May 4, 1937. E. J. WINKLEMAN 2,079,059

VIBRATORY CLASSIFIER

Filed April 12, 1934 3 Sheets-Sheet 1

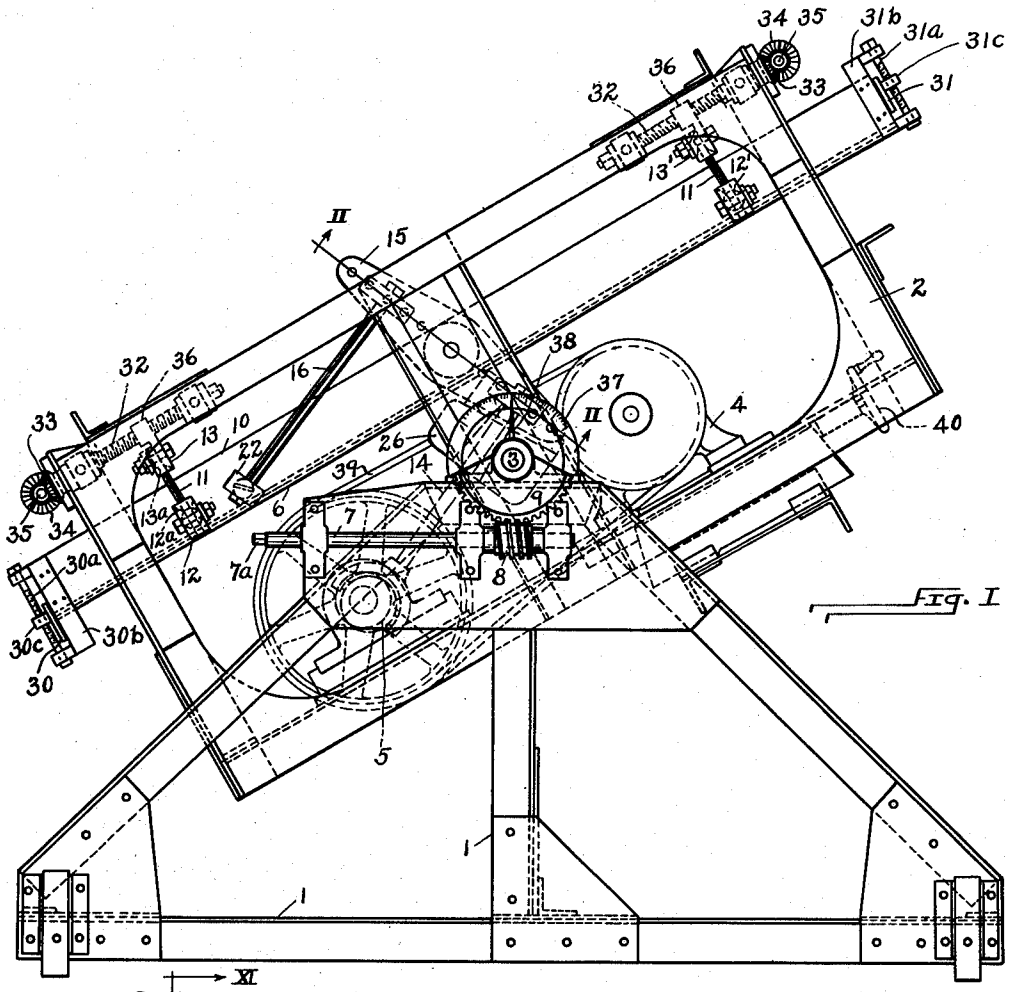

Fig. I

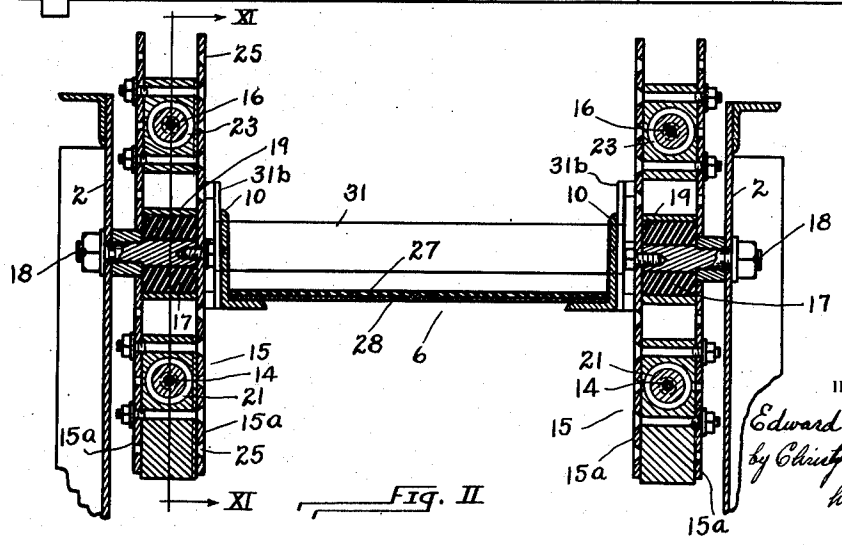

Fig. II

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May 4, 1937. E. J. WINKLEMAN 2,079,059

VIBRATORY CLASSIFIER

Filed April 12, 1934 3 Sheets-Sheet 2

Fig. VI

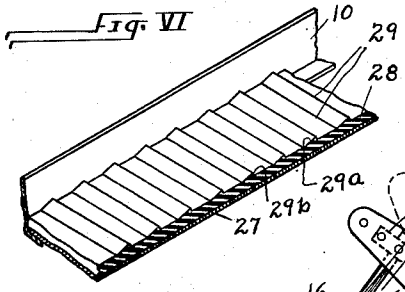


Fig. III

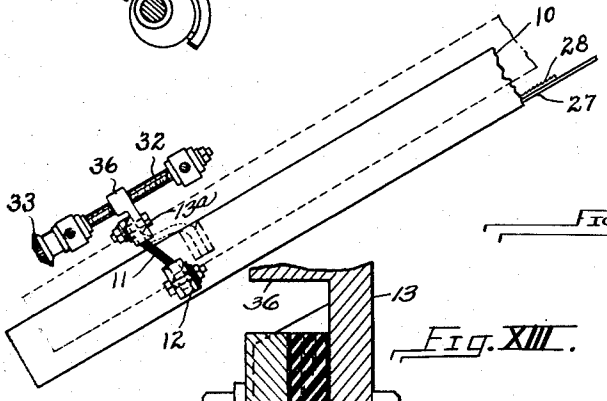
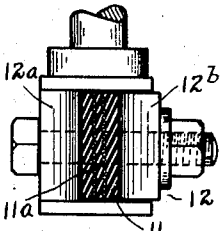


Fig. IV

Fig. VII



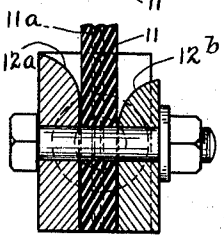


Fig. VIII

Fig. XIII.

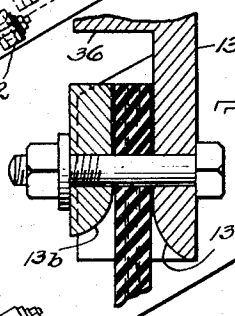


Fig. V

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May 4, 1937. E. J. WINKLEMAN 2,079,059

VIBRATORY CLASSIFIER

Filed April 12, 1934 3 Sheets-Sheet 3

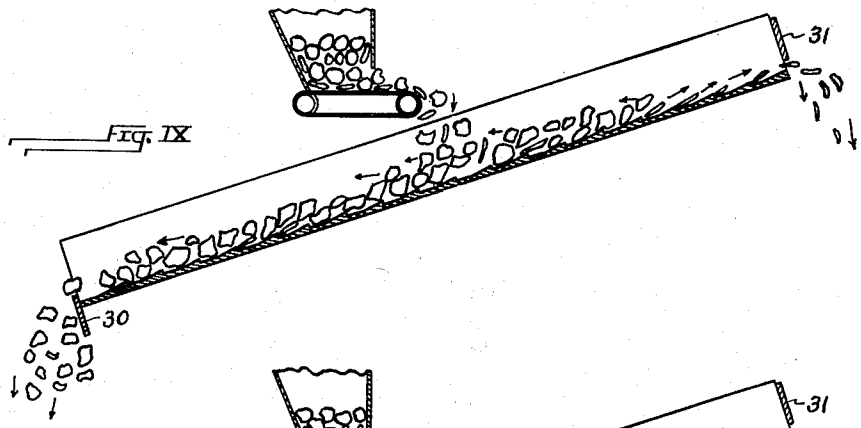

Fig. IX

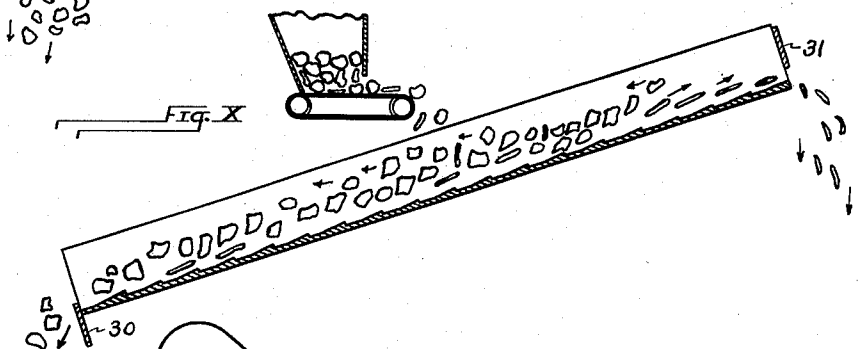

Fig. X

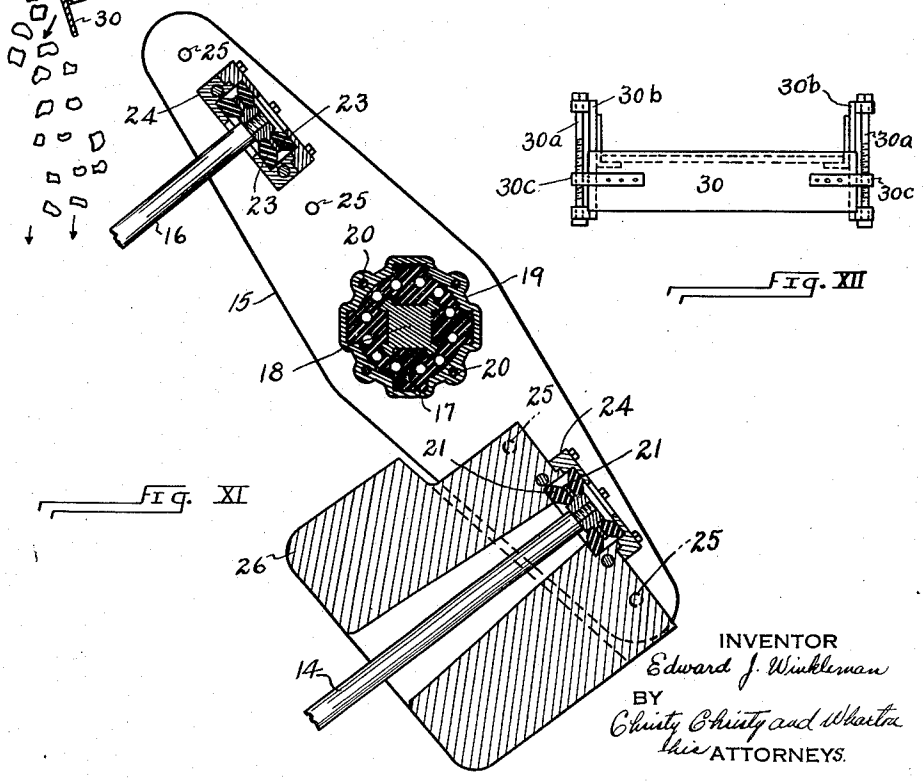

Fig. XI

Fig. XII

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Patented May 4, 1937 2,079,059

UNITED STATES PATENT OFFICE

2,079,059

VIBRATORY CLASSIFIER

Edward J. Winkleman, Oakmont, Pa.

Application April 12, 1934, Serial No. 720,208

13 Claims. (Cl. 209—437)

This invention relates to a vibratory classifier for various solid materials, as for example coal, gravel, hard slag, and ground cork, in accordance with shape or density.

As an aid to the description of shape separation, particles which have substantial extent in all three dimensions will herein be termed "lumps," and particles which have one dimension striking less than the other dimensions will be termed "flats."

In the preparation of coal for the market, it is desirable to remove as much of the refuse as is possible, in order to reduce the ash content of the coal, and thereby to increase the market value of the coal. The refuse in coal, as mined, may be slate, hard clay, or rock. All the refuse of varying sort is, however, of greater density than the coal itself. The slate is usually flat in shape, but in some instances it may be in the form of "lumps." The hard clay and rock is usually in the form of "lumps," but may in some instances be flat. Considering the cleaning of coal, it is of great advantage therefore that the separation between the coal and the refuse be made on the basis of both shape and density.

In gravel there is often no striking difference in the density of the particles, which, however, present a marked difference in shape. Most of the particles are in the form of rounded lumps, but a substantial proportion of the particles are flats. For many uses of the gravel these flat particles are very objectionable, and they should therefore be separated from the more desirable lumps. The classification involved in the removal of these gravel flats is one in accordance with shape alone.

Crushed hard blast furnace slag is used for many of the same purposes for which gravel is used. In crushed slag the particles are irregularly shaped lumps, and all the particles may be considered to be lumps, but in many instances there is great density differences in particles formed from the same general run of slag. Some of the particles are relatively solid and dense, while others are very porous and light in weight. For some purposes for which slag is used, it is desirable to separate the slag in accordance with comparative solidity and unit weight. Since the particles are substantially alike in both shape and size, but differ in density, the classification involved in their relative separation is one in accordance with density alone.

By use of the apparatus, there is also possible a rough grading in accordance with size, even though the shape and density of the particles are approximately uniform. As, however, such separation is readily performed by well known apparatus, it cannot be considered a valuable capability of my apparatus. It is, however, of advantage in that coal dust is separated out with the refuse, and sand with the flats in gravel.

Primarily, my apparatus comprises a platform, which is mounted in a position of inclination to a horizontal plane, and which is suspended in such position for swinging movement in a curved path of relatively short radius. The means for producing swinging movement of the platform and the suspending means for the platform are so arranged that, in normal operation, the platform does not swing through a true arc of a circle, but rather follows an irregular curve, so plotted that there is in the movement of the platform an abrupt vertical component of movement, or "kick." In order that the path of platform movement may be varied, the suspending means for the platform are made adjustable, so that the exent of the vertical component of platform movement, and the kick, may be regulable; and, further, the actuating means for the platform are made adjustable, in order that the total movement of the platform may be regulable.

It should be understood that the platform position may have a fixed relation to the mounting means provided for it, and that any desired adjustment in the angular position of the platform may be effected by adjusting the angular position of a frame in which the platform is suspended. For reasons of structural convenience and simplicity of adjustment, my apparatus, therefore, comprises an angularly adjustable platform-supporting frame, with the classifying platform of the apparatus suspended and maintained in a position of rest corresponding substantially to the angular position of the frame. With such arrangement, a simple, angular adjustment of the frame serves to vary the angle of inclination of the classifying platform. This adjustment provides a nice regulation of the angular position of the platform in accordance with the character of the material being classified and the tendency of certain components undergoing classification to descend the platform under the influence of gravity.

In order to obtain under various conditions of classification the nice separation which is desired, I prefer also to vary the speed of the classifying platform. As the simplest means for varying the speed of movement of the platform actuating connections, and thereby varying the

speed of platform movement, I prefer to use as the power element for my apparatus a variable speed motor, or a motor comprising variable speed connections.

In order to conform to varying classes of materials undergoing separation, I also desirably provide the apparatus with certain more specialized, and specific, adjustable means for influencing the conditions of separation. Such means, as will be hereinafter seen, comprise means for retarding downward movement of certain materials on the platform, and also means for preventing passage of certain shapes and sizes from the platform at both the upper and the lower end thereof.

In the accompanying drawings, Fig. I is a side elevation of my vibratory classifying apparatus.

Fig. II is a fragmentary cross-sectional view on an enlarged scale, taken on the line II—II of Fig. I, showing the classifying platform and certain of the actuating elements for it.

Fig. III is a side elevation, on the scale of Fig. I, showing the classifying platform, together with its proximate mounting and actuating means, and illustrating the path followed by the platform as moved under certain conditions of adjustment.

Fig. IV is a similar but fragmentary view illustrating the path followed by the platform in its movement under a notably different condition of adjustment.

Fig. V is a fragmentary side elevation of the platform, similar to Fig. IV, but illustrating an extreme regulation in the path of movement of the platform, effected by an extreme adjustment of the platform-suspending means.

Fig. VI is a fragmentary, isometric view on an enlarged scale, showing a surface detail of the classifying platform, and illustrating a structure tending to retard downward movement of particles on the platform.

Fig. VII is a detailed plan view of one of the clamps which serve to connect the platform-suspending elements to the classifying platform.

Fig. VIII is a detailed view of the clamp shown in Fig. VII, but showing the clamp in central, vertical section.

Fig. IX is a fragmentary, detailed view of the classifying platform, illustrating the classifying action of the platform in separating lumps and flats, the view showing the platform at the end of an oscillation.

Fig. X is a similar view, but illustrating the action of the platform intermediate a period of its oscillation, and illustrating the abrupt vertical movement involved in the action of the platform, and imparted to materials on the platform.

Fig. XI is a detailed elevational view on an enlarged scale, and on the plane XI—XI of Fig. II, showing one of the oscillating arms which constitutes an element of the actuating connections for the platform.

Fig. XII is a detail elevation of the baffle, and baffle mounting at the lower terminal of the classifying platform.

Fig. XIII is a detailed central vertical section through one of the clamps for connecting the suspending elements to mounting means carried by the platform frame of the apparatus.

In the accompanying drawings, reference numeral 1 designates a stationary main frame or supporting frame, and reference numeral 2 designates generally the operating frame of the apparatus. Operating frame 2 is mounted for angular adjustment in the main frame 1 on a transverse mounting shaft 3.

The operating frame 2 is shown as carrying an electric motor 4 and an eccentric 5, belt-driven by the motor. The frame 2 also carries the classifying platform 6, together with adjustable suspending means for the platform, and actuating connections operative between eccentric 5 and the platform.

It will be noted that the entire operating frame 2 is inclined from the horizontal, and that the classifying platform 6 is equally inclined. Means are provided for varying the degree of angularity of frame 2 as a whole, and for maintaining the frame in angularly adjusted position. Such means comprise a worm shaft 7, carried by the main frame, and having thereon a worm 8, meshing with a worm gear 9, fixed to the operating frame 2. Worm shaft 7 is shown as squared terminally at 7a, for the attachment of manually-operable means or any other suitable means for rotating worm shaft 7, and thereby rotating frame 2 about the axis provided by transverse mounting shaft 3. Classifying platform 6 is shown as provided with sides or guard flanges 10, and is suspended flexibly in the frame 2.

The means for suspending classifying platform 6 in operating frame 2 are such as to cause deviation from an arcuate path when the platform is swung or oscillated from a position of rest. The character of the platform suspension and the operating connections to the platform result in the peculiar vibratory movement noted, which vibratory movement is an important factor in the classification of material on the platform. The suspending means here shown are substantially identical with those disclosed in my co-pending application, Serial No. 676,438, filed June 19, 1933, for an improvement in a Vibratory screen.

The suspension comprises, primarily, relatively short, thick straps 11 of suitable resilient material, such as live rubber or laminated spring steel, secured to the classifying platform at one terminal of each strap by means of two pairs of clamps 12 and 12'. At its opposite terminal, each of the straps is attached to an upper element of operating frame 2, by pairs of clamping means 13 and 13'. If of rubber, the straps 11 are desirably made as shown, with cords 11a extending longitudinally of the strap along the neutral axis of the strap, mid-way between the wider strap faces. These cords 11a give a definite center of flexion to the straps. The flexion of the straps is positively controlled by the curved face 12a on each of the clamps 12 and 12', for attaching the straps to oscillating platform 6, and a similar curved face 13a on the clamps 13 and 13' for attaching the strap to the operating frame 2. It is also controlled in degree by the curved faces 12b and 13b, which are of lesser extent than the faces 12a and 13a.

As will be hereinafter explained in detail, the path followed by the platform when it is thrown is regulable by regulation in the relative positions of the clamps connecting the straps to the platform and to the frame, respectively, adjacent the lower end of the platform; or by regulation in the relative positions of the clamps 12' and 13', which similarly engage the straps adjacent the opposite end of the platform. As will also be hereinafter described, such regulation may be made during operation of the apparatus by adjustment of two or more of the clamps

which engage one terminal of each of the straps 11.

The operating connections between eccentric 5 and classifying platform 6 comprise two pitmen 14, each of which connects with an oscillating arm 15, formed of two spaced plates 15a. From each of the oscillating arms 15 an actuating arm 16 leads to a point of connection with classifying platform 6.

It may here be noted that throughout the apparatus, I have, where possible, replaced the usual metal-to-metal centers of oscillation with resilient deformable connecting elements, which are desirably made of live rubber. Such centers are less affected by grit and dust than are pivot connections of usual form, and have the additional advantage that they tend to lessen vibration transmitted to the frame of the apparatus.

As shown in Figs. II and XI of the drawings, each of the oscillating arms 15 has, as its center of oscillation, a rubber block, desirably perforate, which is fixed to a mounting shaft 18, and which is also fixed to a casing 19. Casing 19 extends between the two plates 15a forming the oscillating arm, and is attached to the plates as by means of through bolts 20. Adequate movement of oscillation is provided by internal distortion of the rubber block 17.

In somewhat similar manner the pitmen 14 and the actuating arms 16 are connected with the oscillating arms 15. As will be seen in Figs. II and XI of the drawings, rubber blocks 21 are mounted in the oscillating arms 15, and are arranged to be compressed and distorted by pitmen 14. Similar rubber blocks are contained in the casings 22, mounted on the classifying platform, and similar blocks 23 are mounted in the oscillating arms, for connection of the actuating arms 16 to the classifying platform and to the oscillating arms.

In order that the stroke of pitmen 14 and actuating arms 16 may be regulable, each of the oscillating arms has two series of bolt holes 25, aligned in the two plates of the arm. By bolting the casings 24, which contain the rubber elements, in various pairs of these bolt holes, the position of the pitmen and actuating arms, with respect to the center of oscillation of the oscillating arms, may be varied. By varying the distance of their mounting from the center of oscillation, the length of stroke is varied within the limits provided by the length of the oscillating arms, and the arrangement of the bolt holes 25.

As shown in Fig. I of the drawings, oscillating arms 15 are provided, each with a counterweight 26. The counterweights tend to overcome the inertia of the parts at the end of the power stroke during oscillation of the platform, and thus lessen vibration transmitted to the frame 2. As mounted on the oscillating arms, in the position shown, the counterweights counterbalance, or neutralize, the momentum of the moving platform in both vertical and longitudinal movement, thereby eliminating vibration in the frame of the apparatus.

To describe the classifying platform in detail, the base 27 of the platform has secured to the upper face thereof a material contacting facing 28, which is provided with a plurality of transversely extending, and longitudinally spaced, battens 29 to provide a riffled surface. The battens 29 are provided with downwardly presented faces 29a, which incline to the base surface of the facing, and upwardly presented abrupt shoulders 29b. The general effect of riffled facing 28 is thus to impede downward movement of material on the platform, and thereby to facilitate upward movement of certain of the materials on the platform.

The riffled facing thus emphasizes the tendency for the particles to classify on the surface of the platform, since classification is in response to the relative tendency of the particles to be either moved upwardly by movement of the platform surface or to pass downwardly during agitation of the platform.

I have found the riffling very useful in effecting some classifications. I do, however, contemplate the use of a smooth surface of frictional material, such as rubber.

In regulating this effect of impeding downward progress of material, I have found it convenient to provide a plurality of facings having thereon various sizes and spacing of battens, to provide variety in the riffling of the surface. The facing as a whole may thus be substituted in accordance with the work performed. This is simpler and more convenient than effecting a regulation by replacing battens of a particular size and shape by others of a different size and shape.

At the lower, discharge, end of the classifying platform I show a stile baffle 30 extending longitudinally across the platform. This baffle, as shown, is supported in vertically adjusted position with respect to the face of the platform by adjusting screws 10a. Adjusting screws 30a are shown as mounted in brackets 30b secured to the sides 10 of the platform, and cooperate with nuts 30c on the plate 30 for vertically adjusting the plate.

The stile baffle 30 has as its primary function to block the discharge of flat shapes, while permitting lumps to pass over it. As a secondary function, it may serve to block the discharge of heavy particles, while permitting the lighter particles to pass over it. Incidentally it prevents the discharge of very small particles at the lower end of the platform.

The stile baffle also chiefly performs the function of regulating the depth of bed on the platform.

It may be desirable to so arrange the mounting for stile baffle 30 that it forms an acute angle, rather than a right angle, with the surface of the platform 6.

At the upper, discharge, end of the classifying platform I show a gate baffle 31, which extends transversely the width of the platform. Gate baffle 31 is mounted above the surface of the classifying platform for adjustment toward and away from the surface of the platform. The mounting for the gate baffle comprises adjusting screws 31a, which are carried by brackets 31b secured to the sides 10 of the platform, and which cooperate with nuts 31c carried by the baffle. The primary function of gate baffle 31 is to prevent the discharge of lumps at the upper end of the platform, while permitting the discharge of flats at that end. The gate baffle may, therefore, be adjusted vertically such distance from the face of the platform as to perform that function, having regard to the size of the particles undergoing separation.

Gate baffle 31 also tends to prevent discharge of the lighter particles, since they tend to leave the surface of the platform during classifying agitation, while the heavier particles, tending to

lie on the surface of the platform, may pass under it.

The adjusting means for the classifying platform suspension comprise four threaded shafts 32 revolubly mounted in the operating frame 2 of the apparatus. These shafts 32 are arranged in transversely aligned pairs in position adjacent the opposite ends of the classifying platform, and each shaft is equipped terminally with a bevel pinion 33 meshing with a bevel pinion 34 on a cross shaft 35. On each of the threaded shafts 32 is a nut 36, which forms part of the clamping assembly 13 engaging one terminal of each of the suspension straps 11.

Both shafts 32 of each pair are mounted and equipped to move the clamps associated with them simultaneously in the same direction. According to the direction of rotation of each pair of shafts, the clamps 13 are moved longitudinally, rearwardly or forwardly of the operating frame 2.

It has been noted that the normal position of the classifying platform 6 is parallel to operating frame 2. This is for the reason that the actuating arms 16 connect the platform to the oscillating arms 15, and to the actuating mechanism of the apparatus as a whole. A similar adjustment might, with more structural complexity, be made by adjusting the longitudinal position of the platform 6 with respect to the operating frame 2. It is, of course, possible to adjust the terminal attachment of the straps to the platform rather than the terminal attachment of the straps to the frame. It would be difficult, however, to make such latter adjustment during operation.

The relative position of the platform being fixed, longitudinal adjustment of the movable clamps 13 alters their position with respect to the clamps 12 which are fixed to the platform. This regulation varies the center of flexion of straps 11, under agitation imparted to the platform by actuating arms 16, and accordingly varies the "kick," or deviation from an arcuate path, produced in the movement. It is to be understood that this variation in kick is progressive with progressive change in the relative position of clamps 13 and clamps 12. In Figs. III, IV, and V of the drawings, certain widely varied positions of adjustment, and consequent action, are shown in order to illustrate the movement of the platform, and the effect of strap adjustment on the movement of the platform.

In Fig. III of the drawings there is shown what may be considered an intermediate adjustment for the vertical component of movement in the oscillation of the classifying platform. In this view, the clamps 13 and the clamps 12, of the lower cooperatively arranged pair, and the clamps 13' and 12' of the upper cooperatively arranged pair, are in alignment at a right angle to the plane of the platform when in its rest position. As the platform is moved, the path described by it is determined by the flexion of the straps, which are sufficiently short and stout to carry the platform out of a path describing a true arc. It will be apparent that the tendency for the straps to wrap about the curved faces 13*a* and 12*a* causes a shortening in the radius about which the path of platform movement is described, thus causing the vertical component of movement to be an abrupt kick effect.

Fig. IV illustrates a movement of the platform comprising an intensified vertical component of movement with a marked "kick" effect, and the adjustment which produces that intensified action. As shown, the horizontal component of movement is equal to that shown in Fig. III, but the vertical component of movement is substantially increased. This is effected, as shown, by moving the pairs of clamps 13 at the lower end of the platform rearwardly, that is, downwardly, while permitting the clamps 13' at the upper end of the platform to remain in alignment with their associated clamps 12. It is to be understood that the same effect may be obtained by moving the other pair of clamps 13', those adjacent the upper end of the platform, rearwardly or downwardly, while allowing the lower, or rearward, pair of adjustable clamps 13 to remain as in Fig. III.

Fig. V of the drawings shows what may be considered an extreme adjustment, and one which is shown as exemplary of a limit to which adjustment may be made. In this illustration, the pair of adjustable clamps 13 have been moved forwardly, and upwardly, out of alignment with their associated clamps 12. This adjustment neutralizes the kick effect, and also resolves swinging movement of the platform into a mere forward and backward sifting movement. The same effect may be obtained by adjusting forwardly and upwardly the two clamps 13' adjacent the upper end of the platform, from the aligned position shown in Fig. III of the drawings, while leaving the pair of clamps 13 adjacent the lower end of the platform in the aligned position shown in Fig. III.

It may be here emphasized that the position of adjustable clamps 13 and 13' may be regulated during agitation of the classifying platform. It is thus possible, during operation of the apparatus, to observe the action of materials on the platform, and to vary the vertical component of platform movement to modify the action to the extent necessary for the particular separation which is being made.

It should be understood further that varied irregular movement, producing special movement of material on the classifying platform, may be obtained by opposed adjustment of the suspending elements adjacent the opposite ends of the platform.

By relative adjustment of the straps at the two ends of the platform, the greater depth of bed may be formed in any desired location on the platform. Thus by giving a greater kick at the upper end of the platform, the greatest depth of bed is formed in the lower platform region. Conversely, by giving the greater kick at the lower end of the platform there is a tendency for the bed to be built up to greater depth in a region spaced upwardly from the lower end. Since adjustment may be made during operation of the apparatus, the bed may in effect be caused to shift in either direction along the platform by appropriate strap adjustment.

As to the other several adjustments of which the apparatus is capable, it should be explained that adjustment in the angle of inclination of the platform should be relatively fine. In some separations the change of much less than a single degree in the angular setting of the platform, causes a marked change in the separating effect on the platform. In order that a fine angular adjustment of operating platform 2 may be made and observed, a protractor scale 37 is mounted on the main frame 1 in position to cooperate with an indicator 38 carried by the transverse mounting shaft 3. This scale and indicator

permits notation of the angular adjustment suitable for a particular separation.

The angular adjustment of the operating frame, with consequent adjustment in the inclination of the classifying platform, is an adjustment which also may be made during operation of the apparatus. This is for the reason that all the platform actuating means, as well as the classifying platform itself, are carried by the operating frame which is the element primarily adjusted angularly.

Another adjustment which may be made during the operation of the apparatus is in the speed of oscillating travel of the classifying platform 6. While this speed regulation may be effected in several ways, it is convenient to regulate the speed by the effect of variable connections actuated by electric motor 4, and acting upon belt 39 which transmits power to the eccentric 5.

To the end that the speed of rotation of eccentric 5 may be varied at will, belt 39 may, at its end adjacent the motor, pass over a variable speed pulley. Fig. I of the drawings shows a hand wheel 40 for producing movement of the motor assembly longitudinally of the frame 2. Such movement is the adjusting movement associated with a Reeves vari-speed motor pulley, as disclosed in United States Patent No. 1,941,417, dated December 26, 1933, to Paul B. Reeves, and Reissue Patent No. 18,333, dated January 12, 1932, to Paul B. Reeves.

The speed adjustment is one useful in accommodating the apparatus to varying size in the runs of material classified. While the adjustment described regulates the rate of travel of the platform, the regulation in length of stroke also affects the period of oscillation of the platform. This latter adjustment, which has been described above, is, for reasons of structural simplicity, so effected that it is made when the apparatus is in a condition of rest.

In operation of the machine it is, of course, necessary to leave much to the skill and experience of the operator, who by trial may readily find the exact conditions of operation best for the work being performed. Skill is more particularly needed for the reason that the separation of some materials involves certain factors which are to some degree in actual conflict.

This may be illustrated by the example of differences in the materials undergoing classification both in the qualities of density and of shape. In a density separation, the tendency is for the denser particles to travel upwardly on the platform, and for the less dense particles to travel downwardly thereon. In a shape separation the tendency is for the flats to travel upwardly and for the lumps to travel downwardly.

If we assume that the flats are of lesser density than the lumps, we have a condition in which inherently the different particles of each type to be separated are subjected to opposing tendencies. Under such conditions, the ultimate separation is in accordance with shape, rather than in accordance with density, the flats ascending the platform in spite of the fact that they are of a lesser density than the lumps. To effect such separation, however, nicety of adjustment is requisite.

There are a few general principles of adjustment, which may be specifically described, and which to some degree indirectly explain the operation of the apparatus. If we take the operation of separating coal and slate as an example, this may be considered primarily a shape separation, the separation in accordance with shape being assisted by the greater density of the slate. In this instance the riffling of the platform surface should be moderate, and a moderate stroke length and speed is desirable. The vertical component of movement may be as shown in Fig. III of the drawings, or slightly greater. A minimized inclination of the classifying platform may be employed. In describing this separation, it is being assumed that a preponderating number of the slate particles are of the pronounced flat shape, which is of usual occurrence.

In this separation, illustrated specifically in Figs. IX and X of the drawings, the stile 30 and gate 31 are adjusted for discharge of the flats at the upper end of the classifying platform, and for discharge of the lumps at the lower end of the platform. In the separating action, the flats find their way through the mass to the riffled surface of the platform, being thus restrained from downward movement, and are thrown upwardly of the platform by the platform oscillations.

Because of the relatively great difference in shape assisted by difference in density, and because there is no marked tendency for the flats to move downwardly on the platform, the moderate tossing of the particles involved in a moderate vertical component of platform movement is sufficient to effect the separation. The bed may be of moderate depth, and it is not necessary that the bed of material on the platform be relatively thin, or shallow, in order that the flats may readily find the surface of the platform.

If a run of the coal is found to contain refuse which comprises a substantial proportion of clay lumps, or slate in lump form, the depth of bed should be increased, and the length of stroke, vertical component, and speed should also be to some extent increased. This is for the immediate purpose of keeping the material in a condition of relatively high agitation, so that the heavier particles may be precipitated to the surface of the platform, and to have a substantial depth of material in order that density difference may be thereby emphasized.

It may be noted that the stile baffle 30, and gate baffle 31 may be adjusted to maintain a desired constant depth of bed on the classifying platform 6, as the material is fed to the platform, and separated thereon. The material should be fed at a uniform rate during each classification, such rate being established in accordance with the rapidity of the classifying operation, and the depth of bed best suited to that particular operation.

Desirably, in making a density separation, with a relatively deep bed of material, the strap adjustment is such that the vertical component of movement is more pronounced at the lower end of the platform than at the upper end of the platform. This is to force the lighter particles over the stile baffle, and to settle the heavier particles of the particulate mass at the lower end of the platform, so that they come into contact with the surface of the platform, and are projected upwardly along the platform.

It has been explained that a relatively deep bed of material is desirable for effecting a density separation, and that a bed of moderate depth is suitable for a shape separation, such as the separation of coal and slate as it ordinarily occurs with coal.

It has been explained that the greatest depth of bed may be located in any region longitudinally of the platform by comparative strap adjustment at the opposite ends of the platform.

In classifying very small sizes, I have found it highly desirable to so adjust the straps that the greatest depth of bed is on the upper half of the platform. This may be done by a relative adjustment which gives a decidedly lesser kick at the upper end of the platform, so that there is a greatly decreased tendency for particles to be discharged at the upper end of the platform.

It may be stated generally that in separating small materials, either in accordance with density or shape, the period of platform oscillation should be shorter than in the separation of materials of greater size. The actuating connections are, therefore, operated at higher speed, and the platform actuating stroke is made shorter. In separating materials of small size, the platform should be at a greater inclination than in separating similar materials of larger size, and there should be less kick, that is to say, a lesser relative component of vertical movement than with the larger sizes. It is also desirable that the bed of material on the platform be of less measured depth than with larger sizes of material, in order that the particle depth may be analogous. This is for the reason that, with equal depth, a decrease in the size of the material on the classifying platform causes a greater number of particles to be present at any one time.

The riffling of the platform surface should be roughly in accordance with the size of the particles, a finer riffling being employed for the separation of materials of small size, such as pea coal and fine gravel, than for larger coal and gravel sizes.

My apparatus is capable of performing difficult separations. For example, I have separated on it two grades of cork of the same approximate shape, but of differing density. In making such separation as a cork separation, in accordance with density, it should be understood that unless the particles be of relatively great size a finely riffled surface should be used on the classifying platform, that the angular inclination should be great, and that the period of platform oscillation should be short, with the platform operated at high speed.

An outstanding feature of my classifying apparatus is that it will operate to separate materials in accordance with either shape or density.

It is of great advantage that important adjustment may be made during operation of the apparatus. This permits accurate adjustment to be made in accordance with observed conditions; so that the operator, by watching movement of material on the platform, may cause the different classes to travel in their opposite directions by appropriate regulation. It avoids the necessity of successively starting and stopping the operation of the apparatus to make adjustment by trial and error.

It may be explained that the classifying platform may be oscillated at relatively great frequency, and that the normal operation is at a frequency materially greater than that commonly employed in "jigging tables", whether or no air or water be employed in conjunction with such tables. It is to be noted that neither air nor water need be used in conjunction with the action of the classifying platform in my apparatus, since the relatively high frequency of oscillation, and the nature of the oscillation, produce a flotation effect in the particulate mass on the platform.

It should be understood that the feature of the apparatus which is of primary importance is the suspension of the platform. It is this specialized suspension which imparts to the classifying platform the peculiar motion resulting in efficient separation.

It has been noted that the suspending straps 11 are relatively short and stout, and it may also be explained that they are of abbreviated length with respect to the throw imparted to the platform.

As explained above, the effective shortening of the straps 11 by curling about the curved faces 12*a*, 13*a*, gives an abrupt vertical component in the path of platform movement. Inherently this abrupt vertical movement occurs in the final stage of the upward travel. This action gives a marked projection toward the upper end of the platform of such particles as are in physical contact with the face of the platform. As the platform begins its return stroke, it first falls away rapidly in a relatively abrupt vertical direction, and then moves downwardly and rearwardly in a more nearly horizontal path. This permits the particles which have been projected toward the upper end of the platform to retain their gain in that direction.

Clearly, if the action at the lower end of the platform be that attendant upon an adjustment such as shown in Figure IV, while the adjustment at the upper end of the platform be as shown in Figure III, there is a greater tendency to upward projection at the lower end of the platform than adjacent the upper end of the platform. With this explanation, it will be clear why such action contributes to clean separation under conditions in which there is a tendency for the entire mass of particulate material to be discharged at the lower end of the platform, because of a substantially equal rolling tendency between particles.

Primarily, as stated, the advantageous action is to be attributed to the peculiar strap suspension, and high speed operation, of the apparatus. The high speed, associated with the abrupt vertical component in the path of movement of the platform, gives a separating effect to which the action of relatively slow jigging tables is not comparable.

There are some instances in which the conditions of a classification are invariable. In such cases it is of course possible, to use my adjustable machine as a calibrating instrument, and on the basis of its adjustment to design a non-adjustable apparatus which will operate satisfactorily under those specific conditions, although useless for any other classifying purpose.

It is to be understood that the effects derivable from my novel suspension, and the associated driving means for the suspended table, are effectively useful in tables so constructed and arranged that they find their utility as screens, conveyors, feeders, and like instrumentalities for conveying, classifying, or classifying and conveying particulate materials. Within the bounds of my invention, as defined in the appended claims, my invention is therefore to be considered as finding embodiment in such specifically varied instrumentalities.

I claim as my invention:

1. In apparatus for classifying solids in accordance with the shape or density of the particles the combination of an inclined platform, means for adjusting the angular position of the platform and maintaining it in various positions of inclination to a horizontal plane, suspending means for the platform comprising suspending

straps relatively short with respect to the length of swinging movement of the platform and thereby capable of supporting the platform in a path deviating from the arc of a circle, clamping means terminally engaging the straps and presenting to the straps to decrease their effective length surfaces tending to produce flexion of the straps during swinging movement of the platform, and actuating means variable in adjustment and arranged to impart to the platform longitudinally directed swinging movement variable in speed and amplitude.

2. In apparatus for classifying particulate solids the herein described apparatus for separating the solid particles in opposite directions on a surface in accordance with difference of particle characteristics in either shape or density comprising a platform mounted in a position of inclination to a horizontal plane, the surface of the said platform being such as to present resistance to movement of the particles down the platform under the influence of gravity, actuating means and connections for the platform arranged to exert on the platform forces tending to produce rapid platform oscillation, structural elements overlying the platform, and flexible suspending elements relatively short with respect to the throw of the platform attached to the platform and having vertically spaced attachment to engaging members mounted on said structural elements and adjustable thereon longitudinally of the platform independently of platform oscillation, said attachment of the suspending elements both to the platform and to the structural elements overlying the platform pressing to the suspending elements curved faces tending to decrease the radius of flexion of said elements during oscillation of the platform, the longitudinal adjustment of said engaging members relatively to the platform serving to vary the flexion of the suspending elements in oscillating movement of the platform thereby to vary the path of platform movement during oscillation thereof.

3. In apparatus for classifying solids the combination of an inclined platform, actuating means and connections for imparting to the platform longitudinally directed high speed swinging movement, suspending straps relatively short with respect to the length of swinging movement of the platform and thereby capable of supporting the platform in a path deviating from the arc of a circle, clamping means engaging the straps terminally, contact elements presenting to both faces of each of the straps curved surfaces extending at both ends of each of the straps a substantial distance therealong, said curved surfaces being arranged to contact the straps at both ends thereof during swinging movement of the platform in both horizontal directions, thereby substantially to decrease the effective length of the straps and radically to vary the path of movement of the platform.

4. In apparatus for classifying solids comprising a segregating table suspended in inclined position for longitudinal swinging movement, and actuating means for vibrating the segregating table longitudinally at high speed and in a path primarily arcuate, table suspending elements comprising straps capable of supporting the segregating table along an abruptly modified path of movement in each oscillation of the table, contact elements presenting to both faces of each of the straps curved surfaces extending at both ends of each of the straps a substantial distance therealong, said curved surfaces being arranged to contact the straps at both ends thereof during swinging movement of the table in both horizontal directions, thereby substantially to decrease the effective length of the straps and radically to vary the path of movement of the table, said actuating means being arranged to force the straps against the strap-contacting surfaces and to cause the straps to flex at the terminals of said surfaces thereby providing a swinging movement in an approximate arc less than the arc provided by free swinging movement of the straps.

5. In apparatus for classifying solids comprising a segregating table suspended in inclined position for longitudinal swinging movement, and actuating means for vibrating the segregating table longitudinally at high speed and in a path primarily arcuate comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, and curved flexing surfaces arranged to contact the straps through a portion of their length during each oscillation of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and departure from the arcuate in the path of table movement and to cause the straps to flex at the terminals of said surfaces thereby causing a swinging movement in an approximate arc substantially less than the arc provided by free swinging movement of the straps.

6. In apparatus for classifying solids comprising a segregating table suspended in inclined position for longitudinal swinging movement, and actuating means for vibrating the segregating table longitudinally at high speed and in a path primarily arcuate, table-suspending means comprising straps capable of supporting the segregating table along an abruptly modified path of movement in each oscillation of the table, flexing surfaces arranged to contact the straps through a portion of their length during each oscillation of the segregating table, said actuating means being arranged to force the straps against the strap-contacting surfaces and to cause the straps to flex at the terminals of said surfaces thereby providing a swinging movement in an approximate arc less than the arc provided by free swinging movement of the strap, and adjusting means arranged to regulate the relative positions of the strap terminals longitudinally of the table thereby to control regulably the flexion of the straps against the flexing surfaces.

7. In apparatus for classifying solids comprising a segregating table suspended in inclined position and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, table-suspending means comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, curved flexing surfaces arranged to contact the straps through a portion of their length during each oscillation of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and departure from the arcuate in the path of table movement and to cause the straps to flex at the terminals of said surfaces thereby causing a swinging movement in an approximate arc less than the arc normally provided by the free swinging movement of the straps, adjusting means arranged

to regulate the relative positions of the strap terminals longitudinally of the table thereby to control regulably the flexion of the straps when forced into contact with the said flexing surfaces.

8. In apparatus for classifying solids comprising a segregating table suspended in inclined position, and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, table-suspending means comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, contact elements presenting to both faces of each of the straps surfaces curved irregularly away from the strap faces and extending at both ends of each of the straps a substantial distance therealong, said curved surfaces being arranged to contact the straps at both ends thereof during swinging movement of the table in both horizontal directions, thereby substantially to decrease the effective length of the straps and radically to vary the path of movement of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and substantial departure from the arcuate in the path of table movement.

9. In apparatus for classifying solids comprising a segregating table suspended in inclined position, and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, table-suspending means comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, contact elements presenting to both faces of each of the straps surfaces curved irregularly away from the strap faces and extending at both ends of each of the straps a substantial distance therealong, said curved surfaces being arranged to contact the straps at both ends thereof during swinging movement of the table in both horizontal directions, thereby substantially to decrease the effective length of the straps and radically to vary the path of movement of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and substantial departure from the arcuate in the path of table movement, and adjusting means arranged to regulate the relative positions of the strap terminals longitudinally of the table thereby to control regulably the flexion of the straps when forced into contact with the said flexing surfaces.

10. In apparatus for classifying solids comprising a segregating table suspended in inclined position, and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, table-suspending means comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, flexing surfaces of substantial length with respect to the length of the straps curved irregularly away from the presented faces of the straps and arranged to contact the straps during each oscillation of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and substantial departure from the arcuate in the path of table movement, and adjusting means arranged to regulate the relative positions of the strap terminals longitudinally of the table thereby to control regulably the flexion of the straps when forced into contact with the said flexing surfaces, said actuating means in adjustment of the straps appropriate to produce contact of the straps with the said flexing surfaces throughout the length of said surfaces being arranged to cause the straps to flex at the terminals of said surfaces thereby causing a swinging movement in an approximate arc substantially less than the arc provided by free swinging movement of the straps.

11. In apparatus comprising a suspended table and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, elements for producing movement of particulate material along the table comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, and flexing surfaces arranged to contact the straps through a portion of their length during each oscillation of the table, said actuating means being arranged to force the straps against the strap-contacting surfaces and to cause the straps to flex at the terminals of said surfaces thereby providing a swinging movement in an approximate arc less than the arc provided by free swinging movement of the straps.

12. In apparatus comprising a suspended table and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, elements for producing movement of particulate material along the table comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, and flexing surfaces arranged to contact the straps through a portion of their length during each oscillation of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of the said surfaces to cause flexion of the straps and departure from the arcuate in the path of table movement and to cause the straps to flex at the terminals of said surfaces thereby causing a swinging movement in an approximate arc substantially less than the arc provided by free swinging movement of the straps.

13. In apparatus comprising a suspended table and actuating means for vibrating the table longitudinally at high speed and in a path primarily arcuate, elements for producing movement of particulate material along the table comprising straps capable of supporting the table along an abruptly modified path of movement in each oscillation of the table, and contact elements presenting to both faces of each of the straps surfaces curved irregularly away from the strap faces and extending at both ends of each of the straps a substantial distance therealong, said curved surfaces being arranged to contact the straps at both ends thereof during swinging movement of the table in both horizontal directions, thereby substantially to decrease the effective length of the straps and radically to vary the path of movement of the table, said actuating means being arranged to force the straps against the curved strap-contacting surfaces by the curvature of said surfaces to cause flexion of straps and substantial departure from the arcuate in the path of table movement.

EDWARD J. WINKLEMAN.