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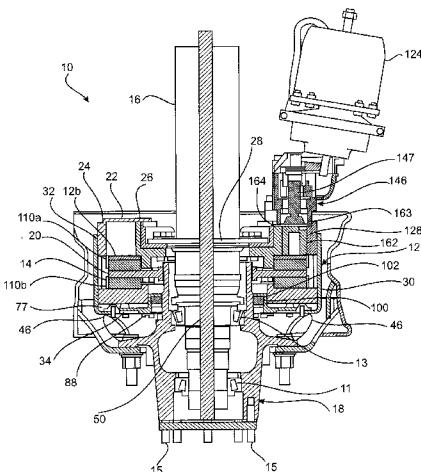


FIG. 1

(57) Abstract: Wet disc brake system (10) comprises a housing assembly (12) and brake callipers (14). Housing assembly (12) is provided with openings (24) for seating cylinders (22) of respective brake callipers (14). The callipers (14) are coupled to a structural component of a vehicle to which the system (10) is fitted and in particular a flange (28) of an axle housing (16). This enables reactive forces created during a braking operation to be transmitted via the callipers to the flange (28) and axle housing (16) rather than being carried by housing assembly (12). As housing assembly (12) does not bear any substantive load, it may be made of a relatively light weight construction or material. The application is also directed to a disc brake system comprising a service and park brake calliper provided with at least two cylinders wherein at least one cylinder houses a hydraulically operated service piston and at least one cylinder houses a park piston that is applied by a spring and released by air pressure.

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WET DISC BRAKE SYSTEM

Field of the Invention

5 The present invention relates to a disc brake system, and in particular, but not exclusively, to a wet disc brake system that is suitable for heavy vehicles which undergo a large number of braking events.

Background of the Invention

10 The present invention was developed to provide a solution to the high cost in servicing and maintaining the braking system of a garbage truck. As an example, one municipal authority indicated that a typical single front axle, tandem rear axle, garbage truck having a tare weight of over 11,500kg, with

15 419 mm x 152mm (6") S-cam brake drums on the front axle, and 419mm x 178mm (7") S-cam brake drums on the rear axle, requires a rear brake overhaul every six months, and a front brake overhaul every 12 months. This maintenance schedule incurs an annual cost in the order of US\$6,000 – US\$8,700.

20 While the present invention was developed to reduce braking system maintenance costs for a garbage truck, embodiments of the invention are not limited to such applications. Embodiments of the invention may be applied to other vehicles including other types of truck or heavy vehicle such as buses
25 irrespective of whether a braking profile for the truck comprises a relatively large number of braking events.

Summary of the Invention

30 One aspect of the invention provides a wet disc brake system comprising:
a housing configured to form a sealed cavity about a body rotating relative to the housing;
one or more brake callipers disposed in the housing, the brake callipers provided with one or more cylinders, the housing being provided with an
35 opening for each of the cylinders, wherein each cylinder is seated in a respective opening.

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The housing may comprise an outer casing which extends circumferentially about the one or more callipers, and a first plate demountably coupled to the outer casing, wherein the first plate is provided with the openings for the cylinders.

5

The wet disc brake system may comprise a respective seal located between each cylinder and forming a seal between that cylinder and a corresponding opening in which that cylinder is seated.

10 The first plate may comprise a plurality of holes through which fasteners pass to attach the callipers to an axle housing wherein load on the calliper during braking is transferred to the axle housing via the fasteners.

In one embodiment the outer casing has opposite first and second axial ends
15 and a lip projection radially inward extending about the second axial end.

The housing may comprise a second plate demountably attached to the lip of the outer casing, the second plate provided with an opening for recovering a hub which extends into the housing.

20

The second plate may be formed with an outer diameter greater than an inner diameter of the lip and wherein the second plate is disposed on a side of the lip inside of the outer casing.

25 The second plate may comprise an axially extending boss which defines the opening in the second plate for receiving the hub, the boss having a circumferential seat, and a seal on the seat which forms a liquid seal about the hub.

30 Each calliper may comprise first and second shells demountably coupled together, the first shell provided with the plurality of cylinders, the first and second shells being relatively shaped to form a cavity therebetween and through which the body rotates, the cavity opening onto an outer surface of the calliper to form a gap between the shells.

35

Each calliper may comprise at least one strap extending across the gap and coupled to each of the first and second shells.

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Opposite ends of each strap may seat in respective recesses formed in the first and second shells.

5 A second aspect of the invention may provide a brake system comprising a service and park brake calliper provided with at least two cylinders wherein at least one of the cylinders houses a hydraulic operated service piston to facilitate a service braking, and at least one cylinder housing a park piston which is applied by a spring and released by air pressure to facilitate a park 10 braking.

The brake system may further comprise a wear compensating actuator which transmits pressure from the spring to the park piston.

15 The park piston may comprise a central raised land against which pressure from the spring is transmitted by the wear compensating actuator to the park piston.

At least two of the cylinders may house respective service pistons, and at least 20 one cylinder may house the park piston is disposed between the cylinders housing the service pistons.

A third aspect of the invention may provide a heavy vehicle comprising:

25 a receptacle configured to transport material;
an air compressor;
a braking system driven by compressed air from the air compressor to brake motion of the heavy vehicle the brake system comprising a service brake and a park brake, the service brake being a wet air over hydraulic actuated disc brake, and the park brake being a spring applied and air released.

30 The braking system may comprise at least one brake calliper configured to provide both service brake and park brake.

35 The brake system may comprise service brakes on at least one axle of the heavy vehicle, and a combination of service and park brakes on at least one rear axle.

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The heavy vehicle may have a tare weight of at least 6 tonnes. In alternate embodiments the heavy vehicle may have a tare weight of at least 10 tonnes, or at least 12 tonnes. In a further embodiment the heavy vehicle may have a tare weight of at least 16, 24 or 30 tonnes.

5

In one embodiment the heavy vehicle is a garbage truck and the receptacle is arranged to hold and compress waste matter.

10 The braking system for the heavy vehicle may comprise the wet brake system according to the first aspect of the invention.

15 A fourth aspect of the invention may comprise a method of overhauling an air operated drum brake system on a heavy vehicle having an air compressor and a drum brake assembly and a hub on one or more axles, the method comprising:

removing the hub and associated drum brake assembly from respective axles; and,

fitting a brake system according to the first or second aspect of the invention to the respective axles together with a corresponding hub.

20

The method may comprise preassembling the brake system together with the corresponding hub remote from the heavy vehicle and subsequently fitting the preassembled brake system and hub onto a corresponding axle.

25 Fitting the preassembled brake system and hub onto a corresponding axle may comprise using mechanical fasteners to attach the callipers in the brake system to a housing of the axle wherein load applied to the callipers during a braking operation is transferred by the fasteners to the axle housing.

30 The method may comprise configuring at least one of the callipers to provide a service brake and coupling an air over hydraulic actuator between the air compressor and the at least one of the callipers to enable hydraulic actuation of the service brake.

35 The method may comprise configuring at least one of the callipers which provide a service brake to also provide a park brake.

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The method may comprise operating the park brake as a spring applied air release park brake.

The invention also provides a brake housing for a vehicle brake system having

5 a rotor and one or more brake calipers capable of selectively applying braking force to the rotor, each caliper having one or more cylinders and associated pistons; the housing configured to circumferentially surround the rotor and the or each caliper, and provided with one or more openings for seating the cylinders.

10

The brake housing may comprise seals capable of forming seals about the openings in the housing.

In invention further provides a brake system for a vehicle comprising:

15 a rotor;

one or more brake calipers capable of selectively applying braking force to the rotor, each caliper having one or more cylinders and associated pistons;

a housing configured to circumferentially surround the rotor and the or each caliper, and provided with one or more openings for seating the cylinders;

20 a structural component coupled to the vehicle and wherein the housing is coupled to the structural component; and,

one or more fasteners which couple the one more calipers to the structural component wherein load generated by operating the calipers to apply braking force to the rotor is transferred through the fasteners to the structural component.

25 In the brake system at least one cylinder of each caliper is provided with a hole capable of coupling with a hose to supply brake fluid to the cylinder and associated piston to facilitate operation of a corresponding caliper, the hole in the cylinder being located within the opening of the housing.

The housing or the brake system may be arranged so that the housing is non structural and substantially decoupled from reactive forces generated during a braking operation.

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Brief Description of the Drawings

An embodiment of the present invention will now be described in the context of a wet brake system by way of example only with reference to the accompanying drawings in which:

5 Figure 1 is a section view of an embodiment of the wet disc brake system mounted on an axle;

10 Figure 2 is a rear view of the wet disc brake system shown in Figure 1;

15 Figure 3 is a plan view of the wet disc brake system shown in Figures 1 and 2;

 Figure 4 is a front view of the wet disc brake system;

 Figure 5a is a front view of an outer casing of a housing assembly incorporated in the wet disc brake system;

 Figure 5b is a view of section A-A of the outer casing shown in Figure 5a;

20 Figure 5c is a perspective view from the front of outer casing;

 Figure 5d is a perspective view from the rear of the outer casing;

 Figure 6a is a rear view of an inner plate incorporated in the housing assembly;

 Figure 6b is a front view of the plate shown in Figure 6a;

 Figure 6c is a side view of the inner plate;

25 Figure 6d is a view of section A-A of the inner plate shown in Figure 6a;

 Figure 7a is a representation of seal carrier incorporated in the housing assembly;

 Figure 7b is a view of section A-A of the seal carrier shown in Figure 7a;

30 Figure 8a is a perspective view of a service and park brake calliper incorporated in the wet disc brake system;

 Figure 8b is a side view of the calliper shown in Figure 8a;

 Figure 8c is a plan view from the bottom of the calliper shown in Figure 8a;

 Figure 8d is a view of section A-A of the calliper shown in Figure 8b;

 Figure 8e is a view of detail B shown in Figure 8b;

35 Figure 8f is a view of section C-C of the calliper shown in Figure 8b;

 Figure 9a is a perspective view of a two piston calliper incorporated in an embodiment of the wet disc brake system;

 Figure 9b is a side view of the calliper shown in Figure 9a;

 Figure 9c is a plan view from the bottom of the calliper shown in Figure 9a;

35 Figure 9d is a view of section A-A of the calliper shown in Figure 9b;

 Figure 9e is a view of detail B shown in Figure 9d;

 Figure 9f is a view of section C-C of the calliper shown in Figure 9b;

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Figure 10a is a perspective view of a three piston calliper incorporated in an embodiment of the wet disc brake system;

Figure 10b is a side view of the calliper shown in Figure 10a;

Figure 10c is a plan view from the bottom of the calliper shown in Figure 10a;

5 Figure 10d is a view of section A-A of the calliper shown in Figure 10b;

Figure 10e is a view of detail B of the calliper shown in Figure 9d;

Figure 10f is a view of section C-C of the calliper shown in Figure 10b;

Figure 11a is a perspective view of a strap incorporated in the callipers shown in Figures 8a – 10e;

10 Figure 11b is a plan view of the strap shown in Figure 11a;

Figure 12a is a perspective of a park piston incorporated in the service and park brake calliper shown in Figures 8a – 8e;

Figure 12b is a side view of the piston shown in Figure 12a;

Figure 12c is a view of one end of the park piston shown in Figure 12a;

15 Figure 12d is an opposite end view of the park piston shown in Figure 12a;

Figure 12e is a view of section A-A of the park piston shown in Figure 12c;

Figure 13 is a section view of a second embodiment of the wet disc brake system;

Figure 14 is a representation of a garbage truck fitted with a wet brake system

20 in accordance with the present invention;

Figure 15a is an elevation view of an inner plate incorporated in a second embodiment of the braking system;

Figure 15b is a view of section A-A of the inner plate shown in Figure a;

Figure 15c is a perspective view of the inner plate shown in Figure 15a from the

25 rear;

Figure 15d is a perspective view of the inner plate shown in Figure 15a from the inside;

Figure 16 is a schematic representation of a cooling circuit which may be incorporated in a wet brake system embodiment of the present invention;

30 Figure 17 is a section view of a further embodiment of the disc brake system;

Figure 18 is a representation of a modified form of a seal carrier;

Figure 19a is a section view of a wheel bearing seal that may be incorporated in the wet brake system; and,

Figure 19b is a view of detail B shown in Figure 19a.

Detailed Description of Preferred Embodiment

With reference to the accompanying figures and in particular Figures 1 – 4 in the context of a wet disc brake system 10 an embodiment of the present

5 invention comprises a number of interacting components and assemblies including a housing assembly 12 and brake callipers 14. The housing assembly 12 forms a liquid tight seal between an axle housing 16 and a wheel hub 18 to enclose and retain a volume of lubricant (not shown) for the wet disc brake system 10. A rotor 20 is splined onto and thus rotates with the hub 18.

10 The rotor 20 is lubricated by the lubricant as it rotates within the housing 12 and brake callipers 14. A portion of the brake callipers 14, and in particular cylinders 22 of the brake callipers 14, extend into and are seated in openings 24 formed in the housing assembly 12. O rings 26 are provided in the opening 24 to form a seal between the housing assembly 12 and the cylinders 22.

15 Seating the cylinders 22 in the openings 24 enables coupling to mechanical, hydraulic or pneumatic actuators for operating the callipers 14. The callipers 14 are coupled to a structural component in the form of flange 28 extending about the axle housing 16. Accordingly reactive forces created during a braking operation are transmitted via the callipers 14 to the flange 28 and axle housing

20 16 rather than being born by the housing assembly 12. This enables the housing assembly 12 to be made of a relatively light weight construction and/or materials such as aluminium because housing assembly 12 that bears minimal load.

25 The housing assembly 12 comprises an outer casing 30 shown in Figures 1 and 5a – 5d which extends circumferentially about the callipers 14; an inner plate 32 shown in Figures 6a – 6d and a seal carrier in the form of a second plate 34 shown in Figures 1, 7a and 7b. With particular reference to Figures 5a – 5d, the outer casing 30 comprises a circumferential wall 36 of constant inner diameter and provided, on an outside surface near one end 38, with a plurality of axially extending spaced apart and integrally formed ribs 40. The ribs 40 provide additional strength and thickness to the wall 36 for forming tapped holes to enable fastening of the inner plate 34. An opposite end 42 of the outer casing 30 is formed with a inwardly directed circumferential lip 44. The second plate 32 is fastened to the outer casing 30 by screws 46 (Figs 1, 3, 4) that pass through the lip 44.

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With reference to Figures 6a – 6d, the inner plate 32 is provided with a central opening 48 through which an axle housing 16 extends and which aids to centralise the brake housing relative to the hole 18. Surrounding the opening 48 is a fixing ring 52 by which the inner plate 32 and indeed the housing 5 assembly 12 is coupled to the flange 28 on the axle housing 16. The fixing ring is provided with a plurality of holes 54 that register with holes formed in the brake callipers 14 as well as holes in the flange 28 enabling attachment of the callipers 14 to the flange 28. Further holes 56 are provided in the fixing ring 52 to couple the inner plate 32 to the flange 28. Additional smaller diameter holes 10 57 are formed in the fixing ring 52 to attach the inner plate 32 to the callipers 14.

The inner plate 32 is formed with a portion 58 radially outward of the fixing ring 52 in which is formed the openings 24 for the calliper cylinders 22. The 15 openings 24 are, in this embodiment, arranged in two banks 62 each comprising three openings 24. The banks 62 are raised in relation to the portion 58 of the inner plate 32. The centres of the two end openings 24 in each bank 62 are separated by approximately 66°. A plurality of bosses 64 is formed about the outer circumferential surface of the inner plate 32 which align 20 with the ribs 40 on the outer casing 30. The bosses 64 are formed with holes for receiving screws to fasten the inner plate 32 to the outer casing 30.

With reference to Figures 1, 7a and 7b, the second plate 34 is in the general form of an annular plate having: a central opening 68 through which fits the hub 25 18; and, an outer circumferential edge 70. The outer edge 70 has a diameter greater than the diameter of the lip 44 on the outer casing 30. When assembling the housing assembly 12, the plate 34 is inserted into the outer casing 30 from end 38. A face 72 of the plate 34 which faces outward from end 42 of the outer casing 30 abuts an inside of the lip 44. In board of the outer 30 edge 70 on the face 72 the plate 34 is formed with an annular seat 74. This seat is provided with a circumferential groove 75 for seating an O-ring 77 (Fig 1). Radially inward of the seat 74 there is a right angle circumferential shoulder 76 which forms one edge of annular band 78. The band 78 is provided with a plurality of blind holes 80 for threadingly engage the screws 46 which fasten the 35 plate 34 to the lip 44 of the outer casing 30. A radial inner edge of the band 78 is delimited by an annular shoulder 82 that projects in the axial direction from the face 72. When the plate 34 is fitted to the outer casing 30, the lip 44 sits

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inside of and abuts the shoulder 82. Radially inward from the shoulder 82 the face 72 is provided with an inner circumferential band 84 having blind holes 86 to facilitate the attachment of a flange seal support 88 (shown in Figure 1).

- 5 The plate 34 also comprises an axially projecting boss 89 having an inner circumferential surface 90 adjacent the inner band 84 which comprises a first portion 92 of constant diameter, a contiguous second portion 94 of progressively decreasing diameter, and a contiguous third portion 96 of constant diameter. Extending radially inward from the portion 94 is a circumferential lip 98. The inner diameter of the lip 98 defines the opening 68. A cassette seal 100 (see Figure 1) is seated in the third portion 96 to form a rotary seal between the housing assembly 12 and an outer surface of the hub 18. A gasket seal 102 (Fig 1) is disposed between the cassette seal 100 and the lip 98.
- 10
- 15 Embodiments of the wet brake system 10 incorporate three similar but different brake callipers. These comprise a service/park brake calliper 14a shown in Figures 8a – 8f; a two piston brake calliper 14b shown in Figures 9a – 9f; and a three piston calliper 14c shown in Figures 10a – 10f. Referring to Figures 8a – 8f, the park/service brake calliper 14a comprises an inner shell 104 and outer shell 106 which are coupled together to define a cavity 108 in which the rotor 20 rotates and which houses opposing brake pads 110a and 110b (shown in Figure 1). The cavity 108 opens onto an outer circumferential surface 109 of the calliper 14a forming a central gap 111 between the shells 104 and 106.
- 20
- 25 The brake pad 110a is seated in a recess 112 formed on an inside of the outer shell 106.

- 30 The inner shell 104 is formed with three cylinders 114a, 114b and 114c (hereinafter referred to in general as "cylinders 114"). Each of the cylinders 114a and 114c is provided with holes 118 to allow connection to hoses providing hydraulic fluid to respective service brake pistons 120 retained in the cylinders 114a and 114c. Extending transversely between the holes 118 on each cylinder 114a and 114c is a land 122 to facilitate connection of a spring canister 124 (shown in Figure 1). The spring canister is pneumatically operated to provide the park brake aspect of the service/park brake calliper 114a.
- 35

Seated on the inside of the outer shell 104 is a reaction plate 126 (shown in Fig

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1) which is in the form of a steel plate of a shape and configuration similar to the brake pad 110a. The reaction plate 126 extends across each of the pistons 120 held in the cylinders 114a and 114c as well as a park brake piston 128 (shown in Figures 1 and 12a – 12e) disposed within the cylinder 114b.

5

The inner and outer shells 104 and 106 are coupled together by sets of bolts 130 that extend from the shell 104 to the shell 106 and from the shell 106 into the shell 102. The bolts 130 are located near the ends of the shells 104 and 106 on the side of the service brake cylinders 114a and 114c distant the cylinder 114b. In addition, metal straps 132 bridge the cavity 108 and are coupled to both of the shells 104 and 106 to provide bracing to the calliper 14a. The straps 132 are provided one on each side of the cylinder 114b. Each strap 132 is in the general shape of a "I" having a central column 134 and cross members 136 at opposite ends. The cross members 136 locate in complimentary shaped recesses formed in the inner and outer shells 104 and 106 with the cross members 136 sitting flush with outer axial faces of the shells 104 and 106. Bolts 140 fix the straps 132 to the shells 104 and 106.

20 A mounting flange 142 is formed integrally with the inner shell 104 to facilitate attachment of the calliper 14a to the flange 28 on the axle housing 16. To this end the mounting flange 142 is provided with holes 144 and 145 that register with the holes 54 and 57 respectively in the fixing ring 52 of the inner plate 32.

25 The park brake piston 128 (see Figures 1, 8a, 8c, 8d and 12a – 12e) is housed within the cylinder 114b and is acted upon by the spring canister 124 via a wear compensating mechanism 146 which includes a rod 147 (see Figure 1). One end 148 of the piston 128 is formed with an axially projecting ring 150. Inside of the ring 150 the piston 128 is provided with a radial face 152 which is formed with a central raised land 154. A slot 156 extends axially on the piston 128 from the ring 150 to a distance approximately one third of the way toward an opposite end 158 of the park piston 128. A circumferential groove 160 is formed about the park piston 128 between the slot 156 and the end 158 for seating an O-ring 162 (shown in Figure 1). The slot 156 accommodates a pin 163 which extends from a face 164 of the rod 147. The face 164 abuts the raised land 154 and is located within the ring 150 of the piston 128.

30 The land 154 provides a pivot between the rod 147 and the interface piston

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128. This provides a means of self-alignment between the rod 147 and the piston 128, allowing lateral movement or rocking at the face due to: the length of the rod 147; and, the mechanism 146 which multiplies the force of the canister 124 comprising a pivoted lever arrangement.

5

Wear of the brake pads 110a and 110b is compensated for in relation to application of the park brake by the mechanism 146 which causes a housing of the rod 147 to rotate about a longitudinal axis of the rod 147 as the rod 147 is advanced linearly by application of force by the spring canister 124. This 10 rotation maintains the rod 147 in a linearly advanced position relative to its position prior to application of force by the spring canister 124 to provide wear compensation.

15 The two piston calliper 14b is shown in Figures 9a – 9f. Each feature of the calliper 14b which is identical to corresponding features of the calliper 14a is denoted with the same reference number. The calliper 14b differs from the calliper 14a in the following two aspects. Firstly, the central cylinder 114b in the calliper 14b is closed and does not house any piston. Thus, braking force is applied only via the pistons 120 in the cylinders 114a and 114c. Secondly, as 20 the calliper 14b does not have a park brake function, it does not require and therefore does not have the lands 122 depicted on the calliper 14a for mounting of the spring canister 124. In the embodiment of the braking system 10 shown in Figures 1 – 4, one piston calliper 14b is used together with a service/park 25 brake calliper 14a to form a rear brake assembly for braking a wheel coupled to the hub 18.

30 Figures 10a – 10f depict the three piston calliper 14c. Features of the calliper 14c which are identical to features of the callipers 14a and 14b are denoted with the same reference number. The three piston calliper 14c differs from the calliper 14b by the provision of a service piston 120 in the central cylinder 114b and the provision of holes 118 in the cylinder 116 to allow the application of hydraulic pressure to the piston 120.

35 Figure 13 depicts an embodiment of the wet disc brake system 10b comprising a housing assembly 12 and two of the three piston callipers 14c held within the housing assembly 12 to brake a rotor 20 mounted on a wheel hub 18b. In this particular embodiment, the wheel hub 18b mounted on a stub axle 50b. The

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callipers 14c and thus the wet disc brake system 10b provides service brakes only with no park (or emergency) braking facility.

Figure 14 depicts a garbage truck 170 having a receptacle 172 for holding and transporting waste matter, and mounted on a chassis having a single front axle and a tandem rear axle. The truck 170 in its original form is provided with drum brakes on each of the hubs on each of the axles. The brakes are pneumatically operated. To this end, the truck 170 is provided with an air compressor (not shown) for activating the brakes. Embodiments of the wet disc brake system 10 may be retrofitted to the truck 170 by first removing the original equipment hubs and drum brakes and retrofitting embodiments of the wet disc brake system. For example, a wet disc brake system 10b as shown in Figure 13 comprising two callipers 14b with a hub 18b may be fitted on the front axles of the truck 170. On each of the rear axles, a wet disc brake system 10 shown in Figures 1 – 4, each provided with a service/park brake calliper 14a and a two piston service brake calliper 14b with a hub 18 can be fitted. In order to provide hydraulic pressure to the service brakes, one or more air over hydraulic actuators (not shown) is provided between the air compressor and the cylinders of callipers that house the service brake pistons 120. Thus the service brakes are hydraulically operated. The parking brake facility provided by the service/park brake calliper 14a is a spring applied air release park brake. The supply of compressed air to the canister 124 operates against the spring within the canister to release the park brake. When either the park brake is actuated, or is there is a loss in air pressure, the spring within the canister 124 is released so that the bias of the spring is applied through the rod 146 to the park piston 144 to apply the park brake.

Due to the configuration of the wet brake system 10, complete brake and hub assemblies for any axle can be preassembled on a work bench and coupled as a single unit to the axle. For example, consider the wet brake assembly 10 illustrated in Figure 1. This assembly comprises a service and park brake calliper 14a, a two piston service brake calliper 14b. When assembling the brake assembly 10, the callipers 14a and 14b are first assembled with the spring canister 124 and associated wear compensating rod system 145 not being attached to the calliper 14a. The rotor 20 is then placed centrally between the callipers with a portion of the rotor extending between the brake pads 110a and 110b in each of the callipers 14a and 14b. The seals 102 and

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100 are seated in the seal carrier / second plate 34. Next, the second plate 34 is passed into the outer casing 30 from the end 38 so as to abut with the inside of the lip 44. The outer casing 30 and second plate 34 are connected together by screws that pass through the lip 44 into the holes 80 in the band 78 of the 5 plate 34. The hub 18 is now inserted into the opening 68 of plate 34. The inner plate 32 is located over the callipers 14a and 14b so that the cylinders of the callipers pass through the openings 24. O-rings 26 seal the cylinder of each of the carriers 14a and 14b to the inner plate 32. Screws which extend through holes 57 into holes 157 connect the inner plate 32 to the callipers 14a and 14b, 10 with the rotor 20 retained within and between the callipers 14a and 14b. The seals 102 and 100 are seated in the plate 34 and the callipers 14a and 14b which are attached to the plate 32 are now lowered into the outer casing 30 with the rotor 20 orientated to slide onto splines on the hub 18. The inner plate 32 is now fastened to the outer casing 30. The entire assembly comprising the 15 callipers 14a and 14b held within the housing 12, and the hub 18 can now be fitted onto an axle assembly. The hub 18 is allowed to rotate on the axle housing 16 via two tapered roller bearings 11, 13 (see Figure 1) which are seated on the axle housing 16. Axle shaft 50 which extends through the axle housing is attended to the face of the hub 18 by axle studs 15. The wet disc 20 brake assembly is attached to the flange 28 on the axle housing using bolts that pass through the holes 54 and threadingly engage with holes 144 in the mounting flange 142 of the callipers 14a and 14b. Thus load applied during a braking operation on the callipers 14a and 14b is transferred via the fasteners to the flange 28 and axle housing 16 rather than being born by the housing 25 assembly 12. Next, hydraulic hoses can be coupled to the cylinders 22 of the callipers 14a and 14b and the canister 124 connected with the calliper 14a.

Figures 15a-15d illustrate an inner plate 32a of a further embodiment of a wet 30 brake system 10. The inner plate 32a differs from the inner plate 32 depicted in Figures 6a-6d by the provision of a finned sump 180 which protrudes in an axial direction away from the seal carrier or second plate 34. The purpose of the sump 180 is to increase the volume of lubricating oil inside the brake without increasing the level of the oil. Further, the sump 180 lies substantially below the level of the O-ring seals 26 provided in the openings 24 which seat the 35 calliper cylinders 22. Thus the positioning of the sump 180 reduces the likelihood of lubricant leakage about the seals.

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The sump 180 is also provided with a plurality of cooling fins 182 to an outside surface of the inner plate 32. The sump 180 and the fins 182 may be dimensioned to protrude beyond the wheel and rims associated with the braking system to increase heat rejection from the braking system 10. A sump

5 fill the hole 184 and sump drainage hole 186 is formed on the outside of the inner plate 32a to allow filling and drainage of the sump 182. The holes 184 and 186 may be closed by conventional plugs.

As an addition or an alternative to the fins 182, the brake system 10 may also 10 incorporate a cooling system 200 depicted in Figure 16 for cooling the lubricant sealed within housing assembly 12 used for lubricating the rotor 20. Cooling system 200 comprises a oil cooling circuit 202 comprising an oil filter 204, oil cooler 206, and pump 208, which are connected in series by a conduit 210 which provides a closed loop with housing 12. Conduit 210 is connected at an 15 outlet 212 in a lower portion of housing 12 and returns via an inlet 214 at a spaced apart location in an upper region of housing 212. Air cooler 206 may be an air cooler similar to a radiator. While one circuit 202 is shown, it is envisaged that each brake system 10 will include a separate fluid circuit although the conduit for each circuit may pass through a common oil cooler 206 20 in a manner where the fluid for each brake system 10 is kept separate. The order of the filter 204, oil cooler 206 and pump 208 in the circuit 202 is of no significance and may change or be varied to suit the chassis and structure of the vehicle to which the brake system 10 is fitted.

25 Now that embodiments of the present invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, the systems 10 and 10b illustrated and described each comprise two callipers disposed within the housing assembly 12. However the 30 specific combination and number of callipers incorporated may be varied. For example the braking system may comprise only a single calliper 14a, 14b or 14c. When the braking system 10 incorporates two or more callipers, a different combination of callipers to those illustrated may be used. For example the braking system may comprise a service/park brake calliper 14a together 35 with a three piston calliper 14c. An alternate braking system may comprise two two piston callipers 14b; in a further variation for larger or heavier vehicles, three or four callipers may be used in a braking system.

Also, the callipers 14 are described as comprising two shells 104 and 106 which are coupled together. However, in alternate embodiments the callipers may be made as a single or unitary piece. Further, while Figure 14 illustrates 5 an embodiment of the invention applied to a garbage truck, embodiments of the invention can be applied to other heavy vehicles such as buses and mining trucks.

Figures 17 to 19b depict further modifications or variations to the system 10. 10 These variations comprise a modified second plate 34a; the provision of a V-seal 230 about hub 18, and, the inclusion of a wheel bearing seal 240 which forms a seal between an inside of the hub 18 and the axle housing 16. Each of these modifications will now be described in greater detail.

15 The second plate 34a which is also shown in Figure 18, differs from the plate 34 of the first embodiment by the inclusion of an insert seal carrier 222. That is, plate 34a in essence comprises plate 34 with insert seal carrier 222. Insert seal carrier 222 is in the form of a ring having a cylindrical wall 224 which is coaxial with central opening 68 of plate 34 and flanges 226 and 228 at opposite axial 20 ends of cylindrical wall 224. Flange 226 extends in a radial outward direction and overlies the circumferential band 84 while flange 228 extends in a radial inward direction toward an outer circumferential surface of hub 18. The outer diameter of cylindrical wall 224 is smaller than the inner diameter of boss 89 to provide a degree of play between plate 34 and carrier 222. Cassette seal 100 is seated within the inner circumferential surface of insert seal carrier 222. The 25 degree of play between insert seal carrier 222 and plate 34 enables adjustment for any misalignment between cassette seal 100 and the outer surface of hub 18 during assembly. Minimising or eliminating misalignment extends the life of a seal substantially. To accommodate for the play between the insert seal 30 carrier 222 and plate 34, holes in the flange 226 to enable coupling of the insert 222 to the plate 34 are slightly oversize for the fastener used. When the system 10 is being assembled and installed, the fasteners used to attach insert 222 to plate 34 are initially loosened to enable adjustment for any misalignment. Once the seal cassette 100 and hub 18 have been properly aligned, the 35 fastener may then be tightened.

V-seal 230 is seated in a shallow circumferential groove 232 machined about

the outer circumferential surface of hub 18 and located so that the V seal 230 bears against flange 228 of the insert seal carrier 222. V-seal 230 rotates with hub 18 and acts as a "flinger" for the lubricant within system 10 as well as preventing the lubricant from reaching the main housing seal.

5

The double lip wheel bearing seal 240 creates a fluid seal to prevent communication between the lubricant used in wet brake system 10, and diff oil used for lubricating the hub wheel bearings 11 and 13. With particular reference to Figures 19a and 19b, the seal 240 comprises an outer hub seal 242 which is pressed into a seat formed on an inner circumferential surface of hub 18, and an inner hub seal 244 that is pressed onto a seat formed on the axle housing 16. Two lip seals 246 are installed back to back between the outer hub seal 242 and inner hub seal 244. Inner hub seal 244 is provided with a radially extending flange 248 which extends across an axial end of the outer hub seal 242. A wear ring 250 which may be made for example from PTFE is located between the flange 248 and adjacent axial end of outer hub seal 242.

20

While various embodiments are described as and in the context of a wet brake system, the very same embodiments may of course be used as dry brake systems by not supplying lubricant to the inside of the housing. In such a dry brake system the non structural nature of the housing is unchanged as reactive forces generated by operation of the callipers are transferred through fasteners which couple the callipers to the flange 28 or other structural component. Indeed the form of the housing may be simplified for a dry brake embodiment as there is no need to form a sealed, or at least liquid tight, cavity to retain lubricant.

30

In yet a further variation of brake system 10, irrespective of whether the brake system is used as a wet brake system or a dry brake system, the first plate 32 may be formed integrally with the outer casing 30. In yet a further variation, the openings 24 formed in housing assembly 12 and in particular plate 32, may be formed with axially extending circumferential walls about which seals such as boot seals may be attached to prevent the leakage of lubricant from within the system 10 and/or prevent ingress of foreign matter into system 10. Such boots, if used will also be provided with sealed openings to allow hydraulic hoses to pass therethrough to supply the callipers with hydraulic fluid for operating the calliper pistons 120. In the event that the boots or other external seals are

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used, it may be possible to dispense with the O-rings 26.

All such modifications and variations together with others that would be obvious to persons of ordinary skill in the art are deemed to be within the scope of the 5 present invention, the nature of which is to be determined from the above description and the appended claims.

CLAIMS:

1. A wet disc brake system comprising:
 - a housing configured to form a sealed cavity about a body rotating
- 5 relative to the housing;
 - one or more brake callipers disposed in the housing, the brake callipers provided with one or more cylinders, the housing being provided with an opening for each of the cylinders, wherein each cylinder is seated in a respective opening.
- 10 2. The wet disc brake system according to claim 1 wherein the housing comprises an outer casing which extends circumferentially about the one or more callipers, and a first plate demountably coupled to the outer casing, wherein the first plate is provided with the openings for the cylinders.
- 15 3. The wet disc brake system according to claim 2 comprising a respective seal located between each cylinder and forming a seal between that cylinder and a corresponding opening in which that cylinder is seated.
- 20 4. The wet disc brake system according to claim 2 or 3 wherein the first plate comprises a plurality of holes through which fasteners pass to attach the callipers to an axle housing wherein load on the calliper during braking is transferred to the axle housing via the fasteners.
- 25 5. The wet disc brake system according to any one of claims 2 – 4 wherein the outer casing has opposite first and second axial ends and a lip projection radially inward extending about the second axial end.
- 30 6. The wet disc brake system according to claim 5 wherein the housing comprises a second plate demountably attached to the lip of the outer casing, the second plate provided with an opening for receiving a hub which extends into the housing.
- 35 7. The wet disc brake system according to claim 6 wherein the second plate has an outer diameter greater than an inner diameter of the lip and wherein the second plate is disposed on a side of the lip inside of the outer casing.

8. The wet disc brake system according to claim 7 wherein the second plate comprises an axially extending boss which defines the opening in the second plate for receiving the hub, the boss having a circumferential seat and a seal on the seat which forms a liquid seal about the hub.

5

9. The wet disc brake system according any one of claims 1 – 8 wherein each calliper comprises first and second shells demountably coupled together, the first shell provided with the plurality of cylinders, the first and second shells being relatively shaped to form a cavity therebetween and through which the body rotates, the cavity opening onto an outer surface of the calliper to form a gap between the shells.

10

10. The wet disc brake system according to claim 9 wherein each calliper comprises at least one strap extending across the gap and coupled to each of the first and second shells.

15

11. The wet disc brake system according to claim 10 wherein opposite ends of each strap seat in respective recesses formed in the first and second shells.

20

12. A brake system comprising a service and park brake calliper provided with at least two cylinders wherein at least one of the cylinders houses a hydraulic operated service piston to facilitate a service braking, and at least one cylinder housing a park piston which is applied by a spring and released by air pressure to facilitate a park braking.

25

13. The brake system according to claim 12 further comprising a wear compensating actuator which transmits pressure from the spring to the park piston.

30

14. The brake system according to claim 13 wherein the park piston comprises a central raised land against which pressure from the spring is transmitted by the wear compensating actuator to the park piston.

35

15. The brake system according to any one of the claims 12 – 14 wherein at least two of the cylinders house respective service pistons, and wherein the at

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least one cylinder houses the park piston is disposed between the cylinders housing the service pistons.

16. A heavy vehicle comprising:
 - 5 a receptacle configured to transport material;
 - an air compressor;
 - 10 a braking system driven by compressed air from the air compressor to brake motion of the heavy vehicle the brake system comprising a service brake and a park brake, the service brake being a wet air over hydraulic actuated disc brake, and the park brake being a spring applied and air released.
17. The heavy vehicle according to claim 16 wherein the braking system comprises at least one brake calliper configured to provide both the service brake and park brake.
- 15 18. The heavy vehicle according to claim 16 or 17 wherein the brake system comprises service brakes on at least one axle of the heavy vehicle, and a combination of service and park brakes on at least one rear axle.
- 20 19. The heavy vehicle according to any one of claims 16 – 18 wherein the heavy vehicle has a tare weight of at least 6 tonnes.
- 25 20. The heavy vehicle according to any one of claims 16 – 19 wherein the heavy vehicle is a garbage truck and the receptacle is arranged to hold and compress waste matter.
- 30 21. The heavy vehicle according to any one of claims 16 to 20 wherein the braking system comprises the wet brake system according to any one of claims 1 – 11.
22. A method of overhauling an air operated drum brake system on a heavy vehicle having an air compressor and a drum brake assembly and hub on one or more axles, the method comprising:
 - 35 removing the hub and associated drum brake assembly from respective axles; and,
 - fitting a brake system according to any one of claims 1 – 15 to the respective axles together with a corresponding hub.

23. The method according to claim 22 comprising preassembling the brake system together with the corresponding hub remote from the truck and subsequently fitting the preassembled brake system and hub onto a 5 corresponding axle.

24. The method according to claim 23 wherein fitting the preassembled brake system and hub onto a corresponding axle comprises using mechanical fasteners to attach the callipers in the brake system to a housing of the axle 10 wherein load applied to the callipers during a braking operation is transferred by the fasteners to the axle housing.

25. The method according to any one of claims 22 – 24 comprising configuring at least one of the callipers to provide a service brake and coupling 15 an air over hydraulic actuator between the air compressor and the at least one of the callipers to enable hydraulic actuation of the service brake.

26. The method according to claim 25 comprising configuring at least one of the callipers which provide a service brake to also provide a park brake. 20

27. The method according to claim 26 comprising operating the park brake as a spring applied air release park brake.

28. A brake housing for a vehicle brake system having a rotor and one or 25 more brake calipers capable of selectively applying braking force to the rotor, each caliper having one or more cylinders and associated pistons: the housing configured to circumferentially surround the rotor and the or each caliper, and provided with one or more openings for seating the cylinders.

29. The brake housing according to claim 28 comprising seals capable of 30 forming seals about the openings in the housing.

30. A brake system for a vehicle comprising:
a rotor;
35 one or more brake calipers capable of selectively applying braking force to the rotor, each caliper having one or more cylinders and associated pistons;

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a housing configured to circumferentially surround the rotor and the or each caliper, and provided with one or more openings for seating the cylinders; a structural component coupled to the vehicle and wherein the housing is coupled to the structural component; and,

5 one or more fasteners which couple the one or more calipers to the structural component wherein load generated by operating the calipers to apply braking force to the rotor is transferred through the fasteners to the structural component.

10 31. A brake system according to claim 30 wherein at least one cylinder of each caliper is provided with a hole capable of coupling with a hose to supply brake fluid to the cylinder and associated piston to facilitate operation of a corresponding caliper, the hole in the cylinder being located within the opening of the housing.

15 32. The housing or the brake system according to any one of claims 28 to 31 wherein the housing is non structural and substantially decoupled from reactive forces generated during a braking operation.

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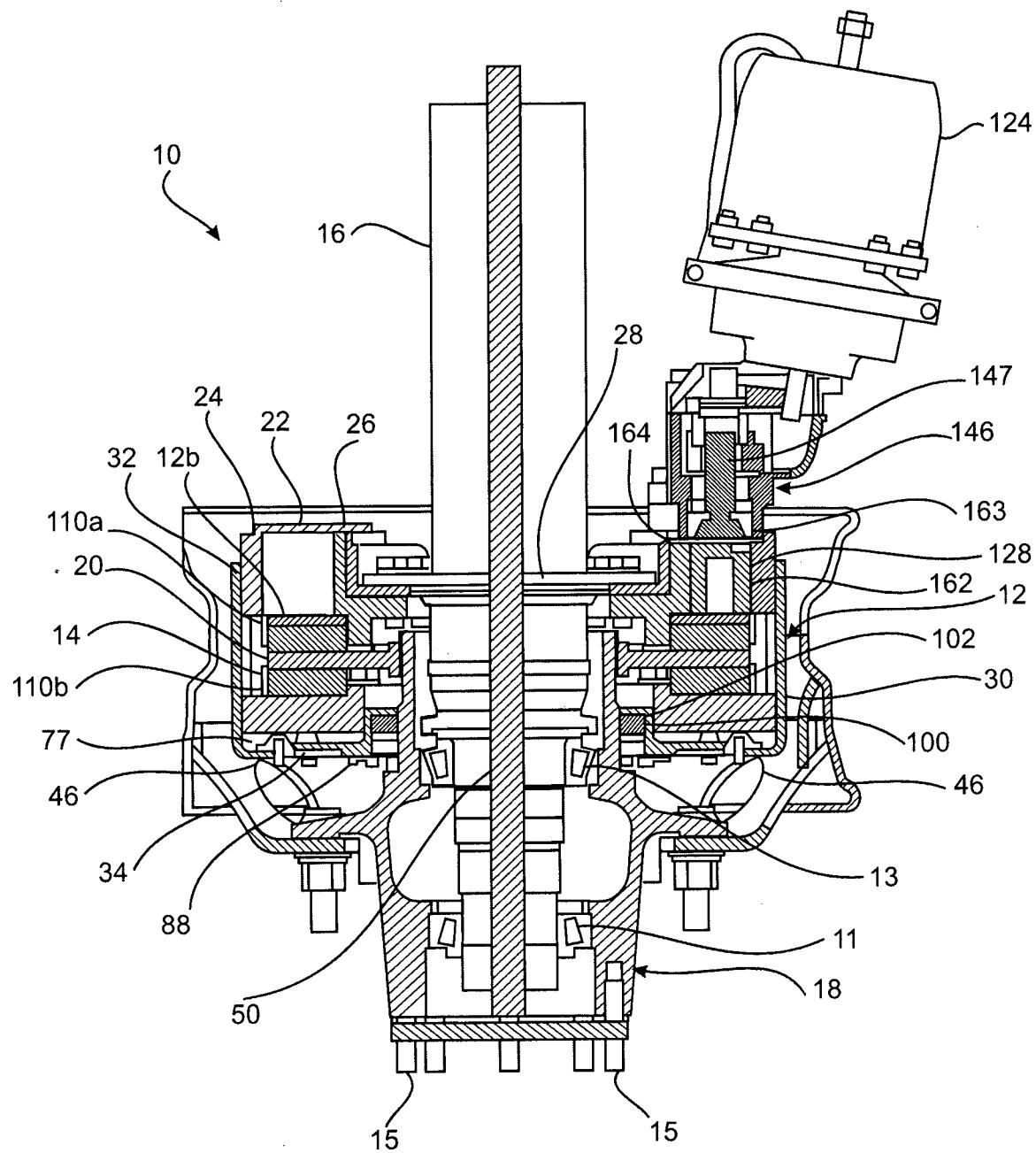


FIG. 1

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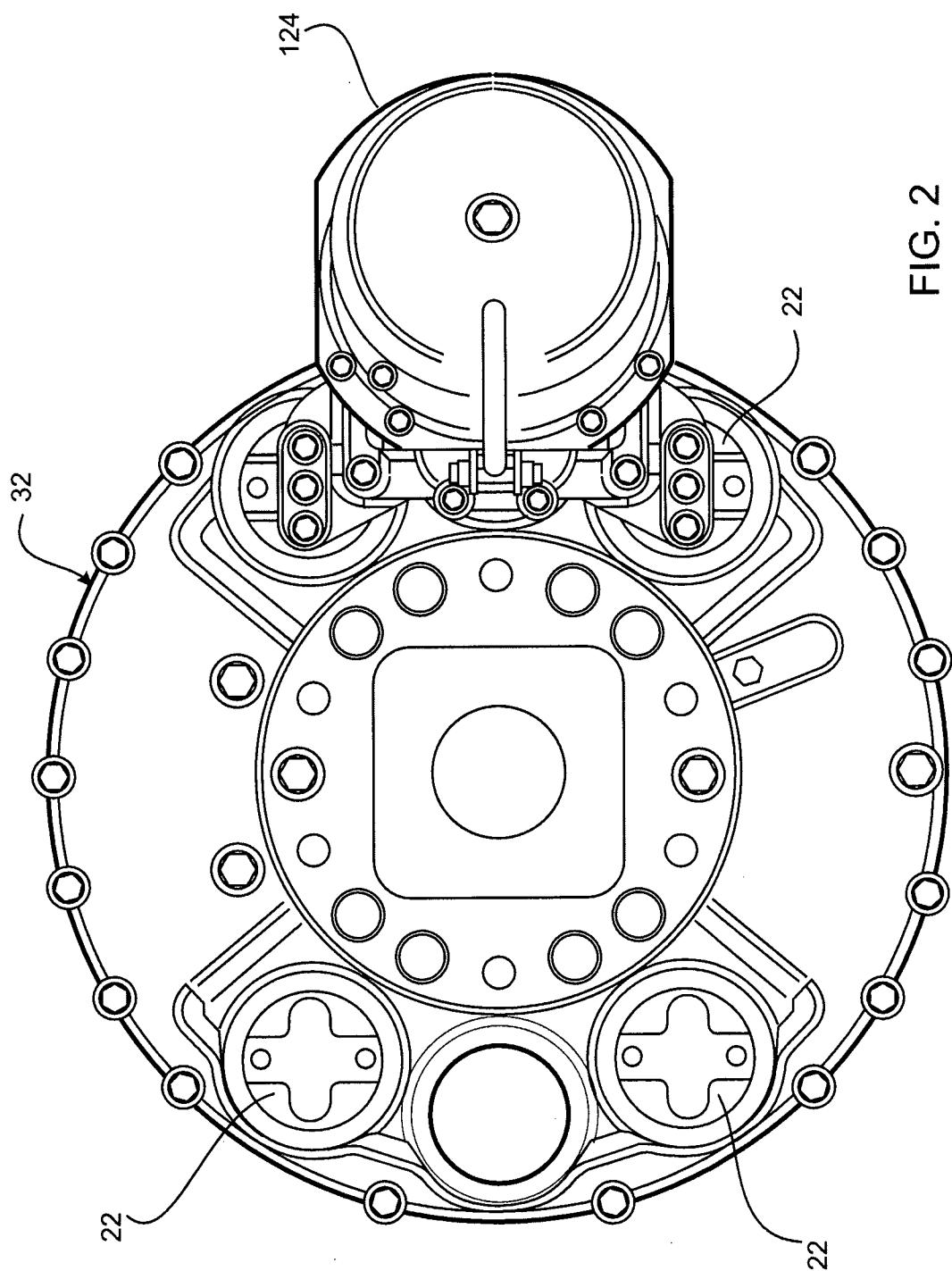


FIG. 2

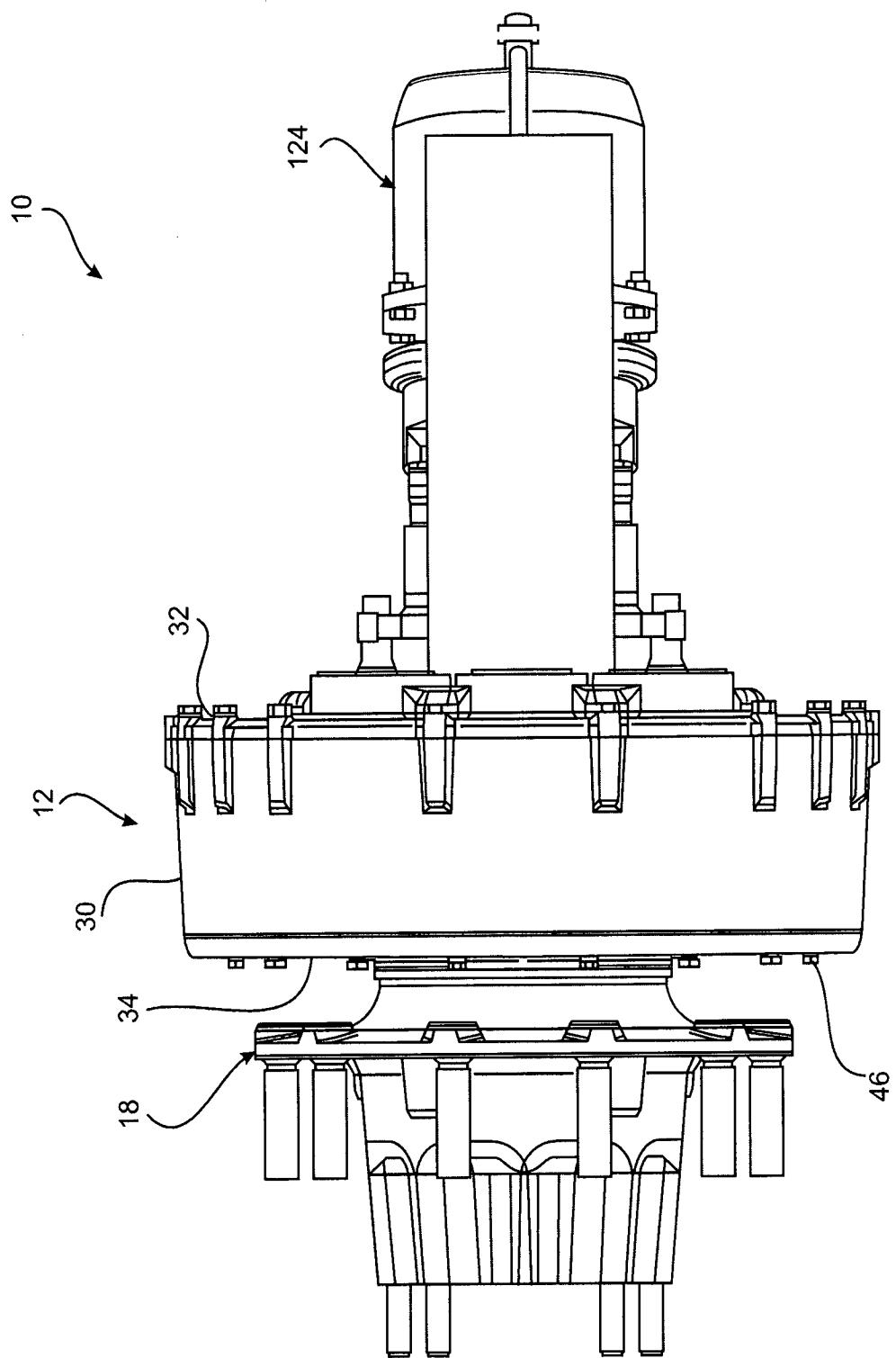


FIG. 3

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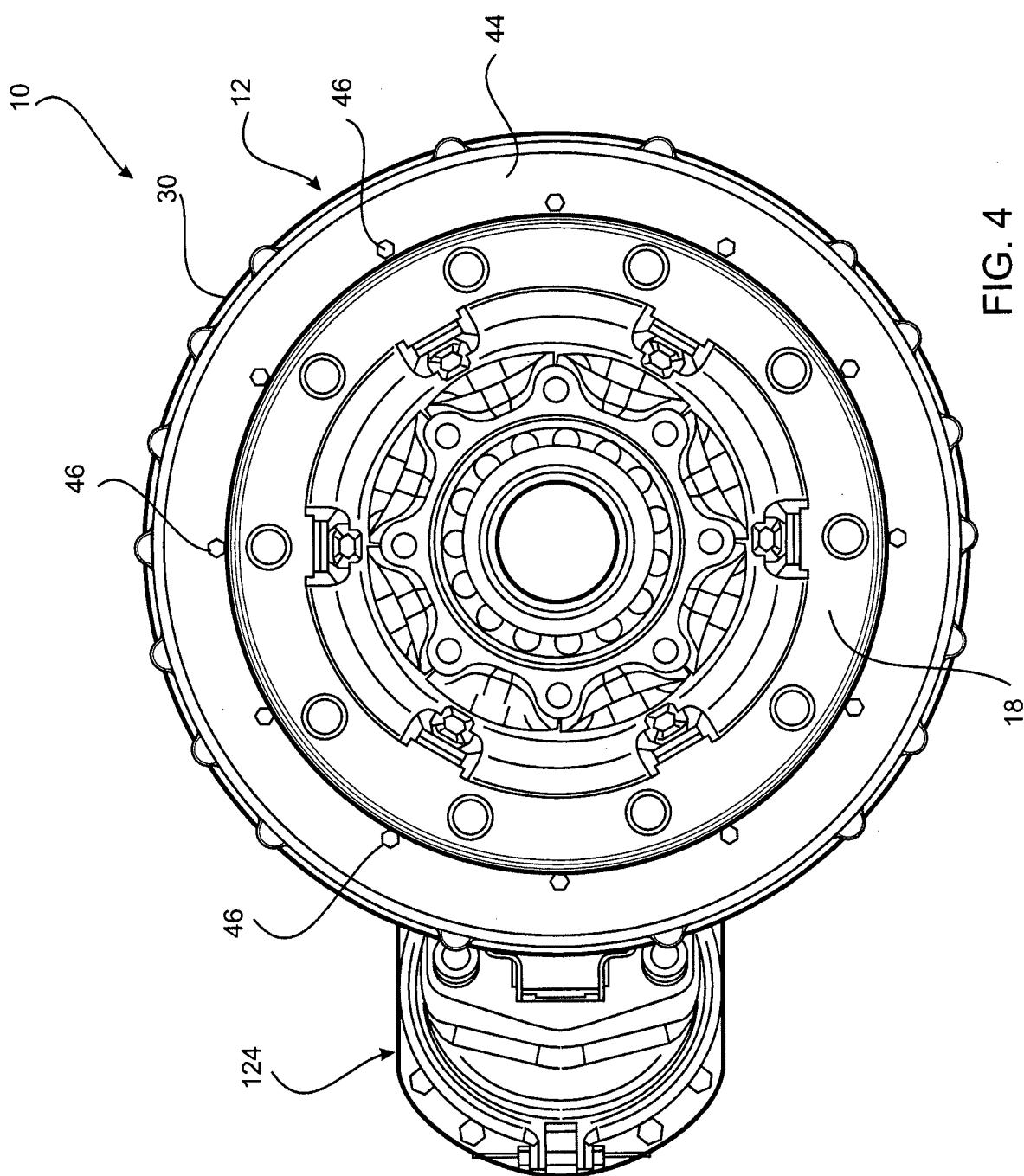


FIG. 4

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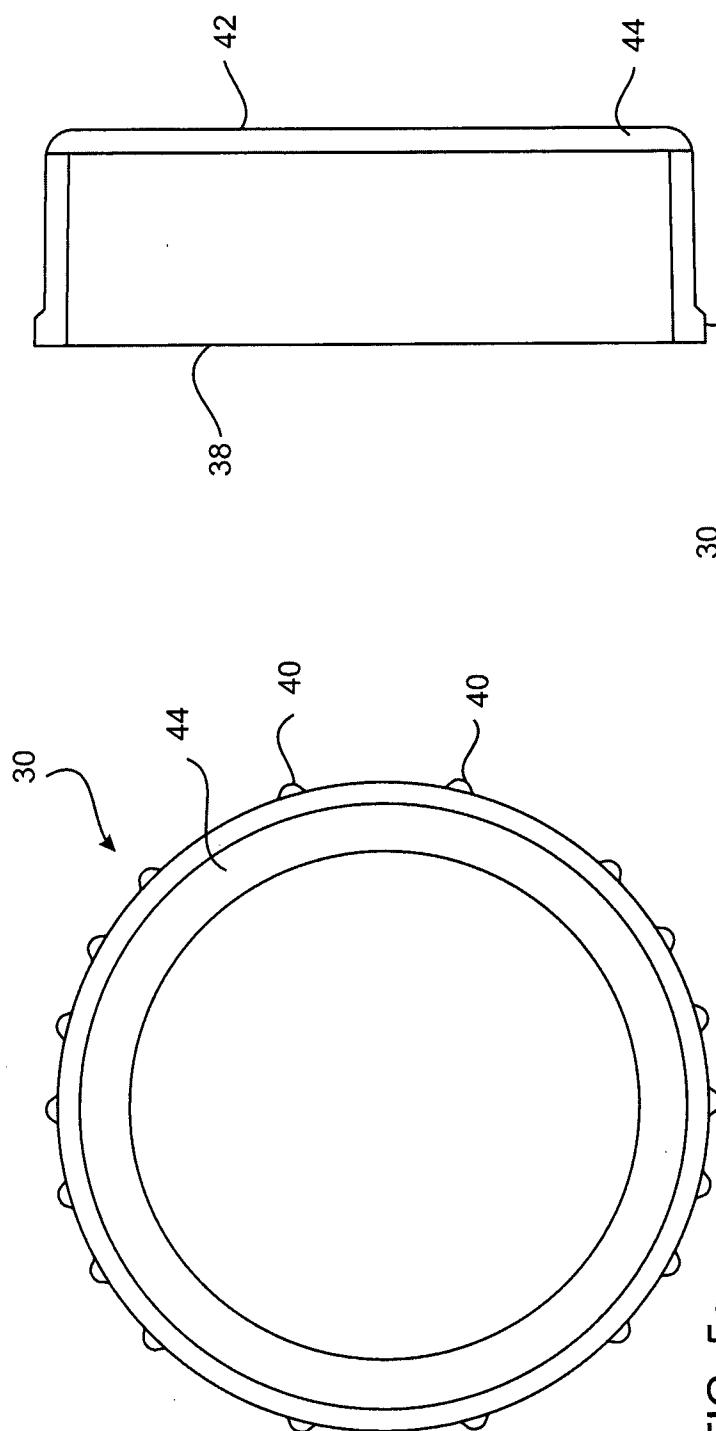


FIG. 5a

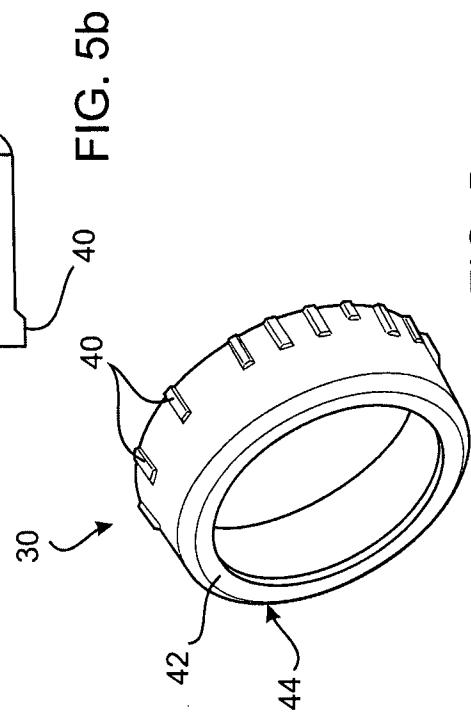


FIG. 5b

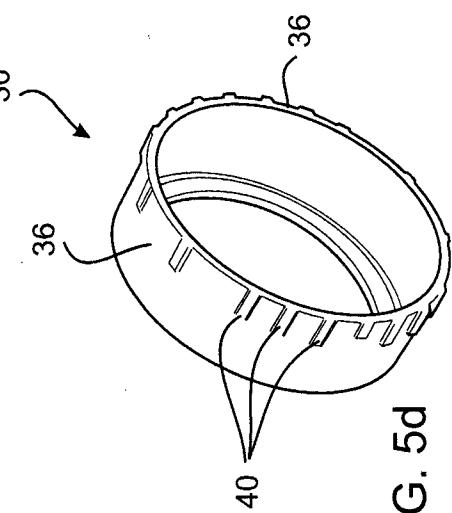


FIG. 5c

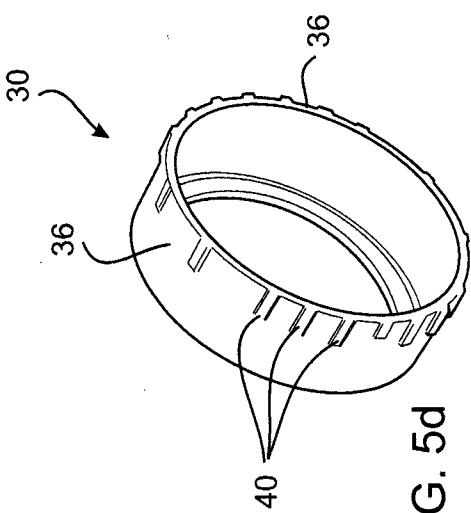


FIG. 5d

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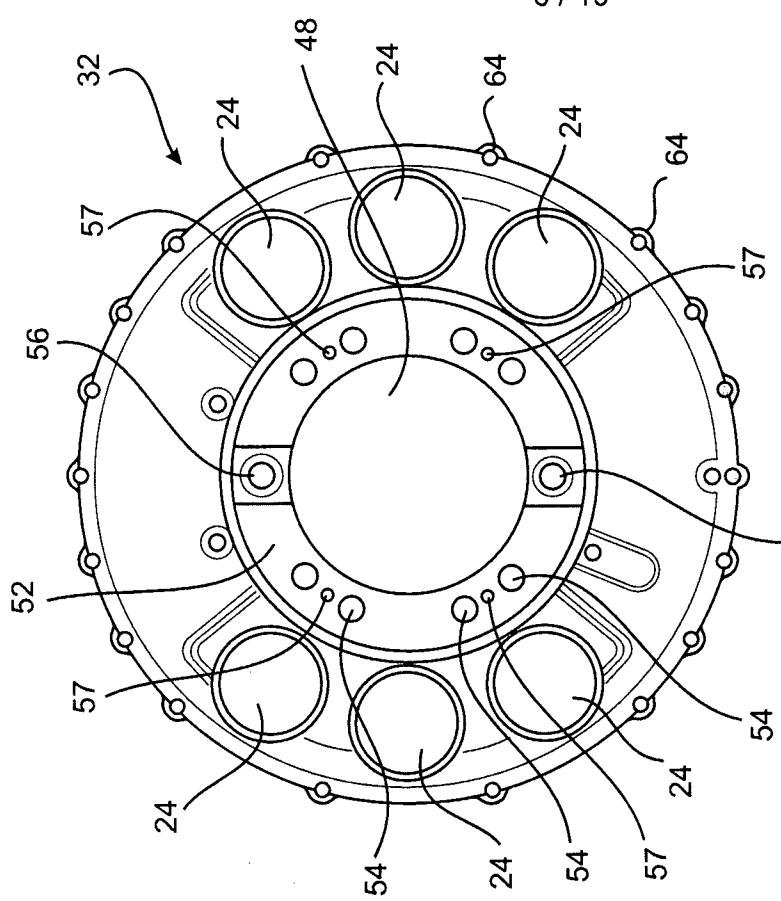


FIG. 6b

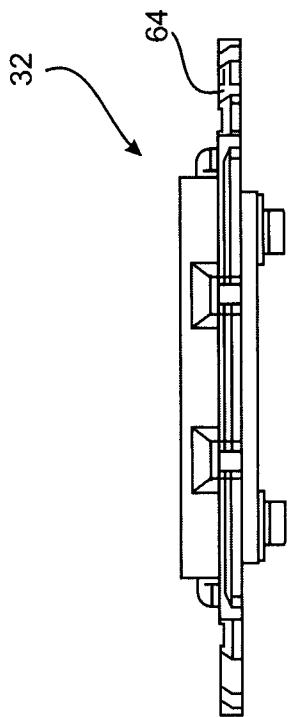


FIG. 6c

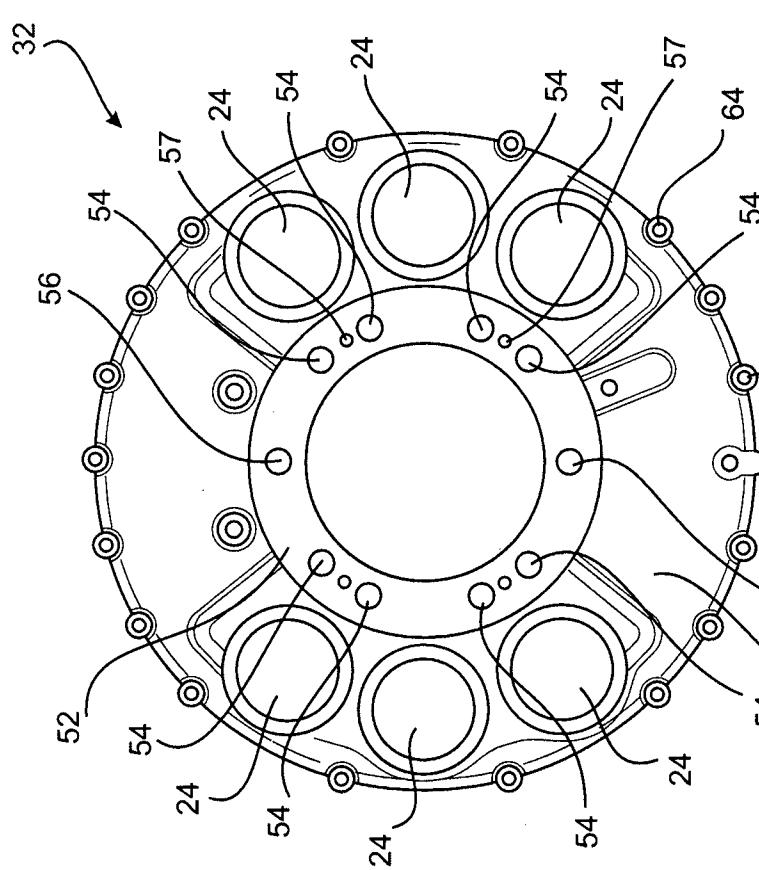


FIG. 6a

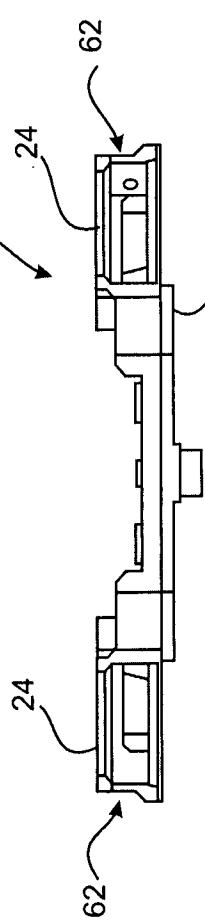


FIG. 6d

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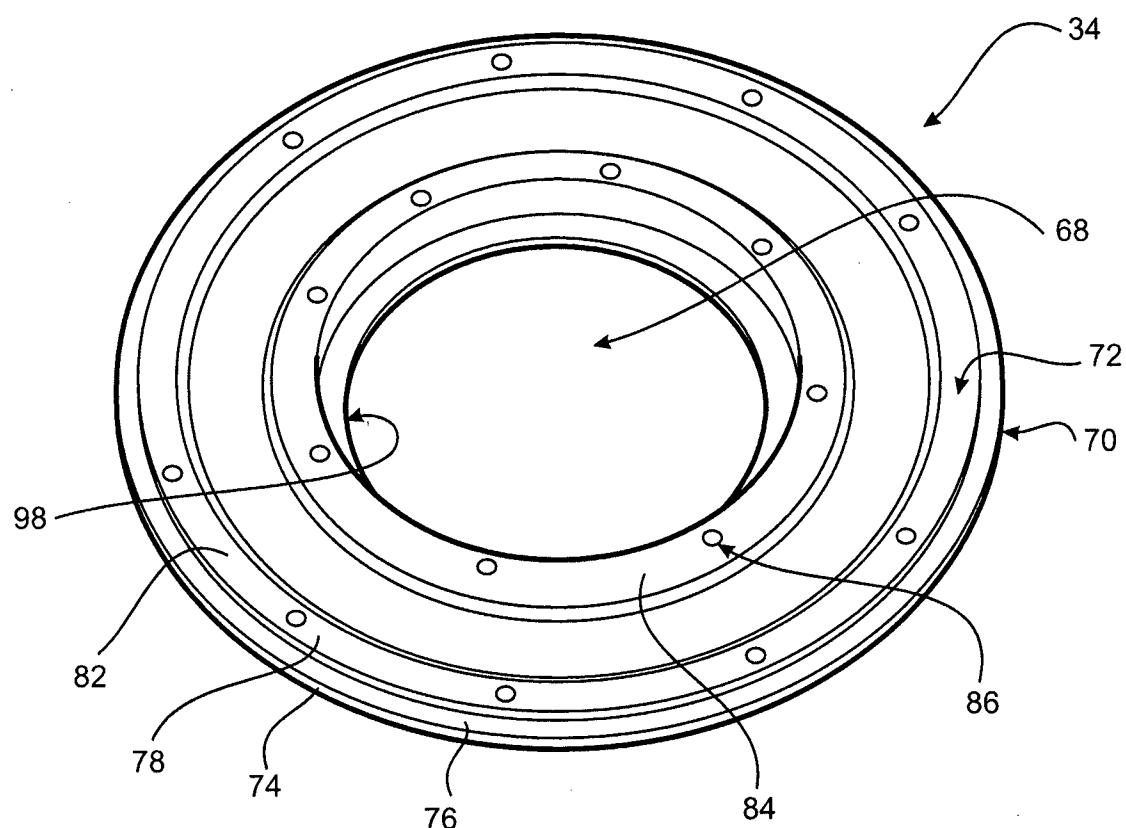


FIG. 7a

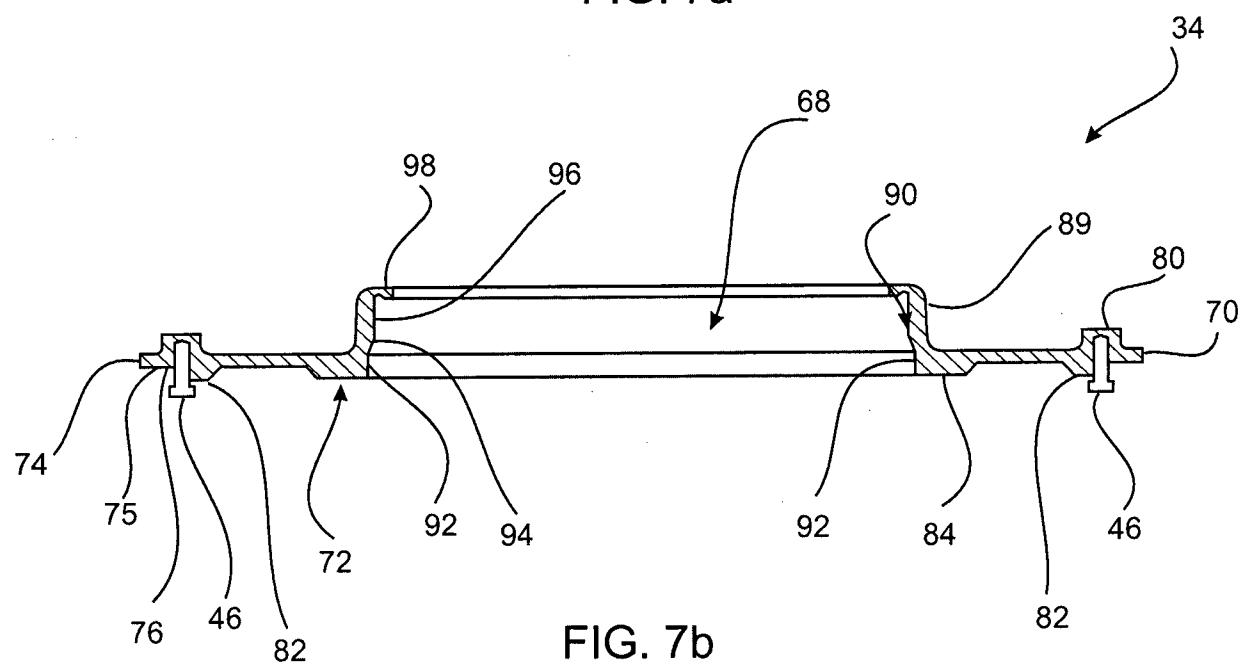
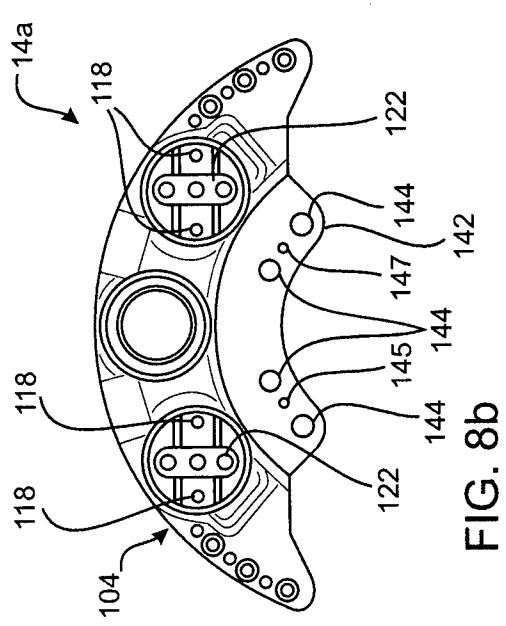


FIG. 7b



Substitute Sheet
(Rule 26) RO/AU

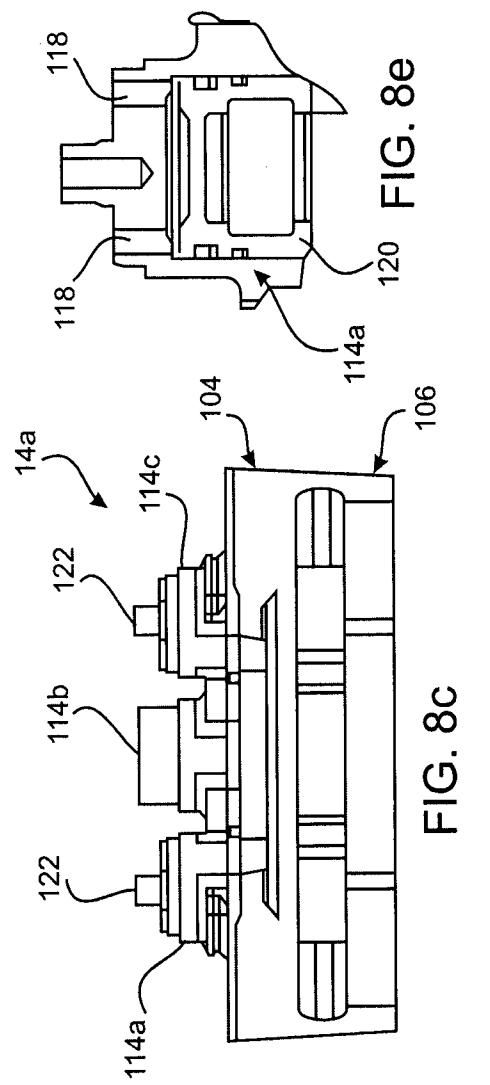


FIG. 8C

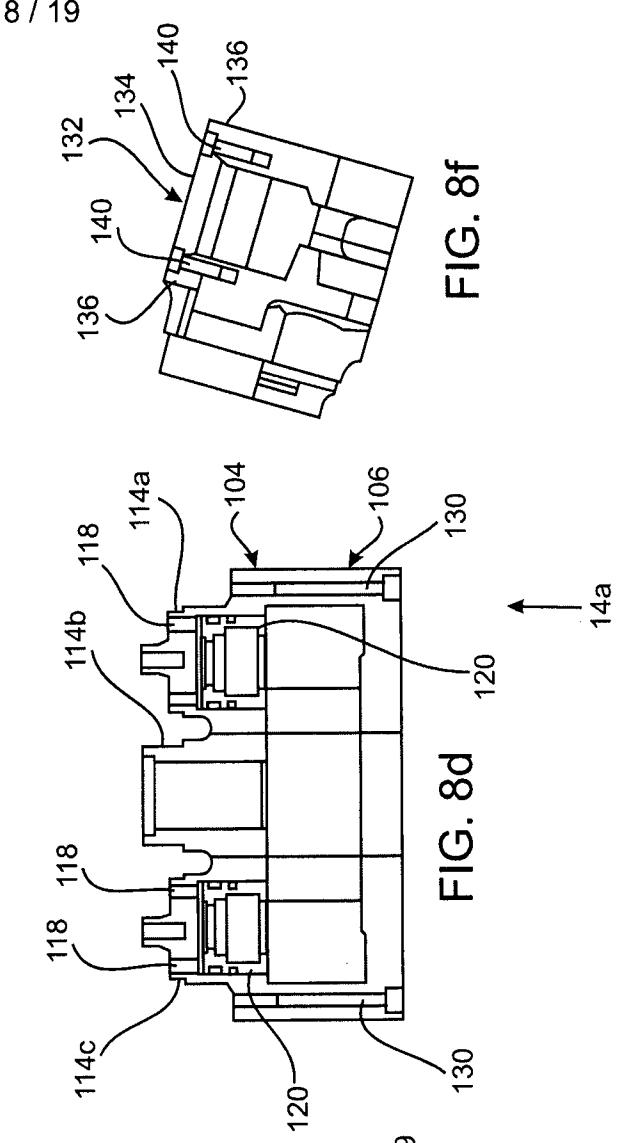


FIG. 8d 120
FIG. 8e 130
FIG. 8f 140

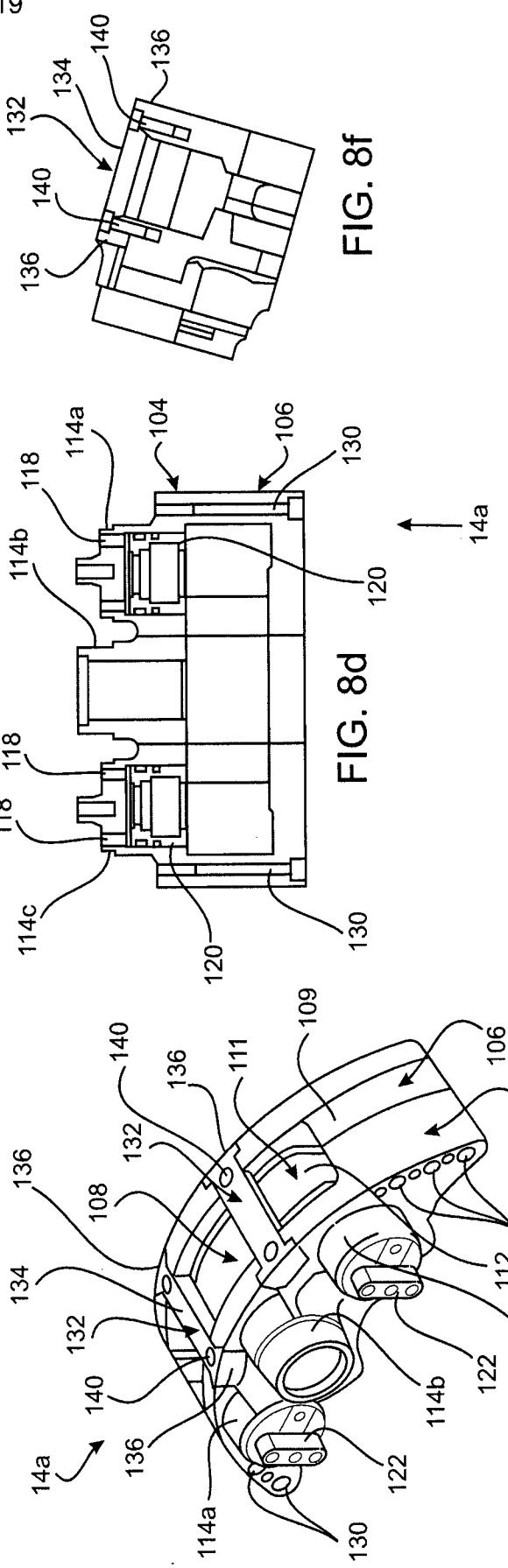


FIG. 8a

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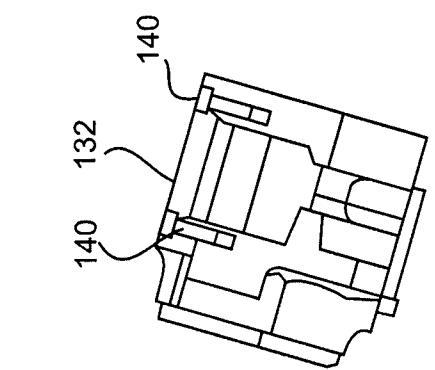


FIG. 9f

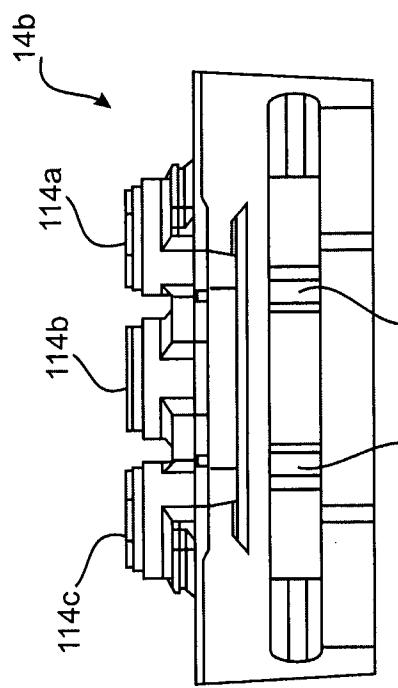


FIG. 9c

132

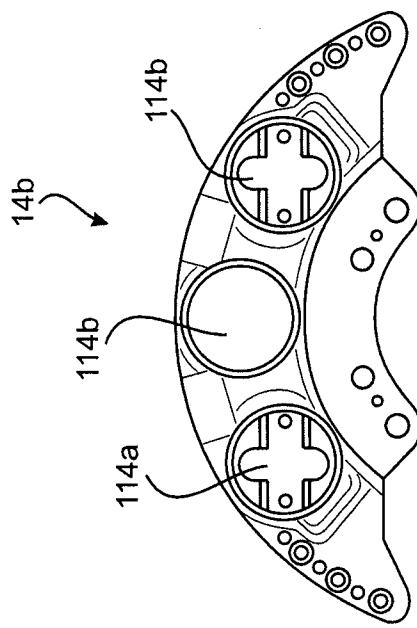


FIG. 9b

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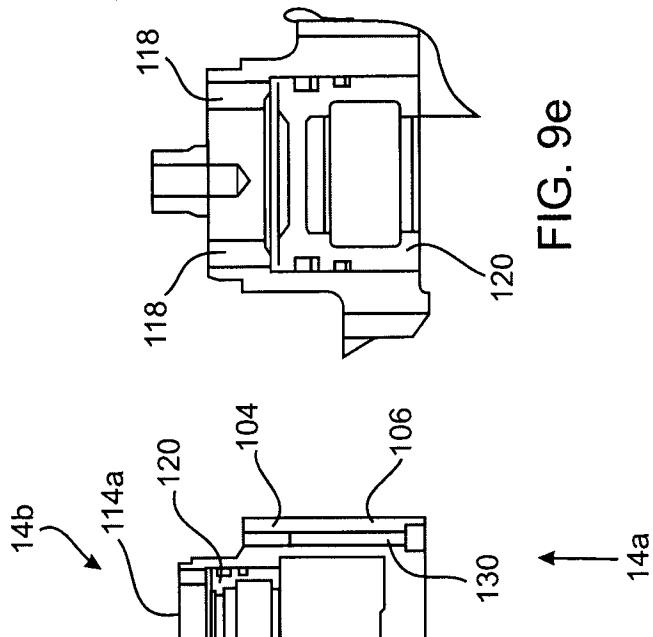


FIG. 9e

132

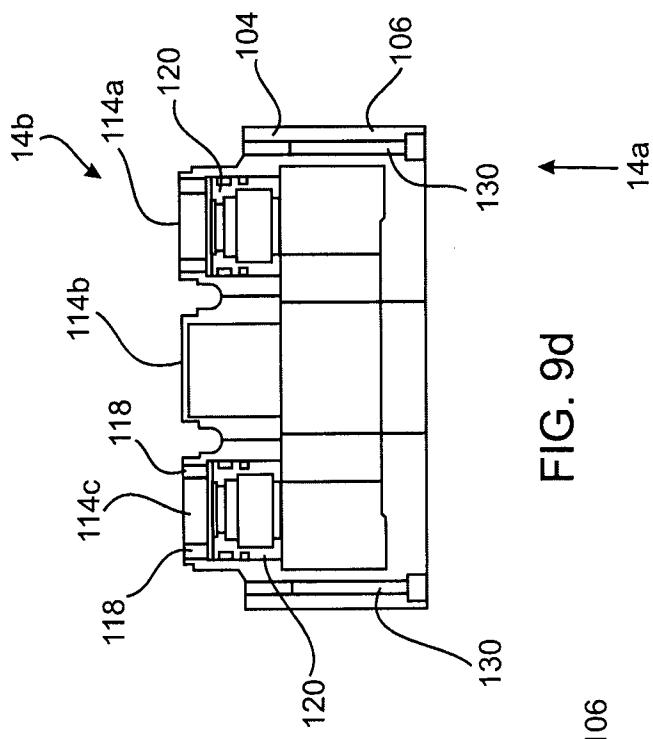


FIG. 9d

132

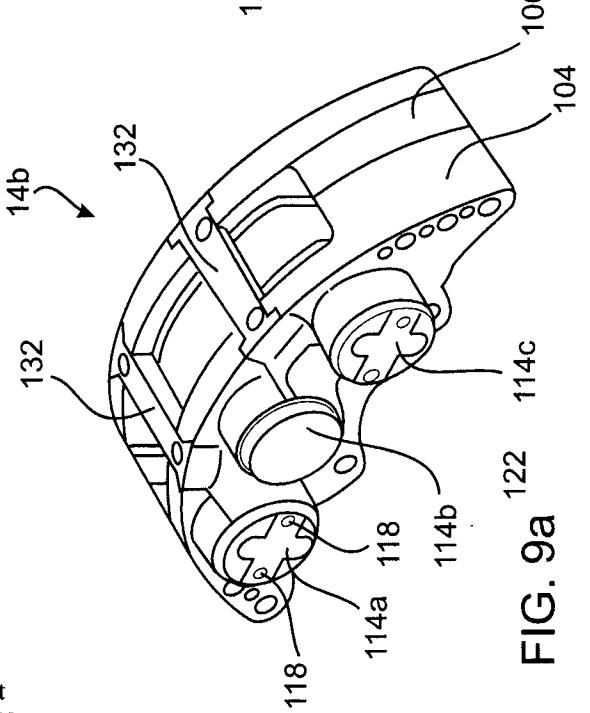
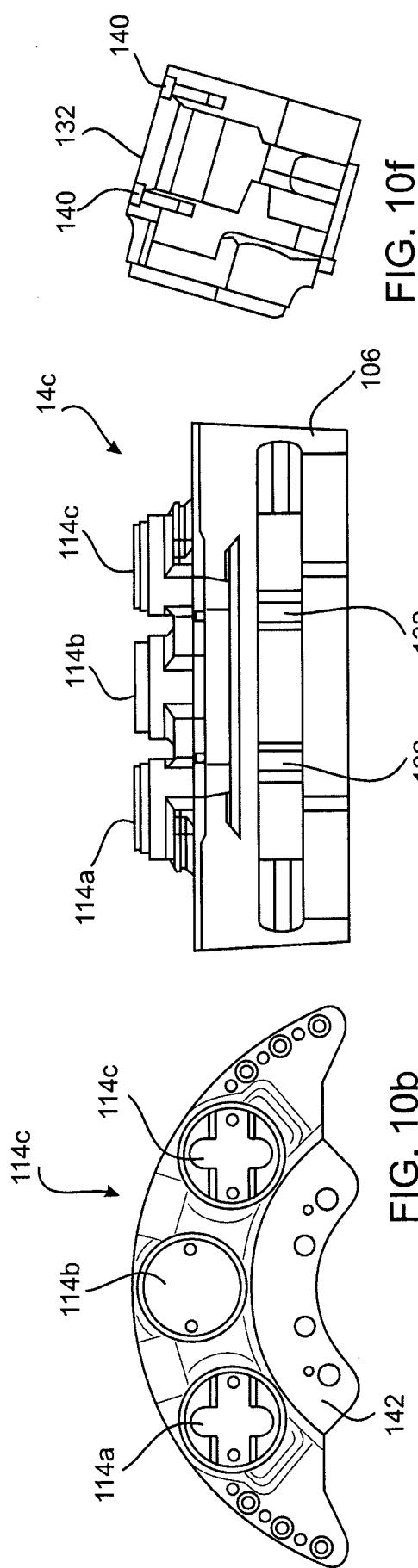


FIG. 9a

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Substitute Sheet
(Rule 26) RO/AU

FIG. 10f

FIG. 10c

FIG. 10b

FIG. 10d

FIG. 10e

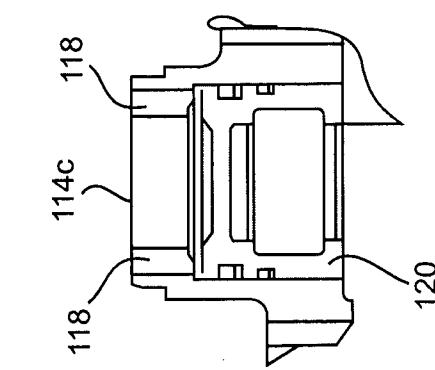
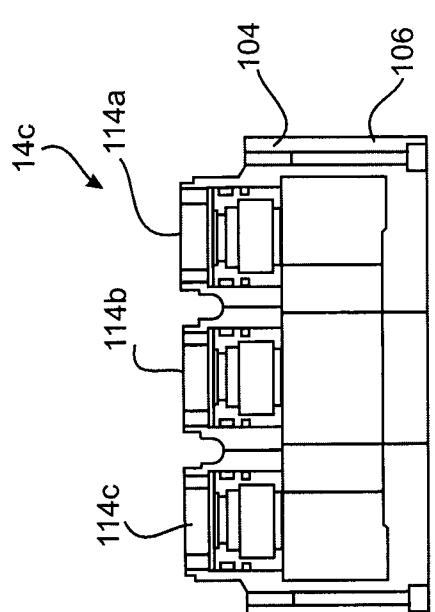
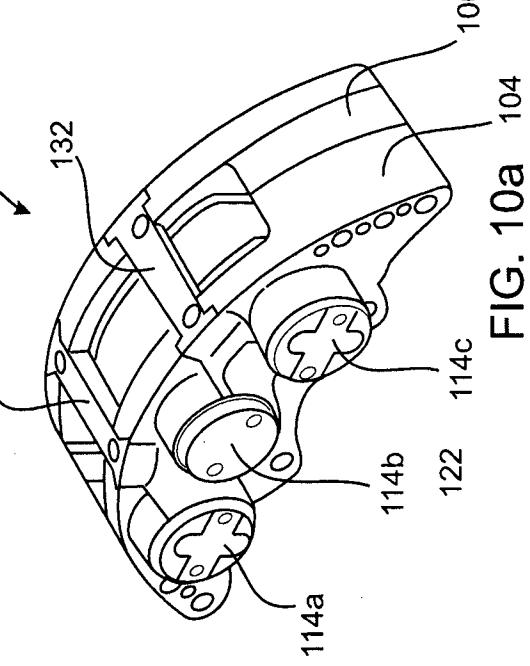


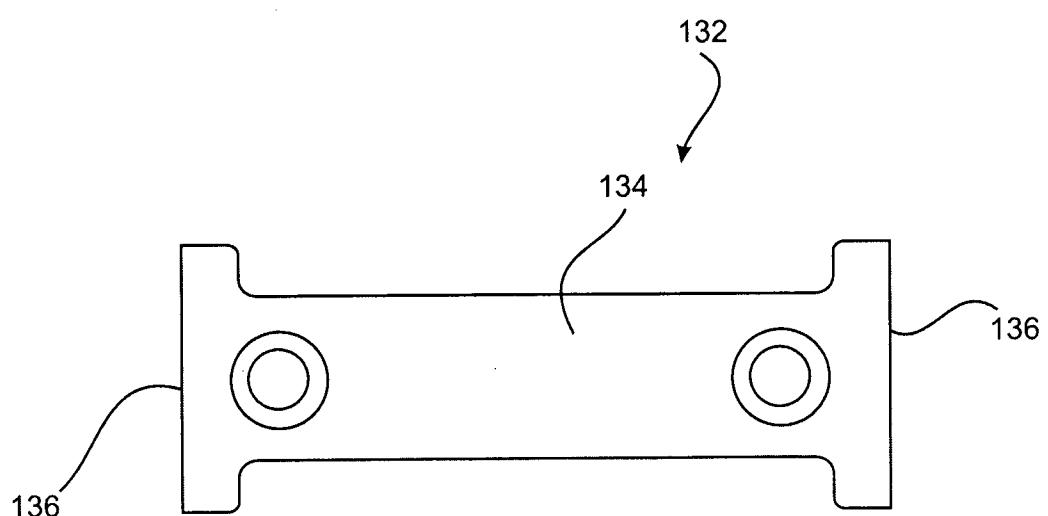
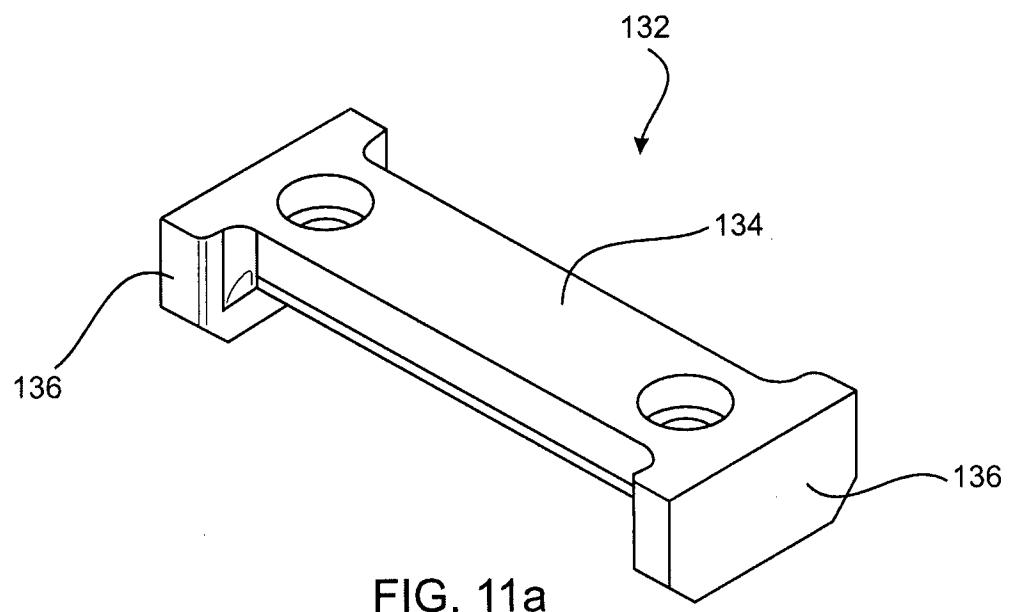
FIG. 10f

FIG. 10c

FIG. 10b

FIG. 10a

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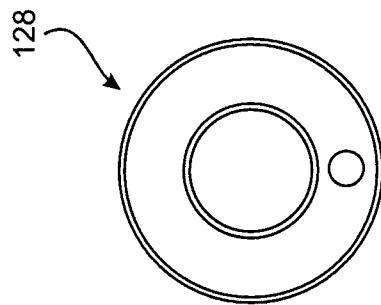


FIG. 12c

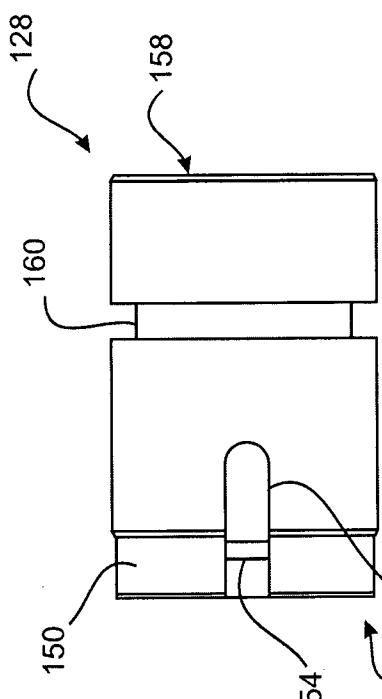


FIG. 12b

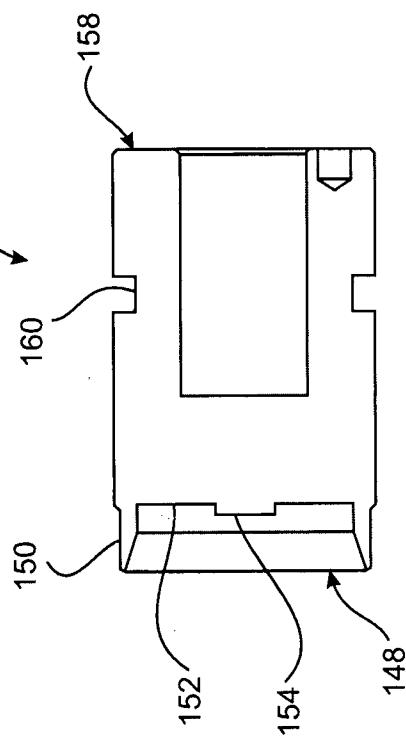


FIG. 12e

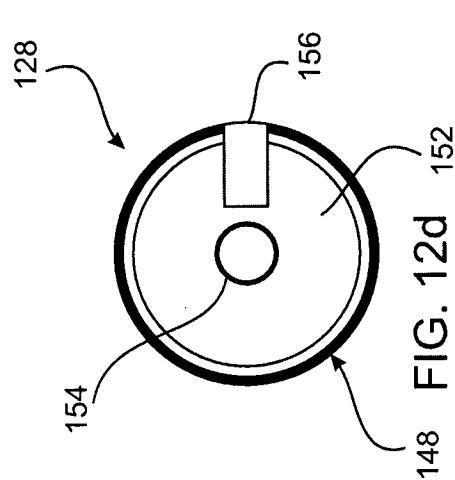


FIG. 12d

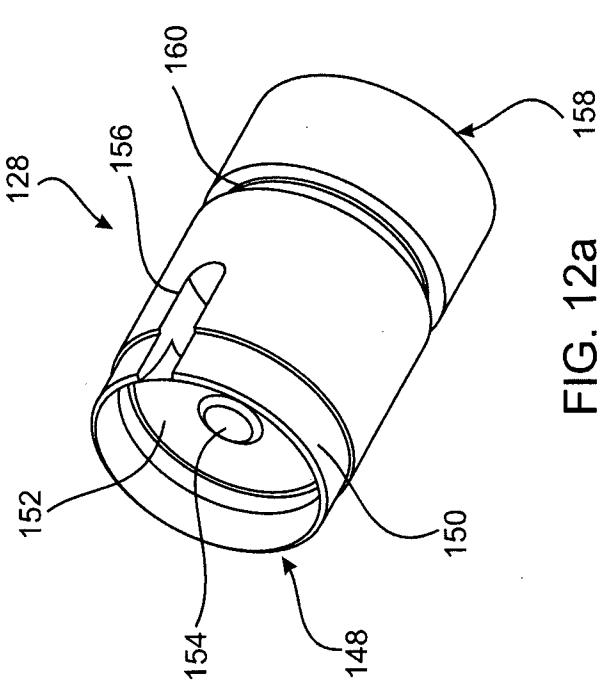
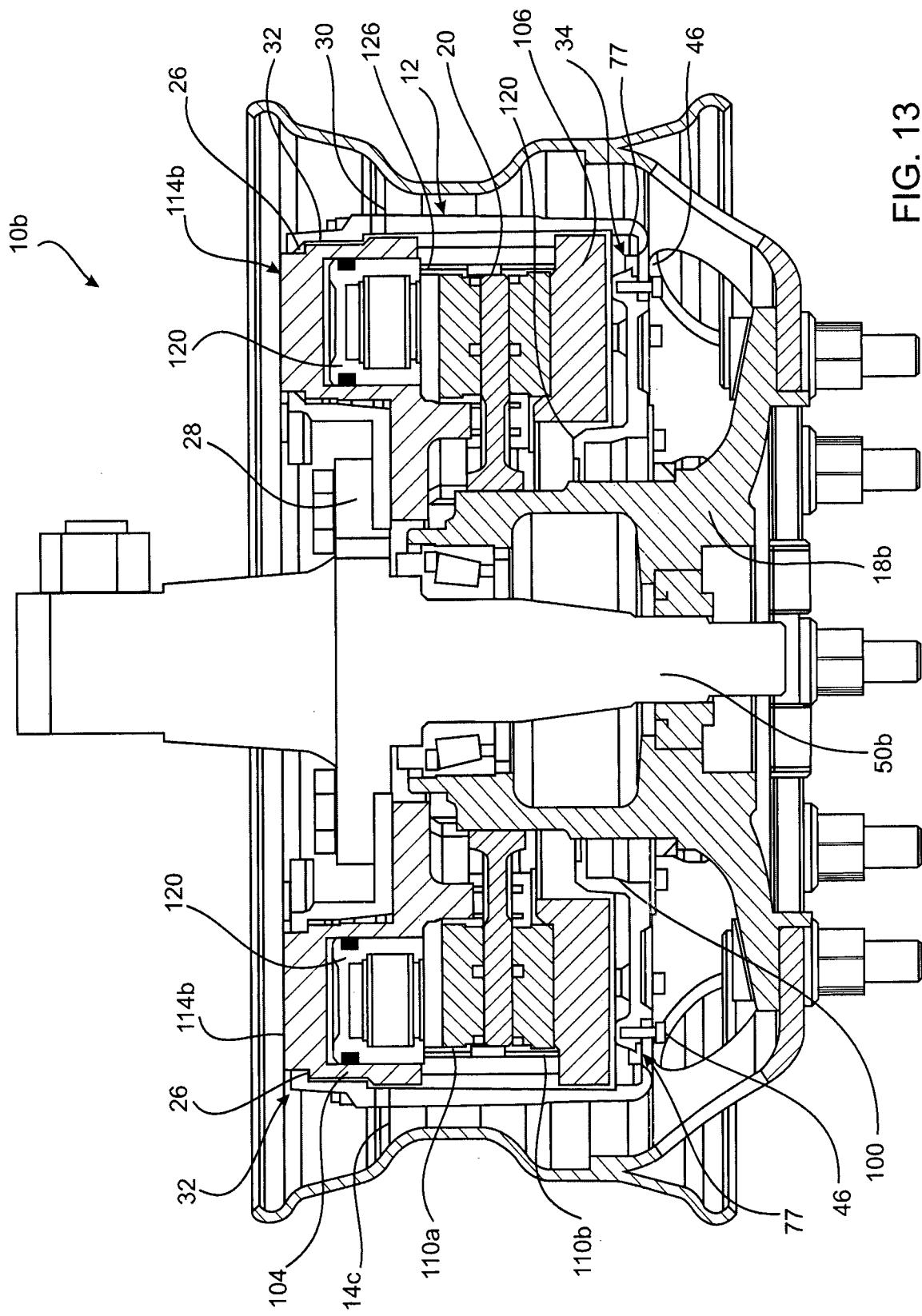


FIG. 12a

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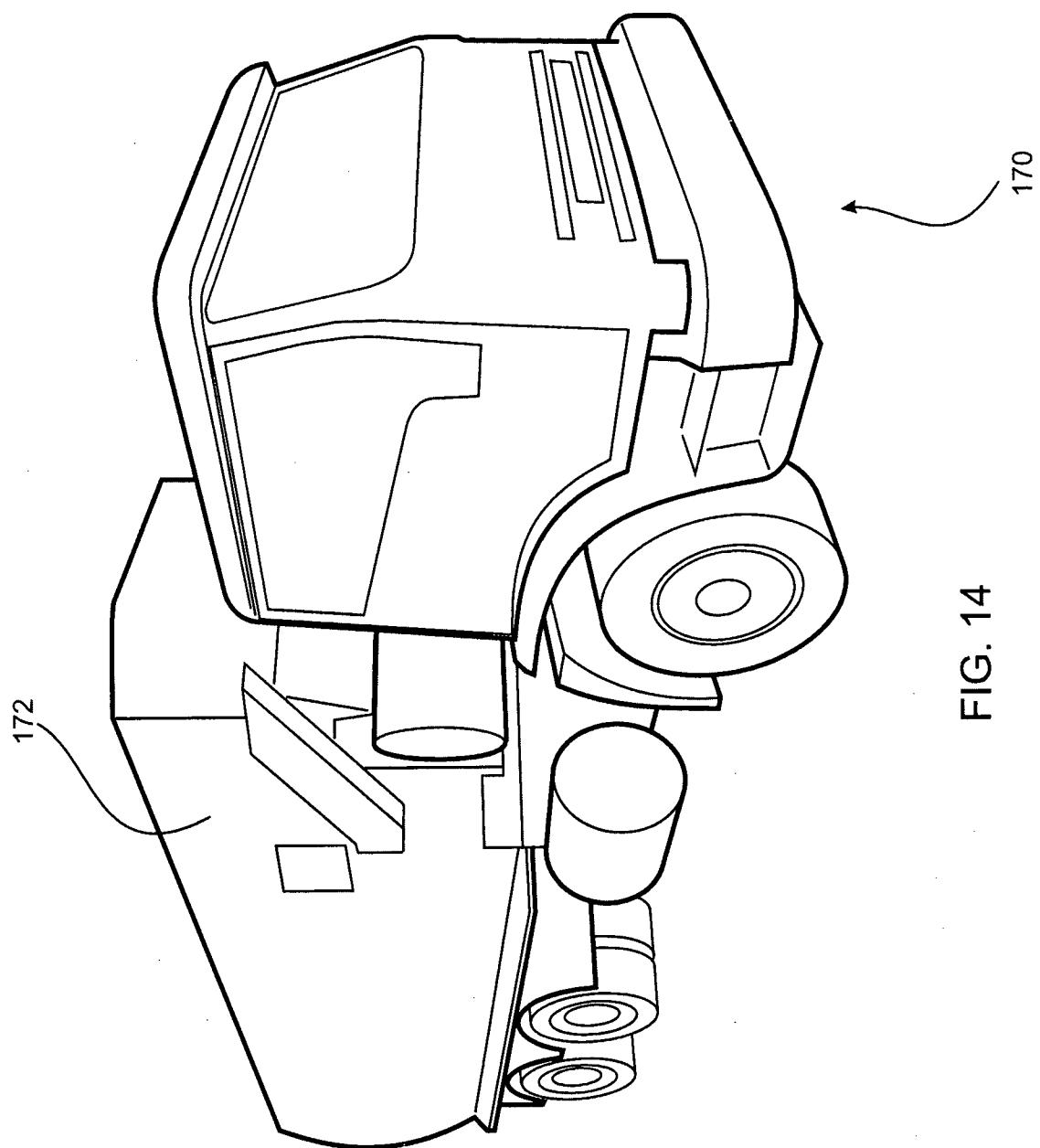
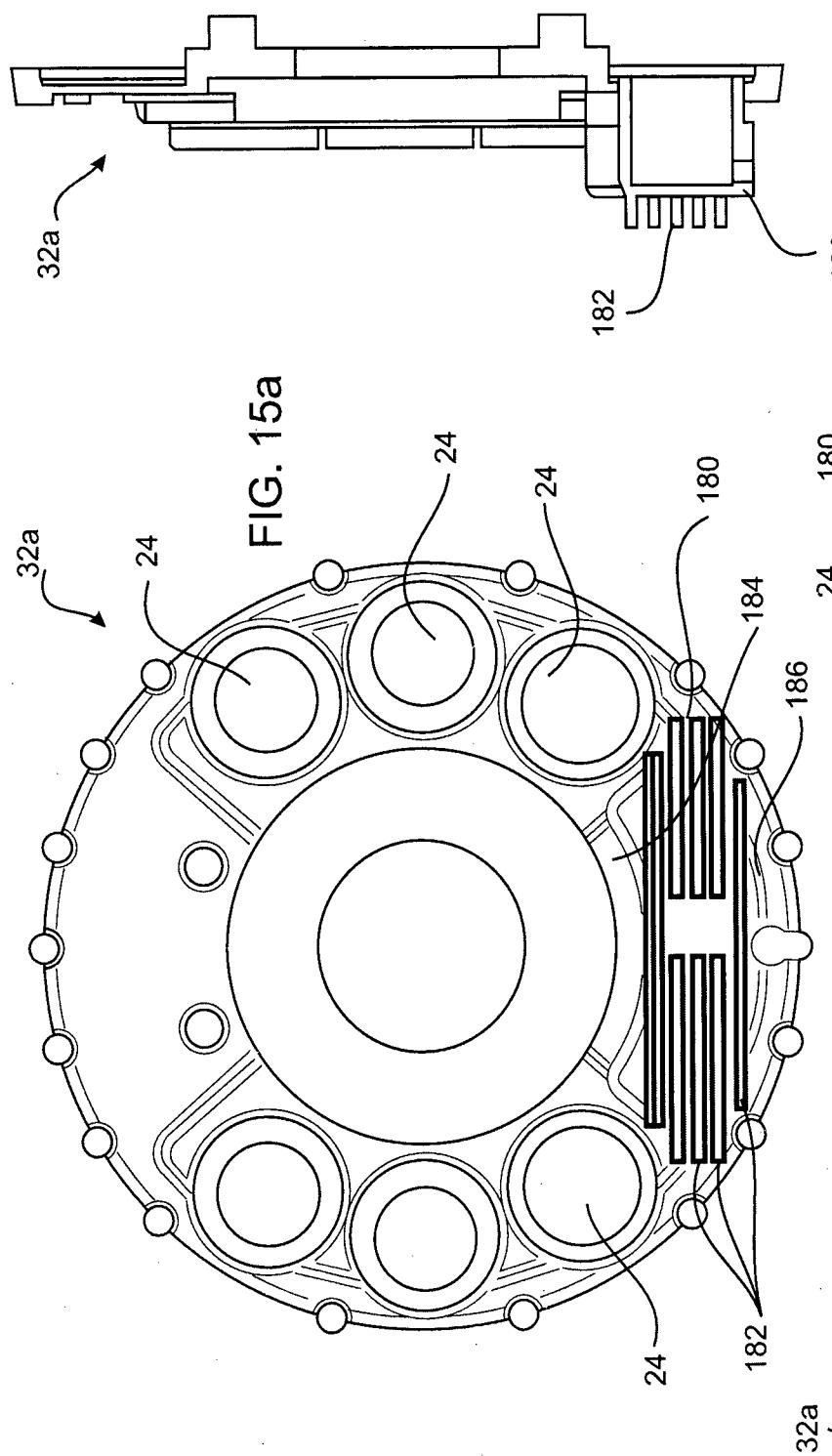


FIG. 14

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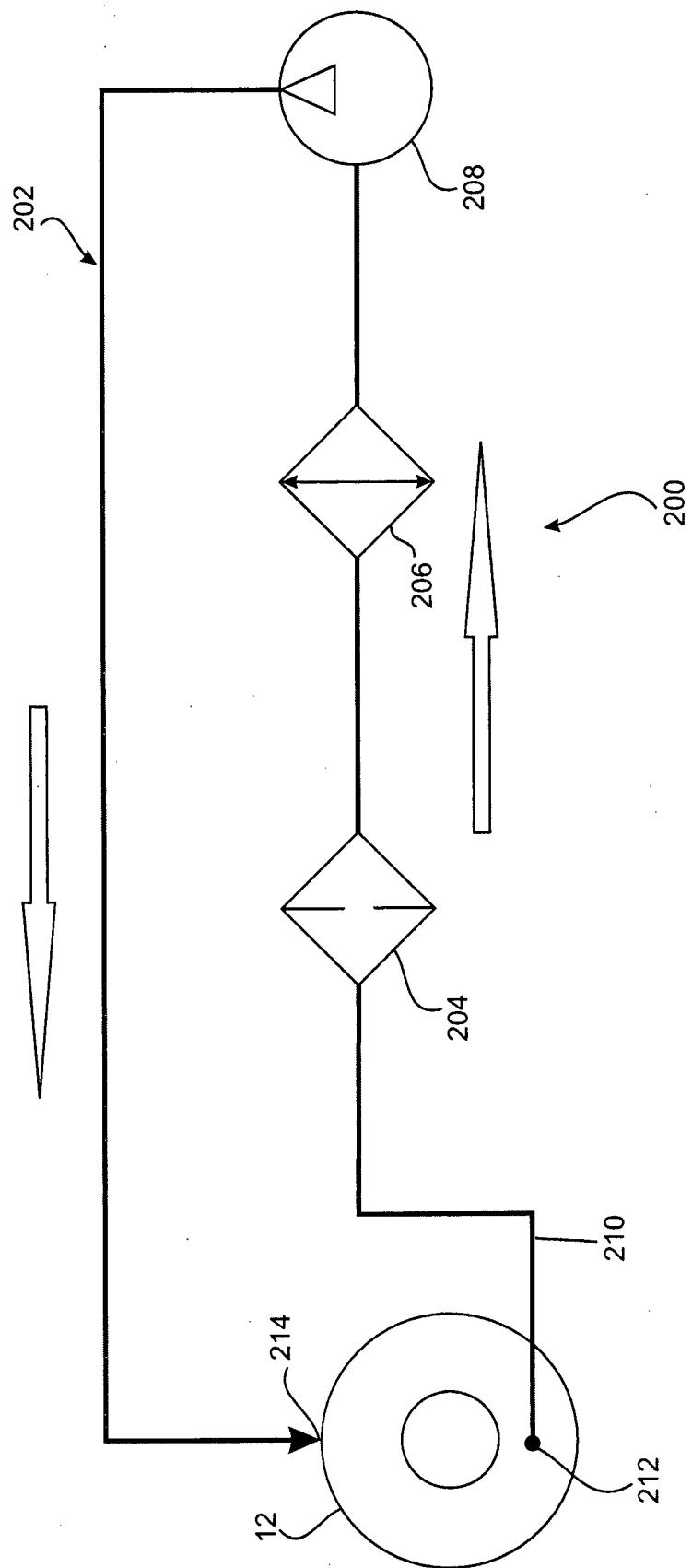


FIG. 16

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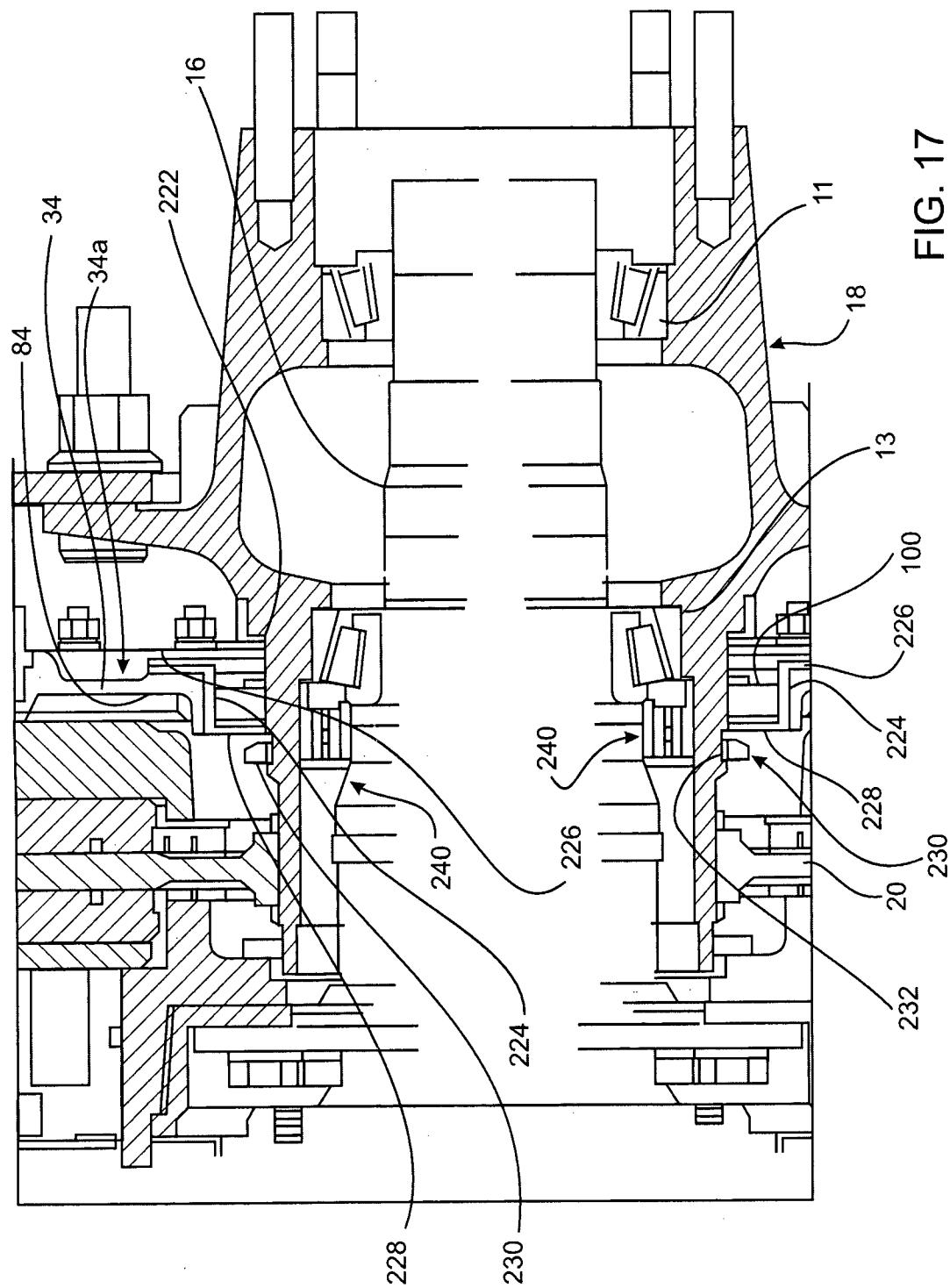


FIG. 17

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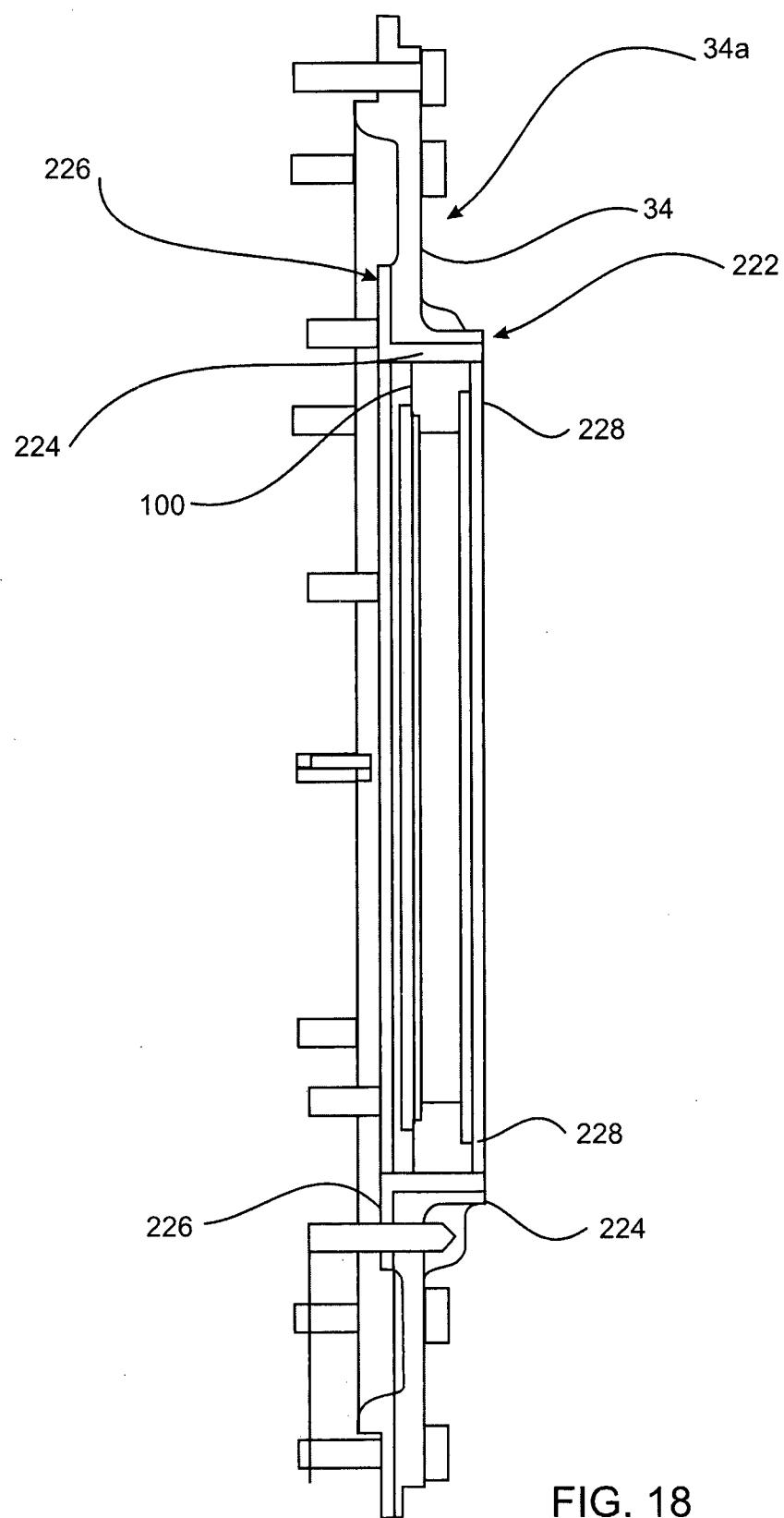
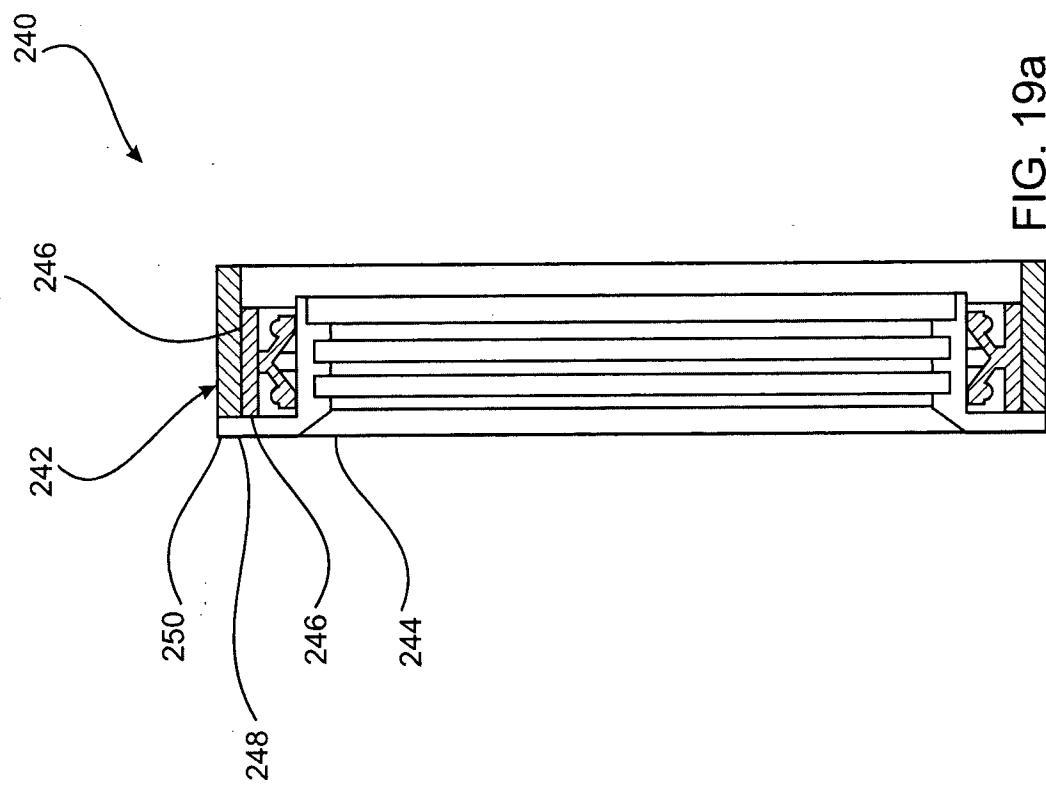
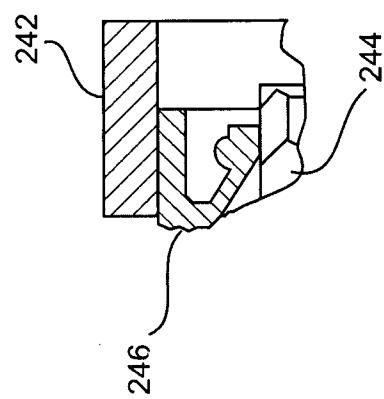


FIG. 18

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2010/001653

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F16D 55/226 (2006.01) **B60T 13/38** (2006.01)
B60T 13/12 (2006.01) **F16D 65/853** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

1) WPI & EPODOC: KEYWORDS wet, disc, brake, calliper, and similar terms.
 2) WPI & EPODOC: IPC & ECLA F16D 55/- and KEYWORDS housing, casing, encased, cover, shell, cavity, enclosed, sealed, heat, oil, liquid, fluid, wet, calliper, cylinder, two, part, piece, and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-018290 A (FURUKAWA CO LTD) 18 January 2000 English language abstract retrieved from ESPACE, and figure 1	1 - 11, 21 - 27, 30 - 32
X	US 2006/0054426 A1 (FILLMORE et al.) 16 March 2006 Whole document, in particular paragraphs 24 - 36, 43, and figures 1, 2, 5, and 6	28, 29
Y	Whole document, in particular paragraphs 24 - 36, 43, and figures 1, 2, 5, and 6	1 - 11, 21 - 27, 30 - 32

Further documents are listed in the continuation of Box C See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
18 February 2011

Date of mailing of the international search report
- 8 MAR 2011 - 8 MAR 2011

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2010/001653

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5009293 A (TAKAHASHI) 23 April 1991 Whole document, in particular column 3 line 14 – column 4 line 18, and figure 1	28, 29 1 - 11, 21, 30 - 32
Y	US 2006/0231353 A1 (GILLILAND) 19 October 2006 Whole document, in particular paragraphs 21 – 24, and figure 5	9 - 11
A	US 5228543 A (HEIDENREICH) 20 July 1993 Abstract and figure 1	1 - 11, 30 - 32
A	WO 1993/007402 A1 (PARSONS) 15 April 1993 Abstract and figures 4 and 6	1 - 11, 30 - 32
A	US 6488132 B2 (MATSUISHI) 3 December 2002 Abstract and figure 1	21 - 27

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2010/001653

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:

because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos. 1 – 11 and 21 – 32.

Remark on Protest

The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

No protest accompanied the payment of additional search fees.

Supplemental Box

(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: Box No. III Observations where unity of invention is lacking

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are eight different inventions as follows:

1. Claims 1 – 11 are directed to a wet disc brake system comprising a housing forming a sealed cavity, one or more brake callipers disposed in the housing, each calliper includes one or more cylinders, and the housing is provided with openings for each of the cylinders, wherein each cylinder is seated in a respective opening.
2. Claims 12 – 15 are directed to a brake system comprising a service and a park brake calliper provided with at least two cylinders wherein at least one of the cylinders houses a hydraulically operated service piston and at least one cylinder houses a park piston applied by a spring and released by air pressure.
3. Claims 16 – 20 are directed to a heavy vehicle having a receptacle, an air compressor, and a braking system driven by the compressed air, the brake system comprises a service brake and a park brake, the service brake being a wet air over hydraulic actuated disc brake and the park brake being a spring applied and air released.
4. Claim 21 is directed to a heavy vehicle as defined by claim 16 with the wet disc brake system of claim 1.
5. Claims 22 – 27 are directed to a method of overhauling an air operated drum brake system on a heavy vehicle and replacing the drum brake with the wet disc brake system of claim 1 OR the service and park brake system of claim 12.
6. Claims 28 and 29 are directed to a housing for a vehicle brake system, the housing circumferentially surrounding the brake rotor and callipers and provided with one or more openings for seating the cylinders of the callipers.
7. Claims 30 and 31 are directed to a brake system for a vehicle comprising a rotor, one or more brake callipers, each calliper having a piston, a housing circumferentially surrounding the brake rotor and callipers and provided with one or more openings for seating the cylinders, a structural component coupled to vehicle and fastened to the callipers such that load generated by operation of the callipers is transferred through the fasteners to the structural component.
8. Claim 32 is directed to either the housing of claim 28 OR the brake system of claim 30 wherein the housing is non-structural and decoupled from forces generated during a braking operation.

For the purpose of search and examination inventions numbered 1, 4, 5, 6, 7, and 8 can be considered together as a first invention distinguished by the features of a brake system having a housing having openings to receive the cylinders of the brake calliper; whilst inventions numbered 2 and 3 can be considered together as a second invention distinguished by a disc brake system having a hydraulically operated service brake and a spring apply – air release park brake.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art. Each of the abovementioned two inventions has a different distinguishing feature and they do not share any feature which could satisfy the requirement for being a special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2010/001653

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member				
JP	2000-018290	NONE					
US	2006/0054426	NONE					
US	5009293	DE 3941928	JP	H0285036U			
US	2006231353	EP 1877676	US	7137488	US	2006/0231354	
		US 2007089943	WO	2006113233	WO	2007/118173	
US	5228543	NONE					
WO	1993/07402	AU 27511/92	BR	9206618	CA	2121037	
		EP 0607248	HK	1014382	NZ	244701	
		OA 9934	US	5564533	ZA	9207798	
US	6488132	EP 0936372	JP	11230201	US	2002/0007989	

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX