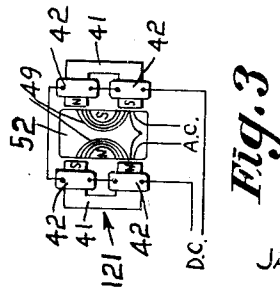
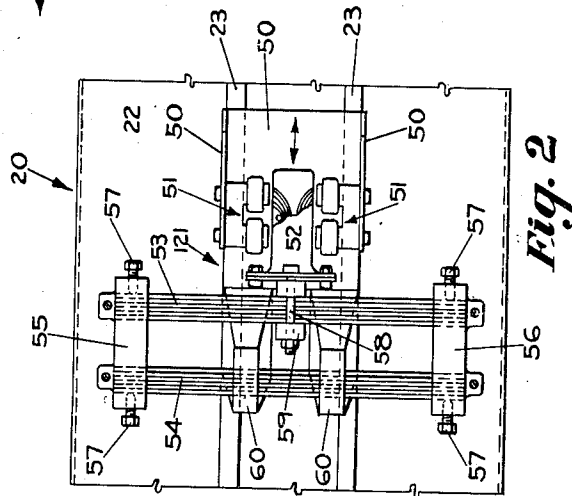
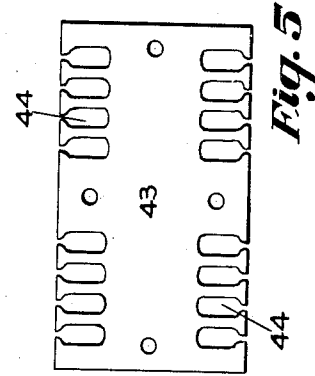
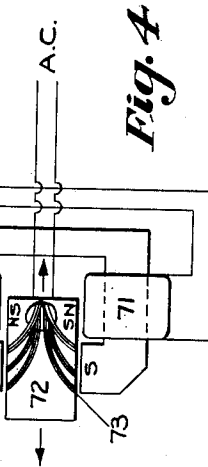
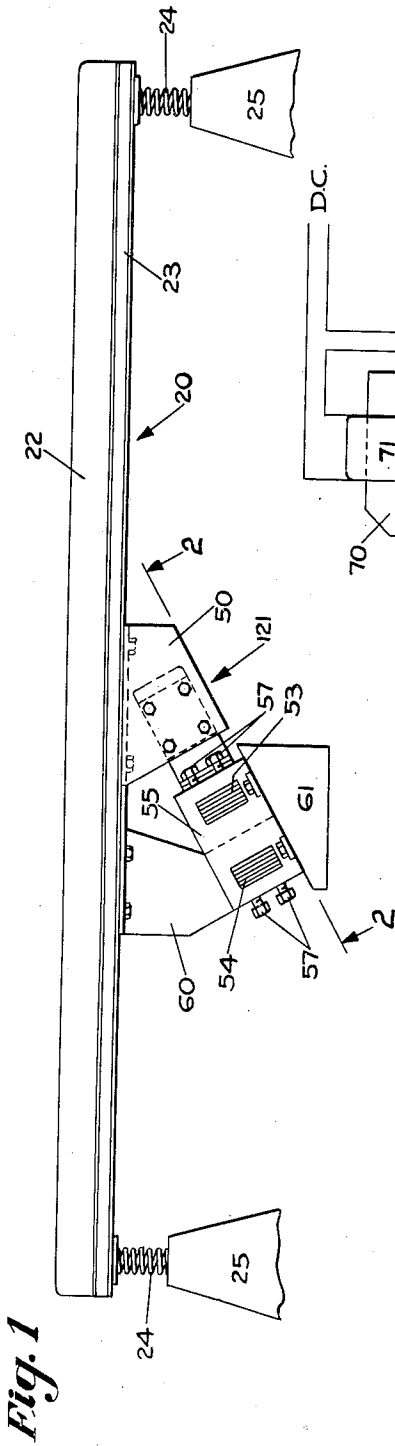


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J. R. LINDSAY
VIBRATING APPARATUS
Filed Nov. 1, 1941

2,481,131



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UNITED STATES PATENT OFFICE

2,481,131

VIBRATING APPARATUS

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3 Claims. (Cl. 198—220)

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This invention relates to vibratory apparatus and more specifically to a vibratory motor and still more specifically to a vibratory conveyor of the electromagnetic type.

An object of the invention is to provide apparatus of the above-mentioned type incorporating an improved vibratory motor of the indefinite stroke type.

A further object of the invention is to provide an improved vibratory electromagnetic motor preferably, but, in a broader aspect, not essentially of the indefinite stroke type and also preferably, but, not essentially in the broader aspects, of the reaction mass type in which the vibratory springs or bars of the motor are formed in two groups thereby to maintain them of overall length with increased maximum amplitude of vibration within the safe bending limits of the springs or bars and in which end clamps are provided which are substantially free of vibration and are fixed to a base.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Fig. 1 is a side elevational view of a conveyor and vibratory electromagnetic motor incorporating features of my invention;

Fig. 2 is a plan view taken on the line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 3 is a wiring diagram showing the preferred circuit employed;

Fig. 4 is a combination diagrammatic illustration and wiring diagram of the motors of Figs. 1 and 2, showing a modified form of motor, armature and winding therefor; and

Fig. 5 is an enlarged view showing the structure of one of the laminations of the armature in its preferred form as employed by the motors of Figs. 1 and 2.

Referring particularly to Figs. 1 and 2 of the drawings, I have illustrated a vibratory conveyor comprising a deck 20 adapted to be vibrated with a rectilinear vibratory motion having both a perpendicular and parallel component relative to the plane of said deck 20, by a vibratory electromagnetic motor 121. The deck 20 comprises a trough 22 having spaced upright sides and a substantially flat bottom and supported upon spaced channels 23, 23 which are rigidly attached to the trough 22, as by welding. In some of the broader aspects of my invention the deck 20 need not be formed as a trough but may take any desired shape and as one illustration may be a flat plate to support a barrel or other receptacle containing

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material to be packed by vibratory action. In such a case the motor 121 may only have a vertical and no horizontal component of movement with respect to the plane of the deck. Said deck 20 is resiliently supported as by a pair of spaced coil springs 24, 24 associated with and attached to the opposite ends of each of the channels 23 which coil springs 24 rest upon and are attached to any supporting structure such as spaced posts 25. As is well understood in the conveyor art, if vibratory motion is imparted to the deck 20, by forces the resultant of which preferably passes through the center of percussion, having a rectilinear type of movement with a component parallel to the plane surface of the deck and another component at right angles thereto, conveying action will be imparted to any granular material on said deck and, as illustrated in Figs. 1 and 2 of the drawings, the material will be conveyed from the left to the right.

The motor 121 is of improved construction and has for its function the imparting of rectilinear vibratory motion of the type above described to the deck 20. Said motor includes a U-shaped bracket 50 which is rigidly attached to the channel members of the deck 20, either by welding or by machine screws, and this bracket 50 supports spaced field cores and field coils which are indicated generally by the reference character 51 and which are described more completely hereinafter. An armature 52 is also provided which is described more in detail hereinafter. There are two sets of flat spring plates or bars seen at 53 and 54, respectively. Each of said sets of spring bars 53 and 54 has its ends clamped in rectangular openings in end clamps or brackets 55, 56 by appropriate set screws 57. A center clamp 58 attaches the armature 52 to the centers of the bars 53 and also supports an adjustable reaction weight 59. Intermediate their ends and generally adjacent the center thereof the bars 54 are rigidly clamped, as by set screws, to a pair of downwardly extending brackets 60 which are provided with rectangular windows or openings similar to those in the brackets 55 and 56. The brackets 60 are rigidly attached to the channel members 23, 23 of the deck 20 either by welding or by machine screws. The electric circuits for the motor 121 are described hereinafter.

From the above description it is evident that in the motor 121 the flexible connection between the deck 20 and the center clamp 58 extends from the bracket or what may be called a deck clamp 60 through a little less than half the length of the bars 54 and then by way of a rigid clamp 55 or 56

through substantially half of the length of the bars 53 to the center clamp 58. The armature 52 is formed by a plurality of stacked laminations 43 the detailed structure of which is shown in Fig. 5 of the drawings. These laminations are provided with spaced apart coil receiving slots 44 into which the armature coil is wound preferably as illustrated in Fig. 3 of the drawings. The stacked laminations 43 are clamped together by a plurality of through bolts which extend between spaced top and bottom plates. An armature winding 49 is wound on the laminations 43 and is covered by the top and bottom plates. The wires of said winding 49 extend into the slots 44 of said laminations 43 so that they do not project beyond the pole faces of said armature 52 adjacent the pole faces of the cores 41.

Referring again particularly to Fig. 2 of the drawings it will be seen that the spring bars or plates 53 are free to vibrate at their centers so as to permit the armature 52 to move along the faces of the U-shaped laminated cores 41 (see Fig. 3) of the two spaced field structures 51 and during this movement there is no variation from instant to instant in the air gap between said pole faces of said cores 41 and the laminations of armature 52, consequently the maximum stroke of the armature 52 is indefinite or indeterminate because regardless of what it is the laminations thereof will never strike the pole faces of said cores 41. This is sometimes called a constant air gap type of motor but in this specification I prefer to call it an indefinite stroke type motor because under certain conditions with certain modifications of the armature there is actually a variation in the effective air gap and so the expression "constant air gap" would not apply with strict accuracy to all conditions. The extreme importance of this indefinite stroke type of vibratory motor in connection with the other features of the vibratory motor which I employ will be pointed out hereafter but it is to be understood that in certain broader aspects of the invention the vibratory motor need not be of this indefinite stroke type.

Referring to Fig. 3 of the drawings showing the preferred wiring diagram of the motor it will be seen that the four coils 42 are preferably connected in series to a source of direct current and they are so poled as to give the polarities on the pole faces of the cores 41 which are indicated in said Fig. 3. The coils 49 on the armature 52 are connected in series and to a source of alternating current and the polarities indicated for the armature are of course only instantaneous. This provides what is known in the art as a push pull type or system. When both the field and armature coils are energized in this manner the frequency of vibration of the armature and of the deck 20 will be the same as the frequency of the alternating current supplied to said armature coils. For example, if the frequency of said alternating current is 60 cycles the deck will vibrate at 60 vibrations per second or at 3600 vibrations per minute. If the field coils 42 are de-energized or if they are left off entirely as they may be in a modified form of my invention the vibratory frequency of the armature 36 and deck 20 would be twice the frequency of the applied alternating current and in the illustration given would be 7200 vibrations per minute.

Another possible connection is to connect the stator and armature coils 42 and 49 in series and supply them with either rectified half wave

pulsations from an alternating current source or with mixed current in which case the armature will vibrate at the frequency of the alternating current source which in the illustration mentioned would be 3600 cycles per minute.

When the vibratory electromagnetic motor 121 is energized in any desired manner as above suggested there is brought into play two vibratory masses. One of these is the mass comprising the armature 52, the reaction weight 59 and all parts which are rigidly connected to either of them such as center clamp 58 and a portion of the bars 53 which in fact and also in theory forms a part of this vibratory mass. The second vibratory mass comprises the deck 20 and the field structure of the motor 121 including the bracket 50, cores 41, coils 42 and all parts which are connected to either said deck or said field structure or which interconnect them. It is, of course, evident that all those parts which vibrate, vibrate at the same frequency which is determined by the frequency of the alternating current or the pulsating current on the coil 49. Preferably the masses are so related to the restoring force of the bars that the natural period of vibration of the complete vibratory system is substantially the same as the frequency at which the device is operated.

One of the serious objections to one type of prior known vibratory motors, particularly of the type in which the air gap varies from instant to instant during operation by the movement of the armature toward and from the pole faces of the field structure, is the fact that motors of this type are substantially devoid of inherent regulation. One example of such a device is found in Patent No. 2,094,787, dated Oct. 5, 1937, to James A. Flint. That is, these motors do not have a characteristic whereby they automatically draw more current and therefore automatically increase their power as the load on their vibratory decks increases. In other words, they have no tendency whatever to maintain their amplitude of vibration even approaching a constant value for variations in load.

An important characteristic of the motor which I employ is that it possesses a high degree of inherent regulation and consequently there is not the wide variation in the amplitude of vibration of the deck from no load to full load which is the characteristic of previous motors employed with vibratory conveyors particularly of the type above-mentioned. By this I do not mean that the amplitude of vibration of the deck is constant or even substantially so for wide variations in load but I do mean that it has a tendency to be so, much more than said other type of motor which I have mentioned, which is a desirable characteristic.

Furthermore, it is to be noted that I have eliminated entirely the heavy and costly main frame which is usually found in these electromagnetic vibratory conveyors, screens and the like of the type above mentioned, and consequently I have saved appreciably, and in many instances more than half of the entire weight of the complete unit. In these particular old type of conveyors the two masses which vibrated with respect to each other were the deck and the main frame and any change of vibration in the main frame was not only detrimental but generally represented a complete loss of energy. In short, this work was useless work. In my improved apparatus the two reaction masses are the deck (the same as before) and a relatively small re-

action mass which has taken the place of the very heavy main frame. As previously mentioned, the main frame in said particular old type apparatus was made heavier than the deck and in general it was preferably made at least twice as heavy. The reaction mass including the weight 59, the armature 52, etc., has a weight substantially less than that of the working mass or deck 20 and parts rigidly attached thereto which were above described and preferably the reaction mass has a weight which is not more than one-fourth of the weight of the working mass. It is a known characteristic common to both the mentioned previous device and mine that the amplitudes of vibration of the two reaction masses are substantially inversely proportional to their weights, therefore, whereas in the mentioned previously known devices the amplitude of vibration of the base or main frame was approximately half that of the deck, where the two to one ratio was maintained as previously suggested, in the apparatus of my invention the amplitude of vibration of the reaction mass 52, 59, etc., will in the preferred embodiment be approximately four times that of the working mass comprising the deck 20, etc. It is to be understood, however, that in somewhat broader aspects of my invention this four to one ratio need not be maintained and the ratio may approach one to one.

This increased or higher amplitude of vibration in the armature of the motor which results from my apparatus over that in the mentioned previous apparatus where the armature was connected directly to the deck, while maintaining the amplitude of vibration of the deck substantially the same, is made possible by virtue of the indefinite stroke type of vibratory motor which I employ. In other words, because of the indefinite stroke type of said motor 121 the amplitude of vibration of the armature 52 may be appreciably greater. For example, it may be four times as great (or even greater) than the maximum permissible with the older type of motor above described.

Therefore, the indefinite stroke type of motor has two important advantages in my particular combination of parts in that it permits a very large amplitude of vibration without any possibility of hammering or striking of pole faces and it also has a characteristic of inherent regulation.

It is therefore to be seen that in the feeder, screen, packer, or simply in the vibratory motor of my invention, I have eliminated entirely the necessity for any heavy base or main frame while preserving adequate vibration for the deck by a particular combination of elements including an indefinite stroke and reaction mass type of motor in which the reaction mass is relatively small in weight as compared with the weight of the deck which does the useful work. This results in a very appreciable saving of material also providing a motor with the desirable characteristic of inherent load regulation.

As previously set forth the amplitude of vibration of the armature 52 is large as compared with most known prior machines and this particular arrangement of spring bars makes for an increase in the effective length of the spring bars thus permitting greater vibration of the armature 52 for the same maximum deflection of each spring bar which, of course, is limited, as excessive deflection of any bar will cause it to break.

There is another feature of the motor 121

which in a specific aspect of it I prefer to employ but which in some instances need not be employed. By proper adjustment of the number of spring bars forming any group, such as the group including bars 53 or the group including bars 54, which will be determined by the relative weights of the reaction mass 52, 58, 59 etc., and the reaction mass including the deck 20 and parts rigidly attached thereto, the parts may be so correlated that the end brackets 55 and 56 are at points of zero vibration in the entire system. In general, this will require more restoring force in the bars 54 as a group than in the bars 53, due to the weight of the deck 20 and parts attached thereto as compared with that of the armature 52 and the parts attached to it. When this balanced condition is realized and the end clamps or brackets 55, 56 are substantially devoid of vibration I have a motor which accomplishes a very desirable result because due to the absence of vibration in said brackets or end clamps 55, 56 they may, if desired, constitute all or part of the supporting means for the entire unit.

In Fig. 1 of the drawings I have illustrated the end clamps or brackets 55, 56 bolted solidly to the base 61 which, for example, may be a part of a building frame or any beam or other structural part rigidly attached thereto. This overcomes one undesirable characteristic of commonly known vibratory motors in that in them it has been generally impossible from a practical standpoint to connect the base or any other part thereof directly to a building structure without causing a very disturbing vibration in the building structure.

In Fig. 1 of the drawings I have shown the deck 20 supported not only by the motor 121 through the base 61 but also through the end springs 24 and this will preferably be followed when a single motor 121 is employed in combination with a deck. In practice, however, there are many cases where a plurality of motors, such as motors 121, will be employed and in such a case any support for the deck 20 in addition to that provided by said motor 121, such as coil springs 24 or the equivalent, may be eliminated.

As above indicated, the points of zero vibration need not be in end clamps or brackets 55 and 56, in which case they will vibrate and will not be clamped rigidly with the base 61, but in such an instance they may be supplied with resilient feet to support the entire unit, either alone or with other supporting means such as springs 24.

By adjusting or preselecting the bar groups 53 and 54 three possible conditions may result. First, the points of zero vibration may fall in the end clamps or brackets 55 and 56. In this case, these brackets 55 and 56 are in effect, insofar as any vibratory system is concerned, negligible and their weights are of no concern and are not calculated as in any vibratory system. The second condition is one where the points of zero vibration fall in the bars 53, which will result if they are relatively weak as compared with the first condition. In this case, the end brackets 55 and 56 become a part of the vibrating mass which includes the deck 20 and must be so considered. However, the effect of this mass may be varied because it will vary with the distance the points of zero vibration are from said end brackets 55 and 56, as obviously, even under this second condition, said end brackets 55 and 56 will not have the same amplitude of vibration as said deck 20. The third condition, is where the points

of zero vibration are in the bars 54, obtained by making bars 54 relatively weak as compared with the first condition. In this case, the weight of end brackets 55 and 56 becomes a part of the vibrating mass which includes armature 52.

It is evident that when said end brackets vibrate, under the second or third conditions possible, as above stated, they may have weights added to them to adjust the natural period of vibration of the entire vibratory system.

In Fig. 4 of the drawings I have shown another possible arrangement of field structure and armature windings. The field core is illustrated diagrammatically at 70, the field coils at 71, the armature core at 72 and the armature winding at 73. The windings previously described, for example in Fig. 3, are in effect double armature windings, in that there are two sets of coil sides traversing similarly poled pole faces at the same time. In the proposed arrangement of Fig. 4 there is a single set of coil sides opposite only one pole face of the same polarity. The construction in Fig. 4 is preferred where a relatively small motor of small power is desired and the arrangement of Fig. 3 is preferred where motors of greater size and power are desired. In the system of Fig. 4 the field coils 71 are preferably energized in series with direct current and the armature coil with alternating current. This arrangement may be connected in the various ways above described in connection with Fig. 3 of the drawings and will produce the various frequencies for the several connections as there pointed out.

To review briefly the several aspects of my invention as illustrated in the conveyor or feeder of Figs. 1 and 2 it is to be seen that I have eliminated the base or main frame from one common type of vibratory conveyor. I have preserved completely the characteristics of a vibratory non-rotary rectilinear conveyor or feeder in that I have no frictional bearings of any type since the vibration is straight line in character. In said device of Figs. 1 and 2 the vibratory motor may be supported entirely from the deck which supports and does work on the material being treated or conveyed. Essentially the complete apparatus comprises two vibratory masses, one which for brevity may be called the deck mass and includes for the main part the deck 20 and the other which for brevity may be called the reaction mass which includes the reaction weight 59 and the armature 52 as the principal parts. The energy of the electromagnetic vibratory motor causes each of these masses to vibrate and their amplitudes of vibration are inversely proportional in relative values to their relative weights. This causes a relatively high vibration in the armature 52 to obtain the desirable and customary vibration of deck 20 and to accomplish this relative high amplitude of vibration in said armature 52 I employ an indefinite stroke type of vibratory motor.

Furthermore, the natural period of vibration in the system can be very easily adjusted without requiring any change in the bars, such as bars 53 and 54, by the simple expedient of changing a relatively small mass such as reaction mass 59 and this tunes the entire vibratory system which as a whole will have a natural period of vibration. The armature 52 is mounted to vibrate in space. By this it is meant that there is no rubbing friction which interferes with its vibration as dictated by the deflection of bars 53 and 54. An important characteristic of my invention not above pointed out in particular detail

is that due to the inherent regulation it is possible to tune the natural period of vibration much closer to the actual operating frequency than is possible with prior art devices and thus a higher efficiency is realized. In practice the natural period of vibration may coincide exactly with the operating frequency but in some of the other large units it may be set off as much as 5%.

Certain features generic with the invention herein disclosed and claimed are disclosed and claimed in my divisional application, Serial No. 89,843, filed April 27, 1949, for a Vibratory conveyor or other apparatus.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by claims here-appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

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

1. Vibratory apparatus comprising a deck adapted to support and act on material when vibrated, a motor for vibrating said deck including a pair of spring means both of which are connected to a clamp, means fixing said clamp to a base, a field structure, said deck and said field structure being connected to one of said spring means at a position to vibrate relative to said clamp, and a vibratory electromagnetic motor armature connected to the other spring means at a position to vibrate relative to said clamp, the spring means and associated masses being so related that the clamp is substantially devoid of vibration when said apparatus is operating.

2. Vibratory apparatus comprising an electromagnetic motor including at least two spaced-apart bar spring means connected to a common end clamp, means fixing said clamp to a base, a deck connected to one of said spring means at a position to vibrate relative to said end clamp, and electromagnetic means comprising an armature and a field structure one of which is connected to said deck to vibrate therewith and relative to said end clamp and the other of which is connected to the other of said spring means at a position to vibrate relative to said end clamp.

3. Vibratory apparatus comprising an electromagnetic motor including at least two spaced-apart bar spring means each connected at opposite ends to end clamps, means fixing said clamps to a base, a deck connected to the center of one of said spring means, and electromagnetic means comprising an armature and a field structure one of which is connected rigidly to said deck to vibrate therewith the other of which is connected rigidly to the center of the other of said spring means.

JAMES ROBERT LINDSAY.

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