Title: A SCREEN ASSEMBLY FOR A VIBRATORY SHAKER

Abstract: A screen assembly for a vibratory separator, the screen assembly comprising at least one lower coarse screen member, at least one upper fine screen member above the at least one lower coarse screen member and fused with plastic to the at least one lower coarse screen member, and a strip member beneath and adhered to the at least one lower coarse screen member.
A SCREEN ASSEMBLY FOR A VIBRATORY SHAKER

The invention relates to a screen assembly for a vibratory shaker, such as a shale shaker for separating particles and/or particles from a fluid.

The need for solids control in drilling mud used in hydrocarbon well drilling is well known in the prior art. Drilling mud, typically a mixture of clay and water and various additives, is pumped down through a hollow drill string (pipe, drill collar, bit, etc.) into a well being drilled and exits through holes in a drillbit. The mud picks up cuttings (rock) and other solids from the well and carries them upwardly away from the bit and out of the well in a space between the well walls and the drill string. At the top of the well, the solids-laden mud is discharged over a shale shaker, a device which typically has a series of screens arranged in tiered or flat disposition with respect to each other. The prior art discloses a wide variety of vibrating screens, devices which use them, shale shakers, and screens for shale shakers. The screens catch and remove solids from the mud as the mud passes through them. If drilled solids are not removed from the mud used during the drilling operation, recirculation of the drilled solids can create weight, viscosity, and gel problems in the mud, as well as increasing wear on mud pumps and other mechanical equipment used for drilling.

In some shale shakers a fine screen cloth is used with the vibrating screen. The screen may have two or more overlying layers of screen cloth. The prior art discloses that the layers may be bonded together; and that a support, supports, or a perforated or apertured plate may be used beneath the screen or screens. The frame of the vibrating screen is resiliently suspended or mounted upon a support and is caused to vibrate by a vibrating mechanism, e.g. an unbalanced weight on a
rotating shaft connected to the frame. Each screen may be vibrated by vibratory equipment to create a flow of trapped solids on top surfaces of the screen for removal and disposal of solids. The fineness or coarseness of the mesh of a screen may vary depending upon mud flow rate and the size of the solids to be removed.

Many screens used with shale shakers are flat or nearly flat (i.e. substantially two-dimensional). Other screens, due to corrugated, depressed, or raised surfaces are three-dimensional. U.S. Patents 5,417,793; 5,417,858; and 5,417,859 disclose non-flat screens for use with shale shakers. These screens have a lower planar apertured plate with a multiplicity of spaced-apart apertures or openings therethrough. Undersides of troughs of undulating screening material are bonded to the apertured plate. Such screens present a variety of problems, deficiencies, and disadvantages, including: decreased flow area due to area occluded by solid parts of the apertured plate; necessity to either purchase relatively expensive apertured plate or provide for in-house perforating of a solid plate; plate weight increases wear on parts such as rubber screen supports or cushions and can inhibit required vibration; large plate surface area requires relatively large amount of bonding means for bonding screens to the plate; and a finished screen which is relatively heavy increases handling problems, hazards, and cost of shipping.

Vibrating screens have been employed for many years to separate particles in a wide array of industrial applications. One common application of vibrating screens is in drilling operations to separate particles suspended in drilling fluids. The screens are generally flat and are mounted generally horizontally on a vibrating mechanism or shaker that imparts either a rapidly reciprocating linear, elliptical or circular
motion to the screen. Material from which particles are to be separated is poured onto a back end of the vibrating screen, usually from a pan mounted above the screen. The material generally flows toward the front end of the screen. Large particles are unable to move through the screen remaining on top of the screen and moving toward the front of the screen where they are collected. The smaller particles and fluid flows through the screen and collects in a pan beneath the screen.

A vibrating screen may be formed from one or more layers of wire mesh. Wire mesh is generally described with reference to the diameter of the wires from which it is woven, the number wires per unit length (called a mesh count) and the shape or size of the openings between wires. Wire mesh comes in various grades. "Market" grade mesh generally has wires of relative large diameter. "Mill" grade has comparatively smaller diameter wires and "bolting cloth" has the smallest diameter wire. The type of mesh chosen depends on the application. Smaller diameter wires have less surface and thus less drag, resulting in greater flow rates. Smaller diameter wires also result, for a given opening size, in a larger percentage of open area over the total area of the screen, thus allowing greater flow rates and increased capacity. However, screens of bolting cloth tears more easily than market or mill grade screens, especially when used in harsh conditions such as drilling and mining operations. The smaller diameter wires tend to have less tensile strength and break more easily, and the finer mesh also tends not to retain its shape well. Most meshes suffer from what is termed as "near sized particle blinding. During vibration, wires separate enough to allow particles of substantially the same size or slightly larger than the openings to fall between the wires and become lodged, thus "blinding" the openings of
the screen and reducing capacity of the screen. If a particle becomes lodged when the wires are at a maximum distance apart, it is almost impossible to dislodge the particle. Sometimes, however, wires will subsequently separate further to release the lodged particle. Unfortunately, some wire mesh, especially bolting cloth, is tensioned. Tensioning restricts movement of the wires. Restricting movement assists in holding the shape of the wire mesh, keeping the size of the openings consistent to create a more consistent or finer "cutting point" and reducing abrasion from wires rubbing against each other. However, restricted movement of the wires reduces the probability that, once a near sized particle becomes stuck, the wires will subsequently separate to allow the particle to pass. Use of smaller diameter wires, with smaller profiles, helps to reduce blinding. With a smaller diameter wire, a particle is less likely to become lodged midway through the opening.

Multiple layers of mesh may be used to alleviate blinding. U.S. Patent No. 4,033,865, describes layering two meshes in a manner that results in at least one wire of the lower of the two meshes bisecting each opening in the upper mesh. The openings in each mesh are at least twice as wide as the diameters of the wires and the lower mesh has openings the same size as or slightly larger than the openings in the upper mesh. The lower mesh, when held tightly against the upper mesh, prevents particles from migrating far enough into an opening in the upper mesh to be trapped. Some relative movement of the layers also helps to dislodge particles caught in the upper layer. The two-layer arrangement has the further benefit of a finer "cutting point," allowing smaller particles to be separated out. A third "backing" layer of relatively coarse, mill grade mesh is often used to carry most of the load on the screen and to increase the
tensile strength of the screen.

Another problem faced in most applications is the tearing of the screen. The problem can be especially acute in heavy duty applications such as drilling and mining. A torn screen must be replaced or repaired. To facilitate repair, the screen layers are bonded to a rigid or semi-rigid support panel that has a pattern of large openings, forming on the screen a plurality of small cells of wire mesh. When a tear occurs in the screen, the mesh remaining within the cell in which the tear occurred is cut out and the cell is plugged. The capacity of the screen is diminished but its life is extended. Typically, several cells of a screen can be repaired before its capacity drops far enough to require replacement. Unfortunately, bonding the screen to the support panel further restricts relative movement of the layers and the wires in each mesh layer, thus compounding the problem of blinding.

Blinding and tearing of the screens reduce the capacity of the screen continually through its useful life. Although capacity can be increased by increasing the total area the screens, the size of the screen is limited in most applications, such as on drilling rigs, especially those on offshore platforms. There has thus been generally a trade-off between capacity, longevity, repairability and resistance to blinding of the screens.

There is a need for a supported (either non-flat or flat) screen which is consumable, efficient and cost-effective, yet readily and inexpensively made, easy to handle, and relatively inexpensive to transport.

SUMMARY OF THE PRESENT INVENTION
The present invention discloses, in certain embodiments, a screen for vibrating screen apparatus. The screen has one or more upper layers of screen, screen cloth, and/or mesh. If more than one layer is used, they may be bonded together at discrete points, at discrete areas, or over their entire surface. The layer or layers are mounted on frame apparatus which may include a solid side support on each of two spaced apart sides of the layer(s), or may include a full four sided screen frame.

A strip or strips of support material (e.g. flat steel, aluminium or plastic strips — of any width, but in certain preferred embodiments ranging between a half inch to three inches in width; and of any thickness, but in certain preferred embodiments ranging between one-thirty second and one-eighth inches thick, or rods of these materials with a diameter between one-thirty second and one-eighth inches; any screen may use strips made from different materials, e.g. cross-strips of plastic and end strips of steel, or vice versa) are secured across two or more frame sides. With respect to a two sided frame wherein the two sides are parallel and spaced apart, a strip or strips may be, in accordance with this invention, disposed parallel to the two sides; and, if more than one strip is used, spaced apart across the area of the layer or layers. It is also within the scope of this invention to use a strip or strips which are disposed in a manner non-parallel to the two sides. In one aspect such non-parallel strips may extend diagonally from one end of one side of the frame, across the layer or layers, to a diagonally opposite end of the other side. In another aspect such a strip may extend from any point of a frame side to any point on a non-framed side of the layer or layers. Any such strip (or rod) may be bonded, sintered, welded or otherwise secured (herein referred to collectively as "bonded") at any point to the
layer or layers; at substantially every point of contact between the strip(s) and the layer(s); or at selected intermediate contact points.

In certain embodiments a screen assembly for a vibratory separator is provided that has a corrugated support plate having a plurality of alternating raised portions and lower portions, the corrugated support plate having a plurality of spaced apart openings therethrough, a screen frame with a first pair of spaced apart first sides and a second pair of spaced apart second sides, the first sides spaced apart by the second sides and connected thereto, the frame having a plurality of spaced apart support strips extending beneath the corrugated support plate, each support strip independent of and not connected to the other support strips along its length, each support strip having two spaced apart ends each connected to a spaced apart side of the frame and to which the corrugated support plate is secured. Such a screen assembly may, optionally, have at least one projecting portion on each support strip for reception within a raised portion of the corrugated support plate, and screening material on the corrugated support plate. In certain embodiments such a strip (or strips) is used with an undulating three-dimensional layer or layers of screen, screen cloth, screen mesh, or some combination thereof (either non-bonded layers or bonded layers if multiple layers are present). If the undulating layer(s) present certain downwardly projecting areas, e.g. troughs between valleys, some or all of the troughs may, within the scope of this invention, be bonded to the strip(s) or portions thereof, and all or only a portion of a trough may be bonded to the strip(s).

Certain prior art shaker screens have a frame side with an in-turned edge which facilitates hooking of the
screen, e.g. to a vibrating basket. In one embodiment of the present invention a strip as described above extending between two frame sides also extends into and becomes this in-turned hooked edge. In another aspect a strip is secured to a portion of a hook. To inhibit or prevent fluid leakage at the hook/strip interface, a steel strip may be welded to a metal hook (or a non-metal strip may be bonded to a metal or non-metal hook). In one aspect typical frame sides are not used and only a series of strips with hook edges support the screening material and provide for its mounting to a shale shaker. In other embodiments in which two frame sides are used, support strips at opposite ends of the frame sides may also serve as end members across the layer(s) ends which do not have frame sides. In one aspect such strips are emplaced at the leading and trailing edges of the layers. In embodiments of this invention in which the layer (or layers) are non-flat (e.g. undulating) and there is some sort of extended depressed or lower areas on or across the layers which provide a generally lower path for fluid moving on part of or all the way across a screen, the strip or strips in accordance with this invention may be placed beneath the layer or layers at any desired angle to the direction of flow of the fluid across the screen. Also, in those cases in which the entire screen surface has undulations in a same general direction, the screen may be disposed so that fluid flows across the screen either generally in the same direction as the undulations or transverse to such a direction. In either case, a strip or strips beneath the layer(s) may be in the direction of flow or transverse to it.

In one aspect the strips (or rods) described above 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. 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 as previously described. 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. In any screen disclosed herein the screening material may be sintered to itself, individual screen wires may be sintered to each other, one or more layers of screen material, cloth, mesh, or screen may be sintered to each other; and any screen material may be sintered to any strip disclosed herein, either entirely along its length or at selected points or areas thereof.

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.
It is within the scope of this invention to provide a screen as disclosed in U.S. Patents 5,417,793; 5,417,858; and 5,417,859, but to delete the apertured plate required by these patents and to use instead a coarse mesh or a coarse flexible mesh. In certain preferred embodiments this mesh ranges in size between a 1 mesh to a 3 mesh, with a 2 mesh used in one particular embodiment. It is within the scope of this invention to use any strip, combination of strips, strip member, or pattern of strips in place of the apertured plate required by the three listed patents. It is within the scope of this invention to use any strip or strips disclosed herein in combination with the apertured plate required by the three listed patents.

The invention, in certain embodiments, discloses a screen for a vibrating separator or shaker that has increased capacity without an increase in overall dimensions. It furthermore accommodates desirable attributes such as resistance to blinding, repairability and longevity. The screen, substantially horizontal when placed on a separator for operation, is formed from one or more layers of mesh. The one or more layers of mesh are formed into an alternating series of ridges and channels lying substantially within the plane of the screen. The ridges increase the surface area of the screen without increasing the overall dimensions of the screen, thus improving flow capacity. Additionally, particles tend to drop into the channels, leaving the tops of the ridges exposed to fluids for relatively unimpeded flow through the screen that further improves flow rates. Furthermore, the ridges and channels tend to assist in evenly distributing separated particles across the screen. Uneven distribution, due to for example rolling of the screen from side to side when used on
offshore platforms, degrades flow capacity of the screen.

In accordance with another aspect of the invention, the wire mesh is bonded to a rigid or semi-rigid panel having an array of openings that are very large as compared to those of the mesh. The support panel is formed with or bent into a series of alternating ridges and channels to create the ridges and channels in the wire mesh when it is bonded to the panel. The openings in the panel create, in effect, a plurality of individual screen cells when the wire mesh is bonded to the panel around each opening. When a portion of wire mesh fails or is torn within a cell, the screen is repaired by cutting the remaining mesh from the cell opening and plugging the cell opening with a solid piece of material.

In accordance with another aspect of the invention, the ridges and channels of the panel have substantially flat surfaces on which the openings are located. A substantially planar opening allows a flat plug to be inserted into the opening for improved fit and sealing. The plug is preferably formed with an edge that facilitates insertion into opening and into which the edge of the cell opening snugly fits, making a repair quick and easy.

In accordance with another aspect of the invention, the ridges have a generally triangular cross section. In a preferred embodiment, the ridges are formed from two surfaces in a triangular configuration and the channel is formed from a flat bottom surface extending between the ridges. This geometry tends to maximize effective or useful surface area of the screen, especially if flat surfaces are used on the ridge to facilitate repair. During normal operation of the separator or shaker, most of the particles fall into the channel and the material to be separated tends to flow through the screen along the sides of the ridges and the bottom of the channel. A
generally triangular configuration of the ridge tends to expose greater screen area to the flow and to minimize the amount of area on top of the ridge that tends not to be exposed to material flow.

In another aspect a screen in accordance with the present invention has a lower perforated corrugated plate with a plurality of triangular apertures or openings forming the perforations through the plate. In one aspect the triangles are congruent, of similar size, and are arrayed side-to-side across the plate. In certain aspects when a corrugated plate is used, no plastic grid is placed or used between screens or meshes or between a plate and screening material. The mesh, meshes, screen, screens, or screening material(s) are secured on the plate directly with the use of adhesive on the plate, e.g. but not limited to powder adhesive, without the use of a plastic or adhesive grid. Alternatively such a grid may be used. In certain aspects in which a corrugated perforated plate is used, the screen, mesh or screening material does not contact a strip or multiple strips disposed beneath the plate. In one aspect a corrugated perforated plate is secured to a frame comprised of sides. In another aspect strips as described herein are used with such a frame for certain embodiments. In such a device screening material or mesh secured to the corrugated perforated plate does not contact or bond to the strip/frame assembly.
For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1A is a schematic view of a prior art system;
Figure 1B is a schematic view of a system in accordance with the present invention;
Figure 2A is a top view of a panel in accordance with the present invention for a screen assembly;
Figure 2B is a front view of the panel of Figure 2A;
Figure 2C is a left end view (as viewed from Figure 2A) of the panel of Figure 2A;
Figure 2D is a bottom view of a part of a panel in accordance with the present invention of Figure 2E;
Figure 2E is a top view of a panel in accordance with the present invention;
Figure 2F is an exploded view of the screen assembly of Figure 2E;
Figures 2G - 2P are top views of panels in accordance with the present invention;
Figures 3A and 3D-H are perspective views of screen assemblies in accordance with the present invention;
Figure 3B is a top view and Figure 4C is an end view of the screen assembly of Figure 4A;
Figure 4A is a perspective view of a screen assembly in accordance with the present invention;
Figure 4C is a top view, Figure 4D is an end view, and Figure 4B is an enlarged view of a portion (shown outlined in Figure 4C) of the screen assembly of Figure 4A;
Figure 5A is a perspective view of a screen assembly in accordance with the present invention; Figure 5C is a top view, Figure 5D is an end view, and Figure 5B is an enlarged view of a portion (shown outlined in Figure 5C) of the screen assembly of Figure 5A; Figure 5E is a bottom view of the screen of Figure 5A;
Figure 6A is a perspective view of a screen assembly in accordance with the present invention; Figure 6C is a top view, Figure 6C is an end view, and Figure 6B is an enlarged view of a portion (shown outlined in Figure 6C) of the screen assembly of Figure 6A;

Figure 7A is a perspective view of a screen assembly in accordance with the present invention; Figure 7B is a top view of the screen of Figure 7A; Figures 7C - 7E present variations, in top view, of the screen assembly of Figure 7A;

Figure 8 is a perspective view of a screen assembly in accordance with the present invention; and

Figures 9 - 20 show designs of a screen in accordance with the present invention.

Figure 1A discloses one example of a typical prior art shaker system (e.g. as shown in U.S. Patent 5,190,645). Figure 1B shows a system 1 in accordance with the present invention with parts like those of the system of Figure 1A; but with a shale shaker K having a screen or screens S in accordance with the present invention (any screen or screens disclosed herein, including, but not limited to, those in Figures 3A - 3H). The screen(s) S are mounted in a typical shaker basket B and one or more vibrators V (any known suitable shaker vibrator) vibrate the basket B and hence the screen(s) S.

Figures 2A - 2D show a screen panel 10 in accordance with the present invention with two opposed spaced-apart sides 11 and 12 spaced apart by two opposed sides 13, 14 and by a plurality of strips 15. Each pair of spaced-apart strips, with portions of the sides 11, 12 define an open space 16 through the panel 10. At each side 13, 14, a strip 15 and a portion of the side 13 and side 14 define an open space 17 through the panel 10. The rear view corresponds closely with the front view as shown in Figure 2B. The right end view corresponds closely with
the left end view as shown in Figure 2C.

In one aspect the panel 10 (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 0.19cm (0.074 inches) thick.

The openings in the panel may be made by any suitable method, including, but not limited to, drilling, sawing, high pressure water cutting, or laser cutting. In one particular aspect a panel of 14 gauge cold rolled steel about 0.19cm (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 15, in one aspect with strips about 0.56cm (0.22 inches) wide, about 3.30cm (1.3 inches) apart from each other.

In other aspects, the strips 15 may range in width between about 0.25cm (0.10 inches) to about 7.6cm (3.00 inches) and they may be spaced apart between about 0.51cm (0.2 inches) to about 10.16cm (4.00 inches). In one particular screen with about 0.56cm (0.22 inch) wide strips spaced about 3.30cm (1.3 inches) apart, the panel is 14 gauge cold rolled steel about 118.75cm (46.75 inches) long, about 91.08cm (35.86 inches) wide, about 0.19cm (0.074 inches) thick with end portions, as viewed from above, about 4.19cm (1.65 inches) wide between the screen ends' outer edge and the edge of an open space.

Alternatively, the strips 15 may be vertically oriented as viewed in Figure 2A and the panel 10 may be corrugated.

Alternatively, the outer edges of the panel 10 may be provided and the strips, as separate pieces, connected thereto in any manner, shape, or design as described
above herein.

Figure 2E shows a screen assembly 20 in accordance with the present invention with a panel 10. A first mesh (in one aspect a fine mesh) 21, e.g. 180 mesh, is bonded to a second mesh (in one aspect a backup mesh) 22, e.g. 12 mesh which is then bonded to the panel 10. 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.

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 0.11cm (0.045 inches), the middle mesh was 130 mesh 304 stainless steel with wire diameter of 0.043mm (0.0017 inches), and the top mesh was 304 stainless steel 180 mesh with a wire diameter of 0.030mm (0.0012 inches). A panel like the panel 10 was coated with a powder coating (e.g. such as commercially available TK NOVO B Powder from Tuboscope Vetco) and bonded to the three meshes.

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 0.64cm (0.025 inches), and the top mesh was 304 stainless steel 200 mesh with a wire diameter of 0.053mm (0.0021 inches). A panel like the panel 10 was coated with a powder coating and bonded to the two meshes.

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 0.030cm (0.0012 inches)
(or alternatively 200 mesh with a wire diameter of
0.025mm (0.0010 inches). A panel like the panel 10 was
coated with a powder coating and bonded to the three
meshes.

Figures 2G - 2P are top views of screen panels in
accordance with the present invention which have strips
in various orientations and of various widths and
spacing. Any panel, side, and/or strip depicted in these
figures may be made of any material listed above for the
panel 10 and any strip in these figures may have the
dimensions described for a strip 15. Any screen,
screens, mesh or meshes or mesh or screen combination
described herein may be used with any panel in Figures 2G
- 2P and these panels may be flat, corrugated, or
undulating as any such shape for a frame or panel
disclosed herein and the screen(s) and/or mesh(es)
thereon may have a shape corresponding to the panel
shape.

Figure 2G shows a panel PG with strips SG. Figure
2H shows a panel PH with strips SH and one wider strip
SQ. Figure 2I shows a panel PI with vertically extending
(as viewed in the figure) strips SI. Figure 2J shows a
panel PJ with vertical strips SJ and horizontally
extending (as viewed in the figure) strips SS.

Figure 2K shows a panel PK with vertical strips SK
and horizontal strips ST. Figure 2L shows a panel PL
with vertical strips SL and slanted (as viewed in the
figure) strips SV. Figure 2M shows a panel PM with
chevron shaped (as viewed in the figure) strips SM.

Figure 2N shows a panel PN with slanted strips SN.
Figure 2O shows a panel PO with partially curved strips
SO and optional horizontal strips SV.

Figure 2P shows a panel PP with undulating curved
(as viewed from above) strips SP.

Each panel in Figures 2G - 2P has an outer frame FR to which some or all of the strips or attached or formed with. As in Figures 2J, 2K, and 2L, some of the strips are connected to other strips. Spaces between strips may be formed by cutting the strips, e.g. with a laser or other suitable tool or instrument. Any plastic grid disclosed herein may be configured and shaped to correspond to any panel disclosed herein.

Figures 3A - 3C show a screen assembly 30 with a lower strip member 31 (including individual strips 32, 33), with four sides 32 (one shown), multiple cross-strips 33, upturned edges 34 (called an "L" hook; one shown in Figure 3A). The entire screen 30 is shown in Figure 3B and Figure 3A shows a portion of the screen 30 in cut away revealing the various components. It is to be understood that the strip member, grid and screens cover substantially the entire screen assembly area as viewed in Figure 3B.

A coarse screen 35 rests on the strip member 31. In one aspect, optionally, the strip member 31 is bonded to the coarse screen, e.g. with glue or epoxy. A plastic grid 36 is initially (prior to the bonding of the strip member to the coarse screen) interposed between the coarse screen 35 and a fine screen 37. By subjecting the grid/screen combination to heat (e.g. between heated plates or in an oven at 480°F for five minutes to eight minutes) and, optionally, pressure (e.g. with weight on top of the combination and/or between plates pressed together with one or more pneumatic cylinders), the plastic fuses the screens together and permeates them, encapsulating wires where it is present. The screens, bonded together by the plastic, are then emplaced on the strip member and an adhesive is used to bond the strip member 31 to the screen combination. The upturned edge
34 (made, e.g. with a press brake) of the strip member 31 is bent up and over edges of the screens and plastic and this structure provides a hook strip apparatus for the connection of the screen assembly 30 to various shakers and vibratory separators that use hook-strip connection. A channel-shaped or "C" hook strip may be used instead of the "L" hook. Alternatively all the edges of the screen assembly may be relatively flat with no hook strip. The plastic grid can be placed initially above the fine screen(s), below the coarse screen(s), or between any two screen layers. Upon heating, the plastic flows to all layers above and/or below it bonding all layers together. Instead of a plastic grid any suitable plastic pieces or strips, or glue, may be used.

The coarse screen 35 may be any suitable coarse screen, including but not limited to, those disclosed herein. The fine screen 37 may be any suitable fine screen, including but not limited to, those disclosed herein. Two or more coarse screens may be used and two or more fine screens may be used. The strip member 31 may be any strip member disclosed herein or any frame or support with strips disclosed herein. The plastic grid 36 may be any plastic grid disclosed herein; any suitable polyurethane hot melt; and/or any plastic or plastic grid and bonding process associated therewith as in U.S. Patents 5,417,793; 5,868,929; 5,417,858; 5,417,859; 5,221,008; 4,575,421; 5,720,881; 5,636,749 and 5,330,057 which are incorporated fully herein for all purposes. The plastic grid 36 may be bonded to the screens by any suitable known cooking, curing, pressing, and/or cooling method, including but not limited to, methods as disclosed herein and/or in the patents listed above.

In certain particular preferred embodiments a screen assembly 30 either 36" X 45S" or 36" X 64" has screens as follows:
Coarse screen: S" openings, 88 mesh; S" openings flattop wire cloth
Mesh: 1 to 50; 19; 32; or calendared 12 - in a square or oblong weave or any suitable weave
Material: steel; stainless steel; 304 SS; 314 SS; 316 SS

Fine Screen:

Mesh: 12 to 500; 200 X 125; 240 X 150; 280 X 180; 370 X 200 (In one aspect two fine screens, one 130 mesh, one 160 mesh or one 130 mesh and one 180 mesh)
Material: same as coarse screen or synthetics (e.g. nylon)

Plastic grid:

Type of plastic: polypropylene; polyethylene; nylon
Distance between centers: about 4.2cm (1.65")
Thickness: about 0.8cm (0.032") to 0.7cm (0.028")

Strip member:
Material: 14 gauge cold rolled steel (in one aspect less than fifteen percent carbon)
Distance between adjacent strips: about 3.28cm (1.29")
Thickness: about 14 gauge

In one aspect a powdered epoxy is applied to the top of the strips and sides of the strip member and the screen(s) are then emplaced on top of the strip member. Instead of using a plastic grid 36, glue may be applied (e.g. automatically with a glue applying machine or with a glue gun by hand) to one of the screens in a desired pattern, e.g. but not limited to, to resemble any pattern of any grid disclosed herein. Alternatively a patterning roller may be used to so apply the glue in a desired pattern.

Figures 3D - 3G are perspective views of various alternatives to the screen 30 of Figure 3A (and the same
Numerals identify the same components as in the screen 30. A screen 40 in Figure 3D is like the screen 30 but has no layer of coarse screen beneath the plastic grid 36. A screen 42 shown in Figure 3E has a plastic grid 43 with openings 44 that differ in size from those of the grid 36. A screen 45 shown in Figure 3F has cross-members 46 interconnecting strips 33. Crossmembers connect the outermost strips to the panel sides. A screen 47 shown in Figure 3G has cross-members 48 interconnecting strips 33, some of which connect an outermost strip to a panel side. Cross members as in Figures 3G and 3H may be above the strips, below the strips, or at the same level as the strips. In one particular aspect, the cross members may be as disclosed in U.S. Patent Application Ser. No. 09/344,145 filed 6/24/99 entitled "Vibratory Separator Operations And Apparatuses" which is incorporated fully herein for all purposes.

Figures 4A - 4D show a screen assembly 50 in accordance with the present invention that has a lower strip member 51 and a screen/plastic combination mounted on the lower strip member 51.

The screen/plastic combination includes a lower coarse screen 55 and two upper fine screens 58a and 58b. Fusing the screens together is a plastic grid 56 that initially is placed on the coarse screen 55 below the fine screens 58a and 58b, e.g. as shown in Figures 4A and 4D; but which, following heat treatment, permeates both screens fusing them together and encapsulating in plastic portions of wires in each screen. Any process described herein for applying plastic may be used instead of the plastic grid as shown and any heating process described herein may be used to fuse the screens together. Alternatively any glue and gluing process described above may be used instead of a plastic strip or plastic pieces.
The screen assembly 50 (as described for the screens of Figures 3A - 3G) may have no coarse lower screen or one or more coarse screens and may have one, two, three or more fine screens.

As shown in Figure 4A, it is within the scope of this invention to form and shape a plastic grid (or to apply plastic strips, plastic pieces, or glue) in such a way that areas of the intersection of lines of plastic (or lines of glue) such as the areas 57 are located above individual strips 59b of the lower strip member 51 or above a side 59a of the member 51.

A bent edge 54 provides a hook strip connection for those machines that use hook strip connectors. As shown the edge 54 is an "L" shaped hook strip, but it is within the scope of this invention to use a channel shaped or "C" shaped hook strip instead of the "L" shape.

It is to be understood that the screen assembly as shown in Figures 4A and 4B show the plastic grid 56 as a separate member or separate material, not yet heated and pressed, which has not yet permeated the screen layers. The lower strip member 51 (including strips 989a and 989b) is adhered to the screen plastic combination as described above for the screen 30.

Figures 5A - 5E show a screen assembly 60 in accordance with the present invention that has a lower strip member 61 (with strips 61a, 61b and end pieces 61c) and a screen/plastic combination mounted on the lower strip member 61.

The screen/plastic combination includes a lower coarse screen 65 and an upper fine screens 68a and 68b. Fusing the two screens together is a plastic grid 66 that initially is placed on the coarse screen 65 below the fine screens, e.g. as shown in Figures 5A and 5B; but which, following heat treatment, permeates both screens fusing them together and encapsulating in plastic
portions of wires in each screen. Any process described herein for applying plastic may be used instead of the plastic grid as shown and any heating process described herein may be used to fuse the screens together. Alternatively any glue and gluing process described above may be used instead of a plastic strip or plastic pieces. The screen assembly 60 (as described for the screens of Figures 3A - 3G) may have no coarse lower screen or one or more coarse screens and may have one, two, three or more fine screens.

As shown in Figure 5A, it is within the scope of this invention to form and shape a plastic grid (or to apply plastic strips, plastic pieces, or glue) in such a way that areas of the intersection of lines of plastic (or lines of glue) such as the areas 67 are located above individual strips 61a or 61b of the lower strip member 61 or above an end piece 61c of the member 61.

A bent edge 64 provides a hook strip connection for those machines that use hook strip connectors. As shown the edge 64 is an "L" shaped hook strip, but it is within the scope of this invention to use a channel shaped or "C" shaped hook strip instead of the "L" shape.

It is to be understood that the screen assembly as shown in Figures 5A and 5B show the plastic grid 66 as a separate member or separate material, not yet heated and pressed, which has not yet permeated the screen layers. The lower strip member 61 is adhered to the screen plastic combination as described above for the screen 30. Figures 6A - 6D show a screen assembly 100 in accordance with the present invention that has a lower strip member 101 (like the strip member 61, Figures 5A and 5E) with strips 101a, 101b and end pieces 101c and a screen/plastic combination mounted on the lower strip member 101.

The screen/plastic combination includes a lower
coarse screen 105 and an upper fine screen 108. Fusing the two screens together is a plastic grid 106 that initially is placed on the coarse screen 105 below the fine screen 108, e.g. as shown in Figures 6A and 6B; but which, following heat treatment, permeates both screens fusing them together and encapsulating in plastic portions of wires in each screen. Any process described herein for applying plastic may be used instead of the plastic grid as shown and any heating process described herein may be used to fuse the screens together. Alternatively any glue and gluing process described above may be used instead of a plastic strip or plastic pieces. The screen assembly 100 (as described for the screens of Figures 3A - 3G) may have no coarse lower screen or one or more coarse screens and may have one, two, three or more fine screens.

As shown in Figure 6A, it is within the scope of this invention to form and shape a plastic grid (or to apply plastic strips, plastic pieces, or glue) in such a way that areas of the intersection of lines of plastic (or lines of glue) such as the areas 107 are located above individual strips 101b of the lower strip member 101 or above a strip 101b of the member 101. Also plastic (or glue) lines, strips or pieces 109 connect adjacent areas of intersection 107 and the strips or pieces 109 also are located above portions of the strips.

A bent edge 104 provides a hook strip connection for those machines that use hook strip connectors. As shown the edge 104 is an "L" shaped hook strip, but it is within the scope of this invention to use a channel shaped or "C" shaped hook strip instead of the "L" shape. It is to be understood that the screen assembly as shown in Figures 6A and 6B show the plastic grid 106 as a separate member or separate material, not yet heated and pressed, which has not yet permeated the screen layers.
The lower strip member 101 is adhered to the screen plastic combination as described above for the screen 30.

Figures 7A and 7B show a screen assembly 110 like that of Figure 3A, but with the addition of a top coarse screen 115 that covers the entire area of an uppermost fine screen 37. (Like numerals in Figures 3A and 8 indicate the same item or component.) The coarse screen 1015 may be any desired mesh, e.g. but not limited to 20 mesh, 30 mesh, 40 mesh or 50 mesh. Such a top coarse mesh protects the finer screens, takes some of the solids loading off the lower screens (a scalping effect), catches sharp sand particles preventing them from wearing away fine screen(s), and inhibits or prevents solids from sticking to a top screen and pulling it up as a shaker vibrates. The coarse top screen 115 may be fused together with the other screens below it in a plastic-heating-pressing process as described above. In certain preferred embodiments in which only a portion of a screen assembly (as viewed from the top) has the top coarse mesh on it, edges of the top coarse mesh are located so that they overlie a strip in a strip support member that is positioned under the lowermost coarse mesh layer. Any screen or screen assembly disclosed herein can have a top mesh as in Figure 7A or a portion or portions thereof as in Figures 7C - 7D.

Figures 7C, 7D and 7E show variations of the screen assembly 1010 in which only a portion of the upper most fine screen has a top coarse screen located above it. In Figure 7C a coarse top screen portion 116 is positioned at the back end of a screen assembly 111 at which location fluid to be processed is introduced onto the screen assembly. In Figure 7D a coarse top screen portion 117 is positioned at a front end of a screen assembly 112 at which location material exits from the screen assembly. In Figure 7E a screen assembly 113 has
both screen portions 118 (like the screen portion 116, Figure 7C) and 119 (like the screen portion 117, Figure 7D). Like numerals in Figures 7A and 7C - 7E indicate the same item or component.

Figure 8 shows a screen assembly 120 like the screen assembly of Figure 3A (like numerals indicate the same item or component), but with a second coarse mesh layer 121 between the upper fine mesh or meshes and the lowermost coarse mesh. In one embodiment of a screen assembly 120 the lower most coarse mesh 35 is a 12 mesh screen which is, optionally, calendared relatively flat, and/or with tops of ridges flat, or calendared no more than 30% of original height (original mesh thickness) and the mesh 121 above the mesh 35 is a 30 mesh screen. The 30 mesh screen 121 acts as a cushion between the lowermost coarse mesh 35 and the fine screen 37 or screens above the coarse mesh screen 121. The mesh 121 also is, preferably, flatter than the mesh 35 [and may be flatter than upper fine mesh screen(s)] and thereby inhibits injury to the upper fine screen(s) by the lowermost coarse mesh. Any screen or screen assembly disclosed herein can have a less coarse mesh interposed between a lower most coarser mesh and upper or fine screen or screens. Any two adjacent screens in any embodiment disclosed herein and/or any two screens with parts in contact may be sintered together at the points of contact instead of or in addition to any fusing with plastic described herein. Any screen or screen assembly disclosed herein may be used in a shaker or vibratory separator, e.g. but not limited to, as in Figures 14 and 1B.

The present invention, therefore, in some but not necessarily all embodiments, provides a screen assembly for a shaker or a vibratory separator, the screen assembly with at least one lower coarse screen member, at
least one upper fine screen member above the at least one lower coarse screen member and fused with plastic to the at least one lower coarse screen member, and a strip member beneath and adhered to the at least one lower coarse screen member. Such a screen assembly may have one, some, or any possible combination of the following: wherein the at least one lower coarse screen member is two coarse screens, one on top of the other, either of the same mesh or of different mesh; wherein the strip member has a plurality of spaced-apart support strips of the same or of different width; wherein the support strips are made of a material from the group consisting of metal, plastic, fiberglass, rubber or cermet; wherein the strip member includes two spaced apart end pieces each at an angle to the plurality of spaced apart support strips, each of the plurality of spaced apart support strips having two spaced-apart ends terminating at, on, or in one of the two spaced-apart end pieces; wherein the at least one upper fine screen is two fine screens, one on top of the other of the same mesh or of different mesh; a fused plastic grid (made of plastic material, plastic pieces, or a single piece) fusing the at least one lower coarse screen member and the at least one upper fine screen member together, the fused plastic grid comprising a plurality of intersecting lines of plastic which intersect at a plurality of intersection areas; wherein a plurality of the intersection areas lie above one of a plurality of spaced-apart support strips which are included in the strip member; wherein each of the intersection areas lie above one of a plurality of spaced-apart support strips which are included in the strip member; wherein each intersection area on a particular support strip is connected to adjacent intersection areas above the particular support strip by an additional line of plastic; at least one secondary
coarse screen or coarse screen portion disposed above the at least one upper fine screen member; wherein the at least one secondary coarse screen portion is two spaced-apart coarse screen portions; wherein the at least one secondary coarse screen portion is located at an area at which fluid to be treated is introduced onto the screen assembly; wherein the at least one secondary coarse screen portion is located at an area at which fluid to be treated exits from the screen assembly; wherein the at least one secondary coarse screen portion is defined by opposed spaced-apart edges, either both of which or at least one of which overlies a support strip of a plurality of spaced-apart support strips that are included in the strip member; wherein the at least one lower coarse screen member is at least partially sintered to the at least one upper fine screen member; wherein the at least one lower coarse screen member is sintered over substantially its entire area to the at least one upper fine screen member; and/or two spaced-apart hook strips (e.g. L shaped, C shaped, channel shaped – viewed on end) on opposite sides of the screen assembly.
CLAIMS:
1. A screen assembly for a vibratory separator, the screen assembly comprising at least one lower coarse screen member, at least one upper fine screen member above the at least one lower coarse screen member and fused with plastic to the at least one lower coarse screen member, and a strip member beneath and adhered to the at least one lower coarse screen member.
2. The screen assembly of claim 1 wherein the at least one lower coarse screen member is two coarse screens, one on top of the other.
3. The screen assembly of claim 1 wherein the strip member further comprises a plurality of spaced-apart support strips.
4. The screen assembly of claim 3 wherein the support strips are made of a material from the group consisting of metal, plastic, fiberglass, rubber or cermet.
5. The screen assembly of claim 3 wherein the strip member includes two spaced apart end pieces each at an angle to the plurality of spaced apart support strips, each of the plurality of spaced apart support strips having two spaced-apart ends terminating at, on, or in one of the two spaced-apart end pieces.
6. The screen assembly of claim 1 wherein the at least one upper fine screen is two fine screens, one on top of the other.
7. The screen assembly of claim 1 further comprising a fused plastic grid fusing the at least one lower coarse screen member and the at least one upper fine screen member together, the fused plastic grid comprising a plurality of intersecting lines of plastic which intersect at a plurality of intersection areas.
8. The screen assembly of claim 7 wherein a plurality of the intersection areas lie above one of a plurality of
spaced-apart support strips which are included in the strip member.

9. The screen assembly of claim 7 wherein each of the intersection areas lie above one of a plurality of spaced-apart support strips which are included in the strip member.

10. The screen assembly of claim 8 wherein each intersection area on a particular support strip is connected to adjacent intersection areas above the particular support strip by an additional line of plastic.

11. The screen assembly of claim 1 further comprising at least one secondary coarse screen portion disposed above the at least one upper fine screen member.

12. The screen assembly of claim 11 wherein the at least one secondary coarse screen portion is two spaced-apart coarse screen portions.

13. The screen assembly of claim 11 wherein the at least one secondary coarse screen portion is located at an area at which fluid to be treated is introduced onto the screen assembly.

14. The screen assembly of claim 11 wherein the at least one secondary coarse screen portion is located at an area at which fluid to be treated exits from the screen assembly.

15. The screen assembly of claim 1 wherein the at least one secondary coarse screen portion is at least a first and a second portion, the first portion located at an area at which fluid to be treated is introduced onto the screen assembly and the second portion is located at an area at which fluid to be treated exits from the screen assembly.

16. The screen assembly of claim 11 wherein the at least one secondary coarse screen portion is defined by opposed spaced-apart edges, at least one of which overlies a
support strip of a plurality of spaced-apart support strips that are included in the strip member.

17. The screen assembly of claim 1 wherein the at least one lower coarse screen member is at least partially sintered to the at least one upper fine screen member.

18. The screen assembly of claim 1 wherein the at least one lower coarse screen member is sintered over substantially its entire area to the at least one upper fine screen member.

19. The screen assembly of claim 1 further comprising two spaced-apart hook strips on opposite sides of the screen assembly.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B01D33/00  B01D33/03  B07B1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D B07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 417 793 A (BAKULA JOHN J) 23 May 1995 (1995-05-23) cited in the application abstract column 4, line 46 - column 5, line 5 column 5, line 26 - column 6, line 6 column 6, line 47 - column 7, line 31 column 9, line 15 - line 66 claims; figures 6,8,21,22</td>
<td>1,6,7, 11,19</td>
</tr>
<tr>
<td>Y</td>
<td>WO 97 28906 A (LUCAS BRIAN RONALD; ADAMS THOMAS COLE (US); LEONE VINCENT DOMINICK) 14 August 1997 (1997-08-14) page 13, line 5 - line 24 page 15, line 4 - line 19 claims; figures 13A,18,19</td>
<td>3-5</td>
</tr>
</tbody>
</table>

X Further documents are listed in the continuation of box C.

X Patent family members are listed in annex.

* Special categories of cited documents:
  *A* document defining the general state of the art which is not considered to be of particular relevance
  *E* earlier document published on or after the international filing date
  *L* document which may throw doubts on priority claims or which is cited to establish the publication date of another citation or other special reason (as specified)
  *O* document referring to an oral disclosure, use, exhibition or other means
  *P* document published prior to the international filing date but later than the priority date claimed

*P* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents. Such combination being obvious to a person skilled in the art.

* & document member of the same patent family

Date of the actual completion of the international search

11 December 2000

Date of mailing of the international search report

19/12/2000

Name and mailing address of the ISA

European Patent Office, P. B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel: (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016

Authorized officer

Hilt, D
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 636 749 A (WOJCIECHOWSKI KEITH F) 10 June 1997 (1997-06-10) cited in the application the whole document</td>
<td>1, 6, 7, 19</td>
</tr>
<tr>
<td>A</td>
<td>US 4 575 421 A (DERRICK JAMES W ET AL) 11 March 1986 (1986-03-11) cited in the application the whole document</td>
<td>1-19</td>
</tr>
</tbody>
</table>
## INTERNATIONAL SEARCH REPORT

**Informal patent family members**

<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AU 690096 B</td>
<td>23-04-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 6084494 A</td>
<td>15-08-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2152602 A</td>
<td>21-07-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69420701 D</td>
<td>21-10-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69420701 T</td>
<td>02-03-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 680385 T</td>
<td>31-01-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0680385 A</td>
<td>08-11-1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2135563 T</td>
<td>01-11-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6000556 A</td>
<td>14-12-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 9415723 A</td>
<td>21-07-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5417859 A</td>
<td>23-05-1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6053332 A</td>
<td>25-04-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5783077 A</td>
<td>21-07-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5876552 A</td>
<td>02-03-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5958236 A</td>
<td>28-09-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 693086 B</td>
<td>25-06-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 6023194 A</td>
<td>15-08-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 714591 B</td>
<td>06-01-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 6593998 A</td>
<td>09-07-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2152610 A</td>
<td>21-07-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69421381 D</td>
<td>02-12-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69421381 T</td>
<td>06-04-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 680386 T</td>
<td>24-01-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0680386 A</td>
<td>08-11-1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2137356 T</td>
<td>16-12-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 9415724 A</td>
<td>21-07-1994</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5720881 A</td>
<td>24-02-1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5868929 A</td>
<td>09-02-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5944993 A</td>
<td>31-08-1999</td>
</tr>
</tbody>
</table>

- **WO 9728906 A** 14-08-1997
  - US 5971159 A 26-10-1999
  - AU 1799397 A 28-08-1997
  - CA 2240693 A 14-08-1997
  - EP 0880411 A 02-12-1998
  - NO 982680 A 03-08-1998
  - US 6029824 A 29-02-2000
  - US 6032806 A 07-03-2000
  - US 5988397 A 23-11-1999

- **US 5636749 A** 10-06-1997
  - NONE

- **US 4575421 A** 11-03-1986
  - NONE