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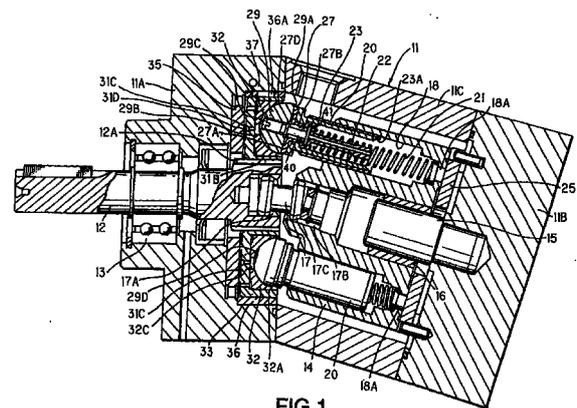
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(54) **HYDRAULIC PUMP OR MOTOR**

(57) Pistons and shoes are allowed to slide slightly on contact surfaces thereof, but are surely prevented from separating from each other. There are provided a rotating disk rotatably supported in a housing, and a cylinder block rotatably supported in the housing. The cylinder block has an of rotation inclined relative to an axis of rotation of the rotating disk. A plurality of cylinder bores are arranged on a circle about the axis of rotation of the cylinder block, and pistons are slidably accommodated in the respective cylinder bores. Semi-spherical shoes having spherical surfaces contacted with the rotating disk and flat smooth surfaces on the opposite side contacted with the pistons are provided. Connecting devices are further provided for connecting the pistons and the shoes to each other. The connecting devices allow the pistons and shoes to slide on each other in a direction along their contact surfaces, but prevent them from moving in a direction away from each other. A valve plate fixed to the housing is slidably contacted with a bottom surface of the cylinder block, and allows successive inflow and outflow of a working fluid to and from the respective cylinder bores as the cylinder block rotates. A joint is provided to connect the rotating disk and the cylinder block to each other to cause synchronous rotation of both. Either the rotating disk or the cylinder block is connected to a drive shaft.



Description

Technical Field

[0001] The invention relates to a hydraulic axial piston pump or motor, and more particularly, to an improvement in a mount construction of a piston and a shoe.

Background of the Invention

[0002] In hydraulic axial piston pumps, pistons suffer lateral forces in a direction perpendicular to the axes of the pistons in accordance with inclination of a swash plate. As a result, great frictional forces are generated on sliding surfaces of the pistons and cylinder bores.

[0003] Japanese Utility Model Laid-Open Nos. 48-55229, 48-68204, 48-57702, and 48-68203 or Japanese Patent Laid-Open No. 8-151975 have proposed, as a measure for reducing lateral forces acting on pistons, a construction in which pistons and shoes are in contact with each other in planes perpendicular to axes of the pistons.

[0004] With this construction, the shoes exert no component forces on the pistons in a direction perpendicular to the axes of the pistons, so the lateral forces acting on the pistons become very small. It is therefore possible to reduce friction between the pistons and cylinder bores.

[0005] In this case, however, since the shoes which are made to be in contact with the pistons can not be fixed to the swash plate, the pistons are pushed by springs in a direction of extension so as to maintain the contact with the shoes at any time, thereby preventing the shoes from dropping from the swash plate, even when the pump is not operated.

[0006] When the shoes are held by such relatively small spring forces, however, the following problems may arise.

[0007] For example, when there is a failure of lubrication and a grinding of foreign matter between the shoes and a rotating disk which supports the shoes, the forces pressing the pistons against the shoes become weak, especially when the pistons are performing a suction stroke and the pressures in associated cylinders are low. Therefore, some of the shoes may not be pressed against the rotation disk sufficiently, then these shoes may partially separated from the rotating disk, and, as a result, uneven contact between a piston and a shoe may occur. Such an uneven contact damages the contact face of the shoe.

[0008] On the other hand, when the pistons are brought into a discharge stroke, the pressures in the associated cylinders rise, and the shoes are intensely pushed by the pistons, so that the shoes are returned to a full surface contact condition from the condition of uneven contact, at which noises due to collision may be generated.

[0009] It is therefore an object of this invention to

prevent the separation of shoes and pistons while allowing slight sliding movement of contact surfaces of the shoes and the pistons.

5 Disclosure of the Invention

[0010] A hydraulic pump or motor according to the invention comprises a rotating disk rotatably supported in a housing, a cylinder block rotatably supported in an inner space of the housing, the cylinder block having an axis of rotation inclined relative to an axis of rotation of the rotating disk. A plurality of cylinder bores are arranged on a circle a center of which coincides with the axis of rotation of the cylinder block, and pistons reciprocate in the respective cylinder bores. Semi-spherical shoes having spherical surfaces held on the rotating disk and flat smooth surfaces on the opposite side, are provided. The flat surfaces are adapted to contact with the pistons. A valve plate is fixed to the housing. The valve plate has a sliding contact with a bottom surface of the cylinder block, and allows successive inflow and outflow of a working fluid to and from the respective cylinder bores as the cylinder block rotates. A joint is provided to connect the rotating disk and the cylinder block to each other to cause the synchronous rotation thereof, and a drive shaft is connected to the rotating disk or the cylinder block. Further, a connecting mechanism is provided for connecting the shoes and corresponding pistons respectively. The connecting mechanism allows the shoes and the corresponding pistons to slide on each other along contact surfaces thereof while preventing relative movements in a direction away from each other.

[0011] Preferably, a biasing mechanism is further provided for bringing the contact surfaces of the shoes and the corresponding pistons into close contact with each other.

[0012] The connecting mechanism preferably comprises a connecting rods which connect the shoes and the corresponding pistons to each other. The connecting rods are inserted into through holes provided in the pistons such that flanges formed at tip ends of the connecting rods are latched on interiors of the pistons. Base ends of the connecting rods are fixed to the shoes such that minute gaps are provided between the pistons and the shoes, and predetermined gaps are provided between inner peripheries of the through holes and outer peripheries of the connecting rods.

[0013] The biasing mechanism preferably comprises spring members or ring-shaped elastic members interposed between flanges formed at tip ends of the connecting rods and inner surfaces of the pistons.

[0014] The connecting mechanism may alternatively comprise spaces formed in the shoes and large diameter portions provided on the pistons. The large diameter portions are accommodated in the storage spaces such that predetermined gaps are provided between inner peripheries of the storage spaces and

outer peripheries of the large diameter portions.

[0015] In this case, the biasing mechanism preferably comprises spring members or ring-shaped elastic members interposed between the shoes and the large diameter portions in the spaces.

[0016] The connecting mechanism may alternatively comprise rods projecting from the shoes and inserted into through holes formed in the pistons, threaded portions provided at tip ends of the rods, and nuts screwed onto the threaded portions such that predetermined gaps are provided between inner peripheries of the through holes and outer peripheries of the rods.

[0017] In this case, the biasing mechanism preferably comprises spring members interposed between the nuts and the pistons.

[0018] Forces are acting on the pistons in axial directions, as reaction forces from the shoes, in accordance with the inclination of the rotating disk with respect to the cylinder block and with pressures in the cylinder bores. Since the shoes are in contact with the pistons at smooth surfaces perpendicular to the axes of the pistons, no forces parallel to the contact surfaces are generated, and the pistons suffer almost no lateral forces. Therefore, friction between the pistons and the cylinder bores becomes extremely small, thus making it possible to reduce abrasion on the sliding surfaces of the pistons. Since the rotational axis of the cylinder block is inclined relative to the rotational axis of the rotating disk, a circular path which the pistons take is slightly offset from a circular path which the shoes take. However, the pistons and the shoes can slide slightly relative to each other in directions along the contact surfaces thereof, so that smooth operation can be maintained.

[0019] Further, the shoes are connected to the pistons through the connecting mechanism, and the connection is ensured even when the pistons are performing the suction stroke, where forces exerted on the shoes from the pistons become small. Thus the shoes will not separated from the pistons, the contact surfaces between the shoes and the pistons will not be abraded, and noises due to collision will not be generated when the discharge stroke begins.

Brief Description of the Drawings

[0020]

Fig. 1 is a cross-sectional view of an axial piston pump showing a first embodiment of this invention.

Fig. 2 is an enlarged cross-sectional view of an essential part of Fig. 1.

Fig. 3 is a cross-sectional view of a part of a piston according to a second embodiment of this invention.

Fig. 4 is a cross-sectional view of a part of a piston according to a third embodiment of this invention.

Fig. 5 is a cross-sectional view of a part of a piston

according to a fourth embodiment of this invention.

Fig. 6 is a cross-sectional view of a part of a piston according to a fifth embodiment of this invention.

Fig. 7 is a cross-sectional view of a part of a piston according to a sixth embodiment of this invention.

Fig. 8 is a cross-sectional view of a part of a piston according to a seventh embodiment of this invention.

Fig. 9 is a cross-sectional view of a part of a piston according to an eighth embodiment of this invention.

Fig. 10 is a cross-sectional view of a part of a piston according to a ninth embodiment of this invention.

Fig. 11 is a cross sectional view of a part of a piston according to a tenth embodiment of this invention.

Preferred Embodiments

[0021] According to a first embodiment in which this invention is applied to an axial piston pump, a pump housing 11 comprises a cylindrical casing 11C gripped by a side block 11A and a port block 11B, as shown in Fig. 1.

[0022] A pump drive shaft 12 extending through the side block 11A is rotatably supported by a bearing 13. A cylinder block 14 is arranged in the inner space of the pump housing 11. A rotation shaft 15 inserted in the center of the cylinder block 14 supports the cylinder block 14 via a bearing 16, thereby allowing the cylinder block 14 to rotate about the rotation shaft 15.

[0023] Axes of the pump drive shaft 12 and the rotation shaft 15 intersect each other, such that the cylinder block 14 is inclined at an angle relative to the drive shaft 12. The drive shaft 12 connects to the cylinder block 14 through a joint 17, so that rotation of the drive shaft 12 is transmitted to the cylinder block 14.

[0024] The joint 17 has spline heads 17C on both ends. On of the spline heads 17C is spline jointed to a spline hole 17A formed at an end of the drive shaft 12, and the other spline head 17C is spline jointed to a spline hole 17B formed at the center of an end surface of the cylinder block 14. Outer peripheries of the spline heads 17C are formed so as to have spherical surfaces such that favorable spline engagement with the spline holes can be constantly maintained, even when axes of the spline hole 17A and the spline hole 17B intersect each other, and rotation can be transmitted from the drive shaft 12 to the cylinder block 14.

[0025] The cylinder block 14 has a plurality of cylinder bores 18, which are disposed at a regular interval on a circle about the rotation shaft 15 as center such that each bore axes are in parallel to the rotation shaft 15. Pistons 20 are accommodated slidably in the cylinder bores 18, respectively.

[0026] The pistons 20 are pushed in the direction of extension by coil springs 21 disposed in the cylinder bores 18. In each of the coil springs 21, a spring support 22 is inserted so as to prevent the spring 21 from bend-

ing. The spring support 22 is disposed inside the hollow piston 20 and an end of the spring support 22 is fixed to the piston 20. With this construction, the spring 21 is prevented from buckling and from contacting with an inner periphery of the piston 20. The spring supports 22 are formed from a material having low friction characteristics.

[0027] A tubular-shaped piston cover 23 formed of a synthetic resin (an engineering plastic) is fixed to an outer periphery of the piston 20 by means of an adhesive, etc., thereby reducing the friction between the sliding surfaces of the cover 23 and the cylinder bore 18. The piston cover 23 has a length at least of an effective stroke range of the piston 20, and a flange 23a formed inward from an end of the cover 23 engages with a bottom end of the hollow piston 20. The piston cover 23 is formed of a polymer material having a small frictional coefficient. A reinforcement material such as carbon fiber may be added to the polymer material.

[0028] A valve plate 25 adapted to contact with a bottom surface of the cylinder block 14 is fixed to the port block 11B. The valve plate 25 is provided with a pair of kidney ports (not shown), one for suction and the other one for discharge. These ports are made to successively connect to ports 18A which are formed through the cylinder block 14 from the bottoms of the respective cylinder bores 18. When the pistons 20 contract the cylinder bores 18, a working fluid is discharged therefrom, and when the pistons 20 expands the cylinder bores 18, the working fluid is sucked into the cylinder bores 18.

[0029] A discharge passage and a suction passage, not shown, which are made to connect to the kidney ports, are formed in the port block 11B.

[0030] As shown in Fig. 2, a top end of the piston 20 is provided with a flat surface 20A perpendicular to the piston axis, and a pad 27 made of a synthetic resin with a small friction coefficient is fitted to the piston 20 to cover the flat surface 20A. The pad 27 has a projection 27A on its back, which is fitted into a hole of the piston 20. A through hole 27B is formed at the center of the projection 27A, and is communicated with the inside of the piston 20. Also, the pad 27 has a flat support surface 27C with a pocket 27D, to which a pressure in the cylinder bore is introduced through an interior of the piston 20.

[0031] Semi-spherical shoes 29 are provided to contact with the pads 27. The shoes 29 are respectively supported on a side of the side block 11A by sockets 32 fitted to a torque plate 31, which is a rotating member arranged around the pump drive shaft 12.

[0032] The sockets 32 are formed of a synthetic resin with a small coefficient of friction, and are respectively fitted into recesses 31A, formed in the torque plate 31. Each of the socket 32 is provided with a semi-spherical recess 32A, in which a spherical surface 29B of the shoe 29 is rotatably fitted.

[0033] The shoe 29 is provided with a smooth sur-

face 29A which has a diameter slightly greater than or substantially the same as that of the flat support surface 27C of the pad 27. These smooth surface 29A and the support surface 27C are brought into surface contact with each other. As described above, the pressure in the cylinder bore is introduced into the pocket 27D, thereby forming a fluid hydrostatic bearing between the shoe 29 and the pad 27. Due to the pressure in the pocket 27D, the surfaces 29A and 27C are subject to a hydrostatic pressure which makes the abrasion therebetween as small as possible.

[0034] Further, a through hole 29C is formed between the smooth surface 29A and the spherical surface 29B of the shoe 29, and a fluid from the pocket 27D of the pad 27 is introduced into a pocket 29D, which is formed on the spherical surface 29B of the shoe 29, to promote a fluid bearing which reduces friction between the contact surfaces of the shoe 29 and socket 32.

[0035] The piston 20 and the shoe 29 is connected by a connecting rod 40. The connecting rod 40 couple the piston 20 and the shoe 29 so as to allow a relative movement in a direction along the contact surfaces of the pistons 20 and the shoes 29 within a small range while preventing a relative movement of the pistons 20 and the shoes 29 in a direction away from each other. The connecting rod 40 is inserted into the through hole 29C of the shoe 29 as well as the through holes 27B of the pads 27, which is fitted into the through hole 20B of the piston 20.

[0036] A flange 41 is formed at an end of the connecting rod 40 so as to contact a spring seat 42 inside the piston 20. A male screw portion 43 is formed at another end of the connecting rod 40 so as to engage with a female screw portion formed on an inner periphery of the through hole 29C of the shoe 29. It should be noted that the spring seat 42 is a part of the spring support 22.

[0037] A step 45 is formed midway along the connecting rod 40. By screwing the connecting rod 40 into the shoe 29 until the step 45 interferes with the shoe 29, the connecting rod is precisely positioned, and a minute gap is defined between the flange 41 and the spring seat 42.

[0038] A predetermined gap is provided between an outer periphery of the connecting rod 40 and an inner periphery of the through hole 27B of the pad 27, whereby the shoe 29 and the piston 20 are displaceable in a direction along the contact surfaces thereof while limiting their relative movement in the axial direction of the piston within a quite limited range.

[0039] A fluid passage 46 is formed through the connecting rod 40 along its center axis, and branch passages 47 extending radially from the fluid passage 46 are formed midway along the fluid passage 46.

[0040] Via the fluid passage 46, the working fluid from the hollow piston is introduced to the contact surfaces of the shoe 29 and pad 27 as well as to the contact surfaces of the shoe 29 and semi-spherical recess

32A of the socket 32, so as to lubricate the contact surfaces. The working fluid introduced between these contact surfaces also form the hydrostatic bearings.

[0041] If an orifice, a choke or the like is provided in the fluid passage 46, a quantity of the fluid supplied to the shoe 29 and the pocket 27D can be suitably controlled.

[0042] The torque plate 31 has a central spline hole 31B engaged with a spline portion 12A provided on an outer periphery of the pump drive shaft 12. Due to this engagement, the torque plate 31 rotates together with the pump drive shaft 12, and, as a result, rotates in synchronism with the cylinder block 14 in the same direction. Therefore, the shoe 29 supported in the socket 32 on the torque plate 31, and the piston 20 contacting it through the pad 27, rotate along a circle around the pump drive shaft 12, while always maintaining the same positional relationship therebetween.

[0043] The torque plate 31 is fitted in a circular recess 33 formed in the side block 11A about the pump drive shaft 12 as center, and its bottom surface is in contact with a disk-shaped thrust plate 35. The thrust plate 35 is formed of a synthetic resin with a small coefficient of friction and is fixed to the side block 11A. The torque plate 31 is provided with pockets 31C on a sliding surface thereof facing the thrust plate 35, and the fluid pressure is introduced to each of the pockets 31C. The fluid pressure is led into each of the pocket 31C from a part corresponding to the fluid bearing of the shoe 29, via a through hole 32C formed through the socket 32 and a through hole 31D formed through the torque plate 31. Due to this fluid pressure in the pockets 31C, the contact surfaces between the torque plate 31 and the thrust plate 35 are supported by the hydrostatic bearings, so the friction there between is reduced.

[0044] Also, a bush 36 formed of a synthetic resin with a small coefficient of friction is provided facing an outer periphery of the torque plate 31, and the fluid pressure is conducted to sliding surfaces between the outer periphery of the torque plate 31 and an inner periphery of the bush 36, so as to reduce the friction therebetween by forming a hydrostatic bearing. In order to supply fluid pressure for this purpose, a pressure introduction passage 37 communicated with the pump discharge passage is formed in the side block 11A, and pockets 36A which communicate with the pressure introduction passage 37 are provided facing the sliding surfaces of the bush 36 and the torque plate 31.

[0045] When the pump drive shaft 12 is rotated by a prime mover (not shown), the torque plate 31 rotates therewith, and simultaneously the cylinder block 14 is rotated through the joint 17.

[0046] Since the cylinder block 14 is inclined relative to the torque plate 31, the distance between the cylinder block 14 and the torque plate 31 facing each other changes as they rotates.

[0047] In a rotation position range where the distance between the cylinder block 14 and the torque

plate 31 increases after the position at which the distance therebetween has taken the smallest value, the piston 20 expands the cylinder bore while maintaining contact between the piston 20 and the shoe 29 by being pushed by the spring 21 and the working fluid is sucked to the cylinder bore 18 via the port 18A. On the other hand, in another rotation position range where the distance between the cylinder block 14 and the torque plate 31 decreases after the position at which the distance therebetween has taken the largest value, the piston 20 is pushed by the shoe 29 and the fluid in the cylinder bore 18 is discharged from the port 18A. The fluid is sucked via the suction passage and discharged via the discharge passage by operation of the valve plate 25.

[0048] In this way, by rotating the cylinder block 14, the pistons 20 reciprocate while maintaining the contact with the shoes 29 held by the torque plate 31, and suction and discharge of the working fluid from and to the cylinder bore 18 is repeated to thereby function as the axial piston pump.

[0049] Hereupon, a force in the axial direction is exerted on the piston 20 corresponding to the fluid pressure in the cylinder bore 18. This force is supported by the torque plate 31 via the shoes 29. In this case, since the torque plate 31 is not perpendicular to the center axis of the piston 20, but is inclined instead at a certain angle relative thereto, a reaction force from the shoe 29 poses a component force in a direction perpendicular to the axis of the piston 20.

[0050] However, the piston 20 and the shoe 29 are always brought into contact with each other by planes perpendicular to the center axis, i.e., the support plate 27C of the pad 27 fitted to the piston 20 is in contact with the flat smooth face 29A of the shoe 29. Accordingly, almost no force in the direction perpendicular to the center axis of the piston 20 which is parallel to these contact faces is exerted on the piston 20 by the shoe 29.

[0051] Therefore, the pistons 20 are free from the lateral forces acting in the direction perpendicular to the axes thereof, so a frictional force acting on the sliding surfaces of the cylinder bores 18 is very small.

[0052] Rotational torque of the pump drive shaft 12 is transmitted to the cylinder block 14 via the joint 17, as well as to the torque plate 31 via the spline portion 12A. Accordingly, the cylinder block 14 rotates together with the torque plate 31 and the pistons 20 and the shoes 29 rotate around the pump drive shaft 12 while maintaining substantially the same positional relationship therebetween. Therefore, no relative torque acts between the pistons 20 and the shoes 29 at any rotation angle and also thereby, large lateral force is not exerted on the piston 20.

[0053] Friction on the sliding surfaces of the pistons 20 and of the cylinder bores 18 mainly corresponds to lateral forces exerted on the pistons 20, so that the weaker the lateral forces, the less sliding frictional forces can be reduced. Also, the cover 23 formed of a

resin material is fitted to the outer periphery of the piston 20 so as to reduce sliding resistance of the piston 20 with respect to the cylinder bore 18.

[0054] As a result, the frictional force of the sliding surface of the piston 20 on the cylinder bore 18 is reduced. Therefore, even when water is used as the working fluid, wear of the sliding face is reduced and high durability is achieved.

[0055] Also, the pad 27 made of a synthetic resin having a small friction coefficient are interposed between the piston 20 and the shoe 29, so as to prevent metal contact between the piston 20 and the shoe 29. Further, the pocket 27D is formed in the pad 27, inner pressure of the cylinder bore 18 is conducted to the pocket 27D via the interior of piston 20, and a hydrostatic bearing is constituted between the contact faces of the pad 27 and shoe 29. As a result, the contact pressure therebetween is reduced by the hydraulic pressure, and the wear of the contacting faces is reduced.

[0056] The contact pressures between the pad 27 and the shoe 29 is high during the discharge stroke of the piston 20, and is conversely low during the suction stroke thereof. Accordingly, the pressure required for the hydrostatic bearing becomes high during the discharge stroke, and low during the suction stroke. Since the inner pressure of the cylinder bore 18 is conducted to the pocket 27D via the piston 20, the characteristics of the pressure provided to the pocket 27D coincides with those required for the hydrostatic bearing. The pocket 27D, therefore, functions as an excellent hydraulic bearing.

[0057] Also, the sockets 32 formed of a synthetic resin are provided between the shoes 29 and the torque plate 31 so as to eliminate direct contact between the shoes 29 and the torque plate 31, thus preventing metallic contact therebetween. Further, the fluid pressure is conducted to spherical-shaped contact surfaces between the socket 32 and the shoe 29 via the pocket 29D, so as to constitute a hydrostatic bearing between the contact surfaces of the socket and the shoe. Accordingly, metallic contact occurs less often between these contact surfaces, thus enabling a reduction of abrasion.

[0058] The torque plate 31 rotating together with the pump drive shaft 12 suffers a reaction force of the pistons 20 in the discharge stroke, and is pushed towards the recess portion of the side block 11A in the thrust direction and the radial direction in accordance with the inclination of the pistons 20. The torque plate 31 is supported by the thrust plate 35 in the direction of the rotational axis thereof against the thrust force and is supported by the bush 36 in the lateral direction against the radial force. Accordingly, the metallic contact of the sliding surfaces is prevented under the action of these forces. Further, fluid pressures are introduced so as to constitute a hydrostatic bearing between the contact surfaces of the thrust plate 35 and the bush 36, thus reducing mechanical contact forces. Accordingly, mechanical contact of these members is avoided, wear

of the torque plate 31 is reduced, and the durability is enhanced.

[0059] Since the axis of the cylinder block 14 is inclined relative to the axis of the torque plate 31, the pistons 20 arranged in the cylinder block 14 draw an elliptical path slightly offset from a circular path, which the shoes 29 rotating together with the torque plate 31 draw. Accordingly, the contact surfaces of the piston 20 and of the shoe 29 slides relative to each other. Such sliding is allowed by a gap existent between the connecting rod 40 and the through hole 27B, whereby a smooth operation is maintained.

[0060] On the other hand, the piston 20 and the shoe 29 is connected to each other by the connecting rods 40 so as to allow little movements in the axial direction. Therefore, even when pushing force between the shoe 29 and the piston 20 is weak during the suction stroke, the shoe 29 will not separate from the piston 20, so neither uneven contact between the shoe 29 and the piston 20 nor abnormal noise due to their collision will occur.

[0061] Fig. 3 shows a second embodiment of this invention.

[0062] In this embodiment, the gap between the flange 41 of the connecting rod 40 and the spring seat 42 is made larger, so as to allow a belleville spring 51 to be interposed between the flange 41 and the spring seat 42. In this embodiment, the spring seat 42 is formed with an annular-shaped step 42A, into which the belleville spring 51 is fitted.

[0063] With such an arrangement, the piston 20 and the shoe 29 are closely pressed against each other by the resilient force of the belleville spring 51, whereby the shoe 29 can be prevented from separating from the piston 20 in the suction stroke, and noises due to collision can be certainly reduced.

[0064] It should be noted that the spring supports 22 and the pads 27 made of a synthetic resin in the first embodiment are omitted in this embodiment and in the embodiments to be described hereafter.

[0065] Fig. 4 shows a third embodiment of this invention.

[0066] In this embodiment, in place of the belleville spring 51, a ring-shaped elastic member 52 is interposed between the flange 41 of the connecting rod 40 and the spring seat 42 of the piston 20. For example, rubber, resin material or the like is used for the elastic member 52.

[0067] Fig. 5 shows a fourth embodiment of this invention.

[0068] In this embodiment, in place of the belleville spring 51 in the second embodiment, a coil spring 53 is interposed between the flange 41 and a bearing seat 20D formed on an inner wall of the piston 20. With such an arrangement, the shoe 29 is biased to closely contact with the piston 20, and is surely prevented from separating from the piston.

[0069] Fig. 6 shows a fifth embodiment of this

invention.

[0070] This embodiment employs another connecting means in place of using the connecting rod 40 in the first - fourth embodiments described above.

[0071] This connecting means comprises a cylindrical portion 54 extending axially from the outer periphery of the shoe 29.

[0072] The cylindrical portion 54 is inwardly bent at its end at right angles to form a flange 54A, thereby defining a cylindrical space 55 in the shoe 29. The space 55 accommodates a large diameter portion 20C formed at an end of the piston 20. A predetermined gap is provided between an outer periphery of the large diameter portion 20C of the piston 20 and an inner periphery of the space 55. A predetermined minute gap is provided between the large diameter portion 20C of the piston 20 and the inner periphery of the space 55 in the direction of the center axis of the piston 20 based on the difference of the thickness of the large diameter portion 20C and the axial height of the storage space 55.

[0073] The large diameter portion 20C of the piston 20 is accommodated in the cylindrical space 55, and is prevented by the flange 54A from falling out, so that the shoe 29 will not separate from the piston 20 and is allowed to move slightly in a direction along contact surfaces of the two members.

[0074] Fig. 7 shows a sixth embodiment of this invention.

[0075] In this embodiment, a belleville spring 56 is interposed between the large diameter portion 20C of the piston 20 and the flange 54A, so as to bring the piston 20 and the shoe 29 into close contact with each other.

[0076] In a seventh embodiment shown in Fig. 8, in place of the above belleville spring 56, an annular-shaped elastic member 57 is interposed between the large diameter portion 20C and the flange 54A, so as to bring the piston 20 and the shoe 29 into close contact with each other.

[0077] It needless to say that any elastic means such a waver washer or the like can be employed instead of the belleville spring or annular-shaped elastic member.

[0078] Fig. 9 shows an eighth embodiment of this invention.

[0079] In this embodiment, a shoe 29 is integrally provided centrally with a rod 58, of which a tip end is formed with a threaded portion 58A. The rod 58 penetrates a through hole 20B of the piston 20 and a nut 60 is screwed onto the tip end of the rod 58 via a washer 59 therebetween.

[0080] A predetermined gap is provided between an inner periphery of the through hole 20B and an outer periphery of the rod 58, and the washer 59 is made to abut against a step portion 58B of the rod 58, so as to ensure a minute gap between the washer 59 and a spring seat 42 of the piston 20.

[0081] With this construction, the shoe 29 can slide

relative to the piston 20 at contact surfaces thereof, but is separated only a minute amount therefrom in an axial direction. Therefore, it is possible to prevent occurrence of uneven contact and noises due to collision, while ensuring a smooth lateral movement between the piston 20 and the shoe 29. In this case, the arrangement is made simple and the manufacturing cost can be reduced as compared with the case where the connecting rod is provided.

[0082] Fig. 10 shows a ninth embodiment of this invention.

[0083] In this embodiment, two nuts 60A, 60B are employed so as to form a double nut locking mechanism in order to position a washer 59, thereby precisely setting a minute gap between the washer 59 and a spring seat 42.

[0084] Fig. 11 shows a tenth embodiment of this invention.

[0085] In this embodiment, an elastic member 62 is interposed between the washer 59 and the spring seat 42, and the elasticity of the elastic member 62 is used to prevent separation of the shoe 29 and the piston 20 from each other. For the elastic member 62, it is possible to use an elastic material such as rubber, resin or the like and a spring material such as coil springs, wave washers, belleville springs or the like.

[0086] While the respective embodiments described above are application of this invention to an axial piston pump, it goes without saying that they are also applicable to an axial piston motor.

Claims

1. A hydraulic pump or motor comprising:

- a rotating disk rotatably supported in a housing;
- a cylinder block rotatably supported in an inner space of the housing, the cylinder block having an axis of rotation inclined relative to an axis of rotation of the rotating disk;
- a plurality of cylinder bores arranged on a circle a center of which coincides with the axis of rotation of the cylinder block;
- pistons reciprocating in the respective cylinder bores;
- semi-spherical shoes having spherical surfaces held on the rotating disk, and flat smooth surfaces on the opposite side, the flat surfaces being adapted to contact with the pistons;
- a valve plate fixed to the housing, the valve plate having a sliding contact with a bottom surface of the cylinder block, and allowing successive inflow and outflow of a working fluid to and from the respective cylinder bores as the cylinder block rotates;
- a joint connecting the rotating disk and the cylinder block to each other to cause the synchro-

nous rotation thereof;
 a drive shaft connected to the rotating disk or the cylinder block; and
 connecting means for connecting the shoes and corresponding pistons respectively, the connecting means allowing the shoes and the corresponding pistons to slide on each other along contact surfaces thereof while preventing relative movements in a direction away from each other.

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2. The hydraulic pump or motor as defined in Claim 1, further comprising biasing means for bringing the contact surfaces of the shoes and the corresponding pistons into close contact with each other. 15
3. The hydraulic pump or motor as defined in Claim 1 or 2, wherein the connecting means comprises a connecting rods which connect the shoes and the corresponding pistons to each other, the connecting rods being inserted into through holes provided in the pistons such that flanges formed at tip ends of the connecting rods are latched on interiors of the pistons, base ends of the connecting rods being fixed to the shoes such that minute gaps are provided between the pistons and the shoes, and predetermined gaps are provided between inner peripheries of the through holes and outer peripheries of the connecting rods. 20
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4. The hydraulic pump or motor as defined by Claim 2, wherein the biasing means comprises spring members or ring-shaped elastic members interposed between flanges formed at tip ends of the connecting rods and inner surfaces of the pistons. 35
5. The hydraulic pump or motor as defined in Claim 1 or 2, wherein the connecting means comprises spaces formed in the shoes and large diameter portions provided on the pistons, the large diameter portions being accommodated in the storage spaces such that predetermined gaps are provided between inner peripheries of the storage spaces and outer peripheries of the large diameter portions. 40
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6. The hydraulic pump or motor as defined in Claim 5, wherein the biasing means comprises spring members or ring-shaped elastic members interposed between the shoes and the large diameter portions in the spaces. 50
7. The hydraulic pump or motor as defined in Claim 1 or 2, wherein the connecting means comprises rods projecting from the shoes and inserted into through holes formed in the pistons, threaded portions provided at tip ends of the rods, and nuts screwed onto the threaded portions such that pre-

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determined gaps are provided between inner peripheries of the through holes and outer peripheries of the rods.

8. The hydraulic pump or motor as defined in Claim 7, wherein the biasing means comprises spring members interposed between the nuts and the pistons.

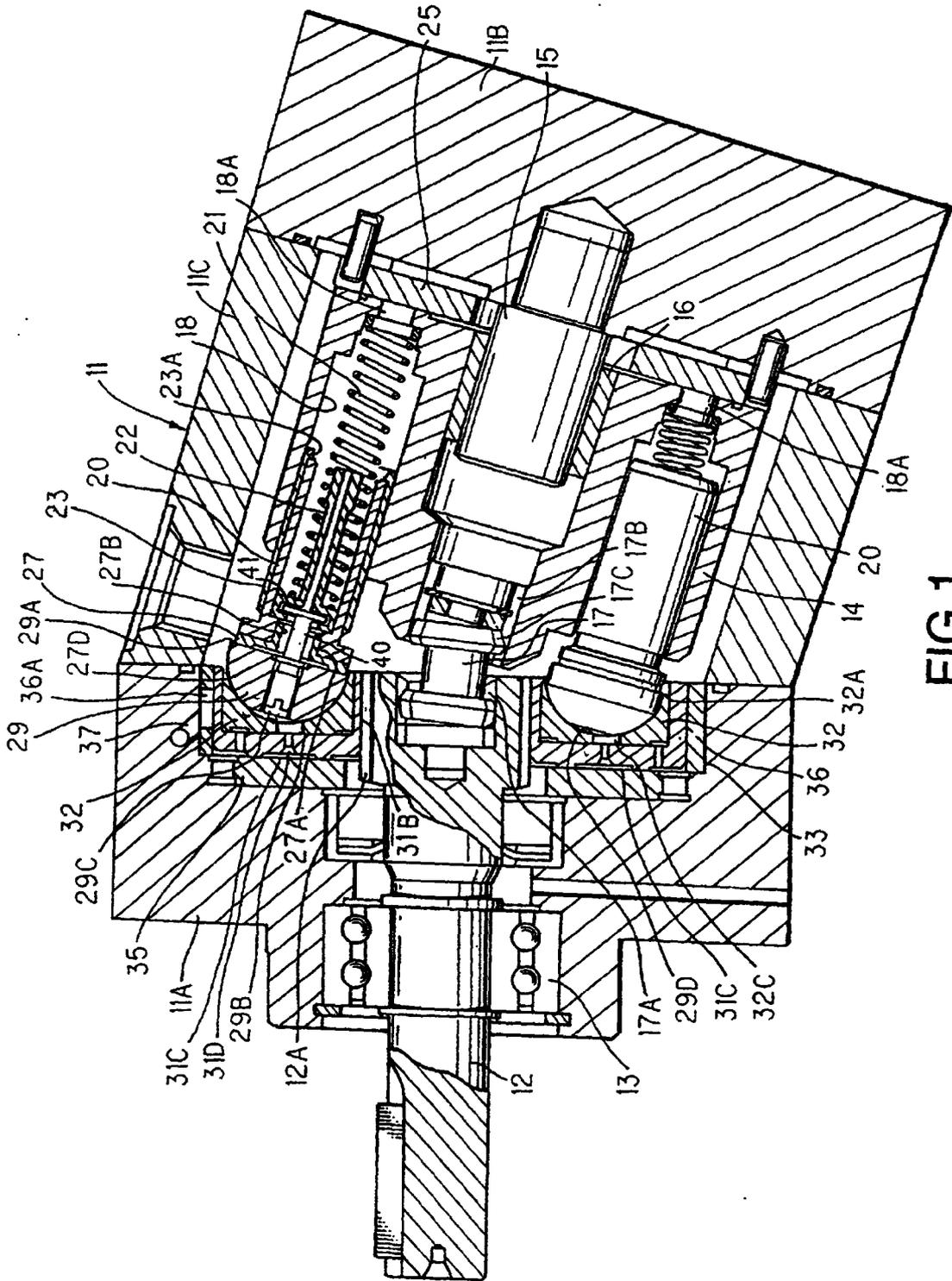


FIG. 1

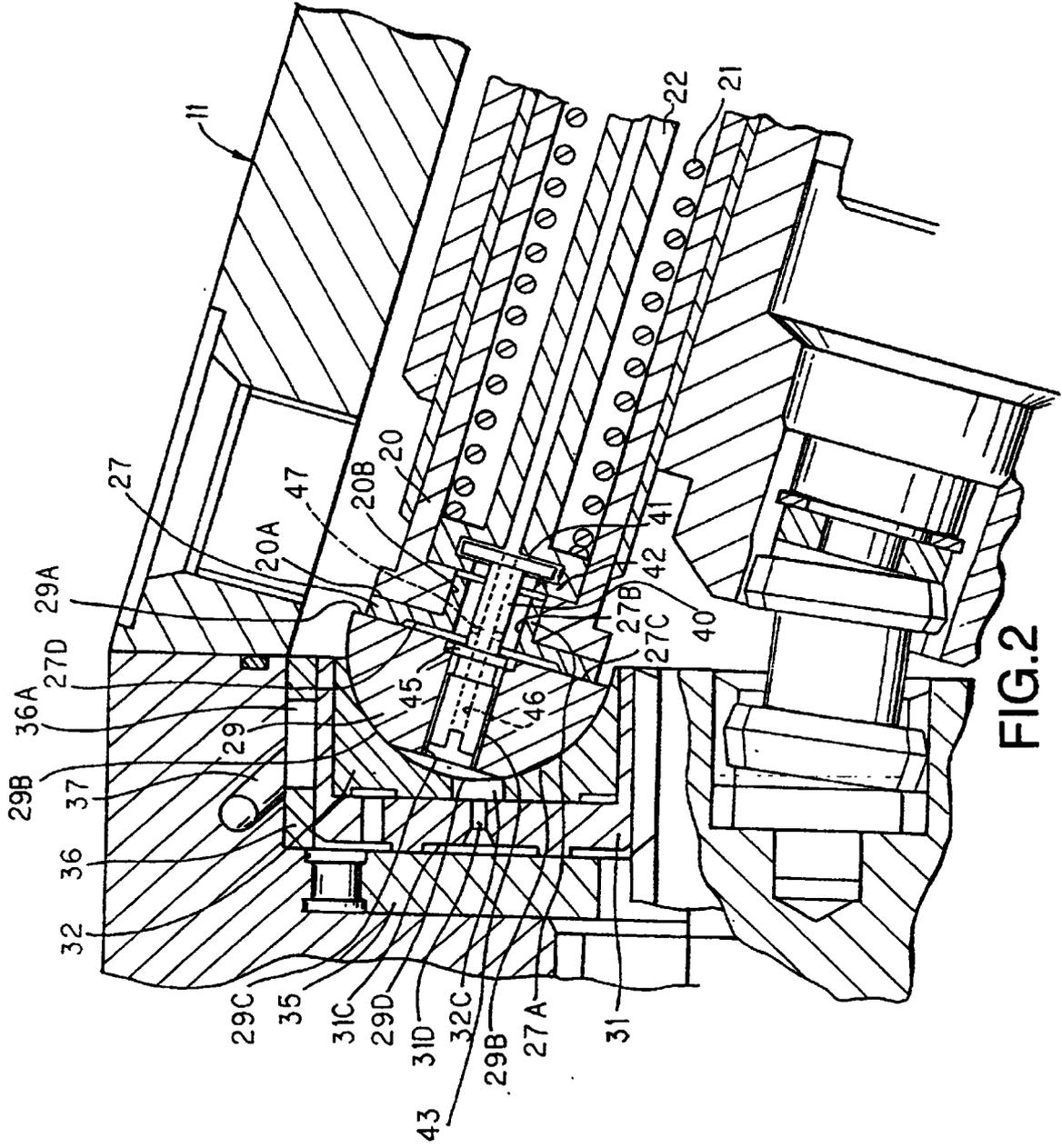


FIG.2

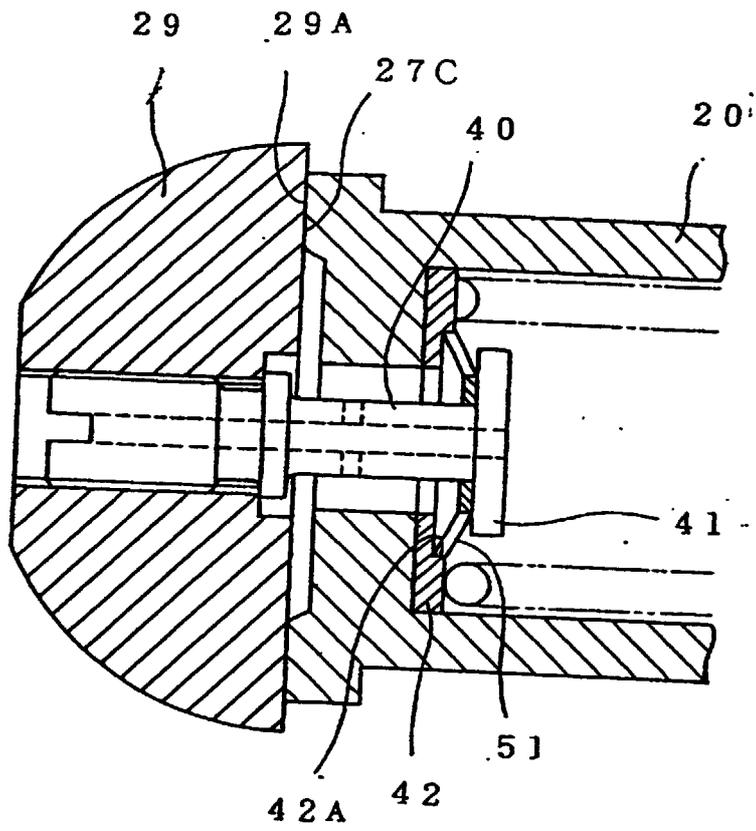


FIG.3

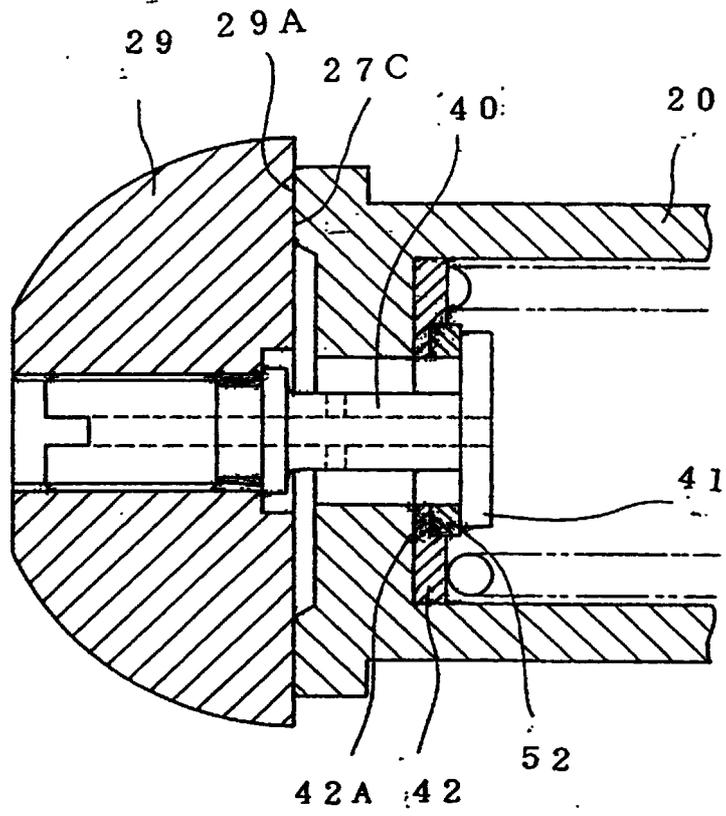


FIG.4

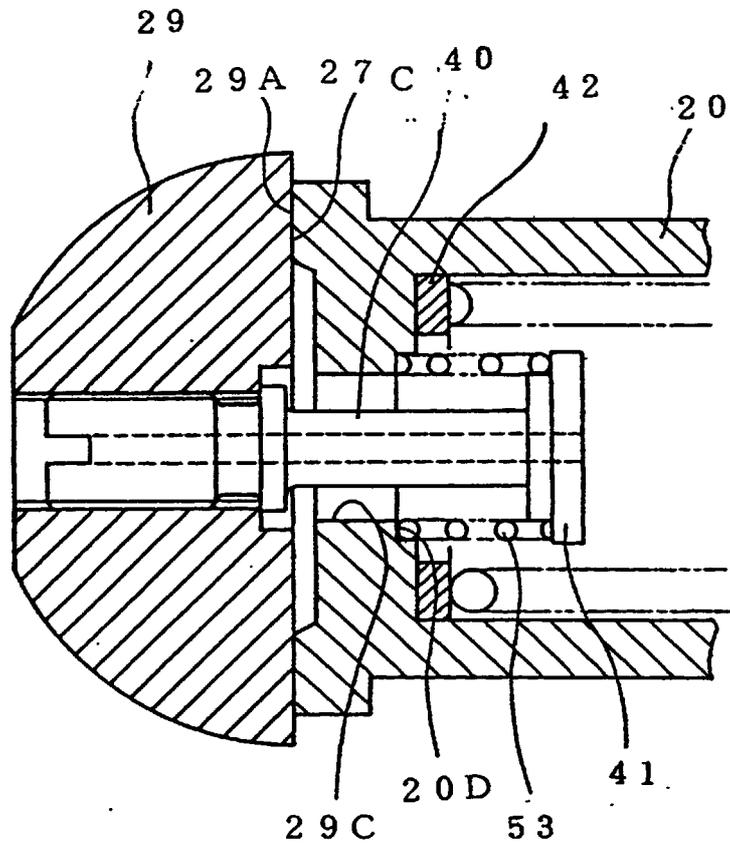


FIG.5

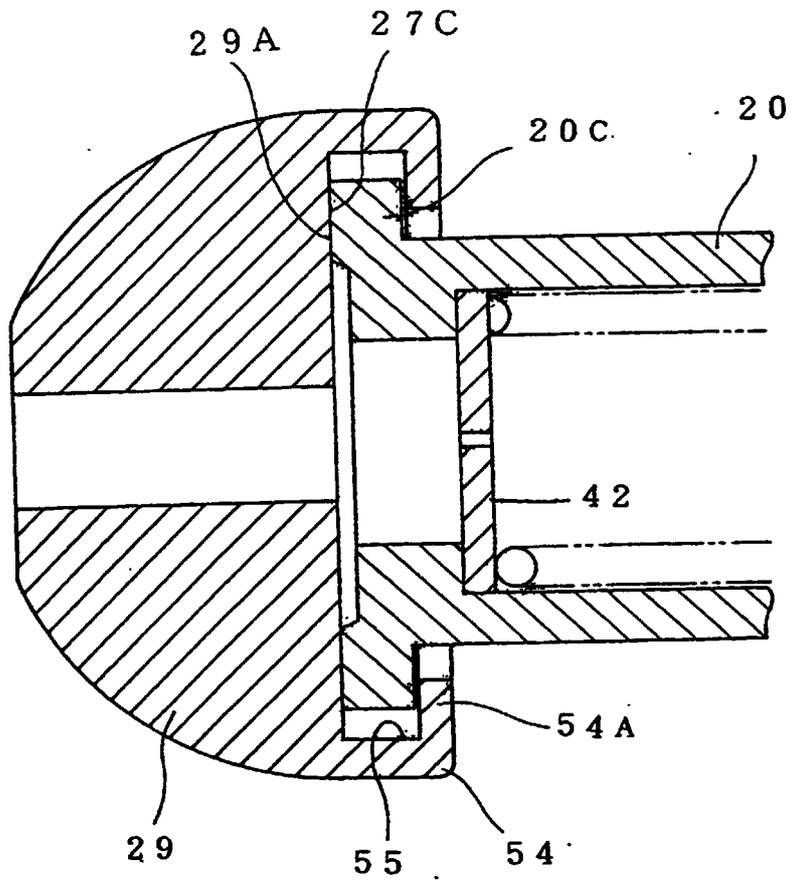


FIG.6

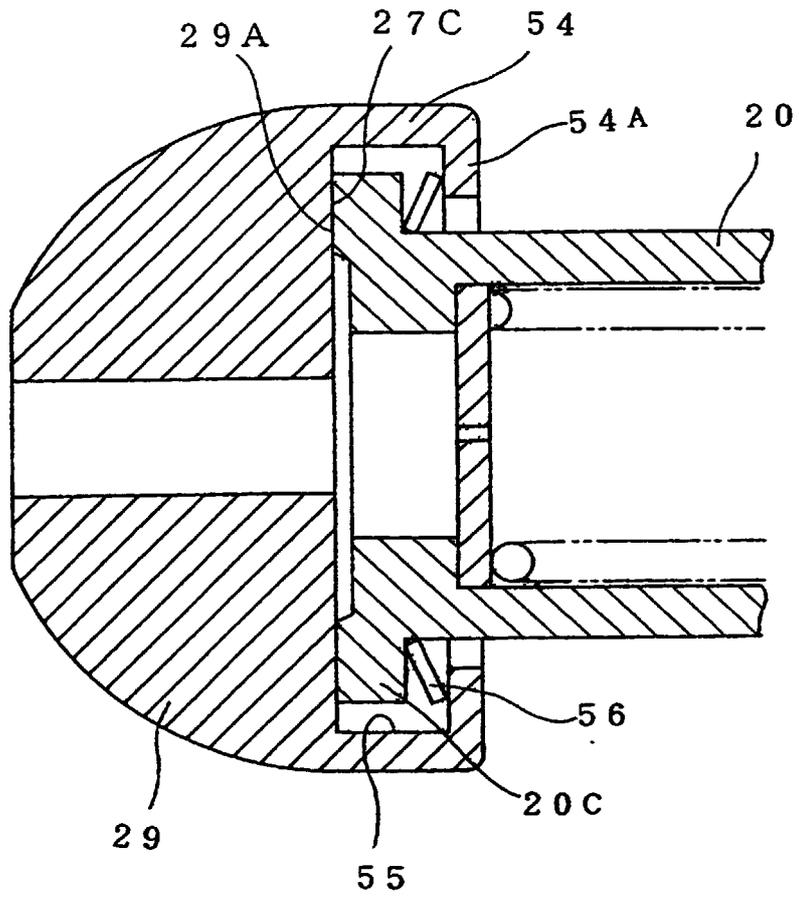


FIG.7

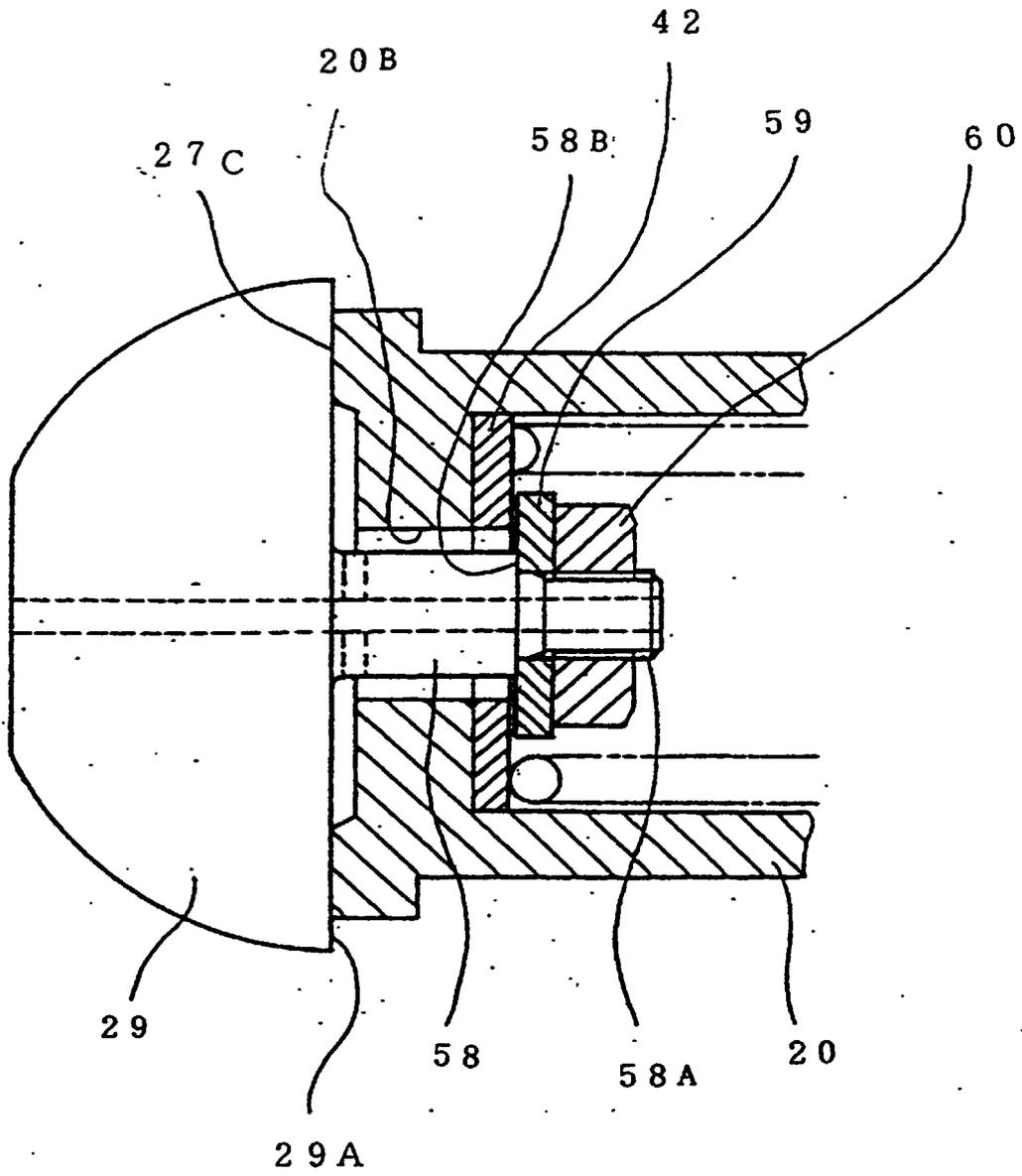


FIG.9

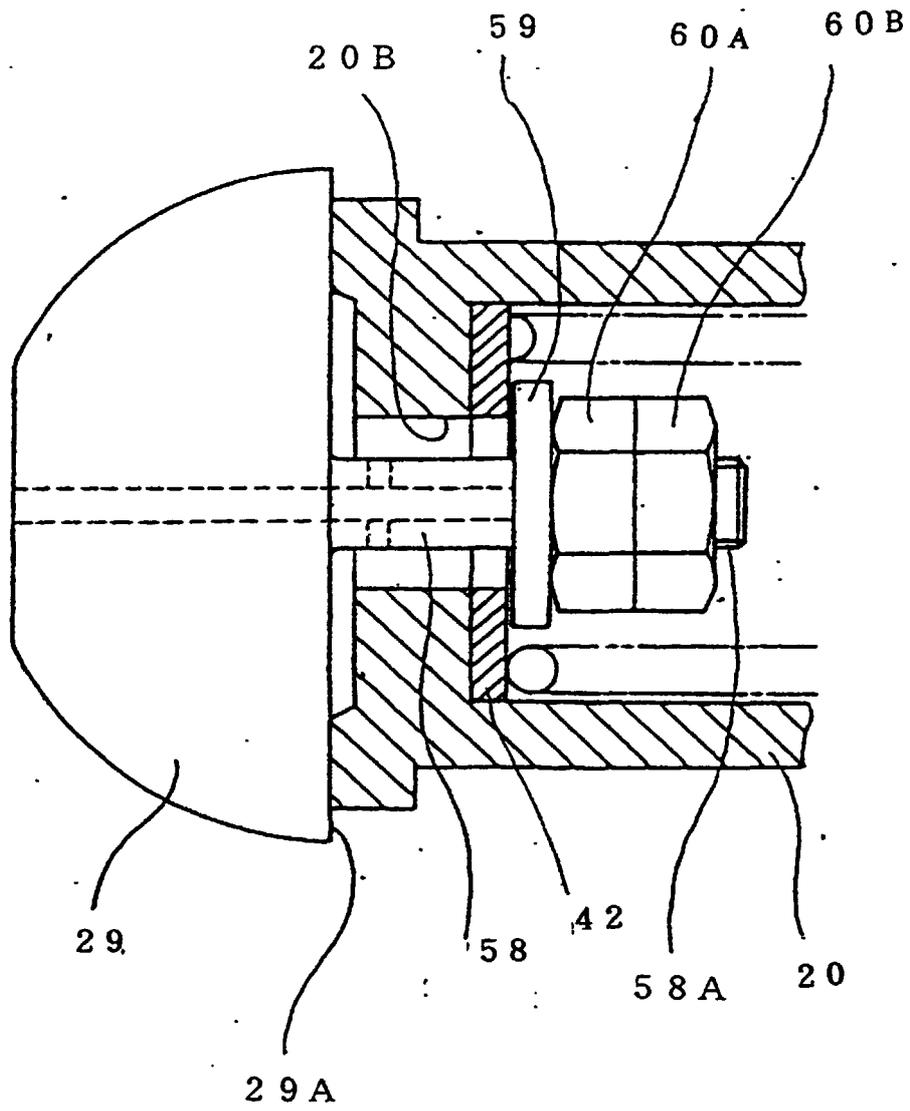


FIG.10

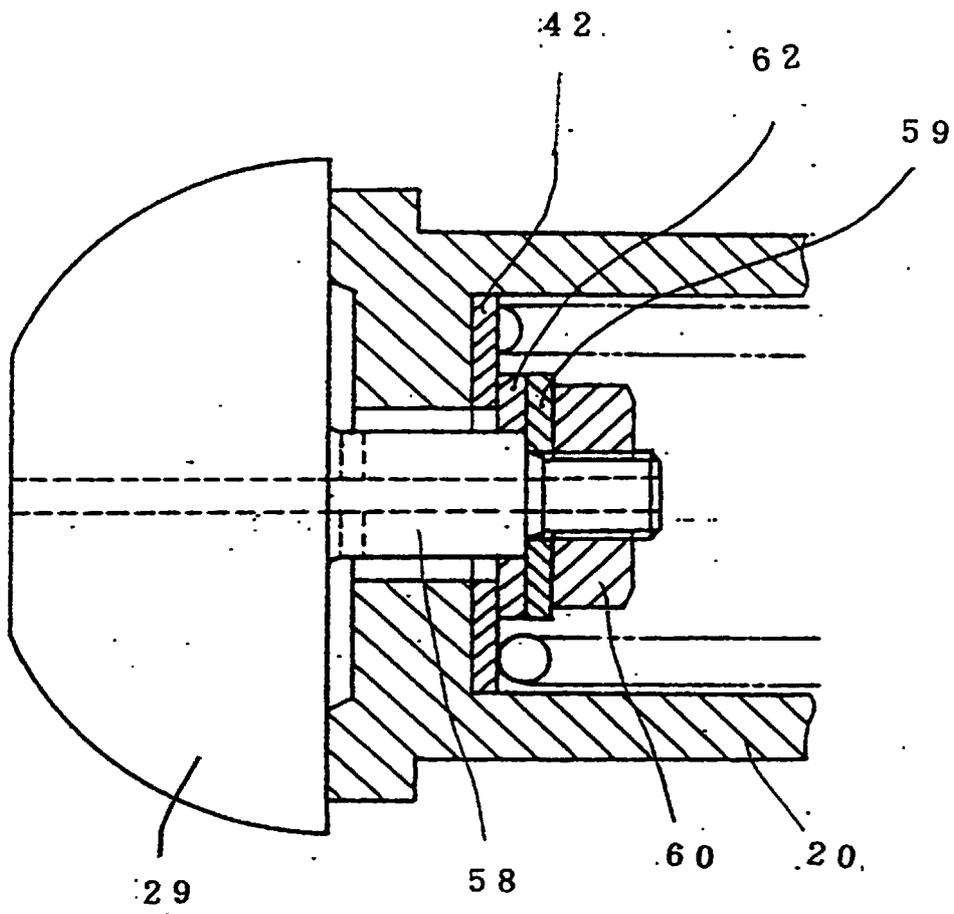


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/04732

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁶ F04B1/24, 53/18		
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) Int.Cl ⁶ F04B1/00-7/06, 53/18		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1998 Kokai Jitsuyo Shinan Koho 1971-1995 Jitsuyo Shinan Toroku Koho 1996-1998		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 8-151975, A (Kayaba Industry Co., Ltd.), 11 June, 1996 (11. 06. 96) (Family: none)	1, 2, 5, 6
A		3, 4, 7, 8
Y	JP, 48-68204, U (Komatsu Ltd.), 30 August, 1973 (30. 08. 73) (Family: none)	1, 2, 5, 6
Y	JP, 48-55229, U (Komatsu Ltd.), 16 July, 1973 (16. 07. 73) (Family: none)	1, 2, 5, 6
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		<input type="checkbox"/> See patent family annex.
* Special categories of cited documents:	"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	
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Date of the actual completion of the international search 4 January, 1999 (04. 01. 99)	Date of mailing of the international search report 19 January, 1999 (19. 01. 99)	
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