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(54) **APPARATUS FOR SEPARATING PARTICLES FROM A FLUID FLOW**

VORRICHTUNG ZUM ABTRENNEN VON TEILCHEN AUS EINEM FLUIDSTROM

DISPOSITIF PERMETTANT DE SEPARER DES PARTICULES D'UN ECOULEMENT FLUIDIQUE

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Description

[0001] The present invention relates to apparatus for separating particles, such as dirt and dust particles, from an airflow.

[0002] It is well known to separate particles, such as dirt and dust particles, from a fluid flow using a cyclonic separator. Known cyclonic separators are used in vacuum cleaners, for example, and have been known to comprise a low efficiency cyclone for separating fluff and relatively large particles and a high efficiency cyclone located downstream of the low efficiency cyclone for separating the fine particles which remain entrained within the airflow (see, for example, EP 0 042 723B). It is also known to provide, in vacuum cleaning apparatus, an upstream cyclonic separator in combination with a plurality of smaller, downstream cyclonic separators, the downstream cyclonic separators being arranged in parallel with one another. An arrangement of this type is shown and described in US 3,425,192 to Davis.

[0003] In vacuum cleaner applications, particularly in domestic vacuum cleaner applications, it is desirable for the appliance to be made as compact as possible without compromising the performance of the appliance. It is also desirable for the efficiency of the separation apparatus contained within the appliance to be as efficient as possible (ie. to separate as high a proportion as possible of very fine dust particles from the airflow). It is therefore an object of the present invention to provide improved apparatus for separating particles from a fluid flow. It is a further object of the present invention to provide apparatus for separating particles from a fluid flow having an improved separation efficiency or pressure drop and having a compact arrangement. It is a further object of the invention to provide improved apparatus for separating particles from a fluid flow and suitable for use in a domestic vacuum cleaner.

[0004] The invention provides a domestic vacuum cleaner according to claim 1.

[0005] The arrangement of the invention makes use of the high separation efficiency achievable by a plurality of parallel cyclones whilst also allowing the combination of the upstream and downstream cyclonic separators to be compactly packaged. This allows the apparatus to be utilised in an appliance such as a domestic vacuum cleaner.

[0006] Preferably, each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to at least one third of the length of the respective downstream cyclonic separator. More preferably, each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to at least half of the length of the respective downstream cyclonic separator. Still more preferably, each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to at least two thirds of the length of the respective downstream

cyclonic separator. These arrangements give rise to convenient and compact packaging solutions.

[0007] Embodiments of the invention will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a schematic perspective view of apparatus according to a first embodiment of the present invention;

Figure 2a is a longitudinal section through apparatus according to a second embodiment of the present invention;

Figure 2b is a sectional view taken along the line II-II of Figure 2a;

Figure 3a is a longitudinal section taken through apparatus according to a third embodiment of the present invention;

Figure 3b is a section taken along the line III-III of Figure 3a.

[0008] The basic principle of the present invention is illustrated in Figure 1. In Figure 1, the apparatus 10 for separating particles from a fluid flow comprises an upstream cyclone 12 having an upper end 14 and a base 16. A side wall 18 extends between the upper end 14 and the base 16. The side wall 18 is frusto-conical so that the upstream cyclone 12 tapers outwardly away from the upper end 14. A tangential inlet 20 is provided in the side wall 18 adjacent the upper end 14. The tangential inlet 20 is capable of delivering particle-laden fluid to the interior of the upstream cyclone 12 in a direction which is tangential to the side wall 18 so as to set up a swirling flow in the interior of the upstream cyclone 12. In many of the applications for which the apparatus 10 is intended to be used, the fluid is air and the particles are dirt and dust such as will be found in a domestic environment.

[0009] The upstream cyclone 12 has an outlet (not shown) which is located centrally of the upper end 14 and communicates with the interior of the upstream cyclone 12. The outlet comprises a generally cylindrical pipe which extends vertically upwardly from the upper end 14 of the upstream cyclone 12. The outlet divides into four inlet conduits 24 in a symmetrical and even manner. Each inlet conduit 24 is dimensioned and arranged so as to receive one quarter of any fluid flow traveling along the outlet from the upstream cyclone 12.

[0010] Each inlet conduit 24 communicates with a downstream cyclone 26. Each downstream cyclone 26 has an upper cylindrical portion 28 with which the respective inlet conduit 24 communicates in a tangential manner. A frusto-conical cyclone portion 30 depends from each upper cylindrical portion 28 and has an open cone opening 32 remote therefrom. Each downstream

cyclone 26 has a longitudinal axis (not shown) about which the respective upper cylindrical portion 28 and frusto-conical cyclone portion 30 are arranged. The four downstream cyclones 26 are inclined to the vertical so that their longitudinal axes approach one another in a downward direction. The cone openings 32 are therefore arranged close to one another and symmetrically about a longitudinal axis of the upstream cyclone 12.

[0011] Each of the frusto-conical cyclone portions 30 passes through the upper end 14 of the upstream cyclone 12. In the upper end 14, four appropriately-sized apertures 31 are arranged. Each of the frusto-conical cyclone portions 30 is fixed to the rim of the respective aperture 31 in a manner which maintains a seal therebetween.

[0012] A cylindrical collector 34 is arranged inside the upstream cyclone 12. The cylindrical collector 34 extends between the base 16 of the upstream cyclone 12 and meets the frusto-conical cyclone portions 30 of the downstream cyclones 26 at a location which is slightly above the cone openings 32. Although it is not shown in Figure 1, the cylindrical collector 34 has an upper face through which the lower ends of the frusto-conical cyclone portions 30 pass in such a manner as to seal the interior of the cylindrical collector 34 from the remainder of the interior of the upstream cyclone 12.

[0013] Each of the four downstream cyclones 26 has an outlet conduit 36 located centrally of the respective upper cylindrical portion 28. The outlet conduits 36 meet at a junction 38 to form a combined outlet 40. Fluid entering the apparatus 10 via the tangential inlet 20 is expelled via the combined outlet 40. In some applications, for example in vacuum cleaner applications, the combined outlet 40 will be connected in a known manner to a vacuum source.

[0014] The apparatus 10 described above operates in the following manner. A fluid flow in which particles are entrained enters the apparatus 10 via the tangential inlet 20. The orientation of the tangential inlet 20 causes the fluid flow to follow a helical path within the upstream cyclone 12 so that the fluid flow travels downwardly towards the base 16. Relatively large particles entrained within the incoming fluid flow are deposited in the lower portion of the interior of the upstream cyclone 12 adjacent the base 16. The fluid flow, in which smaller particles remain entrained, moves inwardly and upwardly towards the upper end 14 of the upstream cyclone 12. The fluid flow exits the upstream cyclone 12 via the outlet (not shown) along which the fluid flow travels until it is split into four separate fluid flows which travel along the inlet conduits 24 to the downstream cyclones 26. When each portion of the fluid flow reaches the upper cylindrical portion 28 of the respective downstream cyclone 26, it again follows a helical path therein in view of the tangential orientation of the inlet conduit 24. The fluid flow then follows a further helical path down the frusto-conical cyclone portion 30 of the downstream cyclone 26 and, during this time, many of the fine particles are sep-

arated from the fluid flow. The separated fine particles are deposited inside the cylindrical collector 34 whilst the particle-free fluid leaves the downstream cyclone 26 via the outlet conduit 36. The separate fluid flows are recombined at the junction 38 and leave the apparatus 10 via the combined outlet 40.

[0015] In this embodiment, the downstream cyclones 26 project into the interior of the upstream cyclone 12 to such an extent that approximately one third of the length of each downstream cyclone 26 is located inside the upstream cyclone 12. The arrangement is compact and efficient and therefore suitable for use in an application where dimensions are to be kept as small as possible. An example of such an application is a domestic vacuum cleaner in which considerations of size and weight are of considerable importance. In such an application, the combined outlet 40 will be connected to a vacuum source and the tangential inlet 20 will be connected to a dirty air inlet of the vacuum cleaner. In a cylinder vacuum cleaner, the dirty air inlet will take the form of a hose and wand assembly. In an upright vacuum cleaner, the dirty air inlet will take the form of a cleaner head forming part of the vacuum cleaner as a whole. Arrangements can, of course, be made within an upright vacuum cleaner for conversion to operation in a cylinder mode. The mode of operation of the vacuum cleaner has no effect on the apparatus illustrated above.

[0016] In all vacuum cleaner applications, the apparatus 10 described above will require periodic emptying of separated particles. One way to achieve this would be to arrange for the base 16 to be made removable from the side wall 18 for emptying purposes. In this case, it is specifically advantageous if the cylindrical collector 34 is formed primarily by way of a cylindrical wall which meets and abuts against the base 16. The interior of the cylindrical collector 34 is therefore delimited at the lower end by the base 16. This allows both the cylindrical collector 34 and the remainder of the upstream cyclone 12 to be emptied simultaneously. Alternatively, the upstream cyclone 12 can be made separable at a position between the upper end 14 and the base 16, preferably in the vicinity of the upper end 14. The point of separation is advantageously located so that the upper end 14 and a portion of the side wall 18 incorporating the tangential inlet 20, together with the downstream cyclones 26, are separable from the remainder of the side wall 18 together with the cylindrical collector 34.

[0017] A second embodiment of the invention is shown in Figures 2a and 2b. In this embodiment, the upstream cyclone 112 again has an upper end 114 and a base 116. The side wall 118 is cylindrical so that the overall shape of the upstream cyclone 112 is also cylindrical. A tangential inlet 120 is again provided adjacent the upper end 114 of the upstream cyclone 112.

[0018] In this second embodiment, only two downstream cyclones 126 are provided. Therefore, the outlet 122 from the upstream cyclone 112 is divided into only two separate inlet conduits 124. The inlet conduits 124

each communicate in a tangential manner with the upper cylindrical portion 128 of the respective downstream cyclone 126.

[0019] In this embodiment, the longitudinal axis 142 of each downstream cyclone lies parallel to the longitudinal axis 144 of the upstream cyclone 122. Each downstream cyclone 126 has a generally cylindrical collector 134 depending from the frusto-conical cyclone portion 130. Each cylindrical collector 134 extends downwardly from the frusto-conical cyclone portion 130 just above the cone opening 132 to the base 116 of the upstream cyclone 112. Each downstream cyclone 126 also has an outlet conduit 136 which is located centrally of the respective upper cylindrical portion 128 and which merges with the other outlet conduits 136 to form a combined outlet 140.

[0020] The operation of the apparatus 110 illustrated in Figures 2a and 2b is similar to that of the apparatus 10 shown in Figure 1. Fluid in which particles requiring separation are entrained enters the cyclone 112 via the tangential inlet 120. The fluid follows a helical path down the cylindrical side wall 118 of the upstream cyclone 112 and larger particles are deposited inside the upstream cyclone 112 adjacent the base 116. Partially cleaned fluid then leaves the upstream cyclone 112 via the outlet 122 and the fluid flow is then divided into two separate fluid flows. Each separate fluid flow is then conducted to a downstream cyclone 126 in which the fluid flow follows a helical path about the upper cylindrical portion 128 and the frusto-conical cyclone portion 130 during which time the fluid flow is accelerated to high angular velocities. In this way, fine particles are separated from the fluid flow and deposited in the cylindrical collectors 134. The cleaned fluid flow leaves the downstream cyclones 126 via the outlet conduits 136 and, subsequently, via the combined outlet 140.

[0021] As can be seen from Figure 2a, the downstream cyclones 126 project into the upstream cyclone 112 through the upper end 114 thereof. The arrangement is such that the downstream cyclones 126 project into the upstream cyclone 112 to such an extent that approximately two thirds of the length of each downstream cyclone 126 is located in the interior of the upstream cyclone 112. This arrangement provides an extremely compact and useful arrangement in which the efficiency of the upstream cyclone 112 is not compromised to any significant extent. In other respects, the apparatus 110 is similar to the apparatus 10 shown in Figure 1 and described above.

[0022] A third embodiment of the invention is shown in Figures 3a and 3b. In this embodiment, as in the embodiment shown in Figure 1, the apparatus 210 comprises an upstream cyclone 212 and four downstream cyclones 226. Also, as shown in Figure 1, the longitudinal axes 242 of the downstream cyclones 226 are inclined towards the longitudinal axis 244 of the upstream cyclone 212. A further similarity between the embodiment shown in Figure 1 and that shown in Figures 3a

and 3b is that all four of the downstream cyclones 226 have cone openings 232 which are surrounded and enclosed by a single cylindrical collector 234.

[0023] There are two major differences between the apparatus 10 shown in Figure 1 and the apparatus 210 shown in Figures 3a and 3b. In the apparatus 210 shown in Figures 3a and 3b, the side wall 218 of the upstream cyclone 212 is frusto-conical and tapers inwardly from the upper end 214 towards the base 216. Thus, the interior of the upstream cyclone 212 has a generally inwardly-tapering configuration.

[0024] The second difference between the apparatus 10 shown in Figure 1 and the apparatus 210 shown in Figures 3a and 3b is that, in the apparatus 210 shown in Figures 3a and 3b, each downstream cyclone 226 projects into the interior of the upstream cyclone 212 to such an extent that approximately one half of each of the downstream cyclones 226 is located inside the upstream cyclone 212. This, in combination with the inwardly-tapering shape of the upstream cyclone 212 provides another compact and economical arrangement of the apparatus 210.

[0025] The operation of the apparatus 210 is similar to that of the apparatus previously described in detail.

[0026] It will be appreciated from the foregoing description of the three illustrated embodiments that the invention is not limited by the shape of the upstream cyclone or the extent to which the downstream cyclones project into the interior thereof. Furthermore, any convenient manner of emptying the apparatus illustrated above can be employed. The skilled reader will also appreciate that the means by which the fluid flow is divided and recombined does not have a material effect on the fundamental aspects of the invention. Therefore, modifications and variations to these and other aspects of the embodiments illustrated are intended to fall within the scope of the invention as defined by the claims.

Claims

1. A domestic vacuum cleaner incorporating apparatus (10) for separating dirt and dust particles from an airflow comprising an upstream cyclonic separator (12) and a plurality of downstream cyclonic separators (26) arranged in parallel with one another, **characterised in that** each of the downstream cyclonic separators (26) projects, partially, into the interior of the upstream cyclonic separator (12).
2. A domestic vacuum cleaner as claimed in claim 1, wherein the upstream cyclonic separator comprises a generally cylindrical chamber having a tangential or scroll entry thereto.
3. A domestic vacuum cleaner as claimed in claim 1, wherein the upstream cyclonic separator comprises an outwardly tapering chamber having a tangential

or scroll entry thereto.

4. A domestic vacuum cleaner as claimed in claim 1, wherein the upstream cyclonic separator comprises an inwardly tapering chamber having a tangential or scroll entry thereto.
5. A domestic vacuum cleaner as claimed in any one of the preceding claims, wherein each of the downstream cyclonic separators comprises a frusto-conically - tapering cyclone.
6. A domestic vacuum cleaner as claimed in any one of the preceding claims, wherein each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to substantially one third of the length of the respective downstream cyclonic separator.
7. A domestic vacuum cleaner as claimed in claim 6, wherein each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to substantially half of the length of the respective downstream cyclonic separator.
8. A domestic vacuum cleaner as claimed in claim 7, wherein each of the downstream cyclonic separators projects into the interior of the upstream cyclonic separator by a distance equal to substantially two thirds of the length of the respective downstream cyclonic separator.

Patentansprüche

1. Haushaltstaubsauger, der eine Vorrichtung (10) zum Abscheiden von Schmutz und Staubeilchen aus einem Luftstrom einschließt, die einen stromaufwärts gelegenen Zyklonabscheider (12) und eine Vielzahl von stromabwärts gelegenen, parallel zueinander angeordneten Zyklonabscheidern (26) umfaßt, **dadurch gekennzeichnet, daß** jeder der stromabwärts gelegenen Zyklonabscheider (26) teilweise in das Innere des stromaufwärts gelegenen Zyklonabscheiders (12) vorsteht.
2. Haushaltstaubsauger nach Anspruch 1, bei dem der stromaufwärts gelegene Zyklonabscheider eine allgemein zylindrische Kammer mit einem Tangential- oder Spiraleintritt zu derselben umfaßt.
3. Haushaltstaubsauger nach Anspruch 1, bei dem der stromaufwärts gelegene Zyklonabscheider eine sich nach außen verjüngende Kammer mit einem Tangential- oder Spiraleintritt zu derselben umfaßt.
4. Haushaltstaubsauger nach Anspruch 1, bei dem

der stromaufwärts gelegene Zyklonabscheider eine sich nach innen verjüngende Kammer mit einem Tangential- oder Spiraleintritt zu derselben umfaßt.

5. Haushaltstaubsauger nach einem der vorhergehenden Ansprüche, bei dem jeder der stromabwärts gelegenen Zyklonabscheider einen sich kegeltumpfförmig verjüngenden Zyklon umfaßt.
6. Haushaltstaubsauger nach einem der vorhergehenden Ansprüche, bei dem jeder der stromabwärts gelegenen Zyklonabscheider um eine Entfernung, die wesentlich einem Drittel der Länge des jeweiligen stromabwärts gelegenen Zyklonabscheiders entspricht, in das Innere des stromaufwärts gelegenen Zyklonabscheiders vorsteht.
7. Haushaltstaubsauger nach Anspruch 6, bei dem jeder der stromabwärts gelegenen Zyklonabscheider um eine Entfernung, die wesentlich der Hälfte der Länge des jeweiligen stromabwärts gelegenen Zyklonabscheiders entspricht, in das Innere des stromaufwärts gelegenen Zyklonabscheiders vorsteht.
8. Haushaltstaubsauger nach Anspruch 6, bei dem jeder der stromabwärts gelegenen Zyklonabscheider um eine Entfernung, die wesentlich zwei Dritteln der Länge des jeweiligen stromabwärts gelegenen Zyklonabscheiders entspricht, in das Innere des stromaufwärts gelegenen Zyklonabscheiders vorsteht.

35 Revendications

1. Aspirateur domestique incorporant un appareil (10) pour séparer les particules de saletés et de poussières d'un écoulement d'air, comprenant un séparateur cyclonique amont (12) et plusieurs séparateurs cycloniques aval (26) agencés parallèlement les uns aux autres, **caractérisé en ce que** chacun des séparateurs cycloniques aval (26) déborde en partie dans l'intérieur du séparateur cyclonique amont (12).
2. Aspirateur domestique selon la revendication 1, dans lequel le séparateur cyclonique amont comprend une chambre généralement cylindrique comportant une entrée tangentielle ou en volute.
3. Aspirateur domestique selon la revendication 1, dans lequel le séparateur cyclonique amont comprend une chambre effilée vers l'extérieur comportant une entrée tangentielle ou en volute.
4. Aspirateur domestique selon la revendication 1, dans lequel le séparateur cyclonique amont com-

prend une chambre effilée vers l'intérieur comportant une entrée tangentielle ou en volute.

5. Aspirateur domestique selon l'une quelconque des revendications précédentes, dans lequel chacun des séparateurs cycloniques aval comprend un cyclone effilé en tronc de cône. 5
6. Aspirateur domestique selon l'une quelconque des revendications précédentes, dans lequel chacun des séparateurs cycloniques aval déborde dans l'intérieur du séparateur cyclonique amont d'une distance représentant à peu près un tiers de la longueur du séparateur cyclonique aval respectif. 10
7. Aspirateur domestique selon la revendication 6, dans lequel chacun des séparateurs cycloniques aval déborde dans l'intérieur du séparateur cyclonique amont d'une distance représentant à peu près la moitié de la longueur du séparateur cyclonique aval respectif. 15 20
8. Aspirateur domestique selon la revendication 7, dans lequel chacun des séparateurs cycloniques aval déborde dans l'intérieur du séparateur cyclonique amont d'une distance représentant à peu près les deux tiers de la longueur du séparateur cyclonique aval respectif. 25

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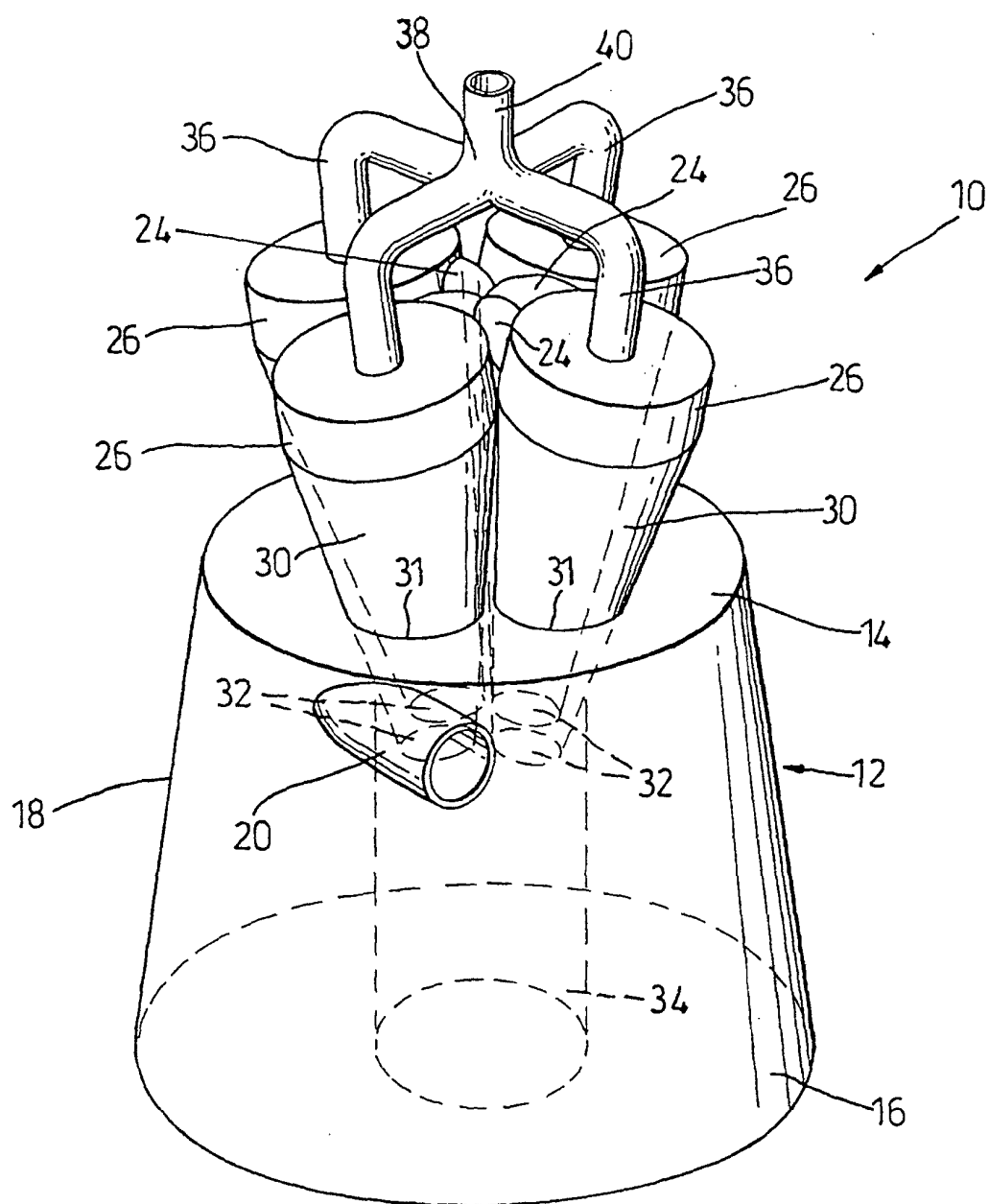


Fig. 1

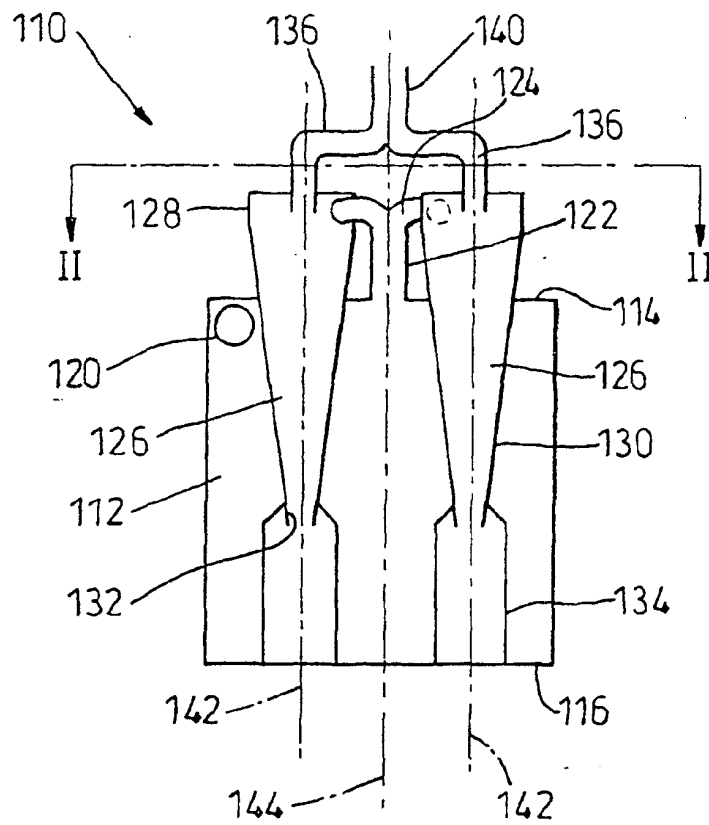


Fig. 2a

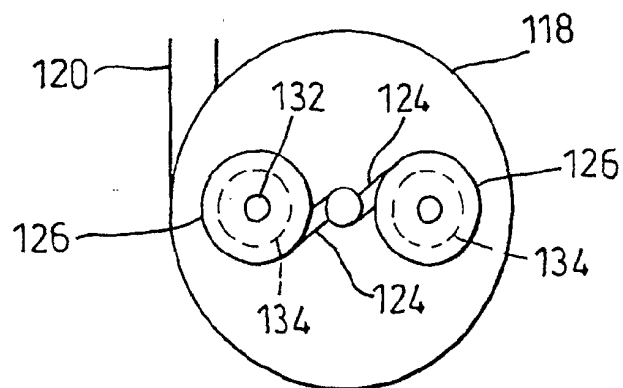


Fig. 2b

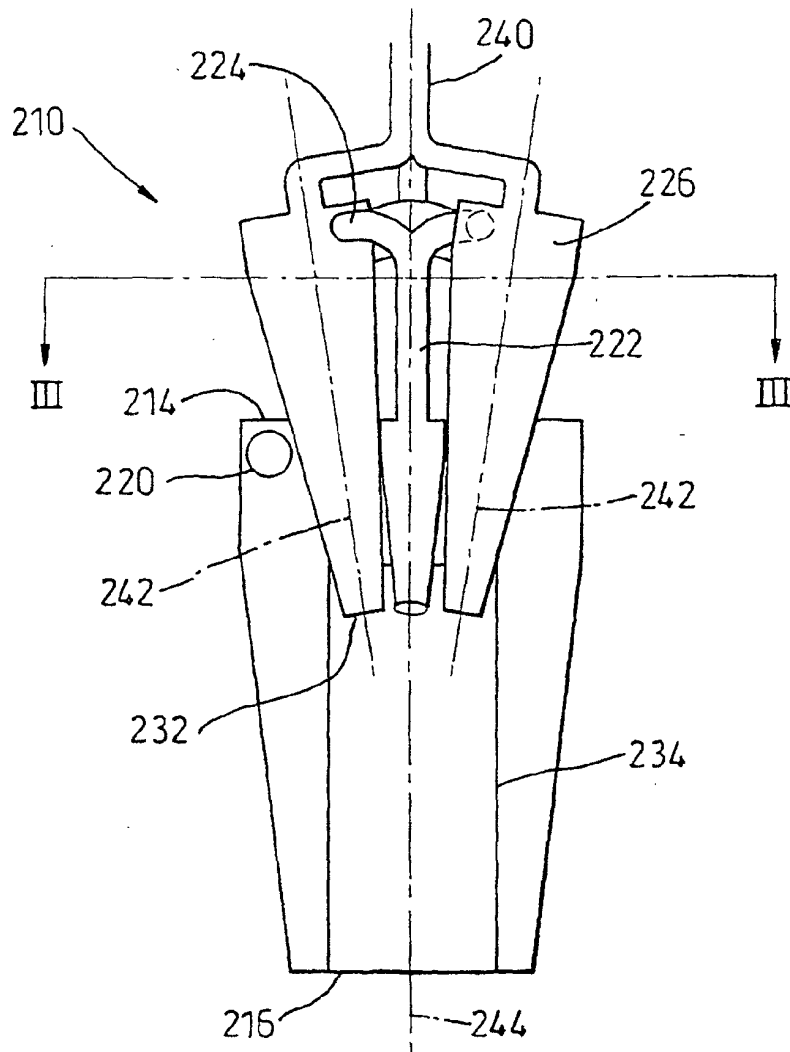


Fig. 3a

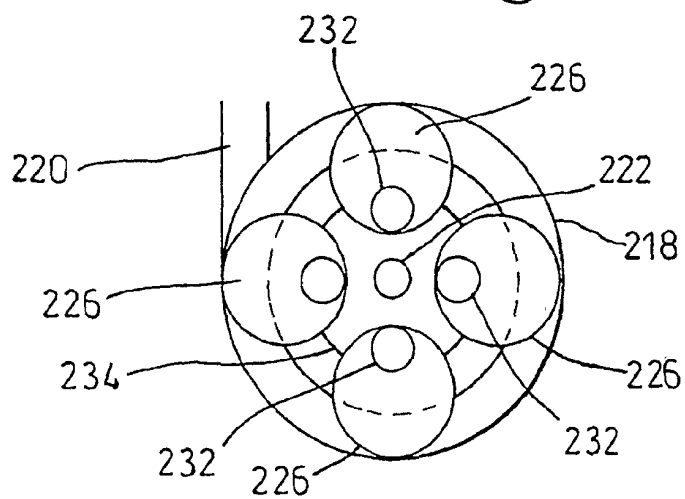


Fig. 3b