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(54) **Temperature control system for a roller in an image forming apparatus**

Temperatursteuerungssystem für eine Walze einer Bilderzeugungsvorrichtung

Système de contrôle de la température pour un rouleau dans un appareil de formation d’images

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JP-A- 8 145 045
JP-A- 57 106 416
JP-A- 60 122 979
US-A- 5 426 495

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Description

[0001] A temperature control system for a roller that is detachably mounted in a frame of an image forming apparatus, the system comprising:

- a primary liquid circuit formed in the roller and containing a first liquid;
- a secondary liquid circuit formed outside of the roller and containing a second liquid; and
- a heat exchanger arranged to bring the first and second liquid circuits into thermal contact with one another and comprising a first heat exchange member (30) that is in thermal contact with the first liquid circuit and projects outwardly from the roller,

[0002] In an image forming apparatus such as a printer, a copier or the like, several types of rollers need cooling or, more generally, temperature control during the image forming process. Such rollers include, for example, cooling rollers in a heat fuse station of a printer or the like, rollers supporting a photoconductor or a developing unit, guide and deflection rollers for image carrier belts, photoconductor drums or other image forming drums such as drums for a direct induction (DI) image forming process, and many more. It is preferable to use a liquid as coolant or heat transfer medium, because it permits to dissipate more heat in high speed image forming apparatus and or to provide a more uniform temperature distribution within the roller. However, if the liquid coolant is to circulate through the interior of the roller and through an external cooling device in order to permit efficient and uniform cooling, the coolant liquid circuit inside the roller has to be connected to an external circuit through a rotary seal, and this makes it more difficult to detach the roller for maintenance or repair purposes or for exchanging the roller. This is particularly cumbersome for rollers that need to be exchanged regularly because their lifetime is shorter than the lifetime of the apparatus as a whole. In particular, there is a risk that coolant liquid leaks out when the roller is disconnected from or connected to the external circuit.

[0003] JP 60-122 979 A, JP 08-145 045 A and JP 57-106 416 discloses a temperature control (cooling) systems of the type indicated above, which have the advantage that the coolant may be permanently enclosed in an internal liquid circuit of the roller, so that it will not leak out when the roller is detached. In a preferred embodiment disclosed in JP 60-122 979 A, the heat exchanger is simply formed by cooling fins projecting from the roller, and the secondary or external coolant medium is simply formed by air that is blown against the cooling fins. Although this document mentions also the possibility that the secondary coolant medium may be a liquid, it does not disclose how a secondary liquid circuit could be configured so as to permit easy detachment of the roller. If the liquid of the secondary coolant circuit is to flow past the cooling fins of the roller, then there is still the problem that the liquid has to be sealed against the detachable roller. In JP 08-145 045 A, the second cooling liquid is sprayed directly onto the cooling fins of the roller. JP 57-106 416 proposes a system where a heat pipe projects axially from the roller an is immersed in the second cooling liquid.

[0004] JP-A-07049192 and US 5 426 496 A discloses a roll equipment and heating means for heating a hollow, rotating cylinder shaft of the roll equipment. The cylinder shaft has an end portion that is rotatably received in a heater, so that the end portion of the cylinder is heated by the heater. The cylinder shaft further contains a working liquid for distributing the heat in the cylinder.

[0005] It is an object of the invention to provide a temperature control system permits to efficiently control the temperature of the roller and nevertheless permits to easily and quickly detach and re-install the roller.

[0006] According to the invention, this object is achieved by a temperature control system of the type indicated above, wherein:

- the secondary liquid circuit is defined inside of a part that is stationary relative to the frame, said secondary liquid circuit being enclosed in said part so as to be separated from the roller;
- a temperature control device is provided for controlling the temperature of the second liquid;
- the heat exchanger comprises a second heat exchange member arranged on the stationary part to be in thermal contact with the second liquid circuit;
- and the first and second heat exchange members form heat transfer surfaces that are opposed to one other to permit heat transfer from one member to the other.

[0007] In this system, the liquid of the secondary circuit is temperature-controlled directly and is permanently enclosed inside of the stationary part and is thus separated from the roller, so that the roller may be detached without difficulty. An efficient heat transfer is assured by the two opposed heat transfer surfaces of the two separate members of the heat exchanger, so that the temperature of the first liquid and of the roller can be controlled indirectly.

[0008] More specific features of preferred embodiments of the invention are indicated in the dependent claims.

[0009] The term "roller", as used in this specification, designates a member or assembly that may be detached from the apparatus as a unit and includes at least one rotating component. If the roller includes also a stationary component, e.g. a stationary axle that supports a rotating drum, the first heat exchange member is preferably provided on the stationary member of the roller. In that case, the first and second heat transfer surfaces of the heat exchanger may be in direct contact with each other.

[0010] Optionally, a compensation member such as a metallic wire mesh or an indented metal sheet having a good thermal conductivity may be firmly interposed between the two heat transfer surfaces, so that a possible misalignment of the roller, manufacturing tolerances and the like, may be compensated for. A heat conductive paste, e.g. a paste including silver powder, may be used for further improving the thermal contact between the two heat transfer surfaces or between the compensation member at each of the heat transfer surfaces.

[0011] If the roller has a stationary axle, the first heat exchange member is preferably formed by at least one end portion of that axle. The primary liquid circuit may be defined by an annular space formed between the axle and the walls of a hollow drum of the roller that is rotatably supported on the axle. Thermal contact between the liquid in the primary circuit and the first heat exchange member may be established by the heat conductivity of the axle. Optionally, the primary liquid circuit may also extend into the interior of the axle, so that the liquid may circulate directly through the first heat exchange member.

[0012] The first liquid may be caused to circulate in the primary circuit by any known means, e.g., a pump that is integrated in the roller. Such means may also be formed by impeller blades formed in the rotating member or drum of the roller and possibly also on the stationary axle, so that the rotation of the drum may directly be utilised for propelling the liquid. In yet another embodiment, the primary liquid circuit may include passages that extend in a circumferential direction of the roller and include one or more check valves that permit a flow of the liquid through these passages only in one sense. Then, the inertia of the liquid may be utilized to enforce a flow of the liquid when the roller is accelerated or decelerated. If the roller rotates only at a very low speed or is only driven intermittently, with sufficiently long rest periods between the intervals in which the roller is driven, then the flow of the liquid may also be induced by thermal convection that establishes during the rest periods of the roller.

[0013] If the roller is arranged to rotate as a unit, i.e. has no stationary component, then the heat transfer surfaces of the first and second heat exchanger members will be arranged to rotate relative to one another and to maintain their mutually opposed relationship in spite of the rotation. For example, the heat transfer surfaces may extend in a plane normal to the axis of rotation, or they may be cylindrical surfaces centered on the axis of rotation. In order to avoid friction, the heat exchange surfaces will preferably be separated by a narrow gap which permits heat transfer through radiation. Optionally, the heat transfer may be promoted by a heat conductive grease or paste-like lubricant in the gap.

[0014] Embodiments of the invention will now be described in conjunction with the drawings, wherein:

- Fig. 1 shows a roller and an associated cooling system in a longitudinal section;
- Fig. 2 shows the roller and the cooling system of Fig. 1 in a condition when the roller is detached;
- Fig. 3 shows a roller and a cooling system according to another embodiment;
- Fig. 4 shows, in an enlarged longitudinal section, a roller according to yet another embodiment;
- Fig. 5 shows, in longitudinal section, an end portion of a roller and an associated cooling system according to yet another embodiment; and
- Fig. 6 is a cross-sectional view taken along the line VI-VI in Fig. 5.

[0015] As is shown in Fig. 1, a roller 10 comprises a stationary axle 12 that is rigidly and detachably flanged to a frame 14 of an image forming apparatus, and a cylindrical drum 16 that is rotatably supported on the axle 12 by means of bearings 18. It shall be assumed here that the peripheral wall of the drum 16 or at least the portion between the two bearings 18 needs to be temperature-controlled, e.g. cooled. To that end, the bearings 18 are configured as liquid-tight seals, so that an annular space formed between the two bearings 18 and between the outer peripheral surface of the axle 12 and the inner surface of the drum 16 defines a primary liquid circuit 20 that is filled with a liquid coolant, e.g., water. Thus, the heat generated at or transferred to the surface of the drum 16, e.g., because the drum 16 supports a belt or roller (not shown) that is heated in the course of the image forming process, is transferred from the peripheral wall of the drum 16 to the axle 12 through the heat conductivity and/or the flow of the water in the primary liquid circuit 20.

[0016] One end of the stationary axle 12 (on the right side in Fig. 1) is connected to a heat exchanger 22 which transfers the heat from the thermally conductive axle 12 onto a secondary liquid circuit 24 that is defined inside of a stationary part 26 of the image forming apparatus, i.e. a part rigidly connected to a portion of the frame 14 that has not been shown here. The secondary liquid circuit 24 contains another coolant liquid, e.g. water, that circulates through the stationary part 26 and a cooling device 28 such as a radiator or an active cooling device (heat pump). The cooling device 28 may also include a pump causing the liquid circulate through the circuit 24 and may be replaced or supplemented by a heating device, if necessary.

[0017] The heat exchanger 22 comprises a first heat exchange member 30 formed by a flange at the end of the axle 12, and a second heat exchange member 32 that is formed by an end wall of the stationary part 26 and is in direct thermal contact with the secondary liquid circuit 24. The first and second heat exchange members 30, 32 form two parallel heat transfer surfaces 34, 36, that are opposed to one another, so that a heat transfer may occur through radiation and/or heat conduction. In the example shown, the heat transfer surfaces 34, 36 form a gap that is filled by a thermally conductive compensation member 38, e.g. a wire mesh, that permits to compensate for any possible misalignment of the axle 12 of the roller 10. The compensation member 38 may also compensate for any possible deflection of the axle

12 when the drum 16 is subject to a mechanical load. Of course, in a modified embodiment, the compensation member 38 may be dispensed with, and the heat transfer surfaces 34, 36 may be in direct engagement with one another.

[0018] It will be appreciated that the first liquid circuit 20 is a closed circuit, so that the liquid therein is permanently sealed inside of the roller 10. On the other hand, the secondary liquid circuit 24 may be an open circuit, but is in thermal contact with the roller 10 only through the heat exchanger 22, and the liquid contained therein is nowhere in contact with any part of the roller 10. Thus, the roller 10 may easily be detached, as has been shown in Fig. 2, without any risk of leakage of liquid from the primary circuit 20 or the secondary circuit 24.

[0019] In the example shown, thermal contact between the first liquid circuit 20 and the first heat exchange member 30 is established through the heat conductivity of the axle 12 which may be made of metal. Further, the axle 12 is shown to have vertical bores 40 through which the liquid may circulate. Since the axle 12 is stationary, the bores 40 will retain their vertical orientation. The liquid in the left bore 40 in Fig. 1 will be cooled, because heat is dissipated towards the heat exchanger 22. As a result, a convective flow of the liquid will be established, as indicated by arrows in Fig. 1. In addition, the liquid may be stirred by the rotation of the drum 16. Of course, the bores 40 might be dispensed with, because the liquid may also flow around the axle 12 in the annular gap.

[0020] Fig. 3 shows a heat exchanger 22' according to a modified embodiment. Here, the first heat exchange member is formed by a cylindrical end portion of the axle 12 that is inserted into a blind bore in the end of the stationary part 26 that forms the second heat exchange member. Thus, the end face and the peripheral wall of the end portion of the axle 12 form heat transfer surfaces 34a and 34b, respectively, that are opposed to heat transfer surfaces 36a and 36b, respectively, formed by the bottom and the internal peripheral wall of the blind bore in the stationary part 26. Again, a gap between the heat transfer surfaces is filled by a heat conductive compensation member.

[0021] The second liquid circuit 24 incudes helical passages that surround the blind bore in close proximity to the heat transfer surface 36b, so that a good thermal contact is achieved when the liquid circulates in the helical passage.

[0022] In order to improve the thermal contact between the first liquid circuit 20 and the heat exchanger 22, the axle 12 according to this example accommodates a heat pipe 42.

Fig. 4 shows another example of a roller 10', wherein impeller blades 44 are formed on the inner peripheral wall of the drum 16, and stationary impeller blades 46 are formed on the outer periphery of the axle 12. The impeller blades 44 and 46 are arranged alternatingly and are inclined in opposite directions, so that the water in the first liquid circuit 20 will be propelled from right to left in Fig. 4 when the drum 16 rotates in the direction indicated by an arrow A. The stationary blades 46 prevent the water from corotating with the drum 10 when the latter is driven for a longer period of time.

[0023] The first liquid circuit 20 extends into the interior of the axle 12 through radial bores 48 and a central axial bore 50 which extends into the first heat exchange member 30 that is shaped as a flange, as in Fig. 1. At the end of the axial bore 50 on the right side in Fig. 4, the liquid that has been pumped into the passage 50 by the blades 44, 46 impinges onto the wall of the heat exchange member 30 forming the heat transfer surface 34 and is then radially spread into return ducts 52 that open into the annular space between the axle 12 and the drum 16, thus closing the liquid circuit.

[0024] In this embodiment, the coolant in the first liquid circuit 20 is still permanently enclosed in the roller 10', but is actively pumped through the member 30 of the heat exchanger, so that the heat transfer will be improved. Of course, this concept can also be used in combination with the heat exchanger 22' shown in Fig. 3.

[0025] Fig. 5 illustrates an example of a roller 10" that is arranged to rotate as a unit and is rotatably supported in the frame 14 by means of bearings 54. The first liquid circuit 20 is formed by the hollow interior of the roller 10". The heat exchanger 22' is of the type shown in Fig. 3, that is, the first heat exchange member is formed by an end portion of the roller 10" engaged in a blind bore of the stationary part 26. The gap between the heat transfer surfaces 34a, 34b and 36a, 36b is in this case not filled by any member that would cause friction, because the roller 10" rotates relative to the stationary part 26.

[0026] The second liquid circuit in the stationary part 26 is in this case formed by a lower supply passage 24a and an upper supply passage 24b that are both connected to an annular chamber 56 in the second heat exchange part 32. This annular chamber 56 surrounds the first heat exchange part 30 the interior of which forms a convection chamber 58.

[0027] The convection chamber 58 is connected to the first liquid circuit 20 via three axial passages 60, the configuration of which is more clearly shown in Fig. 6.

[0028] When the liquid in the convection chamber 58 is cooled because it is in thermal contact with the secondary liquid circuit, it will tend to sink down in the convection chamber 58 and to flow out through the two lower passages 60 shown in Fig. 6, while new hot liquid is sucked in through the upper passage 60. Thus, a convective circulation of the liquid in the first liquid circuit 20 is established. This convective flow may be disturbed when the roller 10" rotates at relatively high speed, but will be established again as soon as the roller 10" comes to rest. The arrangement of the three passages 60 assures that, in any angular position of the roller 10", there will always be at least two of the passages 60 having a height difference that induces the convective flow.

Claims

1. A temperature control system for a roller (10; 10'; 10") that is detachably mounted in a frame (14) of an image forming apparatus, the system comprising:

- a primary liquid circuit (20) formed in the roller and containing a first liquid;
- a secondary liquid circuit (24; 24a, 24b) formed outside of the roller and containing a second liquid; and
- a heat exchanger (22; 22') arranged to bring the first and second liquid circuits into thermal contact with one another and comprising a first heat exchange member (30) that is in thermal contact with the first liquid circuit (20) and projects outwardly from the roller,

characterised in that

- the secondary liquid circuit (24; 24a, 24b) is defined inside of a part (26) that is stationary relative to the frame (14), said secondary liquid circuit being enclosed in said part (26) so as to be separated from the roller (10; 10'; 10");
- a temperature control device (28) is provided for controlling the temperature of the second liquid;
- the heat exchanger (22; 22') comprises a second heat exchange member (32) arranged on the stationary part (26) to be in thermal contact with the second liquid circuit (24; 24a, 24b);
- and the first and second heat exchange members (30, 31) form heat transfer surfaces (34, 36; 34a, 34b, 36a, 36b) that are opposed to one other to permit heat transfer from one member to the other.

2. The system according to claim 1, wherein the first heat exchange member (30) is provided on a component (12) of the roller (10; 10') that is stationary relative to the frame (14).

3. The system according to claim 2, wherein the stationary component is an axle (12) of the roller, and the first heat exchange member (30) is formed by an end portion of the axle.

4. The system according to any of the preceding claims, wherein the heat transfer surfaces (34, 36) of the first and second heat exchange members (30, 32) are configured to engage a heat conductive, deformable compensation member (38) interposed therebetween.

5. The system according to claim 1, wherein the first heat exchange member (30) is formed on a rotating component of the roller (10"), and the opposed heat transfer surfaces (34a, 34b, 36a, 36b) are symmetric under rotation about the axis of rotation of the roller (10").

6. The system according to any of the preceding claims, wherein at least a portion of the opposed heat transfer surfaces (34, 36; 34a, 36a) extends in a plane normal to the axis of rotation of the roller.

7. The system according to any of the preceding claims, wherein at least a portion of the opposed heat transfer surfaces (34b, 36b) is cylindrical.

8. The system according to any of the preceding claims, wherein the first liquid circuit (20) extends into the first heat exchange member (30).

9. The system according to any of the preceding claims, wherein the temperature control device (28) is a cooling device.

Patentansprüche

1. Temperatursteuerungssystem für eine Walze (10; 10'; 10"), die lösbar in einem Gestell (14) einer Bilderzeugungsvorrichtung montiert ist, umfassend:

- einen in der Walze gebildeten primären Flüssigkeitskreis (20), der eine erste Flüssigkeit enthält,
- einen außerhalb der Walze gebildeten sekundären Flüssigkeitskreis (24; 24a, 24b), der eine zweite Flüssigkeit enthält, und
- einem Wärmeaustauscher (22; 22'), der dazu eingerichtet ist, die ersten und zweiten Flüssigkeitskreise in thermischen Kontakt miteinander zu bringen, und der ein erstes Wärmetauscherelement (30) enthält, das mit dem ersten Flüssigkeitskreis (20) in thermischem Kontakt steht und nach außen aus der Walze herausragt,

dadurch gekennzeichnet, daß

- der sekundäre Flüssigkeitskreis (24; 24a, 24b) im Inneren eines Bauteils (26) definiert ist, das relativ zu dem Gestell (14) stationär ist, wobei der zweite Flüssigkeitskreis so in diesem Bauteil (26) eingeschlossen ist, daß er von der Walze (10; 10'; 10") getrennt ist;
- eine Temperatursteuereinrichtung (28) dazu vorgesehen ist, die Temperatur der zweiten Flüssigkeit zu steuern,
- der Wärmeaustauscher (22; 22') ein zweites Wärmetauscherelement (32) aufweist, das so an dem stationären Teil (26) angeordnet ist, daß es mit dem zweiten Flüssigkeitskreis (24; 24a, 24b) in thermischem Kontakt steht, und

- die ersten und zweiten Wärmetauscherelemente (30, 31) Wärmeübertragungsflächen (34, 36; 34a, 34b, 36a, 36b) bilden, die einander gegenüberliegen, so daß der Wärmeübergang von einem Element zum anderen ermöglicht wird.

2. System nach Anspruch 1, bei dem das erste Wärmetauscherelement (30) an einer Komponente (12) der Walze (10; 10') angeordnet ist, die relativ zu dem Gestell (14) stationär ist.

3. System nach Anspruch 2, bei dem die stationäre Komponente eine Achse (12) der Walze ist und das erste Wärmetauscherelement (30) durch einen Endabschnitt der Achse gebildet wird.

4. System nach einem der vorstehenden Ansprüche, bei dem die Wärmeübertragungsflächen (34, 36) der ersten und zweiten Wärmetauscherelemente (30, 32) so konfiguriert sind, daß sie an einem zwischen ihnen eingefügten wärmeleitenden, verformbaren Ausgleichselement (38) anliegen.

5. System nach Anspruch 1, bei dem das erste Wärmetauscherelement (30) an einer rotierenden Komponente der Walze (10") ausgebildet ist und die einander gegenüberliegenden Wärmeübertragungsflächen (34a, 34b; 36a, 36b) unter Drehung um die Drehachse der Walze (10") symmetrisch sind.

6. System nach einem der vorstehenden Ansprüche, bei dem wenigstens ein Teil der einander gegenüberliegenden Wärmeübertragungsflächen (34, 36; 34a, 36a) sich in einer Ebene rechtwinklig zu der Drehachse der Walze erstreckt.

7. System nach einem der vorstehenden Ansprüche, bei dem wenigstens ein Teil der einander gegenüberliegenden Wärmeübertragungsflächen (34b, 36b) zylindrisch ist.

8. System nach einem der vorstehenden Ansprüche, bei dem der erste Flüssigkeitskreis (20) in das erste Wärmetauscherelement (30) hineinreicht.

9. System nach einem der vorstehenden Ansprüche, bei dem die Temperatursteuereinrichtung (28) eine Kühleinrichtung ist.

Revendications

1. Système de thermorégulation pour un rouleau (10 ; 10' ; 10") fixé de façon amovible dans un cadre (14) d'un appareil d'imagerie, le système comprenant :

- un circuit liquide primaire (20) formé dans le rouleau et contenant un premier liquide ;
- un circuit liquide secondaire (24 ; 24a ; 24b) formé à l'extérieur du rouleau et contenant un second liquide ; et
- un échangeur de chaleur (22 ; 22') configuré pour mettre les premiers et seconds circuits liquides en contact thermique l'un avec l'autre et comprenant un premier élément échangeur de chaleur (30) en contact thermique avec le premier circuit liquide (20) et faisant saillie vers l'extérieur depuis le rouleau,

ledit système étant **caractérisé en ce que** :

- le circuit liquide secondaire (24 ; 24a ; 24b) est défini à l'intérieur d'une partie (26) stationnaire par rapport au cadre (14), ledit circuit liquide secondaire étant enfermé dans ladite partie (26), de manière à être séparé du rouleau (10 ; 10' ; 10") ;
- un dispositif de thermorégulation (28) est prévu pour réguler la température du second liquide ;
- l'échangeur de chaleur (22 ; 22') comprend un second élément échangeur de chaleur (32) disposé sur la partie stationnaire (26) pour se trouver en contact thermique avec le second circuit liquide (24 ; 24a ; 24b) ;
- et le premier et le second éléments échangeurs de chaleur (30, 31) forment des surfaces de transfert thermique (34, 36 ; 34a, 34b, 36a, 36b) qui sont opposées l'une à l'autre pour autoriser le transfert thermique d'un élément à l'autre.

2. Système selon la revendication 1, dans lequel le premier élément échangeur de chaleur (30) est formé sur un composant (12) du rouleau (10 ; 10') qui est stationnaire par rapport au cadre (14).

3. Système selon la revendication 2, dans lequel le composant stationnaire est un axe (12) du rouleau et le premier élément échangeur de chaleur (30) est formé par une portion terminale de l'axe.

4. Système selon l'une quelconque des revendications précédentes, dans lequel les surfaces de transfert thermique (34, 36) des premier et second éléments échangeurs de chaleur (30, 32) sont configurées pour venir au contact d'un élément de compensation (38) déformable thermo-conducteur intercalé entre elles.

5. Système selon la revendication 1, dans lequel le premier élément échangeur de chaleur (30) est formé sur un composant rotatif du rouleau (10") et les surfaces opposées de transfert thermique (34a, 34b, 36a, 36b) sont symétriques lors de la rotation autour de l'axe de rotation du rouleau (10").

6. Système selon l'une quelconque des revendications précédentes, dans lequel au moins une portion des surfaces opposées de transfert thermique (34, 36 ; 34a, 36a) s'étendent dans un plan perpendiculaire à l'axe de rotation du rouleau.

7. Système selon l'une quelconque des revendications précédentes, dans lequel au moins une partie des surfaces opposées de transfert thermique (34b, 36b) est cylindrique.

8. Système selon l'une quelconque des revendications précédentes, dans lequel le premier circuit liquide (20) se prolonge dans le premier élément échangeur de chaleur (30).

9. Système selon l'une quelconque des revendications précédentes, dans lequel le dispositif de thermorégulation (28) est un dispositif de refroidissement.

Fig. 1

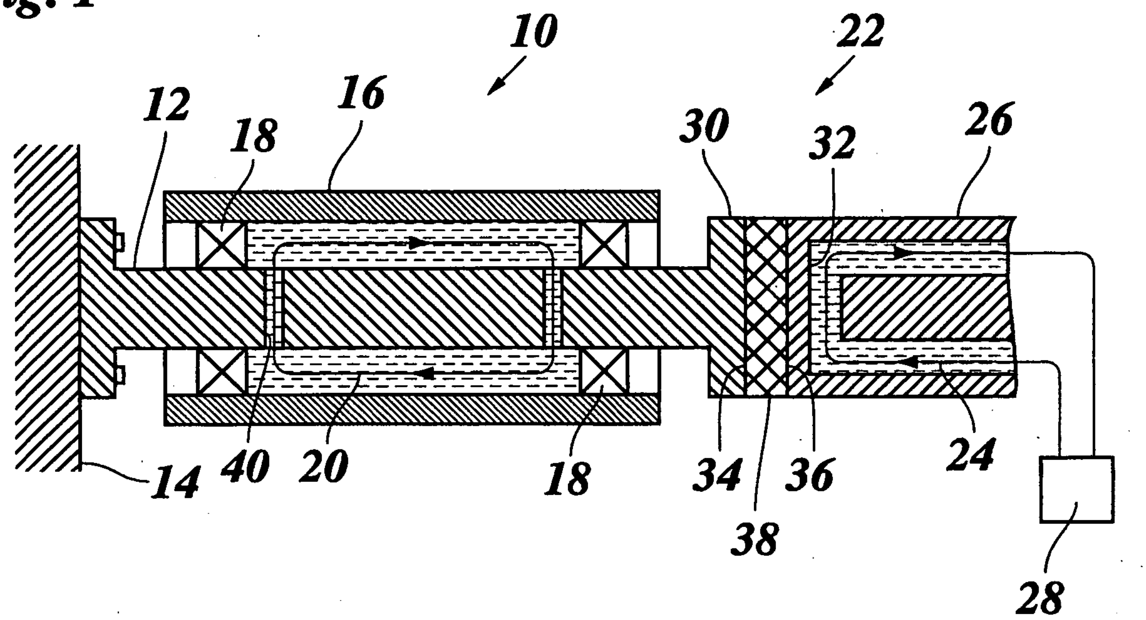


Fig. 2

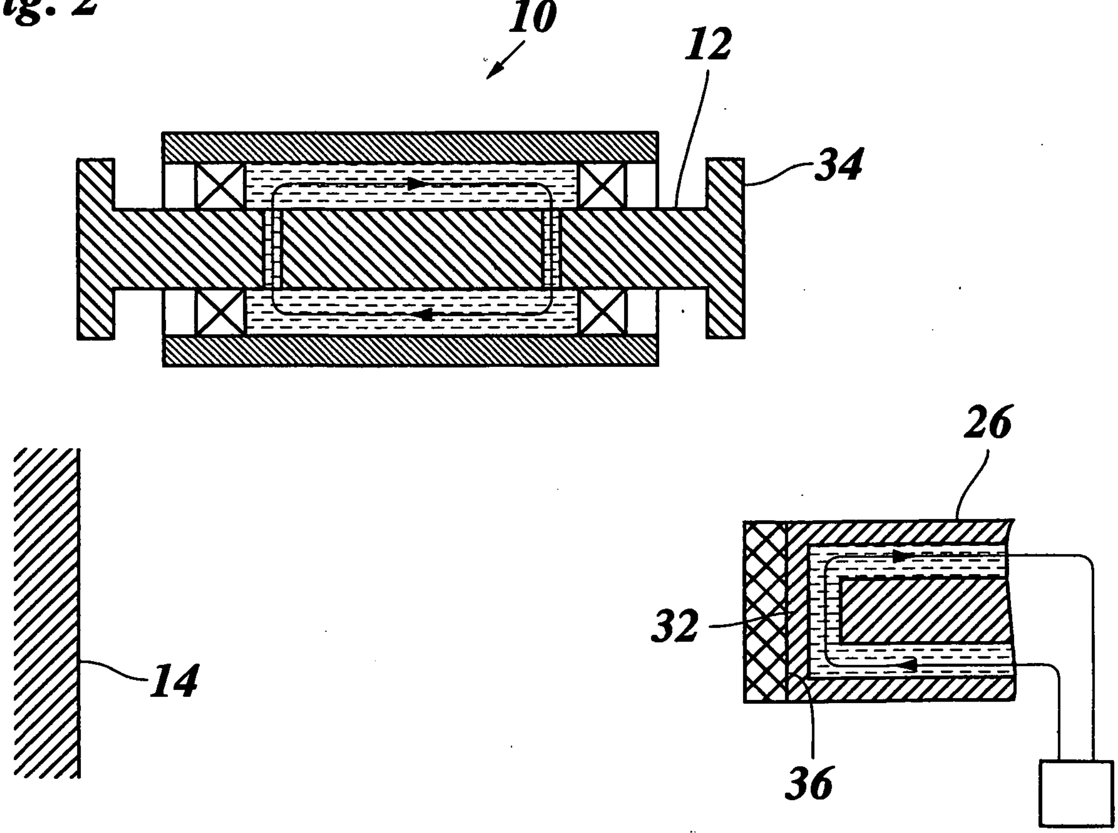


Fig. 3

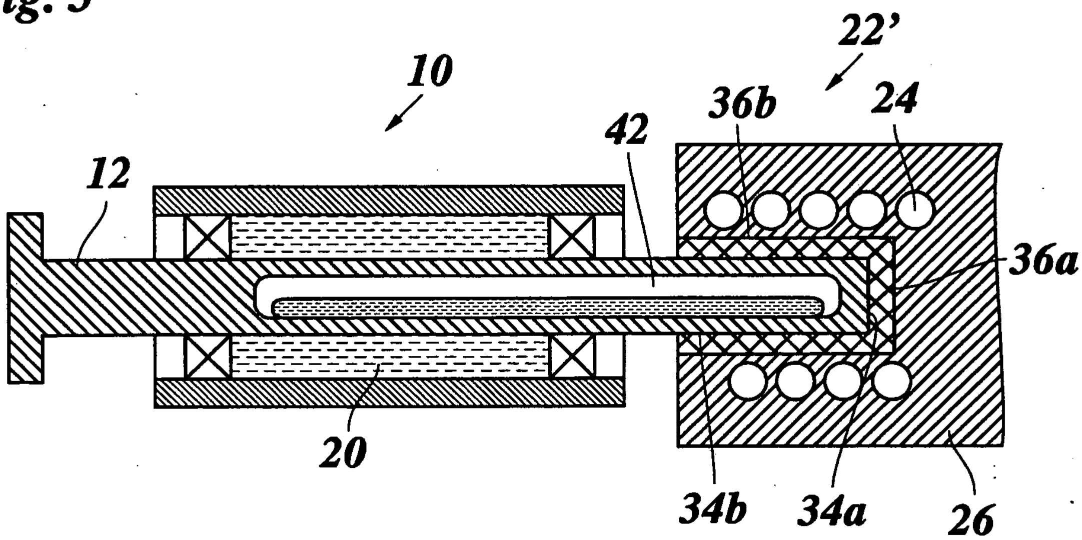

10
22'
36b
24
42
12
36a
20
34b
34a
26

Fig. 4

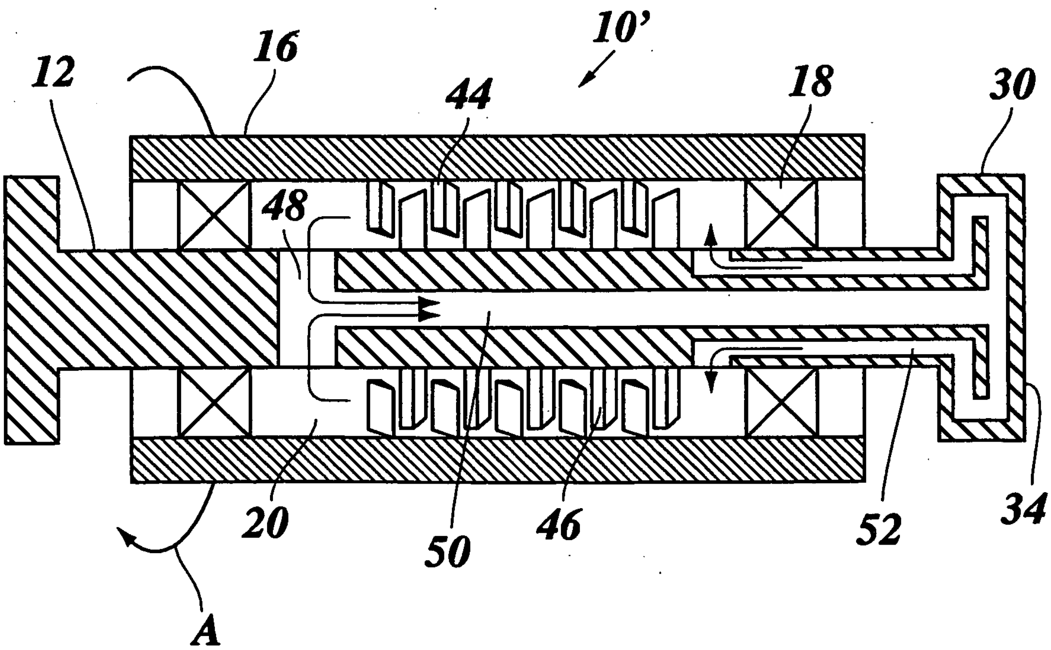

10'
16
12
44
18
30
48
20
50
46
52
34
A

Fig. 5

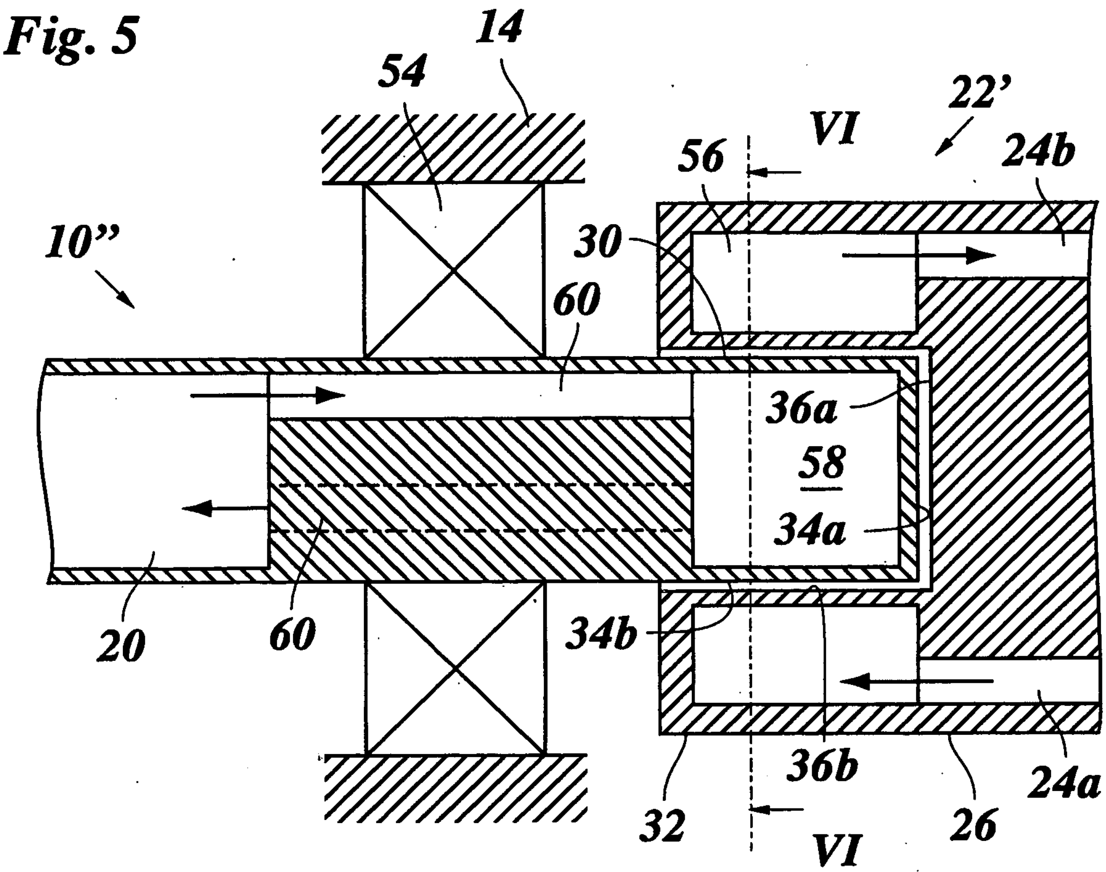
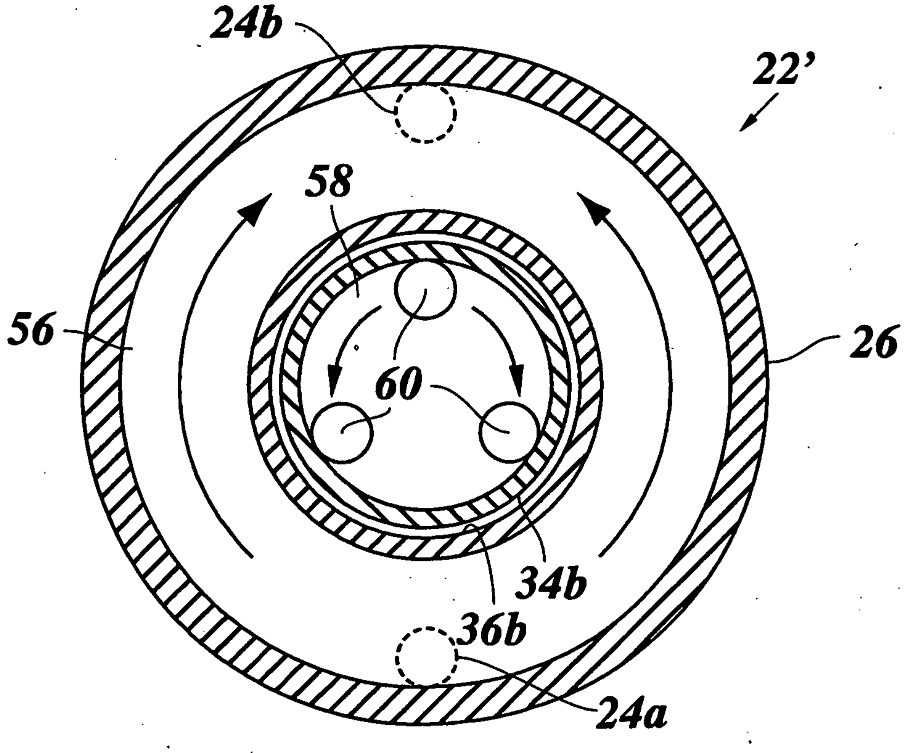

14
54
10"
30
60
56
VI
22'
24b
36a
58
34a
20
60
34b
36b
24a
32
26
VI

Fig. 6


24b
22'
58
56
60
26
34b
36b
24a

REFERENCES CITED IN THE DESCRIPTION

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