

Aug. 13, 1963

M. O. HOLOWATY
SCREENING APPARATUS

3,100,746

Filed April 20, 1960

4 Sheets-Sheet 1

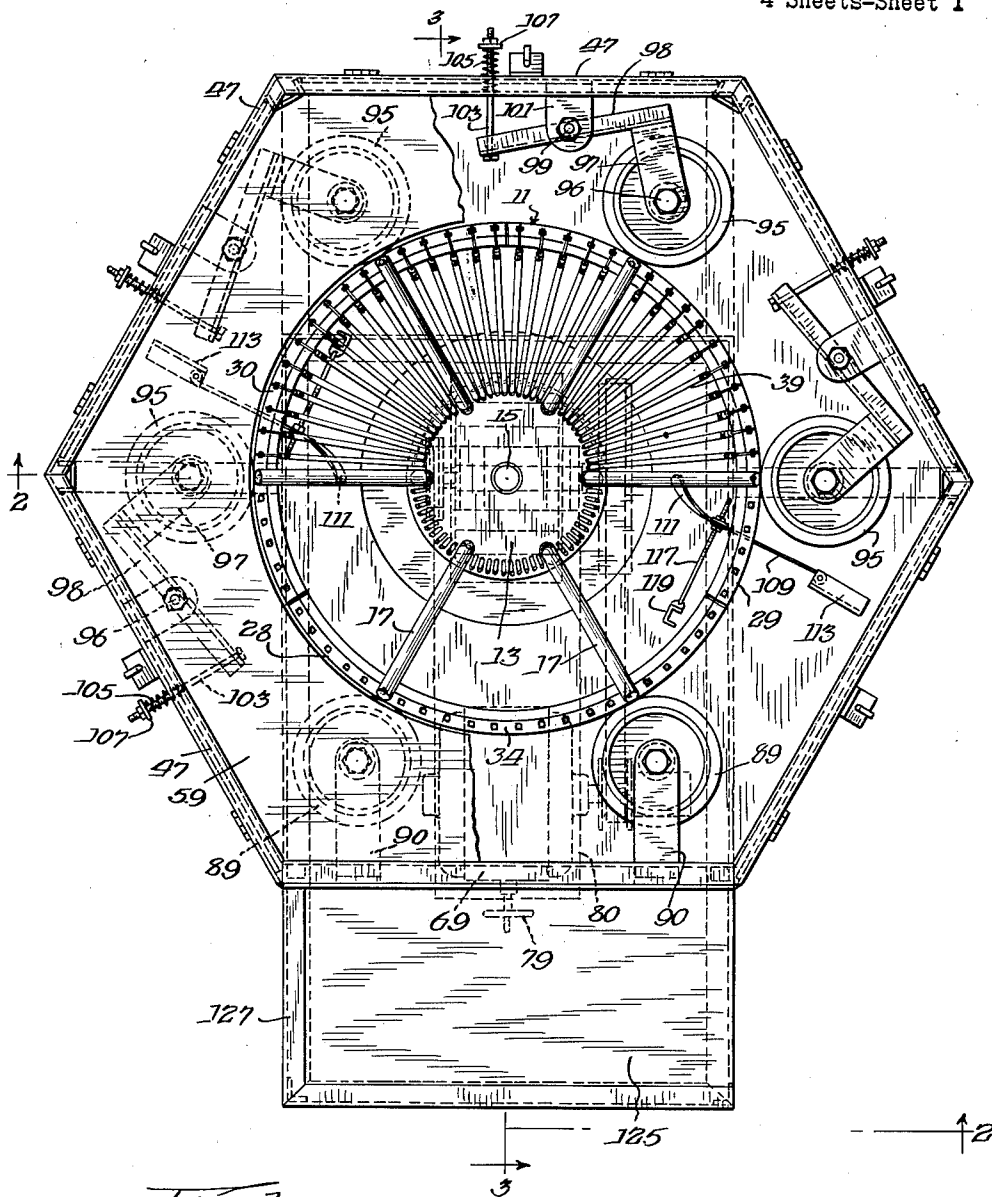


Fig. 1.

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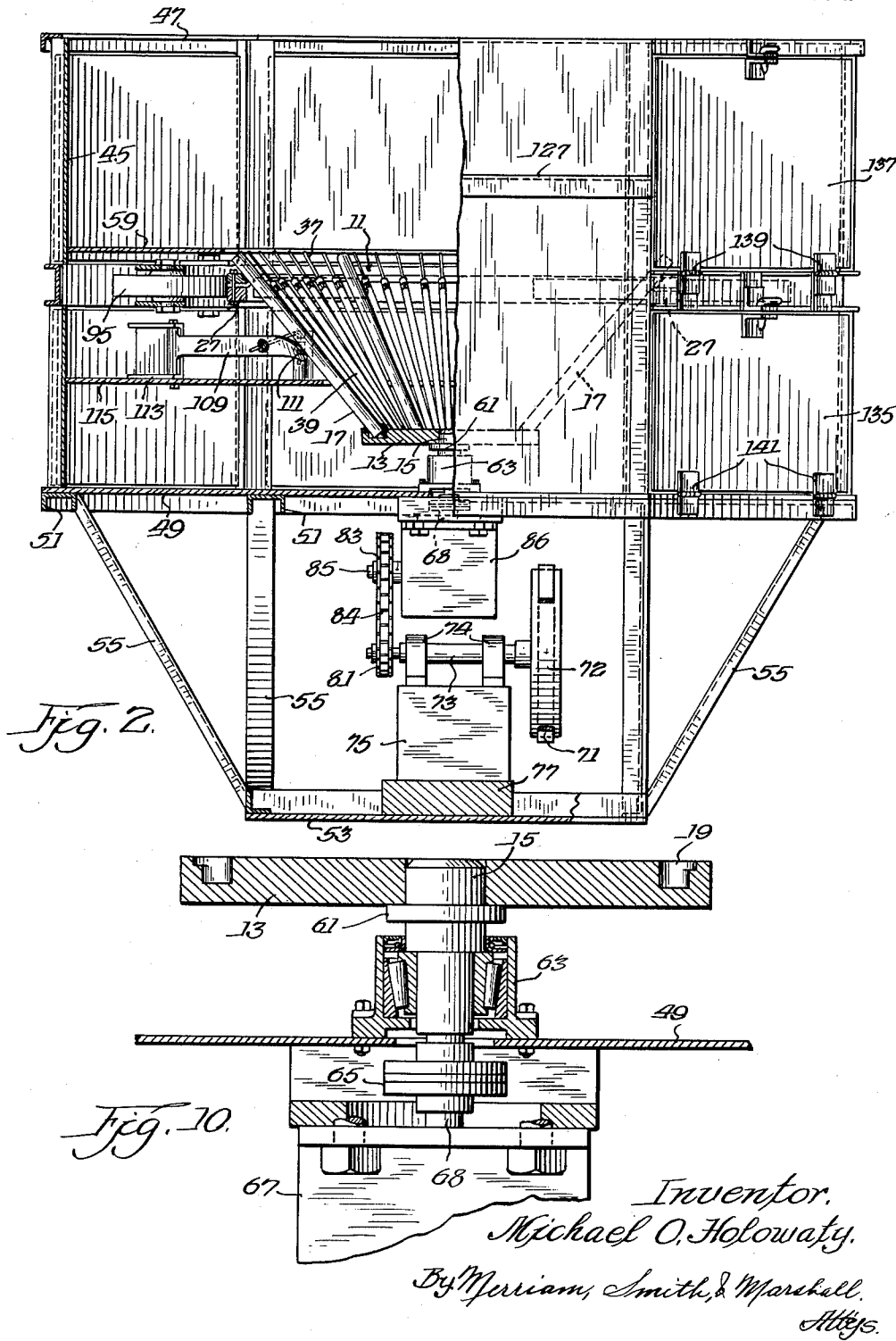
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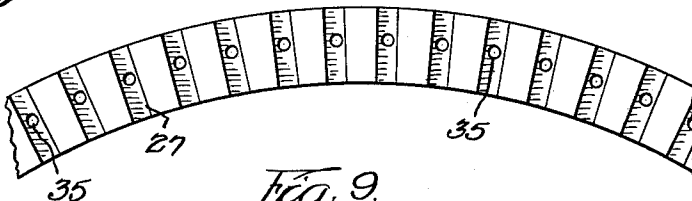
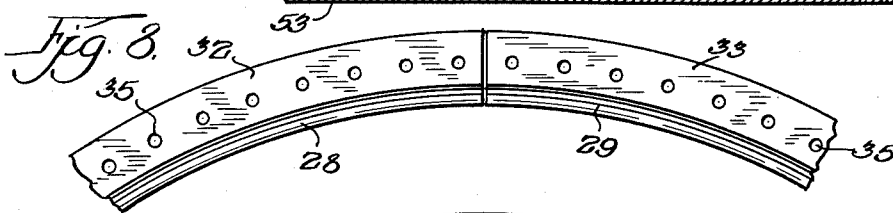
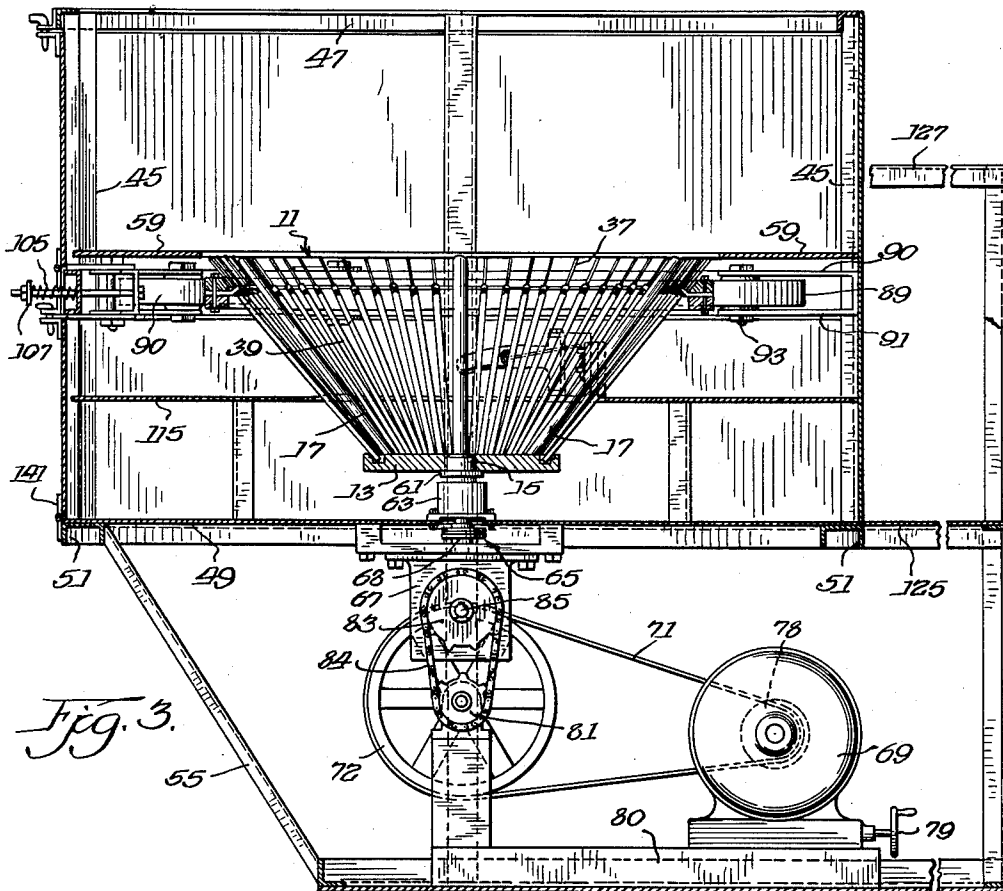
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4 Sheets-Sheet 3



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Fig. 5.

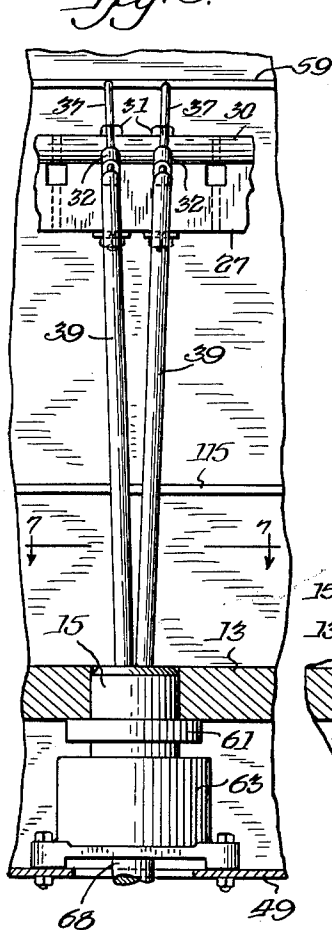


Fig. 11.

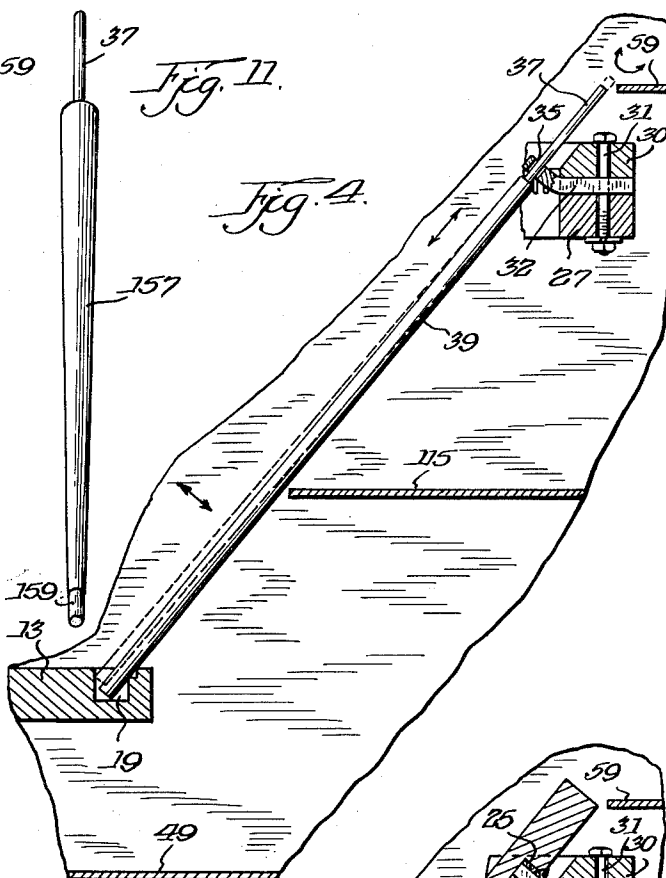


Fig. 4.

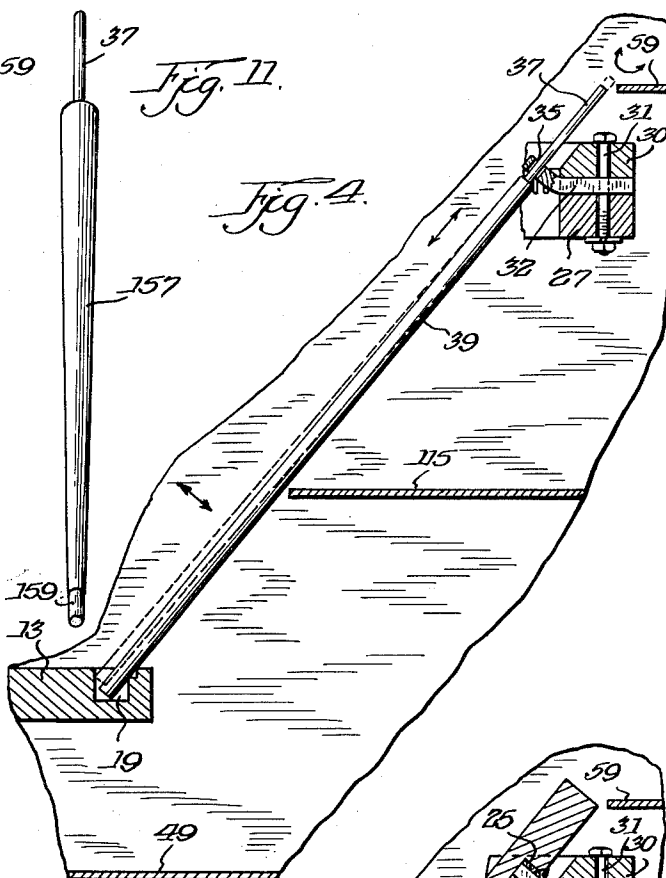


Fig. 6.

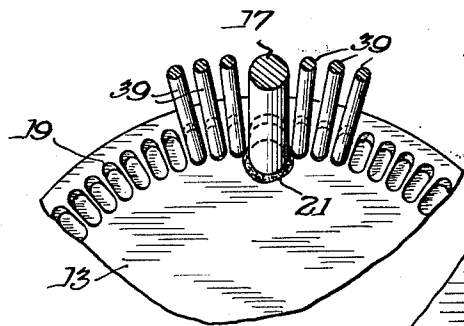
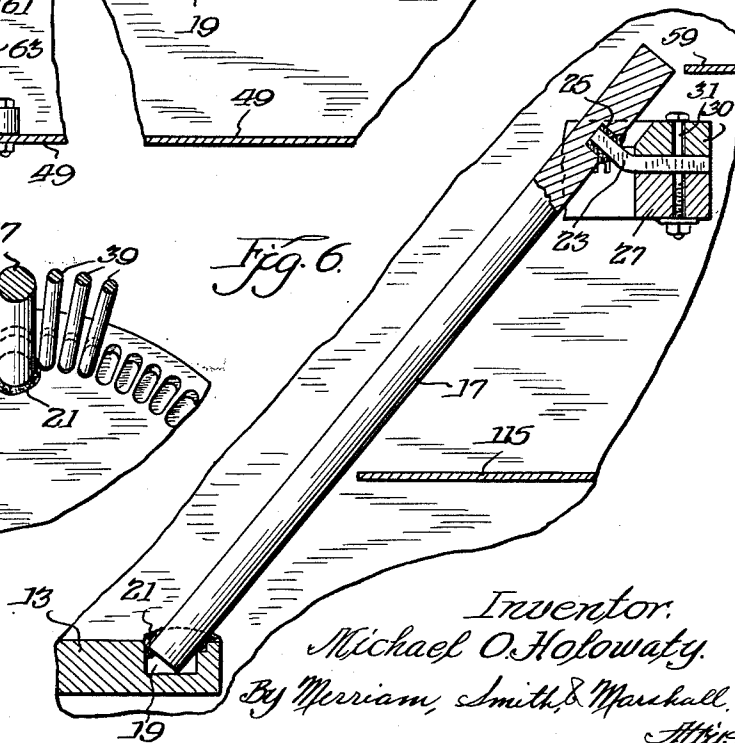


Fig. 7.

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SCREENING APPARATUS

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18 Claims. (Cl. 209—304)

This invention relates to screening devices employing a centrifugal separator mechanism by which various sizes or masses are separated and by which components of substantial size are separated from sticky substances or masses and the like which tend to adhere thereto when the material is collected. One of the principal uses is in separating ore from sticky adhering fines which are inherently present when wet or unduly moist mined material is initially supplied to the user.

Various mechanisms by which size separation of ore is intended to be effected have been proposed. In many instances the ore delivered from the mines includes a large quantity of "clayey" fines and there is an extremely high moisture and silica content. The high moisture content makes the material extremely sticky and screening methods heretofore used have generally not solved the separation problem to the full extent desired. Where screening mechanisms have been used, and even where the screening components are subjected to even relatively violent vibration it has been found that the fines tending to adhere to the larger pieces of the ore soon cause the screen or separating mechanism to become plugged or clogged to an extent to impair substantially efficient and economical operation. Even though prior art screening mechanisms have permitted vibration of screening elements, it frequently has happened that the moist clay-like materials have sufficient retention upon the screening mechanism substantially to disrupt effective operations.

The present invention attempts to solve the prior art difficulties, and particularly the clogging problem, without permitting the ore which is to be separated to exert any substantial abrasive effect upon the separator mechanism, as is usually the case with prior art vibratory screening devices. In this disclosure it will become apparent that use is made of centrifugal force to cause the particles or fines to be removed and separated from the ore proper and to segregate the ore particles into components of selected sizes.

In the preferred form of separating device the moist ore as received from the mines or collected from a stock pile is fed into a generally frusto-conical receiving and screening basket mechanism which, in some respects, resembles an upturned umbrella with supporting ribs extending outwardly from a central base member. Provisions are made for rotating the ore-supporting screening basket in such a way that, with rotation, centrifugal forces are caused to act upon the ore contained therein to move it in a more or less swirling pattern outwardly from the axis of rotation. Where the screening basket has its sides formed from numerous selectively spaced rods extending outwardly, the fines, as separated from the ore, and the ore particles themselves are forced outwardly between the screening rods which provide the screening and selecting effects. With the screening basket arranged in more or less cup-shaped fashion, the smaller wet fines are discharged, with rotation of the basket, between the supporting ribs in a region closely adjacent to the basket base or bottom, the basket having its large opening at the top. As rotation of the screening basket holding the ore saturated with moisture is maintained and the fines are removed to a substantial extent, the remaining basket contents rise and more or less climb up the sides of the rods with discharge of the ore masses taking place

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in the spaces between the rods. Thus, as the rod spacing tends to increase, ore pieces of larger and larger size and mass are discharged and thrown outwardly from the screening basket in accordance with the size selection desired, as measured or determined by the gradual separation of the rod peripheries.

Generally speaking, the rods providing the screening mechanism in the screening basket are loosely mounted and subject to a limited amount of radial and longitudinal, as well as rotary, movement. Further, by loosely mounting the screening rods and providing a suitable rod-vibrating or agitating device to become effective during rotation of the screening basket, the ore particles and masses tend to free themselves from the rods and become discharged at selected regions.

In a preferred form of the mechanism the screening rods are spaced at selected support points about a circular path near the base (the smallest radius part here being termed "base" for convenience) of the frusto-conical member and also located by a ring member which defines the open-ended top of the frusto-conical member. With the base circle being substantially smaller than the top rod-locating ring, the rod spacing toward the larger ring becomes greater where uniform size rods are provided. Where the rods themselves are of conical shape, and provided with a taper commensurate with the slope of the conical wall, the spacing is constant and material in the basket is uniformly separated into selected size components upon basket rotation. Various mechanisms and means, of course, may be provided both for vibrating the screening rods and for rotating the overall component. The angle or slope of the screening rods, as well as the rotational speed thereof, can be variable and adjusted to permit treatment of material of widely variable characteristics.

With the foregoing in mind it becomes an object of the invention to provide ore-screening and separating mechanisms for separating fines or undersize from the ore proper, particularly where the ore contains a high percentage of moisture and silica-bearing oversize.

Other objects of the invention are those of providing a separating mechanism for ore which is of high efficiency characteristics and which may operate in substantially continuous fashion.

Other objects of the invention are those of providing separating mechanism of a character suitable also for selecting and separating gravel and aggregates, as well as crushed slag, particularly for road building operations, as well as many other uses.

Other and further objects and advantages of the invention will become apparent from a consideration of the following description and claims considered in conjunction with the accompanying drawings, showing the mechanism in one of its preferred forms.

By the accompanying drawings:

FIG. 1 is a plan view looking from the top of the mechanism to the bottom and showing particularly the rod and support arrangements for the screening basket together with the guiding and vibrating mechanism;

FIG. 2 is an elevation, partly in section, taken along the line 2—2 of FIG. 1;

FIG. 3 is also an elevational sectional view of the device of FIG. 1, taken along the line 3—3 thereof and showing the mechanism in a position substantially 90° to that of the elevational sectional view of FIG. 2;

FIG. 4 is an enlarged view, partly in section, to show the screening-rod support and mounting;

FIG. 5 is a view of the screening and mounting rods in their supported position and looking at the structure of FIG. 4 from a position at right angles to FIG. 4 and

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from left to right thereof, looking at the positioning on the figure in the set;

FIG. 6 is a view, partly in section, of the screening basket support rods for maintaining the top and bottom screening rod support rings separated and located with respect to each other;

FIG. 7 is a view, also partly in section, taken along the line 7—7 of FIG. 5;

FIG. 8 is a plan view of a portion of two adjacent split rod supporting rings;

FIG. 9 is a plan view of a complete rod supporting ring;

FIG. 10 is an enlarged view to show the support structure for holding the small bottom end of the frusto-conical screening basket and designates particularly the thrust bearing and flexible coupler for holding the base plate; and

FIG. 11 is a modification of the screening rod structure shown in the previous figures.

Referring now to the drawings for a more complete and thorough understanding of the invention, the screening-basket mechanism, generally designated 11, has a generally frusto-conical shape. The cut-off section on the cone terminates in a base plate 13 which is rotatably supported at its center on a drive shaft 15, which will be further described at a later point in this description. Screening frame members 17 of generally rod-like characteristics are held within recesses 19 on the base plate 13, as shown particularly in detail by FIG. 6. The securing of the rods 17 determines the slope of the screening-basket side walls. In each instance the rods 17 are held at their base in the recesses 19 of the base plate 13 by suitable welds, conventionally designated at 21. At an appropriate distance along the rod 17 and at the upper portion thereof a securing bracket member 23 is appropriately welded to the rod, as designated at 25. The bracket members 23 are suitably secured between a continuous ring member 27 and one of a plurality of split ring members 28, 29, and 30, for instance, which are clamped together by any suitable fastening means, such as the indicated bolts 31.

The continuous ring 27 and the split rings 28, 29, and 30 have supported therebetween additional guide brackets 32, 33, and 34, in each of which are suitable apertures 35, through which the outer ends 37 of the screening rods 39 are adapted to extend (see FIGS. 1, 8 and 9, particularly). The apertures 35 (see FIG. 4, for instance) are slightly larger than the diameter of the end 37 of the screening rod 39 so that the rods passed through these apertures may be subjected to movement radially and longitudinally of the rod, as well as in all directions within the aperture. In addition, the rods are free to rotate within the aperture.

In a fashion similar to the support provided for the rigidly mounted side rods the screening rods 39 also rest within recesses 19, circumferentially arranged and equally spaced about the periphery of the disk-like base member 13. As can be seen particularly from the showing of FIG. 4, the lower end of each rod 39 is supported within the recess 19, having its outermost end slightly stepped in contour to provide an effective larger outer opening with a smaller opening within which the rod is positioned. As can be noted from the showing of FIG. 4, and particularly from the dotted outlined position of the rod 39, the rod can be moved within the recess 19 into which it is loosely positioned. The mechanism to provide movement will later be discussed. Suffice it at the moment to point out that the screening basket comprises the multiplicity of rods extending through the apertures 35 of the rod supporting member 32 and the recess 19 in the base 13.

The slope of the rods 39 which form the side walls of the screening basket is determined by the relative size of the circumferentially positioned recesses 19 on the base 13 and the circularly arranged supporting brackets 32

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held between the rings 27 and any of the split rings 28, 29, and 30 and the vertical separation between the base and the rings. In the diagrammed position the rods have been shown in a fashion by which they are arranged at an angle of approximately 45° to the normal. It has been found that the angle of the rods with respect to the vertical axis represented by that of the supporting shaft or spindle 15 is actually somewhat critical. It should not be less than 30°, nor more than 50° or, stated differently, the rods should extend at an angle no greater than 60° with respect to the plane of the base 13 and no less than an angle of about 40° with respect to the plane of the base. With the base plate 13 carrying the side guides and the movable rods, and each of the latter being held at their outer ends by the ring members, it will be appreciated that a generally open-sided frusto-conical screening basket is provided which has a closed base 13 with an open upper section. The basket sides are formed from the movable and spaced screening rods 39. The upward motion of the rods 39 within the support bracket 32 is limited by the aperture size of the opening 35 through which the small end 37 passes, this opening being larger than the small end of the screening rod but smaller than the main portion of the screening rod, as is clearly seen from FIG. 4. The separation between the base plate 13 and the rings 27 and its split rings supported adjacent thereto is determined by the length of the rods 17 and the location of the welds whereat these components are secured.

In order to support the screening basket mechanism a suitable frame work, comprising a multiplicity of side members 45, is provided which may be spaced as desired in any upwardly extending configuration to meet and join with side or top members 47 secured thereto in any desired fashion. The vertical members 45 are appropriately fastened and secured to a bottom plate or platform 49 which, in turn, is held or supported by suitable channel sections or any equivalent mechanism 51 appropriately spaced from a floor member 53, upon which the drive mechanism, later to be explained, is carried. The complete mechanism then may be supported by various outwardly extending supports 55 from the floor member which are also secured to the base. In a preferred form of the mechanism, as herein depicted, the upper support members 47 are arranged in hexagonal configuration with the support shaft for the screening basket centrally located with respect thereto.

About midway along the vertical supports 45 an appropriate sub-base 59 is held to extend outwardly in the direction of the upper section of the rotary screening basket member 11. The outer periphery of the sub-base members 59 is formed to correspond generally to the shape of the top support members 47 and thus preferably corresponds to one side of the indicated hexagon. The inner periphery of each sub-base section is preferably curved to follow the contour of the ring members and the large opening into the frusto-conical screening basket so that the screening basket may turn freely therein. The screening basket receives its complete support from the base 13, held upon the end of the shaft 15, and supported by the shoulder 61 extending outwardly therefrom.

As is clearly indicated by FIG. 10, and which requires no detailed description, the end of the shaft 15, having the shoulder 61 to support the base plate 13 and the screening and supporting rods and rings carried thereby, is held by the thrust bearing structure, generally designated as 63, which is attached at its outer end to the bottom plate or platform 49. The shaft 15 connects to a flexible coupling 65 so as to be driven in any appropriate manner through the conventionally represented gearing mechanism 67 connected to the shaft 15 through coupling 65 and shaft 68. In one form of drive mechanism rotation is imparted to the screening basket 11 by means of a drive motor 69, arranged to drive by belt or other suitable drive mechanism 71 a flywheel 72, supported upon a

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shaft 73 in appropriate bearings 74 which are held upon a support block 75 which, in turn, is carried upon a sub-base member 77, also used to support the motor. The tension provided on the belt 71 between the motor and its drive wheel 78 and the flywheel 72 is controlled in any suitable fashion, such as by the handwheel 79 moving the motor 69 in and out along the guide track, conventionally represented at 80. Rotation of the flywheel 72 and the driven shaft 73 provides rotation of the sprocket 81, carried thereon, to drive the sprocket wheel 83 through an appropriate drive chain 84. Sprocket 83 is keyed to a driven shaft 85 which terminates within the conventionally represented gear box 86 (see FIGS. 2 and 3) and by means of a suitable form of bevel gearing turns the driven shaft 15 through the flexible coupling 65 and thus rotates the screening basket 11.

The screening basket 11 is guided in its rotational movement by means of a plurality of guide-bearing wheels or rollers, adapted to bear upon the outer periphery of the complete ring 27 and the split rings held thereto. In the form of mechanism illustrated the guide-bearing wheels 89 are supported upon outwardly extending brackets 90 and 91 which are secured to the vertical support member 45. They carry the guide bearing rollers in fixed position on a supporting spindle 93 secured thereto. The rollers 89 (see particularly FIGS. 1 and 3) are spaced for the hexagonally arranged locating frame about 60° apart, although this is not critical. They are arranged, however, so that the outer periphery of the rings 27 and the split rings 28, 29, and 30 bear against them generally quite tightly. This leaves the major portion of the ring 27 free from rigid support but it is so held that it serves to locate and guide the frusto-conical screening basket 11. As the basket rotates a plurality of spring pressed rollers 95 are provided to bear upon the ring periphery in regions spaced from rollers 89.

As can be clearly seen from the showing of FIG. 1, bearing rollers 95 are carried upon support pins 96 which, in turn, are supported from the outwardly extending brackets 97. These brackets 97 are secured to one end of a pivoted arm 98, arranged to turn about a pivot point 99 in the form of a pin extending through the outwardly extending lug 101 which is held by and secured to the horizontal support frame member 47. The opposite end of the pivoted arm 98 is attached loosely to a rod 103 about which there is held a spring member 105 whose inner end bears against the horizontal support frame member 47 and whose outer end is adjustably held by a disk member 107, adjustably secured to the free end of the rod 103. Adjustment of the disk 107 provides a suitable tension control effective on the spring, with the result that the roller 95 is caused to bear with greater or lesser pressure, as the case may be, upon the periphery of the ring 27 and the split rings held thereby. At the same time, any tendency toward unevenness in rotation of the rotary screening basket 11 is taken up since the complete ring is resiliently supported at its outer edge for rotation at a multiplicity of points along the periphery. This provides a sturdiness of construction and security of location irrespective of the rate of basket rotation.

In the foregoing description the rotary element in the form of the screening basket 11 is suitably turned and with it the rods are free to rotate and with centrifugal force more or less turn or move as permitted by the mounting arrangement. Vibration, however, is limited to a substantial extent and, therefore, a spring 109 is provided to cause the rods 39 to vibrate. The spring 109 is a generally flat member whose outer end 111 is slightly curved. It is held in a bracket 113 which, in turn, is secured in any appropriate fashion to a plate-like member, extending outwardly from a vertical support member 45 and secured thereto. Appropriate tension may be applied to the flat leaf spring by means of a tensioning member 117 secured toward its end adjustably through the flat

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spring and fixedly secured at 119 in a bracket extending outwardly from the sub-base or support plate 115.

With this arrangement in use during rotation of the screening basket the outer ends 111 of the flat springs 109 continually contact and press against the rods 39 which are freely held through the openings 35 at the top end in the recesses 19 at the bottom so that the rods are continually moved laterally to the various positions indicated by dotted outline, particularly in FIG. 4. Because this rod vibration is brought about at several points during each basket rotation, whenever ore is placed in the upper portion of the screening basket and the basket is rotated the fines tend to be discharged between the screening rods in the region of the rods closely adjacent to their location in the recesses 19 and such fines then tend to accumulate beneath the sub-base 115 and the platform region 49. Larger size ore segments are discharged above the sub-base 115 and in the region between it and the plates 59 so that this discharge occurs in the region above that whereat the fines are discharged and the upper portion of the screening basket. The larger particles which are not discharged until they are caused by centrifugal force to carry up to the top of the screening basket are then discharged over the top of the screening basket and come to rest upon the surface 59.

The rods 39 are kept clean and heavy coatings of fines are prevented from accumulating due to the induced vibration and the general abrasive effect of the ore when the rods are moved longitudinally and radially (i.e., moved transversely to the rod axis), and also rotated.

Loading of the mechanism may take place by moving ore-containing carriers along the platform region exemplified, for instance, at 125, and which load carriers (not shown) are sufficiently high as to carry over to discharge the material into the interior of the screening basket within the inner boundary of the locating ring 27. If desired, a hand rail 127 may be provided for support and guidance of the operator in controlling the operation of the mechanism.

Generally speaking, the ore particles carried by the screening basket and discharged therefrom are heavy and are discharged at a relatively rapid rate. In order that the operators and those in the region of the screening mechanism may be fully protected, it is generally desirable to arrange doors or closure members about the periphery of the complete mechanism. For this purpose doors 134 and 137, respectively, are arranged above and below the screening basket. As can be seen, the doors 137 are pivoted to open downwardly from the top support member 47 about hinges 139 so that screened material may readily be removed. Similarly, the doors 135 are arranged to open downwardly also about the hinges 141, thereby to permit removal of the fines collected in the region between the platform 49 and the plate 115, or the removal of the larger or intermediate size ore particles collected in the region between the plate 115 and the sub-base 59. It is, of course, apparent that the top of the mechanism may remain open, as desired, and loading may be continuous where the ore is discharged from a continuous belt terminating or overlapping the open end of the frusto-conical member. Intermittent loading operations, of course, will permit removal at selected time periods of the screened particles as found in the regions of collection.

The screening rod mechanisms shown at 39, particularly in FIG. 1, are rods of generally uniform diameter and, consequently, with the separation of the rod axis in the region of the ring 27 being greater than the axial separation at the region of the recesses 19, the screening operation becomes a variable, depending upon the rate at which the screening basket is rotated and the height to which the ore particles are forced. Where it is desired that the screening be strictly uniform, the rods 39 may be replaced by the conically shaped rods shown, for in-

stance by the rod 157 in FIG. 11. This rod is provided on one end with a uniform guide portion 37, as was the rod 39, and at the opposite end 159 also with a portion of cylindrical characteristics adapted to rest within the recesses 19. Various other forms of rods may also be used within the scope of the present invention.

While it has not been shown, it frequently becomes desirable to introduce water sprays into the operation and this may be provided in any desired fashion but is preferably accomplished by introducing the water from the upper and loading end. The operation is dependent upon centrifugal force moving the ore in a swirling pattern to the side and up the rods where the screening takes place. The wet fines are always thrown out near the bottom through the nearest openings between the rods as the ore rises up on the rods. As they approach the ring-like support, the spacing increases between the rods and particles of larger size and mass are thrown out as they find their proper openings. The vibration introduced into the rods by the action of the leaf-type spring member 109 provides vibration of the rods and the shelves or sub-bases provide the effect of sorting the discharged material for size. There is no particular speed limit at which the mechanisms need be run. It is preferable, however, to maintain the speed reasonable and to this end speed of the order of 500 r.p.m., with the rod angles as heretofore mentioned, have been found suitable.

Various modifications of the invention within the scope of this disclosure will, of course, be readily apparent to those skilled in the art and it may be pointed out that the effective force upon the vibrating rods is that of gravity, the centrifugal force which is determined by the rate at which the screening basket is rotated, as well as the number of spring vibrators effective upon the rod, and the shape imparted to the screening rods.

Having now described the invention, what is claimed is:

1. Centrifugal screening apparatus comprising an inverted frusto-conical rotatable basket having a lower article support surface, an upper ring-like member having rod-locating and guiding means circumferentially spaced thereon at substantially uniform circumferential distances, said lower article support surface having a plurality of circularly located and substantially uniformly spaced rod-receiving recesses, a plurality of spaced support rods each anchored at one end in said recesses and at the other end to said ring-like member for maintaining fixed spacing between said lower article support surface and said ring-like member, said article support surface also having additional rod-receiving recesses substantially uniformly spaced and each located along a circular path thereon, a screening rod loosely supported at one end in each of the last-named rod-receiving recesses and at the other end in the ring-like member so as to be freely movable therein for each of lateral, radial, and longitudinal movement, a central support for said lower article support surface, said central support being adapted to be turned for rotating said basket whereby due to centrifugal force material loaded within the basket with its rotation is moved outwardly and through the space between adjacent rods with the removed particle size increasing as articles are ejected between the rods in a direction toward the ring-like member.

2. The screening apparatus as claimed in claim 1 comprising, in addition, guide means supported externally of the ring-like member and adapted to bear upon the ring-like member for guiding the rotational path thereof.

3. The apparatus claimed in claim 2 wherein the guide means are rotatable and adapted to establish rolling contact with the periphery of the ring-like member during rotation thereof by drive imparted through base rotation and the screening rods.

4. Screening apparatus as claimed in claim 3 wherein at least a portion of the guide means are resiliently pressed against the periphery of the ring-like member.

5. The screening apparatus claimed in claim 3 wherein a portion of the guide means include roller means fixedly supported relative to the periphery of the ring-like member to bear against the same and additional guide roller means resiliently pressed against the ring-like member.

6. The apparatus claimed in claim 1 comprising, in addition, means positioned adjacent to the screening rods between the said recesses in the article support surface and the rod-locating and guiding means of the ring-like members for vibrating said rods.

7. The apparatus claimed in claim 6 wherein the said vibrating means comprises a resilient member adapted to dislodge the rods within a selected contact region.

8. The apparatus claimed in claim 5 comprising a frame external to the inverted basket for supporting the basket-guiding roller means and means supported from the frame to be contacted by the rods during rotation to produce rod vibration.

9. The apparatus claimed in claim 8 comprising, in addition, a plurality of article-receiving regions spaced from each other in a direction axially of the rotatable basket for receiving discharged material centrifugally removed from the interior of the basket between the screening rods with rod rotation.

10. The apparatus claimed in claim 1 comprising, in addition, a plurality of spaced support rods positioned between the said lower article support surface and the ring-like member and anchored to each of the said article support surface and the ring-like member at an angular position with respect to the axis of rotation of the central support which corresponds substantially to that of the screening rods in their position of rest.

11. The apparatus claimed in claim 10 wherein the screening rods are held at an angle relative to the axis of rotation of the basket which is in a range between 40° and 60°.

12. The screening apparatus claimed in claim 1 wherein the screening rods are of uniform diameter substantially throughout their length.

13. The apparatus claimed in claim 1 wherein the screening rods are of non-uniform diameter throughout their length and vary along their length to increase in diameter near the ring as compared to the article support surface, whereby the spacing between rods is maintained substantially uniform throughout rod length between the recesses of the lower article support surface and the guiding and locating means of the ring-like member.

14. Ore screening apparatus comprising a rotatable support base, a support shaft for carrying said base, said base having a plurality of substantially uniformly spaced rod-receiving recesses arranged thereon in a circular path each equi-distant from the support-shaft axis, a ring-like member of a radius substantially greater than that of the circularly located recesses within the base member, said ring-like member having a plurality of uniformly spaced rod-guiding and retaining means of a number corresponding to the circularly arranged recesses of the base member, means to maintain a fixed separation in a direction axially of the base support means between the said base support and the ring-like member, a plurality of screening rods loosely supported in the recesses of the said base and in the rod-locating and guiding means of the ring-like member, the size of the said recesses of the base and of the rod-guiding and locating means of the ring-like member being such that screening rods supported within the recesses and guided by the rod-guiding and locating means are free to rotate about the rod axis, to be vibrated transversely of the rod axis and to move longitudinally along the rod axis, means to limit the longitudinal movement of the rods and to restrict said movement to an extent that the limit of longitudinal movement of the rods is insufficient to move the rods out of the recesses, and means to rotate the said basket about the base support axis.

15. The screening apparatus as claimed in claim 14

comprising, in addition, guide means supported externally of the ring-like member and adapted to bear upon the ring-like member for guiding the rotational path thereof.

16. The apparatus claimed in claim 15 wherein the guide means comprise a plurality of rotatable elements adapted to establish rolling contact with the periphery of the ring-like member during rotation thereof by drive imparted through base rotation and the screening rods.

17. The screening apparatus claimed in claim 16 wherein a portion of the rolling contact is provided in part by guide rollers fixedly supported relative to the periphery of the ring-like member to bear against the same and the remainder of the rolling contact is provided by guide rollers supported to be resiliently pressed against the ring-like member.

18. The apparatus claimed in claim 17 comprising, in addition, means positioned adjacent to the screening rods between the said recesses and the rod-locating and

guiding means of the ring-like members for vibrating said rods.

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