C. L. MILLER.

RECIPROCATING MECHANISM.

APPLICATION FILED NOV. 10, 1917.

1,280,269.

Patented Oct. 1, 1918.

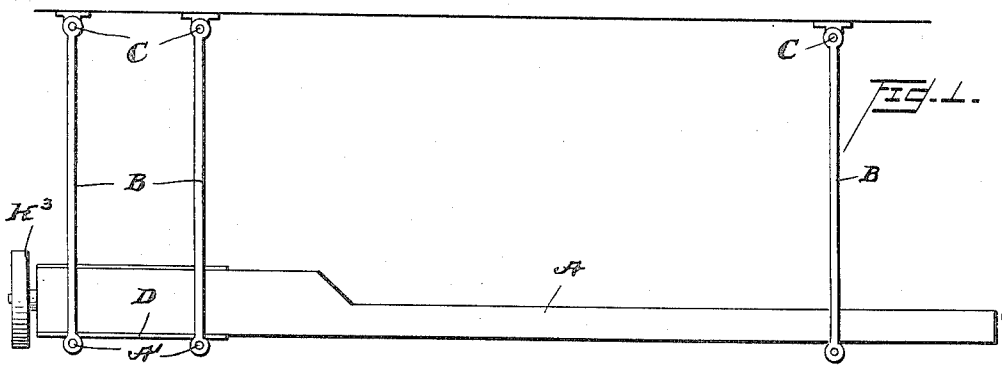



FIG. 1.

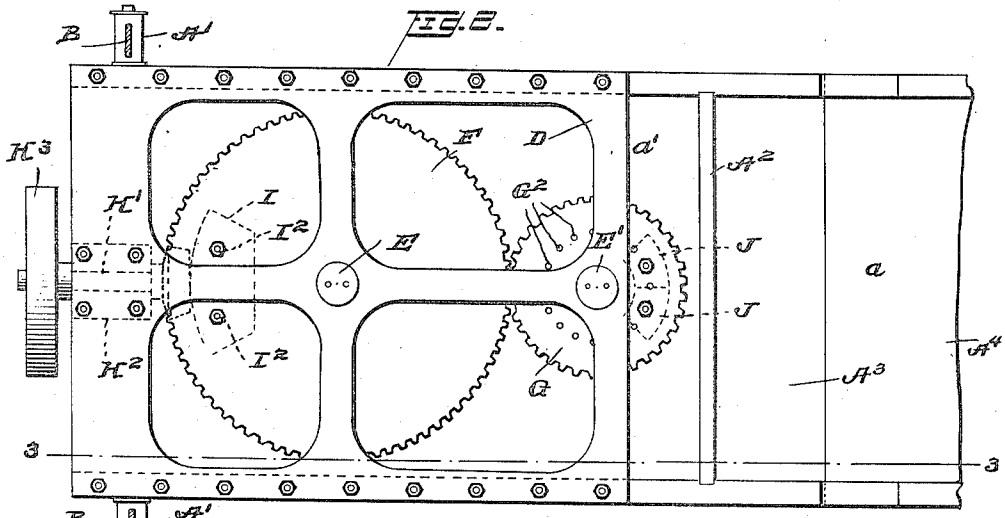



FIG. 2.

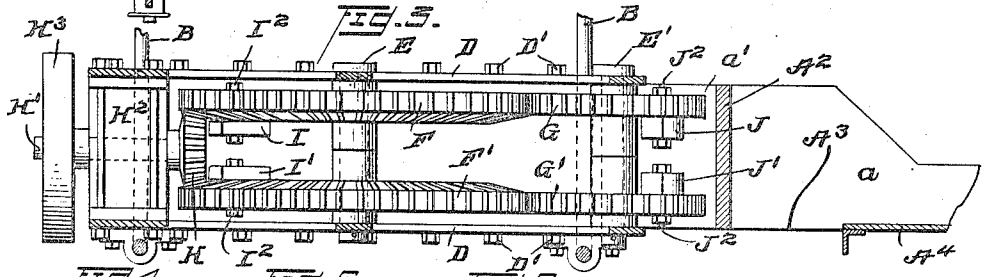



FIG. 3.

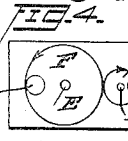



FIG. 4.

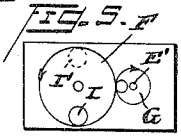



FIG. 5.

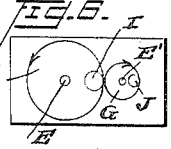



FIG. 6.

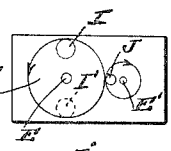



FIG. 7.

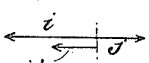



FIG. 8.

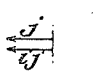



FIG. 9.

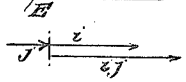



FIG. 10.

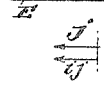



FIG. 11.

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# UNITED STATES PATENT OFFICE.

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## RECIPROCATING MECHANISM.

1,280,269. Specification of Letters Patent. Patented Oct. 1, 1918.

Application filed November 10, 1917. Serial No. 201,266.

*To all whom it may concern:*

Be it known that I, CHARLES L. MILLER, a citizen of the United States of America, and resident of Scottdale, in the county of Westmoreland and State of Pennsylvania, have invented a certain new and useful Improvement in Reciprocating Mechanism, of which the following is a true and exact description, reference being had to the accompanying drawings, which form a part hereof.

The object of the present invention is to provide improved means for giving such vibratory impulses to a body mounted with freedom to reciprocate that the acceleration given the body in one direction will be greater than the maximum acceleration in the opposite direction. The invention is well adapted for use with horizontally disposed reciprocating screens, chutes, troughs, concentrating tables and the like to induce a progressive movement of particles resting on the screen or other body horizontally along the latter.

In carrying out my invention I employ a plurality of systems of revolving bodies which I ordinarily mount directly on the screen or other body to be vibrated. Each system consists of one or more bodies revolving with the same angular velocity which is different from that at which the body or bodies forming the other system or systems revolve. Each of these revolving bodies is mounted to revolve about an axis laterally displaced from the center of gravity of the body. The eccentrically mounted weights of the two systems are so relatively arranged and rotated that the maximum joint centrifugal effect of the various revolving bodies in one of the two directions of movement permitted the screen or other body to be vibrated will be greater than the maximum joint centrifugal effect of the bodies in the opposite direction. In consequence the maximum acceleration given to the vibrating screen or like device will be greater in one direction than the other. This tends to move particles supported by the screen or like object progressively in a direction opposite to that in which the acceleration of the screen or like object is most rapid.

In a simple preferred mode of carrying out my invention each system of revolving bodies comprises two similar eccentrically mounted weights rotating in opposite directions and each exerting its maximum centrifugal effect along the line of movement of the screen or like vibrating body at the same instants and in the same direction, and I revolve the two bodies forming one system with half the angular velocity of the bodies forming the other system. A desirable consequence of employing two similar oppositely rotating weights in each system is that the components of the centrifugal pulls of the weights in a direction transverse to the line of movement of the screen may thereby be balanced.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed hereto and forming a part of this specification. For a better understanding of my invention, however, and the advantages possessed by it reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment.

Of the drawings:

Figure 1 is an elevation of a shaking table actuated by my novel vibration producing means.

Fig. 2 is a plan view on a larger scale of a portion of the shaking table shown in Fig. 1.

Fig. 3 is a section taken on the line 3—3 of Fig. 2.

Figs. 4, 5, 6 and 7 are diagrammatic views illustrating the different relative positions of the revolving weights at successive intervals.

Figs. 8, 9, 10 and 11 are force diagrams showing the centrifugal forces acting in the direction of movement of the table exerted by the revolving weights in the positions of the latter shown in Figs. 4, 5, 6 and 7 respectively.

In the drawings, A represents the shaking table proper, which, as shown, is supported by hangers B, pivoted at their upper ends to supports C, and each pivotally connected at its lower end to a corresponding journal A′ forming a part of the shaking table. The table is thus free to vibrate in a plane transverse to the journal A′. The shaking table, as shown, comprises side frame members which form the side walls of a compartment A of which $A^4$ forms the bottom, or table proper. The material to be treated by the shaking table is fed on to right hand end of the table bottom $A^4$, and

after moving over the latter is discharged through the outlet $A^3$.

The mechanism for giving the shaking table its vibratory motion comprises a pair of revolving members F and F' journaled on a vertical shaft E, which is shown as secured at its ends in the skeleton frame members D and D' secured to the shaking table proper. The members F and F', in the form shown, are similar gear wheels provided with peripheral gear teeth which mesh with the peripheral gear teeth of gear wheels G and G' journaled on a vertical shaft E' also mounted in the frame members D and D'. The members F and F' are also formed with bevel gear teeth on their adjacent sides which mesh with a bevel driving gear H carried by a shaft H' journaled in a bearing $H^2$ secured between the frame members D and D'. The shaft H may be rotated with the desired velocity in any convenient manner. As shown, it is provided at its outer end with a pulley by which the shaft may be rotated through a belt by a motor supported independently of the shaking table.

The revolving member F carries an eccentrically mounted weight I, and the wheel F' carries a similar and similarly mounted weight I'. As shown, each of these weights is secured to the wheel carrying it by a bolt $I^2$. The wheel G in the form shown carries two similar eccentrically mounted weights J, each secured in place by a corresponding bolt $J^2$. Similarly the wheel G' carries a pair of weights J', each of which is secured in place by a corresponding bolt $J^2$. Each of the gear wheels G and G' has half as many gear teeth as each of the gear wheels F and F', so that the wheels G and G' revolve with double the angular velocity of the wheels F and F'. The various weights I, I', J and J', as shown, are so relatively positioned on the corresponding gear wheels that when the latter are in the relative positions shown in Figs. 2 and 3 the center of gravity of the weight I and of the two weights J are in the same vertical plane passing through the axes of the shafts E and E' and on opposite sides of said axes, while the centers of gravity of the weights I' and of the two weights J' also lie in the same plane and on the opposite sides of the axes.

When the shaft H is rotated, the gear wheels F and F' are rotated in opposite directions with the same angular velocity. As the wheel F rotates, the weight I passes successively through the positions relative to the shaft E, illustrated in Figs. 4, 5, 6 and 7. In the positions illustrated in Figs. 4 and 6 the weight I' lies immediately beneath the weight I. In the intermediate positions shown in Figs. 5 and 7 the weights I and I' lie on opposite sides of their common axis of rotation. The weights J and J' vary their positions with respect to their common axis of rotation in a manner similar to that in which the weights I and I' vary their positions with respect to the axis of the shaft E, except that the weights J and J' make twice as many revolutions as the weights I. When the parts are in the positions shown in Fig. 4 the centrifugal effect of the weights I and I' are in the same direction, namely, to the left, and directly opposed to the centrifugal effect of the weights J and J'. In the positions shown in Fig. 6 the full centrifugal effect of the two weights I and I' is to the right and the full centrifugal effect of the weights J and J' is in the same direction.

In all positions of the weights I and I', except those in which the weights have their centers of gravity in a line passing through the axes of the shafts E and E', the centrifugal pulls of the weights I and I', will include components transverse to the said line, but the transverse components of the centrifugal forces exerted by the two weights will always be equal and opposite. Similarly the centrifugal forces exerted by the weights J and J' will include components transverse to the line of movement permitted the table, which are equal and opposite. In consequence, these various transverse components do not tend to give the table any movement of translation transverse to its permitted and intended line of movement.

In the diagrammatic Figs. 8, 9, 10 and 11, $i$ represents the resultant of the components of the centrifugal forces to the weights I and I' in a direction parallel to the line of movement permitted the table, and $j'$ represents the component in the same direction of the centrifugal forces exerted by the weights J and J'. In each of these figures, $ij$ represents the resultant of the centrifugal forces exerted on the table by all of the revolving weights I and I' and J and J'. As these diagrams make clearly apparent, the maximum value of $ij$ occurs when and only when the weights are in the positions shown in Fig. 6. With the weights in the positions shown in Fig. 6 the full centrifugal pull of each is to the right. With the maximum value of the component $i$ much larger than the maximum value of $j$, as indicated in the diagrams, the maximum resultant centrifugal pull of the weights to the left will occur when the weights are in the position shown in Fig. 4. With certain smaller maximum values of $i$ relative to the maximum value of $j$ the maximum pull to the right will occur when the weights are near the positions occupied by them in Fig. 7, as will be readily apparent to those skilled in the art. Regardless of the relative masses of the weights and their eccentricities the maximum centrifugal

pull exerted by them along the path of movement of the table will be greater in one direction than in the other.

With the particular mounting for the table described the table swings upward in each direction from the position occupied by it when at rest and the acceleration of the table produced by the centrifugal forces is modified by the action of gravity to a slight extent. Furthermore, when the material supported by the table starts to slide, as hereinafter explained, the relation between the centrifugal pull or accelerating force, and the acceleration which it gives the table is slightly modified. In general, however, the acceleration of the table at any instant will be in the same direction as, and directly proportional, or approximately so, to the component of the resultant of the centrifugal forces of the various weights I, I′, J, and J′, acting in the direction of movement permitted the table at that instant. In consequence the arrangement described insures a maximum acceleration of the table in one direction greater than the maximum acceleration of the table in the opposite direction. It will be understood, of course, that I use the term acceleration in its generic sense to designate a change in velocity regardless of whether the change in velocity is an increase or decrease.

The movement of the shaking table in either of the two directions of movement permitted it, tends to impart similar movements to free particles supported by the table. The extent to which these particles share the reciprocatory movements of the table depends upon the character of the contact friction between the particles and the table, and the acceleration of the latter. With the table horizontal, and with any usual contact friction, slow reciprocatory movements of the table will be shared by the particles supported thereby. As the speed of reciprocation increases a point will be reached at which the acceleration of the table during a portion of the time required for each complete reciprocation of the table will be so great that the inertia of the particles tending to prevent them from sharing the changes in velocity of the table, overcomes the frictional force tending to cause the particles to travel with the table.

With the table horizontally disposed similar reciprocatory movements, with similar rates of acceleration of the table made rapidly enough to prevent the particles from fully sharing these movements, would simply cause the particles to slide back and forth on the table, and would not give them any progressive movement along the table or screen in either direction. Where, however, as in accordance with the present invention, the maximum acceleration of the table is greater in one direction than in the opposite direction the particles may be given progressive movements in one direction over the table by reciprocatory movements of the table caused by the centrifugal effects of the revolving weights. The direction of progressive movement of the particles will, of course, be opposite to the direction of movement of the screen in which the acceleration is most rapid.

The character of the progressive movement of the particles over the table may be varied, of course, by inclining the table to the horizontal. While the table must necessarily be generally horizontal, a suitable proportioning of the parts and of speed of operation may be employed to give the particles a desired progressive movement in one direction, regardless of whether the table is exactly horizontal or is slightly inclined, either up or down, from the horizontal. An increase in the speed of rotation of the revolving weights tends, of course, to increase the progressive motion of translation of the particles over the screen, and the progressive motion of the particles may also be varied, and in ordinary practice may best be varied by varying the relative centrifugal forces exerted by the weights I and I′ on the one hand, and the weights J and J′ on the other hand. This variation may readily be obtained by varying the distance between the centers of gravity of the two weights J, and similarly varying the relative positions of the two weights J′. For this purpose each of the wheels G and G′ is formed with a series of bolt holes, $G^2$ to receive the bolts $J^2$, by which the weights J and J′ are secured to their carrying wheels. The spreading of the two weights J and J′ thus made possible operates in the same way as would a reduction of the masses of the two weights or an adjustment of the centers of gravity of the weights toward their axis of rotation.

The arrangement described for securing the weights J and J′ to their supporting wheels also makes possible a change in the phase relation of these weights relative to the weights I, so that when the weight I is in the position shown in Fig. 6, for instance, the weight J may occupy a position slightly behind that in which the weight J is shown in Fig. 6. Adjustments if this character may be necessary to get the best results under differing operating conditions, and particularly in handling materials having different coefficients of contact friction with the table. These phase adjustments of the weights tend to displace or shift the portions of the movements of the table in which the particles slip over the table. With the particular setting of the weights illustrated in the drawings, slippage of the particles to the left commences somewhat before the table completes its movement to the left and continues during the initial portion of the

movement of the table to the right. In other words, with this setting, the slippage is started by so suddenly arresting the movement of the table to the left that the particles overrun the table, and is continued during the initial portion of the movement of the table to the right by in effect jerking the table from beneath the particles. By shifting the weights so that when the weight I is in the position shown in Fig. 6 the weight J will occupy a position somewhat in advance of that shown in Fig. 6, the slippage of the particles over the table may be wholly confined to the initial movements of the table to the right. In an analogous manner, by placing the weight J slightly to the rear of the position occupied by it in Fig. 6 when the weight I is in the position shown in that figure, the slippage of the particles may be confined wholly to the final portions of the strokes of the table to the left. It will be understood, of course, that in order to avoid unbalanced transverse components when the weights J are adjusted relatively to the weight I the weights J′ must also be so adjusted that the weights J and J′ will still cross the plane, including the axes of the shafts E and E′ at the same instants.

In general the revolving weights should be so proportioned with regard to their masses, their eccentricities, and their speeds of revolution that slippage between the table and the material supported by, and progressively moved over the latter, will occur in one direction only, though where much agitation of material is required a small slippage in one direction and a greater slippage in the opposite direction may not be undesirable. In general also the parts should be so proportioned and adjusted as to avoid more abrupt changes in acceleration than are required to produce the desired agitation and slippage of the particles over the table, since the more violent the changes in acceleration, the greater are the shocks and wear thereby given the table and its operating mechanism, and in general the greater the power consumption required for a given useful effect.

With the mechanism described the progressive movement imparted to the material in one direction tends to produce a displacement of the table in the opposite direction. This tendency must be counteracted in some way. With the particular mechanism described it is counteracted by gravity, the tendency to progressively shift the table to the left merely causing the left hand end of the path of movement of the table to be farther away from, and higher above the position of the table when the parts are at rest, than is the right end of the path of movement of the table.

While in accordance with the provisions of the statutes I have illustrated and described the best form of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of my invention without departing from its spirit, and that some features of my invention may sometimes be used to advantage without a corresponding use of other features of the invention.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is:

1. The combination with a body to be vibrated, of means for vibrating it consisting of a pair of eccentrically mounted weights revoluble about parallel axes, a second pair of eccentrically mounted weights revoluble about axes parallel with one another and means for rotating the two weights of the first mentioned pair with the same angular velocity but in opposite directions, and for rotating the other weights in opposite direction and each at double the first mentioned angular velocity.

2. The combination with a body to be vibrated, of means for vibrating it consisting of a pair of eccentrically mounted weights revoluble about parallel axes, a second pair of eccentrically mounted weights revoluble about axes parallel with one another, means for rotating the two weights of the first mentioned pair with the same angular velocity but in opposite directions, and for rotating the other weights in opposite direction and each at double the first mentioned angular velocity, and means for varying the centrifugal effect of one system relative to the other.

3. In combination a body free to move back and forth, means for impressing forces thereon tending to give said body to and fro movement comprising two systems of revolving weights mounted on said body, each of said weights being laterally displaced from its axis of rotation, and each system consisting of one or more weights, means for revolving each weight of one system with one angular velocity, and for revolving each weight of the other system with an angular velocity which is an even multiple of the first mentioned velocity, said weights revolving in such phase relation that the maximum components, in the two directions parallel to the line of movement of said body, of the centrifugal effect of one system act one in the same direction as, and the other in a direction opposite to the simultaneously existing parallel components of the centrifugal effect of the other system.

4. In combination a body free to move back and forth, means for impressing forces thereon tending to give said body to and fro movement comprising two systems of revolving weights mounted on said body, each of said weights being laterally dis-

placed from its axis of rotation, and each system consisting of one or more weights, means for revolving each weight of one system with one angular velocity, and for revolving each weight of the other system with an angular velocity which is an even multiple of the first mentioned velocity, said weights revolving in such phase relation that the maximum resultant component in one direction of movement of the body of the centrifugal forces exerted by all of the said revolving weights is greater than the maximum resultant component of the centrifugal forces exerted by all of said weights in the opposite direction.

CHARLES L. MILLER.