

Dec. 4, 1928.

1,693,940

S. D. ROBINS
SCREENING APPARATUS
Filed April 12, 1927

4 Sheets-Sheet 1

Fig. 1.

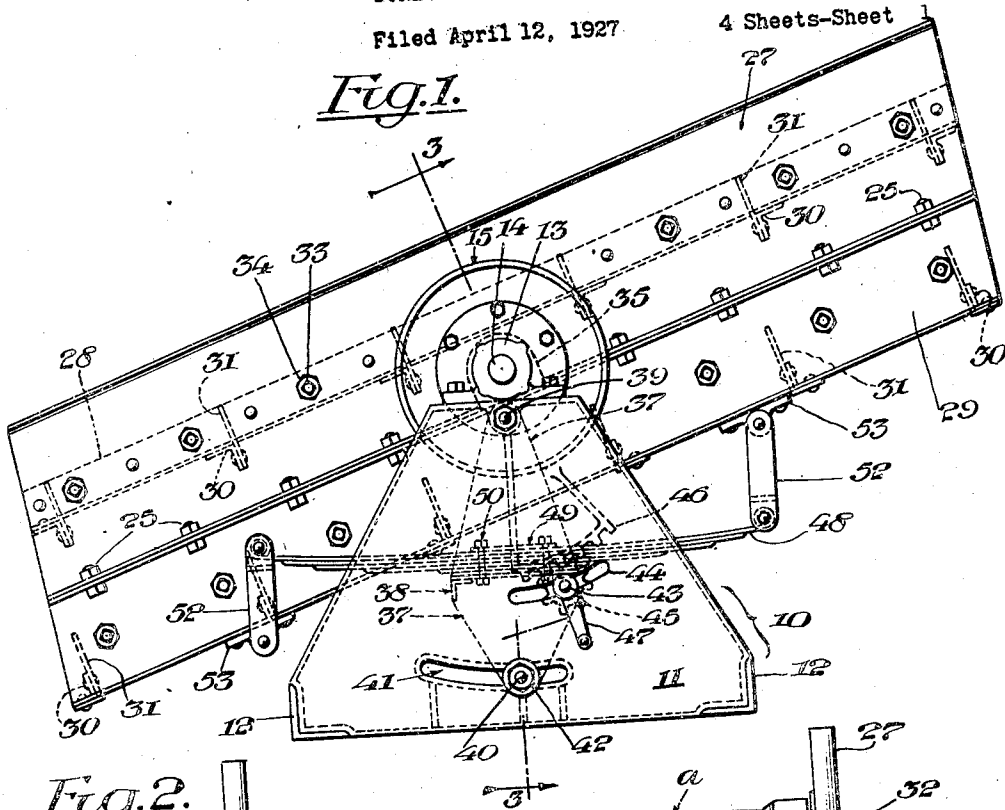
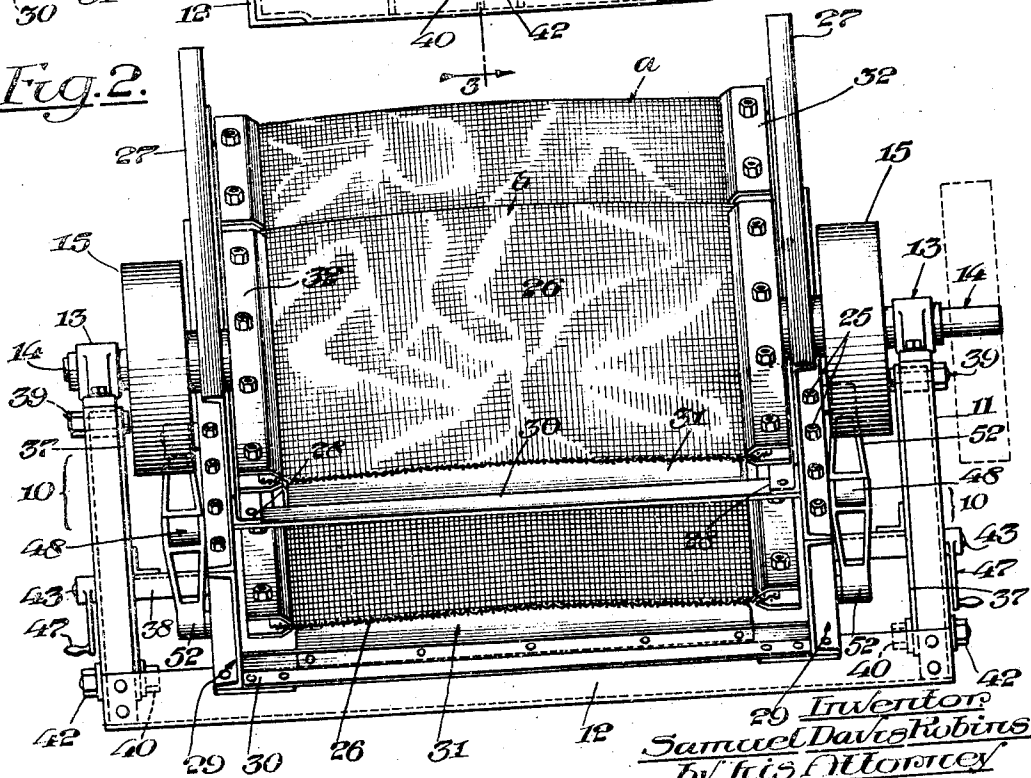


Fig. 2.



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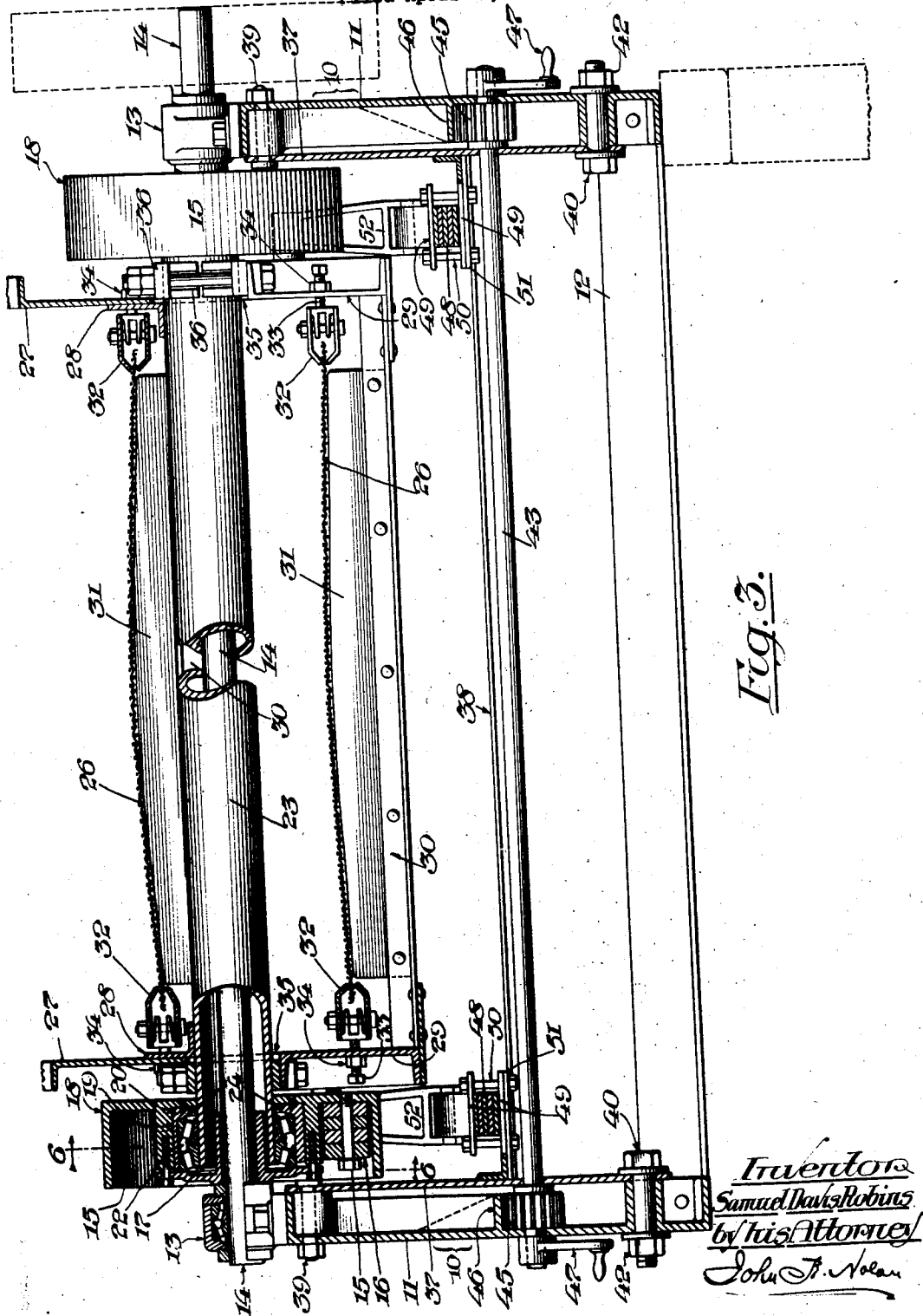
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3
Fig. 4.

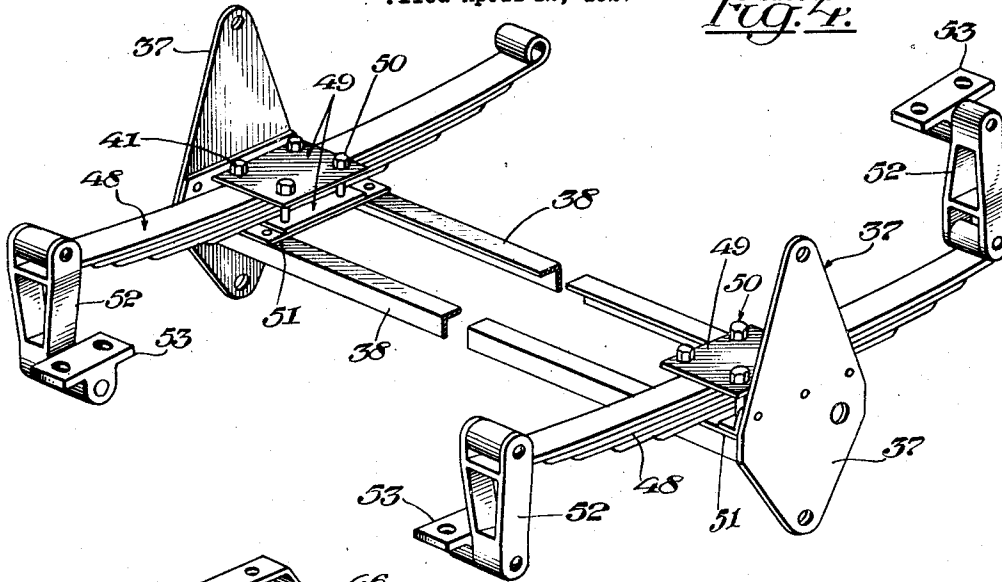


Fig. 5.

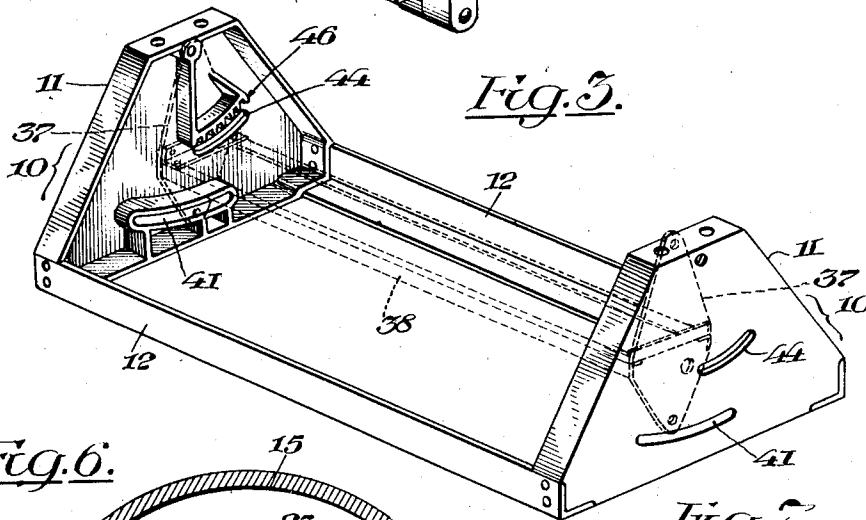


Fig. 6.

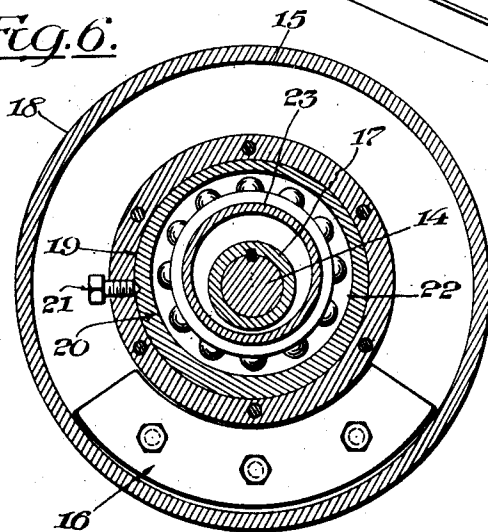
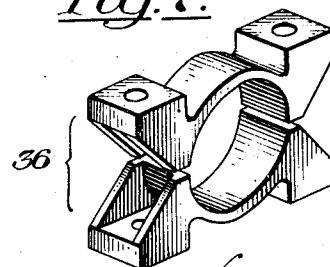


Fig. 7.



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4 Sheets-Sheet 4

Fig. 8.

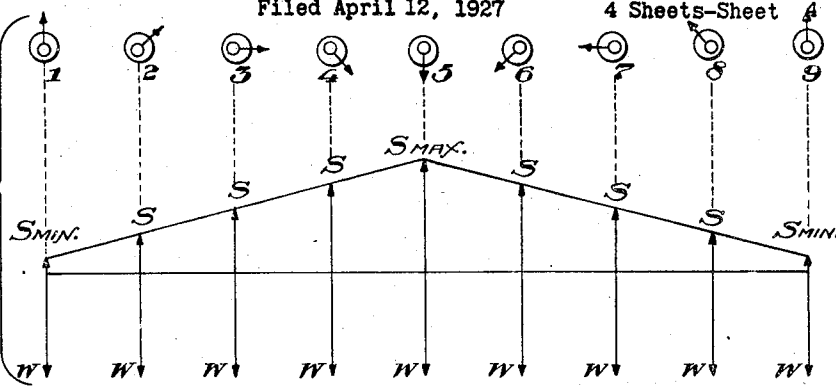


Fig. 9.

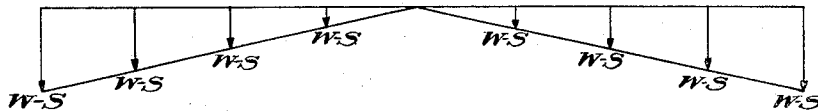


Fig. 10.

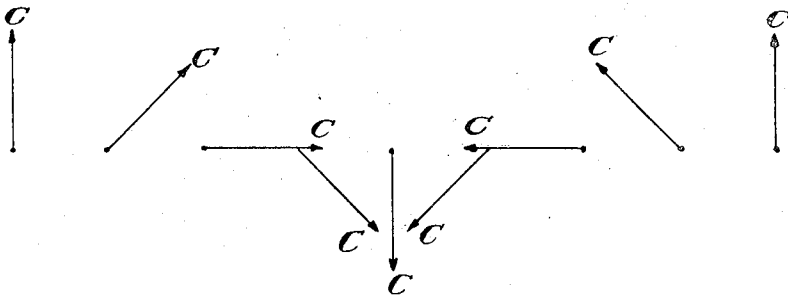


Fig. 11.

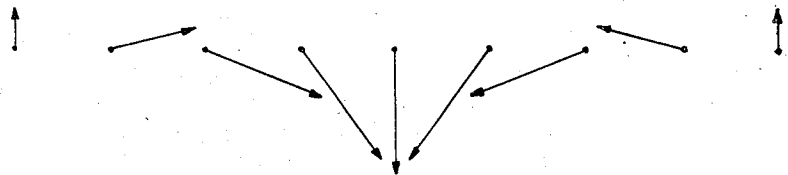


Fig. 12.

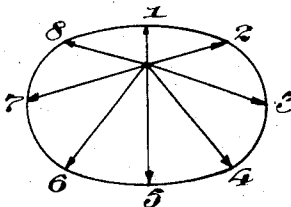
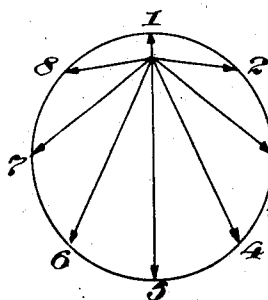


Fig. 13.



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SCREENING APPARATUS.

Application filed April 12, 1927. Serial No. 183,049.

This invention relates to vibratory screens, such as are used for screening coke, crushed stone, ore, sand, gravel, etc., having especial reference to that class of screens wherein a rigid screening element of substantial weight is given a circular motion, or gyration, in planes at right angles to the plane of the screen surface.

As is recognized in the screening art the effective gyratory motion of the screening element is variable in accordance with the character of the material that is being treated; that is to say, for fine screening a motion or vibration of small amplitude and high frequency is employed, whereas for coarse screening, (in which the screen openings are, say, an inch or more in diameter), a motion of relatively large amplitude and low frequency is used. In the screens of the prior art the construction and operation of the mechanism for actuating the heavy screening element is such that the movement of said element tends to set up unbalanced impulses that are transmitted to the supporting structure with destructive results. Even when the frequency of vibration of the screen is relatively low the floor spans and bracing commonly used in the structure have free periods of vibration in consonance with the vibration of the screen.

The principal object of my invention is to overcome the objections mentioned in a screen of the class referred to, by the provision of simple and efficient screen operating mechanism, including eccentric and spring connections which are co-operatively related to effect and maintain the dynamic balancing of the apparatus under all working conditions. Another object of the invention is the provision of means whereby the angle of the screen surface can be readily and quickly adjusted while the screen is in operation, and this without impairing the balance of the apparatus.

With these and other objects in view my invention comprises novel features of construction and principles of operation which, in a preferred embodiment of the invention, will be hereinafter described, and the scope of the invention then be defined in the appended claims.

In the drawings—

Figure 1 is a side elevation of a screen embodying the preferred form of my invention.

Fig. 2 is an end elevation of the apparatus.

Fig. 3 is a transverse vertical section, partly in elevation, of the apparatus, the section being taken on the irregular line 3—3 of Fig. 1.

Fig. 4 is a perspective view of supporting springs for the live screen frame and the adjustable mounting structure for the springs.

Fig. 5 is a similar view of the stationary base frame.

Fig. 6 is a transverse vertical section through the drive shaft and one of the counterweighted fly wheels and adjuncts, as on the line 6—6 of Fig. 3.

Fig. 7 is a perspective view of one of the clamps for securing the live screen frame to the gyratory carrier shaft.

Figs. 8 to 13, inclusive, are stress diagrams hereinafter considered.

Referring to the drawings, 10 designates a substantial base frame mounted on suitable supports (not shown), which frame, in a simple and efficient form, consists of two spaced-apart flanged uprights 11 connected by cross-braces 12 of angle iron to provide a rigid structure. Bolted to the uprights are bearings 13, preferably of the self-aligning roller type, in which are journaled the ends of a shaft 14 that is adapted to be driven from a suitable source of power. Keyed on the shaft, adjacent the respective bearings 13, are fly wheels 15 having appropriate counterweights 16, each wheel being preferably made in two parts, namely a hub portion 17 and an outer portion including the rim 18. The hub is bored to receive the adjacent end of the shaft 14, concentrically with the rim of the fly wheel, and an eccentric annular recess 19 is formed between the hub and the rim. In this recess is mounted, for turning adjustment, a bushing 20 having an eccentric bore, the eccentricity whereof is the same as that of the recess 19 with relation to the concentric hub and rim of the fly wheel. Consequently by properly turning the bushing within the recess 19 the eccentricity of the bore of the bushing with relation to the drive shaft may be varied from zero to a value equal to the eccentricity of the recess plus that of the bushing. A suitably-disposed screw in the wall of the recess engages the bushing and secures it in any desired position of adjustment.

Within the eccentric bore of the bushing is seated the outer race of a ball or roller bearing 22, the inner race of which is seated upon the adjacent end of a hollow cylindrical shaft 23 which surrounds the drive shaft. (See Figs. 3 and 6.) Hence the rotation of the drive shaft, with its fly wheels, causes the hollow shaft to travel in an eccentric path about the axis of rotation of the drive shaft, that is to say, the hollow shaft receives a gyratory motion in planes at right angles to the axis of the drive shaft. If desired a plain bushing may be used instead of the ball or roller bearing 22 referred to.

The counterweight 16 of each of the fly wheels is preferably bolted to the web of the wheel in the space between the rim and the hub, said weight comprising a number of separate pieces which may be secured in various positions to meet balance requirements with different eccentric adjustments of the bearing in the fly wheel.

Grease seals 24, which encircle the hollow shaft, are fastened to and may turn with the eccentric bushings 20. These seals prevent the escape of lubricant from and the entrance of dirt to the bearings.

An inclined screening element is operatively connected, midway between its ends, to the hollow shaft 23 so as to receive uniform gyratory motion therefrom, as will be hereinafter described, such shaft thus constituting in effect a carrier for the screening element. This screening element, in the form illustrated, comprises a rectangular live frame with tensioned screen cloths therein. In the present instance the live frame is composed of two sections, one superposed on the other, fastened together by bolts 25, which sections are provided with spaced-apart screening cloths 26. The upper section is composed of two side plates 27 having on their inner surfaces longitudinally extending reinforcing angle bars 28. The lower section is composed of two side plates 29, preferably in the form of structural channels. Both the two upper side plates 27 and the two lower side plates 29 are rigidly connected at intervals by a number of angle bars 30, each of which has affixed thereto a vertical plate 31 with an upwardly curving upper edge, the purpose of which edge is to elevate the center of the adjacent screen cloth in order to prevent "whipping". Tension of the screen cloths is maintained, and they are kept in contact with the upwardly curving edges of the plates, by means of laterally-disposed grips 32 which engage the margins of the cloths. Screws 33 extend through suitably-disposed apertures in the side plates 27, 29 of the live frame and engage the adjacent cloth grips, and hence as the nuts 34 on the screws are tightened the associated grips are drawn toward the side plates and efficient tensioning of the cloth is effected.

As screening cloths wear out more quickly at the feeding end of the screen, I preferably make each of the screen cloths in two sections of unequal length, with the shorter section, *a*, at the high or feeding end of the screen overlapping the longer section, *b*, thus permitting the section at the feeding end to be readily removed and replaced when worn, without disturbing or discarding the longer portion of the cloth which is still useful. (See Fig. 2.)

The upper side plates 27 of the live frame have formed therein, midway between the ends of the structure, openings 35 through which the hollow shaft 23 extends. This shaft is firmly fastened to the live frame by means, for example, of complementary clamp sections 36 (Fig. 7) which tightly embrace the hollow shaft and are bolted to the adjacent side plates. Therefore the gyratory motion of the hollow shaft is positively imparted to the live frame and all points of the latter are given a true circular motion in paths lying in planes at right angles to the drive shaft; and, since the actuating center of the shaft coincides with the center of gravity of the frame, the inertia of the latter as a whole does not set up moments about the actuating center; it being obvious that if the actuating center were away from the center of gravity of the screening element, such moments would be set up and would influence the paths of motion described by all points of the live frame. Such a motion of this frame, being a compound motion, is impossible to counterbalance effectually, with the result that the escaping vibrations would be disastrously transmitted to the supporting structure.

It is to be understood that the counterweights 16 of the fly wheels 18 are located, with relation to the axis of the drive shaft 14, diametrically opposite the central axis of the eccentrically journaled hollow shaft 23, and that the respective distances of the centers of gravity of the counterweights from the axis of the drive shaft are such that the moments of the counterweights about the drive shaft axis are equal to the moment of the live frame about the same axis. Consequently a dynamic balance is effected at any speed at which the shaft 14 is driven.

As simple and efficient means to relieve the eccentric bearings for the hollow shaft of a large part of their maximum stress during the gyratory motion of said shaft, and at the same time to facilitate the angular adjustment of the live frame with respect to the horizontal, as the screening operation may at any time require, and also to ensure the fixed angular position of the frame under actual working conditions, irrespective of the tendency of the hollow shaft to rotate the live frame in the direction of movement of the drive shaft or the tendency of

unequal loading of material on the screening surface to set up moments tending to turn the frame in one direction or the other about the drive shaft, spring supporting and controlling mechanism is arranged in co-operative relation to the live frame and the actuating devices therefor, which mechanism in its preferred form is as follows:

Supported by and between the uprights of the base frame is a pendant frame comprising two suitably-spaced hanger plates 37 rigidly connected by parallel angle bars 38. In the present instance the hanger plates are pivoted at their upper ends to the adjacent uprights 11 by means of bolts 39, and the lower ends of such plates are secured to the uprights by bolts 40 which extend from the plates through suitably located arcuate slots 41 in the uprights. Hence by loosening the nuts 42 of the bolts 40, the pendant frame can be laterally adjusted within limits to vary its angularity in respect to the vertical, and then by tightening the nuts the said frame can be effectually secured in any desired position of adjustment. To facilitate the operation of adjustment, a shaft 43 is journaled in suitable holes in the hanger plates, the ends of which shaft extend through arcuate slots 44 in the respective plates. The shaft 43 has keyed thereon, between the hanger plates and the respective uprights 11, pinions 45 in mesh with arcuate racks 46 which are integral with or secured to the said uprights; and the shaft has also keyed thereon, at its outer ends, suitable actuating devices, as, for example, hand cranks 47, whereby the shaft 43 may be turned from either side of the apparatus, thus through the intermeshing action of the pinions and the racks effecting the desired adjustment of the pendant frame, and this while the screening apparatus is running.

On the cross-bars 38 of the adjustable pendant frame, adjacent the respective side members of the latter, are supported two springs 48 which, in the present instance, are of the leaf type. These springs are securely clamped in their mid sections between horizontal plates 49 by suitable bolts 50, which bolts also serve to hold the springs securely to bed plates 51 that are, in turn, affixed, as by rivets, to the cross-bars 38. (See Fig. 4.) The respective ends of each spring 48 are flexibly connected by means of parallel links 52 to brackets 53 on the lower section of the live frame, one link preferably depending and the other link upstanding, as shown, to accommodate the inclination of the live frame. As thus mounted and connected to the live frame, the springs simultaneously exert an upward resilient action against the frame in paths equally spaced from the respective sides of the actuating shaft. (See Fig. 1.)

From the foregoing described construction

it will be seen that the live frame and its associated spring supports are adjusted as a unit, coincident with the adjustments of the pendant frame previously explained, and therefore the springs resiliently maintain the live frame in any angular position of adjustment of the latter, and this without impairing the resilient effect of the respective ends of the spring on the live frame.

The loading of the eccentric bearings of the actuating mechanism of screens of the class to which my invention relates is mainly radial loading. The amount of the radial load is the resultant of two forces, one being the dead weight downward, viz a uniform force active in one direction, and the other being the centrifugal force set up by the gyrating live frame, viz a force of uniform magnitude, but changing in direction. The resultant of these two forces is a force changing both in direction and magnitude. By employing the springs acting upwardly against the live frame as aforesaid, the resultant force indicated is greatly reduced and in consequence the eccentric bearings and also the stationary bearings for the drive shaft are relieved of a large part of their maximum stress.

The upwardly acting spring force is a variable one, the magnitude of which changes with each position of the eccentric, that is to say, the maximum is at the bottom of the stroke when the springs are most deflected and the minimum is at the top of the stroke when the springs are least deflected.

By reference to the diagrams, Figs. 8 to 13, inclusive, it will be seen that in a gyratory screening apparatus embodying my invention, the stresses on the eccentric bearings 22 and on the main bearings 13 are reduced to a minimum, and that all forces are counteracted within the stationary base frame 10 to the exclusion of escaping impulses into the supporting structure.

In Fig. 8 are plotted the static forces, (W, S) for eight positions of the eccentric 45 degrees apart. The arrows pointing upward are the vector values of the varying spring force (S) while those pointing downward represent the constant force of gravity (W) which is equal to the total weight of the live frame plus the weight of the shaft and fly wheels.

In Fig. 9 are plotted the static resultants, it being noted that the static forces are vertical because the horizontal leaf springs produce only vertical reactions. Should the angle of the screen be changed, the force diagram will be changed accordingly, but, for the sake of illustration, only the horizontal setting of the springs need be considered.

The gyration of the live frame sets up a centrifugal force (C) which has a constant value for a given eccentricity at any speed. This force is indicated in the diagram Fig.

10, as a radial force, constant in magnitude, but changing in direction at the rotational speed of the shaft, which speed for a given amount of eccentricity must be sufficient to
 5 set up enough centrifugal force to throw the material off the screen surface at each revolution. To fulfil this condition the centrifugal force must slightly exceed the accelerative force of gravity.

10 The diagram, Fig. 11, indicates the combined resultants of the static and kinetic forces acting upon the eccentric bearings for the eight different positions of the eccentric.

Fig. 12 is a polar diagram of the same resultant, and Fig. 13 is a similar diagram of the same system of forces if the spring element be omitted. A comparison of these two diagrams shows that approximately 40% of
 15 the maximum bearing stress has been eliminated from the eccentric bearings by the provision of the spring element.

There are no kinetic forces acting on the main bearings 13 since the flywheel counterweights are designed to balance the weight
 25 of the live frame. Thus the centrifugal force acting upon the counterweights at all speeds is equal in magnitude and opposite in direction to the centrifugal force acting upon the live frame. Hence the introduction of the
 30 springs does not effect the maximum main bearing stress but serves to set up in the main bearings a fluctuating stress varying from zero to W with each revolution of the drive shaft. The main bearings, then, are free
 35 from all except static forces, which are indicated as combined in Fig. 9.

Since the main bearings are free from kinetic stresses as above mentioned, they transmit only static stresses to the base frame, the
 40 fluctuating downward force thus transmitted being indicated in Fig. 9.

The tension in the hanger plates 37 which carry the springs 48, is a fluctuating stress, being greatest at the bottom of the stroke,
 45 when the springs are under greatest compression, and least at the top of the stroke when the springs are under least compression.

It will be noted from Fig. 9 that the downward force transmitted by the main bearings
 50 is least at the bottom of the stroke and greatest at the top. Thus the fluctuating tension in the hanger plates is 180 degrees out of phase with the fluctuating downward forces in the main bearings, with the result that the
 55 base frame transmits only a uniform downward force to its supports.

From the foregoing it will be seen that (1) the resultant stresses are reduced about 40%; (2) the centrifugal stresses are balanced by the counterweights and are confined to the eccentric bearings, and (3) the base frame receives two series of counteracting stresses, thus precluding the escape of vibrations into the supporting structure for the
 65 apparatus.

It is to be understood that my invention is not limited to the particular construction herein disclosed, as the same may be variously modified within the principle of the invention and the scope of the appended
 70 claims.

I claim—

1. A screening apparatus comprising a screen frame, a drive shaft substantially coincident with the center of gravity of the
 75 said frame, stationary bearings for said shaft, connections between said shaft and frame whereby the frame is positively gyrated in circular paths lying in planes at right angles to the drive shaft, and resilient equalizing
 80 means simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft and operative to maintain the said frame constantly in correct screening position while permitting its positive
 85 gyration.

2. A screening apparatus comprising a screen frame, a drive shaft substantially coincident with the center of gravity of the said frame, stationary bearings for said shaft, connections between said shaft and frame whereby the frame is positively gyrated in circular paths lying in planes at right angles to the drive shaft, and resilient means co-acting with said frame to exert upward force thereon simultaneously beyond the respective
 90 sides of the shaft whereby the downward load upon the said drive shaft bearing is relieved and at the same time the said frame is constantly maintained in correct screening position while permitting its positive gyration.

3. In a screening apparatus, a screen frame including a taut screening surface, actuating means substantially coincident with the center of gravity of the frame and operative
 105 positively to gyrate the frame in circular paths, said means including a drive shaft, stationary bearings therefor, and a member fixedly connected to the central portion of the frame, and spring means arranged symmetrically about the actuating means and operative to exert simultaneous resilient pressure in the same direction on the frame, whereby the said frame is constantly maintained in correct screening position while
 110 permitting its positive gyration by the said actuating means.

4. In a screening apparatus, a screen frame including a taut screening surface, a drive
 120 shaft substantially coincident with the center of gravity of the said frame, stationary concentric bearings for said shaft, eccentric bearings on said shaft, a member mounted in said eccentric bearings and fixed to the said
 125 frame, whereby the said frame is positively gyrated in circular paths lying in planes at right angles to the drive shaft, and spring means exerting upward thrust on the said frame simultaneously beyond the respective
 130

sides of the shaft to relieve the said concentric and eccentric bearings of the load caused by the weight of said frame and to maintain the said frame constantly in correct screening position during its positive gyration.

5. A screening apparatus comprising a screen frame, a drive shaft substantially coincident with the center of gravity of the said frame, stationary bearings for said shaft, means, including an eccentric on the drive shaft and a connecting member between said eccentric and the frame, whereby the said frame is positively gyrated in circular paths lying in planes at right angles to the drive shaft, means rotatable with said shaft and adapted and arranged to counterbalance the screen frame, and resilient equalizing means simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft and operative to maintain the said frame constantly in correct screening position during its positive gyration.

6. A screening apparatus comprising a stationary base, a screen frame including a taut screening surface, a drive shaft journaled on the base frame close to the center of gravity of the screen frame, means, including an eccentric on the drive shaft and a connecting member between said eccentric and the central portion of the screen frame, whereby the said screen frame is gyrated at all points in circular paths lying in planes at right angles to the axis of the drive shaft, counterweights carried by the drive shaft and rotating therewith to produce dynamic balance, and resilient equalizing means interposed between the said screen frame and the stationary base frame and simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft to maintain the said screen frame in correct screening position while permitting its positive gyration.

7. A screening apparatus comprising a screen frame, a drive shaft having its axis substantially coincident with the center of gravity of said frame, stationary bearings for said shaft, annular bearings eccentric to and carried by said shaft, a hollow shaft freely encircling said drive shaft and supported in said annular bearings, said hollow shaft carrying the screen frame, whereby during the rotation of the drive shaft the said hollow shaft and frame are positively gyrated in circular paths lying in planes at right angles to the drive shaft, and resilient equalizing means simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft and operative to maintain the said frame constantly in correct screening position during its positive gyration.

8. A screening apparatus comprising a screen frame, a drive shaft having its axis substantially coincident with the center of gravity of said frame, stationary bearings for

said shaft, adjustable annular bearings eccentric to and carried by said shaft, means for securing said annular bearings in predetermined positions of eccentric adjustment, a hollow shaft freely encircling said drive shaft and supported in said annular bearings, said hollow shaft carrying the screen frame, whereby during the rotation of the drive shaft the said hollow shaft and frame are positively gyrated in circular paths lying in planes at right angles to the drive shaft, and resilient equalizing means simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft and operative to maintain the said frame constantly in correct screening position during its positive gyration.

9. A screening apparatus comprising a screen frame, a drive shaft having its axis substantially coincident with the center of gravity of said frame, stationary bearings for said shaft, counterweighted fly wheels on said shaft having annular bearings therein eccentric to the axis of the shaft, a hollow shaft freely encircling the drive shaft and seated in said annular bearings, said hollow shaft carrying the screen frame, whereby during the rotation of the drive shaft the said hollow shaft and frame are positively gyrated in circular paths lying in planes at right angles to the drive shaft, and resilient equalizing means simultaneously acting in the same direction upon said frame beyond the respective sides of the shaft and operative to maintain the said frame constantly in correct screening position during its positive gyration.

10. A screening apparatus comprising a screen frame, a gyratory carrier element therefor, a drive shaft having its axis substantially coincident with the center of gravity of said frame, stationary bearings for said shaft, means operated by said shaft to gyrate the said carrier element and frame in circular paths lying in planes at right angles to the drive shaft, and leaf springs supported adjacent to and longitudinally of the frame, the ends of said springs being connected to the frame at points spaced from the respective sides of the drive shaft and simultaneously acting in the same direction upon said frame to maintain the frame constantly in correct screening position during its positive gyration.

11. A screening apparatus comprising a screen frame, a carrier element therefor, a drive shaft having its axis substantially coincident with the center of gravity of said frame, stationary bearings for said shaft, means operated by said shaft positively to gyrate the said carrier element and frame in circular paths lying in planes at right angles to the drive shaft, an adjustable supporting element adjacent to the said frame, means for fixing said element in positions of adjust-

ment, and springs supported on said element and adjustable therewith, said springs being arranged to act upon the frame at points spaced from the respective sides of the said shaft and to act simultaneously in the same direction upon said frame to maintain the frame constantly in correct screening position during its positive gyration.

12. A screening apparatus comprising a base structure, a screen frame, a carrier element for said frame, a drive shaft mounted on said structure and having its axis substantially coincident with the center of gravity of said frame, means operated by said shaft to

gyrate the said carrier element and frame in circular paths lying in planes at right angles to the drive shaft, a pendant frame pivotally mounted in the base structure, leaf springs secured at their mid sections to said frame and having link connections at their extremities with the screen frame, means for adjusting said pendant frame, and means for securing said pendant frame in positions of adjustment.

Signed at New York, in the county and State of New York, this 11th day of April, A. D. 1927.

SAMUEL DAVIS ROBINS.