Feb. 21, 1967 K. EICKMANN 3,304,883

PISTON SHOES AND GUIDE MEANS IN RADIAL PISTON MACHINES

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Fig. 2

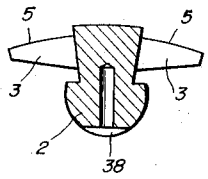


Fig. 1

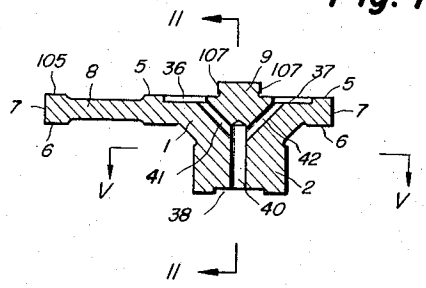


Fig. 3

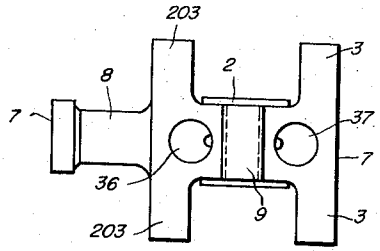


Fig. 6

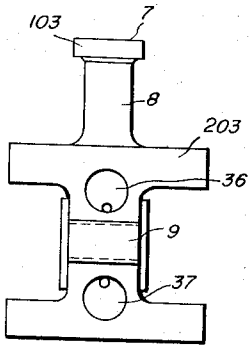


Fig. 5

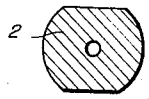
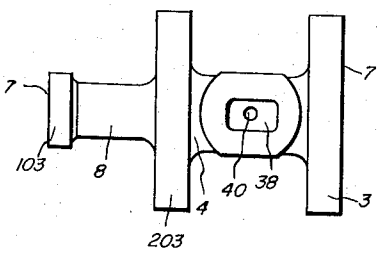


Fig. 4



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PISTON SHOES AND GUIDE MEANS IN RADIAL PISTON MACHINES

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Fig. 7

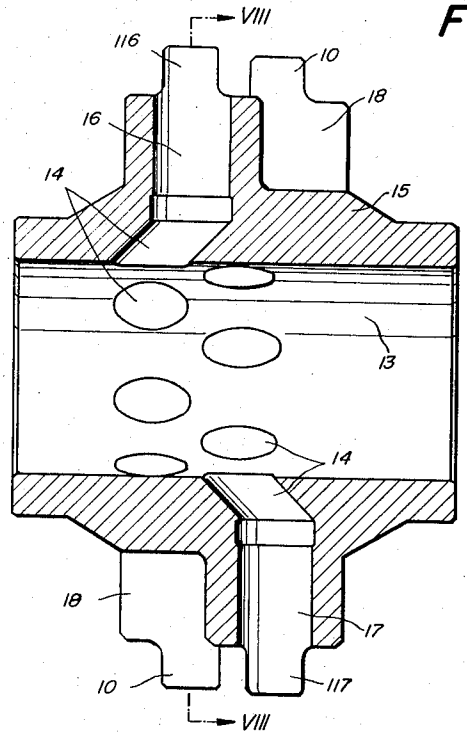
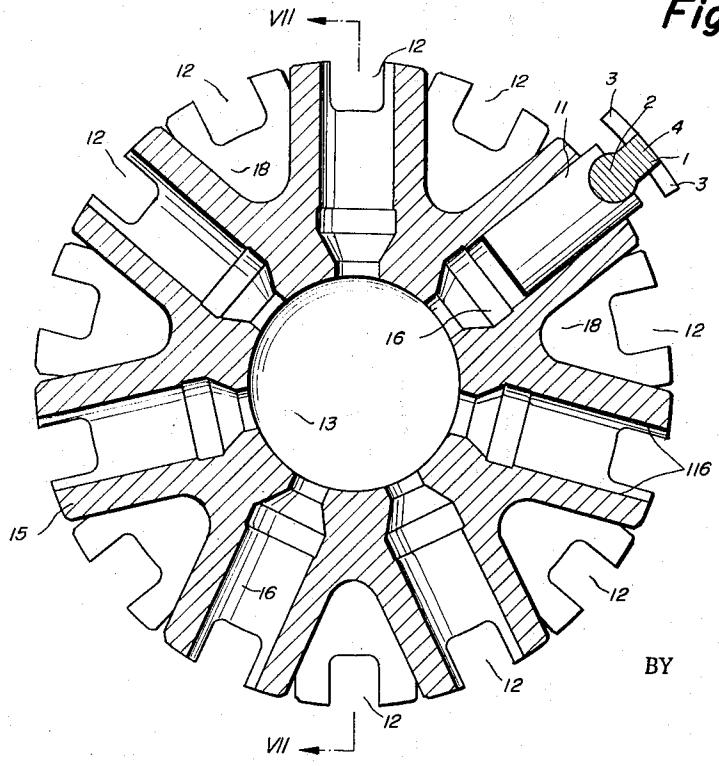


Fig. 8



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PISTON SHOES AND GUIDE MEANS IN RADIAL PISTON MACHINES

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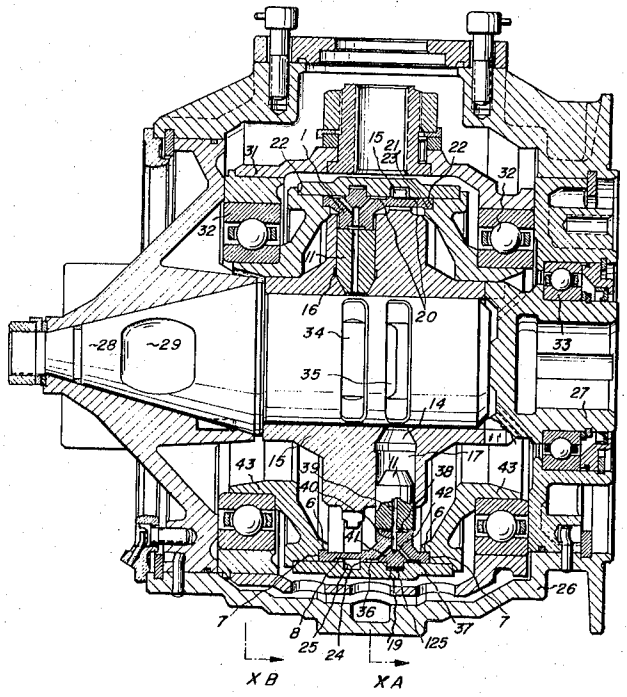

Fig. 9

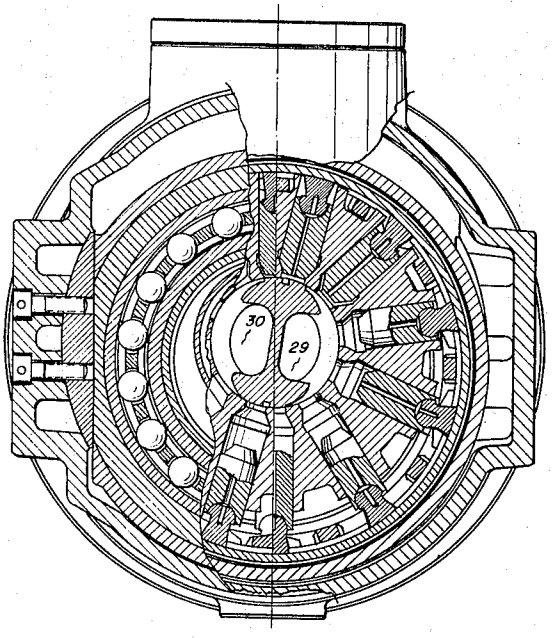

Fig. 10

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Fig. 12

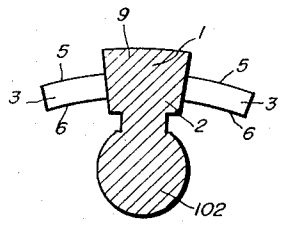


Fig. 11

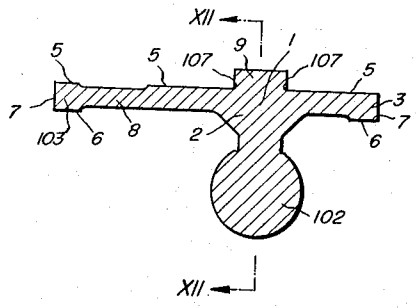


Fig. 14

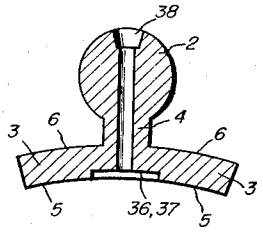


Fig. 13

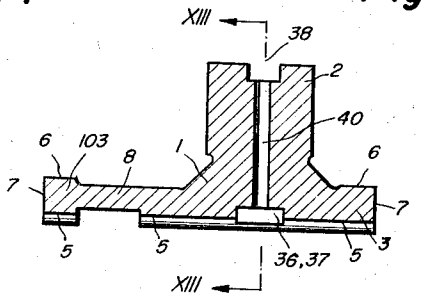


Fig. 15

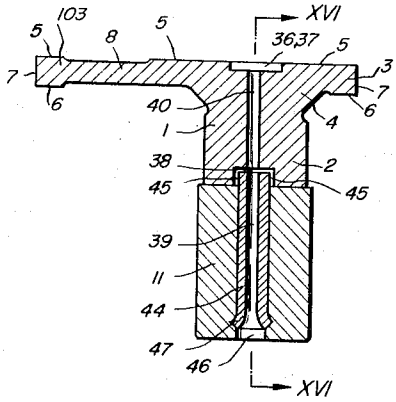
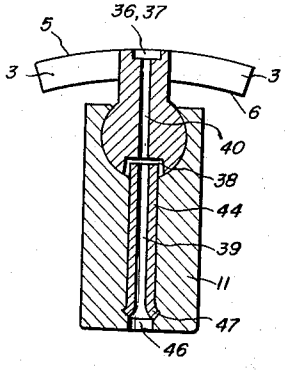


Fig. 16



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United States Patent Office 3,304,883 Patented Feb. 21, 1967

3,304,883

PISTON SHOES AND GUIDE MEANS IN RADIAL PISTON MACHINES

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Filed Aug. 12, 1964, Ser. No. 389,130
Claims priority, application Germany, Aug. 14, 1963, B 73,121
7 Claims. (Cl. 103—161)

This invention relates to radial piston machines with radial cylinders located normally to the rotor axis in a rotor and therein provided piston shoe assemblies.

In such radial piston machines, the pistons move in their cylinders radially outwards and inwards and thereby take in liquid or gas and expel liquid or gas when the machine operates under power.

Such radial piston machines, as well as the pistons with piston shoes are described in my co-pending patent application Serial Number 229,644; radial piston machines with a plurality of cylinder groups are described in my co-pending patent application Serial Number 292,-629 and machines with large piston strokes are described in my co-pending patent application Serial Number 293,657. In the said patent applications, are pistons with piston shoes described, which are able to operate relatively effective and of great strength, while they allow small sizes of radial piston machines. The machines of my patent applications have further been described with a plurality of cylinder groups and with rotors which are especially compact and therefore make inexpensive the manufacturing of relatively compact radial piston machines possible. My other patent application describes a radial piston machine with a relatively large piston stroke by a relatively small diameter of the rotor. That made it possible to increase the efficiency of radial piston machines and the said machines are now very efficient in actual application.

It is, however, possible to increase the efficiency of such radial piston machines still more, for example in fluid or gas driven radial piston machines like hydraulic or pneumatic pumps, compressors, hydraulic motors, gas motors or also in combustion engines.

The object of this invention therefore is to provide a piston shoe central part extension on the piston shoe, whereby the piston shoe for two cylinder group-radial piston machines is simplified and the efficiency and life of the radial piston machine becomes further increased. The central part extensions of the invention extend through the neighbouring cylinder-group of the machine. This reduces the need of material and manufacturing expenses. The efficiency of such machines is further increased. Also the life span of such machines of the invention is prolonged.

More objects, features and details of the invention will become apparent from the accompanying drawings and from study of the description thereof.

FIG. 1 shows a longitudinal sectional view through an example of a piston shoe according to this invention.

FIG. 2 is a cross sectional view through FIG. 1 taken along the line II—II.

FIG. 3 is a view of the piston shoe of FIG. 1 taken from above.

FIG. 4 is a view of the piston shoe of FIG. 1 taken from below.

FIG. 5 is a longitudinal view through FIG. 1 taken along the line V—V.

FIG. 6 is a view of FIG. 2 taken from above.

FIG. 7 is a longitudinal view through an example of a rotor of the machine.

FIG. 8 is a cross sectional view through FIG. 7 taken along the line VIII—VIII.

FIG. 9 is a longitudinal view through an example of a radial piston machine according to this invention.

FIG. 10 is a cross sectional view through a part of FIG. 9 taken along the line XA—XA and a cross sectional view of a part of FIG. 9 taken along the line XB—XB.

FIG. 11 is a longitudinal sectional view through another example of a piston shoe according to this invention.

FIG. 12 is a cross sectional view through FIG. 11 taken along the line XII—XII.

FIG. 13 is a longitudinal cross sectional view through another example of a piston shoe according to this invention.

FIG. 14 is a cross sectional view through FIG. 13 taken along the line XIV—XIV.

FIG. 15 is a longitudinal cross sectional view through a further example of a piston-piston shoe means in accordance with this invention.

FIG. 16 is a cross sectional view through FIG. 15 taken along the line XVI—XVI.

As already known from my said patent applications the piston shoe central part **4** is provided on the piston shoe trunnion **2**, is radially outwards of the said trunnion located and extends axialward beyond the trunnion **2**. The outer piston shoe guide flanges **5** are located on the piston shoe central part **4**. The axial ends of the piston shoe central parts **4** are forming the piston shoe guide portions **7**. The inner faces of the piston shoe guide portions **7** are forming the piston shoe guide faces **6**. The piston shoe trunnion **2** extends into a normal bore of the cooperating piston.

Additional pistons can be provided in the rotor of the machine, as can be seen in my already mentioned patent applications.

In accordance with this invention the piston shoes are provided with the piston shoe central part axial extensions **8** or with the piston shoe central radial extensions **9** or with the piston shoe central part axial extensions **8** and the piston shoe central radial extensions **9**. The piston shoe radial extension guides **107** can be provided on the piston shoe central part radial extensions **9** and can form the axial end walls of the piston shoe central part extension **9**. The piston shoe central part radial extensions **9** extend into the radial ring grooves **25** or **125** in respective piston shoe guide ring or piston shoe guide casing **19**.

The piston shoe guide ring can be rotary or stationary and the piston shoe guide casing **19** can also be either stationary or rotary.

Piston shoe radial extension guide walls **24** can be located on the piston shoe guide rings or piston shoe guide casing **19** and the piston shoe radial extension guides **107** can slide thereon.

The piston shoe central part axial extensions **8** extend in a direction axialwards away from the piston shoe central part and have the advantage that they have on their axial ends an outer piston shoe guide face **105** and/or a sidewards piston shoe guide face **7** and/or an inner piston shoe guide wall **6**. The piston shoe central part axial extension **8** is so narrowly formed, that it is free to enter into a respective rotor radial slot **12** or that it can move in the said rotor radial slot **12**. The piston shoe central part axial extension **8** is therefor smaller configurated then the said respective rotor radial slot **12**. Therefore it is possible, in accordance with this invention, that the axial extension **8** enters into the said rotor radial slot **12**.

On the axialwards end of the piston shoe central part axial extension **8** is an additional piston shoe extension guide **103** provided. Between the already from my patent applications known piston shoe central part **4** and the piston shoe central part axial extension **8** can the

piston shoe guide **203** be provided and it can have also tangential extensions.

The piston shoe central part axial extensions **8** can be further made narrower in radial direction, whereby a simple manufacturing of the piston shoe in accordance with this invention is made possible or whereby it is made possible that the piston shoe central part axial extension **8** needs only to be pressed or casted and thereafter does not need to undergo special machining.

The above described example of a piston shoe according to this invention is shown in detail in FIGS. 1–6.

The rotor **15** of the machine described in FIGS. 7 and 8 is in principle, already known from my prior patent applications and two axially from each other distanced cylinder groups are provided in the said rotor. The radial extending cylinder groups **16** and **17** are provided in the rotor **15**. The cylinders **16** make up the cylinders of one of the cylinder groups while the cylinders **17** made up the cylinders of the other cylinder group. The rotor **15**, which is shown by way of example, has a rotor central bore **13** wherefrom the rotor windows **14** extend into the said cylinders **16** or **17**. The rotor has also two rotor radial straps **10** on which the extended piston guide faces **116** and **117** are provided as extensions of the walls of the cylinders **16** and **17** and on which the pistons, during the long piston strokes are guided inwards and outwards. The rotor can also have the rotor wall recesses **18**. It is of further importance that the rotor is provided with rotor radial slots **12**, which are parallel to the axis of the rotor extend through the cylinders **16** or **17**, thereby dividing the rotor radial straps **10** in separated segmential parts.

The said rotor radial slots **12** are very necessary therefore, that the piston shoe central part axial extensions **8** in accordance with this invention can enter into these slots, when the machine operates under power and move therein outwards and inwards.

The rotor central bore **13** is by way of example and acts for the reception of a control body. In place of providing a rotor central bore, it is also possible to provide on the rotors, cylindrical, conical, plane or spherical control faces.

It is also possible to provide entrance valves or exit valves in place of a control body.

FIGS. 9 and 10 show a rotary radial piston machine by way of example. This is provided with a plurality of cylinder groups in which, by way of example, the piston shoes of FIGS. 1 to 6 and a rotor of FIGS. 7 to 8 are provided. In the casing **26** are bearings **33** provided, which bear the shaft **27**, which is preferably flexibly connected with the rotor **15**.

In the casing **26** or its backwards cover is the control body **28** located and provided with the control body passages **29** and **30** and the control windows **34** and **35**. Therethrough fluid like liquid or gas flows into or out of the machine.

During the operation of the machine the rotor windows **14** move over the control windows **34** and **35** and are periodically in communication with the fluid entrance control port or with the fluid exit control port **34** or **35** during the rotation of the rotor, so that the liquid or gas can enter or leave through the control body, its passages and control ports into or out of the cylinders **16** or **17**. The roller casing **32** can be further provided for bearing the rotating support rings **43**. On the rotary support rings **43** is the piston shoe guide ring **19**. These parts together with the rotary casing **32** of the example of the radial piston machine are forming the piston stroke control vanes.

Through control device **31** the piston stroke or the eccentricity of the guide rings can be changed or turned in opposite direction. In place of a piston stroke control means or control device **31** it is also possible to set the rotary casing **32** directly into the machine casing so that the piston stroke control means can be spared. This machine would then be known as a radial piston machine with an unchangable or fixed piston stroke.

It is also possible to spare the rotary casing **32** and the rotating support rings **43** with its piston guide rings **19** and to construct the casing **26** directly as a piston shoe guide casing. In such case, it is possible to provide on the casing **26**, the piston shoe guide flanges **20**, **21**, **22**, **23** or **24** or the piston shoes travel directly along the control flange of the stationary casing **26**.

In the described example, however, the piston shoe guide ring **19** is connected together with the support ring **43** and the rotary casing **32** able to rotate, whereby friction between the piston shoe and the piston shoe guide ring is spared. In the piston shoe guide ring **19** of this invention are advantageously a plurality of radial ring grooves **25** or **125** located. The rotor radial straps **10** extend then partwise into the radial grooves **25** or **125** of this invention during the operation of the machine with a large piston stroke. It is thereby possible, to enlarge the piston stroke in accordance with this invention.

While, in one of my earlier patent applications special guide rings for the guide of pistons were between the pistons of the different cylinder groups, and the piston shoes were only short in axial direction so that they could not extend through the neighbouring cylinder groups in axial direction, it is the feature in accordance with this invention that the piston shoe axial extensions **8** are extending in axial direction through the other cylinder groups and are guided behind the other cylinder groups by their piston shoe extension guides **103**.

In accordance with this invention, the piston shoe central part axial extensions **8** of the pistons of the cylinders **17** extend through the cylinder group **16** and the piston shoe central part axial extensions **8** of the piston shoes of the cylinder group **16** extend through the cylinder group **17**.

The piston shoe central part axial extensions **8** of the piston shoes of the cylinder group **17** extend further, in accordance with this invention, into the said rotor radial slots **12** of the cylinder group **16**, while the piston shoe central part axial extension of the piston shoes of the cylinder group **16** extends into the rotor radial slots **12** of the cylinder group **17**, when the machine is operating. According to this invention, the described locations of the piston shoe central part axial extension **8** and their extensions into the said rotor radial slots **12** aim for two special advantages. Primarily it makes it possible for the piston shoe central part axial extensions **8** to enter into the said rotor radial slots **12** and it makes it possible that the rotor radial strap segments **10** can extend into the said radial ring grooves **25** and **125** of the piston shoe guide ring or piston shoe guide casing **19**, achieving thereby an extra ordinary large piston stroke. It makes it further possible, that the two cylinder groups **16** and **17** can be provided in a relatively short axial distance from each other.

These two features make it possible to construct, in radial direction, an extremely compact radial piston machine with a plurality of cylinder groups and at the same time to achieve such a compact design of such machines in axial direction.

Besides this, the efficiency is increased in accordance with the large piston strokes of the machine. Also a longer life span of the machine is assured, while at the same time through the, in axial direction compact construction means, simpler guide rings and casings and thereby at the same time stable and bigger power consuming guide rings or piston shoe guide rings or piston shoe guide casings **19** are created. This makes it possible to reach very high efficiency and power in radial piston machines and thereby at the same time to decrease the cost of these machines.

The piston shoes, in accordance to this invention, can further be provided with piston shoe central part radial extensions **9**. The piston shoe central part radial exten-

sions 9 can extend into the said radial ring grooves 25 or 125 of the piston shoe guide ring or piston shoe guide casing 19. The piston shoe radial extension guide 107 can be guided in or on the said piston shoe radial faces 24. If this guide means is provided, then it is possible to spare the piston shoe guide faces 7.

If, on the other hand, the piston shoe central part radial extensions 9 are not provided, it is suggested that the piston shoes are constructed with the piston shoe guide faces 7 on the piston shoe guide 3 and further to guide the piston shoe guide 3 through the said inner piston shoe guide faces 6 radially outwards.

The piston shoe end guide faces 7 are guided on the piston shoe guide faces 22 and the outer piston shoe guide faces 5 are guided on the piston shoe guide faces 20 of the piston shoe guide ring or the piston shoe guide casing 19. The said parts of this piston shoe slide relatively to the said guide faces or on the said guide faces.

In accordance with this invention, it is also possible to provide the end guide faces 7 on the piston shoe extension guide 103. Further outwards piston shoe guide faces 5 and inner piston shoe guide faces 6 can be provided in accordance with this invention. The inner piston guide faces 6 on the piston shoe extension guide 103 are then guided by the pistoin shoe extension guide faces 23, 22 or 20.

In the example of a radial piston machine, the piston shoe guide faces 21 build the piston shoe guide for the piston shoe of one cylinder group, while at the same time they build the piston shoe extension guide faces 23 of the piston shoe extension guide 103 of the piston shoes of the other cylinder group.

The piston passage 39, is shown in each of the pistons 11 in the example of FIGS. 9 and 10, of a radial piston machine of this invention and it is demonstrated thereby how through the piston passages 39 fluid out of the cylinder 16 or 17 can flow through the pistons 11 into the inner piston shoe balancing means 38.

Out of the inner piston shoe balancing means 38 flows the fluid through the piston shoe passages 50 into the piston shoe 1 and branches out of the piston shoe passage 40 into the piston shoe passages branches 41 and 42, which extend into piston shoe balancing means 36 and 37 into which the fluid out of the cylinder 16 and 17 flows. The piston shoe balancing means 36 and 37 are axially distanced from the piston shoe central part radial extension 9 and they are enclosed by the guide faces 20 or by parts of the piston shoe guide rings or piston shoe guide casing 19. The piston shoe balancing means 36 and 37 serve for counteracting and thereby balancing against the forces of pressure in fluid which act out of the interior of the cylinder on the piston 11 in radial direction or directed force. They serve or they may serve also as lubrication means for the outer piston shoe guide faces 5 and the neighbouring piston shoe guide faces 20.

Special attention is requested to the fact that rotors 15 of FIGS. 7 and 8 of this embodiment of the invention are built in the special feature, that the cylinders 17 of the one cylinder group are provided on the split between the cylinders 16 of the other cylinder group. In other words, that when looking on rotor 15 from axial direction, the cylinder of the one cylinder group are provided between and behind or in front of the cylinders of the other cylinder group. Therefrom it can be achieved that the piston shoe central part axial extensions 8 of the one cylinder group, cannot disturb the radialwards movement of pistons and piston shoes of the other cylinder group.

In the examples of FIGS. 11 and 12 it is shown that in place of cylindrical ports 2 it is also possible to provide piston shoe ball heads 102 or piston shoe swing balls 102 on the piston shoe of this invention.

FIGS. 13 and 14 demonstrate that the outer piston shoe guide faces 5 can also be directed radially inwards and thereby can take the form of a part of a cylindrical inner face. The said inner piston shoe guide faces 6 are formed in this way. This example of a piston shoe of this invention is especially applicable for such radial piston machines, wherein the rotor is provided radially outwards of the piston shoe 1 and wherein the pistons 11 are located radially outwards of the piston shoes 1.

Such piston shoes as shown in FIGS. 13 and 14 are therefore also especially applicable for such radial piston machines, in which the cylinders are provided in a stationary radial outwards casing and the piston shoes are driven by a radial inner crank in the casing or can be driven by an eccenter.

In FIGS. 15 and 16, it is further shown, how in accordance with this invention, a central bore 46 can be provided in the piston 11. A piston pipe 44 can be inserted into the central bore 46 and extend into the inner piston shoe balancing means 38 of the piston shoe trunnion 2.

In the example of the figures is the inner piston shoe balancing means 38 provided with guide faces 45 which are guided to planes or to a part of the piston pipe 44. The piston pipe 44 is fastened in the example, through boarderings or insertions in the piston ring groove 47 against falling out of the piston 11. The speciality of this provision is, that the piston pipe 44 guides the guide faces 45 of the trunnion 2 and thereby prevents the piston shoe from falling out of the piston 11.

From the foregoing, it can readily be appreciated by the artisan that the invention provides a piston shoe arrangement for a radial piston machine of the type having a casing, a rotor disposed within the casing for rotation relative thereto, and which includes at least one axial group of radially disposed cylinders with a piston disposed within each cylinder for reciprocatory sliding movement relative thereto. This piston shoe arrangement in essence provides a piston shoe guide means which can include the guide ring 19 either alone or in combination with the support rings 43, and such guide means has at least one annular guide surface, such as the surfaces 25, 125, and/or surfaces machined into the support rings 43, all of which are disposed in surrounding relation to the rotor, and for sliding contact engagement with a corresponding guide portion or portions 6, 7, 105, 107, etc. of shoe members pivotally connected to individually associated pistons. The shoe member guidance thus resulting effects the regulation of the reciprocatory motion of the various associated pistons.

Although this invention is described by way of some of the embodiments, it should be understood that modifications or other combinations are possible, depending on design considerations or on the actual situation, without leaving the scope of this invention. It is therefore intended that the patent shall not be limited to the embodiments shown or described in this specification but that the patent shall be covered by the appended claims.

What I claim is:

1. In a radial piston machine having a casing, a rotor disposed within said casing for rotary movement relative thereto and including at least one axial group of radially disposed cylinders, and a piston disposed within each cylinder for reciprocatory movement relative thereto, a piston shoe arrangement which comprises a piston shoe guide means including a guide ring supported within said casing and having at least one annular guide surface disposed in surrounding relation to said rotor, and a plurality of shoe members each pivotally connected to an associated piston, each shoe member having a guide portion disposed for sliding contact engagement with a corresponding guide surface of said ring to regulate the reciprocatory motion of its associated piston.

2. The piston shoe arrangement according to claim 1 wherein said guide ring has an annular guide surface disposed in radially extending surrounding relation to the rotor, and wherein each shoe member has a radially projecting guide portion disposed for sliding contact engagement with said radially extending guide surface.

3. The piston shoe arrangement according to claim 1 wherein said guide ring has an annular guide surface disposed in surrounding relation to the rotor and axially extending with respect thereto, and wherein each shoe member has an axially projecting guide portion disposed for sliding contact engagement with said axially extending guide surface.

4. The piston shoe arrangement according to claim 1 wherein said guide ring has a first annular guide surface and a second annular guide surface, both disposed in surrounding relation to the rotor and axially extending with respect thereto, said first and second guide surfaces being disposed in axially spaced apart relation to each other, and wherein each shoe member has a first axially projecting guide portion and a second axially projecting guide portion respectively disposed for sliding contact engagement with said first and second axially extending guide surfaces.

5. The piston shoe arrangement according to claim 3 wherein the axially extending guide portion of each shoe member is disposed for sliding contact engagement with an axially extending guide surface on said guide ring displaced an axial distance from the cylinder associated with said shoe member approximately equal to the axial spacing dimension of one axial group of radially disposed cylinders.

6. The piston shoe arrangement according to claim 1 wherein each shoe member is pivotally connected to its associated piston by a spherical portion extending from said shoe member into engagement with a spherical socket portion on the associated piston.

7. The piston shoe arrangement according to claim 1 including means defining radially extending guide surfaces on said rotor, and wherein each piston shoe member has at least one radially oriented guide portion disposed for sliding contact engagement with a corresponding radial guide surface on said rotor.

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