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[54] **APPARATUS FOR SIZING PARTICULATE MATERIAL**

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[52] **U.S. Cl.** ..... **241/69**, 241/87, 241/189 R, 241/191

[51] **Int. Cl.** **B02c 13/284**

[58] **Field of Search** ..... 241/69, 79.2, 86, 241/87, 89, 185 R, 187, 189 R, 191, 195

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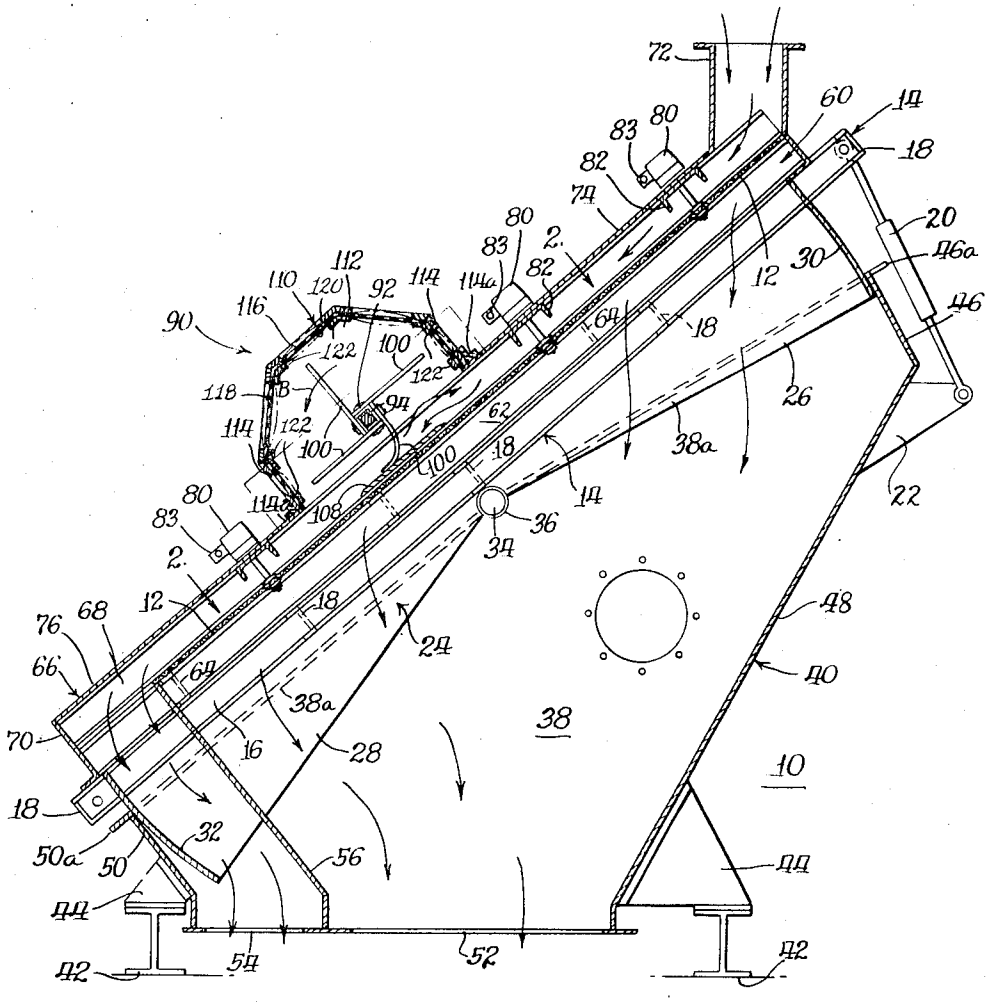
[57] **ABSTRACT**

Apparatus for sizing particulate material comprising an inclined screen mesh for receiving material adjacent the upper end to flow toward the lower end and means for vibrating said mesh to sift on-size particles therethrough. Lump breaker means is provided intermediate the upper and lower ends of the screen for impact breakage of agglomerated oversize lumps of said particulate material and for retarding the downward travel of said oversize material. Said lump breaker includes at least one rotating paddle extending transversely across said screen mesh and formed of flexible material, and a breaker plate above the screen mesh for protecting the screen and cooperating with the paddle to help break up large lumps of material into smaller size. The paddle is rotated in a direction to impact the oversize lumps upwardly on said screen mesh counter to the general flow direction of material downwardly toward the lower end.

17 Claims, 4 Drawing Figures



Patented Aug. 14, 1973 3,752,410

2 Sheets-Sheet 1

Fig. 1.

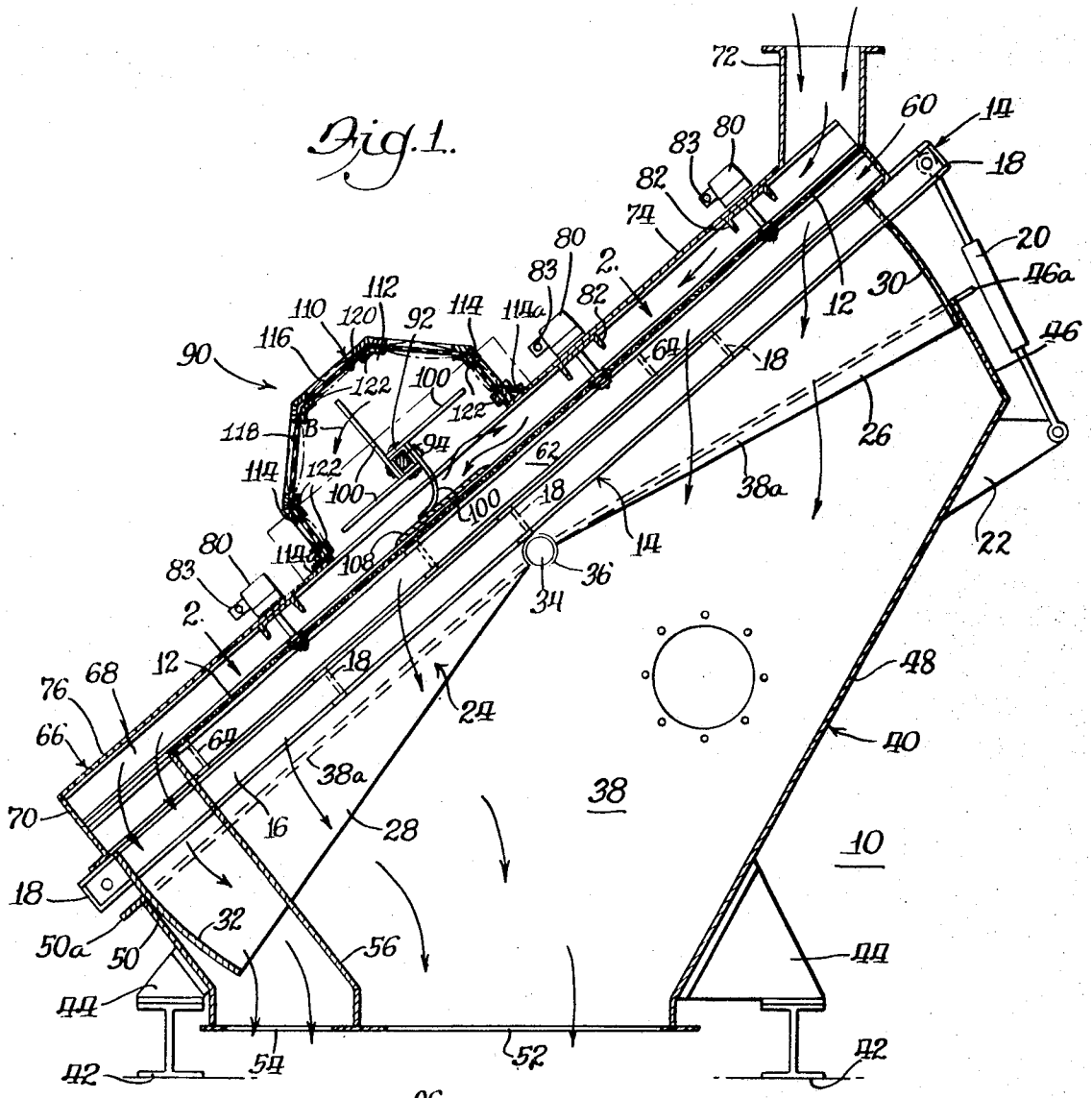


Fig. 2.

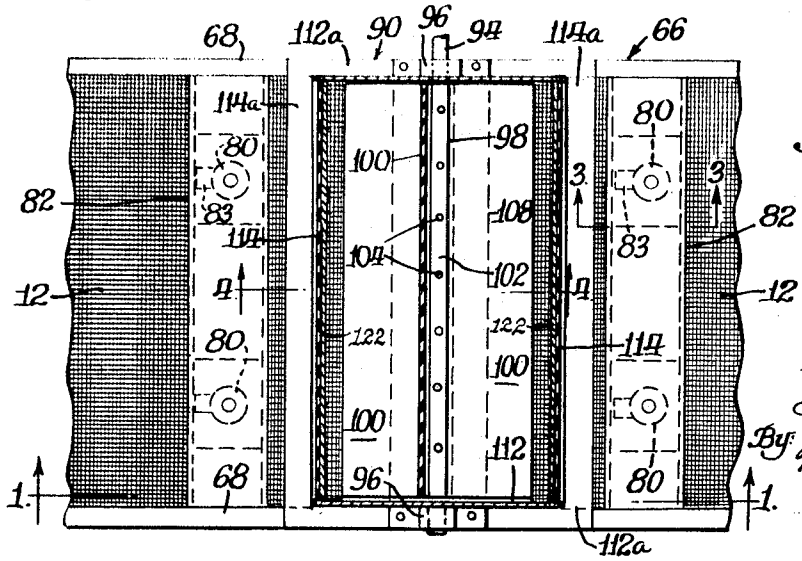


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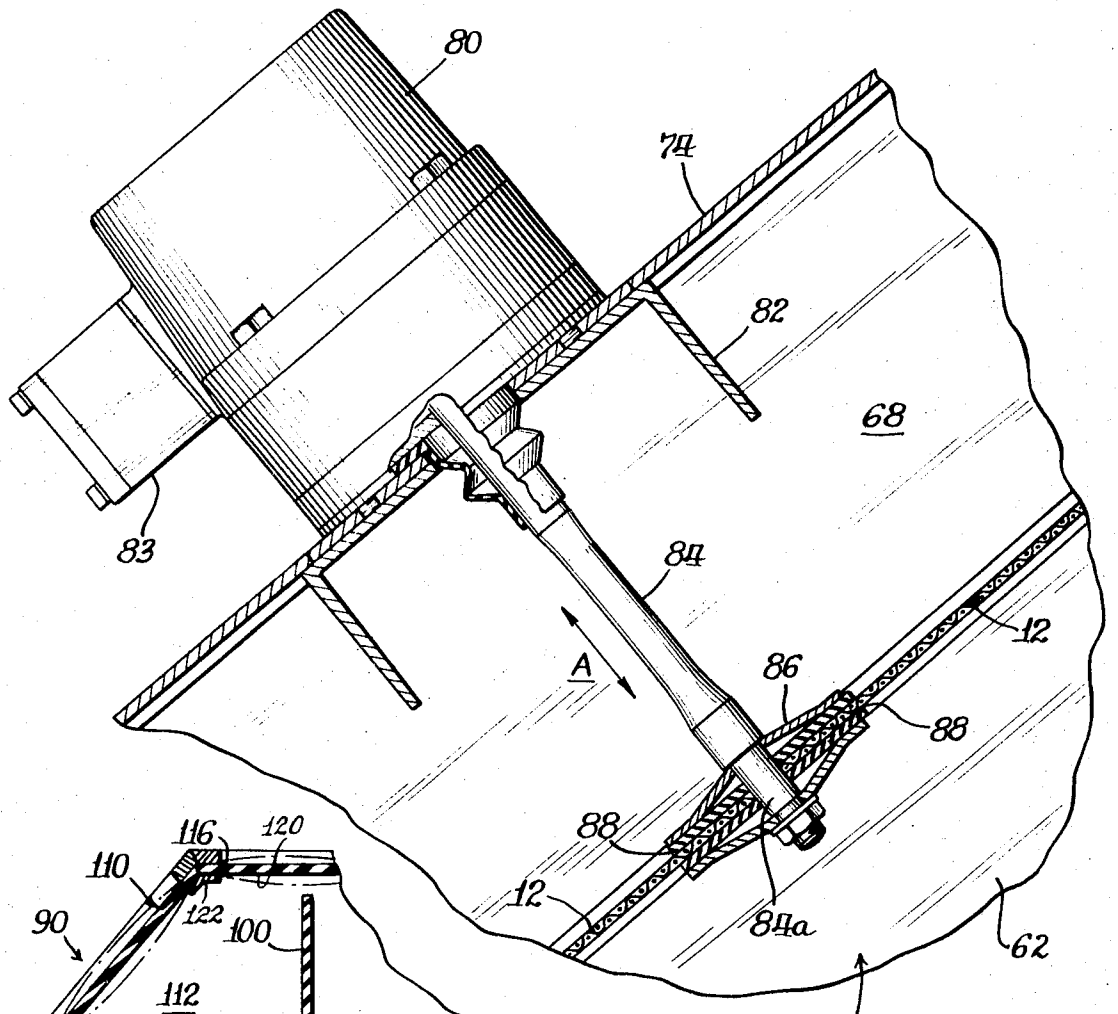
Fig. 3.



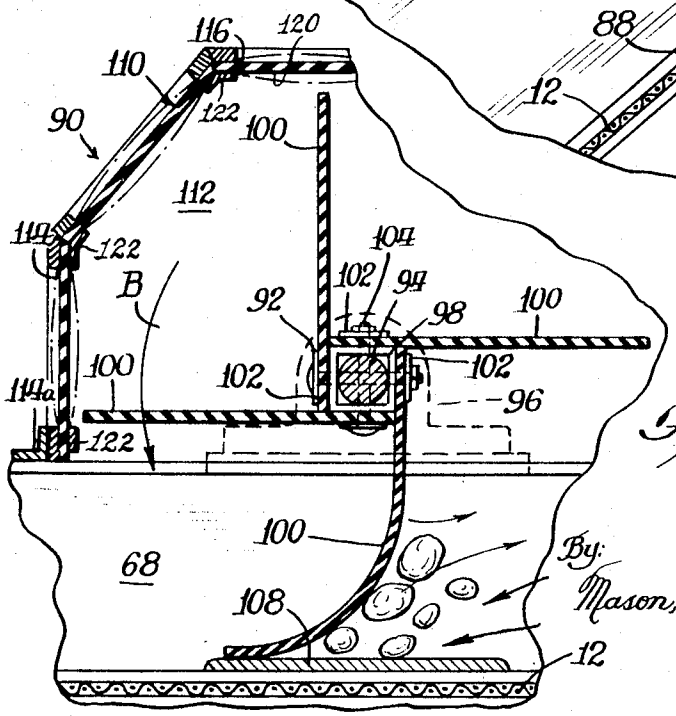


Fig. 4.

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APPARATUS FOR SIZING PARTICULATE MATERIAL

The present invention is directed towards a new and improved apparatus for sizing particulate materials and, more particularly, is directed towards a screen and lump breaking apparatus suitable for reprocessing spent molding sand for reuse in further molding operations. After castings are broken out or shaken out of the mold flasks in a foundry operation, it is highly economical to recondition the sand for further use. It is desirable to remove or break up particles or lumps in the spent foundry sand which are larger than about one-eighth to three-sixteenths inch. These oversize particles or lumps consist of core butts and metal shot or particles which are formed as the molten metal is poured into the sand mold. Some of the oversize material is in the form of hardened sand lumps and agglomerate of the sand and binder material. It is desirable to reduce the large size of the sand lumps so that the sand grains therein may be reused rather than thrown out of the recycling system. It is also economically advantageous to reduce handling and the quantities of oversize material or rejects that occur. Sand lumps and agglomerates are formed because the molding sand, after it has been rammed into the mold, becomes baked when hot metal is poured into it. It is desirable from a molding standpoint to develop dry strength in the sand so that the mold cavities are not easily moved during the solidification process of the metal in the mold, and it is therefore readily explainable why hard sand lumps occur during the molding operation because of the initial tamping and subsequent baking action. It is desirable to screen the used molding sand after removal from the mold flasks not only to eliminate oversize sand particles and metal particles but also to break down the agglomerates or lumps made up of sand particles to their original small size granules.

The sizing apparatus of the present invention is especially well suited for this particular task in connection with foundry operations and employs a highly efficient, vibrating screen which is actuated by electrical vibrators at high speed and low amplitude rather than on a low speed, high amplitude basis which is common to mechanically driven screens. In combination with the screen, there is provided novel lump breaker means for breaking up and reducing the large size sand lumps or agglomerates and for generally retarding the flow of these large size lumps until they have been reduced to proper size and eventually pass through the mesh. Breakage of the lumps is accomplished by direct impact with rotating paddle means and by wearing action of the material itself as the lumps are thrown upwardly on the screen in a direction counter to the general direction of flow of material. The lumps are subject to repeated impacting and wearing action until broken down to sufficiently small size to pass through the screen mesh, and the denser metal particles, or particles that cannot be broken down, eventually pass through the system as oversize. These oversize particles and metal particles, also help to abrade or break down the larger sand agglomerates or lumps before finally passing through the system into the oversize discharge chute.

It is an object of the present invention to provide a new and improved apparatus for sizing particulate material, such as spent foundry sand and the like.

Another object of the present invention is to provide a new and improved apparatus of the character described which is especially well suited for breaking down large lumps comprising agglomerates of particulate material into smaller size particles which are passed through a screen.

Another object of the present invention is to provide a new and improved sizing apparatus of the character described which is extremely efficient in operation and utilizes a high frequency, low amplitude, vibrating screen, yet is effective to retain the larger lumps in the system for a long enough period until a high percentage of the large lumps are broken down to small enough sizes to pass through the screen.

Another object of the present invention is to provide a new and improved sizing apparatus of the character described wherein the oversize lumps are broken down by impact force and are moved in a direction counter to the general direction of material flow across the screen for further abrading action by the material itself.

Another object of the present invention is to provide a new and improved sizing apparatus for granular material, such as foundry sand and the like, which is highly efficient in separating out into oversize the larger sand grains and any metal particles yet is effective in breaking up substantially all of the larger lumps and agglomerates of sand into smaller particles which will pass through the screen.

The foregoing and other objects and advantages of the present invention are accomplished in an illustrated embodiment which comprises a new and improved sizing apparatus having an inclined screen mesh for receiving material adjacent the upper end for screening action as it moves downwardly toward the lower end. Means is provided for vibrating the screen mesh to sift out the on-size material and lump breaker means intermediate the ends of the screen is provided for retarding the rapid downward flow of oversize particulate lumps until substantially all of said lumps are broken up into smaller size for passage through the screen. The lumps are broken up by impact and are thrown upwardly on the screen counter to the general direction of flow of material downwardly on the screen by rotating paddle means extending transversely across the screen. The paddle means is formed of flexible material and operates in conjunction with a breaker plate which protects the screen to impact break the lumps and move them counter to the general material flow until they are broken down.

For a better understanding of the present invention, reference should be had to the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 is a vertical sectional view of a new and improved sizing apparatus for particulate material constructed in accordance with the features of the present invention;

FIG. 2 is a sectional view taken substantially along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged, fragmentary, vertical, sectional view taken substantially along line 3—3 of FIG. 2; and

FIG. 4 is an enlarged, vertical sectional view taken substantially along line 4—4 of FIG. 2.

Referring now, more particularly, to the drawings, therein is illustrated a new and improved apparatus for sizing particulate material constructed in accordance with the features of the present invention and referred

to generally in FIG. 1 by the reference numeral **10**. The apparatus **10** is especially well adapted to treat granular material such as foundry sand, and the like, which may contain oversize sand particles, metal particles, and oversize, hardened lumps or agglomerated buildup of sand held together by baked on resin binders. The apparatus **10** includes a vibrating screen **12** having a plurality of sizing openings defined by the screen mesh and through which on-size particles of material are sifted. The size of the openings in the screen mesh and the type and size of wire may vary in accordance with the particular screening application and a particular material involved. For example, with foundry sand used in nonferrous casting, it is desirable to size the sand particles with a screen mesh having eight to twelve meshes per inch. The screen cloth or mesh may be formed of stainless steel wire or other corrosion resistant wire, if required in some applications.

The screen **12** is supported to lie on a downwardly sloping inclined plane and, for the purpose of supporting the screen, a rectangular frame **14** having longitudinal side members **16** of channel-shaped cross section and a plurality of transverse cross members **18** is provided. The screen support frame **14** may be tilted or pivoted in a range between maximum and minimum slope, as shown, in order that the screen is useful for a range of different materials. For this reason, one end of the frame **14**, for example the upper end, is connected through a hydraulic or pneumatic cylinder **20** to a fixed bracket **22** for tilting the frame and maintaining the screen at a desired angle of tilt, once established. A skirt **24** having upper and lower sidewall portions **26** and **28**, and upper and lower curved end walls **30** and **32**, respectively, is connected to the frame **14**. The upper and lower sidewalls **26** and **28** merge midway between the upper and lower ends of the skirt at a pivot point wherein an axle **34** is mounted. The axles project laterally outwardly of the skirt sidewalls and are supported in suitable bearings **36** which are carried on the sidewalls **38** of a fixed, supporting hopper structure **40**. The screen frame **14** may be supported in many different fashions. For example, the frame may be suspended at a fixed angle by cables at each corner attached to overhead structure, or a building roof truss. In some installations the skirt and support hopper may be replaced with a bottom cover and simple discharge duct at the lower end of the frame.

The fixed hopper structure **40** is supported on cross members or bases, such as the I-beams **42**, by means of support legs or brackets **44**. The fixed hopper is open at the upper end to receive the skirt **24** and includes an upper, transverse end wall **46**, a downwardly and forwardly sloping main bottom wall **48**, and a lower front end wall **50**. Suitable upper edge flanges **38***a*, **46***a*, and **50***a* are provided along the upper edges of the respective walls, as shown, for stiffening purposes. The material passing through the screen **12** on the main support frame **14** flows through the skirt **24** into the fixed hopper **40** and the screen angle can be adjusted relative to the horizontal by the cylinder **20** to provide a desired angle of slope for the particular material involved.

The hopper **40** is provided with a large, rectangular, on-size, discharge opening **52** for discharge of the material passing through the screen **12**. A smaller, rectangular opening **54** for oversize or reject material is provided at the forward portion of the hopper bottom. The discharge openings are flanged so that suitable duct work may be connected thereto and an internal divider wall **56** is provided to prevent the oversize material, which passes off the lower end of the screen mesh **12**, from mixing with the on-size material which passes through the screen.

The screen **12** is supported on an intermediate support frame indicated generally by the numeral **60** which includes a pair of longitudinal side members **62** of channel-shaped cross section and a plurality of transverse cross members **64** at spaced intervals. If a double screening arrangement is used, a second or lower screen layer may be interposed between the lower edge of the intermediate support frame **60** and the upper edge of the main support frame **14**. As best shown in FIG. **3**, the screen **12** is supported on the upper flanges of the channel-shaped longitudinal side members **62** and cross members **64** of the screen frame **60**. An upper screen housing comprising a rectangular framework generally indicated by the reference numeral **66** is provided above the screen **12** and includes a pair of longitudinal side members **68** of channel-shaped cross section. The screen **12** is sandwiched between the lower flanges of the upper side channels **68** and the upper flanges of the lower frame channels **62**. The main support frame **14**, the intermediate support frame **60**, and the upper screen housing frame **66** are connected together by removable bolts or other fasteners (not shown) extending between the flanges of the channels. In addition to the longitudinal side channels **68**, the upper screen housing **66** includes a removable lower end panel **70** and a material feeding detachable inlet chute assembly **72** adjacent the upper end of the screen for delivering material to the screen. Detachable upper and lower top cover panels **74** and **76** are secured to the upper flanges of the side channels to prevent loss of material as it moves over the surface of the screen.

In order to vibrate the screen **12**, in accordance with the present invention, a plurality of electrically powered vibrators generally indicated as **80** are mounted on channel-shaped cross members **82** provided on the upper screen housing **66** and extending between the side channels **68**. Each vibrator unit includes an electromagnetic coil and armature and a depending stem **84** which projects downwardly through an opening in the web of the support channel **82** for connection to the screen **12** in order to vibrate the same. The lower end of the stems **84** are provided with threaded shoulder portions **84a** and a pair of relatively large size coupling discs **86** and resilient discs **88** are provided for connecting the stem with the screen cloth. Because of the relatively large size of the discs, wear and stress on the screen cloth are held at a minimum. The metal discs **86** are slightly cup shaped and are held in place on the threaded stem portions **84***a* by suitable nuts and lock washers, as shown. Electrical power is supplied to the vibrators **80** through junction boxes **83** and power cables and conduits not shown. When the power is turned on, the stems **84** vibrate longitudinally in the direction of the arrows "A" and this results in the screen cloth vibrating at a relatively high frequency in comparison with the mechanical screens and also the screen cloth is vibrated with a relatively small maximum deflection or amplitude. Because of the relatively high frequency of the screen vibration, the slope of the screen may be increased substantially over that of a mechanical screen for a particular kind of material and, with the increased slope, substantially all of the material (except

the oversize) passes through the screen by the time the material reaches the lower end of the screen.

In accordance with the present invention, the sizing apparatus **10** includes a lump breaker assembly generally indicated as **90** for impact breaking of the large lumps and agglomerates of sand and for retarding and blocking the normal downflow of the large, oversize lumps so that these lumps are recycled until eventually broken down into smaller sizes that may pass through the screen. Because of the recycling while on the screen, the amount of oversize material coming off the lower end of the screen **12** is minimized and handling costs for oversize is reduced. In addition to the direct impact breakage of the large lumps and agglomerates of particulate material, the breaker assembly **90** is effective in breaking down the oversize lumps by moving the lumps upwardly back onto the screen in a direction counter to the general direction of flow of the material downwardly over the screen. The lump breaker assembly includes a rotor generally indicated as **92** comprising an elongated shaft **94** extending transversely of the screen frame and supported at opposite ends by suitable pillow block bearings **96** which are mounted on the flanges of the side channels **68.** Shaft **94** is rotated by an electric motor or other conventional power source through a conventional drive pulley arrangement (not shown) and is driven in a counterclockwise direction as shown by the arrow "B" in FIG. **4** and in FIG. **1.** A mandril **98** of polygonal shape, having flat faces thereon, is mounted on the cylindrical shaft **94** and a plurality of paddles **100,** formed of flexible material such as heavy rubber belting, are attached to the mandril along inner edge portions of the paddles by means of holding bars **102** and suitable bolt assemblies **104.** The flexible paddles **100** may be replaced from time to time by removal of the bolts and, as wear occurs during operation, it may be desirable to replace opposing paddles to provide a balanced rotor. The rotor **92** is driven at a speed (for example, approximately 120 RPM) whereat the tip velocity along the outer edge of the paddles is sufficiently high to provide enough impact momentum or force when striking large lumps of the material to break the lumps into smaller size and toss them upwardly onto the screen. Many of the larger lumps will be broken down into smaller lumps and on-size particles by the impact of the paddles alone, and as indicated in FIG. **4,** the general downward flow of material is retarded by the sweeping action of the rotor paddles as the paddles pass in contact with a breaker plate **108.** The paddles contact the breaker plate and are deflected as shown acting to sweep or throw the oversize limps back upwardly onto the screen for recycling with the fresh downwardly flowing material. The breaker plate is positioned beneath the center line of the rotor assembly **92** and also serves to protect the upper surface of the screen **12** from excessive wear, which would otherwise take place because of the paddles **100** sweeping over the screen.

The breaker plate **108** cooperates with the paddles to provide a rigid surface for the paddles to throw the lumps against and is continuously being swept by the lower edge of one or more paddles to provide a relatively continuous blockage to the downward travel of the oversize lumps. As indicated in FIG. **4,** contact between the lower edges of the rotor paddles **100** and the breaker plate deflects the paddles as shown, and a sweeping and abrading action occurs as the material is moved upwardly along the upper surface of the breaker plate. This action further aids in breaking down the large size lumps and agglomerates to sufficiently small size in order to pass through the screen **12.** When the lower edge of one paddle approaches the upper edge of the breaker plate, the lower edge of the next advancing paddle is coming into contact with the lower edge of the breaker plate so that the upper surface of the breaker plate is continuously being covered by a paddle of the rotor. For this reason, the large lumps and agglomerates of material do not pass downwardly on the screen below the rotor assembly **92** without direct contact with a moving paddle at least once, and more likely many times. The tougher, hardened lumps are broken down in gradations involving several impacts with the paddles before finally being reduced to a size small enough to pass through the screen. The paddles also tend to break down the large material lumps by wedging action against the breaker plate as they move the material upwardly counter to the general direction of the material flow over the screen area. The heavier, more dense particles, such as core butts or metal shot or other metal particles, due to the weight and strength, eventually pass downwardly through the paddles and are discharged as oversize.

The rotor assembly **92** is mounted to rotate within a housing generally indicated as **110** having a pair of opposed sidewalls **112,** front and back walls **114,** a top wall **116** and a pair of corner walls **118.** The housing **110** is adapted to be removably attached to the upper flanges of the side channels **68** between the upper and lower top covers **74** and **76,** and for this purpose suitable mounting angles **112a** and **114a** are provided around the periphery of the lower edges of the housing. The housing **110** provides an enlarged open space above the breaker plate **108** and screen in order to enclose the rotor **92** and to accommodate a volume of material as it is being thrown upwardly by the impact with the moving paddles **100.**

Each of the housing walls **114, 116** and **118** comprises a rectangular frame of strap metal forming an enlarged center opening of rectangular shape. In order to prevent material buildup in the housing **110** the inside surface of the wall frames is covered with a resilient lining material **120** such as rubber belting or the like. The enlarged openings of the frames are covered by the liner material providing a live wall action which permits outward deflection of the liner as it is impacted by material thrown by the rotor, and on rebound of the liner the material is returned back toward the rotor assembly. The liner material **120** is held in place on the inside of the wall frames by a plurality of retaining bars **122** which are detachably secured to the wall frames. The continuous live action of the housing walls provides for continuous self-cleaning action for the lump breaker and greatly aids in the overall efficiency of operation.

The apparatus **10** is extremely efficient in reconditioning used foundry sand. The novel combination of a high frequency, low amplitude, high angle, vibratory screen with the rotating impact type lump breaker permits rapid flow rates with a minimum of oversize material resulting. The paddles **100** are driven at a speed to provide a continuous blockage of the material flow past the breaker plate **108** and the oversize material is continuously being recycled in the system while the on-size passes through the screen. The larger, dense, metal particles, which do not break down, and the tough core

butts comprise the bulk of the oversize material passing off the lower end of the screen into the oversize discharge opening **54**. However, because of the recycling action, even the heavy metal particles are put to use in providing abrading action to help break down the lumps of material.

While there has been illustrated and described a single embodiment of the present invention, it will be appreciated that numerous changes and modifications will occur to those skilled in the art, and it is intended in the appended claims to cover all those changes and modifications which fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for sizing particulate material comprising an inclined screen mesh; means for introducing fresh material adjacent the upper end of the mesh for movement toward the lower end and through the mesh; means for vibrating said screen mesh, and lump breaker means intermediate the ends of said screen mesh for retarding the flow of oversize particulate material toward said lower end, said lump breaker means including a rotary paddle wheel assembly having a plurality of paddles extended transversely across said mesh and formed of flexible material, a breaker plate above said mesh adjacent the path of said paddles for supporting material impacted thereby.

2. The apparatus of claim **1** wherein said breaker plate is positioned beneath the axis of rotation of said paddles within the region swept by said paddles for continuous contact with the lower edge portion of at least one paddle.

3. The apparatus of claim **1** including enclosure means above said screen enclosing said paddle wheel assembly providing deflecting impact surfaces.

4. The apparatus of claim **1** wherein said paddle wheel assembly includes a wheel supporting member having planar surfaces thereon and means for removably securing said paddles along the inner edge portions thereon to said planar surfaces.

5. The apparatus of claim **1** wherein said means for vibrating said screen includes high frequency electromagnetic vibrator means for vibrating said screen at least one location thereon upslope on the screen from said rotary paddle wheel assembly.

6. The apparatus of claim **5** including means for driving said paddle wheel assembly to return material upslope on said screen into the vicinity of said vibration location on said screen.

7. The apparatus of claim **1** including frame means supporting said screen around the peripheral edges thereof, said vibrating means supported from said frame means and attached to vibrate said screen relative to said frame, and means for supporting said paddle wheel assembly for rotation about an axis in fixed relation to said frame.

8. The apparatus of claim **7** including housing means above said screen supported from said frame for containing a level of material moving along the surface of said screen, said housing including removable covers spaced above said level of material.

9. The apparatus of claim **8** wherein said enclosure means extends above adjacent portions of said covers for providing an enlarged enclosed area around said paddle wheel assembly for holding an additional volume of material at a level above the adjacent level of material on said screen upslope therefrom.

10. The apparatus of claim **9** wherein said enclosure includes upper wall portions closely and angularly spaced around a cylindrical path traversed by the outer edges of said rotating paddles for impact breakage of material centrifuged outwardly of the axis of rotation of said paddle wheel assembly.

11. Apparatus for sizing particulate material comprising a housing having walls, a paddle wheel mounted in said housing for impacting said material against said walls, said walls including at least one resilient portion deflectable toward and away from said paddle wheel, said resilient portion comprising a sheet of thin resilient material supported around its periphery on a rectangular frame defining an enlarged opening therein, and freely deflectable into and out of said opening to receive and return said material toward said paddle wheel, said paddle wheel including a plurality of paddles formed of resilient material and mounted for rotation about an axis parallel of said walls, said walls positioned substantially parallel of a plane tangent to the path of travel of the outer edges of said paddles, and a rigid breaker plate parallel of said axis of rotation and mounted within the path of travel of said paddles causing deflection of the same on rotation of said paddle wheel.

12. The apparatus of claim **11** wherein said breaker plate is parallel of at least one of said resilient portions of said walls on opposite sides of said axis of rotation.

13. Apparatus for sizing particulate material comprising an inclined screen mesh; means for introducing fresh material adjacent the upper end of said mesh for movement toward the lower end thereof as on size material passes downwardly through the sized openings of said mesh; means for vibrating said mesh; and flow retarding means intermediate the upper and lower end of said mesh for retarding the downward movement of at least some of the material flowing over said screen mesh, said retarding means including rotary paddle means extended transversely of the direction of material flow toward said lower end of the mesh and movable against the direction of material flow to retain some of the material on said mesh for an extended interval.

14. The apparatus of claim **13** wherein said paddle means includes a plurality of paddles formed of flexible material rotating about an axis spaced above said mesh for impacting said material in a direction opposite the downward flow thereof toward the lower end of said mesh.

15. The apparatus of claim **14** including housing means enclosing an upper portion of said paddle means and including surfaces deflecting said material toward said screen mesh.

16. The apparatus of claim **14** including support means for adjusting the inclination of said screen mesh.

17. The apparatus of claim **14** including a shield plate between said screen mesh and said paddle means for engaging said paddle means to prevent contact thereof against said screen mesh.

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