



(86) Date de dépôt PCT/PCT Filing Date: 2003/02/04
(87) Date publication PCT/PCT Publication Date: 2003/08/21
(85) Entrée phase nationale/National Entry: 2004/08/16
(86) N° demande PCT/PCT Application No.: GB 2003/000503
(87) N° publication PCT/PCT Publication No.: 2003/068407
(30) Priorité/Priority: 2002/02/16 (0203723.2) GB

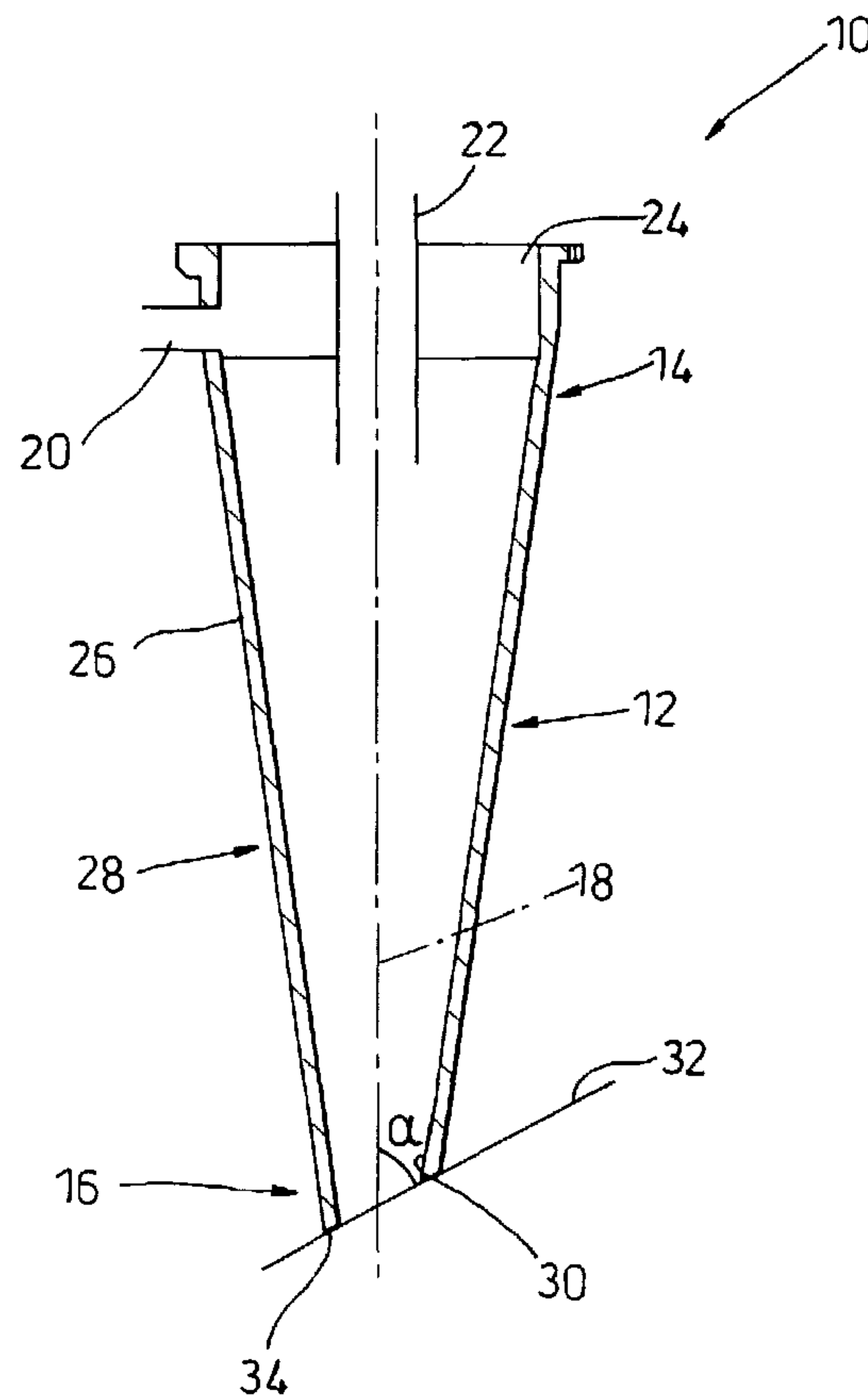
(51) Cl.Int.⁷/Int.Cl.⁷ B04C 5/08, B04C 5/28, B04C 5/185,
B04C 5/14

(71) Demandeur/Applicant:
DYSON LIMITED, GB

(72) Inventeurs/Inventors:
DUMMELOW, ANTHONY JOSEPH, GB;
HARRIS, DAVID STUART, GB;
GOMICIAGA-PEREDA, RICARDO, GB

(74) Agent: MARKS & CLERK

(54) Titre : APPAREIL DE SEPARATION A CYCLONE
(54) Title: CYCLONIC SEPARATING APPARATUS



(57) **Abrégé/Abstract:**

The invention provides cyclonic separating apparatus (10) comprising at least one cyclone having a first end (14) and a second end (16) and a longitudinal axis (18). An inlet (20) is located at the first end (14) for introducing a fluid flow into the cyclone (12) and a cone opening (30) is located at the second end (16). At least part of the cone opening (30) lies in a plane (32) inclined at an angle to the longitudinal axis (18).



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
21 August 2003 (21.08.2003)

PCT

(10) International Publication Number
WO 03/068407 A1

(51) International Patent Classification⁷: **B04C 5/08**,
5/14, 5/185, 5/28

(21) International Application Number: PCT/GB03/00503

(22) International Filing Date: 4 February 2003 (04.02.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0203723.2 16 February 2002 (16.02.2002) GB

(71) Applicant (for all designated States except US): **DYSON LTD** [GB/GB]; Tetbury Hill, Malmesbury, Wiltshire SN16 0RP (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **DUMMELOW**,

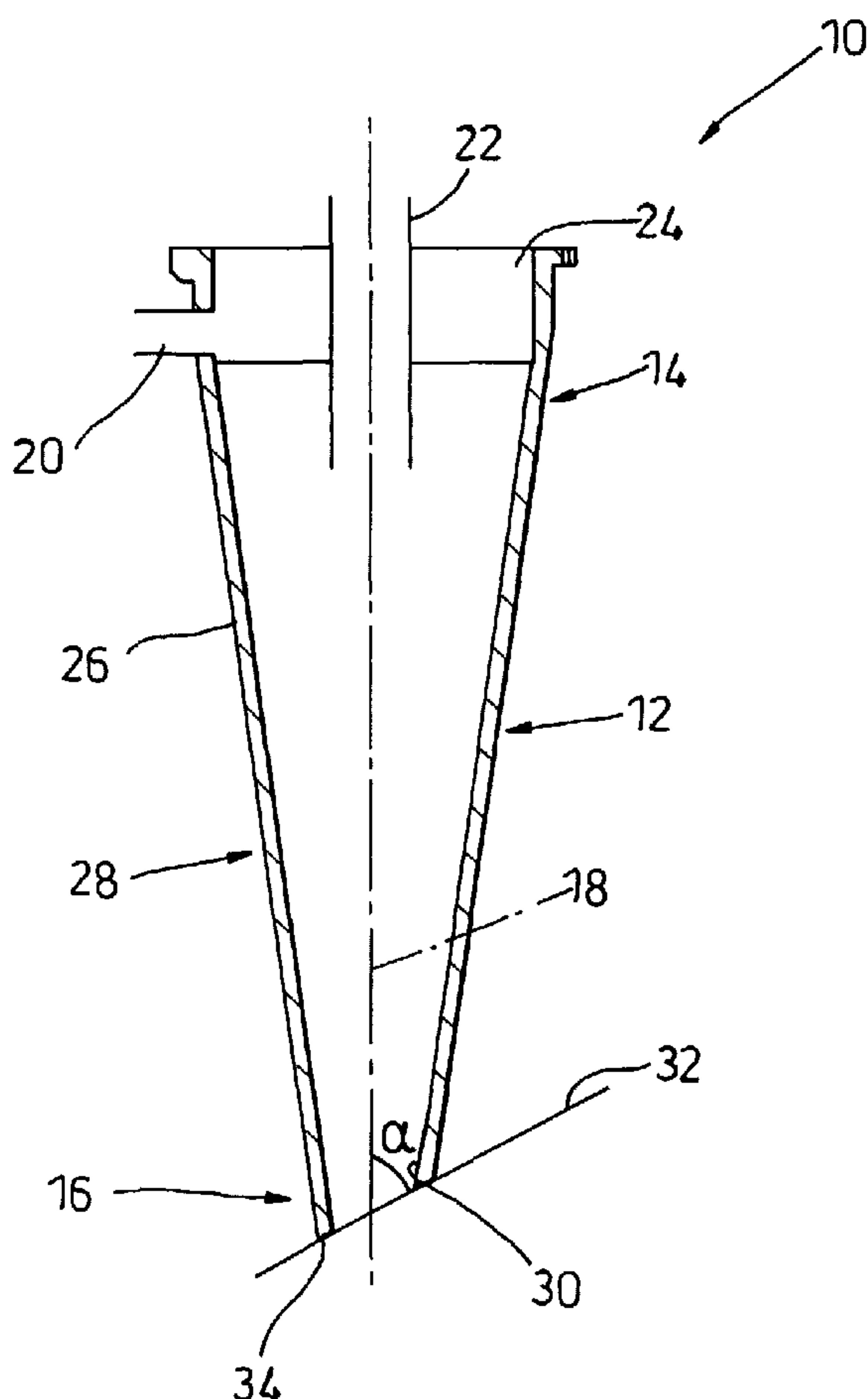
Anthony, Joseph [GB/GB]; 26 The Drive, Summerhayes, Dursley, Gloucestershire GL11 5QP (GB). **HARRIS, David, Stuart** [GB/GB]; 39 Farleigh Rise, Monkton Farleigh, Bradford on Avon, Bath and South East Somerset BA15 2QP (GB). **GOMICIAGA-PEREDA, Ricardo** [MX/GB]; Wynyard Flat, Baskerville, Malmesbury, Wiltshire SN16 9BS (GB).

(74) Agent: **SMITH, Gillian, R.**; Intellectual Property Department, Dyson Limited, Tetbury Hill, Malmesbury, Wiltshire SN16 0RP (GB).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE,

[Continued on next page]

(54) Title: CYCLONIC SEPARATING APPARATUS



(57) Abstract: The invention provides cyclonic separating apparatus (10) comprising at least one cyclone having a first end (14) and a second end (16) and a longitudinal axis (18). An inlet (20) is located at the first end (14) for introducing a fluid flow into the cyclone (12) and a cone opening (30) is located at the second end (16). At least part of the cone opening (30) lies in a plane (32) inclined at an angle to the longitudinal axis (18).

WO 03/068407 A1

WO 03/068407 A1

SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ,
VC, VN, YU, ZA, ZM, ZW.

Published:

— *with international search report*

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Cyclonic Separating Apparatus

The invention relates to cyclonic separating apparatus. Particularly, but not exclusively, the invention relates to cyclonic separating apparatus suitable for use in a vacuum cleaner.

Cyclonic separating apparatus is known, for example, from EP 0 042 723 and US 5,160,356. Both examples show domestic vacuum cleaners which operate using reverse flow cyclones to achieve particle separation. Such apparatus generally provides a cyclone body having a tangential inlet. Dirt-laden fluid flow enters the inlet and follows a helical path around the interior of the cyclone body. Centrifugal forces act on the entrained dirt to separate the dirt from the flow. The separated dirt collects at the base of the cyclone body for subsequent removal from the apparatus. The cleaned flow then changes direction and flows back up the cyclone body to exit the cyclone body via a centrally located outlet provided at the same end of the cyclone body as the inlet. Axial flow cyclonic separators can be used as an alternative to reverse flow cyclonic separators in which the cleaned flow exits the cyclone body at the same end of the cyclone body as the separated dust.

It is a known advantage to have a number of cyclones working in parallel within cyclonic separating apparatus. Each individual cyclone is small in comparison to that used in an equivalent single cyclone apparatus. The relatively small size of each individual cyclone has the effect of increasing the centrifugal force acting on particles entrained in the airflow passing through the cyclone body. This increase in the force results in an increase in the separation efficiency of the apparatus.

Cyclones can be prone to blocking. In particular, small cyclones are more likely to become blocked because there is a smaller area for the dust to pass through. Such blockages can cause a reduction in flow which has the overall effect of reducing the separation efficiency. A substantial blockage may completely stop the flow from passing through the cyclone.

It is an object of the present invention to provide cyclonic separating apparatus in which the risk of blockage of a cyclone is reduced.

The invention provides cyclonic separating apparatus comprising at least one cyclone, the cyclone having a first end and a second end, an inlet being located at the first end for introducing a fluid flow into the cyclone, a cone opening being located at the second end, the cyclone further comprising a longitudinal axis, wherein at least part of the cone opening lies in a plane inclined at an angle to the longitudinal axis. The configuration of the cone opening provides a greater area for the dirt to pass through which helps to prevent blockages occurring in the cyclone.

Preferably, the plane is inclined at an angle of between 40° and 80° to the longitudinal axis. More preferably, the plane is inclined at an angle of substantially 60° to the longitudinal axis. It has been found that at this angle cone blocking is less likely to occur and there is no increased risk of the separated dust being re-entrained.

In a preferred embodiment, the cyclone projects into the collector. This enables any dust which has been separated from the flow to be contained and so prevented from passing into the surrounding atmosphere. The contained dust can then be emptied from the collector in a safe and hygienic manner. Preferably, the collector has a portion having a substantially circular cross section, the diameter of the said portion being at least three times the diameter of the cone opening. More preferably, the said portion lies in a plane which intersects the cone opening. In this configuration, the separation performance may be optimised and the dust collected more efficiently.

The invention is particularly suited to use with a plurality of cyclones. The effect of passing the dust laden flow through a plurality of cyclones arranged in parallel is to enhance the separation efficiency of the apparatus. It is an advantage to have all of the cyclones communicating with a single collector to ensure that all of the dust separated from the flow can be disposed of easily and efficiently.

In this case, it is preferred that the cone opening has a lowermost portion which extends furthest from the first end of the cyclone and the said lowermost portion faces the wall of the collector. In this orientation, it is believed that separation of the entrained dust is optimised and the risk of cone blocking is reduced.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a sectional side view of cyclonic separating apparatus according to a first embodiment of the invention;

Figure 2 is a sectional side view of cyclonic separating apparatus according to a second embodiment of the invention;

Figure 3 is a sectional side view of cyclonic separating apparatus according to a third embodiment of the invention;

Figure 4 is a schematic sectional side view of cyclonic separating apparatus according to a fourth embodiment of the invention; and

Figures 5 and 6 show views of cyclonic separating apparatus according to a fifth embodiment of the invention; and

Figures 7 to 14 show sectional plan views of alternative configurations of cyclonic separating apparatus according to the invention.

Figure 1 shows a first embodiment of cyclonic separating apparatus 10 according to the invention. The cyclonic separating apparatus 10 comprises a cyclone 12 having a first end 14, a second end 16 and a longitudinal axis 18. The first end 14 is generally cylindrical and has an inlet 20 for introducing dust laden fluid, preferably air, into the cyclone 12. The inlet 20 is circular in cross-section and communicates tangentially with

the first end 14. An outlet 22 is also provided at the first end 14 to direct cleaned air out of the cyclone 12. The outlet 22 lies on the longitudinal axis 18 and extends from the interior of the cyclone 12 and through an upper portion 24 of the first end 14.

A side wall 26 tapers inwardly towards the longitudinal axis 18 from the first end 14 towards the second end 16 to form a frusto-conical portion 28. A cone opening 30 is formed at a free end of the frusto-conical portion 28. The cone opening 30 lies in a plane 32 inclined at an angle α to the longitudinal axis 18. The angle α shown in Figure 1 is substantially 60° to the longitudinal axis 18. As can be seen from the Figure, the cone opening 30 has a lowermost portion 34 which extends furthestmost from the first end 14. The inclination of the plane 32 of the cone opening 30 ensures that the area of the cone opening 30 is enlarged in comparison to that of a cone opening lying in a plane arranged perpendicular to the longitudinal axis 18 of the cyclone 12.

In a second embodiment, shown in Figure 2, the cone opening 30 projects into a collector 50. The cyclonic separating apparatus 10 is otherwise the same as that shown in Figure 1. The collector 50 comprises a frusto-conical upper portion 52 and a cylindrical body portion 54 which is closed by a circular base 56. The upper portion 52 abuts against the side wall 26 of the cyclone 12. The diameter d_2 of the circular base 56 is at least three times the projected diameter d_1 of the cone opening 30. The diameter d_2 shown in Figure 2 is approximately six times the diameter d_1 . To minimise any possibility of particle re-entrainment, the cone opening 30 is spaced from the body portion 54 and from the circular base 56.

In use, a dust-laden fluid flow enters the separating apparatus 10 via the inlet 20. The fluid flow is caused to follow a helical path around the interior of the cyclone 12 from the first end 14 downwardly towards the second end 16 and through the cone opening 30. The frusto-conical portion 28 causes the angular velocity of the fluid flow to increase which in turn causes a significant proportion of larger particles originally entrained in the fluid flow to become separated from the main body of the fluid flow and to become deposited in the collector 50. Due to the configuration of the cone

opening 30, the particles can pass easily through the cone opening 30 and into the collector 50. There is a reduced risk of the particles collecting in the area of the cone opening 30 and causing a blockage. The cleaned fluid flow forms a vortex along the longitudinal axis 18 of the cyclone 12 and exits the cyclone 12 by way of the outlet 22. Any particles remaining in the fluid flow can be separated therefrom by providing at least one additional cyclone or filter downstream of the outlet 22 (not shown).

A third embodiment of the invention is shown in Figure 3. This embodiment differs from the first embodiment in that the separating apparatus 100 comprises a cyclone 112 having a cone opening 130 which has a first portion 132 and a second portion 134. The first portion 132 lies in a plane 136 which is inclined at an angle α^1 to the longitudinal axis 118. The angle α^1 shown is substantially 50° but it will be appreciated that the angle α^1 could be varied between 40° and 80° . The second portion 134 lies in a plane 138 which is perpendicular to the longitudinal axis 118. A collector may also be provided around the cyclone 112 in the same manner as the collector 50 in Figure 2. The manner of use of the separating apparatus 100 is the same as that described for the separating apparatus 10.

A fourth embodiment of the invention is shown in Figure 4. The separating apparatus 200 comprises an arrangement of parallel cyclones 212 each having the same configuration as the cyclone 12 of Figure 1. It will be appreciated that the cyclones 212 could alternatively have the configuration of the cyclone 112 shown in Figure 3. The cyclones 212 are arranged so as to lie alongside one another, each having a tangential inlet 220 and an outlet 222. A main inlet 224 feeds dust laden fluid flow into the separating apparatus 200 and a proportion of the fluid flow is directed into each inlet 220. Each cyclone 212 has a cone opening 230 which projects into a common collector 250 having an upper portion 252, tapering side walls 254, a cylindrical body 256 and a base portion 258. The cone opening 230 of each cyclone 212 lies in a plane which is inclined to the longitudinal axis 218 of the respective cyclone 212.

A specific arrangement of parallel cyclones is shown in Figures 5 and 6. Twelve cyclones project into a collector 350. The cyclones are arranged in two imaginary concentric rings 360,362 arranged about the longitudinal axis 352 of the collector 350. Nine cyclones 314 are located in an outer ring 360 and three cyclones 316 are located in an inner ring 362. The cyclones 314,316 are equi-angularly spaced about the respective rings 360,362. Each cyclone 314,316 has a cone opening 330 having a lowermost portion 334 (shown as * in Figure 6) which is furthest from the first end 315. The lowermost portion 334 of each cyclone 314,316 faces the wall of the collector 350.

Different arrangements of parallel cyclones are contemplated. Figures 7 to 14 show alternative arrangements of cyclones in a collector. Figure 7 shows four cyclones 400 being arranged in a ring 402 about a longitudinal axis 452 of the collector 450. Further cyclones 404 are spaced from the axis 452 but are not in any regular orientation. In contrast, Figure 8 shows an outer ring 406 and an inner ring 408 each having four cyclones 409 spaced therein. Figure 9 shows a number of cyclones 410 in an outer ring 412 which are equi-spaced about a longitudinal axis 462. Figure 10 shows an arrangement having three cyclones 420 in an outer ring 422 and one cyclone 424 in an inner ring 426. A cyclone 420a in the outer ring 422 has a lowermost portion 421 which is furthest from the first end of the cyclone 420a. The lowermost portion 421 faces the wall of the collector 470. Figure 11 shows an embodiment having a number cyclones 430 each having a lowermost portion 432 which is furthest from the first end of the cyclone 430. The cyclones 430 are arranged so that alternate cyclones 430a have the lowermost portion 432 facing the wall of the collector 480 whilst the remaining cyclones 430b have their lowermost portion facing the longitudinal axis 482. Alternatively, as shown in Figure 12, all lowermost portions 436 of the cyclones 438 face the longitudinal axis 492 of the collector 490. Figure 13 shows the cyclones 440 arranged so that the lowermost portion 442 of each cyclone 440a in a first ring 444 faces the wall of the collector 498 and the lowermost portion 442 of each cyclone 440b in a second ring 446 faces the longitudinal axis 450. Figure 14 shows an alternative configuration having a number of cyclones 500 and each having a lowermost portion 502. Six cyclones 500 are arranged in a ring 504 so that alternate cyclones 500a have

the lowermost portion 502 facing the wall of the collector 506. The remaining cyclones 500b in the ring 504 have the lowermost portion 502 facing the longitudinal axis 510. Further cyclones 500c are spaced from the longitudinal axis 510 but are not in any regular orientation. Alternate cyclones 500c have the lowermost portion 502 facing the longitudinal axis 510.

The invention is not intended to be limited to the precise features of the embodiments described above. Other variations and modifications will be apparent to a skilled reader. It is intended that the cyclonic separating apparatus would be incorporated into a vacuum cleaner but it will be appreciated that the apparatus may also be utilised in any other suitable particle separation apparatus.

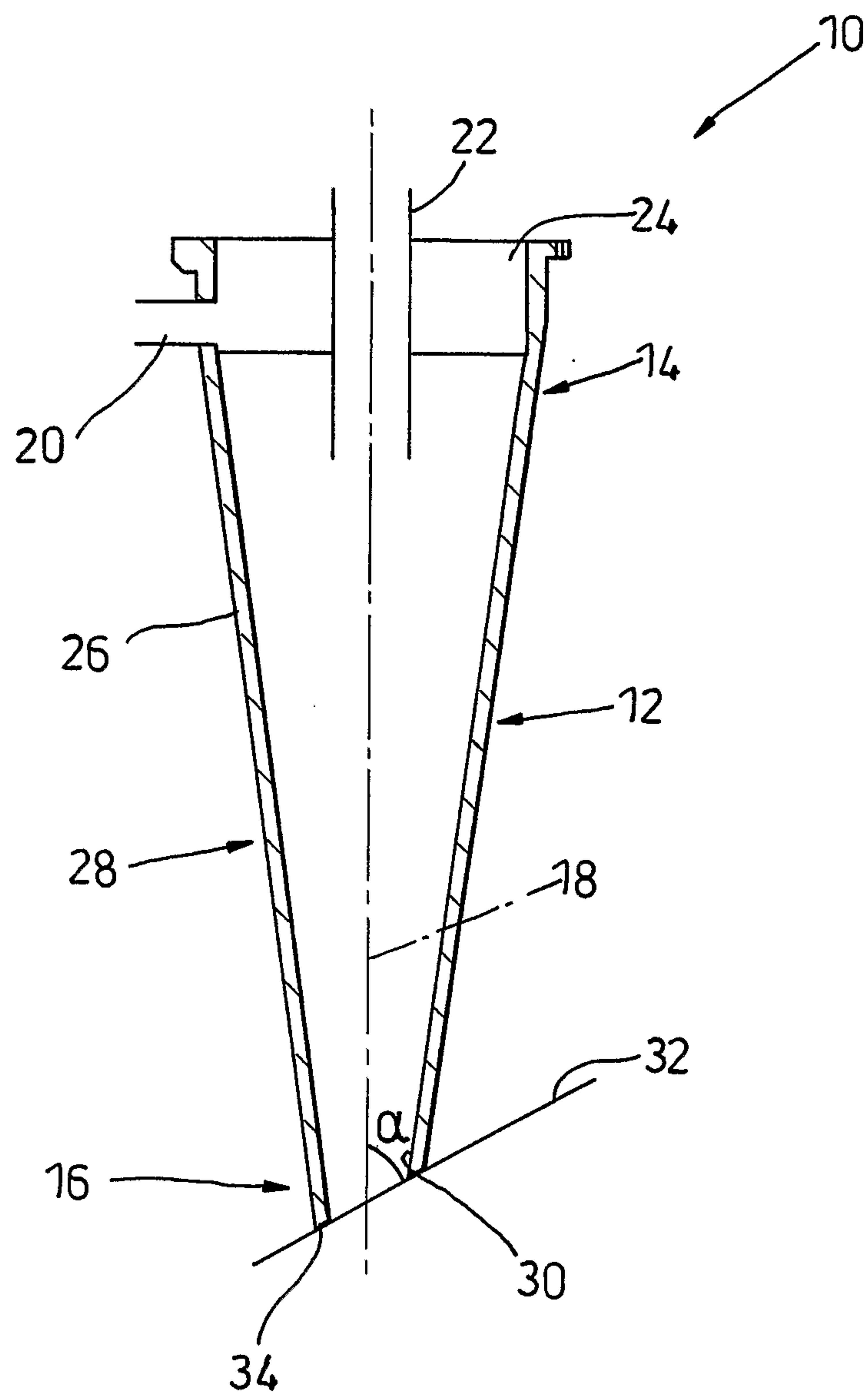
Claims

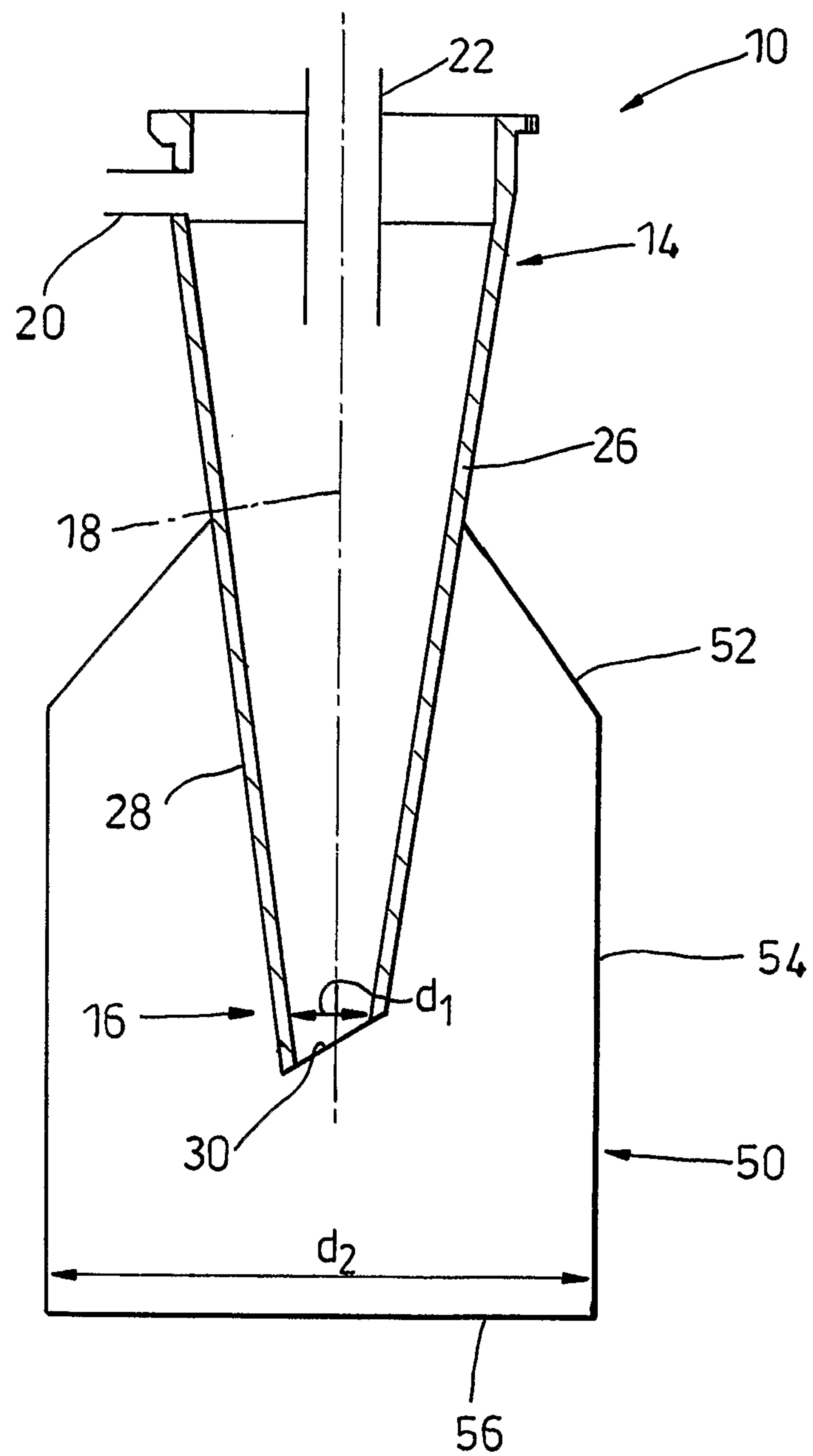
1. Cyclonic separating apparatus comprising at least one cyclone, the cyclone having a first end and a second end, an inlet being located at the first end for introducing a fluid flow into the cyclone, a cone opening being located at the second end, the cyclone further comprising a longitudinal axis, wherein at least part of the cone opening lies in a plane inclined at an angle to the longitudinal axis.
2. Cyclonic separating apparatus as claimed in Claim 1, wherein the plane is inclined at an angle of between 40° and 80° to the longitudinal axis.
3. Cyclonic separating apparatus as claimed in Claim 2, wherein the plane is inclined at an angle of substantially 60° to the longitudinal axis.
4. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein the whole of the cone opening lies in the said plane.
5. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein the cyclone has a tapered portion.
6. Cyclonic separating apparatus as claimed in Claim 5, wherein the tapered portion is frusto-conical.
7. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein the inlet communicates tangentially with the cyclone.
8. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein an outlet is located at the first end.

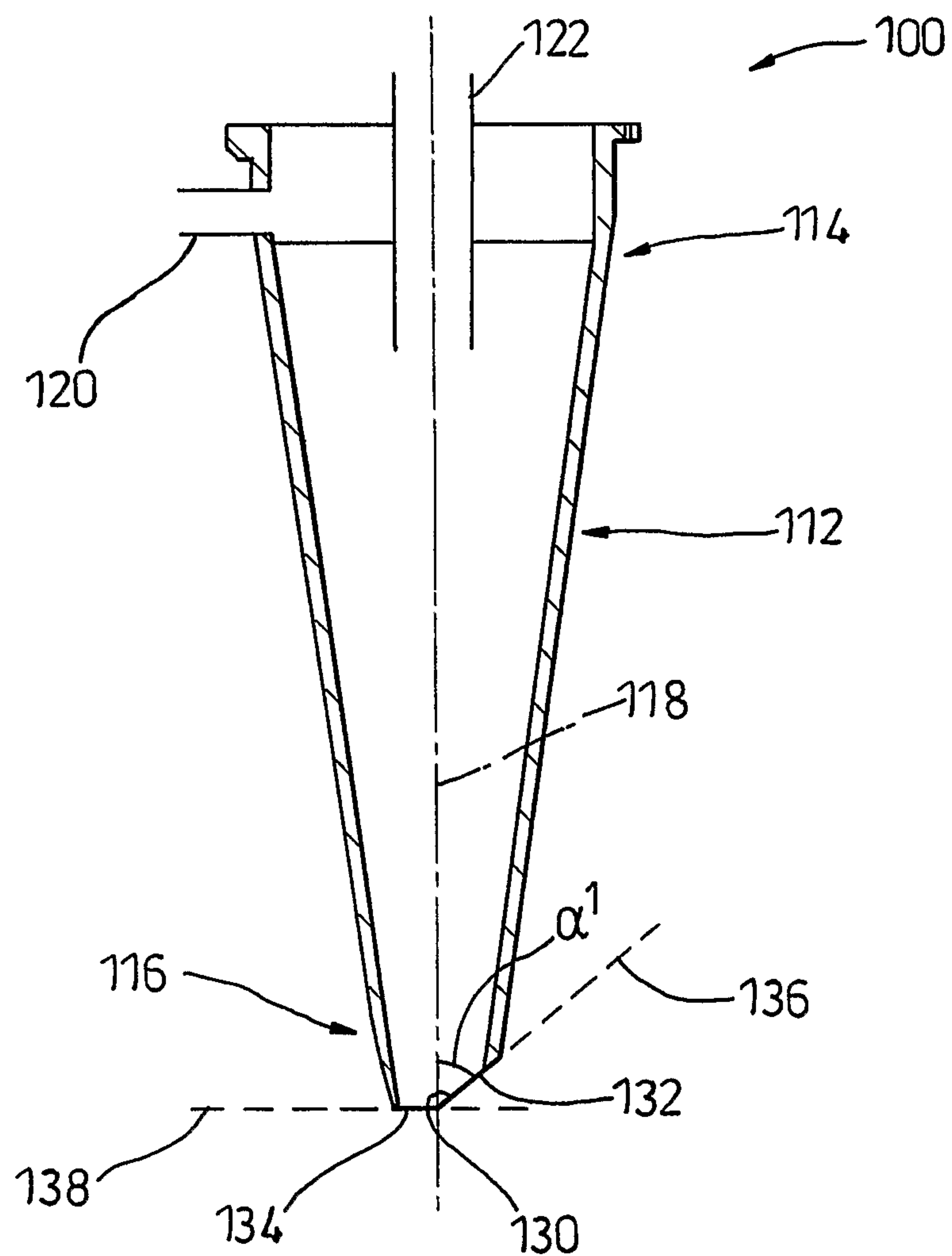
9. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein the cone opening communicates with a closed collector having a longitudinal axis and a wall.
10. Cyclonic separating apparatus as claimed in Claim 9, wherein the cyclone projects into the collector.
11. Cyclonic separating apparatus as claimed in Claim 9 or 10, wherein the collector has a portion having a circular cross section, the diameter of the said portion being at least three times the diameter of the cone opening.
12. Cyclonic separating apparatus as claimed in Claim 11, wherein the said portion lies in a plane which intersects the cone opening.
13. Cyclonic separating apparatus as claimed in any one of the preceding claims, wherein a plurality of cyclones are provided in parallel.
14. Cyclonic separating apparatus as claimed in Claim 13 and any one of Claims 9 to 12, wherein each of the said cyclones communicates with the collector.
15. Cyclonic separating apparatus as claimed in Claim 14, wherein at least some of the cyclones are arranged in a ring about the longitudinal axis of the collector.
16. Cyclonic separating apparatus as claimed in Claim 15, wherein all of the cyclones are arranged in one or two rings.
17. Cyclonic separating apparatus as claimed in Claim 15 or 16, wherein the cyclones are equi-angularly spaced about the or each ring.
18. Cyclonic separating apparatus as claimed in any one of Claims 14 to 17, wherein at least one cone opening has a lowermost portion which extends furthest from the first

end of the respective cyclone and the said lowermost portion faces the wall of the collector.

19. Cyclonic separating apparatus as claimed in Claim 18, wherein all of the cone openings have a lowermost portion and at least some of the lowermost portions face the wall of the collector.
20. Cyclonic separating apparatus as claimed in Claim 19, wherein all of the lowermost portions face the wall of the collector.
21. Cyclonic separating apparatus as claimed in Claim 19, wherein some of the lowermost portions face the longitudinal axis of the collector.
22. Cyclonic separating apparatus as claimed in any one of Claims 14 to 17, wherein at least one cone opening has a lowermost portion which extends furthest from the first end of the respective cyclone and the lowermost portion faces the longitudinal axis of the collector.
23. Cyclonic separating apparatus as claimed in Claim 19, wherein the lowermost portions in an adjacent ring face the wall of the collector.
24. Cyclonic separating apparatus as claimed in 21, wherein alternate lowermost portions face the longitudinal axis of the collector.
25. Cyclonic separating apparatus substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.
26. A vacuum cleaner incorporating the cyclonic separating apparatus as claimed in any one of the preceding claims.

1/7***Fig. 1***

2/7***Fig. 2***

3/7***Fig. 3***

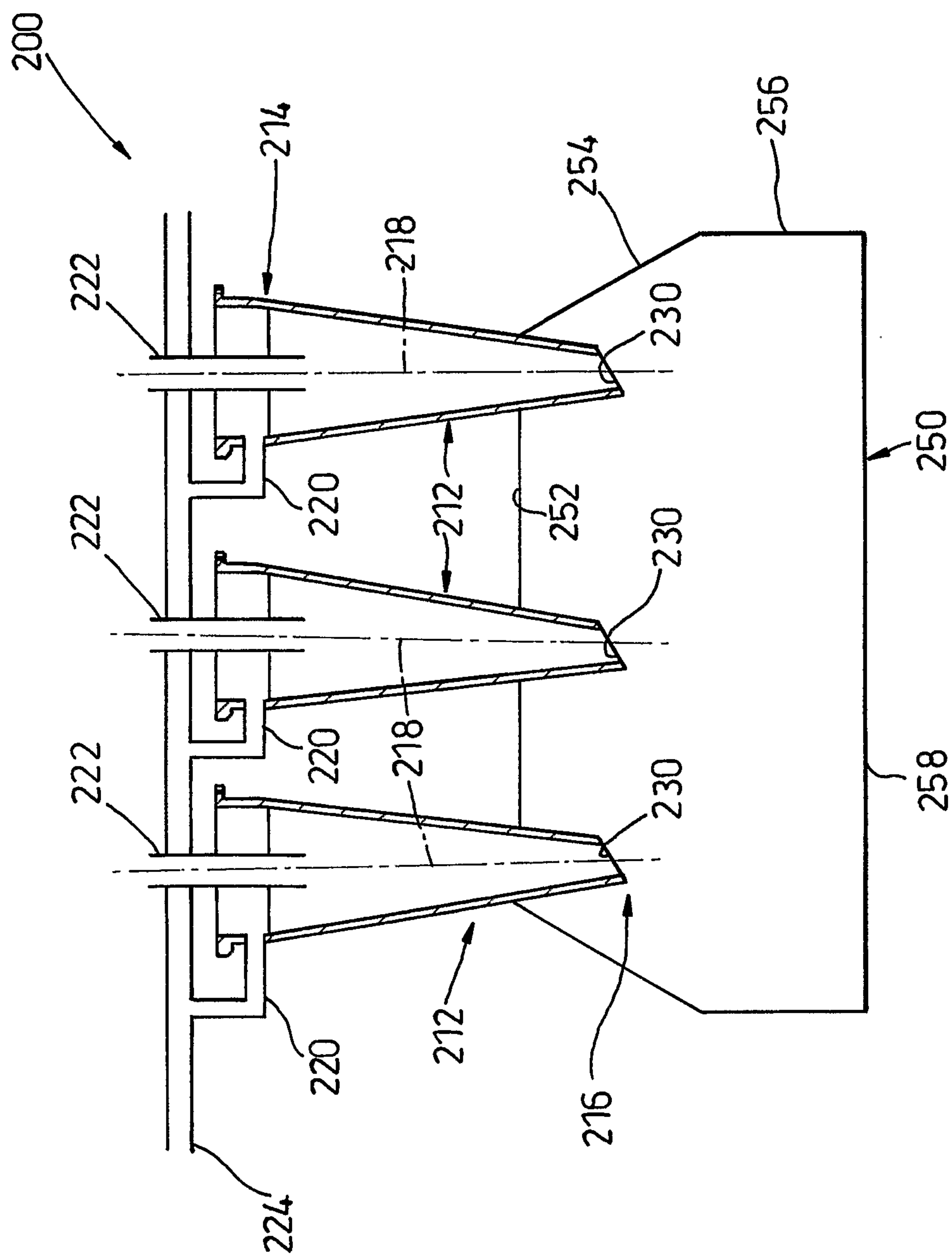
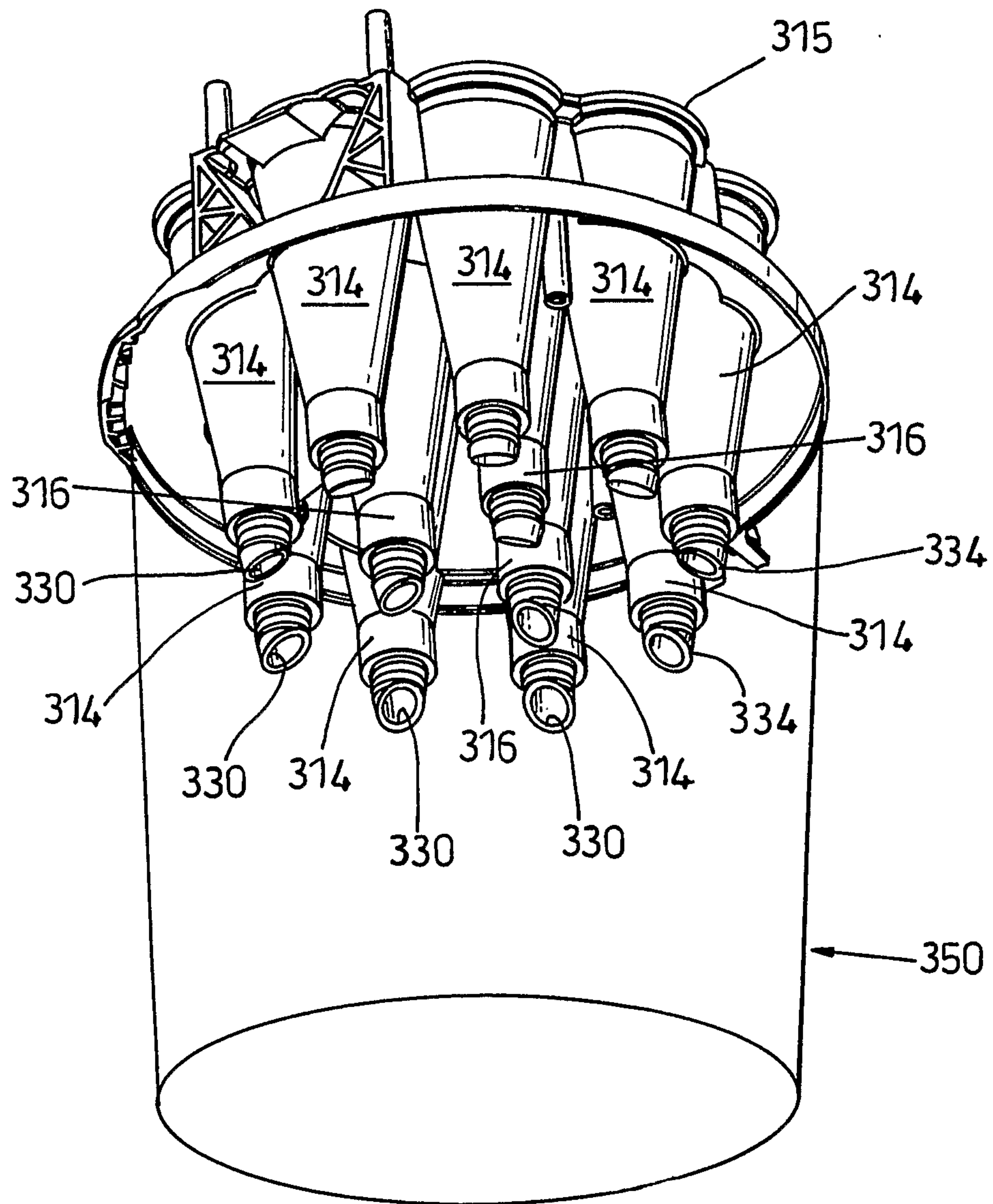
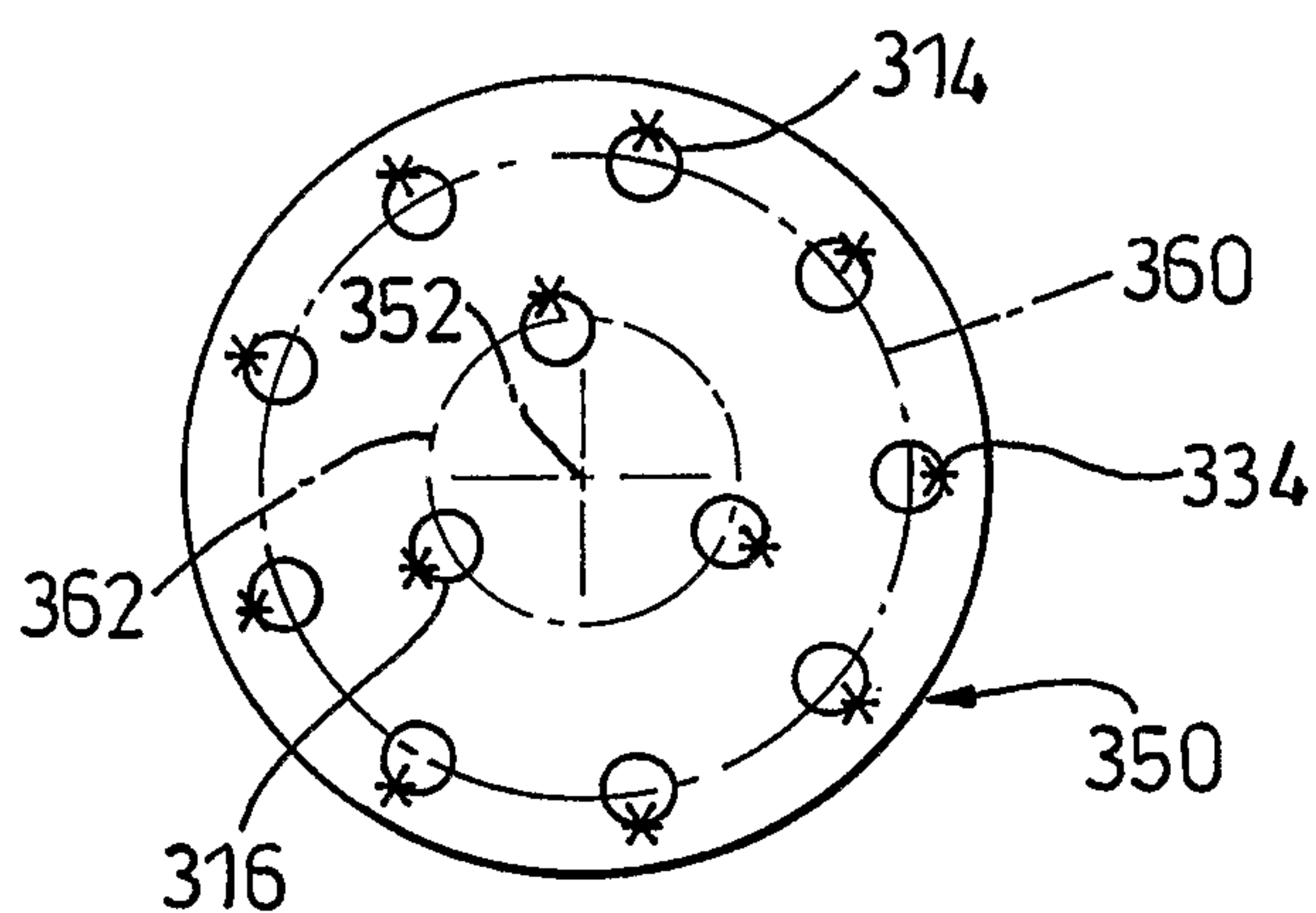
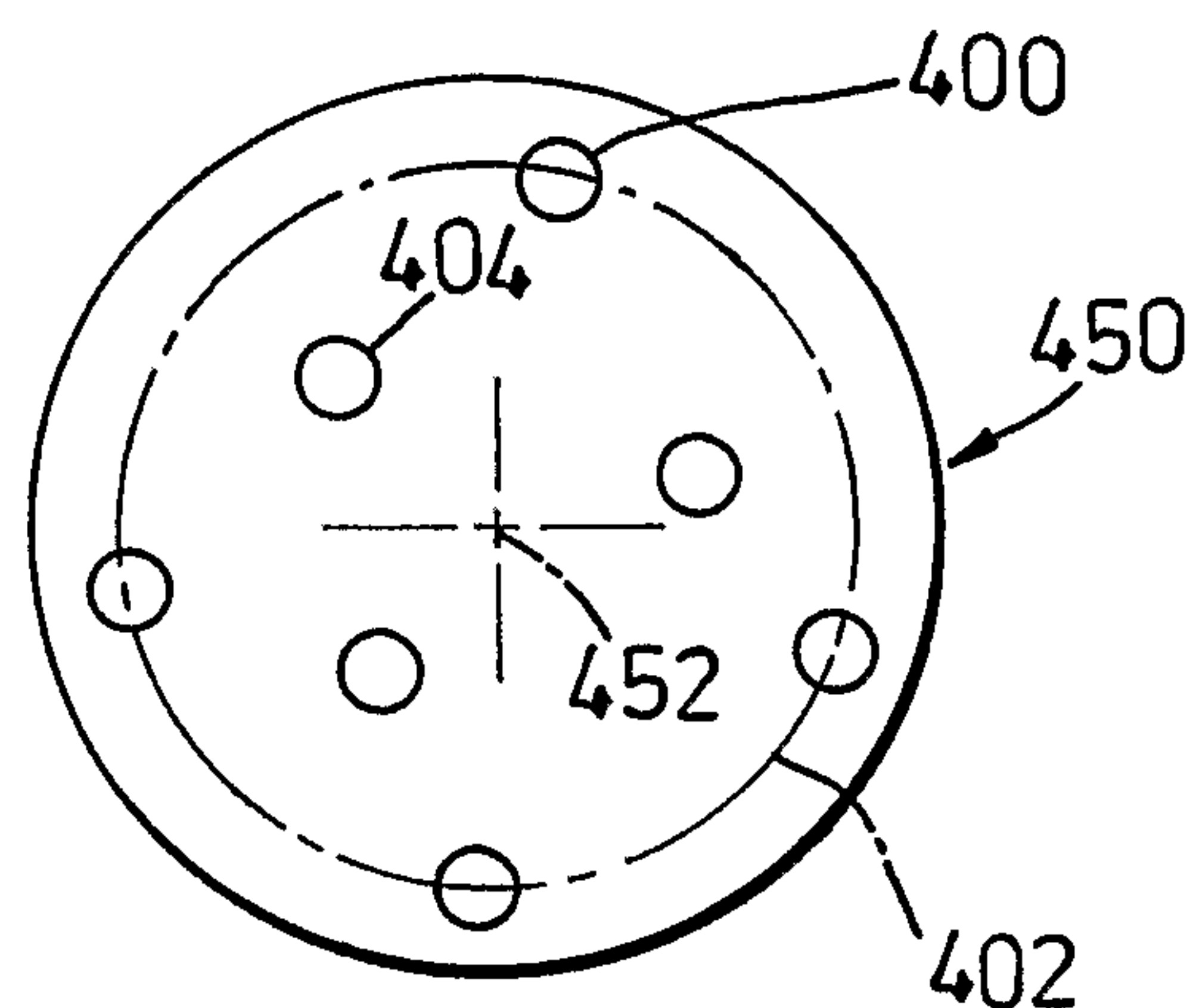
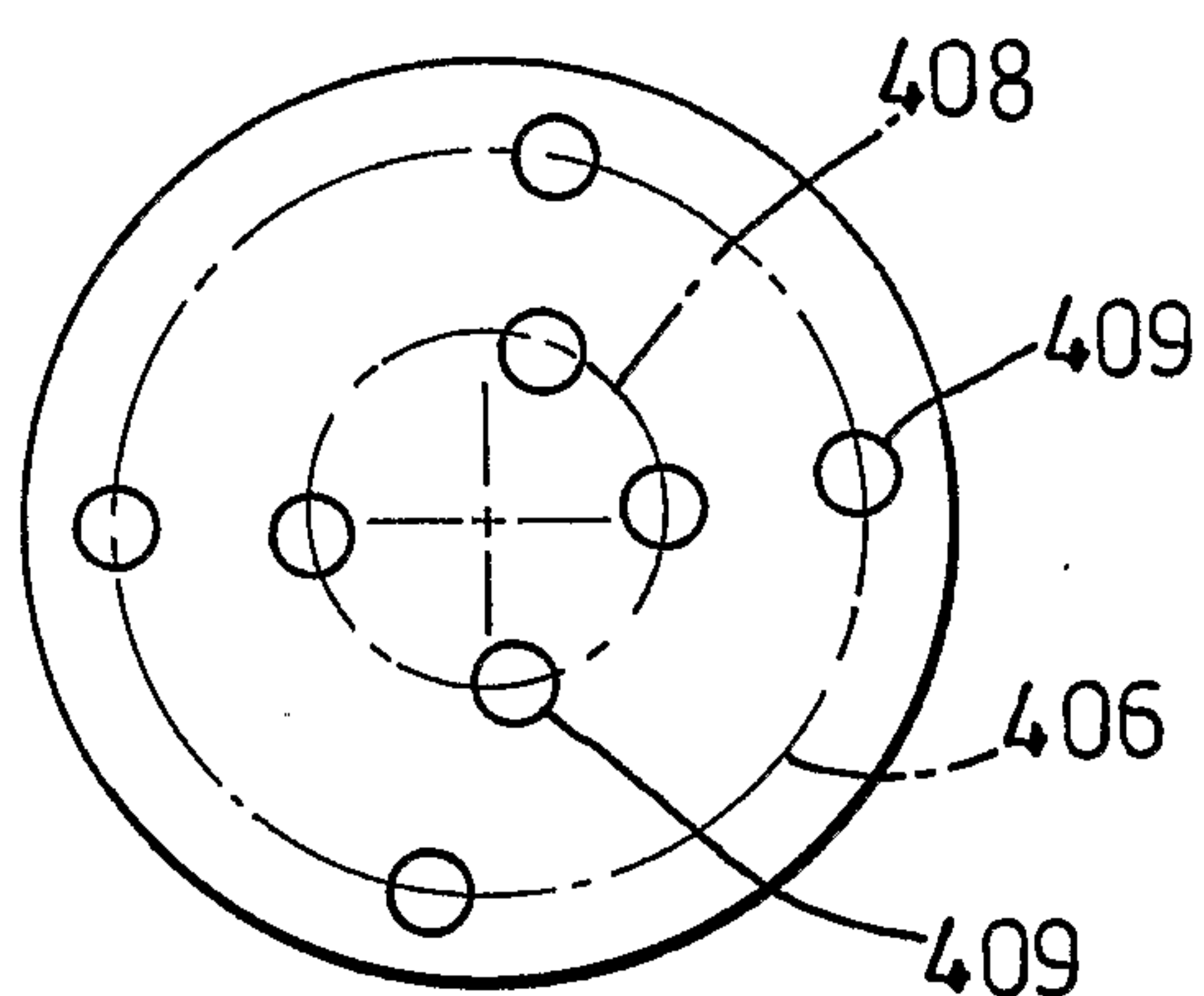
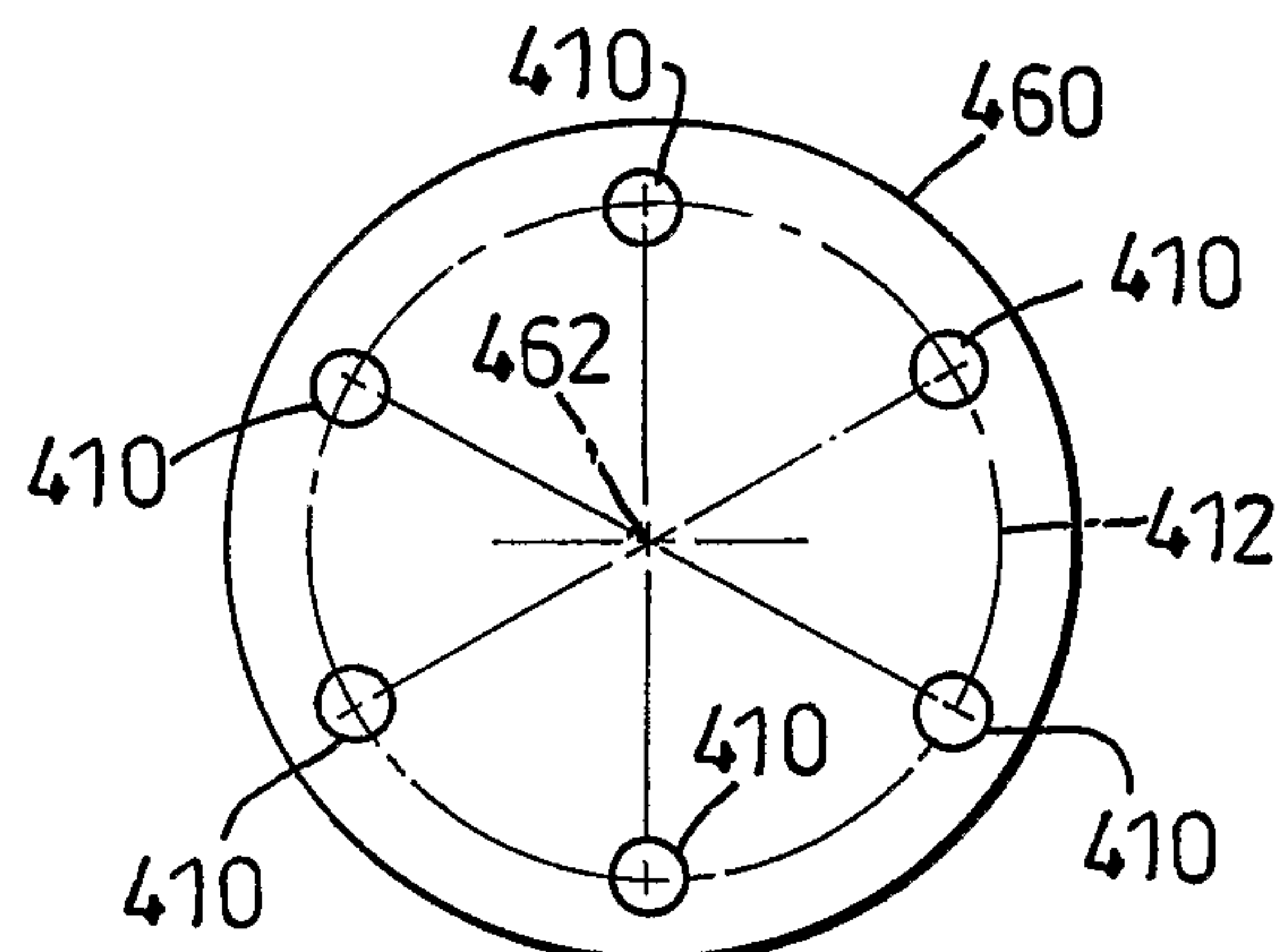
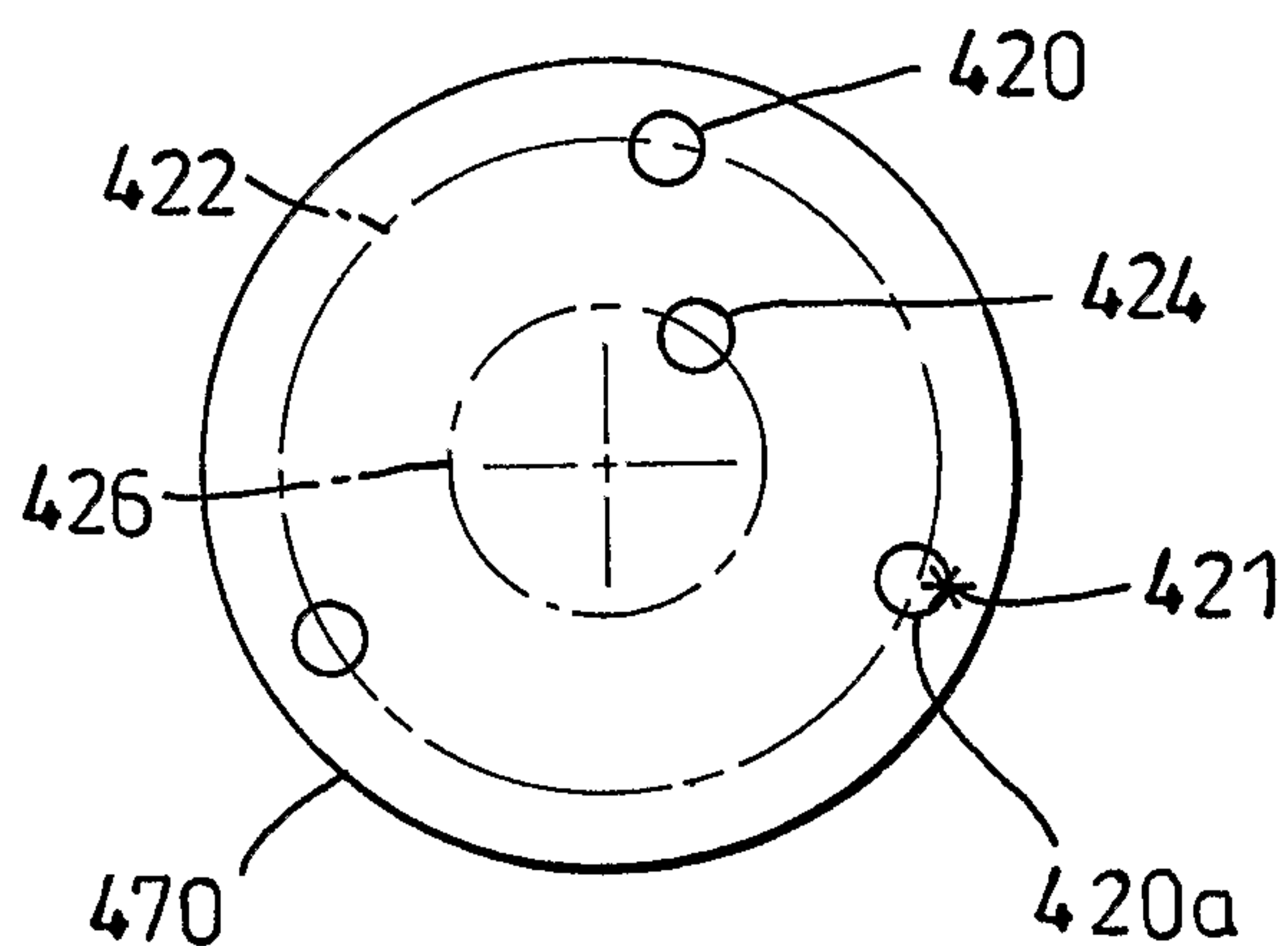
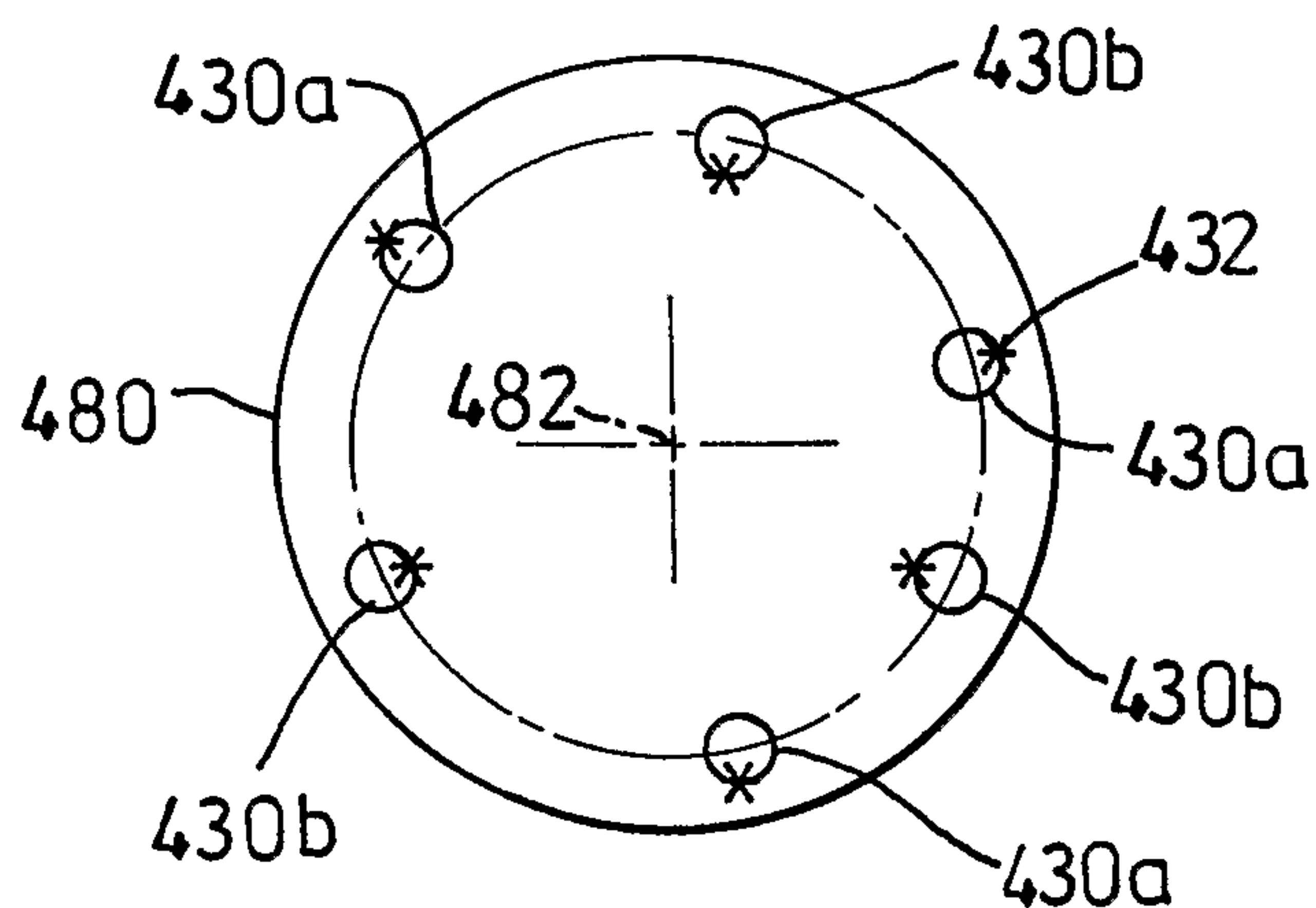


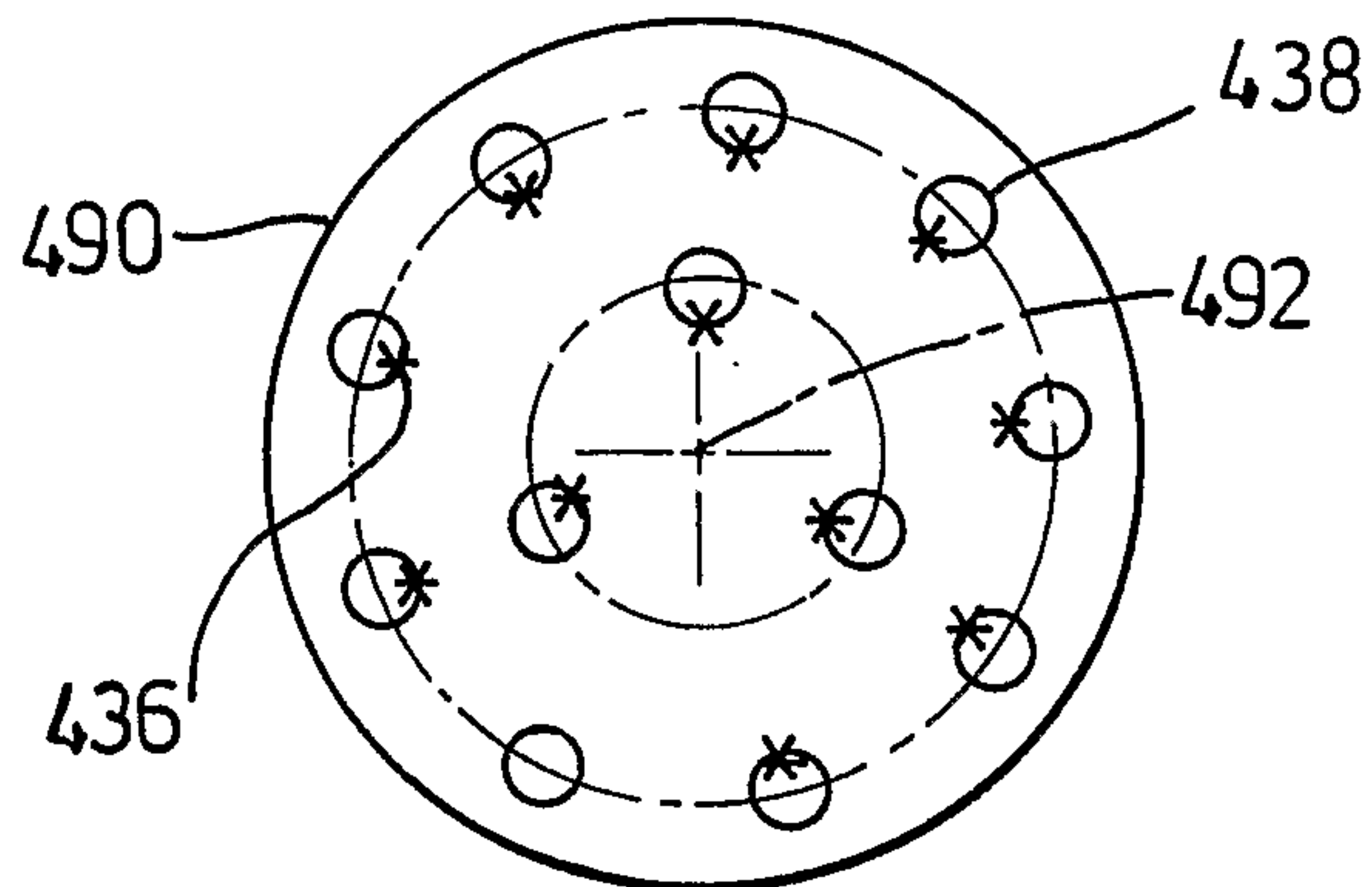
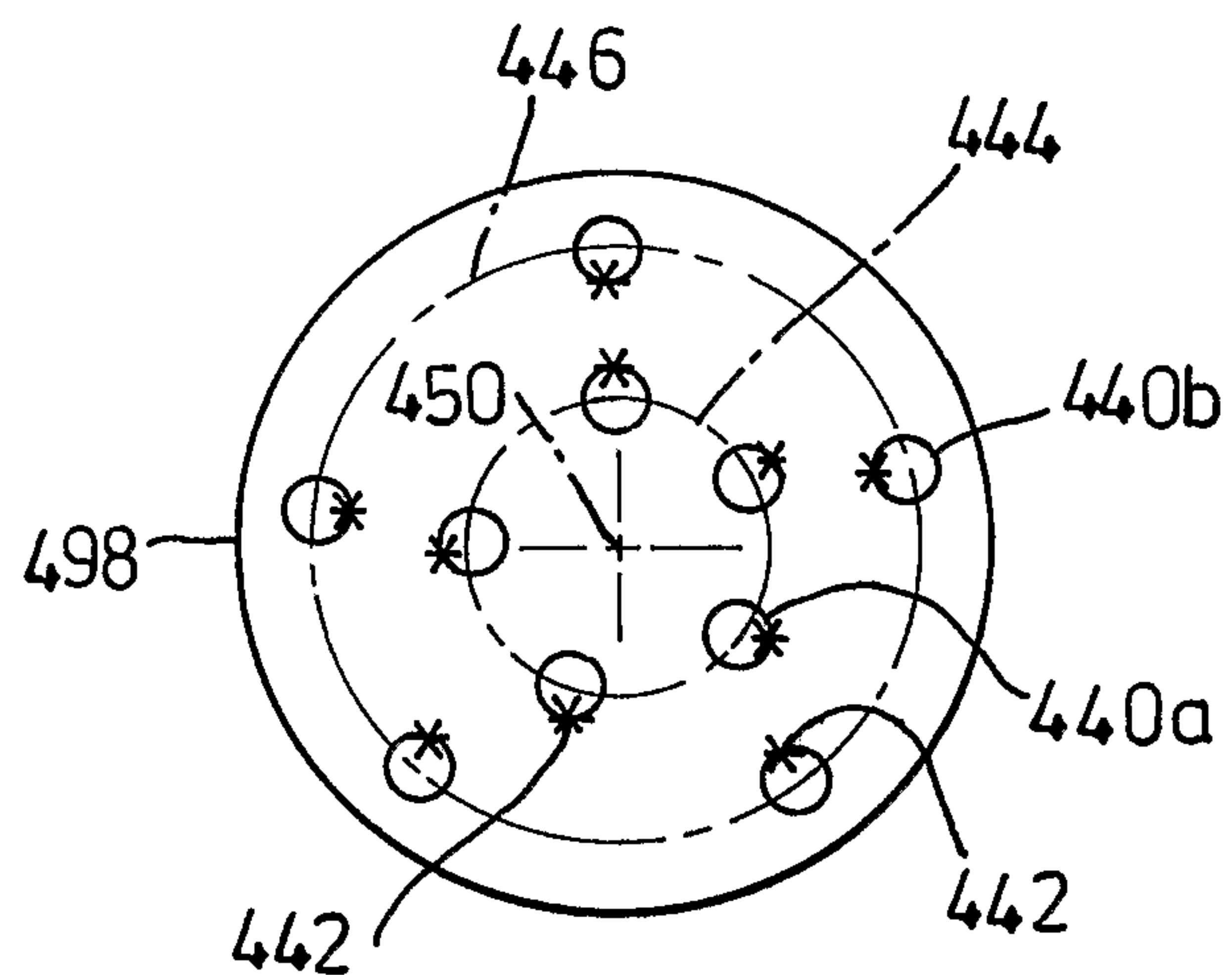
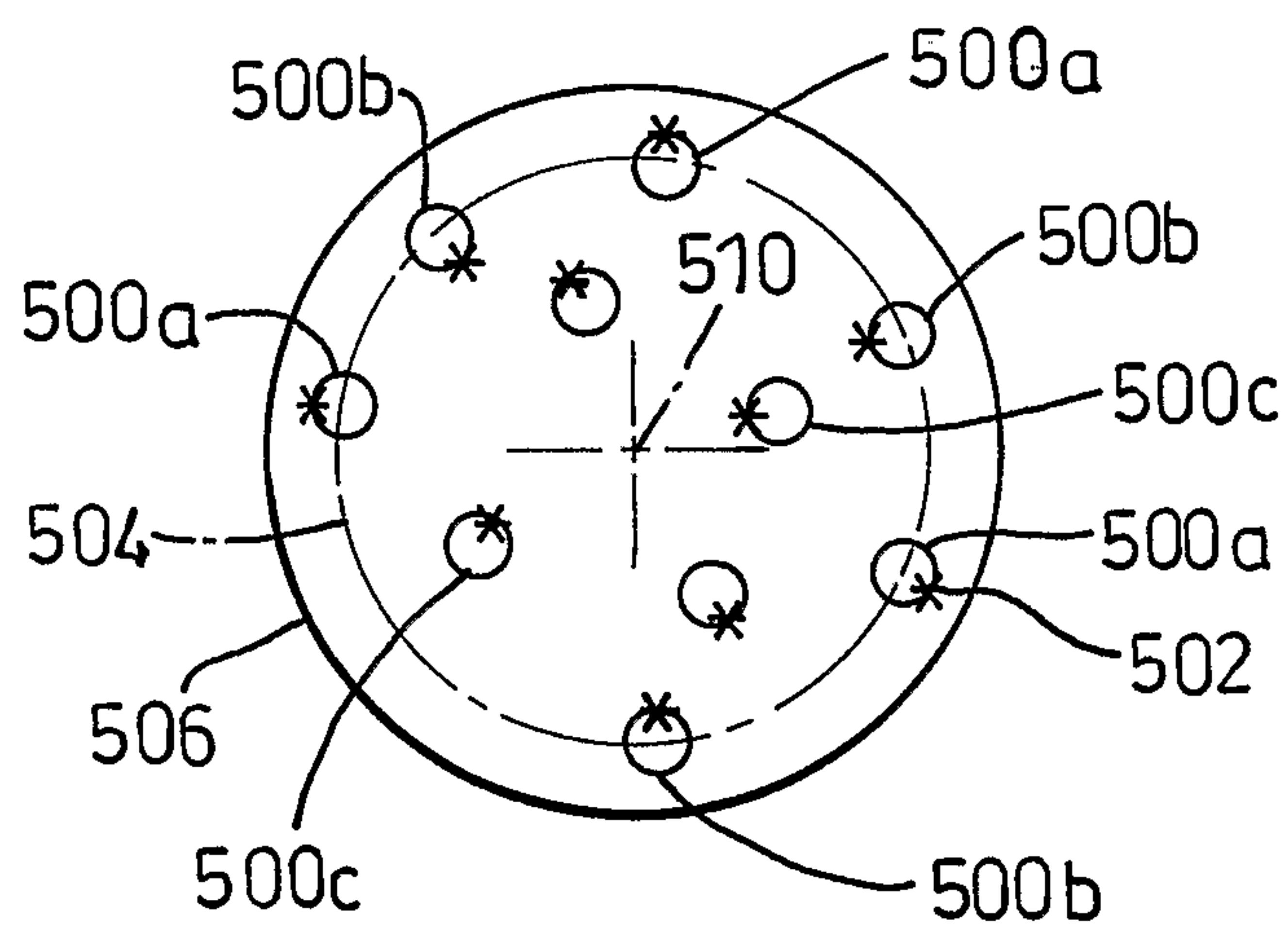
Fig. 4

5/7***Fig. 5***

6/7

**Fig. 6****Fig. 7****Fig. 8****Fig. 9****Fig. 10****Fig. 11**

7/7

**Fig. 12****Fig. 13****Fig. 14**

