March 3, 1936. W. H. HORSCH 2,032,934

ELECTRIC VIBRATOR

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Fig. 1.

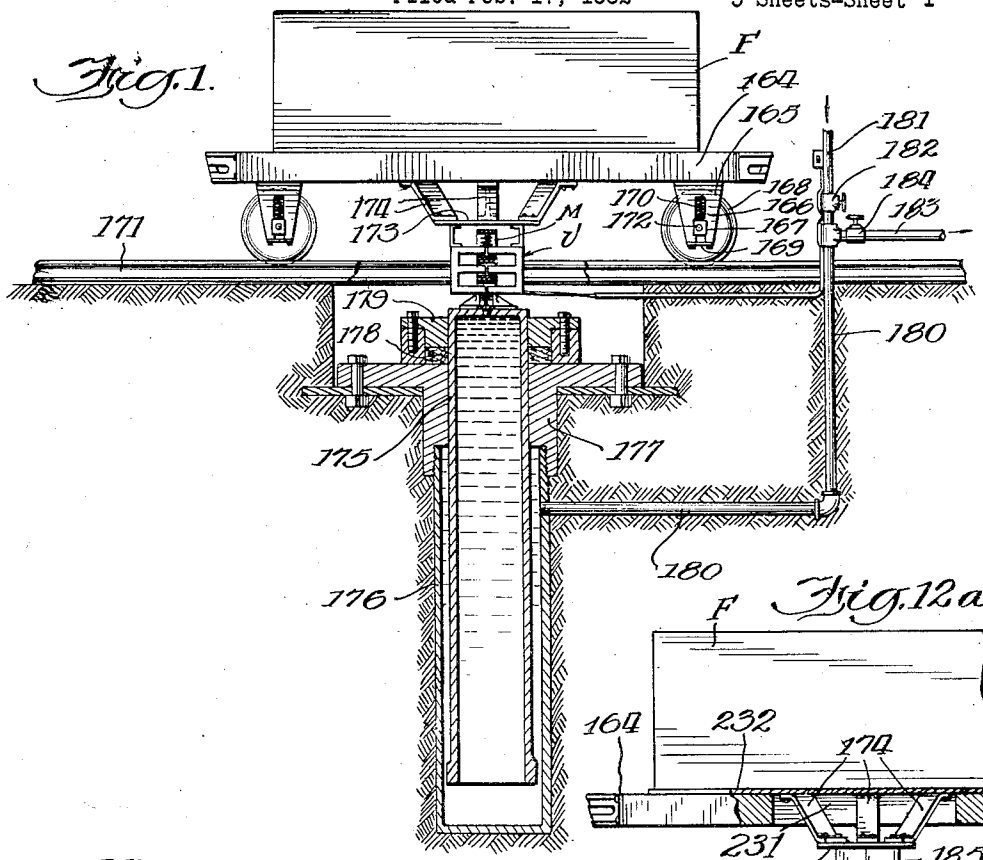
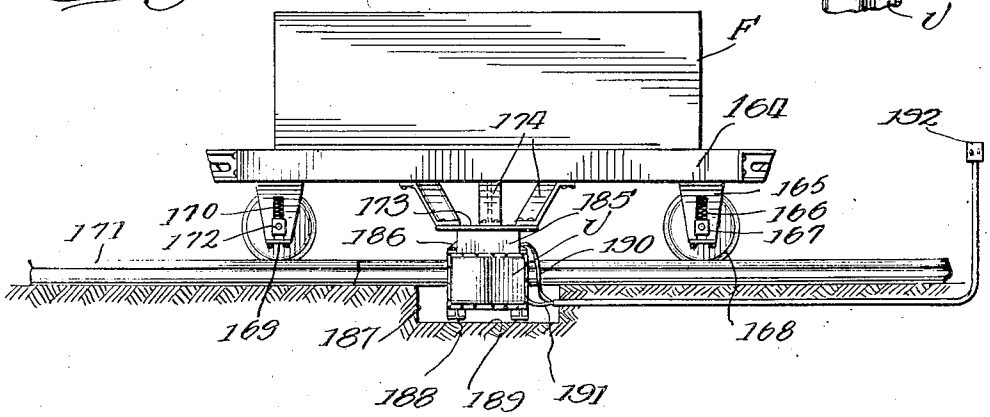


Fig. 12a.

Fig. 2.



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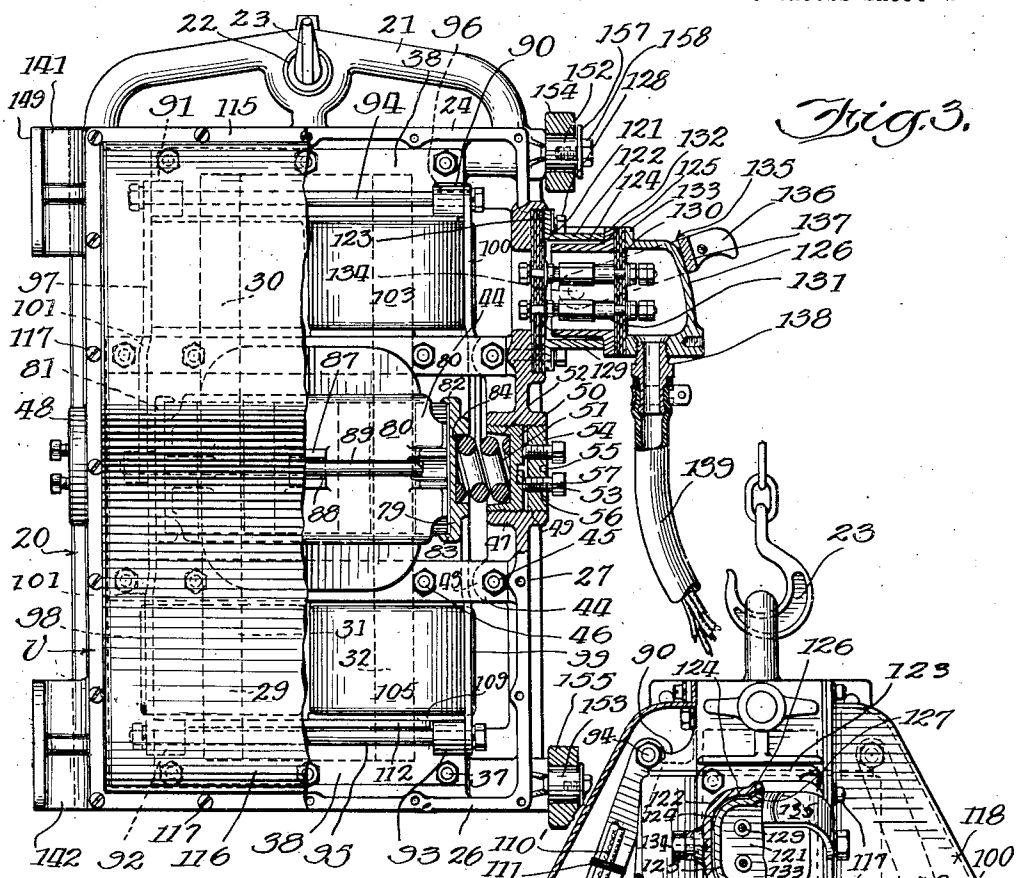


Fig. 3.

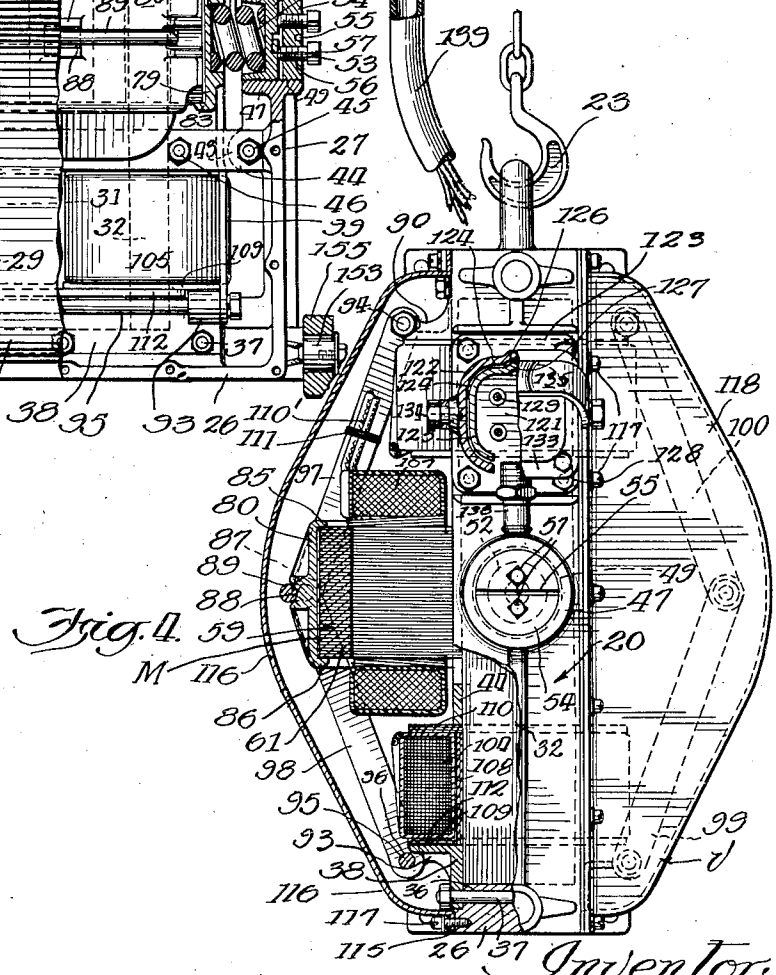


Fig. 4.

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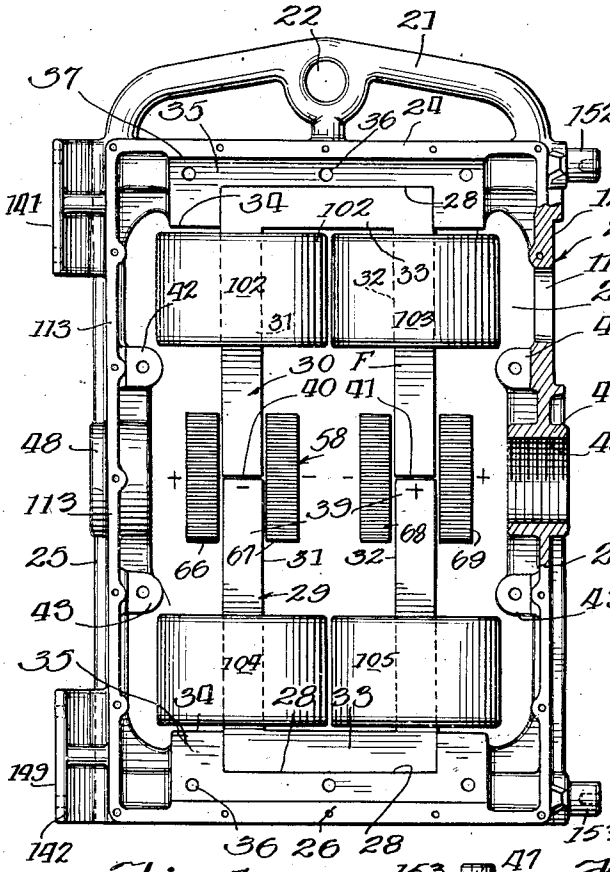


Fig. 5.

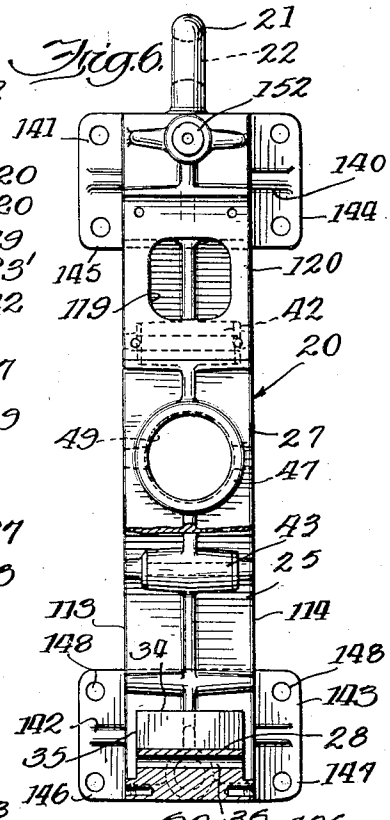


Fig. 6.

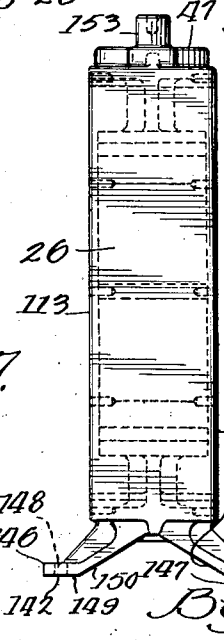


Fig. 7.

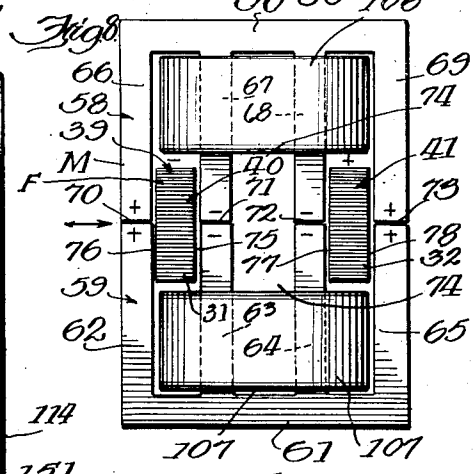


Fig. 8.

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Fig. 9.

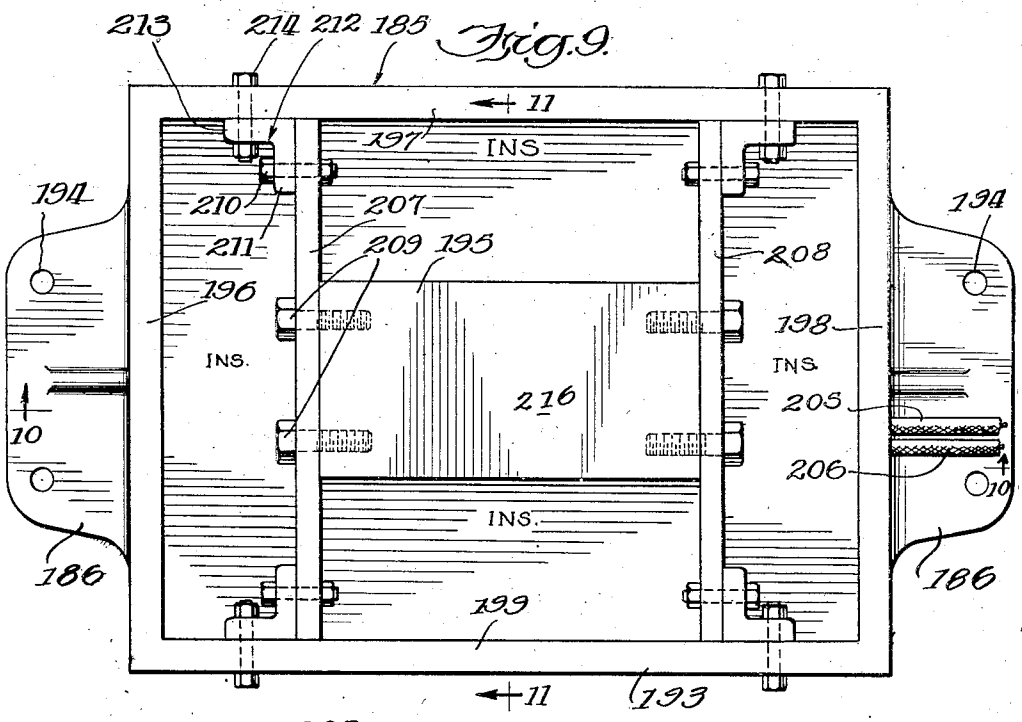


Fig. 10.

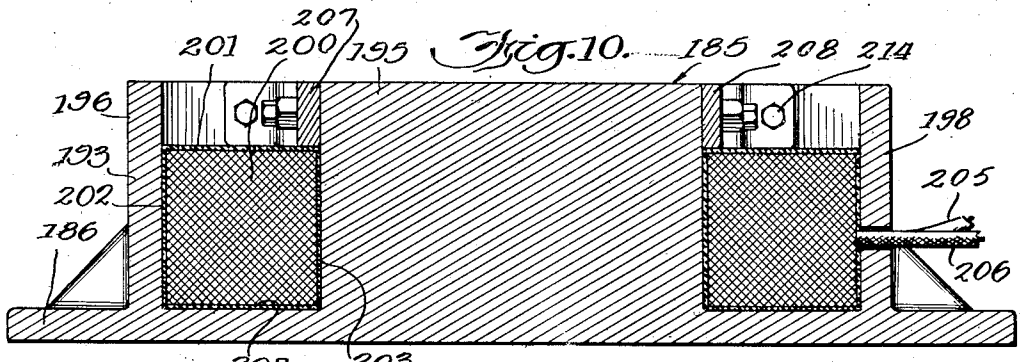


Fig. 11.

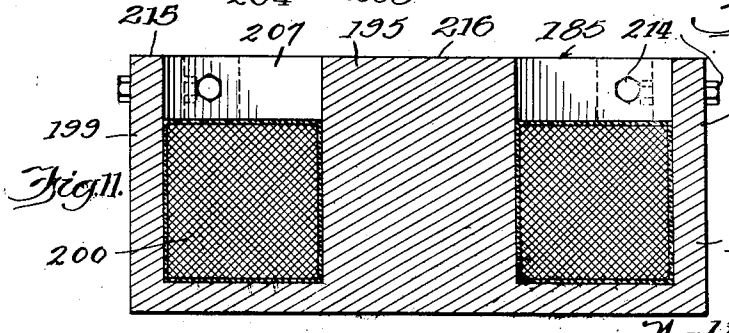
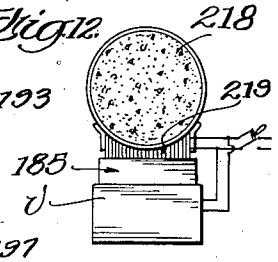


Fig. 12.



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Fig. 13.

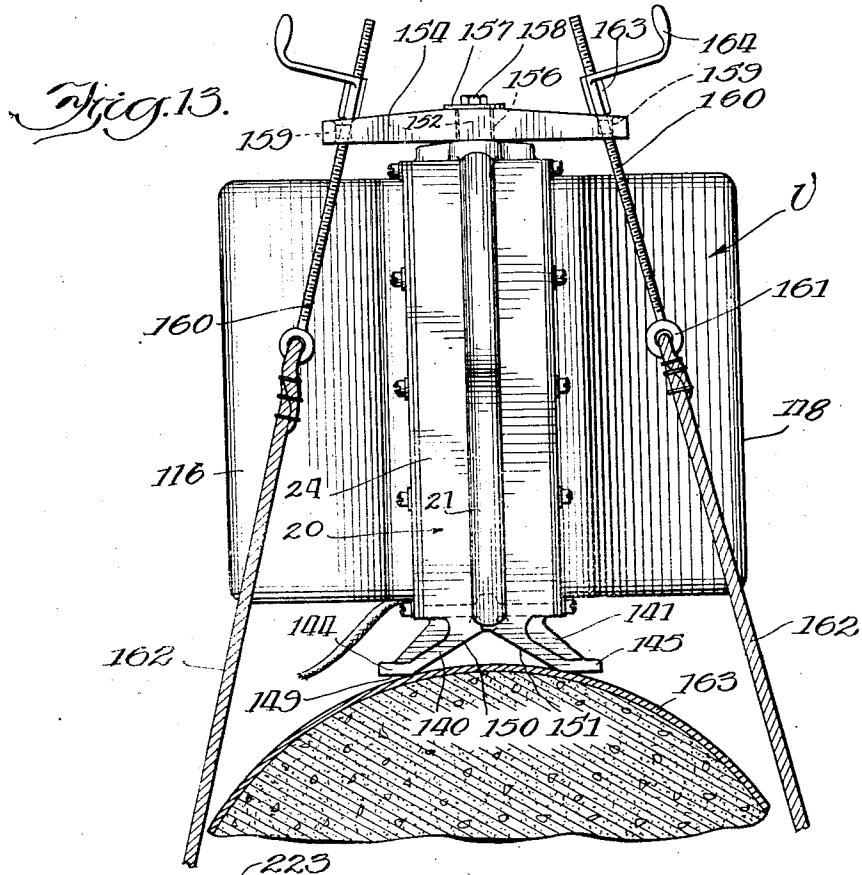
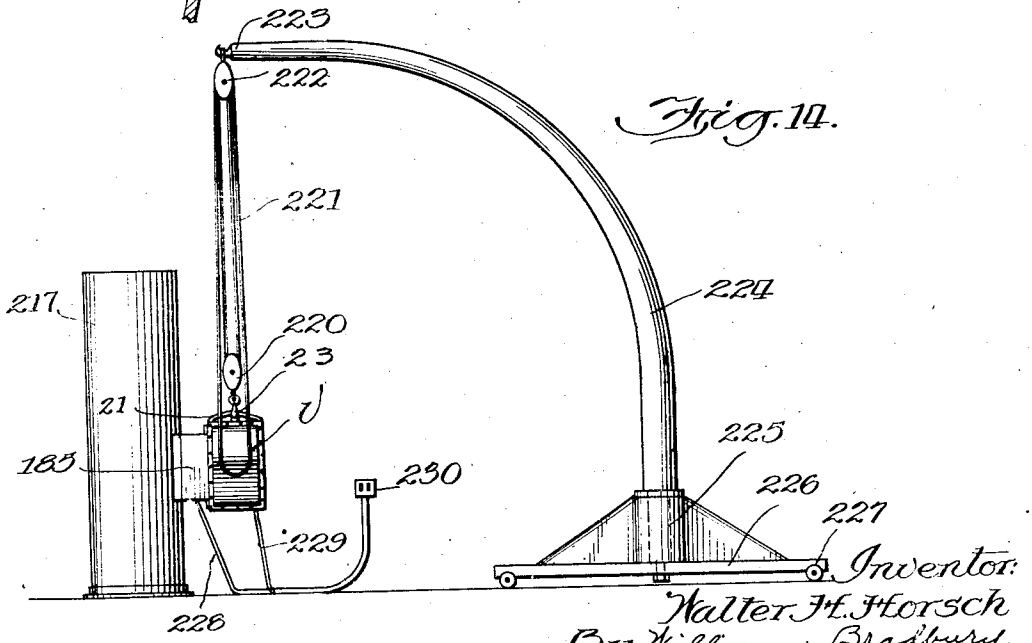


Fig. 14.



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Patented Mar. 3, 1936 2,032,934

UNITED STATES PATENT OFFICE

2,032,934

ELECTRIC VIBRATOR

Walter H. Horsch, Wheaton, Ill., assignor to Massey Concrete Products Corporation, Chicago, Ill., a corporation of Virginia

Application February 17, 1932, Serial No. 593,585

5 Claims. (Cl. 25—41)

The present invention relates to vibrators, and is particularly concerned with electric vibrators adapted to produce high frequency mechanical vibrations for industrial purposes. The present vibrators may be used for high frequency vibration of concrete, sand screens, clay molds, molds for casting metal, and all kinds of molding or casting operations, and I do not wish to limit myself to any particular use for the present vibrators.

One of the objects of the invention is the provision of an improved electrical vibrator of the type disclosed in my prior application, Serial No. 428,995, filed February 17, 1930.

Another object of the invention is the provision of an improved commercial form of a vibrator of the class described, which is adapted to be manufactured economically, which is sturdy, efficient and capable of use for a long period of time without necessity for repair.

Another object of the invention is the provision of an improved device for securing the vibrator to the objects sought to be vibrated so that the vibrator may be attached more quickly, with less labor and less expenditure of time.

Another object of the invention is the provision of an improved electromagnetic holding device for securing an electric vibrator to a concrete form or other object intended to be vibrated by the vibrator, by means of which the vibrator can be attached to the form without the necessity for any chains or other securing devices.

Another object of the invention is the provision of an improved assembly, by means of which an electric vibrator and electromagnetic securing device are so arranged that when the current is turned on the electric vibrator is drawn over against the concrete form or other article and automatically secured in proper position for vibration of the form.

Another object of the invention is the provision of an improved hydraulic installation by means of which a mechanical vibrator may be brought into proper position to vibrate any of a succession of concrete forms preferably mounted on carriages.

Another object of the invention is the provision of an improved electric vibrator of the class described having an improved magnetic field construction, by means of which more efficient action is secured.

Other objects, features and advantages of the invention will be apparent from the following description and from the drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the drawings, of which there are five sheets:

Fig. 1 is a vertical sectional view of a complete installation employing a hydraulic piston and an electric vibrator carried by the piston and adapted to be brought into proper position by the hydraulic piston;

Fig. 2 is a similar view of another modification employing an electromagnetic lifting device for securing the electric vibrator to the article to be vibrated;

Fig. 3 is a side elevational view in partial section showing the specific construction of an improved electric vibrator constructed according to the present invention;

Fig. 4 is another side elevational view in partial section taken from the right of Fig. 3 showing the same vibrator;

Fig. 5 is an elevational view of a vibrator frame, the magnetic structure in partial section showing the coils in elevation;

Fig. 6 is a side elevational view of the frame of Fig. 5 taken from the right;

Fig. 7 is a top plan view of the frame of Fig. 5 with the transverse electromagnetic field structure removed;

Fig. 8 is a plan view of the electromagnetic field structure which is used in the vibrator of Figs. 3 to 7;

Fig. 9 is a plan view of the face of a magnetic lifting or securing device for securing the vibrator of the previous figures on a concrete form or the like;

Fig. 10 is a sectional view of the magnetic securing device of Fig. 9 taken on the plane of the line 10—10 of Fig. 9;

Fig. 11 is a sectional view of the same securing device taken on the plane of the line 11—11 of Fig. 9;

Fig. 12 is a diagrammatic view of another form of installation, in which the concrete pipe form is provided with another electromagnetic vibrator.

Fig. 12A is a fragmentary diagrammatic view of a modification.

Fig. 13 is a plan view with the form in section showing one mode of attachment of the improved vibrator to a form; and

Fig. 14 is a diagrammatic view of another form of installation showing a crane for lifting the vibrator with its electromagnetic securing device and bringing it into juxtaposition with the form

so that the electromagnetic securing device can draw the vibrator into engagement with the form.

Referring to Figs. 5 to 8, the vibrators constructed according to the present invention are provided with a supporting frame **20**, which is adapted to provide a support for the parts of the vibrator and its casing and also provided with means for securing the vibrator on the form and for permitting the lifting of the vibrator to move it from place to place.

The frame **20** preferably comprises a substantially rectangular cast metal member which is provided with a lifting yoke **21** at one end having an aperture **22** for receiving the hook **23** of any form of lifting device, such as a block and tackle or a crane. The frame **20** is provided with a centrally located opening **23'** surrounded by the four sides **24—27** of the frame in such manner that the fixed and movable elements of the vibrator may be carried by the frame and located inside the opening **23** of the frame. The bottom and top **24, 26** of the frame **20** are each preferably formed with a recess or socket **28** located on the inside of the frame members **24, 26** and adapted to receive the fixed core members **29, 30** which are preferably of substantially U shape.

The U shaped core members **29** and **30** are each provided with a pair of parallel legs **31, 32**, joined by a yoke **33** and the yoke **33** is adapted to fit in the socket **28**. The U shaped core members **29** and **30** are preferably formed of a multiplicity of relatively thin soft iron laminations, each of U shape, and sufficient laminations are provided so that the thickness of the pile of laminations in each case is substantially the same or slightly greater than the thickness of the inwardly extending portion **34** of the end frame members **24** and **26**.

The inwardly projecting formations or lugs **34** are provided with upper and lower flat surfaces **35**, and they are provided with a plurality of apertures **36** for receiving bolts **37**. Metal plates **38** are placed on top of the laminations and below the laminations and secured to the lugs **34** by the bolts **37**, the same bolts serving to clamp the laminations **39** together to form the U shaped cores **29** and **30**.

The ends of the legs **31** and **32** abut against each other at **40, 41**, forming a closed, and substantially rectangular fixed magnetic core. It should be understood that the term fixed is employed with respect to the frame **20** but, as a matter of fact, the cores **29** and **30** are also in vibration when the vibrator is in operation, and either one of the magnetic structures may be termed the field and the other the armature, since each reacts against the other one, and both may be energized or polarized.

The side frame members **25** and **27** are preferably formed with inwardly extending lugs **42, 43** located above and below the coils carried by the legs **31, 32** for the purpose of supporting the transverse metal straps **44** which retain the coils in fixed relation with respect to the fixed cores **29, 30**. The straps **44** are secured in place by bolts **45** passing through lugs **42, 43**, and additional bolts **46** serve to clamp the straps **44** against the laminations of the cores **29, 30**.

The side frame members **25, 27** are also provided with substantially tubular horizontally extending formations **47, 48**, each provided with a threaded bore **49** and adapted to receive a socket plug **50** for supporting a spring **51** (Fig. 3). The socket plug **50** comprises a substantially cylindrical member provided with outer threads complementary to the threads of the bore **49**, and it is also formed with a substantially cylindrical socket **52** of sufficient size to form a seat for retaining the spring **51** in proper position. The plug **50** is provided with a kerf **53** for receiving a screw driver in adjusting the plug and a locking plug **54** is also preferably provided for assuring the permanent adjustment of the springs, the purpose of which will be described in greater detail hereinafter.

The locking plug **54** comprises a substantially cylindrical metal member threaded to engage the threads of bore **49**, and it may also be provided with a kerf **55**. The locking plug is preferably provided with one or more threaded bores **56** for receiving locking bolts **57**, which are threaded into the bores **56** into engagement with the socket plug **50**. When the bolts **57** are driven home the plug **50** is very positively secured in its predetermined adjusted position.

Referring to Fig. 8, the movable magnetic structure preferably comprises a pair of cores **58, 59**, each having a yoke **60, 61** and a plurality of inwardly extending parallel legs **62—69**. The ends of the legs **62—69** abut against each other at **70—73**. The legs of the two cores **58, 59** may be maintained in alignment with each other and in fixed relation to each other by the clamping members **79** which engage the legs **62, 66, 69** and **65**. In effect the cores **58, 59** are substantially E shaped cores with the central leg separated by the slots or spaces **74**.

The space **74** is provided for the purpose of preventing the short circuiting of the magnetic flux from one pole of the cores **58, 59** to another pole and assuring the direction of the flux into more useful channels, as will be described in detail later on.

The legs **68** and **69, 64** and **65, 62** and **63, 66** and **67** are spaced from each other a distance sufficient to receive the legs **31, 32** of the cores **29, 30**, leaving an air gap **75, 76, 77, 78** at each side of the fixed core **29, 30** to permit the movement of the movable core **58, 59** during the vibration of the device. The relative position of the cores and the size of the air gaps **75—78** may be adjusted by means of the adjustable plugs **50** with the springs **51** and the threading of the plugs to the left or the right in the frame **20** determines the position of the springs **51**, and consequently the position of the movable core **58, 59** which is supported by the springs.

The cores **58, 59** are also preferably formed of a multiplicity of relatively thin soft iron stampings or laminations, as shown in Figs. 4 and 5, and the laminations may be secured together by a plurality of clamping members **79, 80, 81** shown in Figs. 3 and 4. The side clamping members **79** may comprise substantially rectangular cast metal members having inwardly extending lugs or flanges **82, 83** for engaging above and below the laminations of the E shaped cores **58, 59**. The laminations may also be secured together by rivets or other convenient fastening means, but they are also preferably clamped by the flanges **82, 83** which extend parallel to the top and the bottom of the laminations of cores **58, 59**.

The clamping members **79** are also provided with substantially cylindrical sockets **84** extending outward and located in registration with the socket **52** in the plug **50**. Socket **84** is adapted to receive the other end of the spring **51**, one spring being provided on each side of the

vibrator. The compression of the springs 51 retains the clamping members 79 on the cores 58, 59, the two springs reacting against each other to urge the other clamping members into engagement with the cores.

The springs 51 are preferably relatively heavy springs, and these springs are preferably sufficiently short and heavy so that the movement of the armature in either direction is stopped by the spring before the armature comes into contact with the fixed core 29, 30. In other words, if a relatively light spring is used, the armature may be resiliently supported for movement with respect to the fixed core, and vibration will result, but the armature may impact with the core.

The force with which a spring of this type resists the movement of the movable core increases with the displacement of the core, and this increase in the resistive force is greater in a relatively thick and short spring than it is in a light and long spring.

The force exerted by the spring may be adjusted by means of the plug 50, and if the springs 51 are of the proper characteristics, the springs may be so adjusted that they not only tend to retain the movable core midway between the elements of the fixed core, but the spring absorbs the force of the armature in a predetermined direction and tends to return the armature before the armature comes into actual impact with the fixed core.

In some embodiments of the invention the mechanical characteristics of the masses of the fixed core and the movable core and the mechanical characteristics of the springs may be such that the vibrator is adapted to vibrate at the natural frequency of the energizing current, which may be any of the standard frequencies employed for alternating current. Thus, if 25 cycle current is employed, the natural or resonant frequency of the mechanical vibrator would be 25 cycles per second, or if 60 cycle current were employed, the natural frequency of the mechanical vibrating system might be made 60 cycles per second, or any multiple thereof, depending upon the mode of use of the alternating current and construction of the vibrator.

I prefer to make the characteristics of the springs such that the natural or resonant frequency of the mechanical system is slightly below the frequency of the current, such as 40 or 50 cycles per second for a 60 cycle current, in order that the springs may tend to return the movable core from any position of maximum displacement before the core reaches said position. This prevents the movable core from impacting the fixed core because the springs are compressed more quickly to the point where they resist the movement of the movable core with a force greater than the force exerted on the core.

In some embodiments of the invention the masses and resiliency of the articles or concrete sought to be vibrated, may be taken into consideration in determining the proper mechanical frequency for the vibrator to secure the most efficient results, and either resonant mechanical frequencies may be employed or forced vibrations may be induced.

The movable cores 58, 59 are also preferably provided with some form of support outside the yokes 60, 61 for maintaining them in proper predetermined position transverse to the yokes 29 and 30. For this purpose the yokes 60 and 61 have their laminations engaged by the clamping members 80, which may be identical in form. Clamping member 80 may consist of a cast metal member or plate having a flat surface for engaging the edges of the laminations and having inwardly extending flanges 85, 86 engaging above and below the yoke 61. The clamping member 80 is also provided with a plurality of outwardly projecting lugs 87 formed with a transverse semicircular groove 88 for receiving the rod 89. The lugs 87 may be located at each end of the clamping member 80, and in the middle of the same, and the rod 89 extends transversely of the clamping member substantially parallel to the yoke 61 for supporting this end of the core 62.

The plate 38 is also provided with outwardly projecting lugs 90—93 located approximately in the four corners of the opening 23 of the frame for receiving the rods 94, 95. Both sides and all four corners of the vibrator may be identical in construction, and therefore only one side or corner will be described in detail. Each of the lugs 90 is provided with a transverse bore 96 extending substantially parallel to the plane of the frame and adapted to receive a rod 94 or 95. The rods 94—95 provide pivots for the securement of resilient metal straps 97—100 for supporting the rod 89 on the frame. Each of the resilient metal straps 97—100 may be identical in shape, and each is provided with an aperture at one end for receiving the rod 94 and an aperture at the other end for receiving the rod 89.

The straps 97—100 may also be provided with offsets 101 to increase the resiliency of the straps and since the straps extend upward and downward from the rod 89 to the frame 20, it will be evident that they are adapted to hold the clamping member 80 in engagement with the outer surface of yoke 61. A similar arrangement engages the outer surface of yoke 60, and the movable core, which may be designated by the letter E and which comprises parts 58—59, is thereby supported for movement in a horizontal plane in Fig. 3 in the direction of the arrows in Fig. 8. The amount of play in the pivotal joints is sufficient to permit lateral movement of the core, even though the linkage is such as to constitute a substantially closed linkage, for the reason that the amount of movement of the movable core is very small. The movable core M is thus prevented from tilting about the axis of the springs 51 and it is only permitted to move back and forth along the axis of the springs 51.

The fixed core F, which comprises the U-shaped members 29 and 30 of Fig. 5, is preferably provided with windings 102—105 located on each of the legs of the fixed core F above and below the movable core M. The windings 102—105 may be connected in series or parallel, but their connection and the direction of winding is such that the flux induced by the winding 102 opposes that of the winding 104, and that induced by winding 103 opposes that of winding 105. Thus the windings may tend to produce a negative pole at the point 40, as indicated by the minus sign, and a positive pole at the point 41, as indicated by the plus sign. The two legs 67 and 68 of the movable core M are preferably embraced by a winding 106, and the two legs 63, 64 embraced by a winding 107.

The windings 106 and 107 may be connected in parallel or series and energized from the same source, but the connection and direction of winding is preferably such that they tend to produce flux in opposite directions and thereby cause the formation of a magnetic pole at the points 71, 72. These poles will naturally be of the same polarity and may be negative at any particular instant,

as indicated by the minus signs in Fig. 8. The windings 106—107 are preferably energized from a source of alternating current, and consequently the polarity of the pole pieces 71, 72 will be periodically changing at the same frequency as the frequency of the source of current. When the poles 71, 72 are negative, the poles 70, 73 will naturally be positive, since the magnetic circuit is completed by the outer legs of the core M. Supposing the polarity to be as indicated in Figs. 5 and 8 at any given instant, this would result in an attraction between the poles 70 and 40 and poles 72 and 41, since they are opposite in sign, while a repulsion would take place between poles 40 and 71 as well as poles 73 and 41.

It will be evident that if the fixed core F is polarized as shown by a source of direct current, and alternating current is applied to the windings of the movable core M, the movable core will be caused to vibrate back and forth periodically in the direction of the arrows of Fig. 8, and the extent of this movement will be limited by the clearance provided by the action of the springs 51. If desired, in some embodiment of the invention, the cores may be provided with resilient bumpers, or they may be permitted to impact against each other, but one of the objects of the invention is the provision of a device which will produce mechanical vibration with a minimum amount of noise and wear on the parts of the vibrator, and consequently the springs are so proportioned and adjusted that they prevent impact.

The windings of the vibrator may be energized according to any of the systems disclosed in my prior application, Serial No. 428,995, filed February 17, 1930, for Method and apparatus for treatment of concrete and the like, and the present application is a continuation in part of said prior application.

The windings on the fixed and movable cores are preferably fixedly secured in place and insulated from the cores by fiber plates 108, 109, 110 (Fig. 4). The windings are wrapped with insulating tape, and the connections are taped to the parts of the vibrator to prevent wear on the leads. Thus the leads 110' are taped or wrapped at 111 to secure them to the metal strap 97. The transverse straps 44 effectively block the windings 102—105 in fixed relation with respect to the fixed core F by engaging the fiber plates 110. Plate 38 may be formed with an outwardly extending flange 112 for engaging the fiber plate 109 below the winding 104.

The windings on the movable core M may likewise be secured in place and suitably insulated, and the respective windings may be grounded to the frame at their mid-points between two coils. This provides a balanced construction in which a short circuit on one winding merely results in the disablement of half of the windings, and there is less danger of burning out of the entire windings.

The frame 20 is preferably formed with a substantially flat surface 113, 114 on each side bordering the entire frame for receiving a complementary flat attaching flange 115 carried by a sheet metal cover 116. The cover 116 may be stamped out of sheet metal to substantially the shape shown in Fig. 4 to enclose and protect the mechanism of the vibrator, and it may be secured to the frame by a plurality of screw bolts 117. A similar cover 118 upon the other side of the frame 20 completes the casing.

The frame 20 is also preferably provided with an aperture 119 at one side, leading to a depressed socket 120 formed in the outer surface of the frame and adapted to receive the laminated fiber plates 121. A socket fitting 122 may be formed of cast metal and provided with outwardly projecting attaching flanges 123 and with a socket 124 for receiving the complementary socket fitting 125.

Referring to Fig. 4, it will be noted that the socket 124 is substantially rectangular in shape but is provided with a groove 126 for receiving the pointed formation 127 on the complementary fitting 125, so that the plug 125 can only be inserted in one position, and the fiber plates 121 may be secured to the frame by means of screw bolts 128, and the fiber plate 121 may carry a plurality of male contact prongs 129. The connection plug comprises a fiber support consisting of a plurality of plates of insulating fiber 130 which carry a plurality of female contacts 131 for engaging the male contacts 129. In the present case, where a direct current and alternating current are preferably employed, four contacts would be necessary in each fitting. The fiber support 130 may be clamped between the attaching flanges 132, 133 of the fitting 125 and the outer casing 126. The fitting 122 pivotally supports at 134 a latching stirrup 135 substantially U shaped, having a handle 136 and a yoke 137 for engaging a casing 126. The outer surface of the casing 126 slopes downward and outward so that the yoke 137 may come into wedging engagement with it and fixedly secure the connector in place so that there is no possibility of the connector being dislodged by the vibration.

The contact prongs 129 and connectors 131 are, of course, provided with appropriate leads extending in the first place to the coils and in the second place out the tubular fitting 138 into the rubber covered cable 139 leading to the source of supply.

The frame 20 is preferably provided with the laterally projecting legs 140—143 terminating in attaching flanges or feet 144—147, which are provided with apertures 148. The feet 144 may be provided with a substantially flat lower surface 149 for use in engaging a flat form and the legs 140, 141 and 142, 143 may be separated by the angular surfaces 150, 151. The angular surfaces 150, 151 are adapted to engage the curved parts of a curved form when it is desired to secure the vibrator to the form in some manner similar to that shown in Fig. 13.

The vibrator, which is indicated in its entirety by the letter V, is preferably provided with the rearwardly extending cylindrical lugs 152, 153 carried by the side 27 of the frame and the lugs 152, 153 pivotally support the bars 154, 155. The bars 154, 155 are provided with cylindrical bores 156 for receiving the lugs 152 upon which they are retained, by washer 157 and screw bolt 158. At each end of the bars 154 there is provided an enlarged aperture 159 for receiving an eye-bolt 160, the eye 161 of which may be secured to cable 162.

A turnbuckle 163, provided with a crank 164, engages the outside of bar 154 and enables the cable 162 to be drawn tight at both ends, the cable 162 extending about the cylindrical pipe form 163. The vibrator may thus be fixedly secured on the pipe form 163 or on any other form adapted to be embraced by the cable 162. Two cables are preferably employed, one at the bottom and one at the top of the vibrator.

Referring to Fig. 1, this is an improved vibrator installation in which the vibrator V is adapted to

be brought into engagement with a number of different objects or forms to be vibrated, successively, and the form F is preferably supported upon a truck or carriage 164.

The truck 164 may be of any suitable construction such as wood, but is preferably made of metal, and is provided with brackets 165 having guides 166 for slidably supporting the bearings 167 of the truck wheels 168. The bearings 167 may be of substantially H shape, looking from the top, being retained in the guides 166 by end plate 169, and the bearings 167 are resiliently engaged by the helical coil spring 170, which is seated in a socket in the end of guide 166.

Any suitable form of truck may be utilized, but it is preferable to use a flanged wheel truck mounted upon tracks 171 so as to bring the truck into a predetermined position over the vibrator V. In order to enable the truck axles 172 to clear the vibrator V without moving the vibrator so far as would otherwise be necessary, the platform of truck 164 is provided with an inverted table consisting of a plate 173 which is supported on the lower side of the truck by a plurality of legs 174, the legs being riveted to the truck and plate. The vibrator V is adapted to engage the lower surface of plate 173 and lift the truck 164 and form F until the major portion of the weight or all of the weight is taken off the wheels 168, after which the operation of the vibrator will effectively place the truck 164, form F, and the concrete in the form in a state of vibration.

With a vibrator of the type shown in Figs. 2 and 3, the truck, form and concrete would be vibrated by virtue of the inertia effect of the movable core M, but in some embodiments of the invention the movable core M may be directly connected to the plate 173 so that direct mechanical impulses are transmitted to the truck, form and concrete, the frame of the vibrator reacting against its support.

In order to movably support the vibrator V in position to be brought into engagement with successive trucks, it is preferably mounted on a tubular piston 175, which is mounted for reciprocation in a cylinder 176. The cylinder 176 comprises a closed tubular member mounted in a cast fitting 177, which is provided with a packing 178 and a gland 179 for compressing the packing.

The pipe 180, which communicates with cylinder 176, leads to a source of supply of hydraulic fluid, such as oil or water, through the pipe 181 and control valve 182, but in some embodiments of the invention a source of compressed air may be used. The pipe 183 communicates with pipe 180 below valve 182, and is provided with a release valve 184. When the valve 184 is closed and the valve 182 is turned on, the piston 175 is urged upward by the pressure in cylinder 176, and the vibrator V is brought into engagement with the plate 173 of the truck. The valve 182 may be closed when the vibrator has reached the proper position, and the vibrator may be turned on and the concrete subjected to high frequency vibration to improve its characteristics and cause it to flow into place in the form.

Many other articles may be subjected to vibration besides the concrete, which has been selected to illustrate the invention.

When the valve 182 is closed, the vibrator V will be maintained in fixed elevated position, but when the valve 184 is open the pressure will be released through pipe 183 and the vibrator will be permitted to drop below the level of the axles 172 so that the truck may be moved away, and a new truck with another form may be brought into proper position. A suitable stop may be provided for the truck 164 so that when it is moved into engagement with the stop it is located with its plate 173 in predetermined position under the truck, and if one vibrator is utilized it is preferably symmetrically located with respect to the contents of the form, but any number of vibrators may be utilized and operated synchronously, as described in my other applications.

Referring to Fig. 2, this is another diagrammatic illustration of the same truck which is employed with another illustration in which the vibrator V is adapted to be attached to the truck 164 by means of an electromagnetic securing device 185. In such case the metal plate 173 may act as an armature and the electromagnetic securing device is provided with attaching flanges 186 fixedly secured to the fitting 144 of the vibrator by means of bolts or other securing devices. The vibrator V is then preferably located in a concrete pit 187, the vibrator resting upon rails or bars 188 which engage the flat bottom 189 of the pit 187. The location of the vibrator is such that when the electromagnetic securing device 185 is energized the armature 173 is within the range of action of the electromagnet 185, and the vibrator V is drawn up into engagement with the plate 173 and held in place while the vibrator is operated.

It will be evident that the present system, using an electromagnetic securing device, eliminates much of the labor of securing the vibrator upon successive forms, such as would be entailed by the structure of Fig. 13, and the mere closing of the circuit of the electromagnet causes the vibrator to move into securement with the truck or the form. The vibrator V and electromagnet 185 may be energized through the conductors 190, 191, each including a plurality of appropriate leads extending to one or more control switches 192. The control switches may be provided with a single actuating member whereby both the vibrator and electromagnet may be turned on at the same time, although they are energized by different forms of current.

Referring to Fig. 12A, this is another modification, in which the truck is provided with a centrally located opening 231 so that the vibrator may be brought into direct engagement with the form itself without vibrating the truck, except such vibration as is effected incidentally. Either type of securing device may be utilized, and the spider-like frame may be secured to a plate 232 which may consist of the bottom of the form, or which may consist of an extra plate loosely placed upon the top of the truck. The vibration is more effectively transmitted to the form and concrete by this direct mode of attachment.

Referring to Figs. 9 to 11, these are detailed views of the electromagnetic securing device, which may be indicated in its entirety by the numeral 185. The electromagnet preferably comprises a metal casing 193 which may be circular or oval in plan, but which is preferably substantially rectangular in shape, and which is provided with the attaching flanges 186 having apertures 194. The casing 193 is provided with a centrally located pole piece 195, which may be substantially rectangular in plan and which forms one of the poles of the magnet. The outer walls 196—199 form the other pole of the magnet and also enclose the coils 200 and prevent leakage. The space between the central pole 195 and the walls 196—199 may be filled by the energizing

coils 200, which are suitably insulated from the metal of the electromagnet by means of fiber plates 201—204. The leads 205, 206 from the coils 200 may be brought out through the same connector 129, 131, which is used for the vibrator, or the leads may be brought out through any suitable form of protecting cable.

The windings 200 are preferably secured in place by the transverse bars 207, 208 of non-magnetic metal, such as brass, or in some cases magnetic metal may be utilized, such as steel, provided the bars are so small that they will be saturated and only short circuit a small portion of the flux. The bars 207, 208 are forced down against the windings and located adjacent the side of the pole 195 to which they are secured by screw bolts 209 passing through the bars and threaded into the pole 195. The ends of the bars 207, 208 may be secured by bolts 210 to the flanges 211 of angle brackets 212, having their other flanges 213 secured to the walls 197, 199 by bolts 214.

The surfaces 215, 216 of the walls and central pole piece of the electromagnet may be made substantially flat when the magnet is intended to engage a flat plate 173 which acts as the armature, but when the electromagnet is intended to be used with curved pipe forms such as the form 217 of Fig. 14, the face of the electromagnetic securing device 185 may have its surfaces 214—216 complementarily curved to the pipe 217.

Where the electromagnet is intended to come into direct engagement with a metal pipe form or some other form which cannot be conveniently constructed of laminated metal, the electromagnet is preferably energized from a source of direct current for the reason that the use of alternating current would unduly heat the form on account of the eddy currents induced in the form.

In some embodiments of the invention, such as Fig. 12, the pipe form 218 may have permanently secured to it a laminated armature 219 which is adapted to be engaged by the electromagnet 185 and utilized for the armature of the electromagnet. In such case, the laminations of the armature 219 preferably extend substantially radially with respect to the center of the pole piece 195 in such a manner as to permit the passage of flux from the inner pole 195 to the outer wall most readily, but economical construction may dictate a change from the purely radial lamination in constructing a laminated armature for the magnet 185.

Where such laminated armature is provided on the form the electromagnet may be energized by alternating current, and the connections and control of the electromagnet and vibrator are greatly simplified by such an arrangement, since both the magnet and vibrator may be controlled by a single switch.

Referring to Fig. 14, this is a modified form of installation in which the vibrator V is provided with an electromagnetic securing device 185 having a cylindrically formed pole piece for engaging the pipe form 217. The vibrator is supported by means of a hook 23 which is carried by the lower pulley 220 of the hoisting tackle 221, the upper pulley 222 being carried by the end 223 of a crane 224. The arm of the crane 224 is rotatably mounted in a bearing 225 of a base 226 which is mounted upon casters or wheels 227, the weight of the base being sufficient to support the vibrator in the position of Fig. 14. The electromagnet 185 may be energized by direct current through leads 228, and the vibrator V may be energized through leads 229 which are controlled by switches 230 interposed between the devices and the source of supply.

It will thus be observed that I have invented an improved electric vibrator which is adapted to be utilized for producing high frequency mechanical vibrations in concrete or any other subject to which it may be desirable to apply vibration. The present vibrator is capable of applying a larger amount of power, the vibrations are direct mechanical impulses in a predetermined direction, and this power may be applied most efficiently and with a minimum amount of noise.

The vibrator is capable of being applied to various kinds of forms and capable of being easily manipulated, and the installation may be so arranged that the vibrator is automatically attached to the subject-matter by an electromagnetic securing device, thereby eliminating the necessity for fastening ropes, cables, chains or the like. The vibrator may also be moved into predetermined position by mechanical appliances such as a hydraulic piston or a crane, so that a number of objects may be vibrated successively with a minimum amount of labor.

The electromagnetic securing device may be actuated by the same switch which closes the circuit of the vibrator so that the vibrator is simultaneously secured and energized and the concrete form or other object immediately subjected to vibrations.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim is new and desire to secure by Letters Patent of the United States, is:

1. In an apparatus for vibrating concrete or the like, the combination of a form with an electric vibrator adapted to produce vibrations of predetermined frequency, an electromagnetic securing device carried by said vibrator, and an armature for said securing device carried by said form whereby said vibrator is automatically secured to said form when said securing device is energized and the vibrator is brought into sufficient proximity with said armature.

2. In an apparatus for vibrating concrete or the like, the combination of a supporting base with a movable crane arm carried by said base and electric vibrator means carried by said crane arm and attached to said vibrator for supporting said vibrator, a magnetic securing device carried by said vibrator, and a metal form adapted to be engaged by said magnetic securing device when the latter is energized to hold the vibrator on the form.

3. In an apparatus for vibrating concrete, the combination of a form having a metal part with an electromagnetic securing device adapted to be secured to said metal part when said securing device is energized, a vibrator carried by said securing device, and means for simultaneously energizing said vibrator and securing device to effect a vibration of said form.

4. In an electric vibrating apparatus, the combination of a high frequency electric vibrator having a moving body adapted by virtue of its

inertia to induce vibrations in a member to which the vibrator is secured, with a member to be vibrated, said member having a paramagnetic part serving as an armature, and electro-magnetic means for securing said vibrator to said armature comprising an electro-magnet carried by the vibrator, whereby the vibrator is fixedly secured to the member to be vibrated when the electro-magnet is energized and brought into sufficient proximity to the armature.

5. In an apparatus for vibrating concrete, the combination of a form provided with a metallic part having paramagnetic qualities with an electromagnet adapted to utilize said metallic part as an armature, a vibrator carried by said electromagnet, means for energizing said vibrator electrically to vibrate the concrete, and means for energizing said electromagnet to secure said vibrator to said concrete form.

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