Feb. 18, 1941. G. E. MARKLEY 2,232,124

MECHANICALLY VIBRATED MECHANISM

Original Filed Nov. 25, 1933 3 Sheets-Sheet 1

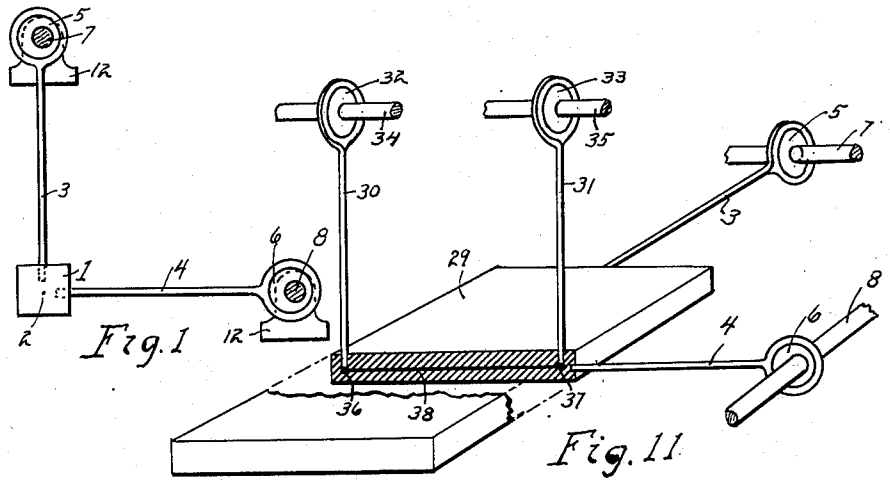


Fig. 1

Fig. 11

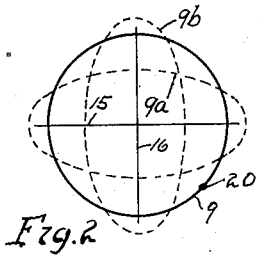


Fig. 2

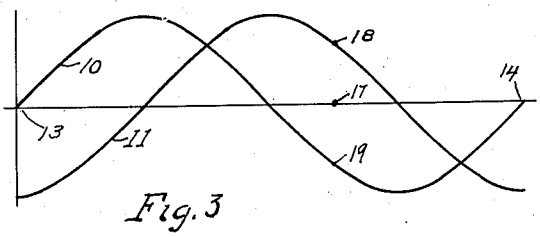


Fig. 3

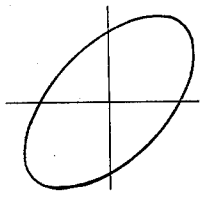


Fig. 4

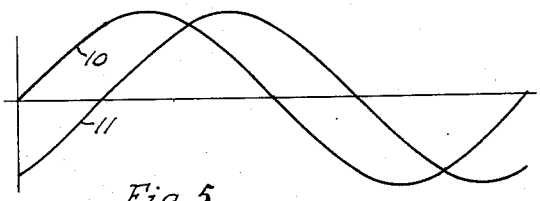


Fig. 5

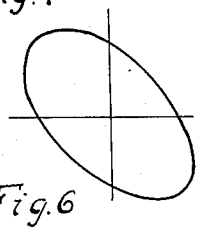


Fig. 6

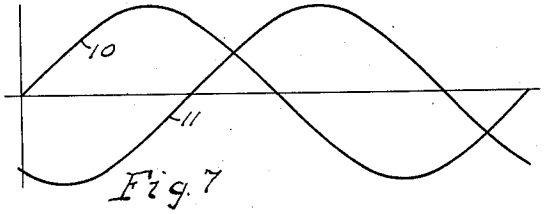


Fig. 7

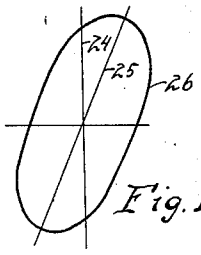


Fig. 10

INVENTOR.

BY George E. Markley
Harry R. Caufield
ATTORNEY.

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MECHANICALLY VIBRATED MECHANISM

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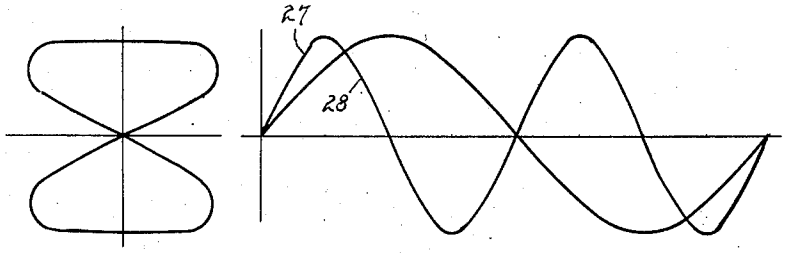


Fig. 8 Fig. 9

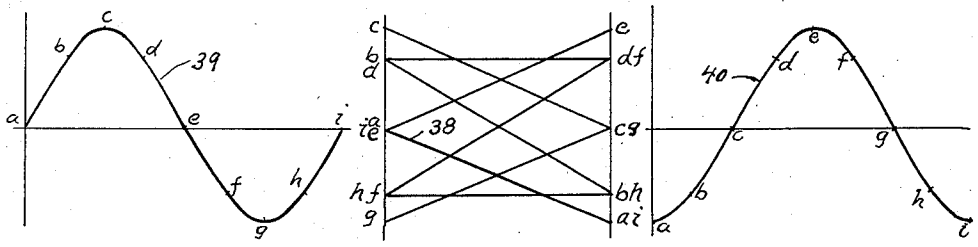


Fig. 12

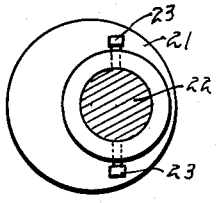


Fig. 16

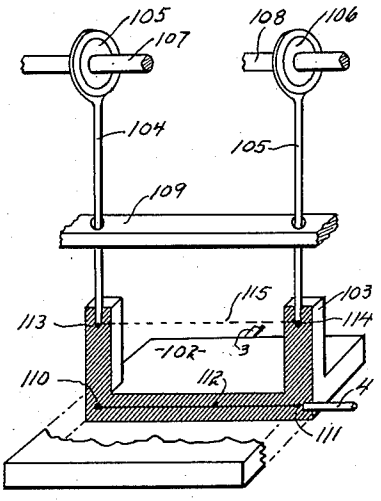


Fig. 17

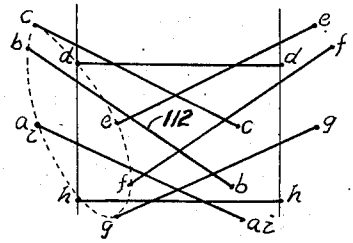


Fig. 18

INVENTOR.

BY George E. Markley
Harry R. Caufield
ATTORNEY.

Feb. 18, 1941. G. E. MARKLEY 2,232,124

MECHANICALLY VIBRATED MECHANISM

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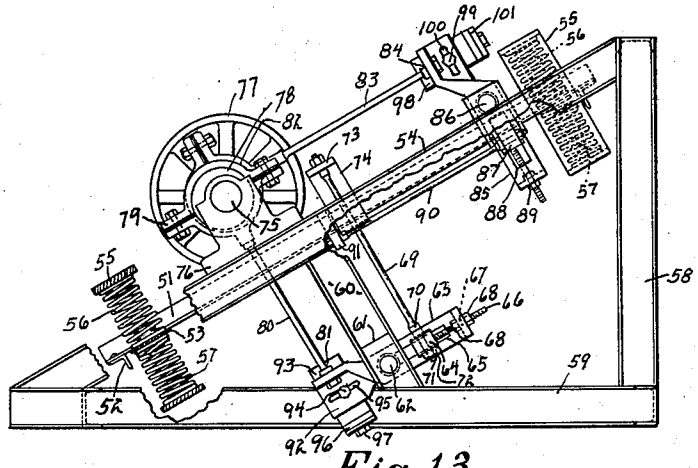


Fig. 13

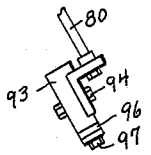


Fig. 15

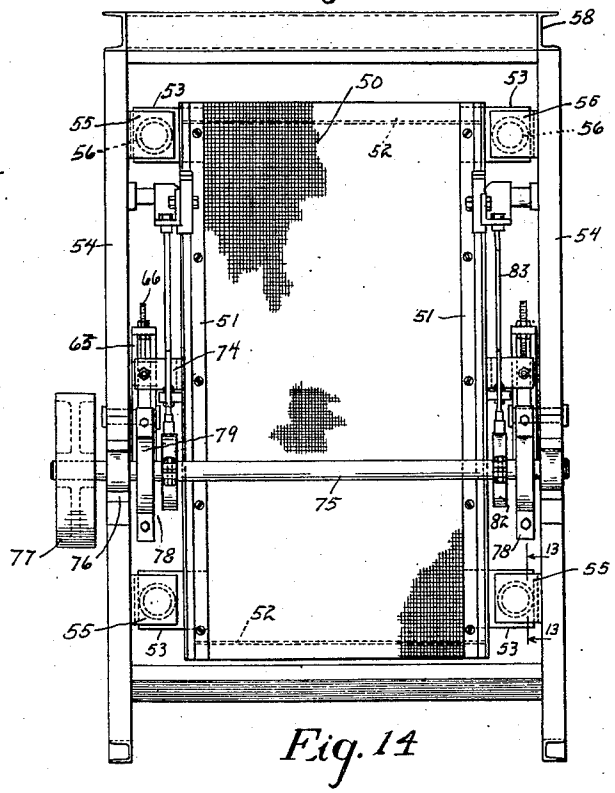


Fig. 14

Inventor

George E. Markley

Harry R. Caufield

Attorneu

Patented Feb. 18, 1941 2,232,124

UNITED STATES PATENT OFFICE

2,232,124

MECHANICALLY VIBRATED MECHANISM

George E. Markley, Cleveland Heights, Ohio

Original application November 25, 1933, Serial No. 699,691. Divided and this application October 27, 1937, Serial No. 171,252

3 Claims. (Cl. 209—325)

This invention relates to cyclical movements and the methods and means of producing them.

Cyclical movements are employed in various of the practical arts illustrative of which is the art of screening material by cyclically moving a perforated sheet or open fabric screen upon which discrete material is supported.

In some instances and in some arts the cyclical movements employed are so rapid as to be correctly described as vibratory; and hereinafter the term cyclical-movements or its derivatives is used as inclusive of vibratory movements.

Hereinafter is described the theory underlying the production of cyclical movements according to my invention together with a general means and method of producing the same for any purpose or in any mechanical art; and this is followed by an illustrative application of my invention to the art of screening material.

Among the objects of my invention are:

To provide an improved cyclical movement and an improved method and means for producing the same;

To provide a novel cyclical movement which may be variously modified and adapted to various uses;

To provide an improved means for producing cyclical movements whereby the nature of the movement and the amplitude thereof may be adjustably changed;

To provide, in a support for an object or article to be cyclically moved, an improved means for counter-balancing the weight and inertia of moving portions of the article or object cyclically moved, to prevent or reduce the transmission of the movement to the support;

To provide an improved means for vibrating a cyclically movable material handling screen, conveyor, etc.;

To provide an improved cyclical movement which can be applied to a material handling screen, conveyor, etc., in an improved manner;

To provide a mechanism for communicating to a material handling screen, conveyor, etc., improved movements;

To provide an improved means for effecting cyclical movement of a material handling screen, conveyor, etc., susceptible of variations of movement to adapt the screen to the screening of different kinds of material;

To provide a means for converting harmonic mechanical movement into vibratory movement for vibrating a material handling screen, conveyor, or other object.

Other objects will be apparent to those skilled in the art to which my invention appertains.

My invention is fully disclosed in the following description taken in connection with the following drawings, in which;

Fig. 1 is a view, generally diagrammatic, illustrating an apparatus where my invention may be embodied and wherein the method thereof may be practiced;

Fig. 2 is a diagram illustrating one path of movement which may be produced by the apparatus of Fig. 1;

Fig. 3 is a diagrammatic view illustrating in wave form periodic movements of elements utilized in the practice of my invention and illustrated in diagrammatic form in Fig. 1;

Figs. 4, 6 and 8 are views similar to Fig. 2 illustrating alternative forms of movement path which may be produced by the apparatus of Fig. 1;

Figs. 5, 7 and 9 are views similar to Fig. 3 illustrating wave forms from which the movement path of Figs. 4 and 6 may respectively be derived.

Fig. 10 is a view generally similar to Fig. 2 but illustrating the effect thereon of a modification of the apparatus of Fig. 1;

Fig. 11 is a diagrammatic view generally similar to Fig. 1, but illustrating another form of apparatus;

Fig. 12 is a diagrammatic representation of movements which may be obtained with the apparatus of Fig. 11;

Figs. 13 and 14 are respectively side elevations and plan views of an actual apparatus whereby my invention may be employed to communicate vibratory movements to a material handling screen;

Fig. 15 is a fragmentary end elevation view of parts shown in front elevation in Fig. 13;

Fig. 16 is a view illustrating a means of adjusting one of the elements of the apparatus of Figs. 1, 11, 13 and 14;

Fig. 17 is a diagrammatic view generally similar to Figs. 1 and 11 but illustrating another form of apparatus; and

Fig. 18 is a diagrammatic representation of movements which may be obtained with the apparatus of Fig. 17.

Referring to the drawings Fig. 1, I have illustrated in diagrammatic form an apparatus whereby a cyclical movement may be produced in accordance with my invention. At 1 is indicated generally a mass which represents any element of the object, screen frame, conveyor, or the like, to which the cyclical movements may be applied, and a central point 2 in the mass illus-

trates a particular point in the mass 1, the movement of which is here under consideration; and hereinafter the path of the point 2 will be described for cyclical movements given to the mass 1.

At 3 and 4 is indicated a pair of laterally flexible, preferably resilient, rods rigidly secured at one end in the mass 1 and extending laterally therefrom at an angle of approximately 90°, converging in the mass 1 toward the point 2. The outer ends of the rods are connected to eccentrics or circular eccentric cams 5 and 6, mounted on rotatable shafts 7 and 8 which have bearings in suitable supports 12—12 and which are arranged to be rotated by power from a source not shown.

When the shafts 7 and 8 are rotated, the eccentrics 5 and 6 will give to the rods 3 and 4 longitudinal movements which are transmitted to the mass 1, moving the point 2. Upon longitudinal movement of the rod 3, the rod 4 will yield laterally so that the point 2 will move vertically and upon longitudinal movement of the rod 4, the rod 3 will yield laterally and the point 2 will have a resultant movement, in a closed path.

According to one mode of practicing my invention, the eccentrics are positioned on their shafts 7 and 8, 90° apart in rotational time phase, so that the rods 3 and 4 move with movements which are 90 degrees out of time phase with respect to each other. In such case, the point 2 of the mass will move with a cyclical movement illustrated by the curve 9 in Fig. 2, and this fact will now be explained in connection with Fig. 3.

In Fig. 3, I have illustrated at 10 and 11 respectively two sine form curves, the curve 11 being 90° later than the curve 10 in phase. Inasmuch as the rods are moved by the circular eccentrics 5 and 6 they will have substantially harmonic longitudinal movements at the mass ends thereof and these longitudinal movements are therefore represented by the vertical distances from the base line 13—14, of Fig. 3, to points on the curves 10 and 11, the curve 10 representing movements of the end of the rod 3 and the curve 11 representing movements of the rod 4, one revolution of the eccentrics being represented by the horizontal distances 13—14.

The vertical distances to the line 10, above and below the line 13—14, are taken as ordinates respectively above and below the axis 15, of Fig. 2; and the vertical distances above or below the line 13—14 to the curve 11 are taken as abscissae respectively to the right or to the left of the vertical axis 16 of Fig. 2. For example, at the point 17 on the line 13—14 there will be an ordinate 17—19 below the axis 15 and there will be an abcissa 17—18 to the right of the axis 16 determining the point 20 in the curve 9. The axes 15 and 16 are chosen parallel to the longitudinal directions of movement of the rods.

With the radii and amplitude of throw of the eccentrics 5 nd 6 equal, and with the eccentrics rotating at the same speed and fixed 90° apart in phase, the curve 9 will thus be a circle as illustrated.

In this connection it will be observed that when the rod 3 moves longitudinally, the rod 4 bends causing the point 2 to move on a line at the left hand end of the rod 4, as viewed in Fig. 1, the line being actually slightly curved around an approximate center somewhere near the eccentric 6. In a similar manner when the rod 4 moves longitudinally, the point 2 moves in a slightly curved path around an approximate center somewhere near the eccentric 5. The extent of movement of the point 2 in these directions is so small compared with the chosen lengths of the rods that the movement is substantially a straight line, and to avoid complications in this discussion of the theory, the vertical and horizontal movements of the point 2 are considered as rectilinear movements.

From the foregoing it will now be apparent that the curve 9 of Fig. 2 is the path of the point 2, a characteristic point in the mass 1, when the mass is acted upon concurrently by both eccentrics.

The radius of the curve of Fig. 2 is obviously greatly magnified, as are the ordinates of the curves 10 and 11 of Fig. 3 from which is is derived.

The form of the cyclical movement or path of the point 2 may be variously modified to adapt it to specific uses. Various modifications may be effected either by changing the angular direction in space of the rods 3 and 4 with respect to each other, or by changing the angle of phase displacement in time of the two eccentrics; or by changing the velocity of the eccentrics or the velocity of one eccentric with respect to the other, or by changing the amplitude or throw of the eccentrics, or the amplitude of one eccentric with respect to the other, or by changing the frequency of the eccentrics, or the frequency of one relative to that of the other, etc. It will be understood, of course, that any one of these changes may be made independently of the other or that they may be combined, and the resulting movement curve (corresponding to Fig. 2) will be the result of changing any one or any combination of two or more of these factors.

Obviously the amplitude of movement will be determined by the radius of the eccentric, and the phase relationship thereof may be adjustably varied by adjusting one eccentric on either shaft relative to the other. One kind of such adjustment being illustrated in Fig. 16, wherein the eccentric 21 may be rotated around the shaft 22 and fixed in any position by set screws 23—23.

The changes in the form of the movement which may be effected by changing the angle between the directions of longitudinal movement of the two rods is illustrated in Fig. 10. In that figure, the axes 24 and 25 represent respectively the directions of movement of the bars 3 and 4, the axes embracing therebetween an angle of approximately 30°. The movement path 26 is obtained from the curves of Fig. 3, with the same values that were used in producing Fig. 2. As will be observed the movement path is generally elliptical.

Obviously other movement curves may be produced by disposing the rods 3 and 4 at other angles.

Again in Fig. 10 the axis 24 is vertical and the axis 25 is inclined. This determines a position in space for the curve 26. That is to say the curve, being generally elliptical has its major axis downwardly toward the left. The same elliptical curve can be produced in any other rotated position in space by correspondingly changing the position in space of the rods 3 and 4.

The changes in the movement path effected by changing the angle of phase displacement of the eccentrics will now be considered.

As stated above, the respective harmonic movements produced by the rods 3 and 4 when the

eccentrics 5 and 6 are displaced 90° apart in phase are illustrated in Fig. 3. With the parts arranged as in Fig. 1, but with the eccentrics 5 and 6 displaced only 60° apart in time phase, the corresponding harmonic curves thereof will be related as illustrated in Fig. 5. If now a motion path be constructed from these curves, by the method described above for Fig. 2, a path such as illustrated in Fig. 4 will result.

Again if the time phase angle be changed to 120°, the harmonic curve will have the relation shown in Fig. 7 and the resulting path curve will be that shown in Fig. 6.

If the throw of one of the eccentrics, say the eccentric 6 be increased and that of the eccentric 5 be decreased, and with the eccentrics 90° apart in phase, the harmonic curves will be similar to those of Fig. 3 except that all of the ordinates of the curve 11 will be longer and those of the curve 10 shorter; which when used to construct a path curve will produce a curve such as Fig. 2, except that all of the horizontal dimensions will be greater and the vertical dimensions shorter, and the curve will therefore be an ellipse with its major axis horizontal, as shown in dotted line at 9a in Fig. 2.

Similarly if the eccentric 5 is given a greater throw and the eccentric 6 a shorter throw, the curve 10 will have a greater amplitude than the curve 11 and an elliptical motion path such as illustrated in dotted line at 9b will result. Obviously an elliptical path will result if the throw of either one of the eccentrics be changed.

By maintaining the direction of the rods 90° apart as in Fig. 1, but rotating the eccentrics around the point 2 to different positions in space, the major axis of the ellipses of Figs. 2, 4 and 6 may be given any angular direction desired.

If the frequency of revolution of one of the eccentrics, such as 6 is made different from that of the eccentric 5, a still further variation of curve shape will be produced. In Fig. 9 is illustrated the harmonic curves produced by the motion of the mass ends of the rods 3 and 4 when the eccentric 6 rotates at twice the speed of the eccentric 5, the curve for the rod 3 being shown at 27 and that for the rod 4 being shown at 28. By the same method of derivation, the path curve, Fig. 8, is derived from the curves 27 and 28.

When an object, such for example, as a material handling screen, is vibrated so that a point therein follows a path of movement having the character of that illustrated in Figs. 2, 4, 6, 8 or 10, different effects may be produced upon the material depending upon the direction in which the point follows the path, that is to say, clockwise or counter-clockwise as viewed in the drawings. For example, if a screen is vibrated according to the motion path of Fig. 4, the effect upon the material on the screen fabric will be different if movement is upwardly along the left side of the curve and downwardly along the right than if it moves in the reverse direction, and movement in either direction of rotation may be accomplished by my invention as will be understood.

As explained in the foregoing the shape of the movement path may be varied by disposing the directions of the rods 3 and 4 at different angles. Obviously the limit of this angle is 180°. My invention contemplates the employment of rods at angles of 180° and in such cases the lines of action are disposed parallel to each other and each rod effects movement of a characteristic point in a mass to be moved and the two points thus considered determine a line.

Referring to Fig. 11 I have illustrated diagrammatically an apparatus which may be employed when the lines of action of the two rods are parallel.

An object to be vibrated, 29, which, in the diagrammatic showing, is in the form of a rectangular bed and horizontally disposed, has a pair of flexible, preferably resilient, rods 30 and 31 connected thereto at their lower ends, extending upwardly therefrom, and connected to the eccentrics 32 and 33, mounted on shafts 34 and 35. The rods 30 and 31 may be considered as respectively vibratingly moving the points 36 and 37, spaced apart transversely of the bed 29, and therefore the line 38 connecting the points will be considered as moved with a characteristic movement instead of a point as in the foregoing examples, and hereinafter a different mode of illustrating the motion will be employed.

For the present purposes of illustration, it will be assumed that the eccentrics 32 and 33 are 90° apart in time phase and that the rods 30 and 31 are parellel. The point 36 will have a harmonic motion which will be represented by the curve 39, Fig. 12, and the point 37 will move according to the curve 40. Simultaneous points on these curves are represented by the letters, *a*, *b*, *c*, *d*, etc. When one end of the line 38 is at the point *c*, in the curve 39, the other end will be at the point *c*, in the curve 40, and so on. The line 38 will therefore take up successive positions indicated in Fig. 12, in the central portion thereof at *a*—*a*, *b*—*b*, etc.

The character of movement of the line 38, may be varied by varying the velocity of the eccentrics 32 and 33, by varying the amplitude thereof, by varying the relative phase relation thereof, etc., as will now be understood from the more complete discussion of the effects of such changes in the foregoing.

When the generally horizontally disposed bed 29 is moved by the rods 30 and 31, as described, the beds will be given in general a rocking movement about a longitudinal axis between the points 36 and 37. As illustrated in Fig. 11, this rocking movement may be combined with a circular or elliptical or other path of motion communicated thereto concurrently. To this end, the rods 3 and 4, of Fig. 1, their eccentrics 5 and 6, and shafts 7 and 8 have been illustrated, the rod 3 being connected to a portion of the bed 29 generally at right angles to the line 38 and the rod 4 being connected generally parallel thereto with an angle of 90° between the rods 3 and 4. When all four shafts 34 and 35, 7 and 8, are rotated at the same time, both types of movement may be independently varied for different purposes, as described above.

If only the rod 3 be operated concurrently with the rods 30 and 31 (the rod 4 being omitted) a longitudinal reciprocatory movement combined with a transverse rocking movement will be produced.

With the combined movements of the bed 29, the inner ends of the bars 30 and 31, 3 and 4 will each move in a curved path of movement made possible by the flexibility in the bars.

In Fig. 17 is illustrated diagrammatically another apparatus which may be employed. The object to be vibrated is, in the diagrammatic showing, in the form of a rectangular bed 102 horizontally disposed and having a pair of posts 103—103 projecting upwardly therefrom and rig-

idly connected thereto. The posts 103—103 may also be considered as depending hangers for supporting the bar 102. Resilient rods 104 and 105 are connected at their lower ends to the upper ends of hangers 103—103 and extend upwardly therefrom being connected at their upper ends to eccentrics 105 and 106 driven by shafts 107 and 108. The lower end portions of the rods 104 and 105 may be guided by a stationary frame element 109, the rods extending through perforations therein. The rods 104 and 105 may be considered as respectively vibratingly moving the points 110 and 111 spaced apart transversely of the bed 102, and therefore the line 112 connecting these points will be considered as moved with a characteristic movement illustrated in Fig. 18 by a mode of representation similar to that of Fig. 12 for the line 38.

Assuming that the eccentrics 105 and 106 are driven 90° apart in time phase, the lower ends of the rods 104 and 105 indicated by the points 113 and 114 in Fig. 17 will have the harmonic movements respectively represented by the curves 39 and 40 of Fig. 12, and for that reason these curves have not been reproduced for Fig. 17. An imaginary line 115 connecting the points 113 and 114 will take up successive positions illustrated by the successive positions for the line 38 in Fig. 12. But the line 112 here under consideration which is spaced below the line 115 will take up successive positions which are at all times parallel to the line 115 (and therefore parallel to the line 38 of Fig. 12) and spaced a constant distance therefrom.

These successive positions for the line 112 are illustrated in Fig. 18. For example, when the points 113 and 114 of Fig. 17 are respectively in the positions indicated by *a* for the curve 39, and *a* for the curve 40, in Fig. 12, the corresponding opposite ends of the line 112 will be represented by the line *a*—*a* of Fig. 18. It will be observed therefore that the line 112 moves with a movement generally similar to the movement of the line 38 of Fig. 12, but with a side to side component of movement superimposed thereupon.

The character of movement of the line 112, as illustrated in Fig. 18, may be varied as above described by varying the velocity of the eccentrics 105 and 106; by varying the amplitude thereof; by varying the relative phase relation thereof, etc., as is believed now to be clear from the more complete discussion of the effects of such changes in the foregoing.

With the form of Fig. 17 also, the rods 3 and 4 of the eccentrics 5 and 6 of Fig. 1 may, either singly or in combination, be used to further modify the character of the movement illustrated in Fig. 18 as was described above for these rods and eccentrics in connection with the form of Fig. 11.

From the foregoing it will now appear that the principles of my invention are susceptible of producing cyclical movements of an almost infinite variety; and that it would be physically impossible to illustrate and describe all of the possible different cyclical movements which may be produced or the apparatus for producing them.

In the foregoing the principle is applied to produce movement in both two-dimensional and three dimensional space.

In Figs. 13 to 15 is illustrated an actual apparatus by which the principles of my invention may be applied in one form to cyclically move or vibrate the screen of a material handling screening apparatus.

The screen 50 is secured to a frame comprising longitudinally extending parallel laterally spaced angle bars 51—51 disposed at an angle from the horizontal as shown in Fig. 13, and transverse end bars 52—52. Projecting laterally from opposite sides at each end of the screen frame are brackets 53—53. A main frame comprising parallel side bars 54—54 is provided having U-form brackets 55—55 projecting oppositely inwardly, and embracing each of the brackets 53—53. Springs 56 and 57 abut at their opposite ends upon the legs of the U-shaped brackets and upon the opposite sides of the brackets 53. The screen frame is thus supported upon the springs and can be freely moved in the directions longitudinally of the plane of the screen and at an angle thereto.

The frame members 54—54 are supported in their inclined positions by vertical and horizontal frame members 58 and 59. A transverse frame member 60 at each side of the frame and adjoining the corresponding frame members 54 and 59 is provided with a bearing block 61 supporting a bearing pin 62, upon which is oscillatably mounted a rocker arm 63. A head 64 is slidably adjustably movable in a slot 65 in the arm 63, and a threaded stud 66 projects outwardly laterally from the head 64, and passes through a suitable perforation 67 in the arm 63, and nuts 68—68 are threaded on the stud 66 on opposite sides of the perforation 67 whereby the position of the head 64 may be adjustably changed to change its distance from the center of the bearing pin 62.

A rod, 69, preferably formed from resilient steel alloy is rigidly secured to the head 64 by a head 70 on the rod disposed on one side of the head 64, and a threaded shank 71 extending through the head and a nut 72 on the shank fastens the head 64 between the head 70 and the nut 72.

The opposite end of the rod 69 is rigidly secured, as at 73, to a bracket 74, which is rigidly secured to a longitudinal middle point of the side bar 51 of the screen frame. On the opposite side of the screen frame is provided a similar construction to that just described including the rod 69, bracket 74, rocker arm 63, and bearing pin 62.

A main shaft 75 extends across the apparatus transversely and is supported in bearing blocks 76—76 on the frame side bars 54—54. Means such as a belt pulley 77 is provided to rotate the shaft. A pair of eccentric cams 78—78 are rigidly secured to the shaft 75 each in a position generally between one of the side bars 54 of the frame and the adjacent side bar 51 of the screen; and an eccentric cam follower or link 79 is provided for each cam and has rigidly secured thereto the upper end of a rod 80, the lower end of which is rigidly secured to the rocker arm 63 on the opposite side of the pin 62 from the rod 69, by a construction at 81 similar to that for securing the rod 69 to the rocker arm.

Adjacent to each eccentric 78—78 is another eccentric cam 82 on the shaft 75 having a cam follower, to which is rigidly connected one end of a horizontally disposed rod 83 the opposite end of which, as at 84, is rigidly connected to a rocker arm 85 oscillatably pivoted upon a bearing pin 86 supported on the frame 54.

On the opposite side of the pin 86 from the bar connection 84, the rocker arm 85 has a head 87 slidable in a slot 88, the head 87 being adjustable by a screw and nut device 89 which may be similar to that associated with the rocker arm 63. A horizontally disposed rod 90 has one

end rigidly secured to the head 87, and extends horizontally therefrom, the opposite end being rigidly secured to a bracket 91 on the side bar 51 of the screen frame.

Both sides of the screen are provided with the rocker arm construction comprising the rocker arm 85, the pin 86, and the rods 83 and 90.

The portion of the rocker arm 63 to which the rod 80 is secured is preferably of angle section having a flange 92 in a plane of oscillation of the rocker arm, and a weight 93 is secured to the flange by a bolt 94 projected through a perforation in the weight and through a slot 95 by which the position of the weight may be adjusted toward and from the pin 62. The weight 93 itself is preferably made adjustable by having the lower portion thereof composed of plates 96—96 secured to the weight proper 93, by a bolt 97.

The portion of the rocker arm 85, to which the rod 83 is connected is likewise made of angular section and has a weight 98 secured thereto by a bolt 99 in a slot 100, and is adjustable by plates 101—101.

Preferably but not essentially the weights 93 and 98 exactly counterbalance the weight of the screen and the screen frame, the weights 93 acting on the rocker arm 63, tending to rock it around the pin 62, and thrusting upwardly on the rod 69 to balance one component of weight of the screen; and the weight 98 on the rocker arm 85 tending to oscillate it on the pin 86 and exert tension in the rod 90 to balance the other component of weight of the screen.

The weight 93 is also adjusted by means of the nut 94 so that the center of gravity of the weight is approximately the same distance from the axis of the pin 62 as the center of the block 64, and similarly the weight 98 is adjusted on its slot 100 until its distance from the axis of the pin 86 is substantially the same as the distance to the center of the block 87.

While not illustrated in Figs. 13 and 14, to avoid complication, it is to be understood that the eccentric cams may be constructed like that illustrated in Fig. 16, whereby the angular phase relation of one cam to another may be adjustably varied.

In one mode of operation of the screen of Figs. 13 and 14, the cams operating the rods 83—83 are in time phase with each other and the cams operating the rods 80—80 are in time phase with each other but displaced 90° angularly from the cams operating the rods 83—83. When this arrangement is provided, and the shaft 75 is driven from a suitable source of power by the pulley 77, the eccentric devices comprising the cam followers 79 and 82 will eccentrically communicate vertical and horizontal vibratory movements to the rods 80 and 83. This movement will vibratorily oscillate the rocker arms 63 and 85 respectively and communicate respectively vertical and horizontal movements to the rods 69 and 90. The rods 69 and 90 communicate an up and down and longitudinal movement respectively and concurrently to the screen frame 51—52 and thereby to the screen 50.

A vibratory cyclical movement is communicated through the flexible rods which are rigidly connected at opposite ends respectively to the screen frame and to the source of the vibratory movement, and the screen being suspended upon springs which expand and contract in correspondence with the movements given to the screen, it is subjected to vibration in accordance with the path of movement determined by the eccentrics. The said rods to which the movement is transmitted longitudinally are themselves flexible whereby pivotal or sliding bearing connections are reduced to the minimum throughout the mechanism.

With the eccentrics set at 90° phase displacement as referred to, the path of motion of all points of the screen will be a circle as described in connection with Fig. 2.

However, the path of movement may be varied by the means hereinbefore described by changing the phase displacement of the eccentrics; by changing the amplitude of the eccentrics and the velocity thereof. And a further variation of movement may be accomplished by connecting different ones of the eccentrics to different driving sources (in a manner not shown but which it is believed will be thoroughly understood by those skilled in the art) whereby the compound movements described above in Fig. 11 or Fig. 17 may be given to the screen frame.

By mounting the eccentric cams 78—78 out of phase with each other a lateral rocking movement of the screen will be accomplished combined with a longitudinal movement effected by the eccentric cams 82—82 with the apparatus shown in Figs. 13 and 14.

Considered transversely the screen will thereby be given a movement such as that indicated in Fig. 12, and considered longitudinally it will be given a longitudinal reciprocatory movement. Such a movement is exemplified in Fig. 11, if the cams 32 and 33 are displaced in phase relationship and the cam 5 is operated, but the cam 6 and rod 4 are removed.

In the foregoing description I have described my invention as being applied to a material handling screen to vibrate the same. As stated hereinbefore this use of my invention is merely illustrative and my invention is not limited thereto but it may be applied with equal usefulness and efficiency to other uses. For example, it may be desirable in some of the arts, to move or convey material on a conveyor element having such movement as that described hereinbefore, for the screen of the specific embodiment of Figs. 13 to 15 inclusive.

An apparatus embodying my invention for this purpose might be constructed substantially the same as that of Figs. 13 and 14, but with a solid plate or the like substituted for the screen of those figures, and with said plate or the like disposed at a suitable angle to the horizontal so that material thereon, during the vibrations of the plate, would progressively move thereover in one direction or the other.

Again in some of the arts, it is desirable to vibrate a mass of material of different kinds or of different sizes, shapes, etc., to stratify the same. My invention may be applied to such uses and an illustrative embodiment thereof would be similar to that of Figs. 13 and 14, but with a sheet or plate substituted for the screen of those figures, and preferably disposed horizontally.

Because of the complete description herein of my invention as applied to a screen, it is believed not to be necessary to further describe or illustrate such other uses.

This application is divisional from my co-pending application, Serial Number 699,691, filed November 25, 1933.

My invention is not limited to the exact details of construction illustrated and described above. Many changes and modifications may be made within the spirit of my invention without

sacrificing its advantages and within the scope of the appended claims.

I claim:

1. In a material handling vibratory apparatus, a bed having a surface for supporting material to be handled, means for applying vibratory forces displaced in time phase relation to laterally opposite portions of the bed and in substantially linear reciprocatory directions at an angle to the bed surface, means yieldably supporting the bed on the main frame permitting it to be moved by said vibratory forces, bed counter-balancing weight means supported on the main frame to move with substantially linear reciprocatory movement, and means connecting the weight means with a said lateral portion of the bed to cause the weight means to be moved oppositely to movement of said lateral portions of the bed.

2. In a material handling vibratory apparatus, a main frame, a bed having a surface for supporting material to be handled, means for applying vibratory forces displaced in time phase relation to laterally opposite portions of the bed and in substantially linear reciprocatory directions at an angle to the bed surface, means for applying vibratory forces to the bed to concurrently move the bed surface with concurrent linear reciprocatory movement in substantially the direction of the bed surface, means yieldably supporting the bed on the main frame permitting it to be moved by said vibratory forces, bed counter-balancing weight means supported on the main frame for reciprocatory movement substantially linearly, and means connecting the weight means with a said lateral portion of the bed to cause the weight means to be moved oppositely to movement of said lateral portion of the bed.

3. In a material handling vibratory apparatus, a main frame, a bed having a surface for supporting material to be handled, means for applying vibratory forces displaced in time phase relation to laterally opposite portions of the bed and in substantially linear reciprocatory directions at an angle to the bed surface, means for applying vibratory forces to the bed to concurrently move the bed surface with concurrent linear reciprocatory movement in substantially the direction of the bed surface, means yieldably supporting the bed on the main frame permitting it to be moved by said vibratory forces, a pair of bed counter-balancing weight means supported on the main frame each for reciprocatory movement substantially linearly, means connecting one weight means with a said lateral portion of the bed to cause the weight means to be moved oppositely to said lateral portion of the bed and means connecting the other said weight means with the bed to cause it to be moved oppositely to said movement of the bed surface in the direction of the bed surface.

GEORGE E. MARKLEY.