May 31, 1960 J. E. DUNN ET AL 2,938,393

VIBRATING APPARATUS

Filed May 31, 1957 2 Sheets-Sheet 1

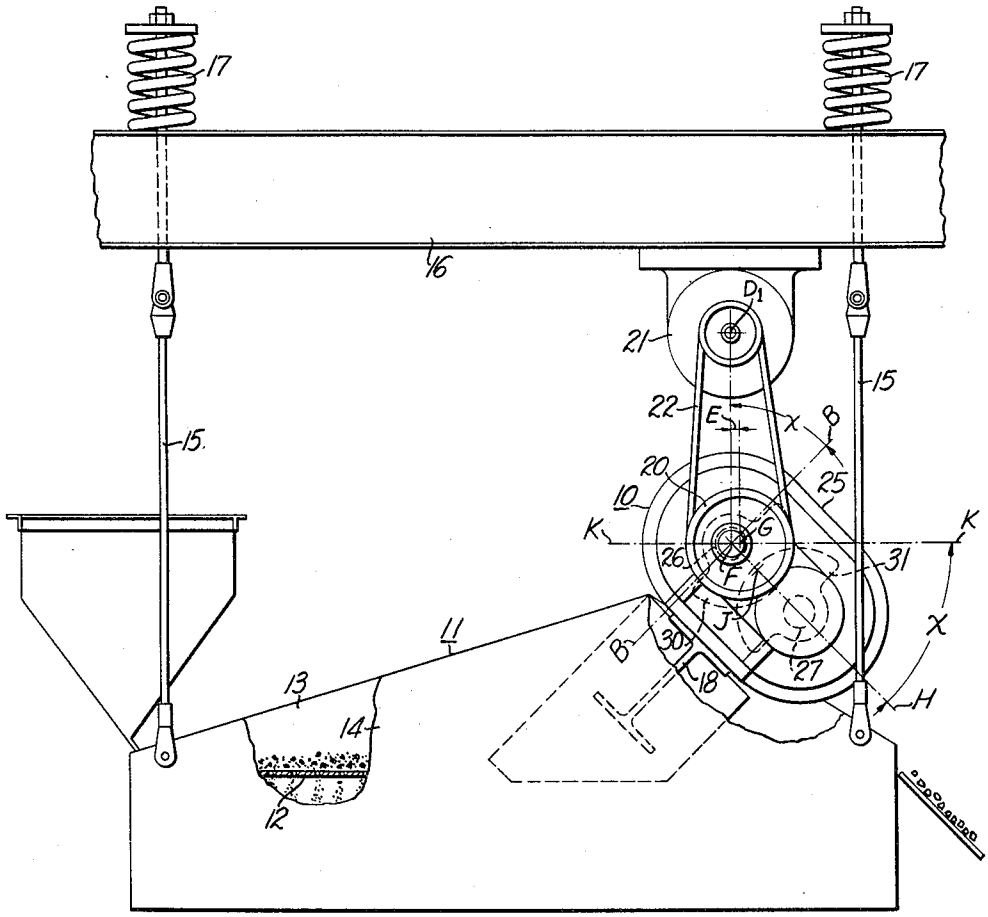


Fig. 1

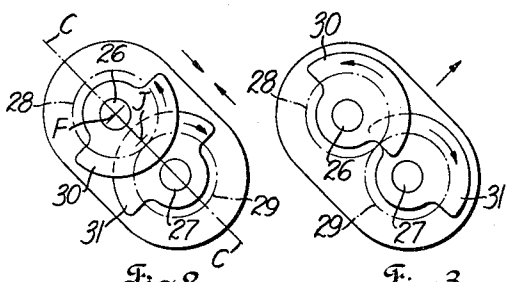


Fig. 2

Fig. 3

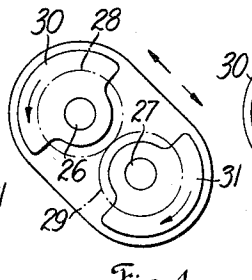


Fig. 4

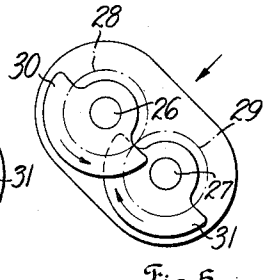


Fig. 5

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VIBRATING APPARATUS

Filed May 31, 1957 2 Sheets-Sheet 2

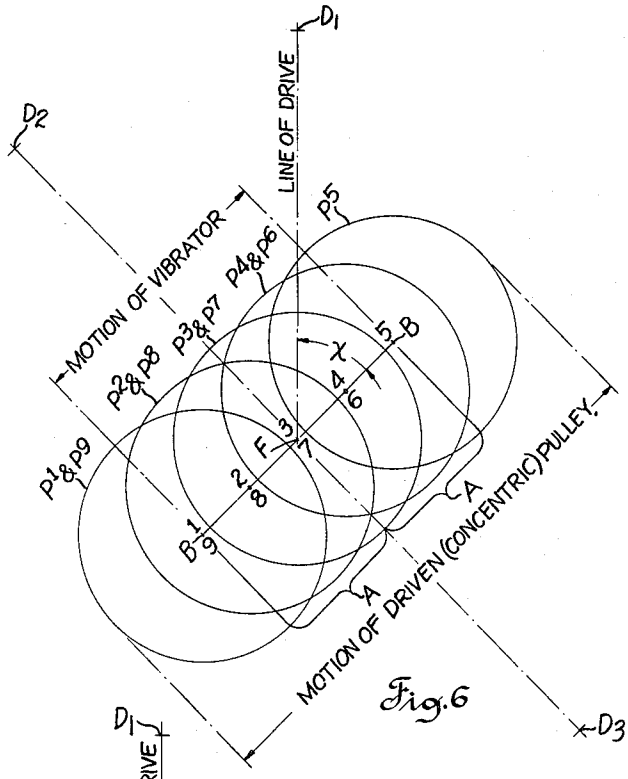


Fig. 6

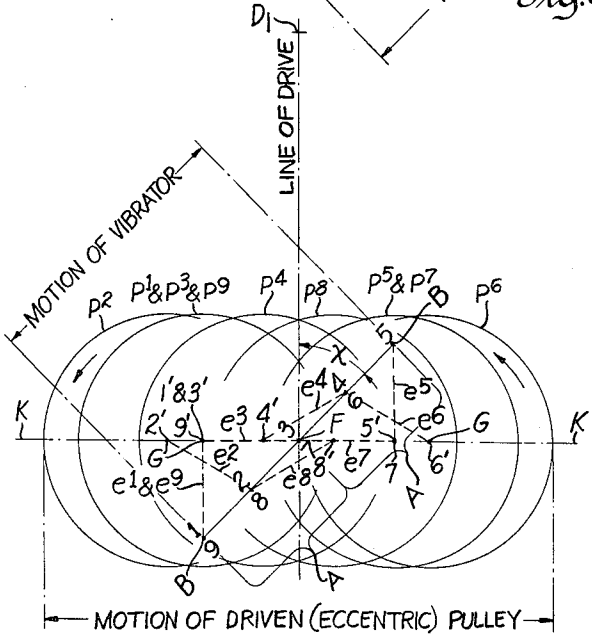


Fig. 7

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United States Patent Office 2,938,393 Patented May 31, 1960

2,938,393

VIBRATING APPARATUS

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Filed May 31, 1957, Ser. No. 662,933

10 Claims. (Cl. 74—61)

This invention relates to vibrating apparatus and particularly to an improved vibrating screen assembly having a vibrator which imparts a straight line or elliptical motion to the vibrating screen body to which the vibrator is attached.

In order to advance material along a screening deck of a vibrating screen as well as agitate it to promote screening action, a vibrator of the type referred to is usually mounted with the major axis of its vibratory motion at an angle of 35 to 50 degrees relative to a horizontally positioned screen deck. In this position the vibrating motion of the vibrator produces a motion of the screen body that has both vertical and horizontal components. The combined motion serves to agitate the material on the screen deck and advance material along the screening surface.

A vibrating screen mechanism of the type referred to herein is disclosed in detail in a patent to C. S. Lincoln et al., U.S. 2,144,382. Mechanisms of this type comprise generally a housing or frame adapted to be connected to a screen body in a position that the line of vibration will be at an angle, usually about 45 degrees, to the horizontally positioned screening surface. To obtain vibrating motion two parallel shafts are mounted in the housing and means, which may be a pair of gears mounted respectively on the shafts in meshing relation, provide counter-rotation of the shafts. Eccentrically positioned weights may be rigidly connected to the shafts and power transmission means such as a pulley connected to one of the shafts for driving the mechanism. Rotation of one of the shafts causes the respective weights mounted on the two shafts to rotate in unison but in opposite directions to provide a reciprocatory motion that is imparted to the screen body. If it is desired to impart an elliptical motion to a screen body, the weights are connected to the shafts in nonsymmetrical relation to each other or the counterweights are attached at different radial positions from their respective shafts or the counterweights may be given different masses relative to each other.

To minimize stretching and slackening of belts connecting the vibrator pulley to a driving motor mounted in a fixed position, it has been necessary in the past to place the driving motor so that a line in the plane in which the pulley rotates, from the driving motor axis to the axis of the vibrator pulley is approximately perpendicular to the path or major axis of the path along which the vibrator vibrates. This line will be hereinafter referred to as the line of drive. According to prior art teachings there are only two positions in which the motor can be placed for the line of drive to be perepndicular to the path of vibration to achieve satisfactory operation with regard to the driving belts, one position being above the vibrator pulley and the other position being below the vibrator pulley. In some installations it has been very difficult or even impossible because of the position of supporting structures or other structures in the building housing the screen assembly, to place the motor at either of the two positions referred to.

It is accordingly an object of the present invention to provide a new and improved vibrating mechanism having a driving motor arranged relative to a pulley on a vibrator, and having a line of drive between the motor and the pulley that may be at any angle to a path of vibratory movement of the vibrator and yet provide the minimum stretching and slackening of driving belts heretofore obtainable only when the line of drive was perpendicular to the major axis of the path of vibratory movement.

Another object of the present invention is to provide a vibrating mechanism having a vibrator driven by a pulley, in which the pulley will move only along a path perpendicular to the line of drive from a driving motor to the vibrator when the direction of vibratory movement relative to the line of drive is not perpendicular.

Another object of the present invention is to provide a vibrating screen assembly having a vibratory motion, in which stretching or slackening of driving belts will be minimized regardless of the position of a line of drive between a driving motor and the vibrating assembly and the path of vibration of the entire screen assembly.

Another object of the present invention is to provide a new and improved vibrating screen assembly having a vibrating mechanism producing a vibratory movement along a line disposed at a predetermined angle to the horizontal and in which arrangement the driving motor may be placed directly above or below the vibrator.

Other objects and advantages will appear from a detailed description of the invention, one embodiment of which will be described as illustrated in the accompanying drawings.

According to a preferred embodiment of the present invention, a vibrating screen is provided with a vibrating assembly of the type referred to as being described in the patent to C. S. Lincoln et al., U.S. 2,144,382. A pulley is mounted on an operating shaft of the vibrating mechanism and this pulley is connected to a driving motor by one or more driving belts. The pulley mounted on the operating shaft of the vibrating mechanism according to the present invention is eccentrically bored and mounted to be eccentric to the axis of rotation of the operating shaft of the vibrating mechanism. The eccentricity of this sheave is of an amount to provide a resulting motion of the eccentric pulley that will be along a path having a major axis that will always be perpendicular to the line of drive from the driving motor to the vibrating mechanism when the vibrating mechanism is at the midpoint of its amplitude of vibration. The manner in which this is accomplished and the significance of this result may be understood with reference to the drawings in which:

Fig. 1 is an elevation view of a vibrating screen equipped with a vibrating mechanism of the type to which the present invention is directed;

Figs. 2, 3, 4 and 5 are diagrammatic views of the vibrating mechanism in four successive positions;

Fig. 6 is a diagrammatic illustration to enlarged proportions showing the motions resulting from the application of a vibrating mechanism constructed according to the prior art and in which a line of drive from the vibrating mechanism to a driving motor lies in a vertical position; and

Fig. 7 is a diagrammatic illustration also to enlarged proportions to illustrate the resulting motions of a vibrating assembly constructed according to the present invention and applied to an arrangement in which the line of drive is in a vertical position.

For simplified explanation, Fig. 1 shows the invention applied to a straight line type vibrating mechanism 10 in a vibrating screen assembly. The explanation will apply to a vibrator having an elliptical path if the line B—B in Figs. 6 and 7 be considered the major axis of the elliptical path.

The vibrating screen illustrated comprises a screen body **11** having one or more screen decks **12** supported between side plates **13, 14**. The screen **11** is suspended by four cables **15** which are attached to an overhead support **16** by helical springs **17**.

The mechanism **10** is mounted rigidly on the screen body **11** by means of a support **18** and is provided with a power transmission member or pulley **20** through which it may be operated. A motor **21** is shown in this embodiment as being mounted on stationary support **16** and is utilized to drive the vibrating mechanism **10** through one or more driving belts **22**. The support **18** is mounted in line with the force exerted by the operation of the vibrating mechanism **10**. The angle between the screen deck **12** and the direction of force exerted by the vibrating mechanism **10** may have any suitable value herein illustrated as approximately 45 degrees. The support **18** which also serves to transmit the vibrating force to the screen body **11** has the longitudinal center line thereof passing substantially through the center of gravity of the screen so that all parts of the screen are reciprocated equally.

The construction of the vibrating mechanism **10** may be as disclosed in the patent to Lincoln et al., U.S. 2,144,382 previously referred to. A housing **25** is provided having side walls which carry a pair of parallel shafts **26, 27**. One end of the shaft **26** protrudes from the housing and the pulley **20** is mounted thereon. Gears **28, 29** shown in broken lines in Fig. 2 are mounted concentrically on the shafts **26, 27** for mutual engagement whereby the rotation of the pulley **20** serves to rotate the two shafts in opposite directions.

To provide straight line vibratory motion equal eccentric weights **30, 31** are mounted on the shafts **26, 27**, respectively, as shown in Figs. 2, 3, 4 and 5. The weights **30, 31** in the particular vibrator illustrated are oriented on the shafts as shown in Fig. 2 so that when the center of gravity of the weight **30** on shaft **26** is between the two shafts and in a plane C—C defined by the axis of both shafts, the center of gravity of the other weight **31** on the other shaft **27** is also between the two shafts and in the plane C—C.

The operation of the vibrating mechanism to produce rectilinear vibrations is illustrated in Figs. 2 through 5 which show diagrammatically the location of the eccentrically positioned weights **30, 31** at four successive positions 90 degrees apart during rotation of the shafts.

In vibrating screens constructed according to the prior art as illustrated in the previously referred to Lincoln patent, a concentrically bored pulley or sheave was mounted on the operating shaft **26** of the vibrating mechanism **10**. Such prior art structures have a serious disadvantage which is illustrated in Fig. 6 of the drawings. Fig. 6 of the drawings illustrates diagrammatically the motion of a concentrically bored pulley along a straight line path of vibration. The mean line of vibration is identified in Fig. 6 as line B—B and numbers 1 through 9 locate arbitrarily chosen points along the line of vibration for reasons which will appear. For a vibrator as shown in the Lincoln patent referred to, the mean path of vibration is a straight line indicating the actual path of vibration. For a vibrator that vibrates along a nonstraight line path such as an ellipse, line B—B is representative of the mean path of vibration which is in the case of an ellipse, the major axis of the ellipse. The vibrating mechanism represented in this figure may be mounted with respect to a screen so that the line of vibration B—B is approximately at a 45 degree angle to the screen decks to obtain effective agitation and advancement of material along a screening deck. The disadvantages of the prior art structures can be illustrated by assuming a driving motor mounted with its axis of rotation located at the point identified as D1 in Fig. 6. The line of drive for such an arrangement is so labeled in Fig. 6 and is a line joining the axis of rotation of the driving motor D_1 with a point numbered 3 and 7 along the line of vibration B—B. The point labeled 3 and 7 represents the position of the vibrating mechanism at the midpoint of its vibration between the point 1–9 on one end of the line and the point 5 on the opposite end of the line. The use of a concentrically bored pulley as illustrated in Fig. 6 results in the geometric center of the pulley always being on a line B—B that represents the path of motion of the vibrating mechanism drawn through the center of the pulley at its midposition 3–7. In other words, the path of travel taken by a concentrically bored driving pulley makes the same angle with the horizontal and with the line of drive as does a line representing the path of vibrating motion of the vibrating mechanism itself.

The motion of the pulley illustrated in Fig. 6 is such that as the pulley moves from a position P^1 with its center at point 1 on line B—B through position P^2 with its center at point 2 and so on to position P^5 with its center at point 5. Thus the pulley has moved substantially closer to the point D_1 which represents the rotating axis of a driving motor. Therefore if driving belts were to be fitted on the pulley when the pulley is in its position P^1 it can be seen that when the pulley moves to position P^5 sufficient slackening of the belts can result so that no rotary motion is transmitted to the pulley in position B5. Likewise if driving belts were fitted on the pulley when in position P^5 movement of the pulley through positions labeled P^6 to P^9 can stretch the belts beyond their elastic limit causing them to break. If the belts are fitted to the pulley for position P^3—P^7 alternate stretching and slackening of the belts will occur. Thus it can be seen that the smaller the acute included angle x between the line of drive 3—D_1 and the line B—B the greater this problem becomes. The solution to this problem before the present invention was to place the driving motor so that its axis of rotation would be at either of the two points labeled D_2 or D_3 in Fig. 6. With the driving motor located at one of these two positions the amount of change in the length of a line from the point D_2 or D_3 to the center of the pulley as the center of pulley moved through positions 1 through 9, is minimized. As previously stated such a solution to the problem was not always possible because of the inability to locate the driving motor at either of the points D_2 or D_3. It has therefore long been desirable to have an arrangement in which the driving motor could be located at points other than D_2, D_3 and yet avoid the problem illustrated in Fig. 6.

According to the present invention the pulley **20** as shown in Fig. 1 is eccentrically bored to be mounted eccentrically with regard to the axis of the shaft **26**. The distance between the geometric center of the pulley **20** and the axis of the eccentric bore of pulley **20** for any desired location of the driving motor **21** other than the locations identified as D_2 and D_3 in Fig. 6 is determined by the formula

$$\underline{E} \text{ equals } \underline{A} \text{ cosine } x$$

A represents the amplitude of vibration of the vibrating mechanism along the line of vibration B—B, which is one-half of the total throw. In other words, as illustrated in Figs. 6 and 7, A is the distance between the point 3–7 and the point 5; or the point 3–7 and the point 1–9. x represents the acute included angle between the path of vibration B—B of the vibrating mechanism **10** and the line of drive 3–D_1. With the eccentricity of the pulley **20** so determined, the eccentrically bored pulley is oriented on shaft **26** as shown in Fig. 1, so that when the vibrator mechanism **10** is at the midpoint of its vibration, as also shown in Fig. 2, that in the plane of the pulley **20** (which is a parallel of the side plates **13, 14**) a line K—K through the axis of rotation F of shaft **26** and the geometric axis G of the pulley **20**, shall be from and form an angle with a second line F—J—H which is a line from the axis of rotation F of the shaft **26** through the center of gravity J of the weight **30**, of x degrees measured in the same

clock reference direction from the line F—H as the line of drive F—D_1 is disposed from the line B—F—B.

With specific reference to the embodiment shown in Fig. 1, wherein the driving motor **21** is directly above the pulley **20** and the line of drive F—D_1 lies 45 degrees in a counterclockwise direction from the line F—B, the eccentricity

E equals A (cos x) which, when x =45° equals $\sqrt{2}/2$ times A

the amplitude of vibration of the vibrating mechanism from its midposition to its maximum displacement in one direction from its midposition. With an eccentricity equal to $A\sqrt{2}/2$ in this specific embodiment the pulley is oriented so that in the plane of the pulley the line F—G—K is disposed from the line F—J—H 45 degrees in a counterclockwise direction.

With an arrangement as has just been described minimum stretching and slackening of driving belts from the driving motor to the pulley **20** is obtained despite the fact that the line of drive is not perpendicular to the line B—B as illustrated by the line of drive D_2—F or D_3—F, illustrated in Fig. 6.

The manner in which this result is accomplished by the construction and arrangement described, can be illustrated with reference to the diagram shown in Fig. 7. Fig. 7 shows a line of drive forming an acute included angle x of 45 degrees with the path of vibratory motion B—B of the vibrating mechanism. The angle x is the same in Fig. 7 as in Fig. 6. Fig. 7 however illustrates the motion of a pulley that is bored and oriented according to this invention. The geometric center G of the pulley shown in Fig. 7 does not move along the line B—B as does the center of the pulley shown in Fig. 6. Fig. 7 shows that the geometric center G of a pulley bored and arranged according to this invention moves along a line K—K which is always perpendicular to the line of drive F3—D_1. The movement of the eccentrically bored pulley shown in the diagram of Fig. 7 can be traced through the same nine positions illustrated in Fig. 6 to point out the difference in the movement of the pulley acheved by this invention.

In the specific embodiment shown in Fig. 1 and diagramed in Fig. 7 when the eccentrically bored pulley is in the position labeled P^1 in Fig. 7 the eccentric axis F will lie upon line B—B at point 1 and the geometric axis G of the pulley will lie along the line K—K at the point numbered 1'. The eccentric axis F and the geometric axis G are spaced apart by the distance E which represents the eccentricity as determined according to this invention. In this figure the two points 1 and 1' are joined together by a dotted line labeled e^1 to more clearly illustrate the relative positions of points 1 and 1' and the motion to be described. When the pulley **20** is rotated by the driving motor **21** in the direction of the arrows shown in Fig. 7 the pulley will move to position P^2 the eccentric axis F of the pulley **20** will move upwardly along the line B—B to the point numbered 2 and the geometric axis G of the pulley will move outwardly along the line K—K to the point 2'. As the pulley continues to rotate and moves to position P^3 the eccentric axis F moves still further up the line B—B to the point 3 while the geometric axis G returns along the line K—K to the point numbered 3' which is coincident with the point 1'. The next position P^4 shows the eccentric axis F of the pulley at point 4 on the line B—B with the geometric center G at point 4' on the line K—K. Position P^5 which represents the uppermost point of travel of the vibrating mechanism **10** finds the eccentric axis F of the pulley at point 5 on the line B—B and the geometric axis G of the pulley at point 5' on the line K—K. From this position the vibrating mechanism **10** begins its downward motion and the eccentric axis F of the pulley moves to point 6 on the line B—B and the geometric axis G to point 6' on the line K—K. The next position illustrated P^7 finds the pulley once again at its midposition with the eccentric axis F at point 7 on line B—B and the geometric axis G of the pulley at point 7' on the line K—K. For this midposition it can be noted that the eccentric axis F at point 7 on line B—B also lies on line K—K and line of drive F—D_1. This of course represents the position at which driving belt should be fitted to the pulley in order to have a minimum and equal change in the distance between the pulley **20** and the driving motor **21** as the pulley **20** moves along the line B—B. The next position shown finds the pulley in position P^8 with the eccentric axis F at point 8 on the line B—B and the geometric axis G at point 8' on the line K—K. The final position P^9 to illustrate one complete cycle of the vibrator finds the eccentric axis F at point 9 on line B—B which is coincident with point 1 and geometric axis G at point 9' along the line K—K which is coincident with the points 1' and 3'.

While a particular embodiment has been shown and described in which a driving motor is mounted directly over the operating pulley of the vibrating mechanism to form an angle of 45 degrees between the line of drive and the path along which the mechanism vibrates and that this provides a long sought construction and arrangement having particular advantages, it is to be understood that the invention is not to be so restricted but that by this invention a construction and arrangement is disclosed which permits the location of a driving motor **21** in any position establishing an acute included angle x between the line of drive G—D and the path of vibration B—B of a vibrating mechanism and achieves the desired result of minimum change in the distance between a driving motor **21** and an operating pulley **20** on a vibrating mechanism of the type described. Moreover, the invention may be applied to other types of vibrators and to vibrate apparatus other than screens, such as sieves, hoppers, sifters, tappers, packing and tamping apparatus etc., and is especially applicable to feeders and conveyors of the reciprocated type.

What is claimed is:

1. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, eccentric weight means fixed on each shaft, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A \cos x$$

when A represents the amplitude of vibration of the vibrator and x the acute included angle between a line representing the mean path of vibration and a line of drive defined as a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration.

2. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal

angular velocities, eccentric weight means fixed on each shaft, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A \cos x$$

when A represents the amplitude of vibration of the vibrator and x the acute included angle between a line representing the mean path of vibration and a line of drive defined as a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; and said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so, in a plane perpendicular to said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft x degrees in the same clock reference direction from said second line as said line of drive measures said x degrees from said line representing the mean path of vibration.

3. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A \cos x$$

when A represents the amplitude of vibration of the vibrator and x the acute included angle between a line representing the mean path of vibration and a line of drive defined as a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; and said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so, in a plane perpendicular to said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft x degrees in the same clock reference direction from said second line as said line of drive measures said x degrees from said line representing the mean path of vibration, and said angle x being less than 90 degrees.

4. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; and said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A \cos x$$

when A represents the amplitude of vibration of the vibrator along a straight line path perpendicular to said plane from midposition to maximum displacement from said midposition in one direction and x the acute included angle between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration.

5. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A \cos x$$

when A represents the amplitude of vibration of the vibrator along a straight line path perpendicular to said plane from midposition to maximum displacement from said midposition in one direction and x the acute included angle between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; and said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so that, in a second plane perpendicular to said first plane and said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft x degrees in the same clock reference direction from said second line as said line of drive measures said x degrees from said path.

6. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of

parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A\cos x$$

when A represents the amplitude of vibration of the vibrator along a straight line path perpendicular to said plane from midposition to maximum displacement from said midposition in one direction and x the acute included angle between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so, in a second plane perpendicular to said first plane and said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft x degrees in the same clock reference direction from said second line as said line of drive measures said x degrees from said path, and said angle x being less than 90 degrees.

7. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance equal to $A(\sqrt{2}/2)$ from the geometric center of said sheave when A represents the amplitude of vibration of the vibrator from midposition to maximum displacement from midposition in one direction along a straight line path perpendicular to said plane, and said driving sheave is located to provide an acute included angle of 45 degrees between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration.

8. In combination with a vibrator resiliently mounted for vibratory movement in space and having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, and a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, the improvement comprising: a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance equal to $A(\sqrt{2}/2)$ from the geometric center of said sheave when A represents the amplitude of vibration of the vibrator from midposition to maximum displacement from said midposition in one direction along a straight line path perpendicular to said plane, and said driving sheave is located to provide an acute included angle of 45 degrees between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; and said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so that, in a second plane perpendicular to said first plane and said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft 45 degrees in the same clock reference direction from said second line as said line of drive measures said 45 degrees from said path.

9. In a screen assembly mounted for vibratory movement comprising a vibrator rigidly connected thereto, said vibrator having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance E from the geometric center of said sheave an amount determined by the formula

$$E=A\cos x$$

when A represents the amplitude of vibration of the vibrator along a straight line path perpendicular to said plane from midposition to maximum displacement from said midposition in one direction and x the acute included angle between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude

of vibration so that, in a second plane perpendicular to said first plane and said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft x degrees in the same clock reference direction from said second line as said line of drive measures said x degrees from said path, and said angle x being less than 90 degrees.

10. In a screen assembly mounted for vibratory movement comprising a vibrator rigidly connected thereto, said vibrator having a pair of parallel coextensive shafts, motion translating means connecting said shafts to rotate one of said shafts in response to rotation of the other of said shafts with rotation of said shafts being in opposite directions at equal angular velocities, and equal eccentric weight means fixed on each shaft with said shafts being so oriented that when the center of gravity of the weight means on one shaft is between said shafts and in a first plane defined by the axis of both shafts the center of gravity of the weight means on the other shaft is also in said plane and between said shafts, said vibrator is arranged to position said first plane at a 45 degree angle to the horizontal, a driving sheave rotatable about an axis substantially fixed in spaced parallel relation to one of said shafts, a sheave eccentrically mounted on a first of said shafts; flexible belt means drivingly connecting said driving sheave to said eccentric sheave to rotate said eccentric sheave and said interconnected shafts; said eccentric sheave being mounted on said first shaft eccentrically a distance equal to $A(\sqrt{2}/2)$ from the geometric center of said sheave when A represents the amplitude of vibration of the vibrator from midposition to maximum displacement from said midposition in one direction along a straight line path perpendicular to said first plane, and said driving sheave is located to provide an acute included angle of 45 degrees between said path and a line of drive being a line between said axis of rotation of said driving sheave and the axis of rotation of said first shaft when said vibrator is at the midpoint of its amplitude of vibration; and said eccentric sheave being oriented on said first shaft when said vibrator is at the midpoint of its amplitude of vibration so that, in a second plane perpendicular to said first plane and said shafts, that a first line from the axis of rotation of said first shaft through the geometric center of said eccentric sheave shall be from a second line from said axis of rotation of said first shaft through the center of gravity of said weighted first shaft 45 degrees in the same clock reference direction from said second line as said line of drive measures said 45 degrees from said path.

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