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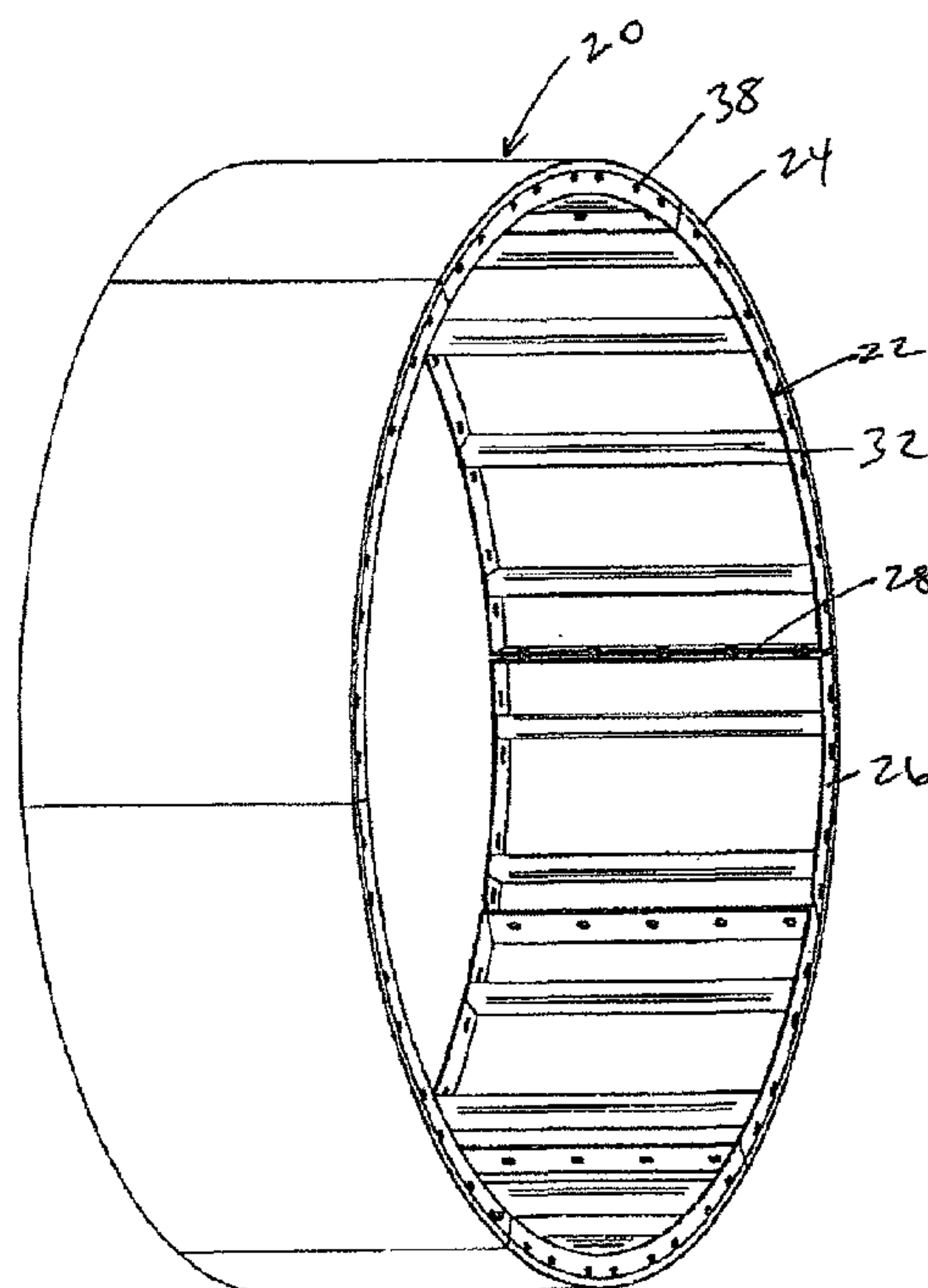
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(54) Titre : PLAQUES DE BLINDAGE EN ACIER POUR TUNNELS

(54) Title: STEEL LINERS FOR TUNNELS



(57) Abrégé/Abstract:

The present invention is directed to a steel segment assembly for lining a tunnel. The segment assembly has a frame to which is attached a steel panel, the frame and panel being a segment of a cylinder dimensioned to the desired tunnel diameter. The frame is preferably square, rectangular or trapezoidal in shape and is constructed of suitably dimensioned members having a square or rectangular cross section welded together. The frame has two curved spaced apart side members to form the long sides of the frame, the curved spaced apart side members being joined together at either end by end members to form the short sides of the frame. At least one intermediate member is provided between the two end members to bridge the two curved spaced apart side members to provide transverse structural support to the steel segment assembly.

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ABSTRACT OF THE DISCLOSURE

The present invention is directed to a steel segment assembly for lining a tunnel. The segment assembly has a frame to which is attached a steel panel, the frame and panel being a segment of a cylinder dimensioned to the desired tunnel diameter. The frame is preferably square, rectangular or trapezoidal in shape and is constructed of suitably dimensioned members having a square or rectangular cross section welded together. The frame has two curved spaced apart side members to form the long sides of the frame, the curved spaced apart side members being joined together at either end by end members to form the short sides of the frame. At least one intermediate member is provided between the two end members to bridge the two curved spaced apart side members to provide transverse structural support to the steel segment assembly.

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STEEL LINERS FOR TUNNELSFIELD OF THE INVENTION

[0001] The present invention is directed to steel liners for tunnels, and in particular to steel liners for tunnels where a tunneling machine may push off from the liners to dig the tunnel.

BACKGROUND OF THE INVENTION

[0002] In a tunneling operation, a tunneling machine, either a tunnel digging machine or a tunnel boring machine, excavates material from the face of the tunnel as it moves forward and deposits the material behind the machine where it is removed from the tunnel. As a tunnel is dug, it is necessary to provide a liner for the tunnel behind the tunneling machine. Presently, liners are either wood beams supported by steel ribs, steel panels or concrete panels. Wood beams supported by steel ribs and steel panels are generally utilized where it is not necessary to provide for a watertight tunnel. If a watertight tunnel is required, concrete panels with a suitable sealing material between the panel sections are provided to result in a watertight tunnel liner.

[0003] Steel panels are easier to install than either of the wood beams or concrete panels. Presently available steel panels for lining a tunnel are generally formed from a steel sheet which is cut and stamped to provide for a surface which is a segment of a curve which lies against the surface of the tunnel. Upstanding flanges extend from the edges of the panel to provide a surface for joining one panel to another.

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[0004] While such steel panels create an enclosure for the tunnel, there are certain disadvantages. In particular, the sealing and joining of the panels, especially at the corners, which due to the stamp forming operation, are generally not square, means that they may not be an optimal solution when a watertight tunnel is required.

[0005] The speed of a tunneling operation is directly related to the force which the tunneling machine can apply to the tunnel face to remove material. In some operations, it is desirable if the machine can push against a surface to increase the forward force at the tunnel face. With the construction of prior art steel liners, the steel panels generally do not provide a suitable surface for the machine to push against as they lack the structural integrity to support the pushing force.

[0006] There thus remains a need for a steel panel or segment for a tunnel liner which overcomes the disadvantages of the prior art.

SUMMARY OF INVENTION

[0007] The present invention is directed to a steel segment assembly for lining a tunnel. The steel segment assembly comprises a steel frame to which is attached a steel panel, the steel segment assembly being a segment of a cylinder dimensioned to the desired tunnel diameter. The frame is constructed of suitably dimensioned members having a rectangular cross section welded together with a curvature on one side of the frame to match the tunnel diameter. The frame comprises two curved spaced apart members to form the long sides of the frame, the curved spaced apart members being joined together at either end

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by end members to form the short sides of the frame. At least one intermediate member is provided between the two end members to bridge the curved spaced apart members to provide transverse structural support to the steel segment assembly.

[0008] In an aspect of the invention, the segment assembly has a square, rectangular or trapezoidal shape.

[0009] In another aspect of the invention, a plurality of intermediate members are provided between the two end members.

[0010] In another aspect of the invention, four intermediate members are provided per segment assembly

[0011] The present invention also provides for a tunnel lining comprising a plurality of steel segment assemblies arranged in rows of end to end joined individual steel segment assemblies. Each of the steel segment assemblies comprises a frame to which is attached a steel panel, the segment assembly being a segment of a cylinder dimensioned to the desired tunnel diameter. The frame is constructed of suitably dimensioned members having a rectangular cross section welded together. The frame comprises two curved spaced apart members to form the long sides of the frame, the curved spaced apart members being joined together at either end by end members to form the short sides of the frame. At least one intermediate member is provided between the two end members to bridge the two curved spaced apart members to provide transverse structural support to the steel segment assembly. A first plurality of steel segment assemblies are joined end to end to complete a cylinder comprising a row of the tunnel diameter. The individual rows are connected to one another to form the tunnel lining.

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[0012] In an aspect of the invention, each of the steel segment assemblies are provided with a plurality of intermediate members between the two end members, the intermediate members of each row being aligned to provide a continuous support so that the load of a tunnel digging machine pushing back against the tunnel lining is transferred along the length of the lining.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Preferred embodiments of the present invention are illustrated in the attached drawings, in which:

Figure 1 is a perspective view of a tunnel section utilizing the steel segment assembly of the present invention;

Figure 2 is an exploded perspective view of the tunnel section of Figure 1;

Figure 3 is an end view of the tunnel section of Figure 1;

Figure 4 is a close up view of the detail of C in figure 3 showing the junction between the two half sections of the segment assembly;

Figure 5 is a perspective view of an embodiment of a tunnel section utilizing a steel segment assembly for a change in direction of a tunnel;

Figure 6 is an exploded perspective view of the tunnel section of Figure 5;

Figure 7 is a cross section view of a tunneling machine and the tunnel liner assembly of the present invention;

Figure 8 is an end perspective view of the tunneling machine and tunnel liner assembly of Figure 7,

Figure 9 is a perspective view of an alternative embodiment of a tunnel liner section utilizing the steel segment assemblies of the present invention, and

Figure 10 is an end elevation view of the tunnel liner section

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of figure 9.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The present invention is directed to a steel segment assembly 20 for lining tunnels. As illustrated in figures 1 and 2, a plurality of individual steel segments assemblies 20, placed end to end provide for a complete circle 10 of the diameter of the tunnel. Each of the segment assemblies 20 is a segment of a cylinder. The number and size of the segment assemblies 20 is selected based upon the diameter of the tunnel. For small diameter tunnels, fewer segment assemblies 20, generally as few as 3 or 4 may be utilized, while for large diameter tunnels, 6, 8, 10 or more segment assemblies 20 are utilized. In the embodiment illustrated in the figures, 6 steel segment assemblies 20 are utilized, each of the steel segment assemblies covering about 60°, although as described in detail below, one of the 60° segments is covered by two half segments 20-1 and 20-2.

[0015] The segment assemblies 20 have a square, rectangular or trapezoidal shape, depending upon the configuration of the tunnel. For straight tunnel runs, the segment assemblies 20 will be generally square or rectangular. Where it is desired to change the direction of the tunnel, the segment assemblies 20 will be trapezoidal in shape as described further below.

[0016] Each of the steel segment assemblies 20 has a frame 22 to which is attached a steel panel skin 24. The frame 22 has parallel, curved spaced apart members 26 along the long side of the frame 22, the curved spaced apart members 26 being joined at their ends by end members 28 to form the short sides of the frame 22. The curved spaced apart members 26 and end members 28

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are formed from a suitably dimensioned material to provide structural support for the segment assembly 20. Preferably, the spaced apart members 26 and end members 28 are formed of $\frac{1}{4}$ to $\frac{1}{2}$ inch bar or plate stock cut and formed to the proper configuration for the final shape of the segment assembly 20.

[0017] The spaced apart members 26 and end members 28 are connected to one another by welds 30 which extend along the full joint between the members. These full length welds 30 leave no openings or voids and aid in making the steel segment assembly 20 useful for watertight tunneling applications as will be described below.

[0018] The frame 22 is also provided with at least one intermediate member 32 which connects the spaced apart members between the ends to provide transverse structural support to the segment assembly 20. The number and location of the intermediate members 32 are provided depending upon the structural design criteria of the overall tunnel liner. Preferably, a plurality of such intermediate members 32, more preferably four such intermediate members 32 are provided for each segment assembly 20. As illustrated in the figures, the intermediate members 32 are located in the interior of the frame 22 such that when the plurality of segment assemblies 20 are joined to form the complete circle, the spacing between the intermediate members 32 around the complete circle is on the order of 15° .

[0019] In order to provide for a suitable surface against which a tunneling machine can push, it is preferred if the intermediate members 32 are formed of a structural component such as structural metal tubing dimensioned to withstand the

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forces exerted by the tunneling machine. As illustrated in the figures, more preferably, intermediate members 32 are of a structural metal tube and the intermediate members 32 are connected to the spaced apart frame members 26 by a continuous weld 34 around the full circumference of the ends of the intermediate members 32.

[0020] The steel panel skin 24 is attached to the curved surface of the frame 22 by continuous welds 36 at the junction between the interior of the frame 22 and the steel panel skin 24. These continuous welds 36 leave no openings or voids between the steel panel skin 24 and frame 22 and aid in making the steel segment assembly 20 useful for watertight tunneling applications as will be described below.

[0021] As the frame 22 provides the structural support for the steel segment assembly 20 of the present invention, the gauge of the steel panel skin 24 may be significantly less than prior art panels. Preferably, the steel panel skin is formed from an 18 gauge steel. This makes for easier bending of the steel panel skin 24 to conform to the desired diameter of the tunnel as compared to prior art panels.

[0022] The steel segment assemblies 20 of the present invention are particularly useful for tunnels requiring a lining resistant to the ingress of fluid into the tunnel. The joints between the individual segments 20 are provided with sealing strips 40 which provide for a seal between the segments 20. Preferably, the sealing strips 40 are of a suitable compressible elastomeric material such as a suitable durometer rubber which is compressible between the edges of the panels 24 to seal against the ingress of fluid into the tunnel, as will be described

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further below.

[0023] There are circumstances when digging a tunnel where the direction of the tunnel may be required to be varied. For example, the depth of the tunnel may change depending upon the design of the tunnel. In other situations it may be necessary to vary the lateral direction of the tunnel. In these situations, the direction of the tunnel liner must also be varied. This may be accomplished by using steel segment assemblies 20A having a trapezoidal shape with varying depths as shown in figures 5 and 6.

[0024] The steel tunnel section 10A will having a tapered depth from one side to another. In the embodiment illustrated in the figures, one side of the tunnel section 10A has a depth of about 6 inches tapering to a depth of 12 inches at the other side. Other dimensions for the segment assemblies will be apparent to those of skill in the art. Through the use of a plurality of such tunnel sections 10A, the direction of the tunnel may be varied.

[0025] As illustrated in figures 5 and 6, the tunnel section 10A is comprised of a plurality of trapezoidal shaped steel segment assemblies 20A, each of the steel segment assemblies 20A having a frame 22A of curved spaced apart members 26A defining the long side of the segment assembly 20A, the curved members 26A being joined at their ends by end members 28A, the depth of the end members 28A of each of the assemblies 20A being selected to provide for the tapered steel tunnel section when the steel segment assemblies 20A are joined end to end. Similar to the embodiments described above, a plurality of intermediate members 32A are provided in each segment assembly between the two end

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members. A steel panel skin 24A is attached to the curved surface of the frame 22A by continuous welds 36 at the junction between the interior of the frame 22A and the steel panel skin 24A. To provide for increased resistance to fluid infiltration into the tunnel, the joints between the individual segments 20A are provided with sealing strips 40 which provide for a seal between the segments 20A as well as between the tunnel liner sections 10.

[0026] The installation of the steel segment assemblies to provide a tunnel lining is illustrated in Figures 7 and 8. While these Figures illustrate a tunnel digging machine 50, the present invention is also useable with tunnel boring machines. The tunnel digging machine 50 has a front end with the digging apparatus 52 to remove earth from the face of the tunnel. The material removed by the digging apparatus 52 is moved along a conveyor 54 to the rear of the tunnel digging machine 50 where it is transported out of the tunnel for disposal. An operator position 56 is provided where the operator can control the functions of the tunnel boring machine 50.

[0027] As the tunnel digging machine 50 moves forward, the steel segment assemblies 20 are installed to provide the tunnel lining. A hydraulically operated lifting apparatus 60 is provided to lift and place the steel segment assembly 20 in the proper location. The sealing strips 40 are placed in the proper position and the steel segment assembly is attached to the existing tunnel lining using suitable bolts 62 placed in the aligned openings 38 of the steel segment frame 22. Nuts 64 are placed on the bolts 62 and tightened down to sealingly connect the steel segment assembly to the tunnel lining.

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[0028] As illustrated in figures 3 and 4, in one embodiment, the last sections of the steel segment assembly to complete the cylinder of the tunnel lining are provided as two half sections 20-1 and 20-2. One of the end members of each of these sections is placed at an inclined angle, preferably about a 45° angle to allow the last of the steel segment assemblies 20-2 to be placed in position. Once the cylinder of the steel segment assemblies is complete, the next row of steel segment assemblies is installed.

[0029] As illustrated in the figures, each row of the steel segment assemblies is offset so that the end joints between adjacent rows do not line up with each other. The rows of steel segment assemblies are aligned so that the transverse intermediate members 32 align to provide a continuous support so that the load of the tunnel digging machine pushing back against the tunnel lining is transferred along the length of the lining.

[0030] While the embodiments described above utilizes half segments 20-1 and 20-2 to fill in the last part of the tunnel liner section, an alternative arrangement could utilize full segments. As illustrated in figures 9 and 10, the tunnel liner section may utilize full size steel segment assemblies 20, the total diameter of the steel segment assemblies being slightly less than the diameter of the tunnel. The gap 70 between the steel segment assemblies 20 is filled by a spacer block 72 to hold the steel segment assemblies 20 in the proper position in the tunnel. A steel plate 74 is located behind the gap between the steel segment assemblies 20 to seal the gap against the ingress of dirt. Sealing strips 40 may be provided between the steel plate 74 and the steel segment assembly 20 to reduce the ingress of fluid into the tunnel.

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[0031] The steel segment assemblies of the present invention provide for an easy to install steel tunnel lining which resists the ingress of fluid and other materials into the tunnel and allows the tunnel digging or boring machine to push against the tunnel lining to increase the digging or boring force to thereby increase the speed of the tunneling operation.

[0032] While various preferred embodiments of the present invention have been described herein in detail, it will be appreciated by those of skill in the art that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

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WE CLAIM:

1. A steel segment assembly for lining a tunnel, the segment assembly comprising a frame to which is attached a steel panel, the segment assembly being a segment of a cylinder dimensioned to the desired tunnel diameter, the frame is constructed of suitably dimensioned members having a square or rectangular cross section welded together, the frame comprises two curved spaced apart members to form the long sides of the frame, the curved spaced apart members being joined together at either end by end members to form the short sides of the frame, at least one intermediate member is provided between the two end members to bridge the two curved spaced apart members to provide transverse structural support to the steel segment assembly.
2. A steel segment assembly according to claim 1 wherein a plurality of intermediate members are provided between the two end members.
3. A steel segment assembly according to claim 2 wherein the segment assembly has a square, rectangular or trapezoidal shape.
4. A steel segment assembly according to claim 2 wherein the curved spaced apart members are parallel to one another.
5. A steel segment assembly according to claim 3 wherein four intermediate members are provided per segment assembly.
6. A tunnel lining comprising a plurality of steel segment assemblies arranged in rows of end to end joined individual steel segment assemblies, each of the steel segment assemblies comprises a frame to which is attached a steel panel, the segment assembly being a segment of a cylinder dimensioned to

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the desired tunnel diameter, the frame being constructed of suitably dimensioned members having a square or rectangular cross section welded together, the frame comprising two curved spaced apart side members to form the long sides of the frame, the curved spaced apart side members being joined together at either end by end members to form the short sides of the frame, at least one intermediate member being provided between the two end members to bridge the two side members to provide transverse structural support to the steel segment assembly, a first plurality of steel segment assemblies being joined end to end to complete a cylinder comprising a row of the tunnel diameter and the individual rows being connected to one another to form the tunnel lining.

7. A tunnel lining according to claim 6 wherein each of the steel segment assemblies are provided with a plurality of intermediate members between the two end members, the intermediate members of each row being aligned to provide a continuous support so that the load of a tunnel digging machine pushing back against the tunnel lining is transferred along the length of the lining.

8. A tunnel lining according to claim 7 wherein each of the steel segment assemblies are provided with four intermediate members.

9. A tunnel lining according to claim 7 wherein the segment assemblies have a square, rectangular or trapezoidal shape.

10. A tunnel lining according to claim 7 wherein substantially all of the segment assemblies have a square or rectangular shape.

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11. A tunnel lining according to claim 7 wherein the segment assemblies of at least one row have a trapezoidal shape to allow for a change in direction of the tunnel lining.

FIG 2

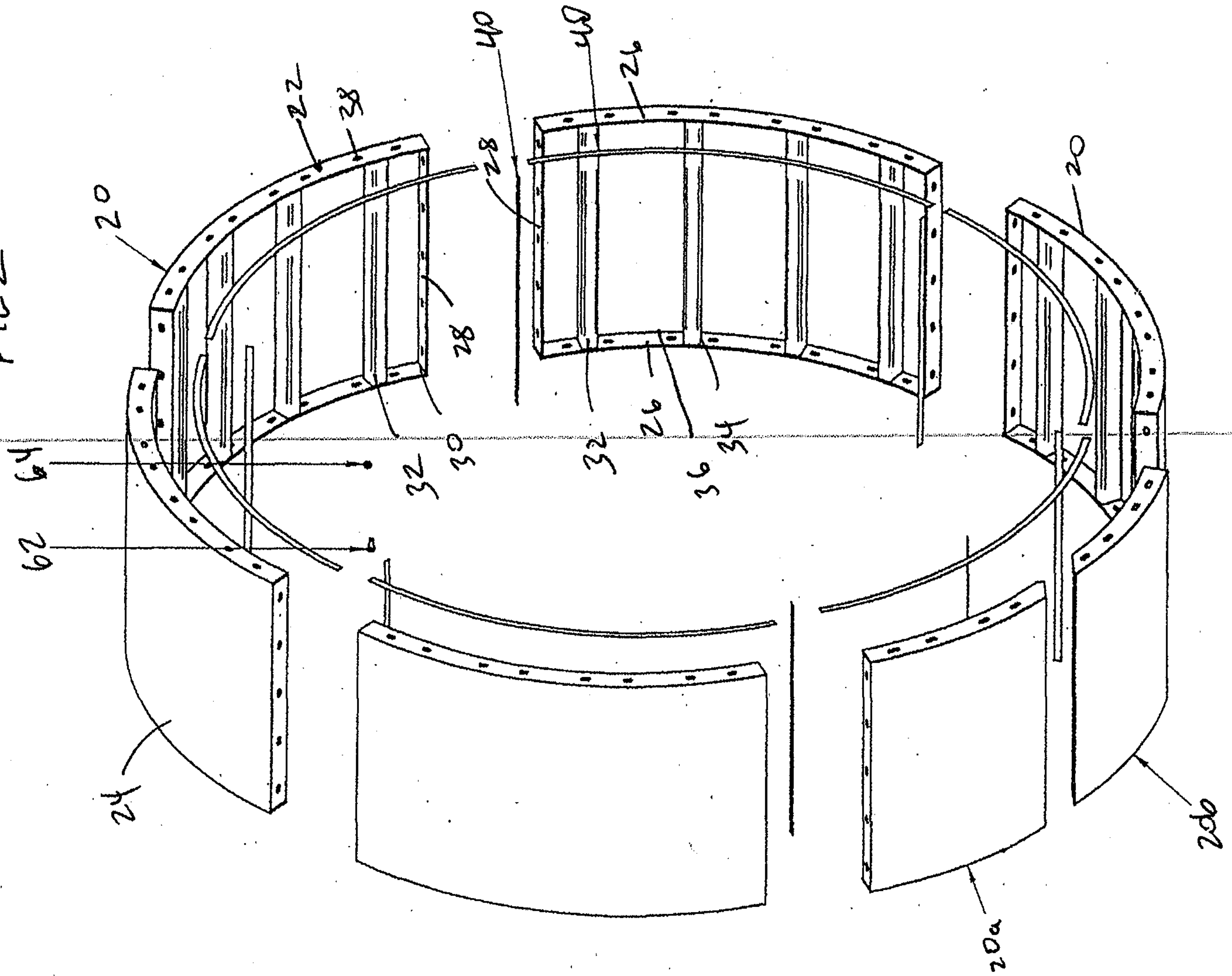


FIG 1

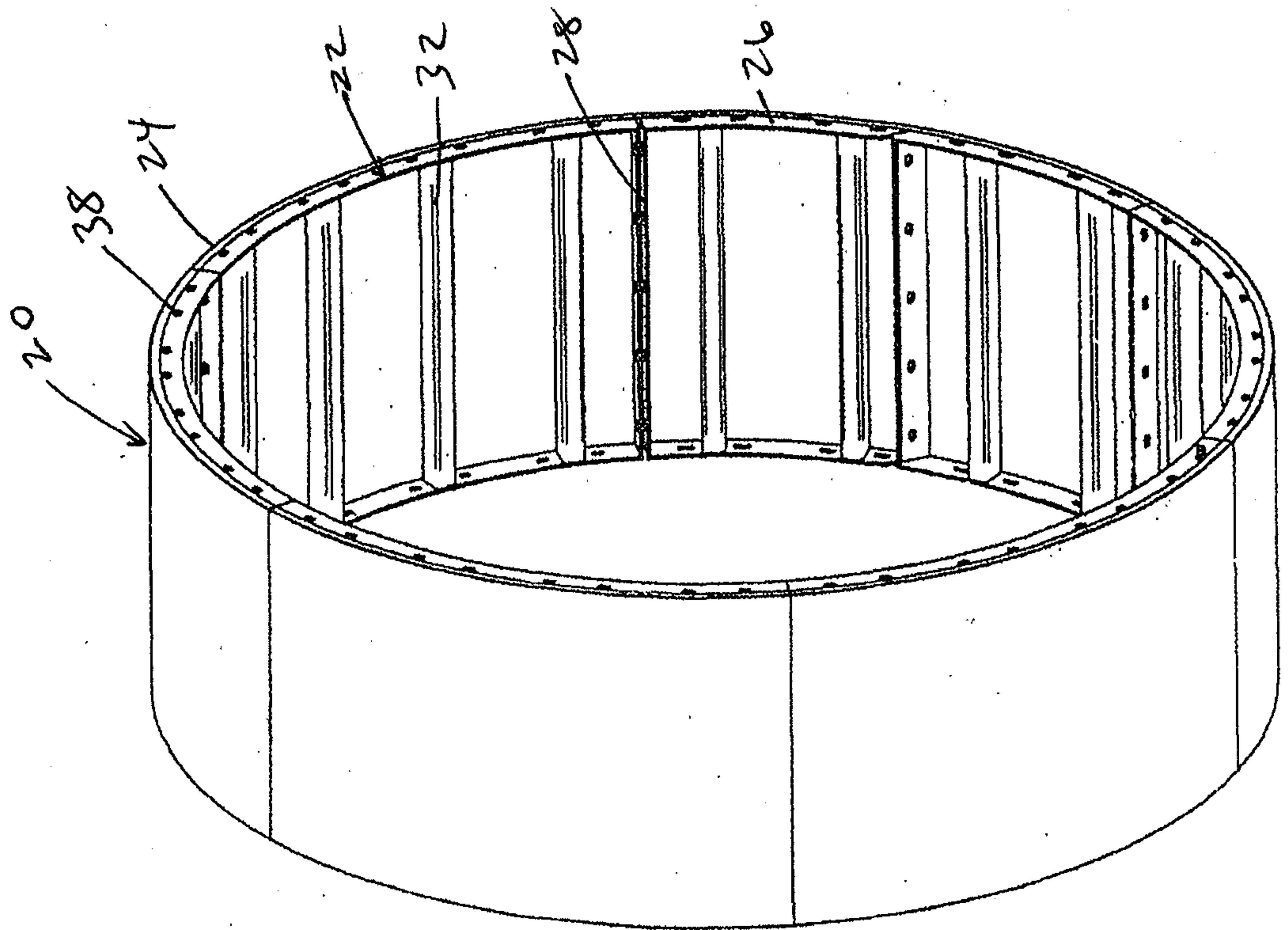


FIG 3

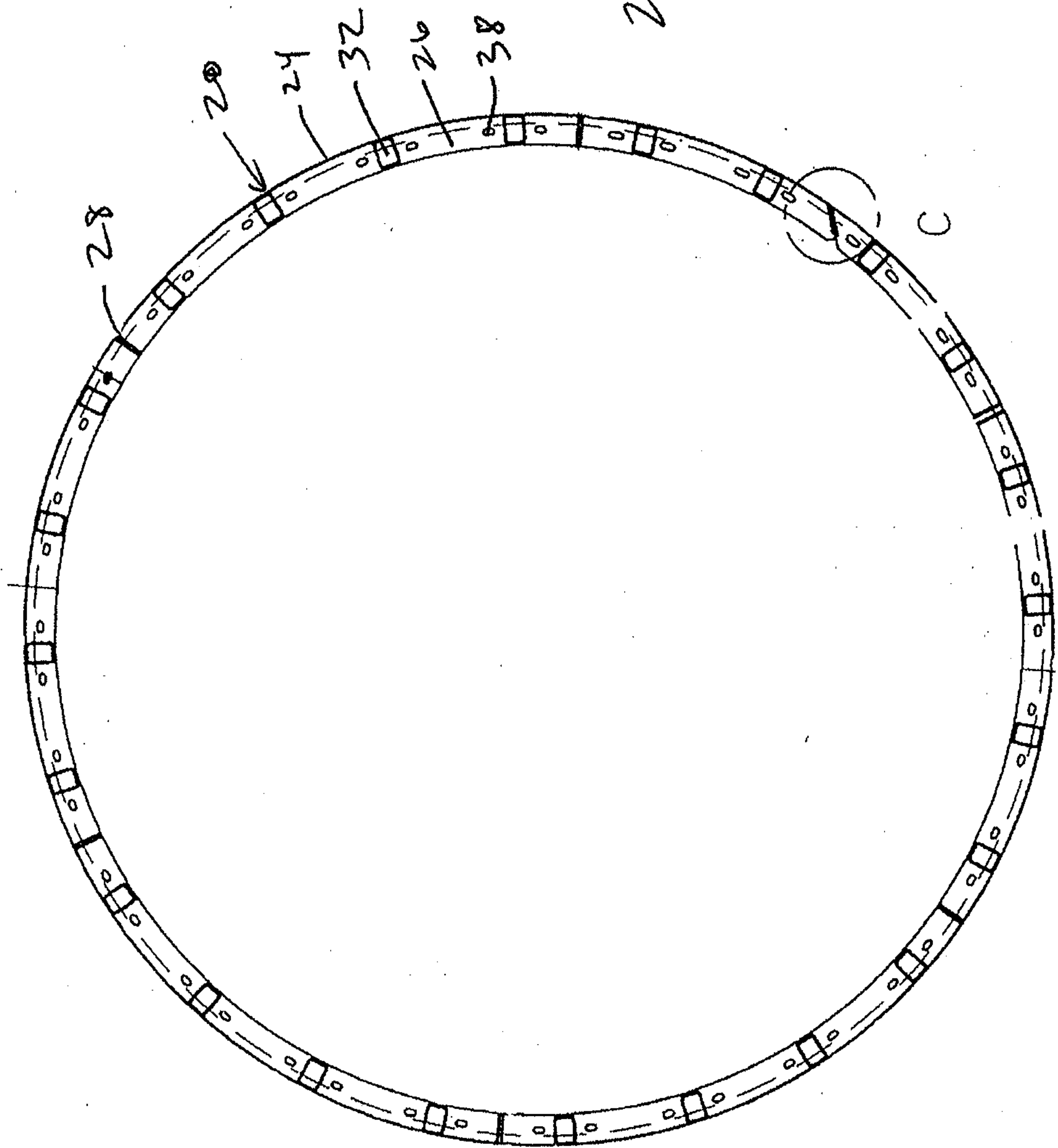


FIG 4

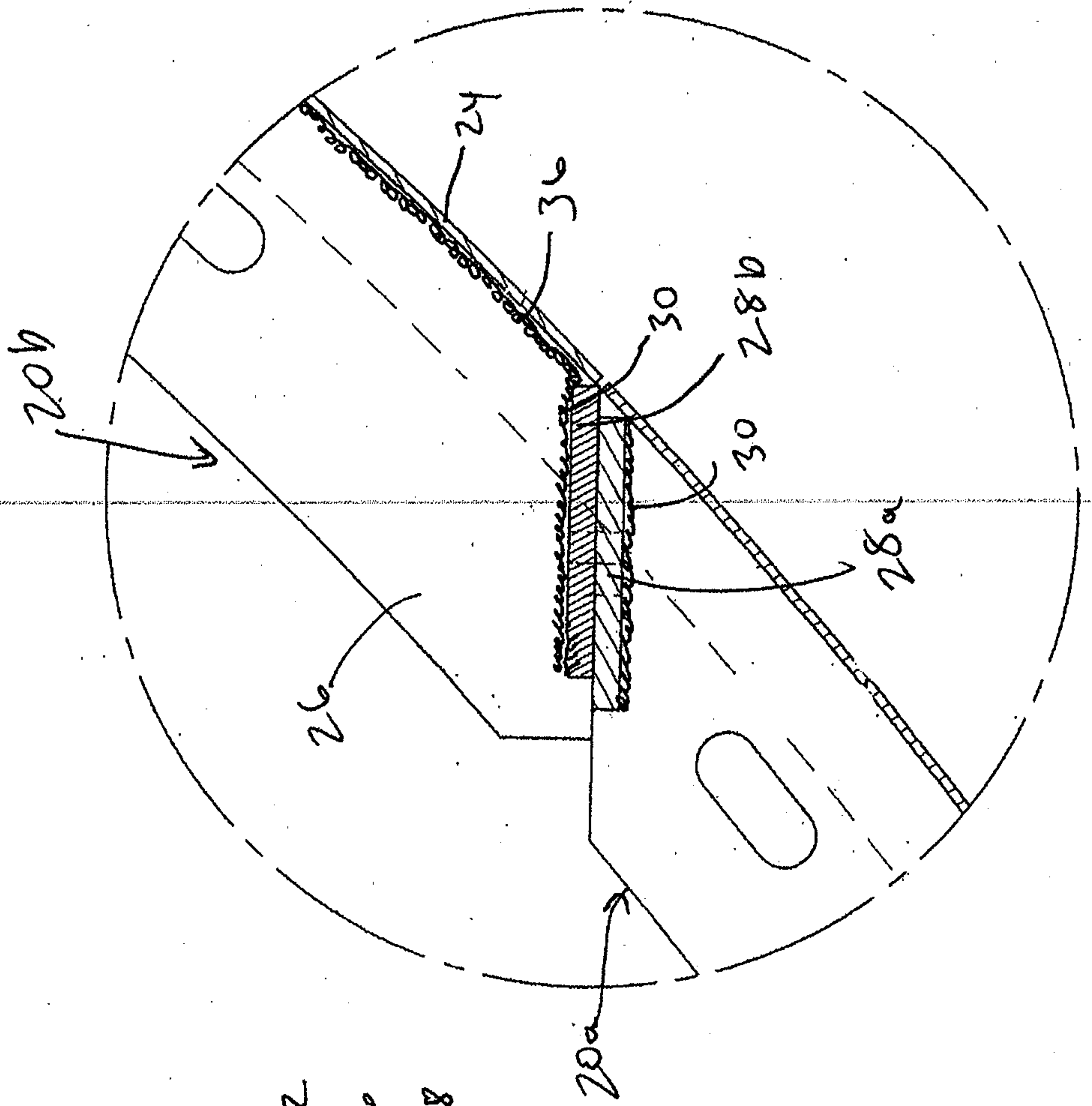


FIG 5

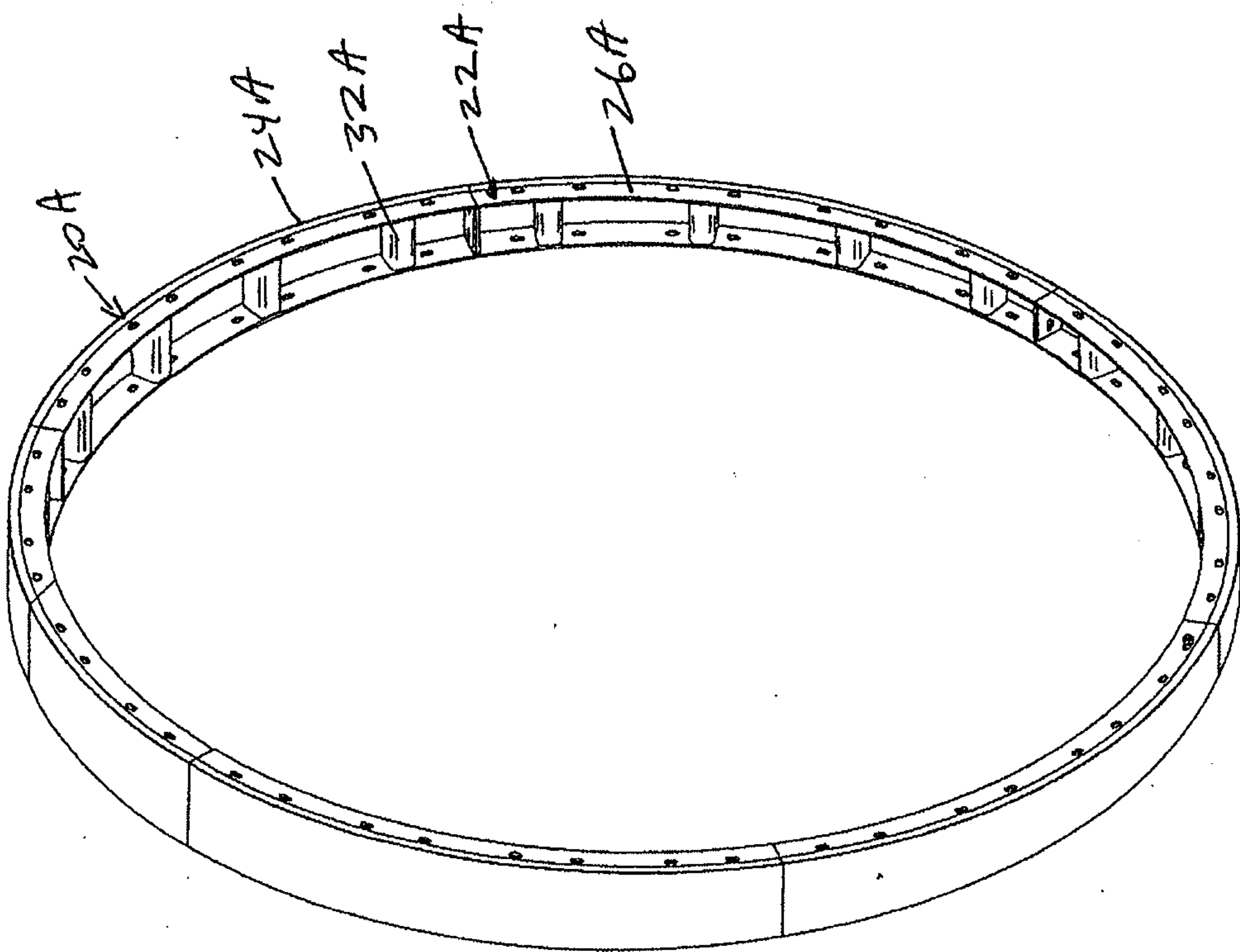


FIG 6

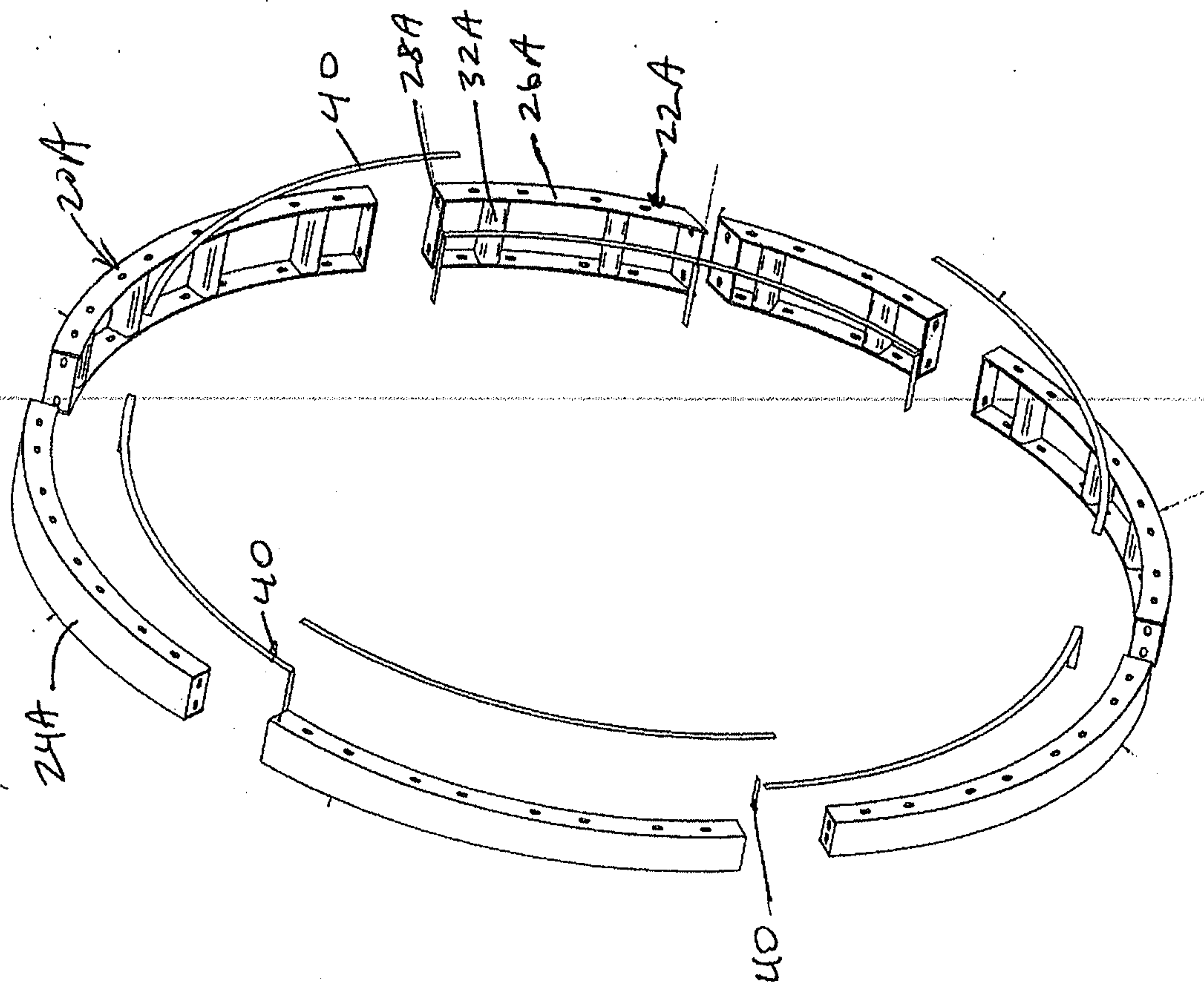
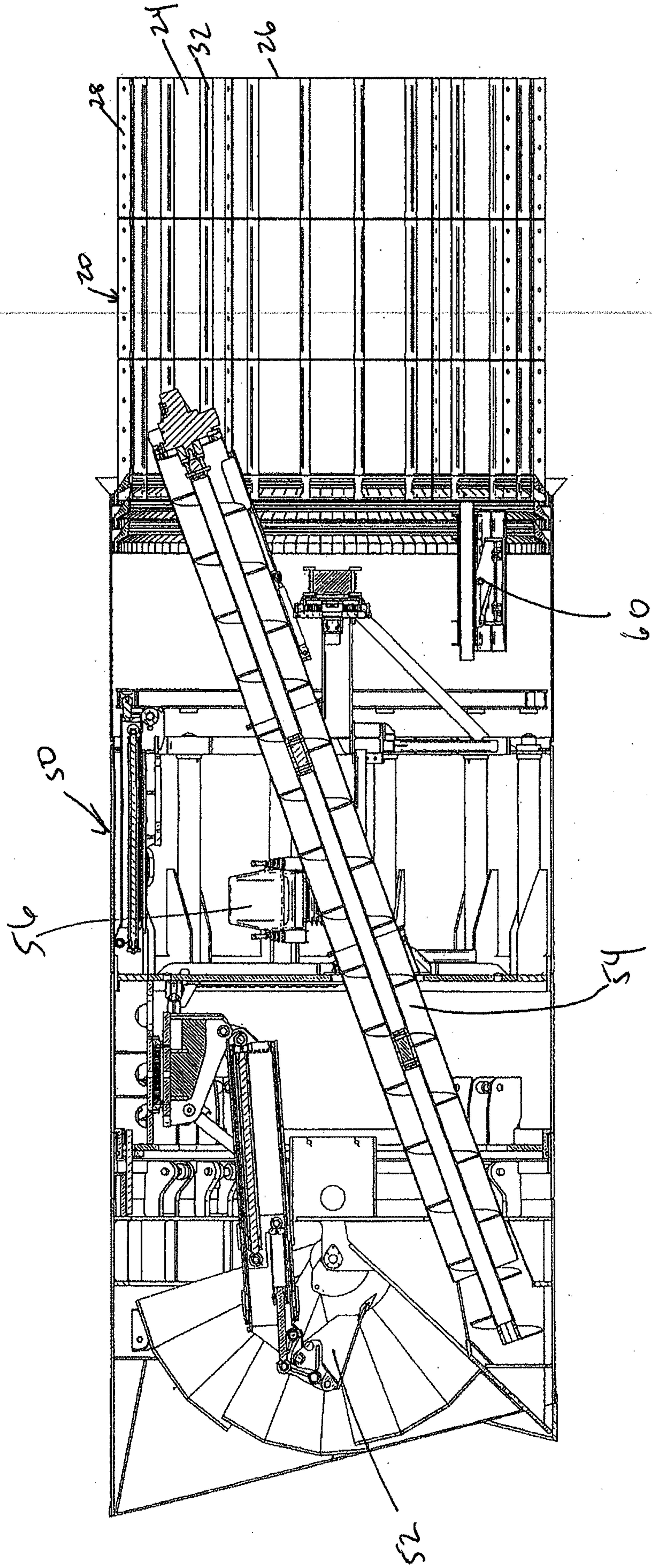
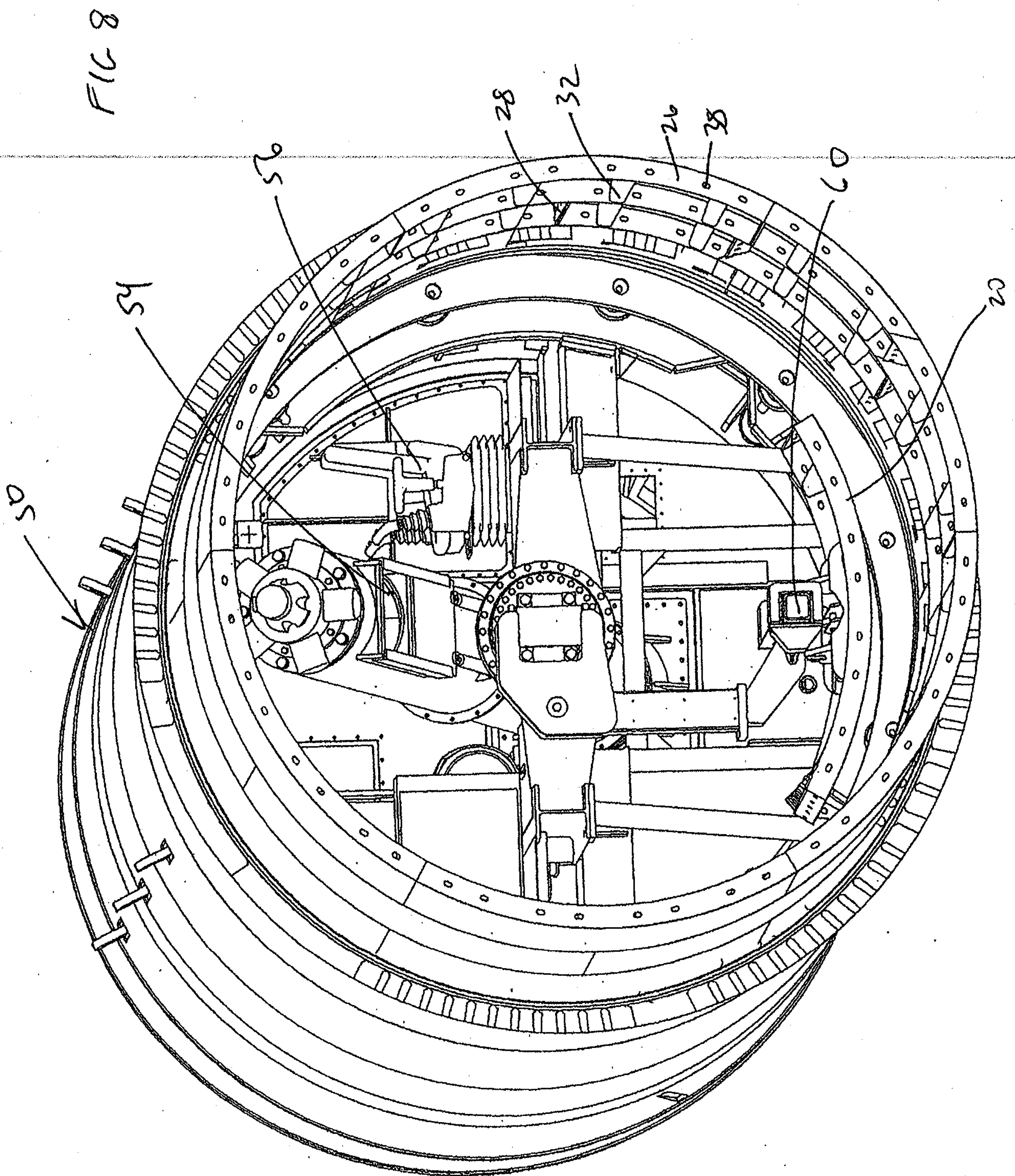


FIG-7





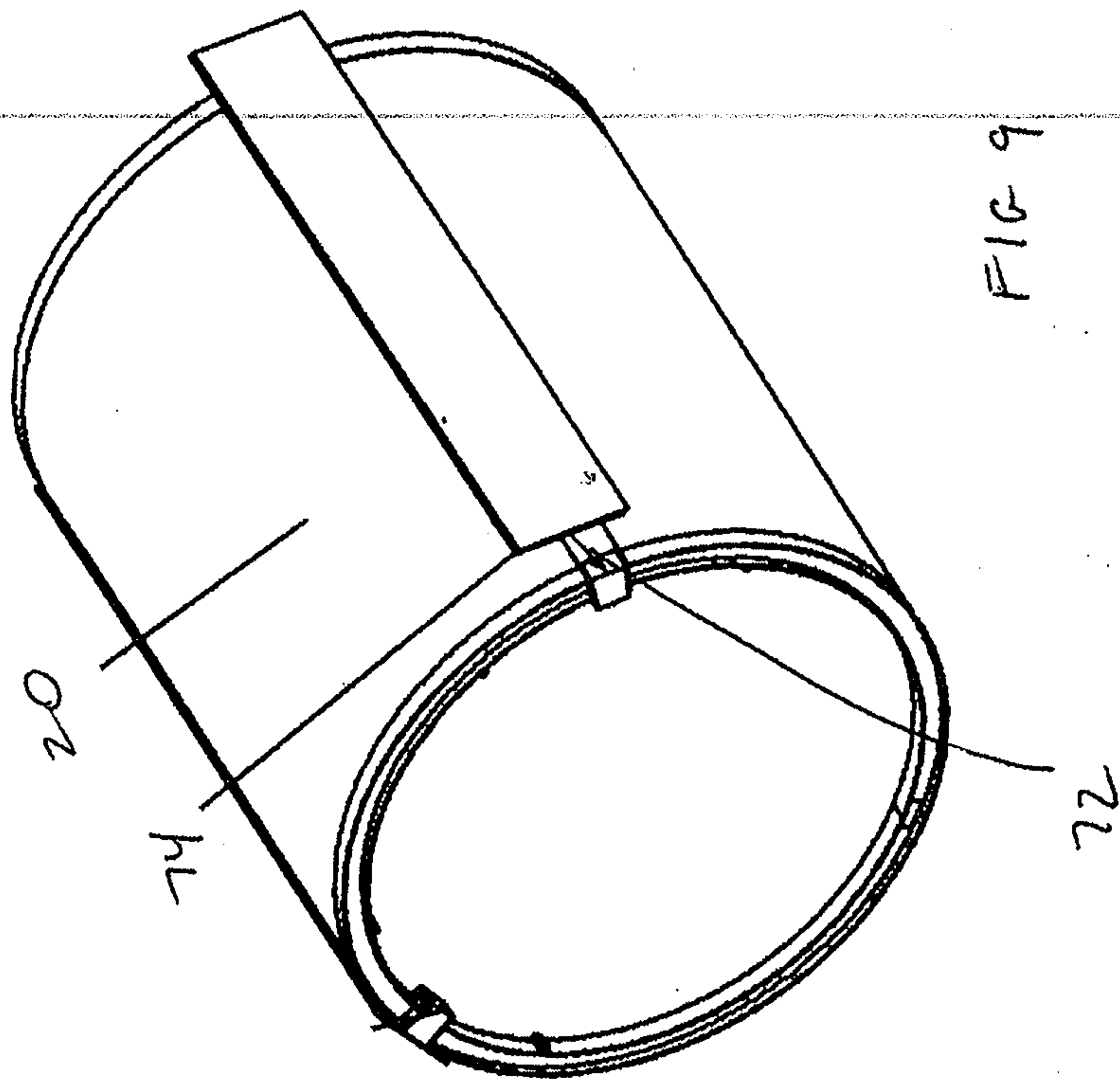


FIG 9

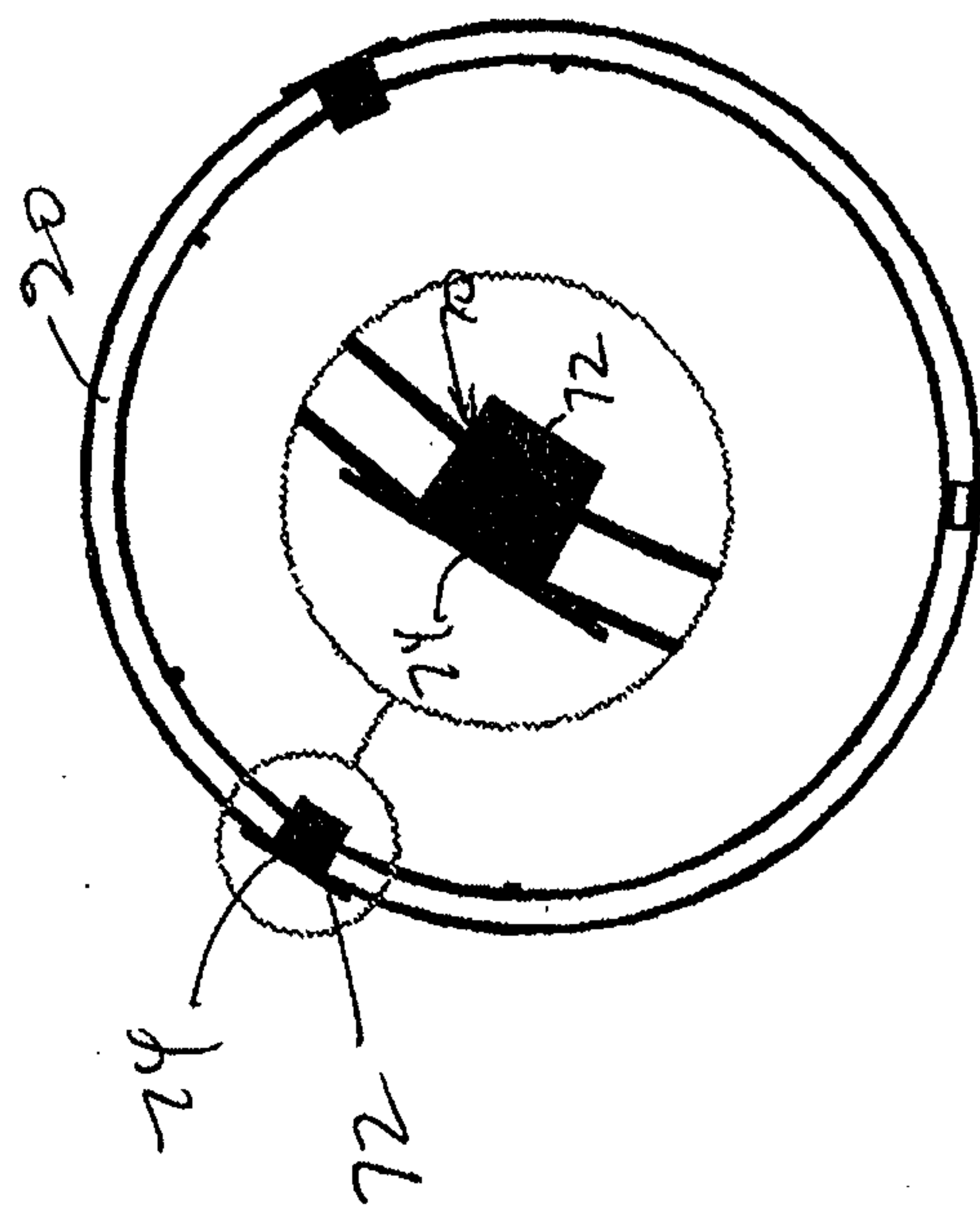


FIG 10

