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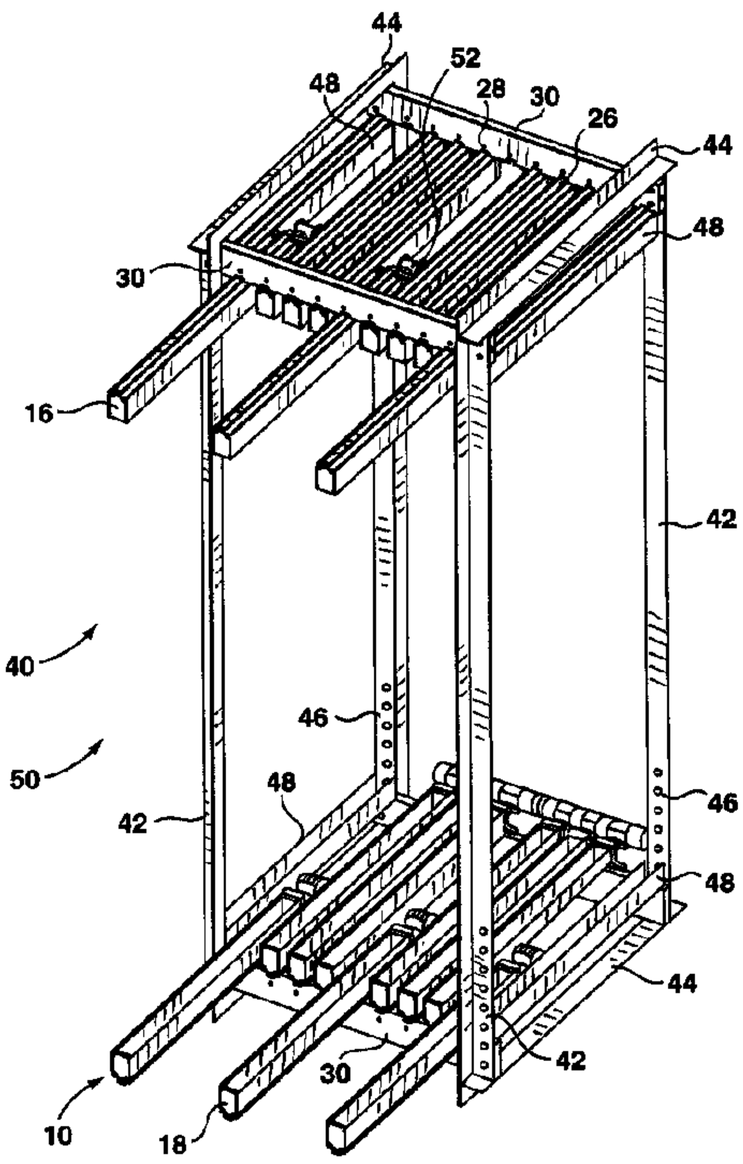
(54) Titre : MODULE DE MEMBRANE IMMERGEE
(54) Title: IMMERSED MEMBRANE MODULE



(57) Abrégé/Abstract:
Elements of immersed, suction driven, ultrafiltration or microfiltration hollow fibre membranes have an upper header and a lower header with the membranes suspended between them. The elements do not include means for holding the headers in position relative to each other. A cassette is made by sliding a plurality of the elements into a frame to place them side by side. The frame restrains the elements in place but the restraint may be released to allow a selected element to be removed in a direction substantially parallel to its headers without disassembling the remainder of the module. The vertical location of cross bars which hold headers may be changed from time to time to maintain the membranes in a slightly slackened condition. The elements are narrow and spaced to promote penetration of the bubbles and tank water into the elements. Cassettes are placed back to back in pairs separated by permeate pipes. The connections between the permeate pipes and the cassettes release when an element is pulled out of the cassette and reseal when the element is replaced in the cassette. The headers are made of an extrusion which may be cut to any desired length. Cassettes may be produce to a variety of desired sizes.

ABSTRACT

Elements of immersed, suction driven, ultrafiltration or microfiltration hollow fibre membranes have an upper header and a lower header with the membranes suspended between them. The elements do not include means for holding the headers in position relative to each other. A cassette is made by sliding a plurality of the elements into a frame to place them side by side. The frame restrains the elements in place but the restraint may be released to allow a selected element to be removed in a direction substantially parallel to its headers without disassembling the remainder of the module. The vertical location of cross bars which hold headers may be changed from time to time to maintain the membranes in a slightly slackened condition. The elements are narrow and spaced to promote penetration of the bubbles and tank water into the elements. Cassettes are placed back to back in pairs separated by permeate pipes. The connections between the permeate pipes and the cassettes release when an element is pulled out of the cassette and reseal when the element is replaced in the cassette. The headers are made of an extrusion which may be cut to any desired length. Cassettes may be produce to a variety of desired sizes.

Title: IMMERSED MEMBRANE MODULE

FIELD OF THE INVENTION

This invention relates to filtering membranes and particularly to modules of immersed, suction driven, ultrafiltration or microfiltration membranes used to filter water or wastewater.

BACKGROUND OF THE INVENTION

Submerged membranes are used to treat liquids containing solids to produce a filtered liquid lean in solids and an unfiltered retentate rich in solids. For example, submerged membranes are used to withdraw substantially clean water from wastewater and to withdraw potable water from well water or surface water.

Immersed membranes are generally arranged in modules or cassettes which comprise the membranes and headers attached to the membranes. The modules are immersed in a tank of water containing solids. A transmembrane pressure ("TMP") is applied across the membrane walls which causes filtered water to permeate through the membrane walls. Solids are rejected by the membranes and remain in the tank water to be biologically or chemically treated or drained from the tank.

U.S. Patent No. 5,639,373, issued to Zenon Environmental Inc. on June 17, 1997, describes one such module using hollow fibre membranes. In this module, hollow fibre membranes are held in fluid communication with a pair of vertically spaced headers. TMP is provided by suction on the lumens of the fibres through the headers. Similar modules are shown in U.S. Patent No. 5,783,083 issued to Zenon Environmental Inc. on July 21, 1998, PCT Publication No. WO 98/28066 filed on December 18, 1997 by Memtec America Corporation and

European Patent Application No. EP 0 931 582 filed August 22, 1997 by Mitsubishi Rayon Co., Ltd.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide elements of immersed, suction driven, ultrafiltration or microfiltration hollow fibre membranes that can be assembled into a cassette and which may be used to filter water or wastewater. Advantages of the invention include: that very few components interfere with the flow of tank water through the cassette; that the permeate pipe connections are efficient; that elements may be removed or isolated without interfering with adjacent elements; that the elements may be economically manufactured to a wide range of sizes; and, that the distance between headers of the elements can be easily reduced to account for membrane shrinkage in use.

In some aspects, the invention is directed at an element of filtering hollow fibre membranes having an upper header and a lower header. A plurality of hollow fibre membranes are attached to and suspended between the headers for collecting permeate through at least one of the headers. The element does not include any means for holding the headers in position relative to each other but the elements may be inserted into a carrying frame if required for transport or handling. A cassette of filtering hollow fibre membranes is made by sliding a plurality of the elements into a frame which holds them side by side. The frame restrains the elements in place but the restraint provided by the frame may be released for a selected element allowing the selected element to be removed or replaced in a direction substantially parallel to its headers without disassembling the remainder of the module. In particular, keys on the distal faces of the headers slidably engage slots in first and second cross bars of the frame which are perpendicular to the headers. Although the headers are only secured to the frame at the slots, wings on

the ends of the headers engage slots in neighbouring headers such that an element being removed or inserted is supported by the adjacent elements. Accordingly, the need for continuous channels in the cassette frame parallel to the headers is avoided.

The cross bars may be located at various horizontal positions on uprights of the frame. The vertical location of the cross bars may be changed from time to time to maintain the membranes in a slightly slackened conditions although their length may decrease in use.

Aerators are mounted generally below the elements and supply scouring bubbles to the cassette and circulate tank water. The elements are narrow, each element being a rectangular skein of hollow fibres having an effective thickness of between 4 and 8 rows of hollow fibres. The headers, being extruded, are thin and do not greatly increase the width of the element. The slots are positioned to provide horizontal spaces between adjacent elements, preferably at least one third of the width of the headers measured in the direction of the horizontal spacing, to promote penetration of the bubbles and tank water into the elements. The absence of structural members between the headers of each element improves the circulation of tank water and bubbles through the cassette as well as avoiding a source of friction which might damage the fibres.

Cassettes are placed back to back in pairs separated by permeate pipes. The connections between the permeate pipes and the cassettes release when an element is pulled out of the cassette and reseal when the element is replaced in the cassette. Thus a single element can be removed for maintenance without disconnecting other parts of the permeate pipe network. Preferably, a large permeate collector is connected to a small group of elements by a short local permeate pipe with a valve that permits the small group of elements to be isolated. Thus, while waiting for repair, permeation can continue with the remaining elements. The large permeate collector is preferably located

above the water surface so that it may be run directly to even larger collectors typically located on the edges of a tank.

The headers are made of an extrusion which may be cut to any desired length. The ends of the headers are capped with caps, the back cap including the wings. The horizontal distance between the cross bars which hold the slots can be altered by changing the dimensions of the frame or the location of the cross bars relative to the frame. Longer or shorter cross bars can be used which hold fewer or more elements. The vertical distance between cross bars can be altered by changing the dimensions of the frame or the location of the cross bars relative to the frame. Accordingly, it is easy to produce a cassette of any desired size merely by altering the length of cut of one or more of the header extrusion, the cross bars or the frame members.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will now be described with reference to the following figures.

Figure 1 is a somewhat schematic front elevation of a filtering element.

Figure 2 is a somewhat schematic side elevation of the filtering element of Figure 1.

Figure 3 is an isometric view of a headers of the filtering elements according to Figures 1 and 2.

Figure 4 is an elevation of the end of 4 adjacent headers of Figure 3.

Figure 5 is an isometric view of a frame for a cassette with headers attached.

Figure 6 is a close up of the top of Figure 5.

Figure 7 is a diagrammatic drawing of part of two elements placed back to back and connected to a permeate pipe.

DETAILED DESCRIPTION OF EMBODIMENT

Figures 1 and 2 show front and side elevations respectively of a filtering element 10. The element 10 has a plurality of hollow fibre membranes 12 in the form of a rectangular skein 14 suspended between an upper header 16 and a lower header 18. The rectangular skeins 14 are between four and eight layers of membranes 12 deep (five layers being shown in Figure 2), less frequently up to 12 layers deep, and are in the range of several tens of membranes 12 wide. The element 10 does not include any permanently attached means for holding the headers 16, 18 in position relative to each other but the element 10 may be inserted into a carrying frame if required for transport or handling. The lack of means for holding the headers 16, 18 in position relative to each other improves the flow of tank water about the element 10 and avoids a possible source of damage to the membranes 12.

The membranes 12 typically have an outside diameter between 0.4 mm and 4.0 mm. The length of the membranes 12 is chosen to maximize flux for a given cost according to relationships known in the art and is typically between 400 mm and 1,800 mm. The membranes 12 have an average pore size in the microfiltration or ultrafiltration range, preferably between 0.003 microns and 10 microns and more preferably between 0.02 microns and 1 micron.

The upper header 16 has a permeate channel 20 in fluid communication with the lumens of the membranes 12. The membranes 12 are plugged in the lower header 18 but, optionally for wastewater and preferably for drinking water, the lower header 18 may also have a permeate channel in fluid communication with the lumens of the membranes 12 to permit permeation from both ends of the membranes 12. The membranes 12 are potted into the upper header 16 (and any other permeating header) such that the membranes 12 are all closely spaced apart from each other. This allows potting resin to completely surround the outside of the end of each membrane 12 to provide a watertight seal so that water can only enter the permeate channel after first flowing though the membranes 12. Suitable potting resins include polyurethane, epoxy, rubberized epoxy and silicone resin. One or more resins may also be used in combination to meet objectives of strength and providing a soft interface with the membranes 12 having no cutting edges.

The inventors prefer to use a potting method like that described in U.S. Patent No. 5,639,373 which is incorporated herein by this reference and which produces layers of membranes 12, but other potting methods known in the art may also be used. In particular, the inventors prefer to use the methods described in Canadian Patent Application No. 2,308,234 filed May 5, 2000 by Zenon Environmental Inc. and in a US Application filed on May 3, 2001 by Rabie et al. entitled Gel Potting Method and Method to Reduce Twinning for Filtering Hollow Fibre Membranes, both of which are incorporated herein by this reference. Regardless of potting method, the thickness of the assembled mass of membranes 12 is preferably between 18 and 40 mm. Typical headers 16, 18 to accommodate such masses of membranes are 40 to 50 mm wide, typically 40 mm. Typical potting densities are between 10% and 40%. A preferred element 10 uses membranes 12 from a commercially available ZW 500 (TM) module made by Zenon Environmental Inc. which have an outside diameter of about 2 mm, an

un-potted length (meaning the unsupported length of membrane 12 between the upper header 16 and lower header 18) of 1,600 to 1,900 mm, and a pore size of approximately 0.1 microns.

Referring to Figure 3, the upper header 16 is shown. The lower header 18 is the same but for its inverted position. The upper header 16 includes a body 22 preferably extruded from a suitable plastic such as PVC or ABS. The extrusion can be cut to a wide range of sizes as desired. A back cap 24 is attached to the body 22 by gluing or welding. The body 22 includes a key 26 running the length of the top of the upper header 16. The back cap 24 is shaped to extend the key 26. The key 26 fits into slots in cross bars 30 of which only short sections are shown. The back cap 24 also has an upper wing 32 and a lower wing 34. The back cap 24 and the body 22 also have an upper channel 36 and a lower channel 38. A front cap is attached to the front of the body 22 but has been omitted from Figure 3 to show the cross-section of the body 22. The front cap need not have any wings 32, 34 but it does have channels 36, 38,

Referring to Figure 4, four upper headers 16 are attached to a section of cross bar 30 spaced to leave about 20 to 25 mm between adjacent upper header 16. The lower headers 18 are similarly attached but in an inverted position. The cross bar 30 can be cut to any desired length. To avoid the need to cut slots 28 into a long cross bar, the one piece cross bar 30 shown can be replaced with a standard extruded section, such as an inverted "C" channel, which supports any suitable hanger containing a slot 28. In that case, the standard extrusion is cut to a desired length and an appropriate number of hangers are attached or slid into it which allows the number of elements 10 to be easily varied.

The upper headers 16 and their associated upper wings 32, lower wings 34, upper channels 36 and lower channels 38 are all designated a, b, c, d to indicate which of those parts is associated with which upper header 16. As shown, the upper wing 32 of a first upper

header 16 engages the upper channel 36 of an adjacent upper header 16 and the lower wing 34 of the first upper header 16 engages the lower channel 38 of an adjacent upper header 16 on the other side. But, the upper wings 32 and lower wings 34 do not interfere with each other in the direction of the length of the upper headers 16. Accordingly, each upper header 16 can be moved into or out of its position in a direction parallel to the upper header 16. Further, although the cross bar 30 provides support at only one point, a moving upper header 16 is supported and vertically positioned by its adjacent upper headers 16 aong its travel. This makes it much easier to insert or withdraw an element 10 despite the lack of (a) means within the element 10 itself for maintaining separation between the headers 16, 18 or (b) continuous frame channels paralleling the length of each header 16, 18 which would add many parts, add to the overall cost and manufacturing time, as well as interfere with bubbles and tank water moving past the headers 16, 18. A releasable catch can be incorporated into the slot 28 and key 26 structure, typically at the front only, to provide a releasable restraint in the direction of the headers 16, 18.

Referring to Figures 5 and 6, a cassette 50 includes a frame 40 holding several elements 10. The frame 40 includes top and bottom, front and back cross bars 30, uprights 42 and struts 44 as shown. Three elements 10 (with membranes 12 removed for clarity) are shown being withdrawn from the frame 40. Extra blank (ie. unpotted) headers 48 are optionally included between the uprights 42 to provide support for the wings 32, 34 of the first element 10 on each side. An element 10 may be completely withdrawn and then supported by hand, but it is typically more convenient to place a single element carrying frame (not shown) against the frame 40. The element 10 is then slid into the carrying frame which allows the element 10 to be more easily worked with.

The length of the uprights 42 is chosen as appropriate for any desired length of membranes 12. The vertical distance between

cross bars 30 is chosen so that the membranes 12 will be slightly slacked, their free length being typically .1% to 2% more than the distance between proximal faces of the headers 16, 18. Particularly for wastewater applications where the tank water will be warm, ie. 30-50 C, the membranes 12 may shrink within the first few weeks or months of operation. To account for this shrinkage, the uprights 42 are provided with a series of mounting holes 46 which allow at least one set of the upper or lower cross bars 30 to be moved to maintain the membranes in a slightly slackened position. Although not shown, a suitable aerator (designs are known in the art) is typically mounted to the frame 40 to provide bubbles from below the cassette 50. The aerator is designed and positioned to encourage bubbles and tank water to flow through the spaces between adjacent elements 10.

To connect the headers 16, 18 to a permeate pipes, the back of any permeating headers 16, 18 are fitted with header permeate connections 52 that can be released and resealed to a permeate pipe located behind the headers 16, 18 and permit movement of the element 10 parallel to the headers 16, 18. For example, Figures 5 and 6 show commercially available clip on adapters sold under the trade mark UNI-SPRAY. These connectors 52 have the disadvantage, however, of requiring a clip to be released at the back of the element 10 which is difficult to do if the elements are placed back to back to share common permeate pipes.

Referring to Figure 7, pairs of cassettes 50 (partially shown) are placed back to back with permeate pipes in between them. The frames 40 (not shown) of the two cassettes 50 are tied together to maintain a fixed distance between them. The upper headers 16 (and lower headers 18 if they are permeating) include male fittings 54 which releasably form a seal with a female fitting 56 attached to a local permeate pipe 60. The seal is made by means of O-rings 58 fitted into O-ring grooves 66 in the male fittings 54. The male fittings 54 are thus

connected to a local permeate pipe 60 which services a small number of elements 10, ie. 2-6 elements 10. The local permeate pipe 60 has an isolation valve 62, typically a ball valve and preferably located above the water line, which permits the small group of elements 10 to be isolated from the rest of the cassette 50. The local permeate pipes 60 connect into a larger permeate collector 64 preferably located at the level of even larger collectors typically located at the edge of a tank. Thus, the necessary connections are made simply and without expensive flexible pipes. If the bottom headers 18 are also permeating, appropriate male fittings 54 are attached to the bottom headers 18 at the level of female fittings 56 on or in communication with a second permeate collector. Once clear of the cassette 50, this second permeate collector is turned upwards to meet the permeate collector 64.

CLAIMS

We claim:

1. A filtration apparatus comprising;

(a) a plurality of elements, each element having,

(i) an upper header;

(ii) a lower header;

(iii) a plurality of hollow fibre membranes attached to and suspended between the headers, the hollow fibre membranes having each at least one open end and having each an outer surface, the outer surface of the open ends of the membranes connected to at least one header with a water impermeable connection; and,

(iv) one or more permeate channels in at least one of the headers in fluid communication with the interior of the hollow fibre membranes for collecting permeate; and,

(b) a frame having cross bars for holding the headers of the elements,

wherein

(c) the elements have no means preventing one header of that element from moving vertically in relation to the other header of that element; and,

(d) the cross bars holding either the upper headers, the lower headers or both is movable relative to the remainder of the frame so as to permit adjustment of the degree of slack of the membranes.

2. A filtration apparatus comprising;

(a) a plurality of elements, each element having,

(i) an upper header;

(ii) a lower header;

(iii) a plurality of hollow fibre membranes attached to and suspended between the headers, the hollow fibre membranes having each at least one open end and having each an outer surface, the outer surface of the open ends of the membranes connected to at least one header with a water impermeable connection; and,

(iv) one or more permeate channels in at least one of the headers in fluid communication with the interior of the hollow fibre membranes for collecting permeate; and,

(b) a frame having cross bars perpendicular to the headers for holding the headers of the elements,

wherein

(c) the elements have keys which engage with slots in the cross bars to support the elements in the frame but permit the elements to be slid into or out of the frame in a direction parallel to the headers.

3. The apparatus of claim 2 wherein the elements have no means preventing one header of that element from moving vertically in relation to the other header of that element.

4. The apparatus of claim 2 wherein the elements have extensions at their backs to support themselves against adjacent elements while being inserted or removed from the frame, the extensions being arranged such that they do not interfere with the extensions of an adjacent element.

5. Two of the apparatus of any of the preceding claims placed back to back with one or more permeate pipe between them and having fittings which permit an element of either cassette to be removed

or replaced by sliding that element parallel to its headers whereby the fitting associated with that element is released or resealed.

6. The apparatus of claim 6 wherein the one or more permeate pipes includes a local permeate pipe associated with a small group of elements and fitted with a valve to isolate that group of elements, and a permeate collector connected to the local permeate pipes and located above water level at the height of larger permeate pipes around a tank.

7. The apparatus of claim 4 wherein the headers are made of an extruded body closed with caps and the extensions are provided on the back cap.

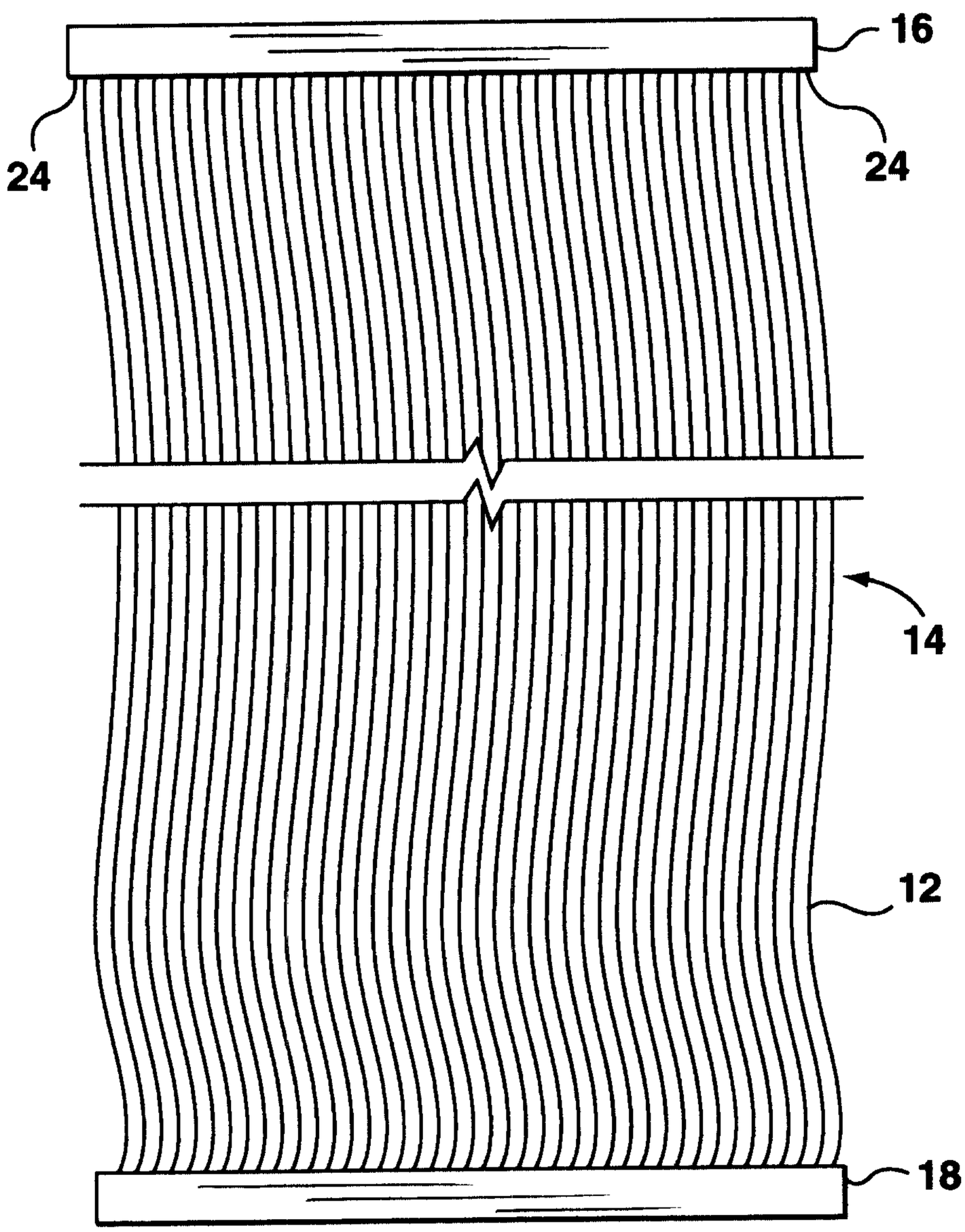


FIG. 1

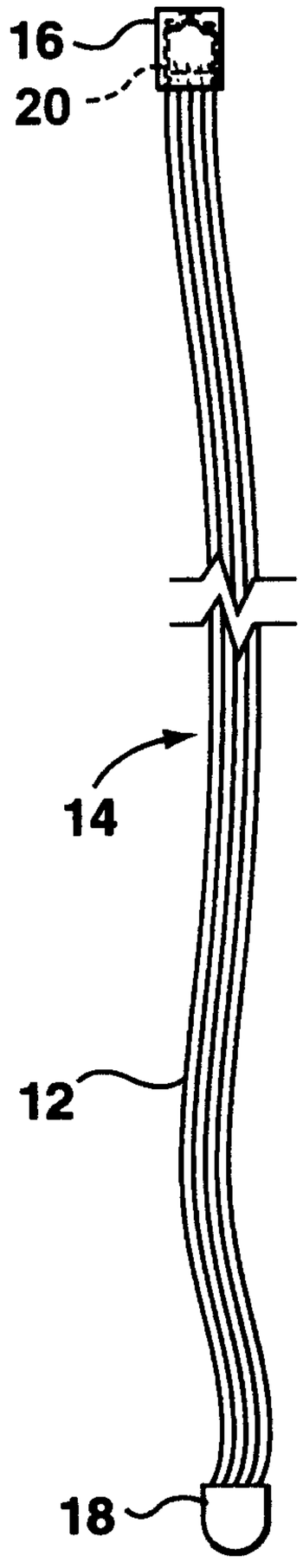


FIG. 2

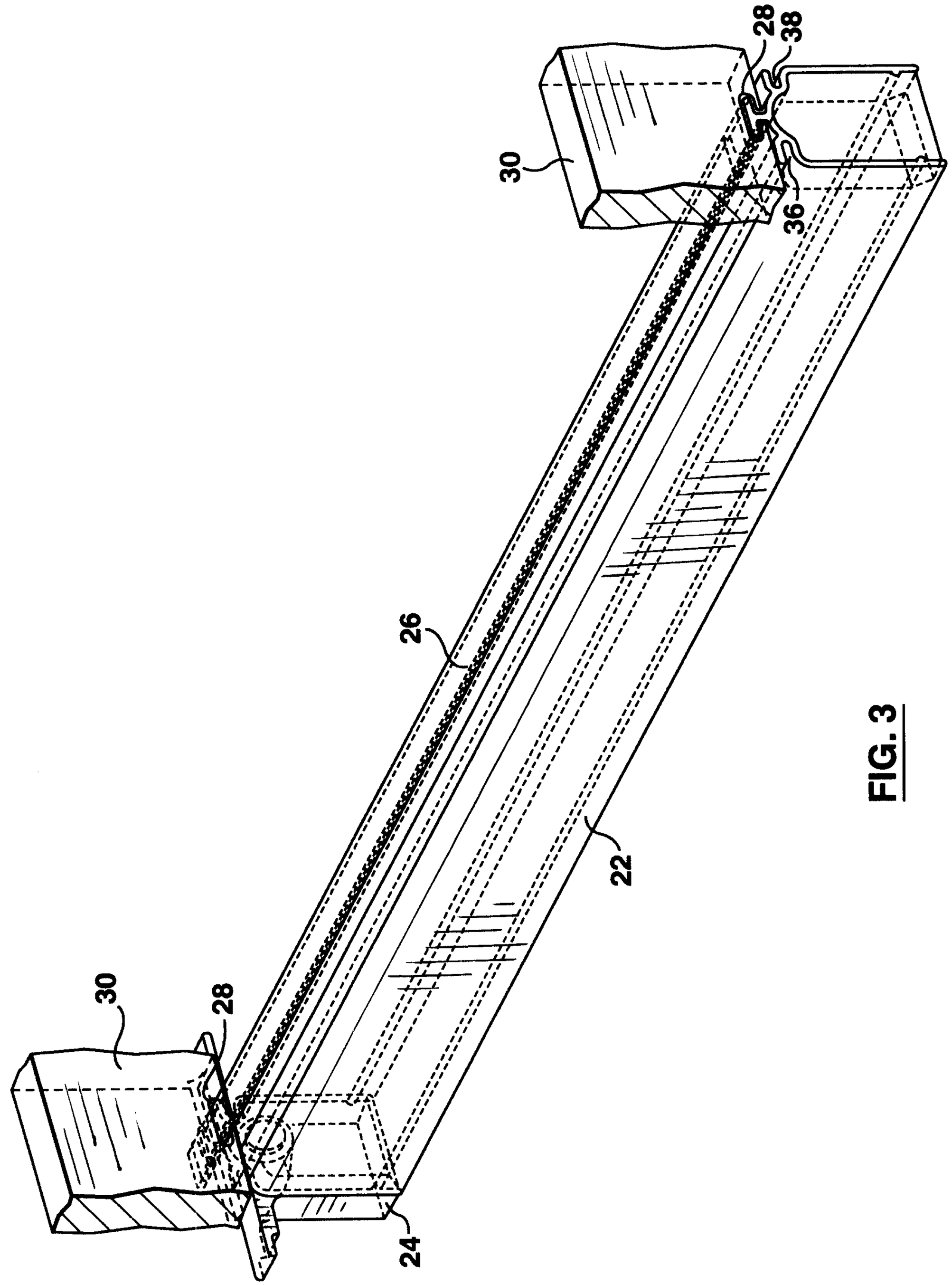


FIG. 3

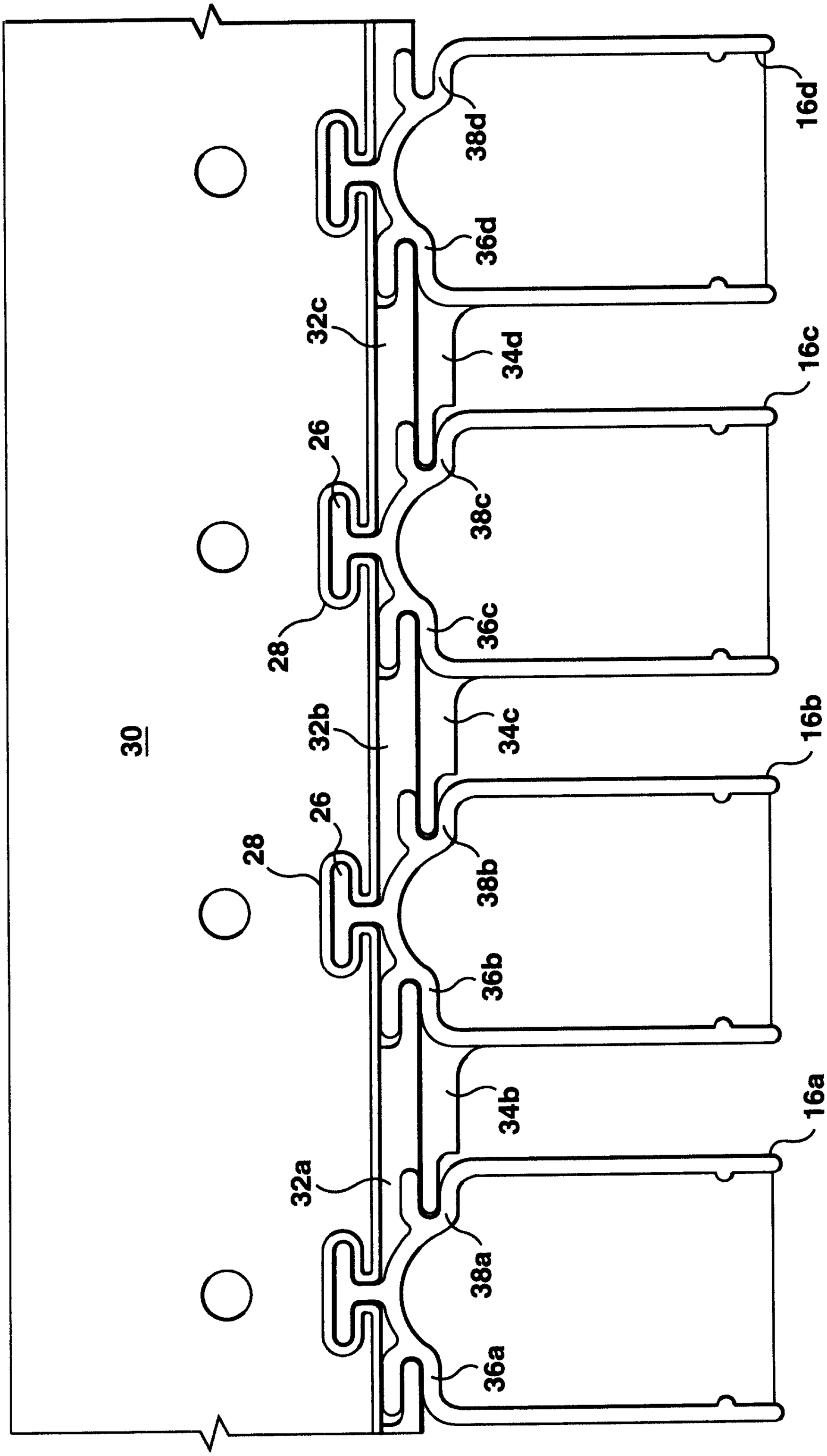

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FIG. 4

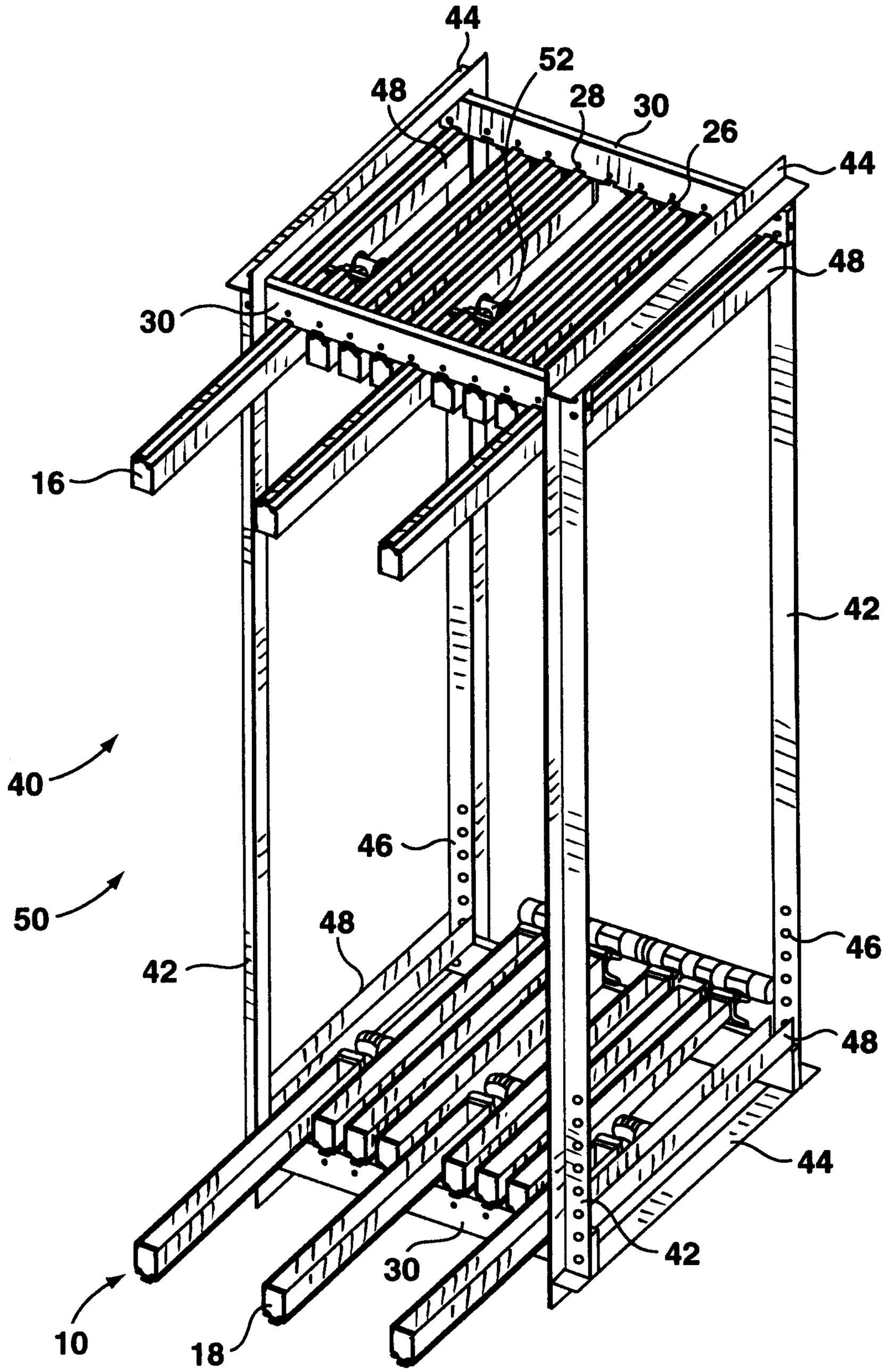


FIG. 5

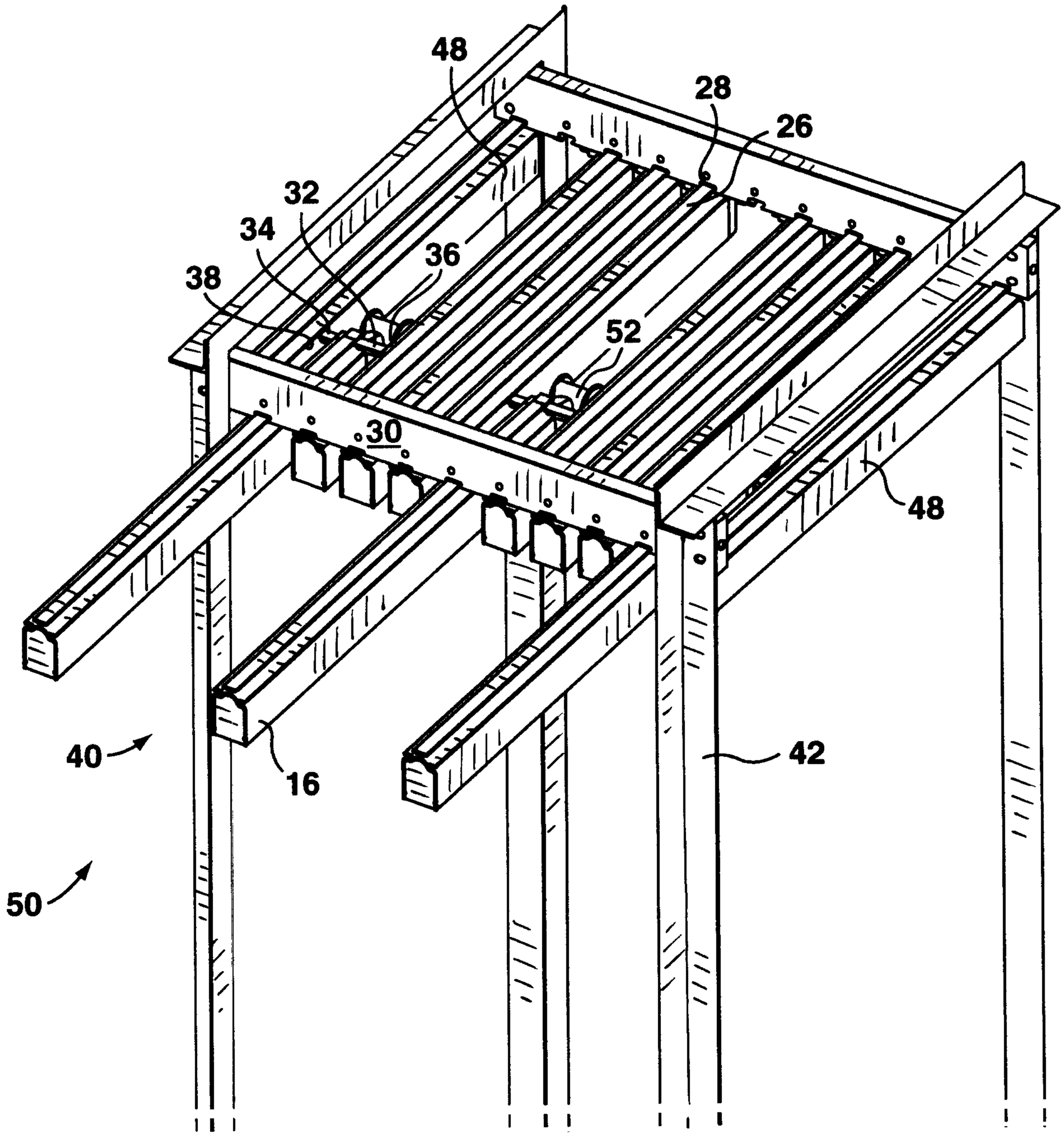


FIG. 6

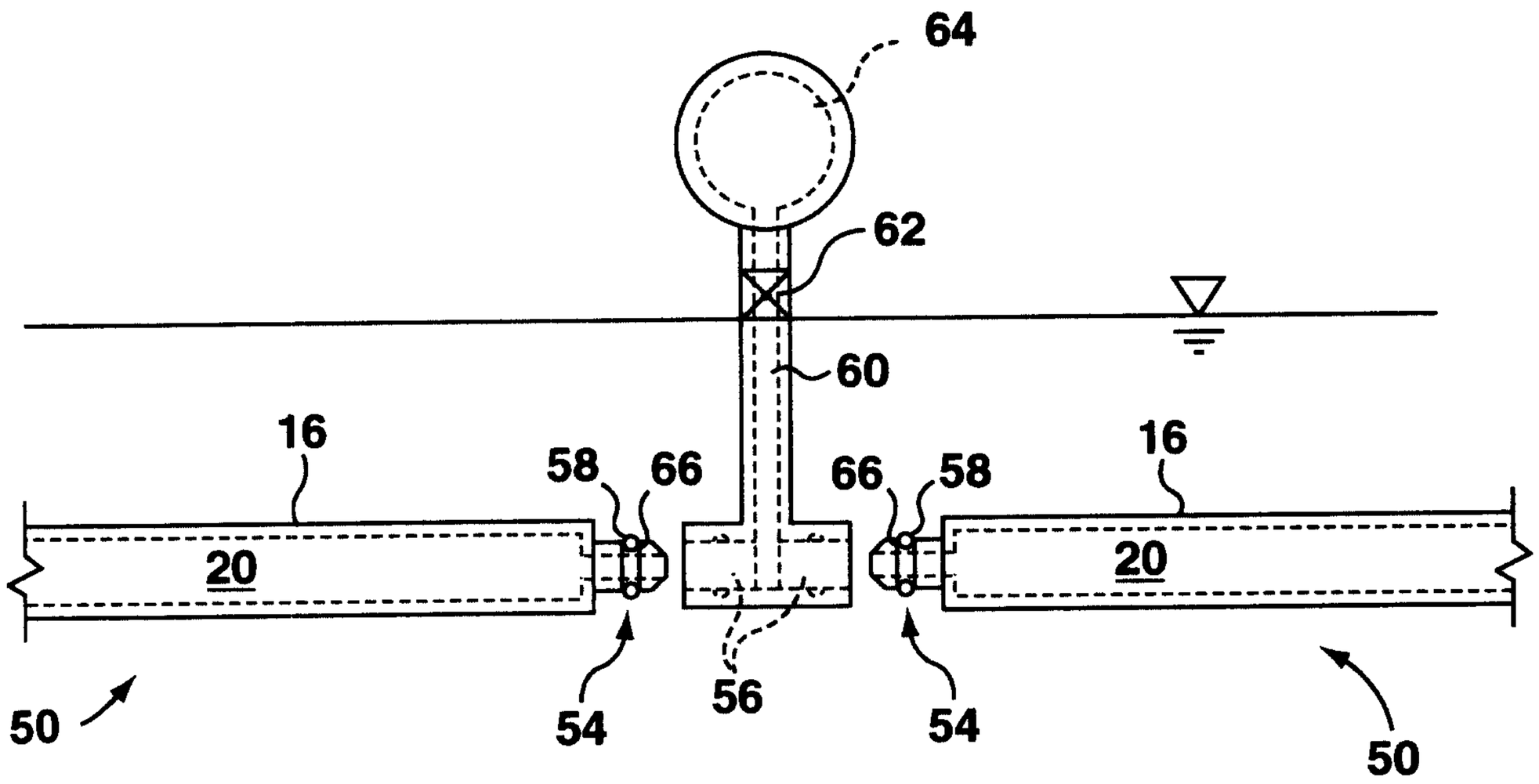
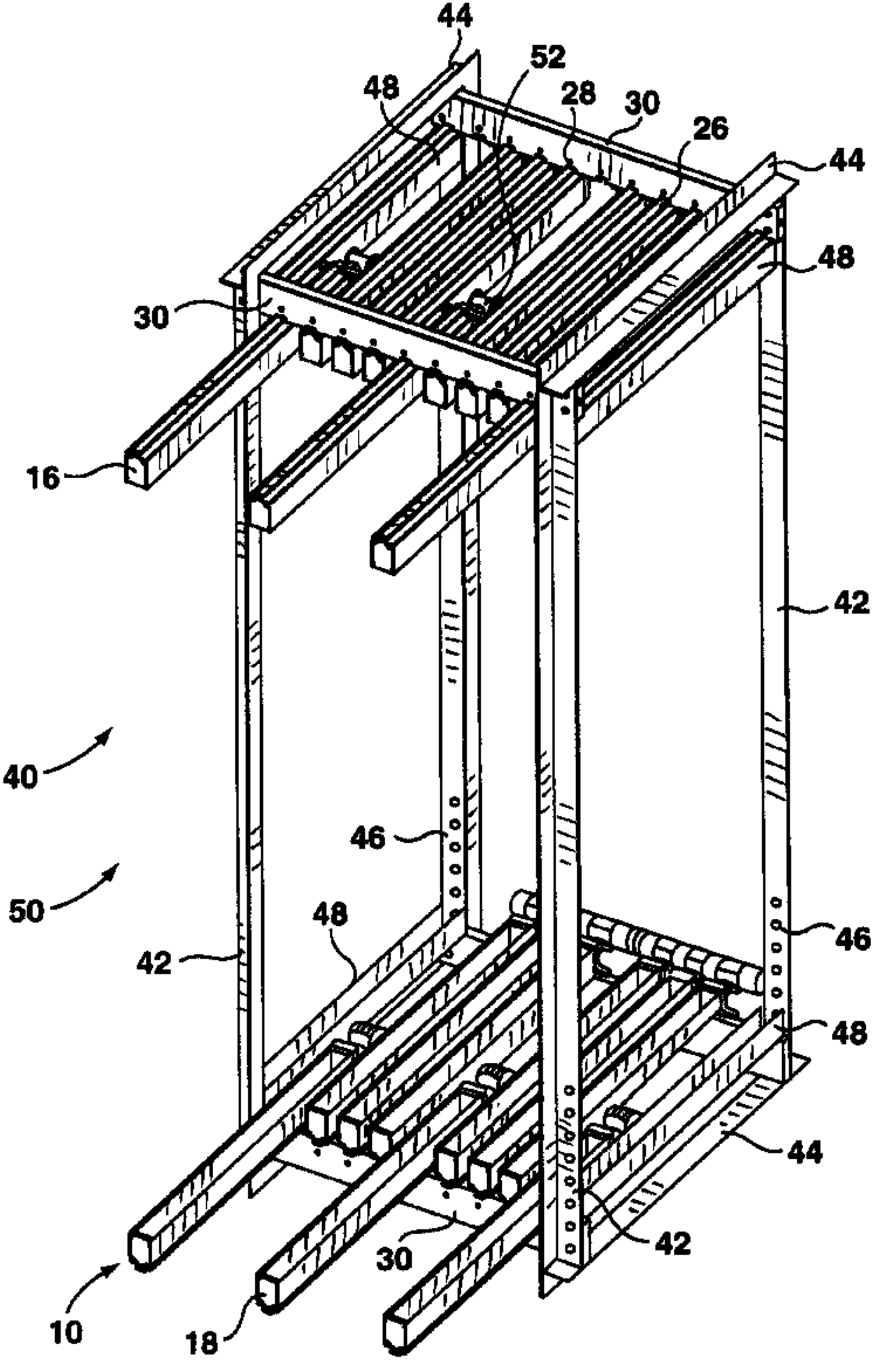


FIG. 7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