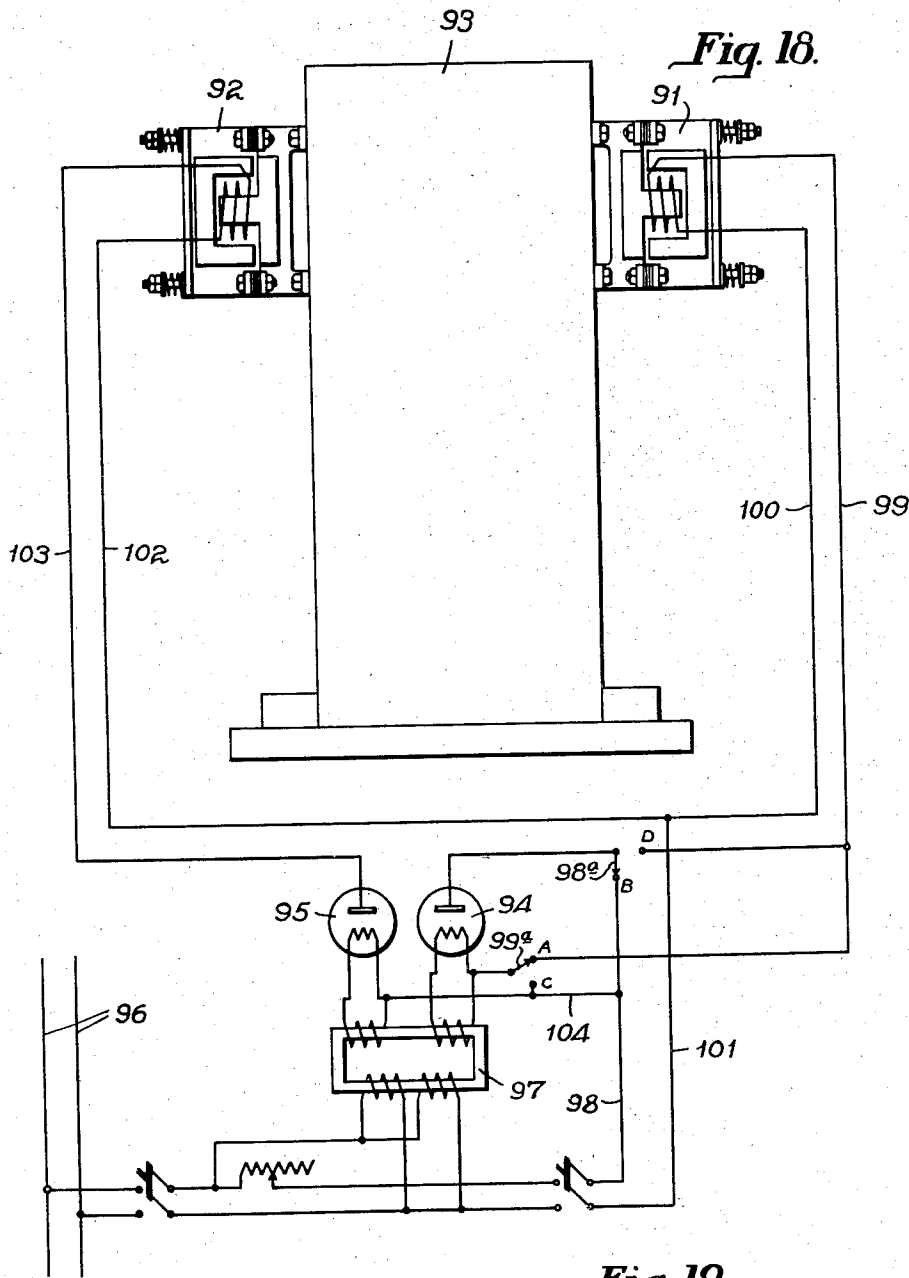
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VIBRATOR

Filed Oct. 13, 1934

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,180,189

VIBRATOR

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a corporation of Pennsylvania

Application October 13, 1934, Serial No. 748,241

21 Claims. (Cl. 172—240)

My invention relates to electromagnetic vibrators of that type which comprises an armature and a core that is periodically energized to effect movements of the armature.

5 The invention is hereinafter described as employed more particularly in connection with the vibration of various objects such as vibrator tables and screens, molds of various types, chutes and spouts through which powdered or finely-
10 divided material is fed, etc.

It will be apparent, however, that various features of the invention are applicable to structures wherein the armature may function as an impact member instead of being operated to effect
15 vibratory movements of the vibrating unit itself when such unit is applied to an article to be vibrated or shaken.

One object of this invention is to provide a vibrator of such construction that it may have
20 very rapid vibrations of small amplitude or may be caused to vibrate with greater amplitudes of movements at a slower rate, as may be desired by the operator.

Another object of my invention is to operate a vibrator by the use of a pulsating electrical current, with means whereby vibratory movement
25 may be effected either upon each of a given series of pulsations of current or may be actuated only once during a plurality of pulsations.

30 Another object of my invention is to provide an arrangement whereby two vibrators may be operated in sequence from a given electrical circuit.

35 Still another object of my invention is to provide a vibrating apparatus that is of simple and rigid construction, economical to manufacture, of small size and light weight, and which can be readily applied to a variety of apparatus with which it is adapted for use.

40 Some of the forms which my invention may take are shown in the accompanying drawings, wherein:

Figure 1 is a perspective view of a vibrator;
Fig. 2 is a plan view thereof; Fig. 3 is a view
45 taken on the line III—III of Fig. 2; Fig. 4 is an end view of the structure; Fig. 5 is a view taken on the line V—V of Fig. 3; Fig. 6 is an enlarged view of a portion of the apparatus of Fig. 5; Fig. 7 is a view taken on the line VII—VII of Fig. 6; Fig. 8 is a sectional plan view of a control
50 switch for the vibrator circuit; Fig. 9 is a view taken on the line IX—IX of Fig. 8; Fig. 10 is another vertical sectional view of the structure of Fig. 8; Fig. 11 shows a wiring diagram with which the switch of Figs. 8 and 10 may be employed;
55 Fig. 12 is a plan view showing a modification of

the structure of Fig. 2 with the casing in section; Fig. 13 is a vertical sectional view of the structure of Fig. 12; Fig. 14 is a plan view showing still another modification; Fig. 15 is a side elevational view thereof; Fig. 16 is an end elevational
5 view; Fig. 17 is a view taken on the line XVII—XVII of Fig. 15; Fig. 18 is a diagrammatic view showing the application of two vibrators to a mold or the like, together, with a wiring diagram of the vibrator circuits, and Fig. 19 is an
10 oscillogram of the current flow.

Referring first to Figs. 1 to 6, the vibrating apparatus is shown as provided with a clamp structure 21 that may be suitably bolted to the vibrator and serve as a means for conveniently attaching the vibrator to the framework 22 of an
15 apparatus or object which is to be shaken or vibrated by the vibrator.

It will be understood that various other forms of attaching means may be employed for securing the vibrator to the apparatus with which it
20 is to be employed.

The vibrator comprises a core assembly A and an armature assembly B. The assembly A includes a flanged channel shaped base 24 within
25 which are set a group of inverted T-shaped laminations 25 comprising the core that are secured in place by means of nonmagnetic rivets 26 passing through the core and the sides of base 24. The base 24 may suitably be composed of a magnesium alloy casting, for strength and lightness, or of steel, while the core laminations 25 may be of silicon steel or other suitable magnetic material of low retentivity. A core winding or coil 27
30 surrounds the upstanding leg of the laminated core 25 and is held in place thereon by a pair of angle plates 28 which are bolted at 29 to the base 24. Suitable insulating discs or washers are provided at the upper and lower ends of the coil
35 27.

The armature structure includes a plurality of
40 inverted U-shaped laminations 31 that are contained within a pair of L-shaped flanged castings 32, the laminations 31 being secured to the casting 32 by nonmagnetic rivets 33 passing
45 therethrough.

It will be seen that there are three air gaps between the core and the armature, namely, at the lower ends of the armature laminations 31 and at the upper end of the lower laminations 25.
50

The ends of the base channel 24 are connected by integral plates or flanges having suitable vertical apertures therethrough. A group of flexible plates or spring leaves 35 is provided at each end of the vibrator structure, each group of springs
55

being supported upon an anvil plate 36 which preferably is of non-magnetic material such as certain stainless steels, bronze alloys, etc., that is mounted on the base 24. A bolt 37, preferably of non-magnetic material, extends through suitable holes in the armature casing 32 and through the midportion of each group of spring leaves 35 as well as through the anvil plate 36 and the upper wall of the base 24. The bolts 37 are shouldered as indicated more clearly at 38 in Fig. 3, so that they will have rigid seating engagement with the upper surfaces of the springs 35, the bolts being securely clamped in place on the springs and the base 24 by nuts 39.

The spring leaves 35 also may be of non-magnetic material such as a chrome nickel alloy. The advantage of having the said various members of non-magnetic material resides in the fact that there will be concentration of magnetic flux across the air gap, between the core and the armature, with minimum leakage and no direct path for the magnetic flux through the connecting members between the base and the armature.

The springs 35 have open-ended slots at their extremities for engagement with bolts 41 that extend through flanges of the armature shell 32. The bolts 41 extend through bifurcated spring seats 42 that are engaged by the lower sides of the springs. The spring leaves also serve as spacers, to prevent the armature from coming into engagement with the pole faces.

The armature is normally held in slightly raised position with respect to the springs 35 and the core base 24 by a pair of coil springs 44 which are interposed between the walls of the shell members 32 and the nuts 45 that have threaded engagement with the bolts 37. Upward movement of the armature is restricted by a pair of coil springs 47 which surround the upper portions of the bolts 37 and are adjustably tensioned against the upper side of the armature casing 32 by nuts 48.

The springs 35 are sufficiently flexible to permit somewhat free movement of the armature relative to the core base 24 and the springs 44 and 47 are so tensioned as to normally maintain the armature in a desired spaced relation to the core base.

It will be seen that the gap between the armature and the core can be varied by adjusting the nuts 45 and 48. When the nuts 45 are turned to place springs 44 under increased tension an upward thrust is transmitted to the armature casing 32 which bows the ends of springs 35 upward and thus increases the air gap and determines the point in the vibration of the armature at which impact occurs. On the other hand, springs 47 can be adjusted by nuts 48 to limit the distance which the armature may move away from the core under influence of the springs 44, upon deenergization of the core and thus limits or determines the amplitude of vibration of the armature in the direction away from the magnet.

The springs 35 function to assist in holding the armature and the core in proper relative alignment and also serve as impact elements which can be readily replaced when they become worn, thus avoiding the necessity of replacing the members 32 and 36. This construction has the advantage that when it becomes necessary to renew the springs, the new springs replace the worn portion of the striking mechanism. Thus the proper air gap is maintained between the pole faces on the impact stroke. Usually the springs

will become broken before the wear has become great enough to allow the pole faces to strike on the impact stroke.

The coil 27 will be periodically energized by successive substantially spaced unidirectional current impulses selected by asymmetrical conduction from a source of alternating current, as for example, in one of the ways set forth and described in the Carl S. Weyandt Patent No. 1,637,401, issued August 2, 1927. Alternately, one of the systems of current supply hereinafter described may be employed.

It will be understood that when the coil 27 is energized, the armature will be drawn sharply into engagement with what may be termed the anvil surfaces 36, thus producing an impacting force. Upon opening of the circuit through the coil, the springs 44 will effect retractive movement of the armature, such retracting movement being cushioned and limited by the springs 47 which will assist in overcoming the inertia of the armature upon the succeeding application of magnetic force thereto.

By the use of a suitable form of valve or rectifier as heretofore referred to, there is a considerable period of zero energy between successive impulses, during which the magnetic energy developed in the armature becomes dissipated, and there is ample time for retractive movement of the armature, so that the kinetic forces which might oppose the next attractive movement of the armature become spent, and there is no retarding force being exerted on the armature by the other half of the A. C. cycle. Also, during this period, there is complete transmission of impact forces through the structure to be vibrated before a succeeding impulse is imparted.

The dissipation of the magnetic energy and kinetic forces above referred to, of course results in the generation of sharper impulses. The delay between successive impulses, which delay may be for the duration of one-half of a 60 cycle current, for example, or may be for one and one-half cycles, as hereinafter explained, is of particular utility in connection with the vibration of hoppers, conveyers, bins, etc., because the delay period between successive impulses can be made of such duration that vibratory waves set up in the material by one impulse will not interfere with or counteract the vibratory waves set up therein by a succeeding impulse. It will thus be seen that with a given amount of electrical energy, the impulses are greater and more effective, than if the said objectionable opposing forces existed.

It will be understood that the vibrations will be quite rapid and that the mass or weight of the armature assembly will be sufficient to secure the desired vibratory forces.

A cable sheath 51 containing a pair of electrical conductors is suitably secured to the core base 24. One conductor is connected to an end of the coil 27 and the other conductor is connected, through a single pole switch 52, with the other end of the coil 27. The switch 52 affords a convenient means for control by the operator, and instead of being a simple single pole switch may be of the construction shown in Figs. 8 to 11.

By the arrangement shown in Figs. 8 to 11, it is possible to vary the power exerted by the coil 27, since the switch can be so positioned that all of the turns of the coil will be included in the circuit or only part of the turns so included. The switch 53 of said figures may be of the

ordinary turn-button type having a suitable base and case. A switch terminal 54 has connection with a conductor 55 and with the movable contact member 56 that is carried by the turn-button 57. Stationary contact members 58, 59 and 60 are selectively engageable by the movable contact member 56 to bring the desired number of coil turns 27 into the circuit.

A further and more gradual variation of electromagnetic force is secured by the use of a variable resistor 61 that is suitably connected in the circuit. As above-stated, unidirectional current is supplied to the solenoid as by an electrolytic valve or thermionic tube 62 which is provided with the usual anode plate 63, and filament 64, in combination with a transformer 65, which operate in a manner well known in the art and as set forth in said Patent No. 1,637,401.

By the arrangement above-described, and using a 60 cycle A. C. current as from a line 66, there will be 3600 pulsations per minute and consequently 3600 vibrations of the armature.

The number of vibrations by the armature can be reduced relative to the number of current pulsations by so adjusting the tension on the armature that only one-half of the 3600 pulsations will operate to move the armature. This adjustment is effected by unscrewing the nuts 48 so as to greatly or entirely relieve the tension of the springs 47, thereby changing the natural period of armature vibration. With this adjustment, the armature, upon termination of a magnetic impulse will, under the expansive force of the springs 45, move so far outward and the recoil of the springs 47 will be so low that the armature will not be acted upon by the next magnetic impulse. In other words, the armature will have only one vibration cycle for each two current pulsations.

From the foregoing description, it will be seen that these vibrators are of very high efficiency and the arrangement is such that the vibrational force will be without destructive effect on the coil and vibrator mounting. The arrangement of U-shaped armature laminations 31, together with the heavy shell casings 32, gives to the armature considerable weight which is, of course, desirable in constructions of this type, while the T-shaped core laminations 25 mounted with the coil on the center poles thereof and in a light magnesium alloy casting are well protected against damage and not subjected to excessive shocks.

The arrangement of the springs 35 that connect the armature and the core structures is such that while they maintain the armature against movement in any direction except away from the pole faces, no guides are required, thereby eliminating frictional resistance and the use of lubrication.

The leaf springs 35 are so located that the armature striking heads strike the springs as they come to rest on the striking plate 36 of the core. In operating the vibrator with a unidirectional pulsating current the tension of the springs and the air gap are so adjusted that the armature motion is abruptly arrested before reaching the normal end of its stroke and while the current is on, and thus is held motionless for a very small increment of time during which it gives up all of its kinetic energy. This produces a severe jolt rather than a sharp instantaneous blow, allowing the object to which the vibrator is attached time to take up the movement and respond to the vibration. This striking through several leaves of the springs produces a greater

rebound than if the armature were to strike directly on the anvil plate. When the current dies down to substantially zero the armature is retracted from the electro-magnet by the springs 44 and is yieldingly brought to rest by the springs 47 and 35, and upon proper adjustment of the springs and air gap the motion of the armature may be adjusted so that at substantially the instant it reaches the end of its motion away from the magnet it is attracted by the next current impulse. Or, the adjustment may be such that the next electromagnetic impulse begins to attract the armature before it reaches the end of its negative movement and thus assists in bringing the armature to rest. The large interval of zero energy between current impulses allows considerable latitude in adjustment. Thus the impact of the vibration occurs in one direction only, the movement of the armature in the reverse direction being brought to a cushioned rest, and thereby the development of counteracting vibrational forces in the body to be vibrated is substantially avoided.

In Figs. 12 and 13, I show a modification of the structure of Figs. 1 to 7. For the most part, the structure is the same as that of Figs. 1 to 7, including a pair of armature castings 68 that correspond to the casings 32 of Fig. 1, and bolts 69 which are mounted similarly to the bolts 37 and are nonmagnetic. In this case, however, the recoil springs at the outer sides of the casting 68 are eliminated and a single coil spring 71 substituted therefor, at the middle of the casting 68. The outer ends of the bolts carry a bar 72, the spring 71 being interposed between said bar and the casting 68.

An adjusting screw 73 extends through the bar 72 and is shouldered at its inner end to provide a seat for a washer 74 which serves as a spring seat so that the screw 73 can be adjusted to vary the tension of the spring 71, in substantially the same manner as and for the same purpose as the adjustments of the nuts 48 to vary the tension of the springs 47. This arrangement is of somewhat simpler form than that of Figs. 1 to 7 in that only one point of adjustment is required at the outer side of the armature.

The structure shown in Figs. 12 and 13 is provided with a case 75 which may be of sheet metal and serves to shield the vibrator from dust and other foreign matter. The shell 75 is held in place by the bolts 69 and the bar 72.

Referring now to Figs. 14 to 17, I show still another modification. In this construction the principal operating elements are similar to those shown in Fig. 1, especially as regards the electro-magnet and core assembly. The armature assembly includes a pair of steel castings 76 between which are clamped armature laminations 77, the casting 76 being provided with skirt-like extensions that partially enclose the coil.

Springs 78 which correspond to the springs 35 of Figs. 1 to 7 tend to lie flat on the striking plate or anvil 79 at which position the gaps between the pole faces are at their minimum, the springs being of such thickness as to prevent the pole faces from striking one another.

In order to widen this gap, flat springs 81 and 82 are clamped at their midportions to the armature casing 76, by means of a plate or clip 83 and screws 84. The ends of the spring leaves 81 are slotted and engage spring seats 85 that are supported on bolts 86, which preferably are of non-magnetic material and extend through

the midportions of spring leaves 78 and through the anvil 79 and the core base 88.

The spring leaves 82 are of short length relatively to the spring leaves 81 and consequently
 5 act mainly to resist inward movement of the armature. The springs 81 are adjusted by moving the spring seats 85 through shifting of the nuts that support the same. If the seats 85 are
 10 moved away from the core, the air gap between the pole faces will, of course, be increased and there will be greater amplitude of vibratory movements by the armature. The armature is pulled toward the core against the resistance of the springs 81 and 82 to deflection, and when re-
 15 leased from the magnetic pull will rebound under the influence of said springs, the rebounding movement being stopped only by the springs 81, whereby a greater amplitude of movement is secured than if the springs 82 cooperated with the
 20 springs 81 to limit the rebound.

The spring tension of the armature can also be changed by varying the number of the spring leaves 81 and the leaves 82 to control the sharpness and degree of vibration. The structure has
 25 the further advantage of utilizing the armature castings as a cover for the coil to protect the same, thereby also increasing the weight of the armature and with the further advantage that a circulation of air is effected during movements
 30 of the armature, to cool the coil.

In this structure, as in the case of the other forms above-described, the connections of the armature to the core assembly is such that the armature can move only in directions at right
 35 angles to the pole faces, thus permitting the vibrator to be mounted in any position, on the object to be vibrated.

Referring now to Fig. 18, I show an arrangement whereby two vibrators 91 and 92, such as
 40 those of the type above-described, may be mounted on a single object to secure more effective vibration. For example, the object may suitably be a concrete pipe mold 93 wherein concrete is to be settled and compacted. The vibrators 91
 45 and 92 are here shown as arranged to operate alternately, that is, their cycles of movement are 180° apart, thus when one armature is under the influence of magnetic force, the other is moving away from its core under spring tension.

It will be understood, however, that the vibrators can be so mounted that their armatures under the influence of the magnetic forces will move in the same direction, to produce certain vibratory effects.

Current is supplied to the vibrators 91 and 92 from thermionic valves 94 and 95, respectively, each operating in substantially the manner set forth above.

However, in the present case, the two cooperating vibrators are supplied with current from a single A. C. circuit 96 that, through a transformer 97, supplies current to the cathodes of the tubes so that in the case of the tube 94, and with the switch 98a closed at B, and the switch
 65 99a closed at A, current will be supplied from a conductor 98 through tube 94 and conductor 99 to the coil winding at 91 and thence through conductors 100 and 101 back to the A. C. line 96, it being understood that by reason of the tube 94,
 70 the current will flow through the core winding in only one direction. In other words, only one-half cycle of the A. C. supply will flow through the coil.

The other half of the A. C. wave will flow
 75 through conductor 101, conductor 102, the core

winding, conductor 103, tube 95 and conductor 104. It will be seen that one-half of each A. C. cycle will cause actuation of the vibrator 91 and the other half thereof will effect actuation of the vibrator 92, as indicated in Fig. 19, wherein
 5 the dotted line represents an A. C. wave and the full lines represent rectified current.

With the switches 98a and 99a in the opposite position, that is closed at D and C, the vibrator 91 will be operated through the same half of the
 10 A. C. cycle as the vibrator 92, and therefore be in synchronism therewith, so that there will be zero periods during which neither of the vibrators is being actuated. The vibrators can, of course, be positioned so that their armatures will move
 15 in the opposite directions under magnetic impulses, as by placing them at opposite sides of the object to be vibrated, or they can operate in conjunction with one another from the same side of the object.

The vibrators of the various forms shown in the drawings are very effective in operation, even though they be of small size relative to the mass of the material or object to be vibrated. For
 25 example, two vibrator assemblies each weighing only 73 lbs. complete, have been very effective in operating grain hoppers that contain 39 tons of grain.

I claim as my invention:

1. Vibrator apparatus comprising an electro-magnet assembly having a core, an armature assembly cooperatively associated therewith, a spring for separating the core and armature upon de-energization of the core, a spring stop limiting the separating movement and initiating return movement of the armature, means for periodically energizing the magnet, and means for adjusting the said spring stop to change the natural period of armature vibration so that the armature is substantially attracted only upon
 30 alternate current impulses.

2. Vibrator apparatus comprising an electro-magnet assembly having a core, an armature assembly cooperatively associated therewith, and flexible strips connected at their ends to one assembly and at their midportions to the other
 45 assembly, the strips being positioned in position to serve as impact receiving elements, and prevent the armature from moving into contact with the pole faces.

3. Vibrator apparatus comprising an electro-magnet assembly having a core, an armature assembly cooperatively associated therewith, flexible strips connected at their midportions to the electro-magnet assembly, means connecting the ends of said strips to the armature assembly, and an anvil surface disposed between the said strips and the electro-magnet assembly, in such position as to receive impacts imposed upon the strips by the armature.

4. Vibrator apparatus comprising an electro-magnet assembly having a core, an armature assembly cooperatively associated therewith, flexible strips connected at their midportions to the electro-magnet assembly, means connecting the ends of said strips to the armature assembly, and an anvil surface of non-magnetic material interposed between said strips and the electro-magnetic assembly, in such position as to receive impacts imposed upon the strips by the armature.

5. Vibrator apparatus comprising an electro-magnet assembly having a core, an armature assembly cooperatively associated with and partially embracing the electro-magnet assembly, flexible strips interposed between the said as-
 75

semblies at each end thereof, means for securing the midportions of said strips to the electromagnet assembly, means for securing the ends of said strips to the armature assembly, the strips being interposed between striking surfaces of the armature and the electro-magnet assemblies.

6. Vibrator apparatus comprising an electromagnet assembly having a base portion and a core projecting upwardly therefrom, an armature assembly partially surrounding said core and movable toward the said base, and flexible supporting means of non-magnetic material connecting each end of the armature to the said base and positioned to receive impacts of the armature.

7. Vibrator apparatus comprising an electromagnet assembly having a base portion and a core projecting upwardly therefrom, an armature assembly partially surrounding said core and movable toward the said base, flexible connecting means mounted between the armature and the said base in position to receive impacts of the armature, and non-magnetic separating means between the base and the armature.

8. Vibrator apparatus comprising an electromagnet element, an armature element, means for periodically energizing the first-named element to effect movement of the armature, and means rendering the armature non-responsive to alternate electrical impulses in the magnet.

9. An electrical vibrator system comprising a pair of vibrating devices, each comprising a coil, an armature and means for moving the armature away from the coil after each application of magnetic force, and means for supplying electrical impulses to said coils either alternately or simultaneously.

10. The combination comprising an armature having considerable mass, an electromagnet, means to develop electromagnetic attractive forces in the magnet by successive substantially spaced unidirectional current impulses selected by asymmetrical conduction from a source of alternating current to repeatedly attract the armature, means to abruptly arrest the motion of the armature while subject to said electromagnetic forces to develop impactive forces, a body to be vibrated, means to transmit said impactive forces to said body, means for retracting said armature and yieldingly arresting the retractive movement thereof, and means to adjust said retracting means to adjust the amplitude of vibration of the armature.

11. Vibrator apparatus comprising an electromagnet, an armature, spring means securing said armature and electromagnet in operative relation, a source of alternating current, means for selecting by asymmetrical electrical conduction successive substantially spaced unidirectional current impulses from said alternating current source for actuating the electromagnet to attract the armature, and means to adjust said spring means to change the natural period of armature vibration so that the armature is impacted upon alternate current impulses.

12. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two resilient members secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, and additional resilient means operatively associated between said armature assembly and support assembly.

13. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two leaf

springs secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, and additional resilient means operatively associated between said armature assembly and support assembly.

14. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two resilient members secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, and coil springs operatively associated between said armature assembly and support assembly.

15. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two resilient members secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting members extending from the electromagnet support at the ends of the armature, and a leaf spring secured to said supporting members at its ends and to said armature assembly at its middle.

16. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two resilient members secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting members extending from the electromagnet support assembly at the ends of the armature, and coil springs operatively associated between said supporting members and armature assembly.

17. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two resilient members secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting posts extending from the electromagnet support at the ends of the armature, and coil springs about said posts in pairs, the armature assembly being operatively associated between said pairs of coil springs.

18. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two leaf springs secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting posts extending from the electromagnet support at the ends of the armature, and coil springs about said posts in pairs, the armature assembly being operatively associated between said pairs of coil springs.

19. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two leaf springs secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting posts extending from the electromagnet support at the ends of the armature, a spring abutment secured to said posts, coil springs operatively associated between said supporting posts and armature assembly, and a coil spring operatively associated between said spring abutment and armature assembly.

20. Vibrator apparatus comprising a support assembly for an electromagnet, an electromagnet mounted thereon, an armature assembly, two leaf springs at the ends of the armature secured at their ends to one said assembly and secured at their respective middle portions to the other assembly, supporting members extending from the electromagnet support at the ends of the arma-

ture, and a leaf spring adjustably secured at its ends to said supporting members and secured at its middle to said armature assembly.

21. The combination comprising an armature having considerable mass, an electromagnet, means to develop electromagnetic attractive forces in the electromagnet to repeatedly attract the armature by successive substantially spaced unidirectional current impulses selected by asym-

metrical conduction from a source of alternating current, means to abruptly arrest the motion of the armature in attracted direction only to develop impactive forces, there being no abrupt obstruction to the armature movement in reverse direction, and spring means for retracting the armature, said spring means yieldingly arresting the retractive movement of the armature.

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