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Leitermann

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[54] **ROTARY-PISTON MACHINE HAVING A LIQUID-COOLED PISTON**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[2] **F01C 21/06**

[52] **U.S. Cl.** **418/84;** 418/87; 418/94; 123/41.13

[58] **Field of Search** 418/84, 87, 94; 417/228; 123/41.13

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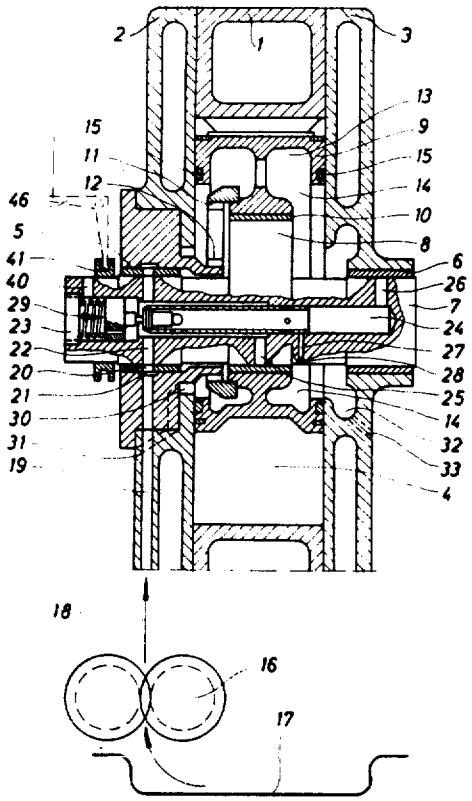
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Primary Examiner—Carlton R. Croyle
Assistant Examiner—Leonard E. Smith
Attorney, Agent, or Firm—Kane, Dalsimer, Kane, Sullivan & Kurucz

[57] **ABSTRACT**

A rotary-piston machine, in particular a rotary-piston combustion engine of trochoid type is provided. The machine includes a housing composed of at least one shell and at least two parallel end pieces and is traversed perpendicular to the end pieces by an eccentric shaft mounted in the end pieces. A liquid-cooled polygonal piston is rotatably mounted on the eccentric of the shaft. The piston contains cavities provided with at least one aperture near their radially inner portion. The eccentric shaft has an axial bore traversed by the liquid and communicating by way of transverse holes with the bearing and with at least one nozzle. The orifice of the nozzle is directed at the aperture of the piston cavities. Controls are arranged in the axial bore of the eccentric shaft for controlling the communication between the axial bore and the nozzle according to the engine load and/or the temperature of the liquid.

4 Claims, 7 Drawing Figures



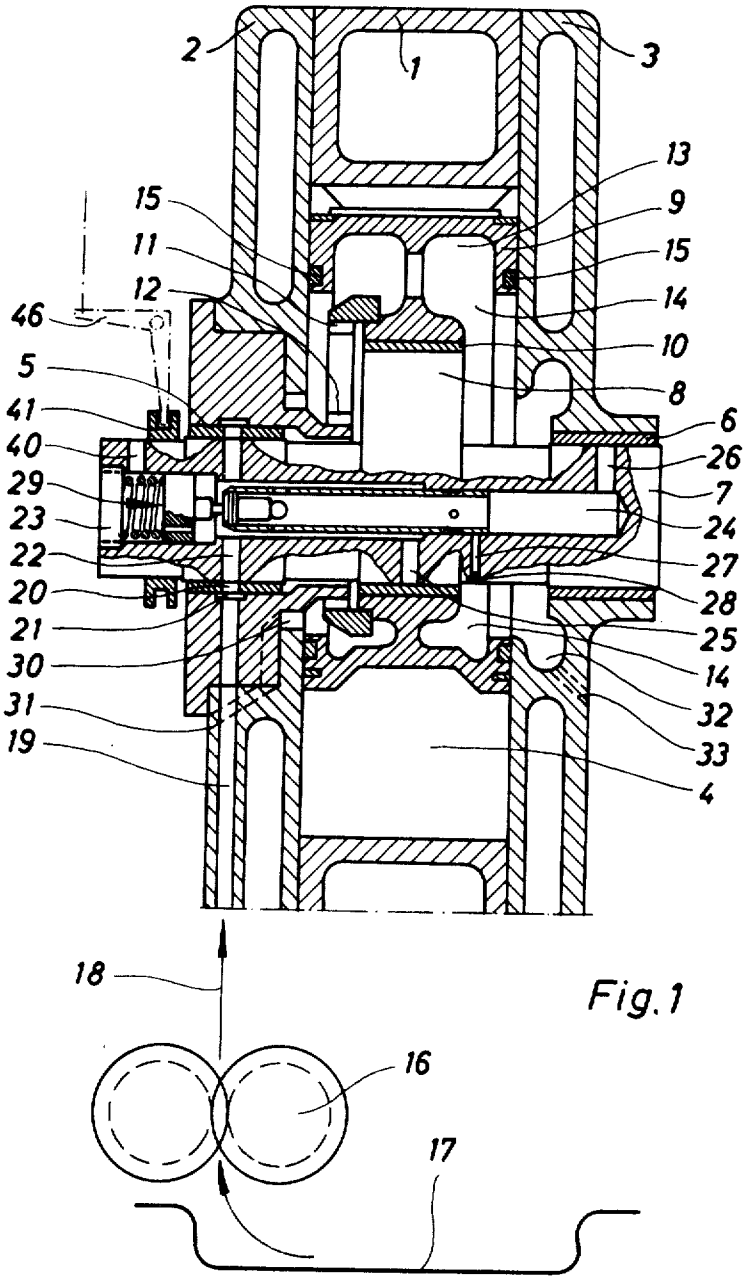

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Fig. 1

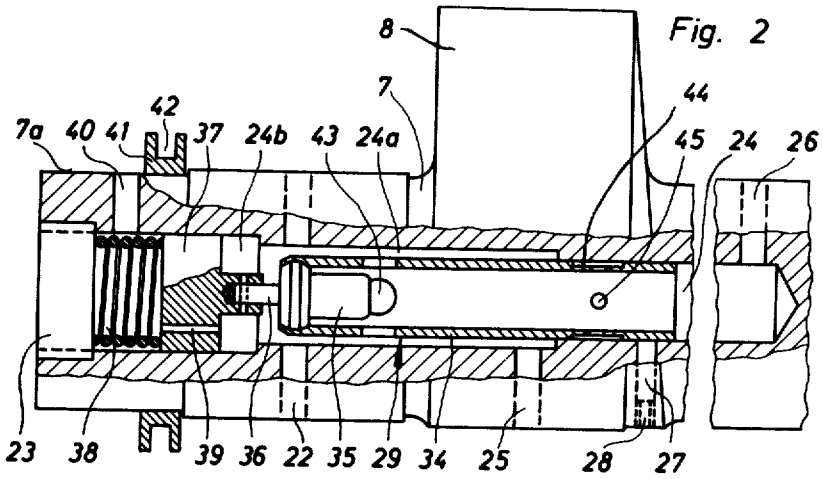


Fig. 2

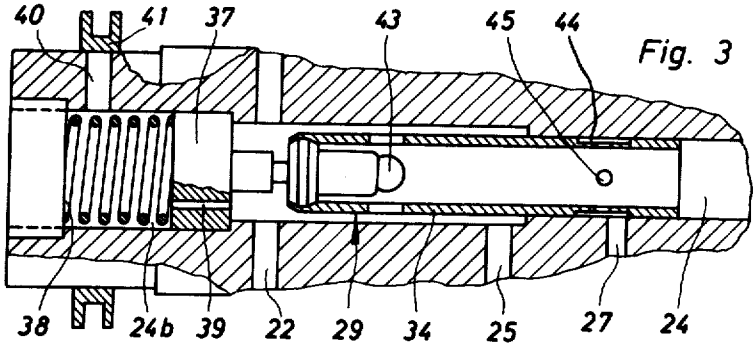


Fig. 3

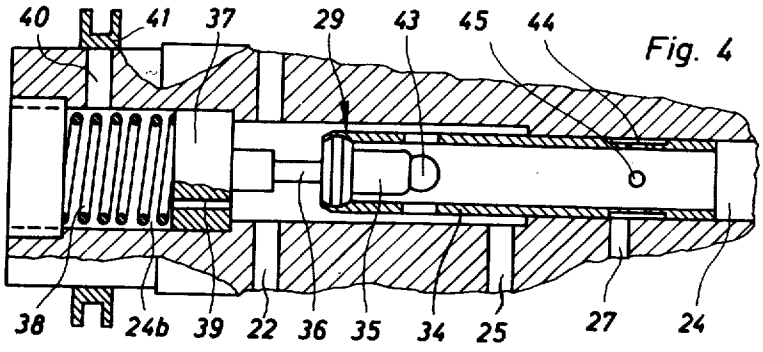


Fig. 4

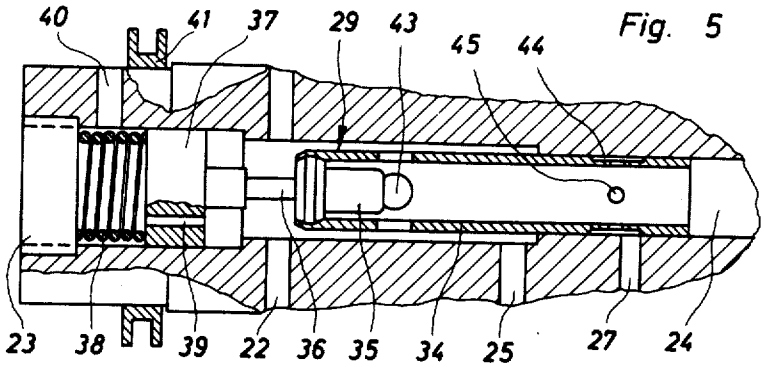


Fig. 5

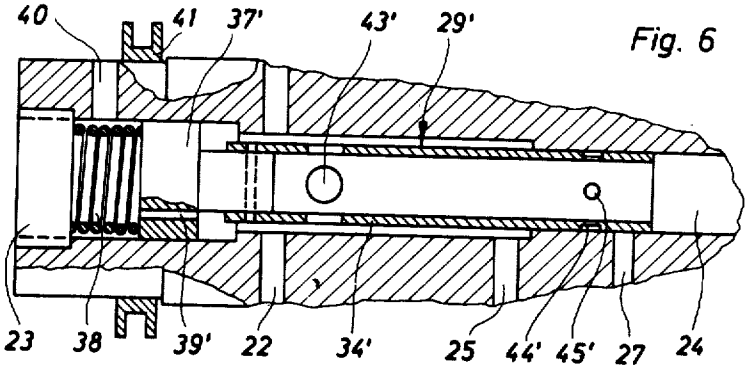


Fig. 6

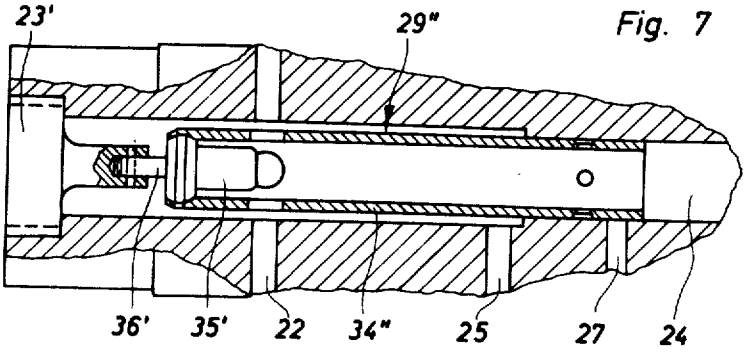


Fig. 7

ROTARY-PISTON MACHINE HAVING A LIQUID-COOLED PISTON

BACKGROUND OF THE INVENTION

The invention relates to a rotary-piston machine, in particular a rotary-piston internal combustion engine of trochoid type having a housing composed of at least one shell and at least two parallel end pieces and traversed by an eccentric shaft mounted in the end pieces and perpendicular thereto. A polygonal liquid-cooled piston is rotatably mounted on the eccentric of the shaft. The piston contains cavities provided with at least one aperture near their radially inner portion. The eccentric shaft has an axial bore through which the liquid flows communicating by way of transverse holes with the bearing points and with at least one spray nozzle. The orifice of the spray nozzle is directed at the aperture of the cavities in the piston.

A rotary-piston combustion engine of the type under consideration is present in German Pat. No. 1,223,610 in that engine, the liquid serving to lubricate the bearings of the eccentric shaft and the piston is employed to cool the piston as well. The cooling of the piston is thus accomplished predominantly by the liquid directly injected into the piston cavities by way of the nozzle, and in smaller, less effective part by the fluid draining from the piston bearing. But since the nozzle has an open cross-section, liquid is delivered through the nozzle into the piston cavities at all times, independently of engine operating temperature and load. Especially after a cold start and in the warm-up phase, this may result in the occurrence of high fuel consumption and unfavorable exhaust properties. This is because the piston has a comparatively large surface giving off heat and the comparatively cool liquid delivered into the cavities will retard rapid attainment of operating temperature in said modes. Another disadvantage of that design, however, is that the constant supply of liquid through the nozzle into the cavities interferes with building up a sufficient liquid pressure to lubricate the shaft and piston bearings at low speeds and idling, especially when the engine is cold.

Another type of rotary piston engine is present in Japanese Pat. No. Des. 47-14481. In that engine, the feed passage in the eccentric shaft to supply liquid to the piston cavities is made to be closable at low temperatures. This setting is effected by an expansion element arranged in the piston. The element acts on a rotary slide surrounding the piston bearing bushing and obturates or exposes the supply passage according to the effect of temperature. However, function of such a control is not necessarily assured because the expansion element is continually subjected to the alternation of centrifugal and centripetal forces owing to the manner of its arrangement on the piston and, hence, to high mechanical stress. The expansion element has a limited service life due to the comparatively high piston temperature. Furthermore, the function of this device cannot be monitored, and in event of damage, it cannot be dismantled without much outlay. Likewise disadvantageous is the fact that the central bearing surface of the bushing in the piston is lost because of the rotary slide surrounding the bushing, which necessitates widening the bushing.

SUMMARY OF THE INVENTION

The object of the invention is to avoid the above disadvantages and provide a rotary-piston machine of the type described above having a means acting on the nozzle which is both largely relieved of inertial forces and readily accessible, and also affords dependable operation according to engine load and/or the temperature of the liquid.

This object is accomplished by arranging a control member in the axial bore of the eccentric shaft. The control member controls communication between the axial bore and the transverse hole to the nozzle according to engine load and/or the temperature of the liquid.

First, with this device ready accessibility of the control means is achieved. It is comparatively simple to insert and pull from one end of the eccentric shaft, and it is not subjected to any influences of centrifugal forces, thanks to its central arrangement. Second, the flow of fluid through the piston is successfully adjusted to engine load and/or liquid temperature in any given time, so that in every operating mode, an advantageous piston temperature results, leading to diminished cold wear, improved exhaust properties and reduced fuel consumption.

The control means may have a sleeve arranged in the axial hole and longitudinally displaceable so that the communication with the nozzle is shut off below a certain temperature and/or load (idling and lower partial load interval), and reopened above at least one of said limits.

At low temperature, as after a cold start or idling and in the lower partial load range, as well as in drag mode, if a temperature drop occurs, the piston is not cooled owing to shut-off or throttling of the liquid feed, so that the correct piston temperature can be reached in a short time and maintained as well. On the other hand, with rising temperature and/or increased load delivery of liquid to the piston cavities is restored so that the piston is suitably cooled by supply of a definite flow of liquid.

To displace the sleeve according to the temperature, an expansion element having two parts movable relative to each other and bathed by the liquid may be provided in the axial bore. The first part is connected to the sleeve and the second part is connected to the eccentric shaft. This type of construction is advantageous for the reason that the temperature of the liquid is a simple and reliable measure of the operating temperature of the engine from time to time.

Alternatively, however, a plunger connected to the sleeve may be provided in the axial bore to displace the sleeve according to laod. The plunger is movable in one direction by the pressure of the liquid in the axial bore to shut off communication with the nozzle and in the other direction by a spring to restore communication with the nozzle. The space behind the plunger may be in communication firstly through a passage with the pressure face of the plunger and secondly with a return of larger cross section, in which a valve gradually closing with increasing load and gradually opening with decreasing load is arranged.

In this version, when the valve is opened—corresponding to idling or lower partial load range setting, a portion of the liquid will drain from the axial bore through the plunger, setting up a pressure gradient in flow direction, with the result that the plunger together with the sleeve can be forced by the liquid against the action of the spring into that extreme position in which

the sleeve shuts off communication with the nozzle, so that the piston is not cooled. When the valve is closed—corresponding to full-load setting—, contrariwise, the same liquid pressure can establish itself on both sides of the plunger, so that the spring forces the plunger into the other extreme position, in which the sleeve restores communication with the nozzle orifice and hence supply of liquid to cool the piston. Of course, depending on the degree of opening of the valve, intermediate settings can result, and hence varying flows of liquid be supplied by the nozzle.

An especially advantageous design has been found when the second part of the expansion element is connected to the plunger.

In this version, the flow of liquid to the piston cavities can be shut off at low load and at low temperature. A rapid rise of piston temperature can thereby occur, and a rapid elevation of operating temperature be achieved. On the other hand, when either of these limits is transgressed, cooling of the piston sets in, so that, contrary to known designs, there is the possibility of preventing overheating of the piston and also achieving an optimum piston temperature according to the temperature and the load.

Further details and features of the invention will be more fully illustrated in the description to follow, with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** shows a longitudinal section of a rotary-piston combustion engine having a control means arranged in the eccentric shaft to control the liquid cooling of the piston;

FIG. **2** shows a portion of the eccentric shaft, in partial section, with a first embodiment of a control means arranged in the axial bore and occupying a first operating position;

FIG. **3** shows the portion of the eccentric shaft as in FIG. **2** with the control means in a second operating position;

FIG. **4** shows the portion of the eccentric shaft as in FIG. **2** with the control means in a third operating position;

FIG. **5** shows the portion of the eccentric shaft as in FIG. **2** with the control means in a fourth operating position;

FIG. **6** shows the portion of an eccentric shaft much as in FIG. **2** with a second embodiment of the control means; and

FIG. **7** shows the portion of an eccentric shaft much as in FIG. **2** with a third embodiment of the control means.

DETAILED DESCRIPTION

Reference is made to FIG. **1**, showing a rotary-piston internal combustion engine having a housing composed essentially of a shell **1** and two parallel end pieces **2** and **3**, and bounding a working chamber **4**. In end pieces **2** and **3**, an eccentric shaft **7** is mounted on journal bearings **5** and **6**, its eccentric **8** bearing a polygonal piston **9** rotatable on a piston bearing **10**. The speed of piston **9**, by virtue of a transmission consisting of an internal gear **11** fixed to piston **9** and a pinion **12** fixed to end piece **2**, bears a fixed ratio to the speed of eccentric shaft **7**. Piston **9** is provided with cavities **13** into which—by way of an aperture **14** directed inward towards the axis of rotation of the piston near its radially inner portion—lubricating and/or cooling liquid can enter. To prevent this liquid from leaking through aperture **14** into working chamber **4**, sealing rings **15** are provided, which sealingly cooperate with the faces of piston **9** and the walls of the adjoining end pieces **2** and **3**.

A liquid circuit is provided to lubricate bearings **5** and **6** and piston bearing **10** and to cool piston **9**. The liquid circuit includes a pump **16** shown schematically and a tank **17**. The pump **16** takes in liquid from tank **17** and delivers it by way of a line **18** to a passage **19** in end piece **2** and to bearing **5**. Bearing **5** has holes **20** communicating firstly by way of an annular groove **21** encircling bearing **5** with the passage **19** and secondly with a transverse hole **22** in eccentric shaft **7**. The transverse hole **22** opens into a centrally arranged axial bore **24**, closed with a plug **23**, of eccentric shaft **7**, whence a transverse hole **25** leads to piston bearing **10** and a transverse hole **26** to the other journal bearing **6**.

Thus the piston bearing **10** and journal bearing **6** are also supplied with liquid. An additional transverse hole **27** communicating with axial bore **24** is provided to cool the piston **9**. Transverse hole **27** has a nozzle **28** whose orifice is directed at aperture **14** of the cavities **13** of piston **9**. A control means **29** is arranged in axial bore **24** to control communication between axial bore **24** and nozzle **28**. The control means releases or shuts off the supply of liquid to nozzle **28** according to engine load and/or liquid temperature. The liquid draining off from journal bearings **5** and **6** and piston bearing **10** and the liquid leaking from cavity **13** of piston **9** is carried away through the annular space **30** between internal gear **11** and pinion **12** and the passage **31** in end piece **2** and through annular space **32** and passage **33** in end piece **3**, the passages **31** and **33** leading back to tank **17**.

As shown in FIG. **2**, the control means **29** in this embodiment by way of example specifically has a sleeve **34** slidable lengthwise in the central axial bore in the vicinity of the transverse hole **27**. From this point on, the axial bore **24** is widened stepwise towards the plug **23** to successive bore diameters **24***a* and **24***b*. The division **24***a* of the bore is provided to ensure unimpeded supply of liquid from transverse hole **22** to transverse hole **25**. At the end of sleeve **34** to the left in the drawing, an expansion element **35** having two parts movable relative to each other is fixed by its first part, and fastened by way of its second part, in the form of a pressure pin **36**, to a plunger **37**. Plunger **37** is arranged displaceable lengthwise in a division **24***b*, opened out to a larger diameter, of axial bore **24**. A compression spring is arranged between plunger **37** and plug **23**. A hole **39** passes through plunger **37**. The port area of the hole is so proportioned that only a small flow of fluid, not adversely affecting the liquid supply, can pass. By way of hole **39**, the region in which transverse hole **22** opens out communicates with a return. The return is formed by a transverse hole **40** leading out of the region of the bore division **24***b* in which the compression spring **38** is arranged. Transverse hole **40** has a larger port area than bore **39**, so that when hole **40** is clear, a pressureless drainage of liquid from this region is assured. A slide ring **41** is arranged on the peripheral surface **7***a* where the transverse hole **40** opens. The slide ring cooperates with hole **40** and with it forms a valve to drain the liquid. Slide ring **41** has a groove **42** on its outer periphery, engaged by a linkage **46** indicated in FIG. **1** and connected to a control means, for example a linkage leading to a throttling flap not shown, transmitting the instantaneous engine load. In sleeve **34**, near

expansion element **35**, ports **43** are provided, to establish communication between the region of bore division **24***a* where transverse hole **22** opens out and the transverse hole **26** emanating from axial bore **24**. In addition, on the outer periphery of the sleeve **34** sliding in axial bore **24**, an annular groove **44** is arranged, in communication by way of radial holes **45** with the axial bore **24** carrying the liquid.

When the rotary-piston internal combustion engine is put into operation cold, and continues idling or in the lower partial-load range after such cold start, the control member **29** assumes the first operating position, shown in FIG. **2**. This position results because firstly slide ring **41** clears transverse hole **40** in idling, and the comparatively small flow of liquid passing through the smaller hole **39** can drain off without pressure through transverse hole **40**, and secondly the liquid delivered by way of transverse hole **22** to axial bore **24** acts against plunger **37** and thus holds control means **29** in this position against the action of spring **38**. Thus sleeve **34** obturates access to transverse hole **27**, so that the piston is not cooled, and operating temperature can therefore be reached comparatively fast.

In FIG. **3**, where only the region immediately surrounding the control means **29** that is pertinent to the invention is represented, the operating position assumed by the control means at full load after a cold start is shown. In this case, the transverse hole **40** is obturated by slide ring **41** so that the liquid passing by way of hole **39** cannot drain off. Instead, a pressure equilibrium takes place on either side of plunger **37**, with the result that the compression spring **38** forces plunger **37** to the right in the drawing towards the shoulder of division **24***b* and thereby displaces sleeve **34** correspondingly to the right. In this position, communication is set up by way of radial holes **45** and annular groove **44** between axial bore **24** and transverse hole **27** with nozzle **28**, so that the piston cooling required in this operating condition sets in, avoiding injurious overheating of the piston and the engine.

The operating position shown in FIG. **4** is assumed by control means **29** at full load after operating temperature of the engine has been reached. Since slide ring **41** closes transverse hole **40** at full load, plunger **37** remains in position pressed against the shoulder. With attainment of operating temperature, the liquid too exhibits a correspondingly elevated temperature, to which the liquid-bathed expansion element **35** responds, and slides sleeve **34** still farther to the right by way of pin **36**. Since annular groove **44** is made wide enough, the supply of liquid to the piston is maintained.

In the operation position of control means **29** shown in FIG. **5**, the engine is running at operating temperature, idling or in the lower partial-load range. This means that plunger **37**, owing to clearance of transverse hole **40**, is pushed by the pressure of the liquid into the position described for FIG. **2**, whereby sleeve **34** is indeed drawn likewise to the left. But, because expansion element **35** is at operating temperature, and because of the broad annular groove **44**, communication between axial bore **24** and transverse hole **27** to nozzle **28** remains open. If the engine idles, there is generally a lowering of operating temperature and a corresponding cooling of the liquid, with the result that expansion element **35** draws sleeve **34** farther to the left into the operating position described for FIG. **2**, whereby the supply of liquid to the piston is interrupted and thus excessive cooling of the piston is avoided.

In FIGS. **2**, **3**, **4** and **5**, only the respective extreme positions are shown that the control means assumes under the influence of load and operating temperature. Obviously with a slighter temperature increase or at smaller load, intermediate settings result, which in these cases also necessitates a corresponding smaller flow of liquid to cool piston **9**.

The control provided for the feed of liquid to the piston, in addition to a rapid rise of operating temperature of piston **9** when the engine is cold and moderation of any undue cooling of the piston when idling, has the further advantage that the control means is easily installed by way of plug **23**, and that the central rotationally symmetrical arrangement is not exposed to any influences of centrifugal force to compromise its function.

When sufficient for applicable requirements, the control means, in departure from the embodiments shown by way of example in FIGS. **1–5**, may be actuated either according to engine load only or according to liquid temperaiure only.

As shown in FIG. **6**, in which the same reference numerals are used for the same or similar parts as in FIGS. **1–5**, sleeve **34'** of control means **29'** is attached directly to plunger **37'**. In this case, control means **29'** operate only according to load, that is, at higher load the feed between axial bore **24** and nozzle **28** is cleared, and in idling or at lower load—as shown—it is shut off.

In FIG. **7**, where likewise the same reference numerals as in FIGS. **1–5** have been used for the same or similar parts, the control means **29''** operates according to the temperature of the liquid. For this purpose, the sleeve **34''** is attached to plug **23'** screwed into eccentric shaft **7** by the second part, in the form of a pin **36'**, of expansion element **35'**. In this embodiment, communication between axial bore **24** and transverse hole **27** to nozzle **28** is released with increasing liquid temperature and closed—as shown—with falling or lower temperature.

Otherwise, the mode of operation of control means **29'** with plunger **37'** (in FIG. **6**) and of control means **29''** with expansion element **35'** (in FIG. **7**) is the same as described for FIGS. **2–5**.

Thus the several aforenoted objects and advantages are most effectively attained. Although several somewhat preferred embodiments have been disclosed and described in detail herein, it should be understood that this invention is in no sense limited thereby and its scope is to be determined by that of the appended claims:

I claim:

1. A rotary-piston machine, in particular a rotary-piston combustion engine of trochoid type comprising; a housing composed of at least one shell and at least two parallel end pieces and traversed perpendicular to the end pieces by an eccentric shaft mounted on bearings in the end pieces, a liquid-cooled polygonal piston rotatably mounted on the eccentric of the shaft, the piston containing cavities provided with at least one aperture near their radially inner portion, the eccentric shaft having an axial bore traversed by the liquid and communicating by way of transverse holes with the bearings and with at least one nozzle, the orifice of the nozzle being directed at the aperture of the piston cavities, control means arranged in the axial bore of the eccentric shaft for controlling the communication between the axial bore and the nozzle according the temperature of the liquid, the control means including a sleeve arranged in the axial bore and longitudinally displaceable

so that the transverse hole leading to the nozzle is shut off by the sleeve below a certain temperature (idling and lower partial-load range) and opened above said temperature, and in order to displace the sleeve in the axial bore according to the temperature, a liquid-bathed expansion element having two parts relative to each other is provided, the first part of the expansion element connected to the sleeve and the second part of the expansion element connected to the eccentric shaft, and the sleeve being traversed by the liquid and a continuation of the sleeve in the shaft leads to a shaft bearing.

2. The invention in accordance with claim 1 wherein in order to displace the sleeve in the axial bore according to load a plunger connected to the sleeve is provided, the plunger is movable in one direction by the pressure of the liquid in the axial bore to shut off communication to the nozzle and in the other direction by a spring to restore communication to the nozzle, the space behind the plunger being in communication firstly by way of a passage with the pressure face of the plunger and secondly with a return of larger diameter, in which a valve is arranged gradually closing with increasing load and gradually opening with decreasing load.

3. A rotary-piston machine, in particular a rotary-piston combustion engine of trochoid type comprising; a housing composed of at least one shell and at least two parallel end pieces and traversed perpendicular to the end pieces by an eccentric shaft mounted on bearings in the end pieces, a liquid-cooled polygonal piston rotatably mounted on the eccentric of the shaft, the piston containing cavities provided with at least one aperture near their radially inner portion, the eccentric shaft having an axial bore traversed by the liquid and communicating by way of transverse holes with the bearings and with at least one nozzle, the orifice of the nozzle being directed at the aperture of the piston cavities, control means arranged in the axial bore of the eccentric shaft for controlling the communication between the axial bore and the nozzle according to the engine load, the control means including a sleeve arranged in the axial bore and longitudinally displaceable so that communication to the nozzle is shut off below a certain load (idling and lower partial-load range) and restored above said limit, in order to displace the sleeve in the axial bore according to load a plunger connected to the sleeve is provided, the plunger is movable in one direction by the pressure of the liquid in the axial bore to shut off communication to the nozzle and in the other direction by a spring to restore communication to the nozzle, the space behind the plunger being in communication firstly by way of a passage with the pressure face of the piston and secondly with a return of larger diameter, in which a valve is arranged gradually closing with increasing load and gradually opening with decreasing load.

4. A rotary-piston machine, in particular a rotary-piston combustion engine of trochoid type comprising; a housing composed of at least one shell and at least two parallel end pieces and traversed perpendicular to the end pieces by an eccentric shaft mounted on bearings in the end pieces, a liquid-cooled polygonal piston rotatably mounted on the eccentric of the shaft, the piston containing cavities provided with at least one aperture near their radially inner portion, the eccentric shaft having an axial bore traversed by the liquid and communicating by way of transverse holes with the bearings and with at least one nozzle, the orifice of the nozzle being directed at the aperture of the piston cavities, control means arranged in the axial bore of the eccentric shaft for controlling the communication between the axial bore and the nozzle according to the engine load and the temperature of the liquid, the control means including a sleeve arranged in the axial bore and longitudinally displaceable so that communication to the nozzle is shut off below a certain temperature and load (idling and lower partial-load range) and restored above said limits, in order to displace the sleeve in the axial bore according to the temperature, a liquid-bathed expansion element having two parts movably relative to each other is provided, the first part of the expansion element being connected to the sleeve and the second part of the expansion element being connected to the eccentric shaft, a plunger is provided connected to the sleeve and movable in one direction by the pressure of the liquid in the axial bore to shut off communication to the nozzle and in the other direction by a spring to restore communication to the nozzle, the space behind the plunger being in communication firstly by way of a passage with the pressure face of the plunger and secondly with a return of larger diameter, in which a valve is arranged gradually closing with increasing load and gradually opening with decreasing load, and the second part of the expansion element being connected to the plunger.

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