

Feb. 8, 1966

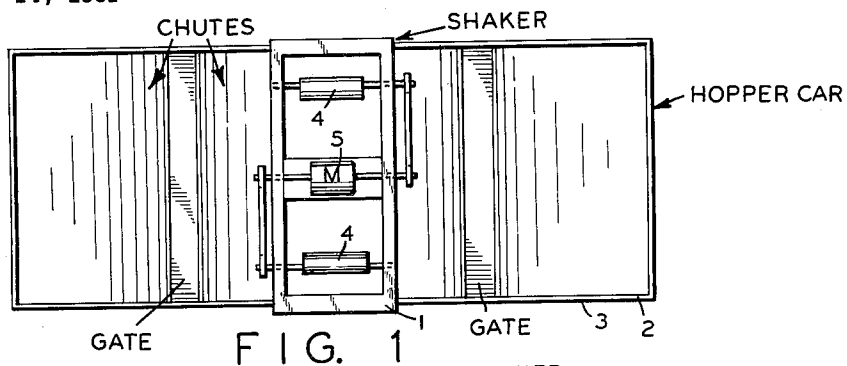
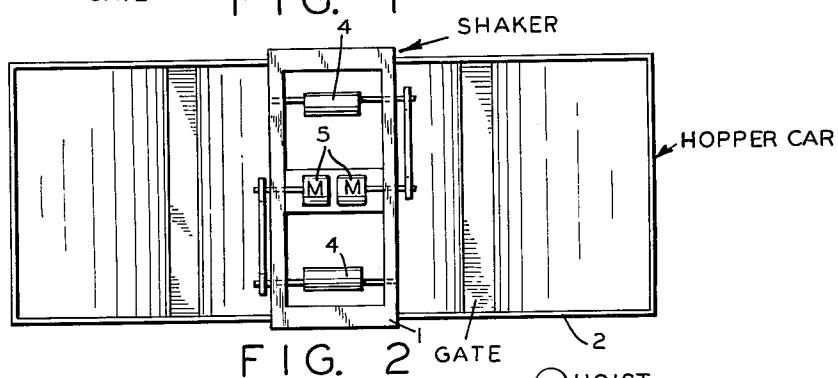
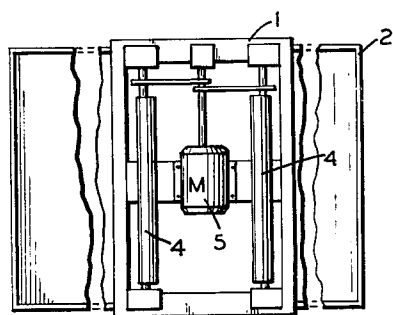
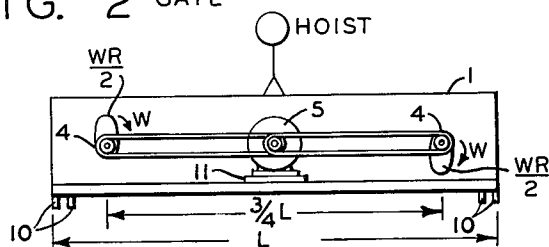
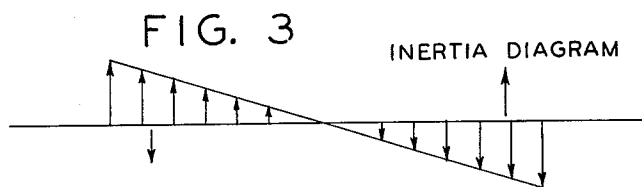
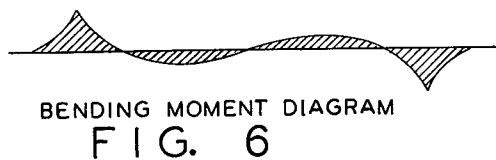
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3,233,474

VIBRATING DEVICES

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2 Sheets-Sheet 1



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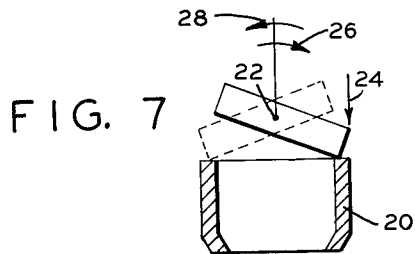
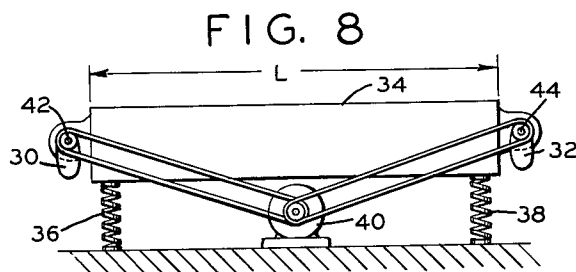


FIG. 9

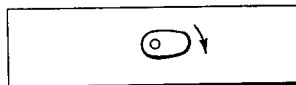
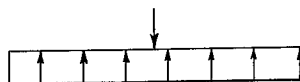


FIG. 10



INERTIA DIAGRAM

FIG. 11



BENDING MOMENT
DIAGRAM

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VIBRATING DEVICES

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9 Claims. (Cl. 74-87)

This invention relates to vibrating machinery and particularly to vibrating machinery such as employed in screening and in the shaking of cars or bins or containers to remove material therefrom.

In some of its broad aspects the invention relates to the discovery of certain principles and effects or results achieved by arrangements and utilization in certain manners of vibrating mechanisms of certain forms in frames or similar devices to effect desired purposes. Thus in one specific embodiment the invention includes means for achieving maximum utilization of a frame, in the functioning of it, to achieve highest efficiency. Still broadly viewed, but more specifically stated, the invention relates to a relative positioning of paired eccentrically weighted shafts in respect to each other and to a frame which mutually supports or mounts the two.

Further, the invention has within its concepts that of achieving specific highly desired effects discovered, as obtainable by certain herein specified relationships.

In one instance the invention has as an object that of obtaining a "circle throw" machine with a certain relationship of elements. This type of machine is known to be desirable for uses such as shaking foundry casks. On the other hand, another object is to achieve a hammering machine useful for other purposes, such as shaking out bins or hoppers.

Still a third object is to provide a method of hammering hopper and the like devices so as to obtain higher than previously realized values of the hammer's kinetic energy potential.

Prior art "circle throw" devices have been made for shaking out flasks, etc., placed upon them. They have also been used for general screening. In many instances these devices have comprised a rotating shaft at the center of the platform upon which the flask, for example, is placed. In other instances, however, a "straight line" motion has been achieved by means of two shafts closely spaced. Variations of these may have from time to time been suggested or even employed. However, the major number of commercially used units embody these two forms. According to our invention two shafts are also used. However, they are spaced a considerable distance, relative frame length, from the center of the "frame," and they are also spaced a substantial distance, relative frame length, from each other.

Further, according to our invention a certain relationship of the shafts relative the frame and each other is chosen to achieve one effect while another relationship is chosen to achieve another effect.

One other object of the invention is to provide "circle throw" and "rocking hammer" machines having two independent shafts which can be spaced lengthwise of the machine. Thus, the total vibrator force or couple needed can be obtained with two shafts instead of one, and smaller shafts bearings and supports can be used than with a single shaft vibrator. Also, the "vibrator" can be more flexibly positioned. A further object is to make larger machines (both of the "circle throw" and "rocking" types) than heretofore practical.

Still another object is to provide a rocking frame type of vibrating device which is usable as a hammer for effectively shaking bins, etc., as hereinafter described.

With respect to a "hammering type" device such as

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shown in U.S. Patent #2,504,789, and the instant FIGURE 9, it is known to utilize such a device for shaking or hammering railroad cars. In some instances single weights are used on the shafts.

In embodiments in use today the motors are usually mounted on separate frames. The latter frames are mounted so that shocks are absorbed or diminished in order to prevent damage to the motors. It has been heretofore thought that a motor would be subject to damaging vibration and other forces if mounted directly on the hammer or other device. We have discovered and utilized a principle by which the auxiliary frame may be dispensed with, yet the motor will not be subject to damaging vibration and movement.

One object of our invention is thus to provide a device for hammering cars which have a motor directly mounted on the vibrating frame or hammer but wherein the motor is substantially free of dynamic loading due to the needed movement of the frame.

A further object is to provide a frame usable as a hammer, as set forth in the preceding object which has a center of oscillation.

Yet another object is to provide an oscillatory or rocking frame hammer device wherein the bouncing heretofore experienced during starting and stopping of such devices can be eliminated.

Another additional object of the invention is to provide a "hopper" vibrator which can be hoisted from one such car to another without the necessity of shutting off the vibrator.

A further additional object of the invention is to provide a hopper hammer device which will transmit hammering forces to the hopper in which the beam stresses of the frame of the device are reduced well below those of presently known hopper car hammer devices for similar output.

Other objects include, with specific relation to hopper unloading, the provision of an improved method of hopper vibration as well as an improved means of hammering or striking hopper bins, etc., with a single frame-like member.

The foregoing objects and advantages and additional features of the invention will be apparent from the following description and the accompanying drawings illustrating a presently preferred embodiment thereof. In the drawings only the essential elements of the invention are illustrated schematically for purposes of clarity and conciseness.

FIGURE 1 is a diagrammatic plan view of a railroad hopper car having a shaker according to the invention applied thereto.

FIGURE 2 is also a diagrammatic plan view along the lines of FIGURE 1 showing an alternative arrangement according to our invention.

FIGURE 3 illustrates another alternative arrangement of the invention in which the eccentrics are located transversely of the car side walls.

FIGURE 4 is a diagrammatic side elevation of a hopper car shaker according to the invention.

FIGURE 5 is an inertia diagram of the system according to FIGURE 4.

FIGURE 6 is a bending moment diagram of the system according to FIGURE 4.

FIGURE 7 is a fragmentary, schematic, partly sectional, elevational view showing a hammer constructed according to the invention in operative association with a hopper.

FIGURE 8 illustrates an embodiment of the invention utilized in a vibrating screen.

FIGURE 9 schematically illustrates a prior art hammer device.

FIGURE 10 is an inertia diagram of the system according to FIGURE 9.

FIGURE 11 is a bending moment diagram of the system according to FIGURE 9.

Referring now to the drawing and particularly to FIGURES 1, 2 and 4, it will be seen that shaker frame 1 straddles a conventional hopper car 2 at approximately the center of the car. Frame 1 is seated on the top of the longitudinal side walls 3. While not shown in detail, the car 2 is of the conventional railroad hopper car construction, and is provided with a pair of chutes comprising sloping bottom walls having gates through which the load is discharged. The frame 1 is of generally rectangular form provided with suitable mounting brackets and bearings supporting the eccentrics 4. The frame is maintained in position on top of the car side walls by flanges 1 which are parallel to the tops of the car walls.

The prime mover 5 is mounted on the frame, at the center of oscillation thereof. The prime mover 5 drives each eccentric 4 in a common clockwise or counter-clockwise direction. Conventional belt drive means allow a 180 degree phase shift between the eccentrics. In other words, one eccentric, or the weight of one eccentric, will operate 180 degrees out of phase with respect to the other eccentric. Thus, when one eccentric is at top center the other eccentric is at a bottom center position. This produces a force couple acting to rock the frame. The vibrators, in fact, supply a pulsating couple to the frame which results in oscillatory frame motion about a nodal point.

The forces imparted to the frame 1 by the eccentrics in the horizontal plane are in opposition and therefore cancel out and produce a resultant of zero when the eccentric weights and angular velocity are equal. The net force imparted to the frame itself by vibrators so related is at all times zero. Because of the nature of this force system it is well to recognize a permitted constructional advantage, namely that identical motions will result whether the vibrators are mid-frame mounted as shown in FIGURE 4 or mounted on top of the frame as shown in FIGURE 3. Such cannot be said for the conventional system of FIGURE 9 where the single vibrator must be located at the CG of the frame in order to achieve uniform frame motion.

FIGURE 7 illustrates the operation of a hammer constructed in accordance with the invention in the shaking of a hopper such as indicated at 20. The hammer is seen to oscillate about the nodal point 22 which is determined by the frame geometry. The hammer, it will be noted, strikes the right end of the hopper a vertical blow as indicated by arrow 24 upon downward movement of the corresponding end of the hammer into contact with the hopper side. This movement is arcuate as indicated by arrow 26. The rotation of the eccentrics constantly continuing, they will then induce, after the action of the blow indicated by the arrow 24, a reverse rotation of the frame as indicated by arrow 28. The latter will continue as the eccentrics move another 180° until the hammer reaches the dotted line position illustrated. At approximately the latter time the hammer will strike the left-hand side of the hopper to deliver a blow to it. Now, again, the eccentrics continue rotating so as to cause reverse rotation of the hammer as indicated by the arrow 26. This oscillatory movement of the frame with the eccentrically weighted shafts phased as shown, it has been discovered, will result with the shafts positioned as illustrated, or positioned within the range set forth below.

It will also be apparent that in the symmetrical arrangement illustrated in FIGURE 4 the motor is positioned at a nodal point; i.e., the point about which the hammer rotates. A prime mover 5, located at this center of oscillation or node will not receive damaging acceleration or other forces. The motor, however, can be mounted on rubber pad 11 although no special motor construction or support is needed.

FIGURE 7 also illustrates a novel method of hammering hoppers consisting of utilizing a hammering device straddling or sub-tending opposite walls of a hopper and causing said hammer to oscillate so as to alternately strike one wall and then the other. It will be noted that the hammer oscillates about a nodal point as described above.

As seen by comparing FIGURES 1, 2, and 3, the eccentrics may be arranged either parallel or transverse to the side wall of the hopper car.

FIGURE 4 illustrates that if a shaker hoist is connected to the frame at the center of oscillation or node the frame can be placed on one car after another without shutting down the shaker, since the hoist and its cable will be free of imposed dynamic forces.

Details of the frame structure, mounting of the eccentrics thereon, and the drive connections between the eccentrics, and one or a pair of motors, are all well known to those skilled in the art and form no part of the present invention. Therefore, detailed descriptions thereof are omitted.

Referring to FIGURES 4, 5, 6, 9, 10 and 11, it can be shown experimentally and by calculation that the ratio of KE_{max} (maximum kinetic energy) for a frame corresponding to the characteristic prior art systems and the KE_{max} for the system according to the invention is approximately 1:1.47 when the eccentrics are spaced apart as shown in FIGURE 4. It can also be shown that the maximum side frame bending moment, and therefore peak stress value for the prior art system is of the ratio of 8:1 as compared to the system of FIGURE 4. The indicated comparisons relate to uniform frames of equal mass, equal total shaft unbalance and equal running speeds, and compares FIGURE 4 with FIGURE 9.

It is noted that the optimum position of the eccentrics on the frame to impart rocking motion thereto at high KE_{max} is dependent upon mass distribution. However, perfectly located drive, rectangular frame construction, or uniformity of live frame weight distribution are not necessary to achieve the features of this invention. The distance between eccentrics may be varied depending on mass distribution. This variation will be approximately within the range $\frac{1}{2}L$ to $0.9L$ to obtain the necessary amplitude of frame oscillation to obtain the maximum KE of the system. This spacing of the shafts is not a critical consideration; i.e., results less than maximum can be satisfactory and absolute accuracy in placement is not necessary.

With the arrangement illustrated in FIGURE 4, rocking as heretofore described will ensue and energy exerted by the frame will be approximately 50% higher than conventional systems (for the same weight, r.p.m., and total shaft unbalance). It has been determined that if the spacing between eccentrics is less than approximately $\frac{3}{4}L$, see FIGURE 4, the total energy developed becomes less than 50% higher than with a conventional machine. At a point where the eccentrics are very close together frame oscillation becomes negligible.

Referring again to FIGURE 4, and also to FIGURE 8, it has also been determined that if the spacing between eccentrics equals L , on a frame on uniform mass distribution, the frame no longer rocks. Instead the vibrators assume an in phase rotating relation, and the frame will generate circles. It has been experimentally determined that the out of phase relation of the vibrators will exist until the distance between shafts equals about $0.9L$.

The discovery that the shafts will shift to an in phase relationship when the distance between shafts reaches approximately $.9L$ provides a means of utilizing principles of the invention in achieving a circular throw machine of highly desirable characteristics.

Thus referring particularly to FIGURE 8, the eccentrics 30 and 32 are there shown to be spaced apart on the frame 34 a distance approximately equal to L (the length of the frame). It should be further noted that the frame is supported on the springs or other resilient members 36 and 38. In this instance the springs are illustrated as

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supporting the screen frame 34 from the floor. It will be understood by those skilled in the art that a support frame may be provided and the resilient members may rest on it. It is also known that the frame 34 may be suspended. In any event the motor 40 is supported upon the fixed structure adjacent the frame 34 and connected to the two shafts by flexible belt drive means. It is known in the art that sheaves can be designed to accommodate relative movement between the two eccentrically weighted shafts 42 and 44 and the motor.

It has been determined that with the spacing as illustrated the very same eccentrically weighted shafts previously positioned relative the frame on which they are supported, or of which they are a part, as described in FIGURE 4, will interact upon each other through and in conjunction with the frame so as to produce an entirely different effect: namely, the frame 34 will move in a circular path. Further, the weights will synchronize automatically in an in-phase relationship. This, in actuality, results in the circular path. The spacing of the shafts is important with respect to the frame but it is not especially critical; i.e., the spacing might, for example, be .97L but it has been experimentally determined the spacing should not go as low as approximately .9L. It will be apparent to those skilled in the art that frame 34 can constitute the live frame of a screening device and can support screen cloth, etc. as may be desired. It might, on the other hand however, be employed as a flask shake-out device. It is obvious that independent motors might be employed, if desired, in place of single motor 40 in the same manner, for example, as illustrated in FIGURE 2.

The connections between the motors and shafts are in all instances such that the shafts may independently assume a preferred mode of operation relative each other. Thus in the example illustrated in FIGURE 2 the shafts are free no matter in what relative position they may be upon starting to assume the relative position illustrated. This is likewise true of the shafts in the form illustrated in FIGURE 8. It is my discovery that the particular relationships described herein will be automatically achieved when the foregoing physical relationships and shaft rotations are as set forth that provides the inventive embodiments herein disclosed.

While we have shown and described a preferred form of our invention it will be understood by those skilled in the art that changes in detail and form may be made. Accordingly we claim exclusive right to all forms or modifications coming within the scope of the appended claims.

We claim:

1. Vibratory apparatus comprising a frame, a pair of spaced parallel eccentrically weighted shafts rotatably mounted rigidly on said frame, drive means for rotating said shafts in a common direction of rotation, said shafts being spaced from each other a distance within the range of approximately $\frac{1}{2}L$ to L where L is the length of said frame transversely of said shafts, said shafts being free with respect to each other and with respect to said drive means to assume a phase relationship with respect to each other governed by the distance between said shafts and the relationship of the latter distance to the length of said frame.

2. The vibratory apparatus of claim 1 wherein the spatial distance between said shafts lies within the range of approximately $\frac{1}{2}L$ to $.9L$.

3. The vibratory apparatus of claim 1 wherein the spatial distance between said shafts lies within the range of approximately $.9L$ to L .

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4. Vibratory apparatus comprising a frame, a pair of spaced parallel eccentrically weighted shafts rotatably mounted on said frame, means located between said shafts and connected thereto to drive each of said shafts in the same direction of rotation, the distance between said shafts and their phase relationship at operating speed being such as to cause said frame to rock about a center of oscillation when said shafts are so rotated, said means being located at the center of oscillation, said shafts being relatively free with respect to each other and the means for driving said shafts to assume a phase relationship with respect to each other which is governed by the distance between said shafts and the relationship of the latter distance to the length of said frame.

5. Apparatus according to claim 4 wherein said shafts are spaced from one another a distance less than the length of said frame but not appreciably less than $\frac{1}{2}$ the length of said frame.

6. An article of manufacture for hammering a hopper comprising a frame, means for supporting said frame on said hopper, a pair of eccentrically weighted shafts rotatably mounted on said frame transversely thereof, prime mover means mounted on said frame and drivingly connected to said shafts, said shafts being mounted respectively at one side of said prime mover means in spaced parallel relation with respect to each other and spaced from said prime mover means, the distance between said shafts being substantially within the range of .5 to .9 of the length of said frame, said shafts being relatively free with respect to each other and the means for driving said shafts to assume a phase relationship with respect to each other which is governed by the distance between said shafts and the relationship of the latter distance to the length of said frame.

7. An article of manufacture according to claim 6 wherein said prime mover means is operative to drive said shafts in the same direction of rotation 180 degrees out of phase.

8. An article of manufacture according to claim 7 wherein said prime mover means comprises at least one motor connected by a pulley and belt means to said shafts, and said shafts are free to assume a phase angle of 180 degrees at operating speed.

9. Vibratory apparatus comprising a frame having a length L , a pair of eccentrically weighted shafts rotatably supported on said frame with their axes extending transversely of the length of said frame and with said shafts being spaced from each other a distance within the range of approximately $\frac{1}{2}L$ to $.9L$, and drive means for rotating said shafts in a common direction of rotation comprising a motor, means mounting said motor on said frame intermediate said shafts at a point of least movement of said frame, means drivingly connecting said motor to both of said shafts.

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