



(22) Date de dépôt/Filing Date: 2005/04/13

(41) Mise à la disp. pub./Open to Public Insp.: 2006/10/13

(51) Cl.Int./Int.Cl. *G01L 7/00* (2006.01),  
*G01F 1/00* (2006.01)

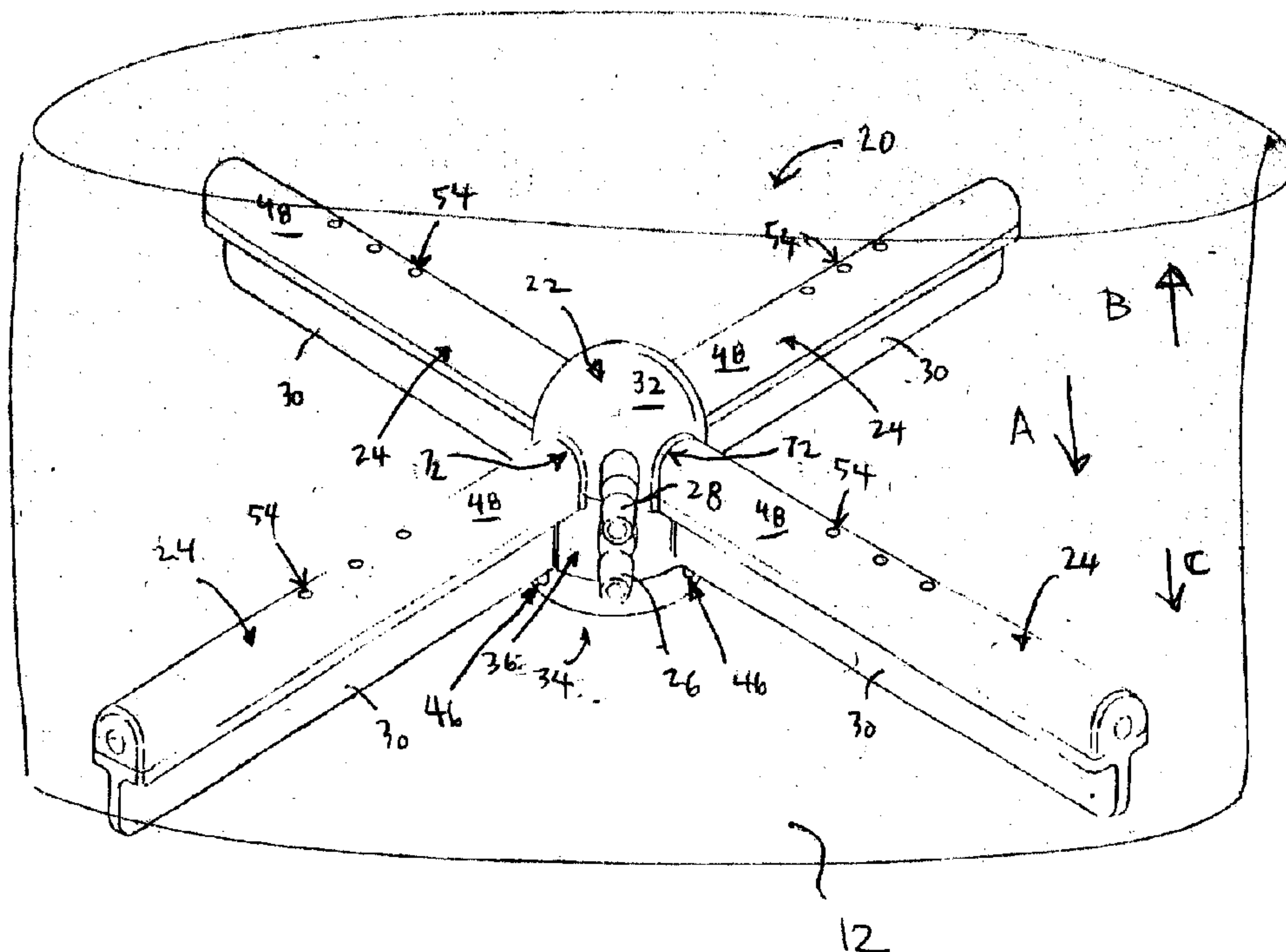
(71) Demandeur/Applicant:  
E. H. PRICE LIMITED, CA

(72) Inventeurs/Inventors:  
GRYC, BOGNA, CA;  
DYCK, ALFRED THEODOR, CA

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : DEBITMETRE D'AIR

(54) Title: AIRFLOW SENSOR



(57) Abrégé/Abstract:

An airflow sensor for use in a conduit is disclosed. The sensor comprises stacked first, second and third portions positioned, in use, in the conduit to define a hub and a plurality of tubes. The hub is centrally disposed in the conduit and has first and second interior chambers, a streamlined upstream-facing surface, a downstream-facing surface and a sidewall connecting said upstream and downstream facing surfaces, said sidewall having defined therein one or more static pressure ports through which the first chamber communicates with the conduit interior. The tubes extend radially from the hub, transverse to the flow. Each tube has: a streamlined upstream-facing surface having defined therein one or more total pressure ports; a downstream-facing surface; an interior passage communicating with the second chamber and communicating with the conduit interior through said total pressure ports. Each static pressure port is located downstream from a respective tube.



## ABSTRACT

An airflow sensor for use in a conduit is disclosed. The sensor comprises stacked first, second and third portions positioned, in use, in the conduit to define a hub and a plurality of tubes. The hub is centrally disposed in the conduit and has first and second interior chambers, a streamlined upstream-facing surface, a downstream-facing surface and a sidewall connecting said upstream and downstream facing surfaces, said sidewall having defined therein one or more static pressure ports through which the first chamber communicates with the conduit interior. The tubes extend radially from the hub, transverse to the flow. Each tube has: a streamlined upstream-facing surface having defined therein one or more total pressure ports; a downstream-facing surface; an interior passage communicating with the second chamber and communicating with the conduit interior through said total pressure ports. Each static pressure port is located downstream from a respective tube.

## **AIRFLOW SENSOR**

### **FIELD OF THE INVENTION**

**[0001]** The invention relates to devices for sensing the volumetric flow rate of a fluid in a conduit or duct, and more particularly, to multi-point, center-averaging airflow sensors used to measure the total pressure and static pressure of an air stream.

### **BACKGROUND OF THE INVENTION**

**[0002]** In variable air volume (VAV) heating, ventilation and air conditioning systems, the flow of air through a duct system is varied to provide thermal comfort and proper ventilation. Multi-point, center-averaging sensors are typically provided at the inlets of terminal boxes in VAV systems to measure the total pressure and static pressure produced by air flowing through the duct system. The difference between these two measurements, known as "differential pressure", is proportional to the flow of air through the duct system. The total and static pressure measurements, which are preferably averaged and amplified by the sensor, are transmitted to a controller which responds by increasing or decreasing the rate of air flow through the duct by opening or closing a damper located downstream from the sensor.

**[0003]** Typical examples of multi-point, center-averaging airflow sensors are disclosed in United States Patent No. 4,453,419 (Engelke) and United States Patent No. 5,481,925 (Woodbury). The sensor disclosed by Engelke comprises a number of pairs of tubes extending radially outwardly from a central hub. One tube of each pair has upstream facing holes and transmits a total pressure signal to a first chamber in the central hub, while the other tube of each pair has downstream facing holes and transmits a static pressure signal to a second

chamber in the central hub. The total pressure signals and static pressure signals are averaged and amplified in the respective chambers of the hub and are then transmitted to the controller. The Woodbury sensor is similar to that of Engelke, however the total and static pressure sensing tubes are not paired and only a single static pressure port is provided at the radially outermost end of each static pressure sensing tube.

**[0004]** Most known airflow sensors operate on a principle similar to that of a standard Pitot tube, traversing the air stream and measuring the pressure at a number of locations in the duct. Such sensors are capable of generating reasonably accurate pressure measurements when the airflow pattern through the duct is substantially symmetrical, that is, when the velocity of air flowing through the duct exhibits a parabolic distribution across the duct section, with the maximum velocity at the center of the duct and the minimum at the walls of the duct.

**[0005]** However, while symmetrical airflow conditions may exist in relatively long, straight portions of the duct system, the presence of obstructions such as elbows, transitions, flexible ducts and dampers in the duct system cause turbulence which disrupt the symmetrical airflow pattern, and can have a negative impact on the accuracy of the pressure measurements generated by the duct.

**[0006]** Another problem associated with known airflow sensors is that the sensor itself can be responsible for a certain amount of turbulence in the duct system. Sensor-generated turbulence causes a drop in pressure across the sensor, as well as noise in the duct system.

**[0007]** Yet another problem associated with known airflow sensors relates to durability. Airflow sensors are typically supplied by manufacturers as assemblies

comprising a sensor installed in either a short sheet-metal sleeve or a terminal box to be incorporated into the duct system. When such assemblies are manually moved from place to place on a job site, it is not uncommon for the assembly to be lifted and carried by grasping one of the arms of the sensor. Due to the fact that the sensor tubes are typically of small diameter, to reduce sensor surface area and minimize flow disruption, they are easily damaged by such handling, the result being that the measurements generated by the sensor may be inaccurate.

**[0008]** Advances have recently been made in the prior art towards overcoming these problems.

**[0009]** Of note in this regard is United States Patent No. 6,237,426 (Gryc et al.), issued May 29, 2001. In this patent, it is explained that, under asymmetric air flow conditions, total and static pressure measurements made close to the walls of the duct are poor indicators of the actual air flow within the duct, and are responsible for a substantial amount of sensor inaccuracy. Thus, in the sensor described in the Gryc et al. reference, the static and total pressure ports are located a sufficient distance from the walls of the duct so as to generate pressure measurements of acceptable accuracy even under asymmetric flow conditions. In this patent, it is also explained that damper back pressure results in inaccuracy in static pressure measurement. To avoid the problem of static pressure measurements being affected by damper back pressure, the static pressure ports are provided on a side surface of the sensor. Gryc et al. also make advances in terms of durability, through the use of metal braces. Further, the sensor of Gryc et al. provides for signal amplification without increasing face area, unlike Engelke and Woodbury, by experimentally-determined optimum location of total pressure ports. However, the advances represented by the Gryc et al. sensor of US 6237426 have an associated manufacturing cost, and improvement to the technology remains of interest.

## SUMMARY OF THE INVENTION

**[0010]** The present invention provides an airflow sensor capable of generating accurate pressure measurements under symmetrical and asymmetrical airflow conditions, which has strength sufficient to withstand relatively rough handling prior to installation, and which is relatively inexpensive to manufacture as compared to prior art sensors of similar utility. The airflow sensor is for use in a flow conduit having a flow direction and upstream and downstream directions defined by the flow direction, and comprises a first portion, a second portion and a third portion. The first portion, second portion and third portion are disposed in stacked relation to one another and positioned, in use, in the flow conduit to define a hub and a plurality of sensor tubes. The hub is centrally disposed in said flow conduit, and has a first interior chamber, a second interior chamber, a streamlined upstream-facing surface, a downstream-facing surface and a sidewall connecting said upstream-facing surface and said downstream-facing surface. The sidewall has defined therein one or more static pressure ports. The first interior chamber communicates with the interior of the flow conduit through said one or more static pressure ports. The plurality of sensor tubes extend radially outwardly from said hub, transverse to the flow direction. Each tube has: a streamlined upstream-facing surface having defined therein one or more total pressure ports; a downstream-facing surface; an interior passage communicating with the second interior chamber of the hub and communicating with the interior of the flow conduit through said one or more total pressure ports; and an end portion. Each of said one or more static pressure ports is located in the downstream direction relative to a respective one of the sensor tubes.

**[0011]** Advantages, features and characteristics of the present invention, as well as methods of operation and functions of the related elements of the structure, and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following detailed description with reference to the accompanying drawings, the latter being described hereinafter.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** FIG. 1. is a top perspective view of a sensor constructed according to a preferred embodiment of the present invention installed in a section of duct, the duct being shown in phantom outline, for clarity;

**[0013]** FIG. 2 is a bottom perspective view of the sensor of FIG. 1;

**[0014]** FIG. 3 is a top plan view of the sensor of FIG. 1;

**[0015]** FIG. 4 is a cross-sectional view along line 4-4 in FIG. 3;

**[0016]** FIG. 5 is a cross-sectional view along line 5-5 in FIG. 3;

**[0017]** FIG. 6 is a cross-sectional view along line 6-6 in FIG. 3;

**[0018]** FIG. 7 is a partially exploded isometric view of the sensor of FIG. 1;

**[0019]** FIG. 8 is an enlarged view of encircled structure 8 in FIG. 7, from a different vantage point;

**[0020]** FIG. 9 is an enlarged view of encircled structure 9 in FIG. 7;

---

**[0021]** FIG. 10 is a partially exploded view of encircled structure 10 in FIG. 2, from a different vantage point;

**[0022]** FIG. 11 is a perspective view of encircled structure 11 in FIG. 10, from a different vantage point.

#### DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

**[0023]** The present invention should be understood to be for use in a duct or flow conduit 12 having a flow direction A, and upstream B and downstream C directions defined by the flow direction A, as shown representatively in FIG. 1. An airflow sensor 20 constructed according to a preferred embodiment of the present invention as shown in FIG. 1 is hereinafter described in an operative position thereof. A description of the sensor 20 in use follows, which is thereafter followed by a detailed discussion of the construction of the sensor 20.

**[0024]** With general reference to FIG. 1, FIG. 2 and FIG. 3, the airflow sensor 20 has: a hub 22, a plurality of sensor tubes 24, preferably, four sensor tubes 24, extending radially outwardly from said hub 22, angularly spaced about 90° from one other; a first fitting 26; a second fitting 28; and a plurality of reinforcing blades 30, preferably, four reinforcing blades 30. The hub 22 is centrally disposed in the flow conduit 12 and has an upstream-facing surface 32 (presenting in a direction B opposite to the flow direction A), a downstream-facing surface 34 (presenting in a direction C parallel to the flow direction A) and a sidewall 36.

**[0025]** As best seen in FIG. 6, the hub 22 defines a first interior chamber 38, a second interior chamber 40, a first gas channel 42 and a second gas channel 44. As shown in FIG. 1 and FIG. 2, the upstream-facing surface 32 is streamlined, preferably rounded. The downstream-facing surface 34 is generally

flat and is preferably orientated normal to the flow direction A. The sidewall 36 connects the upstream-facing surface 32 and the downstream-facing surface 34; is cylindrical, and axially aligned with the flow direction A, with a preferred diameter of about 1.1 inches; and has defined therein one or more static pressure ports 46, preferably four static pressure ports 46, angularly spaced from one another by about 90°. The static pressure ports 46 are U-shaped in cross-section and have a preferred width of about 0.09 inches. As best seen in FIGS. 5,6, the first interior chamber 38 communicates with the flow conduit interior through the static pressure ports 46. The first gas channel 42 extends outwardly from the first interior chamber 38 and has a preferred diameter of about 0.1 inches, and the second gas channel 44 extends outwardly from the second interior chamber 40 and has a preferred diameter of about 0.1 inches.

**[0026]** With general reference to FIG.1 – FIG. 4, the sensor tubes 24 extend transverse to the flow direction A, that is, across the direction of flow. Tubes 24 extend from the hub 22 to the flow conduit 12 and are angularly spaced about the hub 22. Each tube 24 has an upstream-facing surface 48, a downstream-facing surface 50 and an interior passage 52. The upstream-facing surface 48 is streamlined, preferably rounded, and has defined therein one or more total pressure ports 54, preferably three total pressure ports 54, described fully in the following paragraph. The downstream-facing surface 50 is substantially flat, and orientated normal to the flow direction A. The preferred width of each tube 24 is about 0.35 to 0.40 inches, more preferably about 0.375 inches, measured across its flat downstream surface 50 in the transverse direction; the preferred thickness of each tube 24 is about 0.35 to 0.40 inches, more preferably about 0.39 inches measured in the flow direction A. As shown in FIG. 4, the interior cross-section of each tube 24 is substantially semi-circular, with a preferred diameter of about 0.25 inches, the minimum thickness of the walls of the tubes 24 preferably being about 0.04 inches. Each sensor tube 24 has an outermost

end portion 56 having a bore 58 formed therein. The bore 58 preferably has a diameter of about .1 inches and a depth of about 0.5 inches.

**[0027]** The three total pressure ports 54 are provided angularly aligned along the center of the upstream facing surface 48 of the tube 24, the diameter of the total pressure ports 54 preferably being about 0.06 inches. The total pressure ports 54 are arranged on each tube 24 in an evenly spaced arrangement. The spacing between adjacent ports 54 is preferably about 10% of the tube length. The radial distance between the radially outermost total pressure port 54 and the duct 12, expressed in relative terms, is preferably about 30-35% of the length of the tube 24.

**[0028]** As best seen in FIG. 6, the first fitting 26, which is shown as a barbed fitting, communicates with the first gas channel 42.

**[0029]** The second fitting 28, which is also shown as a barbed fitting, communicates with the second gas channel 44, and is disposed such that the first fitting 26 is downstream from the second fitting 26. It will be appreciated that the fittings 18 and 20 are not necessarily barbed and may be of any desired configuration suitable for attachment to conduits (not shown) such as flexible tubing.

**[0030]** The plurality of reinforcing blades 30 are provided one for each sensor tube 24, each blade 30 being associated with the sensor tube 24 for which it is provided, extending along and downstream from said tube 24 and having a preferred thickness, measured in the transverse direction, of about 0.1 inches. The blades 30 extend radially along the center of each tube 24 and extend downstream such that each static pressure port 46 is located downstream from a tube 24, as evident in FIG. 1.

**[0031]** In use, air flowing into the total pressure ports 54 of the sensor tubes 24 creates high pressure signals which are approximately equal to the static pressure of the air plus the velocity pressure. The high pressure signals are transmitted through the interior passages 52 of the sensor tubes 24 to the second interior chamber 40 in hub 22. Since tubes 24 are spaced within the duct 12 and the total pressure ports 54 are spaced along the tubes 24, the sensor 20 detects total pressure at various areas of the duct 12. These pressure signals created in the tubes 24 are resolved into an average high pressure signal in second interior chamber 40 and transmitted through the second gas channel 44 to the second fitting 28. Similarly, the static pressure signals from the static pressure ports 46, which are relatively noise-free, having been shielded by blades 30, are resolved into an average static pressure signal in first interior chamber 38 and transmitted through the first gas channel 42 to the first fitting 26.

**[0032]** From the above, it will be evident that the present invention has substantial usefulness. The sensor 20 can be mounted in a duct system upstream of a damper which is pivotable within the duct to reduce or increase flow of air through the duct system, and flexible tubes can be connected to the first fitting 26 and second fitting 28, to pass outwardly through a hole or holes provided in the duct to the high and low pressure ports of a controller, which can control the operation of a damper in a known manner. Examples of suitable dampers and controllers are discussed and shown in the above-mentioned Engelke and Woodbury patents, which are incorporated herein by reference. The mounting of the sensor can conveniently be effected through the use of self-tapping screws, which extend through the duct into the bores 58 provided in the end portions 56 of the sensor tubes 24.

**[0033]** Turning now the details of construction, it will be evident to persons of ordinary skill in the art that the sensor 20 shown is of a three piece construction,

comprising a first portion 60, a second portion 62 and a third portion 64, best indicated in FIG. 6.

**[0034]** As well indicated in FIG. 7, the first portion 60 has a central part 66; a plurality of arm parts 68 extending from the central part 66 and provided one for each tube 24 and forming part thereof; and the second fitting 28. The central part 66 is in the form of a bowl 66 having a rim 70 provided with a number of notches 72, which bowl defines the upstream-facing surface 32 of the hub 22 and a concave chamber-forming surface 74. The rim 70 of the bowl 66 has a keyway 76. Central part 66 also defines the second gas channel 44, as indicated in FIG. 8. With reference to FIG. 7, each arm part 68 extends from a respective notch 72 in the bowl 66, and has an end portion 56 that corresponds with the end portion 56 of the tube 24 of which said each arm part 68 forms part. Exclusive of its end portion 56, each arm part 68 has a C-shaped cross-section, such that said each arm part 68 defines an elongate trough 78. The outer convex surface of the arm part 68 defines the upstream-facing surface 48 of the sensor tube 24 of which said arm part 68 forms part. The arm part 78 also has an inner concave surface 80. The arm part 68 also defines the total pressure ports 54 of said sensor tube 24. The first portion 60 is molded in one piece out of a rigid polymer such as acrylonitrile-butadiene-styrene (ABS) or polyvinyl chloride (PVC).

**[0035]** As indicated in FIG. 7, the second portion 62 has a central part 82; a plurality of arm parts 84 extending from the central part 82 and provided one for each art part and forming part thereof; and the first fitting 26.

**[0036]** With reference to FIGS. 7,9,10 the central part 82 is in the form of a canister including a tubular outer wall portion 86 and a circular end wall portion 88.

The tubular outer wall portion 86 has a first end 90 and a second end 92 and defines exteriorly part of the sidewall 36 of the hub 22. The second end 92 terminates in a rim 93. The end wall portion 88 occludes the first end 90 of the outer wall portion 86. The central part 82 of the second portion 62 has a boss 94 projecting from and along the rim 93, the boss 94 having formed therein interruptions 96 and also having a radially-outwardly projecting ridge 98. The rim 93 of the canister 82 has a first key 100, and a second key 102 is provided on the end wall portion 88 of the canister 82.

**[0037]** Each arm part 84 of the second portion has a substantially planar portion 103, a flange portion, a pair of radial detents 108 and a transverse detent 110. The planar portion 103 has a first face which defines the downstream-facing surface 50 of the tube 24 of which said each arm part 84 forms part and a second, opposite face 104. The flange portion extends from the first face and defines the reinforcing blade 30 for the sensor tube 24 of which said each arm part 84 forms part. The radial detents 108 are elongate, project from the second face 104 of the planar portion 103 of said each arm portion 84, and are aligned so as to extend, in parallel relation to one another, radially-outwardly relative to the central part 82 of the second portion 62. The transverse detent 110 is elongate, projects from the second face 104 of the planar portion 103 of said each arm part 84 in the same direction as the radial detents 108; is aligned so as to extend in transverse relation to the radial detents 108; and is disposed adjacent to and radially outwardly from the radial detents 108. The second portion 62 is molded in a single piece out of ABS or PVC.

**[0038]** With reference to FIG. 11, the third portion 64 includes a circular plate portion 112 and an annular skirt 114 extending from and around the periphery of the circular plate portion 112. The circular plate portion 112 is provided with an interior annular ridge 122. The skirt is provided with a keyway 116, circumferentially-spaced notches 118 and an interior, radially-inwardly facing

annular groove 120. The third portion 64 is molded in a single piece out of ABS or PVC.

**[0039]** In use, the first portion 60, the second portion 62 and the third portion 64 are disposed in stacked relation to one another and sealed to one another in a conventional manner, such as by adhesive.

**[0040]** The interrelation of the first portion 60 and second portion 62 in use is as follows.

**[0041]** As best seen in FIG. 5, the end wall 88 of the canister 82 is seated in sealing contact against the rim 70 of the bowl 66, such that the chamber forming surface 74 and the end wall portion 88 define the second interior chamber 40. As indicated best in FIG. 2, the key 102 is seated in the keyway 76, to restrain the first 60 and second 62 portions against rotation. In each sensor tube 24, the arm part 68 of the first portion 60 and the arm part 84 of the second portion 62 are in sealing contact with and associated with one another such that the second face 104 of the planar portion 103 and the inner concave surface 80 define the interior passage 52 of said tube 24. Each arm part 84 of the second portion 62 has its radial detents 108 disposed in and frictionally-engaging opposite sides of the trough 78 of the arm part 68 of the first portion 60 associated therewith, as shown in FIG.4. Similarly, each arm part 84 of the second portion 62 has its transverse detent 110 disposed in and frictionally-engaging the end portion 56 of the arm part 68 of the first portion 60 associated therewith, as shown in FIG. 5 and FIG. 6.

**[0042]** The interrelation of the second portion 62 and third portion 64 in use is clearly seen in FIG.4, FIG.5 and FIG. 6. In use, the skirt 114 is disposed in overlapping relation with the boss 94, such that the plate 112 occludes the second end 92 of the outer wall portion 86, to define the first interior chamber

38. The ridge 98 on the boss 94 is engaged in the groove 120 of the skirt 114, to provide for mechanical engagement between the portions 62,64. The key 100 of the rim 93 is seated in the keyway 116 in the skirt 114 of the third portion 64, to fix the orientation of the second portion 62 and third portion 64 to one another, such that the interruptions 96 in the boss 94 are aligned with the notches 118 in the skirt 114, thereby to define the static pressure ports 46.

**[0043]** Although the invention has been described in relation to a single preferred embodiment, it is to be understood that modifications can readily be made thereto. For example, although the duct shown in the drawings has a circular cross-section, it will be appreciated that the sensor can readily be employed in ducts having other cross-sections, such as rectangular. Further, whereas various dimensions have been indicated in the disclosure, modification to such dimensions can be readily made, although it is usually preferable to minimize the area of the sensor, particularly when viewed in the direction of the flow axis, to minimize flow disruption. It is noted that the inventors have found that hubs of substantially smaller diameters may not achieve proper averaging. As a further modification, whereas four sensor tubes are shown, in larger ducts, it may be advantageous to employ additional sensor tubes. Also, whereas the sensor tubes are indicated to extend transverse to the flow, such extension may not occur at perfect right angles to the flow. Routine modifications can also be made in terms of the quantity and placement of ports; United States Patent No. 6,237,426 is incorporated herein by reference. Further, whereas the first portion, second portion and third portion are described herein as being made molded in a single operation, this is not necessary. The gas channels and bores, for example, could be bored rather than molded, and the fittings could be separate molded parts secured to the bowl and canister, respectively, in a conventional manner. Yet further, whereas the disclosure teaches the use of ABS and PVC plastics for the first, second and third portions, it should be understood that other rigid, high-impact plastic materials could easily be

---

substituted therefor. In view of all the foregoing, the invention should be understood as being limited only by the appended claims, purposively construed.

**CLAIMS**

1. An airflow sensor for use in a flow conduit having a flow direction and upstream and downstream directions defined by the flow direction, the airflow sensor comprising a first portion, a second portion and a third portion disposed in stacked relation upon one another and positioned, in use, in the flow conduit to define:

a hub centrally disposed in said flow conduit, said hub having a first interior chamber, a second interior chamber, a streamlined upstream-facing surface, a downstream-facing surface and a sidewall connecting said upstream-facing surface and said downstream-facing surface, said sidewall having defined therein one or more static pressure ports, the first interior chamber communicating with the interior of the flow conduit through said one or more static pressure ports; and

a plurality of sensor tubes extending radially outwardly from said hub, transverse to the flow direction, each tube having: a streamlined upstream-facing surface having defined therein one or more total pressure ports; a downstream-facing surface; an interior passage communicating with the second interior chamber of the hub and communicating with the interior of the flow conduit through said one or more total pressure ports; and an end portion,

wherein each of said one or more static pressure ports is located in the downstream direction relative to a respective one of the sensor tubes.

2. The airflow sensor of claim 1, further comprising a plurality of reinforcing blades provided one for each sensor tube, each reinforcing blade extending along and downstream from the sensor tube for which it is provided and having a thickness less than a width of said sensor tube, wherein each of said one or more static pressure ports is located in the downstream direction relative to a respective one of the reinforcing blades.
  3. The airflow sensor of claim 1, wherein a static pressure port is defined for each sensor tube.
  4. The airflow sensor of claim 1, further comprising a first fitting and a second fitting and further defining a first gas channel providing for communication between the first interior chamber of the hub and the first fitting and a second gas channel providing for communication between the second interior chamber of the hub and the second fitting.
  5. The airflow sensor of claim 2, wherein the second portion defines the reinforcing blades and the downstream-facing surface of each sensor tube.
  6. The airflow sensor of claim 1, wherein the third portion defines the downstream-facing surface of the hub.
  7. The airflow sensor of claim 1, wherein the first portion and the second portion together define the second interior chamber.
  8. The airflow sensor of claim 1, wherein the second portion and the third portion together define the first interior chamber.
-

9. The airflow sensor of claim 4, wherein the first portion defines the second fitting and the second gas channel.
  10. The airflow sensor of claim 4, wherein the second portion defines the first fitting and the first gas channel.
  11. The airflow sensor of claim 2, wherein each of the first portion and second portion includes: a central part; and a plurality of arm parts extending from the central part, the arm parts being provided one for each tube and forming part thereof.
  12. The airflow sensor of claim 11, wherein the central part of the first portion, the central part of the second portion and the third portion together define the hub.
  13. The airflow sensor of claim 11, wherein each arm part of the first portion has an end portion that defines the end portion of the tube of which said each arm part forms part, and wherein, exclusive of its end portion, said each arm part has a C-shaped cross-section, such that said each arm part defines an elongate trough, an outer convex surface of the arm part defining the upstream-facing surface of said tube.
  14. The airflow sensor of claim 13, wherein each arm part of the second portion has:  
  
a substantially planar portion having: a first face which defines the downstream-facing surface of the sensor tube of which said each arm part forms part; and an opposite, second face which defines, in combination with a concave inner surface of the arm part of the first portion which
-

forms part of said sensor tube, the interior passage of said each sensor tube; and

a flange portion extending from the first face which defines the reinforcing blade for said sensor tube.

15. The airflow sensor of claim 14, wherein

each arm part of the second portion has a pair of elongate radial detents which project from the second face of the planar portion of said each arm portion, the radial detents being aligned so as to extend, in parallel relation to one another, radially-outwardly from the central part of the second portion; and

in each sensor tube, the radial detents of the arm part of the second portion forming part of said each sensor tube are disposed in and frictionally-engage opposite sides of the trough of the arm part of the first portion which forms part of said each tube.

16. The airflow sensor of claim 14, wherein

each arm part of the second portion has a transverse detent which is elongate, projects from the second face of the planar portion of said each arm portion in the same direction as the radial detents; is aligned so as to extend in transverse relation to the radial detents; and is disposed adjacent to and radially outwardly from the radial detents; and

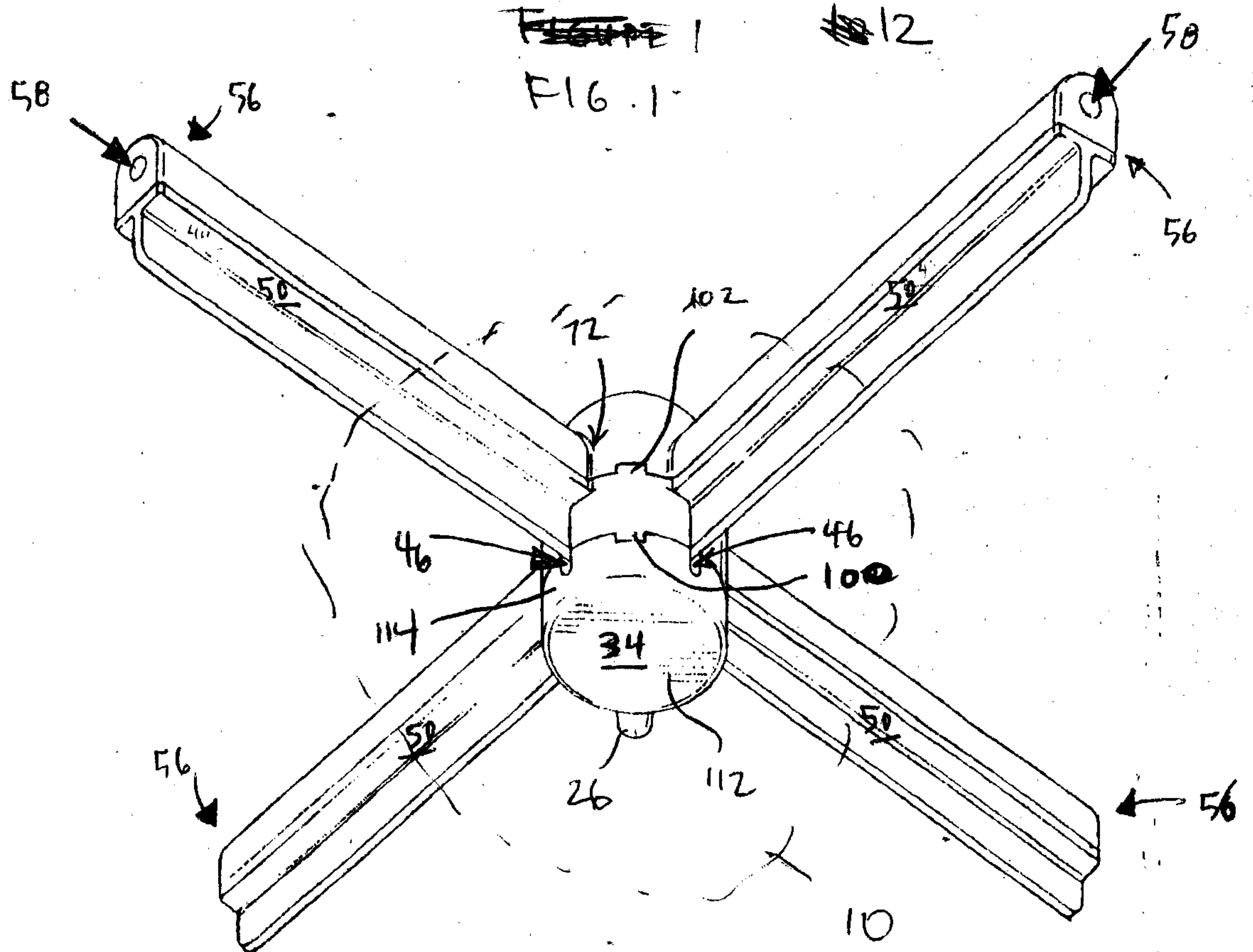
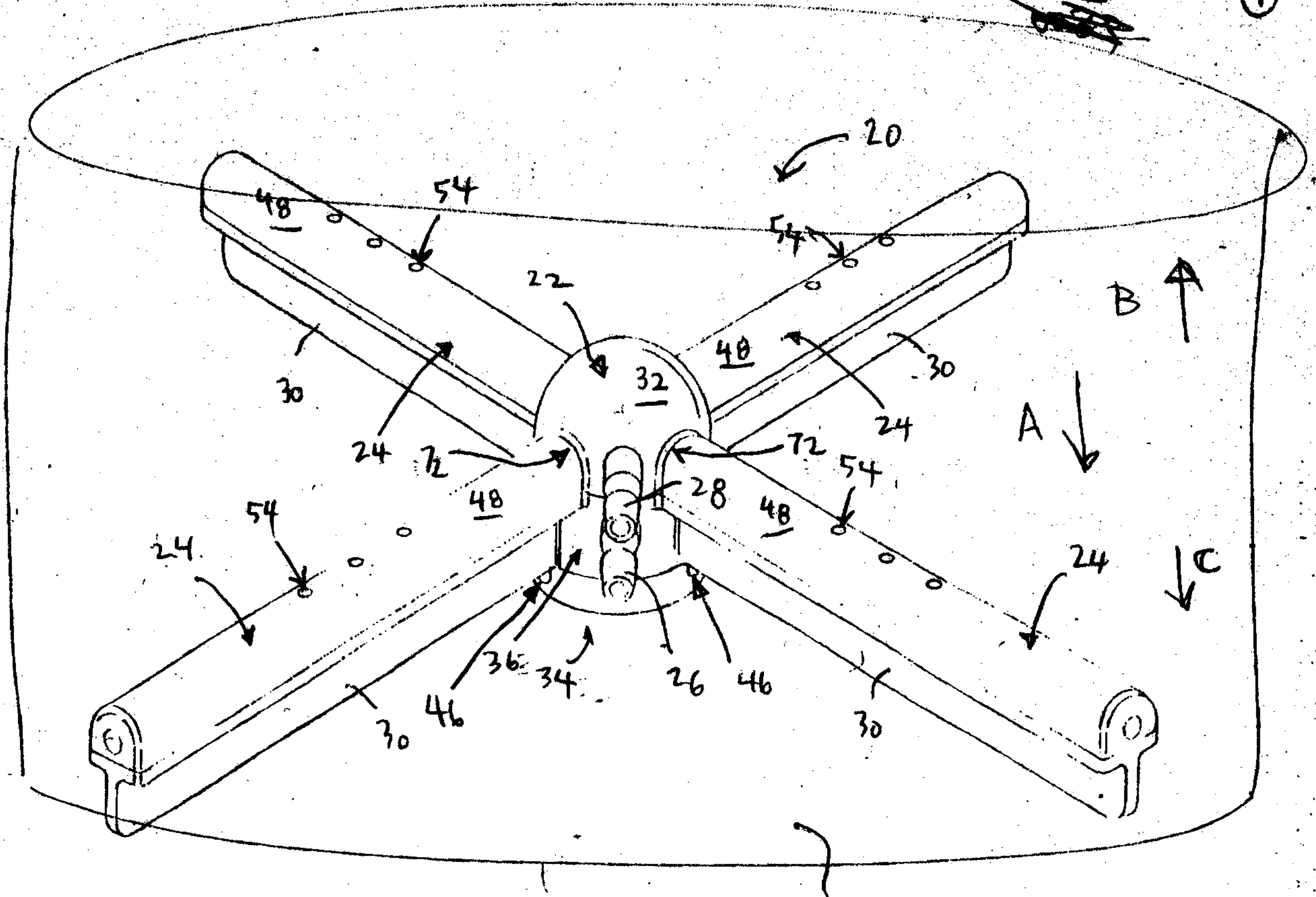
in each sensor tube, the transverse detent of the arm part of the second portion forming part of said each sensor tube is disposed in and

frictionally-engages the end portion of the arm part of the first portion which forms part of said each tube.

17. The airflow sensor of claim 1, wherein the central part of the second portion includes a tubular outer wall portion and a circular end wall portion, the tubular outer wall portion having a first end and a second end and defining exteriorly part of the sidewall of the sensor, the second end terminating in a rim, and the end wall portion occluding the first end of the outer wall portion and defining, in combination with the first portion, the second interior chamber.
18. The airflow sensor of claim 17, wherein the third portion includes a circular plate portion occluding the second end of the outer wall portion, thereby to define the first interior chamber.
19. The airflow sensor of claim 18, wherein the central part of the second portion has a boss projecting from and along the rim, and wherein the third portion includes an annular skirt extending from and around the periphery of the circular plate, in overlapping, mechanically-engaging relation, with the boss.
20. The airflow sensor of claim 19, wherein the boss is interrupted and the skirt is notched to define the static pressure ports.

Ridout & Maybee LLP  
Suite 2400  
One Queen Street East  
Toronto, Canada M5C 3B1  
Patent Agents of the Applicant

0



~~CONFIDENTIAL~~

FIG. 2.

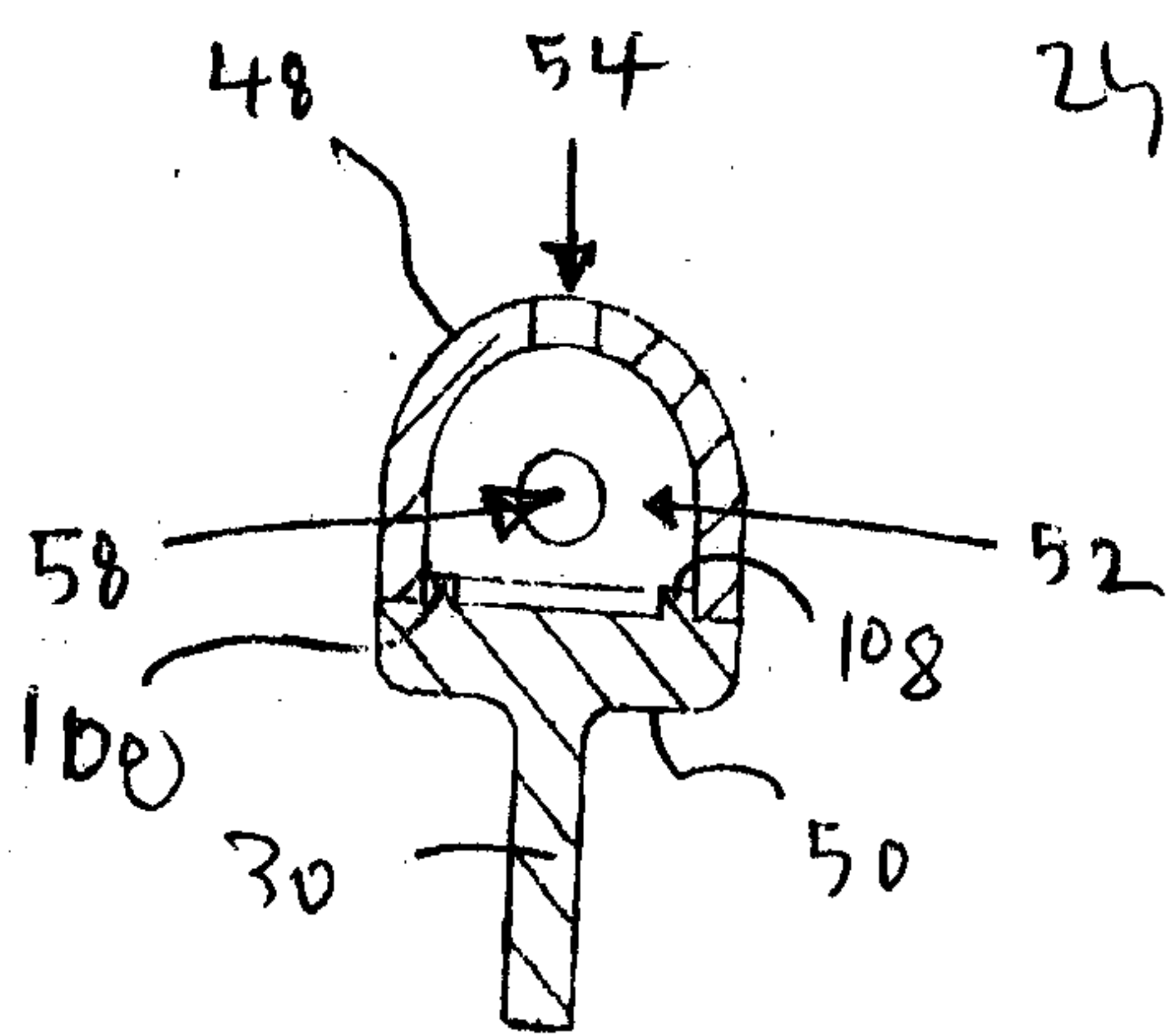
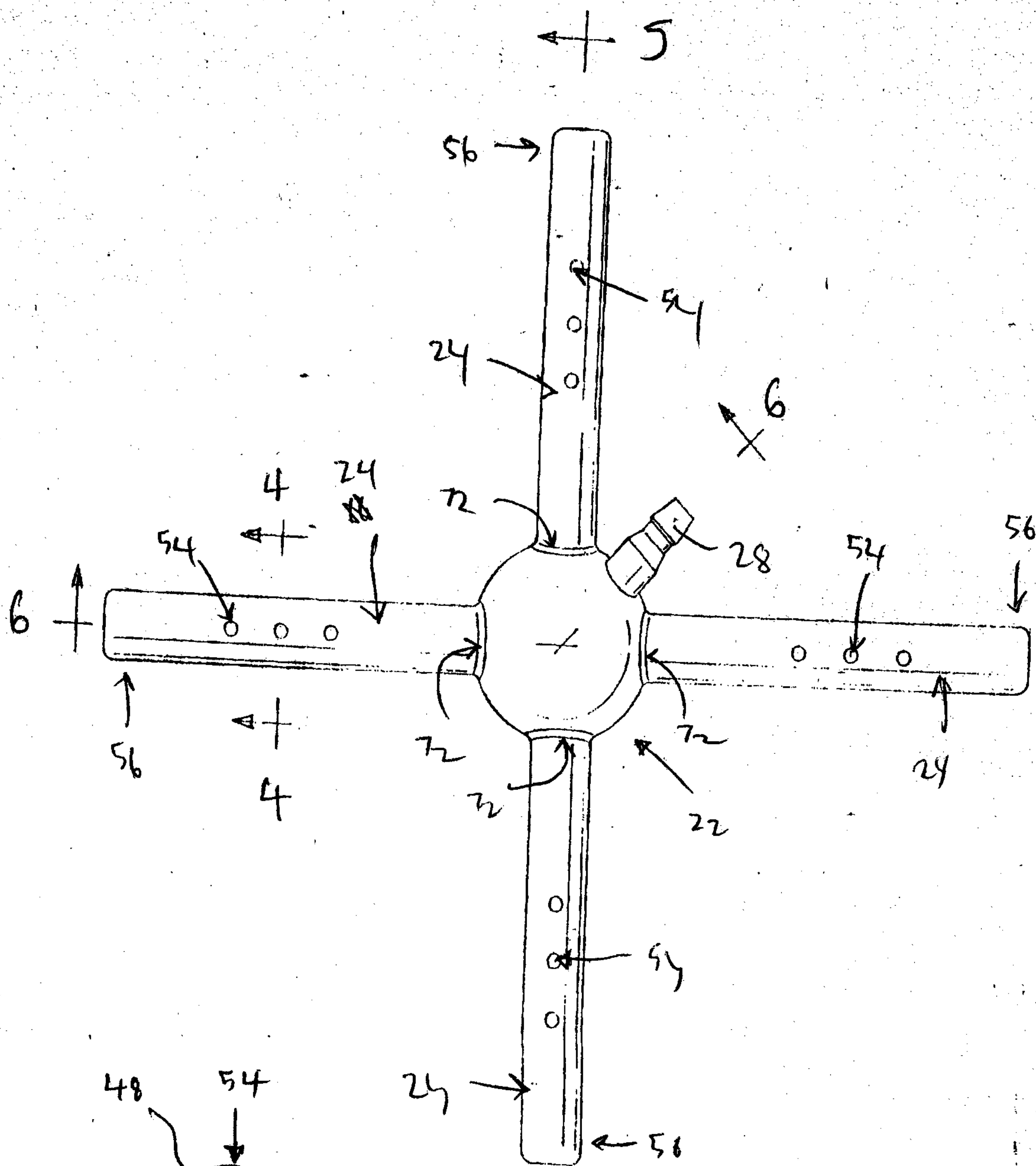
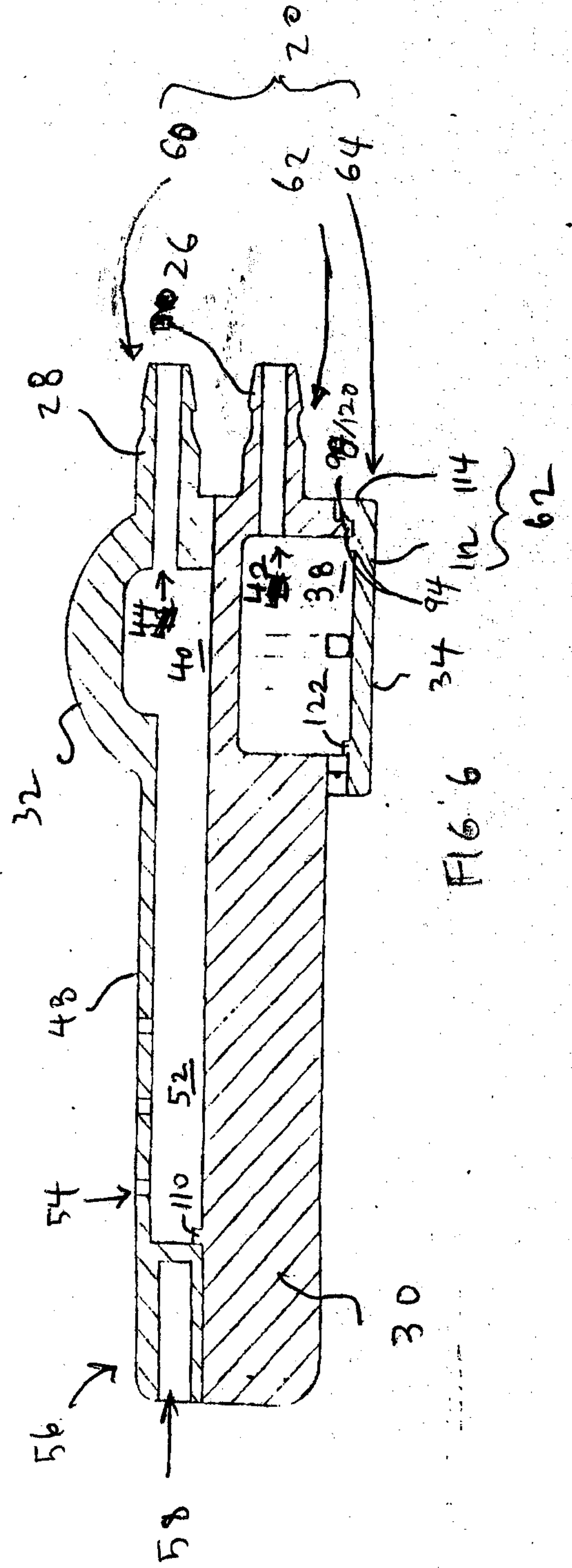
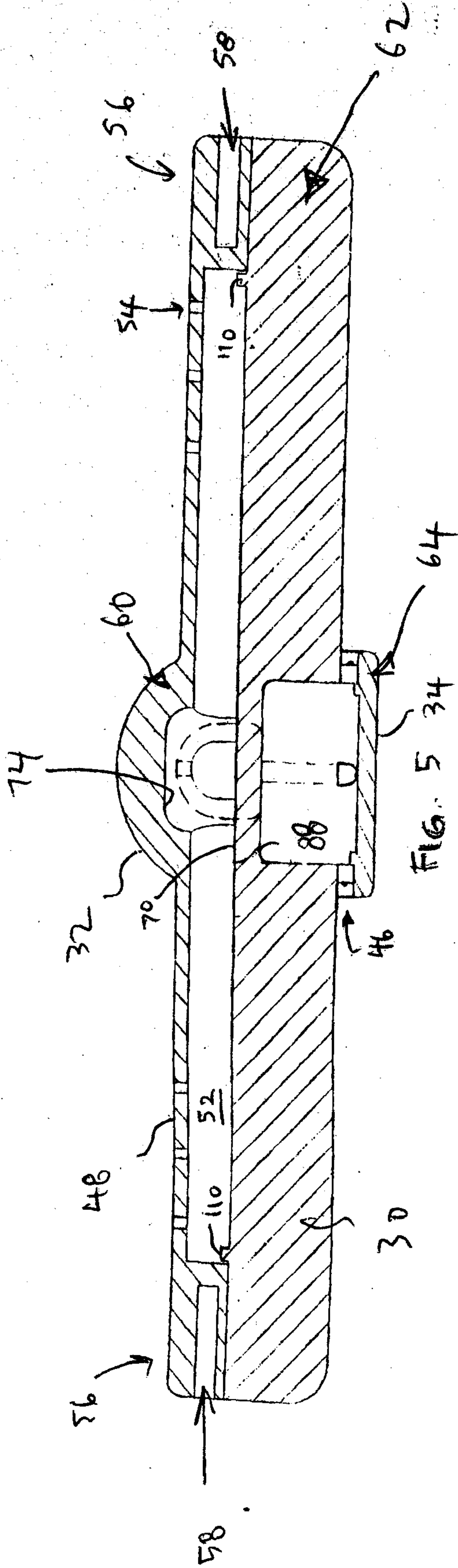


FIG. 4

FIG. 3



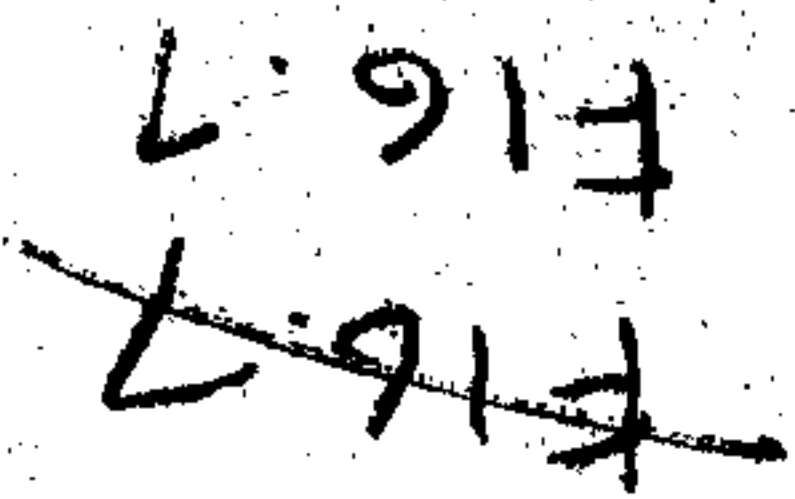
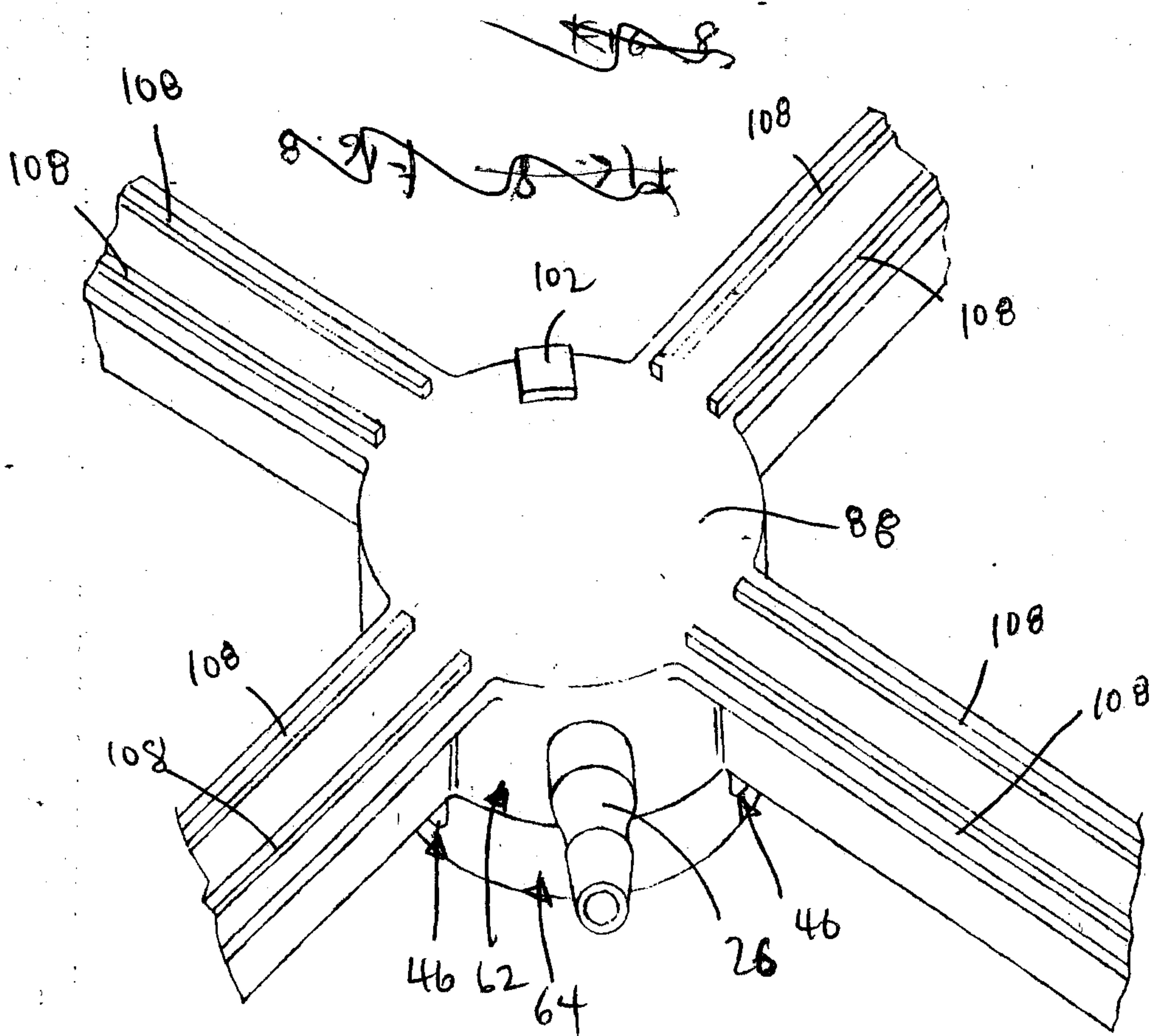
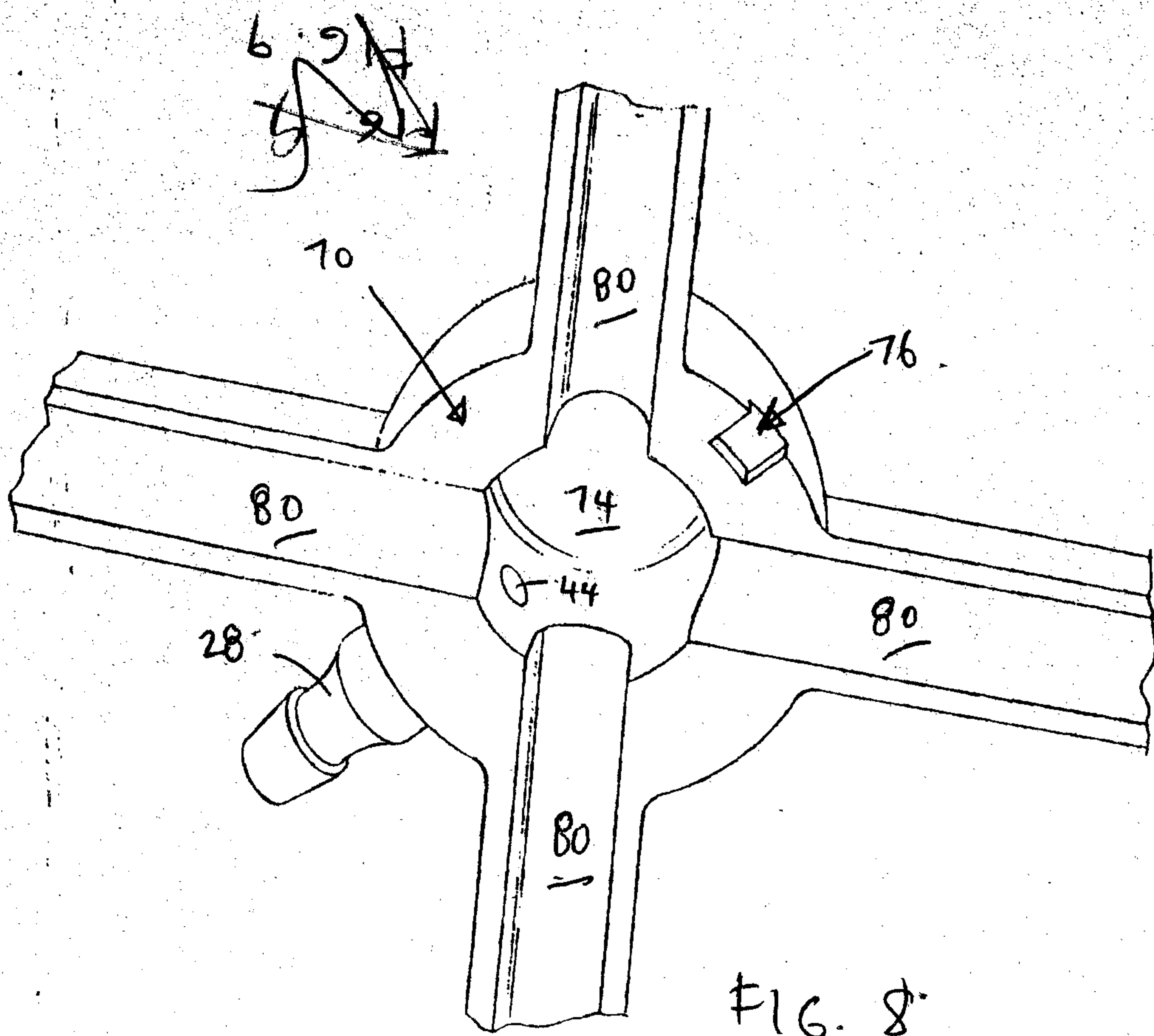
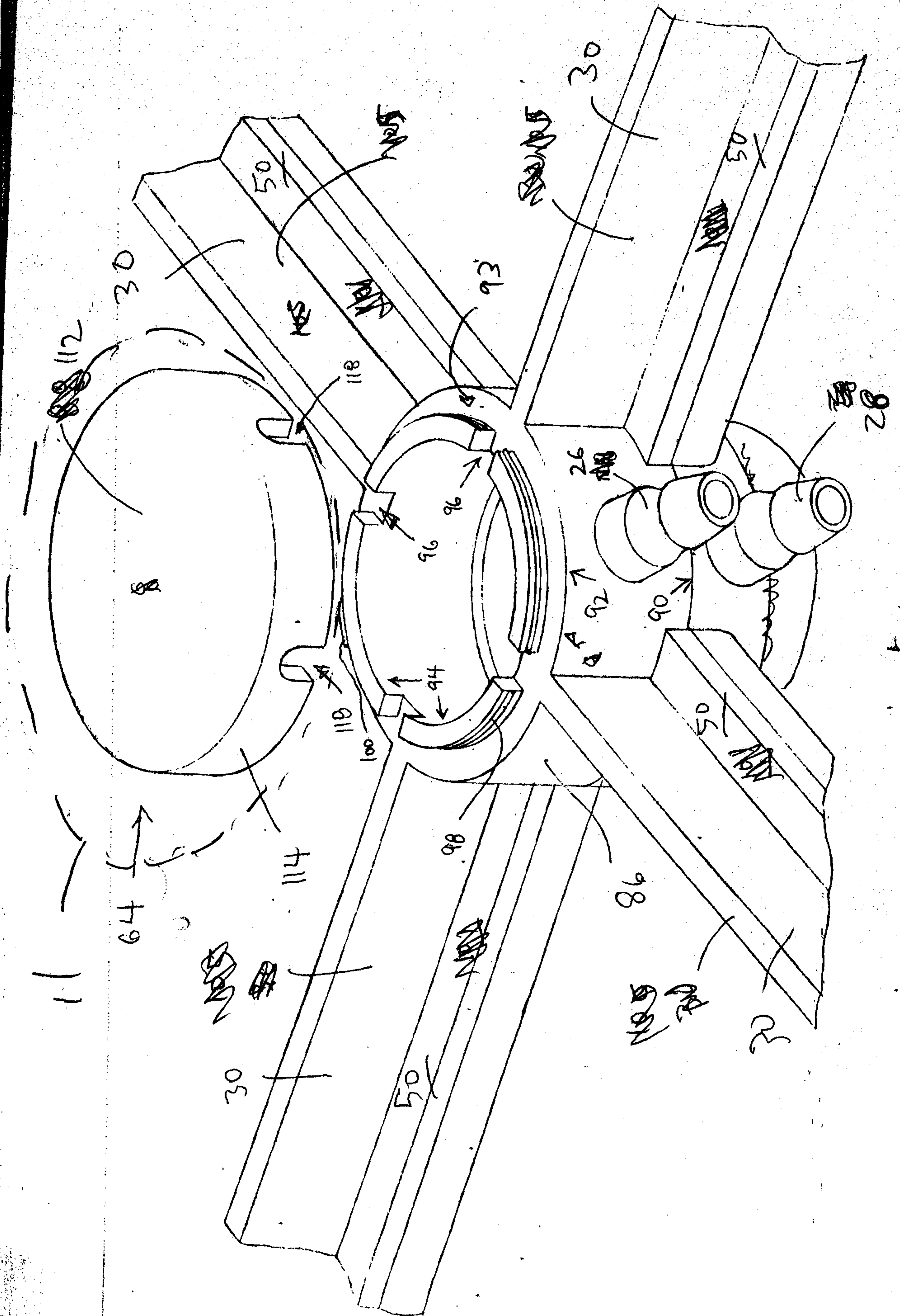


Fig. 7

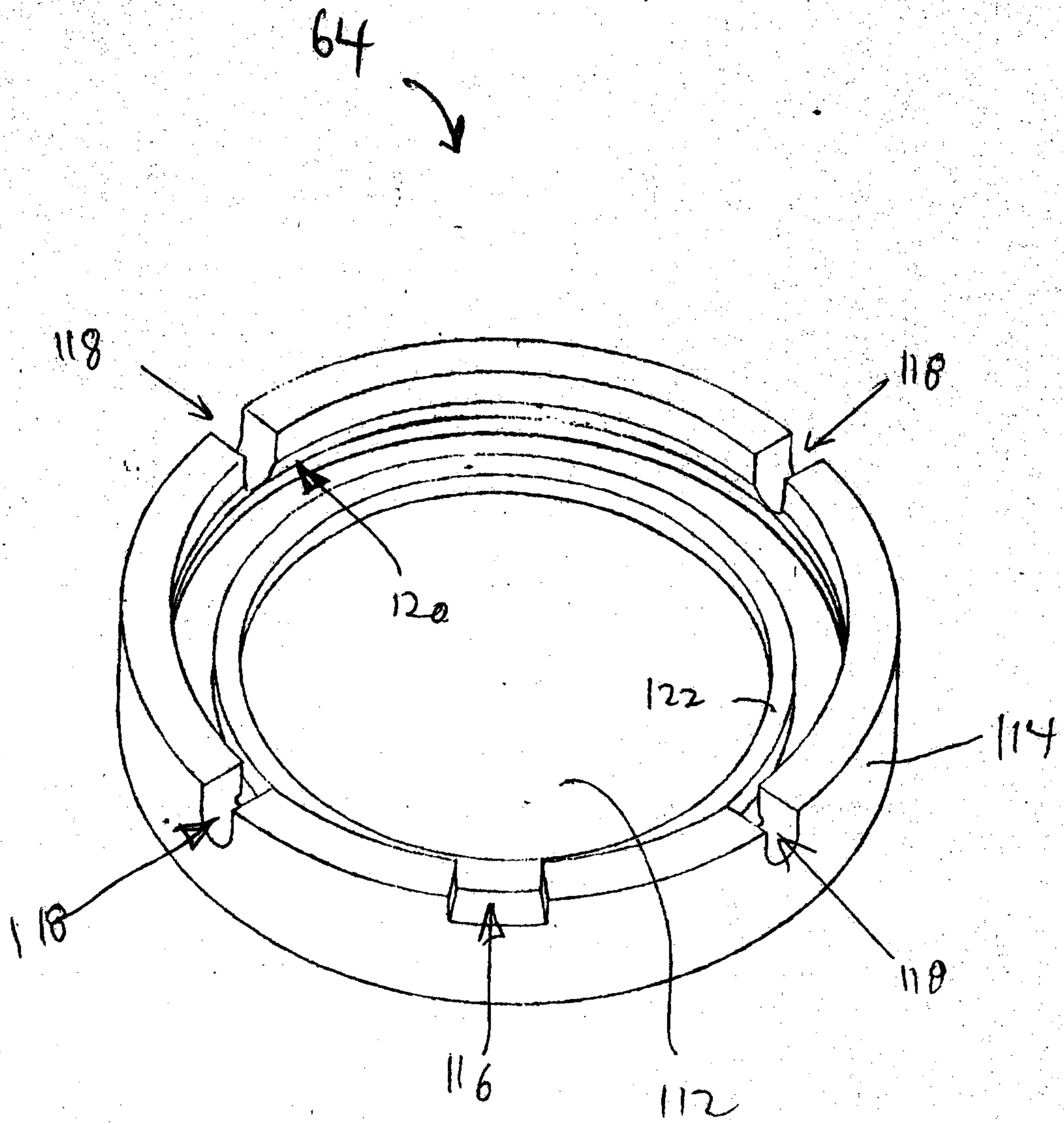
5





~~FIG. 10~~  
FIG. 10

(7)



~~FIG. 17~~

FIG. 11

