VIBRATORY SEPARATORS AND SCREENS FOR THEM

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Related U.S. Application Data

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Division of application No. 09/834,174, filed on Apr. 12, 2001, now Pat. No. 6,530,483, which is a division of application No. 09/544,572, filed on Apr. 6, 2000, now Pat. No. 6,283,302, which is a continuation-in-part of application No. 09/225,572, filed on Jan. 11, 1999, now Pat. No. 6,152,307, which is a continuation-in-part of application No. 09/183,005, filed on Oct. 30, 1998, which is a continuation-in-part of application No. 09/090,554, filed on Jun. 4, 1998, now Pat. No. 6,267,247, which is a continuation-in-part of application No. 08/895,976, filed on Jul. 17, 1997, now Pat. No. 5,988,397, which is a continuation-in-part of application No. 08/786,515, filed on Jan. 21, 1997, now Pat. No. 5,971,159, and which is a continuation-in-part of application No. 08/598,566, filed on Feb. 12, 1996, now abandoned. Said application No. 08/786,515 is a continuation-in-part of application No. 29/048,575, filed on Jan. 4, 1996, now Pat. No. D,377,656, which is a continuation of application No. 29/014,571, filed on Oct. 25, 1993, now Pat. No. D,366,040, which is a continuation-in-part of application No. 08/056,123, filed on Apr. 30, 1993, now Pat. No. 5,385,669, and which is a continuation-in-part of application No. 08/105,696, filed on Aug. 12, 1993, now Pat. No. 5,392,925. Said application No. 08/598,566 is a continuation-in-part of application No. 08/220,101, filed on Mar. 30, 1994, now Pat. No. 5,490,598.

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ABSTRACT

A vibratory separator (in one aspect a shale shaker) and screen assemblies for them; the screen assemblies, in at least certain aspects, having an undulating plate with a plurality of spaced apart openings therethrough, a plurality of spaced apart supports extending beneath the plate and to which the plate is secured, and each support having a length and independent of and not connected to the other supports along its length, each support having two spaced apart ends, and screening connected to the plate.
VIBRATORY SEPARATORS AND SCREENS FOR THEM

RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention is directed to frames, support structures, and screens for vibratory shakers, screens with such a support, and methods of their use.

[0004] 2. Description of Related Art

[0005] The prior art discloses a wide variety of vibrating screens, devices which use them, shale shakers, and screens for shale shakers and vibratory separators. The screens catch and remove entrained solids from fluid, drilling fluid, and/or drilling mud as it passes through them.

[0006] Various prior art screens have one, two or more overlying layers of screening material, mesh, and/or screen cloth which may be bonded together. A support, support, or a perforated or apertured plate is often used beneath the screen, mesh or screens of many prior art screen assemblies.

Also an outer frame is used in many screens. The frame may include one or more crossmembers extending across the frame and connected at the ends to sides of the frame. The frame facilitates connection of the screen to a separator device and provides support for the plate and screening material.

SUMMARY OF THE PRESENT INVENTION

[0007] In at least certain preferred embodiments the present invention provides: new, useful, unique, efficient, non-obvious screens, filtering screens, two- or three-dimensional screens; flat or non-flat screens; mountings for them; such screens with one or more bottom support strips or rods; such screens in which screening material is on a corrugated perforated plate which itself is on strip(s) and/or on a frame; and shale shakers with such items; such a screen with a corrugated perforated solid support plate; such a screen for a shale shaker with one or more bottom support strips; such a screen also with one or more strip or rod projections for projecting above a bottom strip or apertured plate into an indentation or raised part in an upper screen layer or layers; and a shale shaker with one or more such screens.

[0008] In one aspect the strips (or rods) have one or more projecting portions formed integrally thereof or secured thereto which project into troughs or areas of the layer(s). Such projecting portions may be shaped and configured to mate with the shape of a hill, valley, trough or indented area; may be bonded to the layer(s) at such areas; may be bonded only to the sides of such areas and not to the uppermost portion of a top portion thereof; or may be adjacent such areas without bonding thereto. If there is a series of parallel troughs or a plurality of adjacent indented areas, such projections may be provided in all such troughs or areas; in only on such trough or area; in troughs or areas only adjacent frame sides; or in only middle troughs or areas.

[0009] It is within the scope of this invention in embodiments in which the screen has a series of parallel troughs, to use alternating flat strips and strips with one or more projections as described above. It is also within the scope of this invention to use non-flat strips which have a shape that corresponds to the series of troughs, e.g. with undulating layer(s), a corresponding undulating strip is used. Such strips may be used instead of or in combination with flat strips. Any strip herein may have holes through it to facilitate fluid flow. In one aspect any strip, combination of strips, or pattern of strips disclosed herein may be used with a generally flat (“two-dimensional”) screen.

[0010] The present invention, in one embodiment includes a shale shaker with a frame; a “basket” or screen mounting apparatus; one or more screens as described above and below; and basket vibrating apparatus.

[0011] The present invention discloses, in certain embodiments, a unibody structure for a screen assembly for a vibratory separator and a screen assembly with such a unibody structure, the unibody structure, in certain aspects having an integral body member with a portion having a plurality of spaced-apart openings in a pattern of a plurality of spaced-apart screening openings and including a pair of spaced-apart integral side members made of folded portions that form the pair of spaced-apart integral side members.

[0012] In certain embodiments, the screen with a unibody structure according to the present invention has one, two,
three or more upper layers of screen, screen cloth, and/or mesh, bonded or not to the structure. If more than one layer mounted on the structure is used, they may be bonded together at discrete points, at discrete areas, or over their entire surface. The unibody structure may, in certain aspects, include one or two interconnected pairs of spaced-apart integral sides in a generally rectangular configuration. Hook strips, channels, or other mounting structure may be provided on opposite sides of a structure which are formed of either separate or integral portions of the original single piece of material.

[0013] The unibody structure may be made of any suitable plastic or metal, including, but not limited to, steel, stainless steel, aluminum, aluminum alloys, zinc, zinc alloys, PTFE, or some combination thereof. The present invention may include a shale shaker or vibratory separator with one or more screen assemblies with a unibody structure according to the present invention.

[0014] This invention may provide a screen as in U.S. Pat. Nos. 6,000,556; 5,958,236; 5,944,993; 5,876,552; 5,888,929; 5,713,077; 5,720,881; 5,673,797; 5,417,793; 5,417,858; and 5,417,859, (all fully incorporated herein) but to delete the apertured plate or frame and to use instead a unibody structure as disclosed herein.

[0015] In certain aspects according to the present invention, a single piece of material is used to form a four-sided support or frame for screening material (one, two, three or more layers) and/or for a plate or sheet with holes there-through.

[0016] Alternatively, pointed corrugations may be used with no flat top and no flat bottom or with a flat bottom and pointed top. Such a screen (and any screen or screen assembly disclosed herein) may be used on a frame; on a flat perforated plate; on one or more braces and/or strip supports (flat and/or corrugated; and corrugated to correspond to the shape of the screen 330's shapes); on a combination thereof; and/or with upturned side edges or other connection apparatus for connection to a vibratory separator or shale shaker.

[0017] It is within the scope of this invention to have a strip with three, four, five or more sets of upturned fingers and, in one aspect, to have a set of fingers for each raised portion of a plate and/or screen used with the strip.

[0018] In one aspect the top curved portion of a support finger according to the present invention corresponds in shape to a curved portion of a corrugated plate and/or screen used with one or more strips 380. Alternatively, a strip can be made of one integral plastic piece.

[0019] Any support disclosed herein may be fastened to a strip and/or screen and/or plate with one or more fasteners and/or with VELCRO™ material.

[0020] U.S. application Ser. Nos. 08/598,566 and 08/786,515 are incorporated herein in their entirety for all purposes.

[0021] What follows are some of, but not all, the objects of this invention. In addition to the specific objects stated below for at least certain preferred embodiments of the invention, other objects and purposes will be readily apparent to one of skill in this art who has the benefit of this invention's teachings and disclosures. It is, therefore, an object of at least certain preferred embodiments of the present invention to provide:

[0022] New, useful, unique, efficient, non-obvious screen frames, screen assemblies with such a frame, shale shakers and vibratory separators with such screens, and methods of their use.

[0023] Certain embodiments of this invention are not limited to any particular individual feature disclosed here, but include combinations of them distinguished from the prior art in their structures and functions. There are, of course, additional aspects of the invention described below and which may be included in the subject matter of the claims to this invention. Those skilled in the art who have the benefit of this invention, its teachings, and suggestions will appreciate that the conceptions of this disclosure may be used as a creative basis for designing other structures, methods and systems for carrying out and practicing the present invention. The claims of this invention are to be read to include any legally equivalent devices or methods.

[0024] The present invention recognizes and addresses the previously-mentioned problems and long-felt needs and provides a solution to those problems and a satisfactory meeting of those needs. To one skilled in this art who has the benefits of this invention's realizations, teachings, disclosures, and suggestions, other purposes and advantages will be appreciated from the following description of preferred embodiments, given for the purpose of disclosure, when taken in conjunction with the accompanying drawings. The detail in these descriptions is not intended to thwart this patent's object to claim this invention no matter how others may later disguise it by variations in form or additions of further improvements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] A more particular description of embodiments of the invention briefly summarized above may be had by references to the embodiments which are shown in the drawings which form a part of this specification. These drawings illustrate certain preferred embodiments and are not to be used to improperly limit the scope of the invention which may have other equally effective or legally equivalent embodiments.

[0026] FIG. 1A is a top view of a screen assembly according to the present invention. FIG. 1B is a top view of part of the screen assembly of FIG. 1A. FIG. 1C is a side view of the screen assembly part shown in FIG. 1B. FIG. 1D is a cross-section view along line 1D-1D of FIG. 1B. FIG. 1E is a flattened out view of the screen assembly part of FIG. 1B. FIG. 1F is a flattened out view of part of the screen assembly of FIG. 1A. FIG. 1G shows two screens as in FIG. 1D end-to-end.

[0027] FIG. 2 is a perspective view of a shale shaker according to the present invention with a screen assembly according to the present invention.

[0028] FIGS. 3A-3G are top views of alternative embodiments for a part like the part of FIG. 1B of a screen assembly according to the present invention.

[0029] FIGS. 4A-4J are top views of patterns of openings that may be provided in a unibody frame according to the present invention.

[0030] FIG. 5A is a top view of a single piece of material to be used to make a unibody structure according to the
present invention. FIG. 5B shows the material of FIG. 5A with slots cut to form support ribs. FIG. 5C shows the material of FIG. 5B with a pattern of openings. FIG. 5D is a side view of the material of FIG. 5C with support ribs now projecting from the material. FIG. 5E shows the material of FIG. 5D with the portion with the pattern of openings at an angle with respect to the portion with the support ribs. FIG. 5F shows the piece of material with part folded or bend over onto the other part. FIG. 5G is a top view of the piece of material of FIG. 5F and FIG. 5H is a view along line 5I-5I of FIG. 5F. FIGS. 5I (side view), 5I (cross-section view along line 5I-5I of FIG. 5K) and 5K (top view), show screening material on the piece of material of FIG. 5H.

[0031] FIG. 6 is a side cross-section view of a screen assembly according to the present invention.

[0032] FIG. 6A is a top view of a panel according to the present invention for a screen assembly.

[0033] FIG. 6B is a front side view of the panel of FIG. 6A. The back side view is like the view of FIG. 6B.

[0034] FIG. 6C is a left end view (as in FIG. 6A) of the panel of FIG. 6A. The right end view is like the view of FIG. 6C.

[0035] FIG. 6D is a bottom view, FIG. 6E is a top view, and FIG. 6F is an exploded view of the screen assembly of FIG. 6E.

[0036] FIG. 7 is a bottom view of a screen according to the present invention.

[0037] FIG. 8 is a bottom view of part of a screen with cross strips according to the present invention.

[0038] FIG. 9 is a bottom view of a screen according to the present invention.

[0039] FIG. 10 is a bottom view of a screen according to the present invention.

[0040] FIG. 11A is a top view of a screen according to the present invention.

[0041] FIG. 11B is a view along line 23B-23B of FIG. 11A.

[0042] FIG. 11C is a view along line 23C-23C of FIG. 11B.

[0043] FIG. 11D is a cross-section view of a screen according to the present invention.

[0044] FIG. 12A is a perspective view of a support according to the present invention.

[0045] FIG. 12B is a side view along line 12B-12B of FIG. 12A.

[0046] FIG. 12C is a section view along line 19C-19C of FIG. 12B.

[0047] FIG. 12D is a section view of a support according to the present invention.

[0048] FIG. 13A is a section view of a support according to the present invention.

[0049] FIG. 13B is a section view of a support according to the present invention.

[0050] FIG. 14A is a section view of a support according to the present invention.

[0051] FIG. 14B is a section view of a support according to the present invention.

[0052] FIG. 15A is a section view of a support according to the present invention.

[0053] FIG. 15B is a section view of a support according to the present invention.

[0054] FIG. 15C is a section view of a support according to the present invention.

[0055] FIG. 16 is a perspective view of a shale shaker according to the present invention.

[0056] FIG. 17A is a top view, partially cutaway, of a screen according to the present invention.

[0057] FIG. 17B is an exploded side view of the screen of FIG. 17A.

[0058] FIG. 18 is a perspective view of a screen according to the present invention.

[0059] FIG. 19 is an end view of a screen according to the present invention.

[0060] FIG. 20 is an end view of a screen according to the present invention.

[0061] FIG. 21 is a side view of a screen according to the present invention.

[0062] FIG. 22 is a perspective view of a portion of a screen according to the present invention.

[0063] FIG. 23 is a top plan view of a plug for repairing the screen of FIG. 22.

[0064] FIG. 24 is a cross-section of a plug of FIG. 23, taken along section line 45-45.

[0065] FIG. 25 is an end view of a screen according to the present invention.

[0066] FIGS. 26-30 present end views of corrugated perforated plates according to the present invention which structure may also be used for strips according to the present invention.

DESCRIPTION OF EMBODIMENTS
PREFERRED AT THE TIME OF FILING FOR THIS PATENT

[0067] FIGS. 1A-1F show a screen assembly 10 according to the present invention with a unibody structure 20 according to the present invention. The screen assembly 10 has, optionally, three layers 11, 12, 13 of screening material bonded to a top surface 22 of the unibody structure 20. Preferably, the layers 11, 12, 13 are also bonded together over substantially their entire surface area.

[0068] A plurality of openings 24 through the unibody structure 20 define a plurality of support members 26. To the underside of the unibody structure 20 are, optionally, connected a plurality of spaced-apart ribs or strips 28 which, in one aspect are welded to a metal unibody structure 20. In this particular embodiment the ribs 28 are positioned along a substantial majority of their length directly beneath one of the support members 26 that extend across a major portion.
of the unibody structure 20; but it is within the scope of this invention to use no such ribs or to position them anywhere on the underside of the unibody structure 20. The unibody structure 20 has spaced-apart sides 36, 38.

[0069] As shown in FIG. 1C, the screen assembly 10 has an end 14 and a “ledge” end 16. The ledge end has an upper ledge portion 17 that rests on a shoulder 15 of an end 14 of an adjacent screen. Thus one screen end 16 seals against another screen end 14 when such screens are used end-to-end, as shown in FIG. 1G. In one particular embodiment four screens as in FIG. 1D are used on a shaker in two end-to-end pairs with the paras side by side. Each pair is positioned in “C” channels. One of the screens is moved into the “C” channel supports ledge end 16 first. Then the ledge end 16 of the second screen is moved into the “C” channels so that it sealingly abuts the end 14 of the first screen. The other pair is similarly installed.

[0070] As shown in FIG. 1E, the unibody structure 20 is, initially, a single integral piece of material in which the pattern of openings 24 is formed, e.g. by any suitable cutting tool, punch, laser, or plasma beam or arc. Alternatively, the area shown in FIG. 1E with the openings 24 may be removed so that all that is formed according to the present invention is a four-sided structure to which is applied one, two, three or more layers of screening sheet(s) and/or screening material; including but not limited to a perforated sheet or plate and/or any desired number of layers of screening material, bonded or unbonded.

[0071] Extensions 31, 32, 33, and 34 are folded to form, respectively, the end, 14, end 16 and sides 36, 38. It is within the scope of this invention to fold the various extensions of the unibody structure with any suitable press brake, pliers, or bending device with or without applying heat to the structure. FIG. 1F shows a rib 28 which has not yet been bent or folded into the form shown in FIG. 1D. Ends 29 may be introduced into corresponding holes or slots (not shown) in the sides 36, 38 to facilitate securement of the ribs.

[0072] It is within the scope of this invention for the screen assembly 10 to have none, one, two, three or more layers of screening material, i.e., screen, mesh, and/or cloth made, e.g., of stainless steel wire and/or plastic. Any such layer or combination of layers may be bonded together (glued, welded, and/or sintered) in any known manner and bonded to the unibody structure 20 in any known manner. Any such layer or layers of screening material may be substantially flat or may be undulating (with a series of alternating ridges and valleys) as is well known in the art.

[0073] FIG. 2 shows a shale shaker 5 according to the present invention with a screen assembly 8 according to the present invention which may be any screen assembly disclosed herein according to the present invention. Any suitable known shaker or vibratory separator may employ one or more screens according to the present invention including but not limited to shakers as disclosed in U.S. Pat. Nos. 5,392,925 and 5,641,070 and in the reference cited in each patent.

[0074] Edges on both sides of a unibody structure according to the present invention can form hook strips. In such an embodiment with hook strips a hook end (like the hook end 14), FIG. 1C and/or a ledge end (like the ledge end 16, FIG. 1C) may be deleted.

[0075] FIGS. 3A-3G are top views of alternative embodiments for the unibody structure 20, each with a series of different-shaped openings 41, 42, 43, 44, 45, 46, and 47 through, respectively. Instead of placing sheets or layers of screening material over the openings, it is within the scope of this invention to place a plug or module with screening material in some or all of the openings of any screen assembly disclosed herein according to the present invention. In certain aspects, the plugs or modules are as disclosed in U.S. Pat. No. 5,988,397 or 5,490,598, parents of this case.

[0076] Also, e.g. as shown in the embodiment of FIG. 3E, it is within the scope of this invention to provide one or more areas or strips T without openings.

[0077] FIGS. 4A-4I replicate the panels disclosed in FIGS. 45G-4SP of pending U.S. Application Ser. No. 288, 572, filed Jan. 11, 1999, a parent of this case, and are reproduced here to illustrate certain possible opening/support member patterns for a unibody structure according to the present invention. Of course if any such opening/support pattern is used in a unibody structure according to the present invention the ends and sides of the panels as disclosed in FIGS. 45G-4SP of the cited application may be deleted.

[0078] In certain embodiments of a screen assembly with a unibody structure according to the present invention as described above has no separate pieces added to form parts, e.g. sides, hook strips, hook end, ledge end, etc. and is, therefore, relatively less expensive to make. By reducing or eliminating seams and connection areas, a relatively more substantial screen assembly is possible.

[0079] FIGS. 5A-5E illustrate a unibody structure 70 according to the present invention that is initially a single integral piece of material that is cut or machined to the shape shown in FIG. 5A that includes a first portion 71 in which will be made a pattern of openings and a second portion 72 in which will be made a series of rib supports. As shown in FIG. 5B a series of slots 74 are made (cut, drilled, punched, or machined in any suitable manner) in the second portion.

[0080] As shown in FIG. 5C a pattern of openings 76 is made (cut, drilled, punched, or machined in any suitable manner) in the first portion 71. These openings and their pattern may be any suitable shape opening in any desired pattern, including, but not limited to, any opening shape and pattern disclosed herein. The openings 76 may be of such a size that no additional screening material is placed over them; or, alternatively, any screening material disclosed herein, bonded or unbonded, may be placed over the openings 76.

[0081] As shown in FIG. 5D rib supports 78 have been bent or folded away from the second portion 72. As shown in FIG. 5E the first portion 71 has been folded or bent with respect to the second portion 72. As shown in FIGS. 5F-5G the first portion 71 has been folded or bent over onto the second portion 72 so that an underside of the first portion 71 contacts top surfaces 79 of the rib supports 78. The first portion 71 may be glued, bolted, screwed, or welded to top surfaces 79 of the rib supports 78 or Velcro(RM) material may be used to secure the portion 71 to the ribs 78. FIGS. 5I-5K show the structure of FIG. 5F with screening material 80 thereon. The screening material 80 may be, in at least certain preferred embodiments, any known screen, screens, mesh,
and/or meshes in any known combination, bonded or unbonded to each other, bonded or unbonded to the top portion 71, and/or of different weaves or similar weaves. As shown in FIGS. 5H and 5F the ends 73, 75 correspond, respectively, to ends 14 and 16 of the screen of FIG. 1A and function similarly to effect the sealing end-to-end abutment of such screens.

[0082] FIG. 6 shows a screen assembly 90 according to the present invention which has a unibody structure 92 which is substantially flat and with ends 93 folded or bent to form “hook strips” for securing the screen assembly 90 in various shakers and separators that employ such a screen connection apparatus. Such hook strips may be provided with any unibody structure disclosed herein. Such a unibody structure may be used instead of various prior art devices which employ, e.g. a plate to which channel-shaped members are welded or otherwise secured; for example, but without limitation, the unibody structure can be used in devices like those of U.S. Pat. Nos. 5,720,881 and 4,575,421 (and those of the references cited in these two patents) instead of the plate/channel-shaped member combinations disclosed in these patents. Screening material 94 (as any described herein with respect to layer(s), mesh(es), bonding etc.) has an undulating shape as viewed in FIG. 6. It is shown with lower parts touching and fixed to a top surface of the unibody structure 92, but it may be spaced-apart from this surface. It is within the scope of this invention to employ undulating screening material on any unibody structure and with any screen assembly disclosed herein. Optionally, the screening material 94 may be substantially flat. The unibody structure 92 may be, as viewed from above, like any unibody structure disclosed herein. In another aspect, the screening material 94 is a portion like the first portion 71 (FIG. 5A) and is folded over to a position as shown in FIG. 6, rather than affixed as a separate piece. Alternatively, what is shown as the screening material 94 in FIG. 6 may be a support structure for additional screening material placed thereon.

[0083] FIGS. 6A-6D show a screen panel 1150 according to the present invention with two opposed spaced-apart sides 1151 and 1152 spaced apart by two opposed sides 1153, 1154 and by a plurality of strips 1155. Each pair of spaced-apart strips, with portions of the sides 1151, 1152 define an open space 1156 through the panel 1150. At each side 1153, 1154, a strip 1155 and a portion of the side 1153 and side 1154 define an open space 1157 through the panel 1150.

[0084] In one aspect the panel 1150 (and/or strips and/or sides) is made of any suitable metal, e.g. but not limited to iron, steel, stainless steel, zinc, zinc alloys, aluminum, and aluminum alloys. In another aspect the panel is made of any suitable plastic, fiberglass, polytetrafluoroethylene cermet or composite. In one particular aspect the panel is made of 14 gauge cold rolled steel about 0.074 inches thick.

[0085] The openings in the panel may be made by any suitable method, including, but not limited to, drilling, sawing, or laser cutting. In one particular aspect a panel of 14 gauge cold rolled steel about 0.074 inches thick is laser cut with a CO₂ laser producing very precise and well-defined open spaces and very precise and well-defined strips 1155, in one aspect with strips about 0.22 inches wide, about 1.3 inches apart from each other.

[0086] In other aspects, the strips 1155 may range in width between about 0.10 inches to about 3.00 inches and they may be spaced apart between about 0.2 inches to about 4.00 inches. In one particular screen with about 0.22 inch wide strips spaced about 1.3 inches apart, the panel is 14 gauge cold rolled steel about 46.75 inches long, about 35.86 inches wide, about 0.074 inches thick with end portions, as viewed from above, about 1.65 inches wide between the screen ends' outer edge and the edge of an open space. Alternatively, the strips 1155 may be vertically oriented as viewed in FIG. 6A and the panel 1150 may be corrugated.

[0087] Alternatively, the outer edges of the panel 1150 may be provided and the strips, as separate pieces, connected thereto in any manner, shape, or design as described above herein.

[0088] FIGS. 6E and 6F show a screen assembly 1160 according to the present invention with a panel 1150. A first mesh (in one aspect a fine mesh) 1161, e.g. 180 mesh, is bonded to a second mesh (in one aspect a backup mesh) 1162, e.g. 12 mesh which is then bonded to the panel 1150. In additional embodiments, the fine mesh may range between 14 mesh and 500 mesh and the backup mesh may range between 2 mesh and 30 mesh. Also, additional meshes may be used, including, but not limited to, any of the meshes and mesh combinations disclosed above herein, including the above-disclosed corrugated meshes in a flat configuration.

[0089] In other embodiments a backup mesh, middle mesh and a top mesh (in one aspect ranging between 100 mesh to 300 mesh) are used. In one aspect the backup mesh was 304 stainless steel 32 mesh with wire diameter of 0.045 inches, the middle mesh was 130 mesh 304 stainless steel with wire diameter of 0.0017 inches, and the top mesh was 304 stainless steel 180 mesh with a wire diameter of 0.0012 inches. A panel like the panel 1150 was coated with a powder coating (e.g. such as commercially available TK NOVO B Powder from Tuboscope Veteco) and bonded to the three meshes.

[0090] In other embodiments a backup mesh and a top mesh are used bonded together. In one aspect the backup mesh was 304 stainless steel 8 mesh with wire diameter of 0.025 inches, and the top mesh was 304 stainless steel 200 mesh with a wire diameter of 0.0021 inches. A panel like the panel 1150 was coated with a powder coating and bonded to the top mesh.

[0091] In other embodiments a backup mesh, middle mesh and a top mesh are used bonded together. In one aspect the backup mesh was 304 stainless steel calendared 8 mesh (with tops of ridges flattened) with wire diameter of 0.025 inches, and the top mesh was 304 stainless steel 180 mesh with a wire diameter of 0.0012 inches (or alternatively 200 mesh with a wire diameter of 0.0010 inches). A panel like the panel 1150 was coated with a powder coating and bonded to the top mesh.

[0092] FIG. 7 shows a screen 1250 which has a plurality of bottom support strips 1252, each of which has two upper in-turned edges formed into a mounting hook (not shown). Undulating screening material 1256 is bonded to the strips 1252. Flat material may, alternatively, be used.

[0093] FIG. 8 shows a bottom strip support assembly 1290 for a screen according to the present invention. A plurality of strips 1291 extends between and are secured to frame sides 1292 and 1293.
In certain embodiments of a screen as in FIG. 8, the strips 1291 are between one-thirty second and one-eighth inches thick and about forty-five and a half inches long; the frame sides 1292, 1293 are about thirty six inches long; the strips 1291 are made from galvanized steel; and the frame sides 1292, 1293 are made from 20 gauge galvanized steel.

U.S. Pat. No. 5,971,159 issued Oct. 26, 1999 describes the items of FIGS. 9 and 10 in detail and these descriptions are incorporated herein fully for all purposes.

FIGS. 11A-11C illustrate changes to a screen assembly 730 disclosed in U.S. Pat. No. 5,720,881 which is incorporated fully herein. The screen assembly 730 has a plate 731 with holes 738 therethrough and a multi-layer screen 732 epoxied together and bonded to the plate 731.

As shown in FIG. 11B, support 733 underlies a ridge 734 of the screen 732 and support 735 with a series of fluid flow holes 736 therethrough underlies a ridge 737. It is within the scope of this invention to use or more supports 733 and/or 735 and/or one or more of the supports disclosed herein) under one, two, three, more than three, or all of the ridges of the screen 732 (or of any screen or assembly disclosed in U.S. Pat. No. 5,720,881). In one aspect each ridge may have a series of spaced apart supports and, in another aspect, supports under one ridge are offset from those under another ridge. Although it is not preferred, in certain embodiments the support(s) may be loose under the ridges. As shown in FIG. 11B the support 733 is secured to the screen 732 and to the plate 731 and the support 735 is secured to the screen 732.

As shown in FIG. 11C the width of a support may be such that, as viewed from above, it does not block off the openings 738 (support 733) or, alternatively it does block off openings 738 (support 736).

FIG. 11D shows a screen 740 like the screen assembly 730's screen 732, but with no lower plate 731. It is to be understood that the screens 732 and 740 represent any known single or multi-layer screen or screen assembly with screen(s) bonded together or unbounded. It is within the scope of this invention to use or more supports (any disclosed herein) with each of the various screen assemblies disclosed in U.S. Pat. No. 5,720,881 including but not limited to those of this patent's FIGS. 2, 4, 8 and 9.

Ridges 741, 742, 743 of the screen 740 each has an internal support 744, 745, 746, respectively secured thereto and thereunder. It is within the scope of this invention for the screen 740 to have only supports 744, 745, or 746, to have them under each ridge, for such supports to extend along and under the entire length of a ridge, or for there to be a plurality of spaced apart supports beneath each ridge. The support 746 is shown with a series of fluid flow holes 747 therethrough, but it may be solid and either of both of the supports 744, 745 may have a series of fluid flow holes therethrough.

FIG. 12A shows a screen frame 700 according to the present invention. In one aspect the frame 700 is made from a single sheet or frame piece from which areas 702 are removed, e.g. but not limited to by an appropriate saw or laser, to form outer sides 703, 704, 705, 706 and cross strips 707 and cross strips 708. Each cross strip 708 has two raised portions or humps 709. It is within the scope of this invention for any of the strips 707, 708 to have one, two, three, four five or more humps 709. As shown each hump 709 has an internal support 710 therebeneath. The supports 710 are secured to a strip’s underside by any suitable means, including, but not limited to, glue, adhesives, epoxy, sintering, and welding. The strips 707, 708 and the supports 710 may be made of any suitable metal, plastic, fiberglass, or composite material.

As shown in FIGS. 12B and 12C the inner surface of a top of the raised portion or hump 709 is spaced apart from a top surface of the supports 710 to facilitate fluid flow over and around the supports 710. As discussed below, the strips 707, 708 and/or supports 710 may have a series of fluid flow holes therethrough. As shown in FIG. 12A a hump 711 (like the humps 709, FIG. 12B) has a series of fluid flow holes 712 therethrough and a support 713 (like the supports 710, FIG. 12B) has a series of fluid flow holes 714 therethrough.

FIGS. 13A and 13B shows a hump 715 (like the humps 709, 711) on a strip 716. The strip 716 has a series of fluid flow holes 719 therethrough, including holes through the hump 715. An internal support 717 with a series of fluid flow holes 718 therethrough is substantially wide as the strip 716.

FIG. 14A shows a hump 720 (like the humps in FIGS. 12B, 12D, 13A) of a strip 721 (like the strips 708, 716) has an internal support 722, but the support 722 viewed in cross-section as in FIG. 14A, occupies substantially all of the space under the hump 720 when viewed this way. The support 722 and/or hump 720 may have a series of fluid flow holes therethrough. The support 722, as is true of the supports in FIGS. 12D, 13A, 15A, and 15C, may be secured to a strip’s underside as is a support 710 (FIG. 12B) and the strips in these figures and the supports may be made of any of the materials listed above regarding the strips 707, 708 and supports 710.

FIGS. 15A and 15B show a hump 725 of a strip 726 with an internal support 727 adhesively secured to the strip 726 with epoxy. Alternatively, the support 727 may be welded to the strip 726. Preferably when viewed as in FIG. 15B the support 727 occupies less than 10% of the area beneath the hump 725 but most preferably less than 5%. As with any other internal support and hump disclosed herein, the hump 725 and/or support 727 may have one or a series of fluid flow holes therethrough, as shown with the holes 728, 729 in FIG. 15C.

Referring now to FIG. 16, a vibratory separator system 910 according to the present invention has a screen 920 (with screen or screening cloth or mesh as desired) according to the present invention mounted on vibratable screen mounting apparatus or “basket” 912. The screen 920 may be any screen disclosed herein or have any combination of any feature or features of any screen or screen part disclosed herein; and any such screen may be used with any appropriate shaker or screening apparatus. The basket 912 is mounted on springs 914 (only two shown; two as shown are on the opposite side) which are supported from a frame 916. The basket 912 is vibrated by a motor 922 and interconnected vibrating apparatus 918 which is mounted on the basket 912 for vibrating the basket and the screen. Elevator apparatus 928 provides for raising and lowering of the basket end. The screen 920 may be any screen disclosed herein.

FIGS. 17A and 17B show a screen 930 according to the present invention with wire mesh layers 931, 932, 933
FIG. 18 shows a screen 10 according to the present invention with a frame with two sides 12 and 14 with strips 20 extending between the two sides 12 and 14; and screen material 16 on the strips 20 and connected to the sides 12 and 14. Screen material 16 (and any other screen or screening material disclosed herein) represents any known mesh, screen, or screens, used in any combination, bonded together or unbonded. The screen material 16 as shown is “three-dimensional,” i.e., not generally flat and has undulating portions with hills 22 and valleys 24. (It is within the scope of this invention for the screening material 16 and any other screening material herein to be generally flat."

FIG. 19 illustrates a screen 130 according to the present invention with screening material 131 (which may be any screen or screening material disclosed herein) supported by a support strip 132. The support strip 132 has a bottom strip 133 and an undulating strip 134 secured thereto. The screening material 131 may rest on the undulating strip 134 or some or all of the undulating strip 134 may be bonded to the screening material.

FIG. 20 illustrates a screen 140 according to the present invention which has screening material 141 (which may be any screen or screening material disclosed herein) supported by a support strip 142. The support strip 142 has a lower strip 143 and projecting strip portions 144 secured to the lower strip 143. The projecting strip portions 144 project up into hills formed in the screening material 141. In any embodiment of this invention in which part of a support strip projects up into a raised part of a screen, the projecting strip may be connected to, adhesively bonded to, or welded to the screen at any selected point, line, points, or lines in the raised screen part. As shown in FIG. 20, the projecting strip portions are not bonded to, connected to or welded to the tops 145 of screening material 141; nor are they bonded to, welded to, or connected to lower portions 146 of the raised parts of the screening material 141. Alternatively the projecting strip portions 144 may be bonded to, connected to, or welded to only the tops 145 of the raised parts of the screening material; and/or to the lower portions 146.

Any strip or rod disclosed herein may have, in certain embodiments, holes therethrough to promote fluid flow. Any strip or rod disclosed herein with an upper projecting portion and a lower strip or rod may have holes in the upper strip or rod, the lower strip or rod, or both to promote fluid flow.

FIG. 21 discloses an improvement to screens with upper screening material and a lower rigid perforated metal sheet or apertured plate, including but not limited to improvements for screens as disclosed in U.S. Pat. Nos. 5,417,793; 5,417,858; and 5,417,859. A screen 280 with screening material 281 has a lower apertured plate 282 (as disclosed, e.g., in the three listed patents). Upper projecting strips 284 are secured to the lower apertured plate 282. The upper projecting strips may or may not be bonded to the screening material 281 and may or may not have holes therethrough. The screening material may be bonded to itself, and/or to any apertured plate, strip, or rod. Any upper projecting rod, strip, combination of strips or rods, or pattern of strips or rods disclosed herein may be used with screens with a lower apertured plate, including but not limited to those disclosed in the three listed patents.

Referring now to FIG. 22, a perspective view of a portion of a screen 400 shows a layer of wire mesh 562, which includes wire mesh webs bonded to panel 302. Should a tear develop in wire mesh layer 562, the wire mesh surrounding the tear is cut from around the opening 304 in which the tear occurs. A plug 564 is then inserted into the opening in the screen to seal the screen.

Referring now to FIGS. 23 and 24, plug 564 is made of an elastic rubber or similar elastomeric material. Its width and length are very slightly larger than one of the openings 304. It has a flat top section surrounded on all sides by a skirt-like side edge 602. The side edge is adapted for enabling the plug to be manually inserted into one of the openings 304 and to seal securely against the side of the opening. The side edges have an outwardly tapering bottom section 604 and a channel 606. The tapering bottom section is sufficiently flexible enough to deflect inwardly under force of the edges of the opening when the plug is pushed into the opening. Deflection of the bottom of the sides pulls inwardly a lower edge of channel 606, thereby providing sufficient clearance to push the plug further down into an opening 304 to the point the upper edge of the channel engages the upper edge of the opening. The width of channel 606 is slightly larger than the thickness of the edge of an opening 304 (which includes the thickness of the panel and two layers of wire mesh). Therefore, the bottom tapering section 604 springs back, locking the plug into place and sealing it against the edges of the opening. Support ribs 608 provide lateral strength to the plug so that it does not deflect downward when loaded during operation, in a manner that would pull the top edge of the channel away from the edge of the opening and allow the load to force the plug through the bottom of the opening.

FIG. 25 shows a screen 900 with a first layer of wire mesh 902 and a second layer of wire mesh web 904 (shown apart from the frame prior to final assembly after which the meshes are on the frame). It is within the scope of this invention to use only one screening layer for any screen described herein or to use three or more layers. A frame 906 supports the mesh and/or screening layers. In one aspect the layers shown for the screen rest one on top of the other and in another aspect one or more of all the layers are bonded together and in another aspect they are bonded to the frame across their entire surfaces or only around the periphery thereof. The frame 906 is configured and shaped to correspond to the corrugated shape or undulating shape of the layer(s) above it; alternatively the layer(s) may be made to correspond to the shape of the frame. Ridges 908 have relatively elongated flat tops as compared to the length of the flat tops of the ridges of the screen 700 and flat valleys 912 of the frame 906 are relatively short. It is within the scope of this invention for the ridges and valleys to have any desired width or shape.

FIGS. 26-30 present a variety of configurations for corrugated perforated plates according to the present invention and/or for strips according to the present invention.
FIG. 26 shows a corrugated plate A on a support strip B having optional mounting hooks C.

FIG. 27 shows a corrugated plate D on a support strip E. Optionally, mounting hooks may be used with such an assembly.

FIG. 28 shows a support strip F. A corrugated perforated plate may have such a configuration and mounting hooks may be used with the strips or with the plate.

FIG. 29 shows a support strip G. A corrugated perforated plate may have such a configuration and mounting hooks may be used with the strips or with the plate.

FIG. 30 shows a corrugated plate H on a support strip I having optional mounting hooks J.

Any mesh, meshes, screen, screens, screening material(s) or any combination thereof or any such as described herein may be used with any of the items shown in FIGS. 26-30.

In conclusion, therefore, it is seen that the present invention and the embodiments disclosed herein and those covered by the appended claims are well adapted to carry out the objectives and obtain the ends set forth. Certain changes can be made in the subject matter without departing from the spirit and the scope of this invention. It is realized that changes are possible within the scope of this invention and it is further intended that each element or step recited in any of the following claims is to be understood as referring to all equivalent elements or steps. The following claims are intended to cover the invention as broadly as legally possible in whatever form it may be utilized. The invention claimed herein is new and novel in accordance with 35 U.S.C. § 102 and satisfies the conditions for patentability in § 102. The invention claimed herein is not obvious in accordance with 35 U.S.C. § 103 and satisfies the conditions for patentability in § 103. This specification and the claims that follow are in accordance with all of the requirements of 35 U.S.C. § 112. The inventors may rely on the Doctrine of Equivalents to determine and assess the scope of their invention and of the claims that follow as they may pertain to apparatus not materially departing from, but outside of, the literal scope of the invention as set forth in the following claims.

What is claimed is:

1. A screen assembly for a vibratory separator, the screen assembly comprising

a support plate having a plurality of alternating raised portions and lower portions, the support plate having a plurality of spaced apart openings therethrough,

a plurality of spaced apart supports extending beneath the support plate and to which the support plate is secured, and each support having a length and independent of and not connected to the other supports along its length, each support having two spaced apart ends, and screening material on the support plate.

2. The screen assembly of claim 1 further comprising

a frame to which the support plate is secured, and wherein each support has two spaced apart ends each connected to a spaced apart side of the frame.

3. The screen assembly of claim 1 wherein the supports are made of a material from the group consisting of metal, plastic, fiberglass, rubber or cermet.

4. The screen assembly of claim 1 wherein the screening material is connected to the support plate.

5. The screen assembly of claim 1 further comprising the screening material comprising at least one wire mesh connected to the support plate.

6. The screen assembly of claim 1 wherein the screening material is a plurality of layers of wire mesh.

7. The screen assembly of claim 1 further comprising bonding material bonding the at least one wire mesh to the support plate.

8. The screen assembly of claim 1 wherein at least one support has at least one projecting portion for reception within a raised portion of the support plate.

9. The screen assembly of claim 1 wherein for each raised portion of the support plate there is a corresponding projecting portion of each support.

10. The screen assembly of claim 1 wherein the supports of the plurality of spaced-apart supports range in width between about 0.10 inches and about 3.00 inches, and are spaced-apart between about 0.2 inches to about 4.00 inches.

11. The screen assembly of claim 1 wherein the screening material comprises

a first mesh connected to the support plate, and

a second mesh connected to the first mesh.

12. The screen assembly of claim 1 wherein the screening material ranges between 2 mesh and 500 mesh.

13. Vibratory separator apparatus comprising

screen assembly mounting apparatus,

vibrator apparatus for vibrating the screen assembly mounting apparatus,

screen assembly apparatus mounted on the screen assembly mounting apparatus, the screen assembly apparatus comprising a support plate having a plurality of alternating raised portions and lower portions, the support plate having a plurality of spaced apart openings therethrough, a plurality of spaced apart supports extending beneath the support plate and to which the support plate is secured, and each support having a length and independent of and not connected to the other supports along its length, each support having two spaced apart ends, and screening material on the support plate.

14. A method for treating fluid with a vibratory separator, the fluid having material therein to be separated therefrom, comprising

introducing the fluid onto a screen assembly in the vibratory separator, the screen assembly comprising

a support plate having a plurality of alternating raised portions and lower portions, the support plate having a plurality of spaced apart openings therethrough, a plurality of spaced apart supports extending beneath the support plate and to which the support plate is secured, and each support having a length and independent of and not connected to the other supports along its length, each support having two spaced apart ends, and screening material on the support plate.
15. A screen assembly for screening material in a vibratory screening machine, said assembly comprising

a frame,

a plurality of apertures in said frame, spaced frame members on opposite sides of said plurality of apertures,

a screen on said frame comprising a support plate with a support plate undulating shape and screening material connected to the undulating support plate and having a screening material undulating shape corresponding to the support plate undulating shape,

the undulating shapes with elongated substantially parallel ridges having sloping sides, troughs formed between said sloping sides for conducting material which is being screened longitudinally of said troughs while it is being screened, and

at least one support beneath at least one of said ridges, said at least one support within a space defined by a lower surface of said at least one of said ridges and an upper surface of the frame.

16. A screen assembly for screening material in a vibratory screening machine comprising

an undulating apertured plate having ridges and troughs between said ridges,

a screen on and formed in the same configuration as said undulating apertured plate and connected in complementary mating relationship thereto, and

at least one support beneath at least one of said ridges, said at least one support having at least a portion thereof beneath one of said ridges and within a space below a lower surface of said at least one of said ridges.