United States Patent [19]

Klink

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[45] **June 28, 1974**

[54] **PRIME MOVER OF THE RADIAL ENGINE TYPE**

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[52] **U.S. Cl.** **91/481**

[51] **Int. Cl.** **F04b 1/00**

[58] **Field of Search** ..... 91/476, 481, 180; 417/273, 417/479, 516, 517; 92/98 R, 98 D

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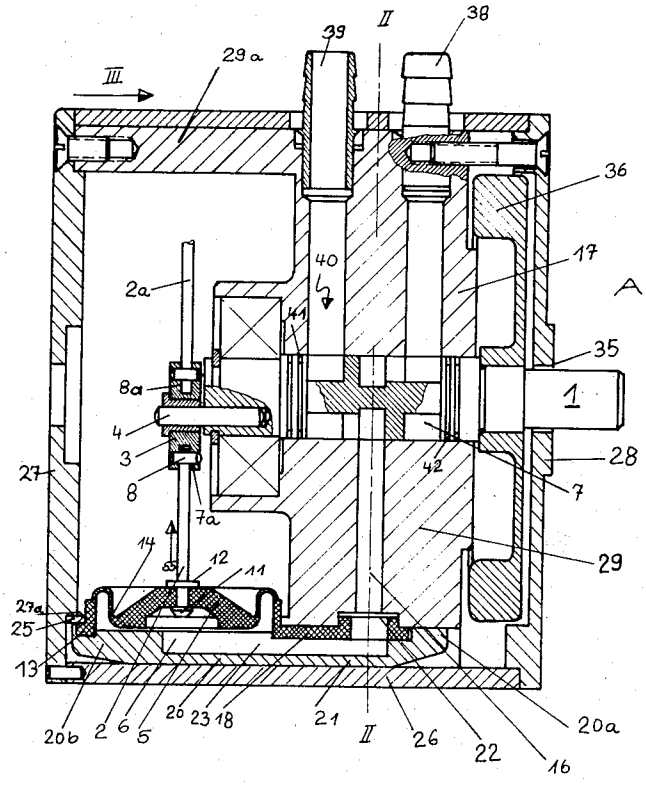
Primary Examiner—William L. Freeh
Assistant Examiner—G. P. LaPointe

[57] **ABSTRACT**

The invention relates to a prime mover of the radial type. The mover is driven by rod-like driving elements which are eccentrically linked to the shaft and are essentially radially directed. The other end of each of the driving elements is connected to a diaphragm of the bellows type which encloses a pressure chamber. The pressure chamber alternately is loaded and exhausted with pressure medium depending on the rotating movement of the shaft thus acting on the driving elements whose oscillating movements are directed to the shaft and transformed to a rotary movement.

2 Claims, 11 Drawing Figures



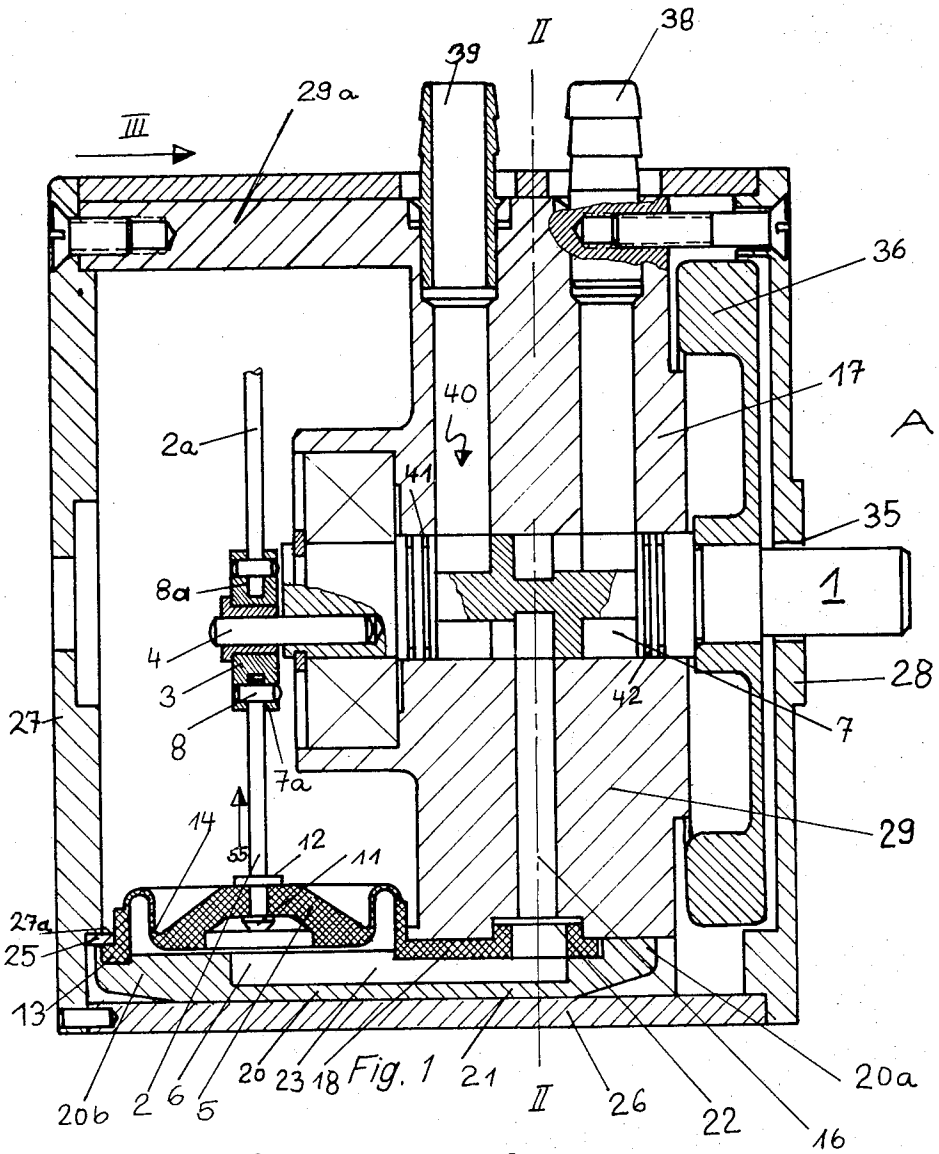

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Fig. 1

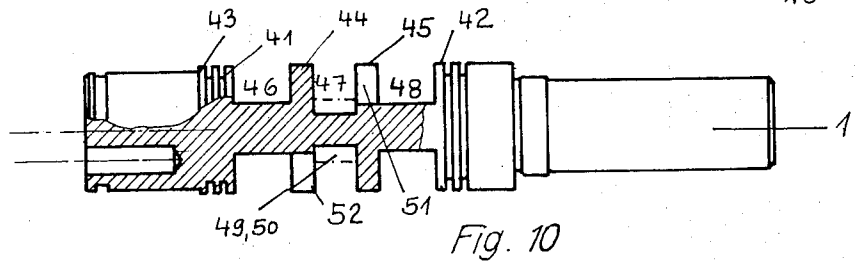
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Fig. 10

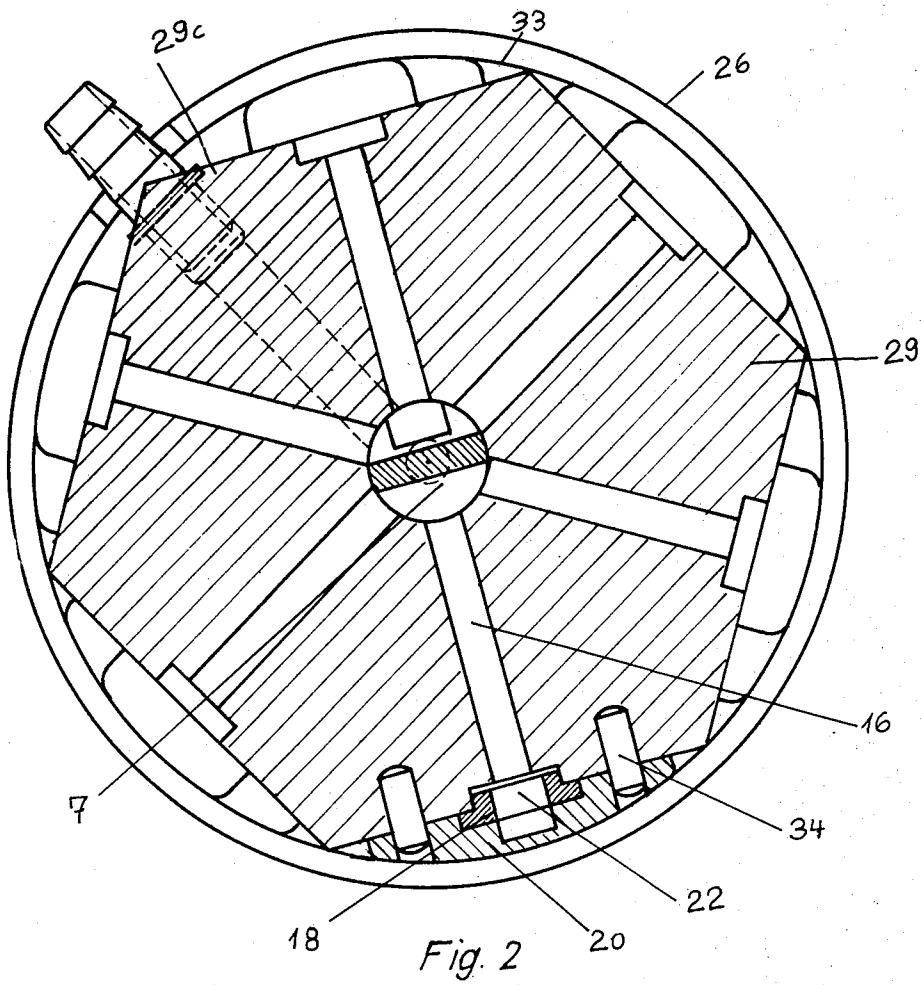

Fig. 2

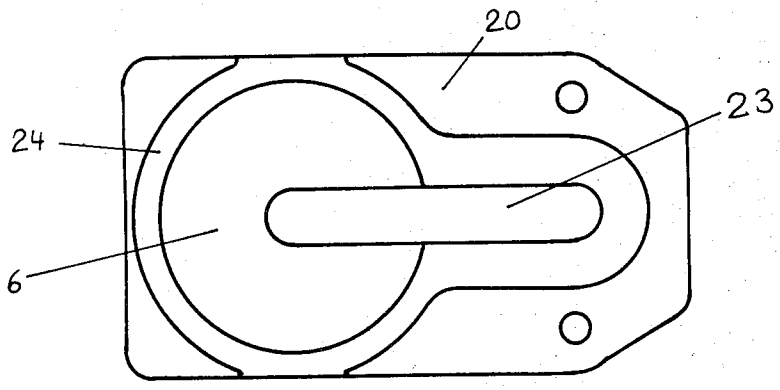

Fig. 8

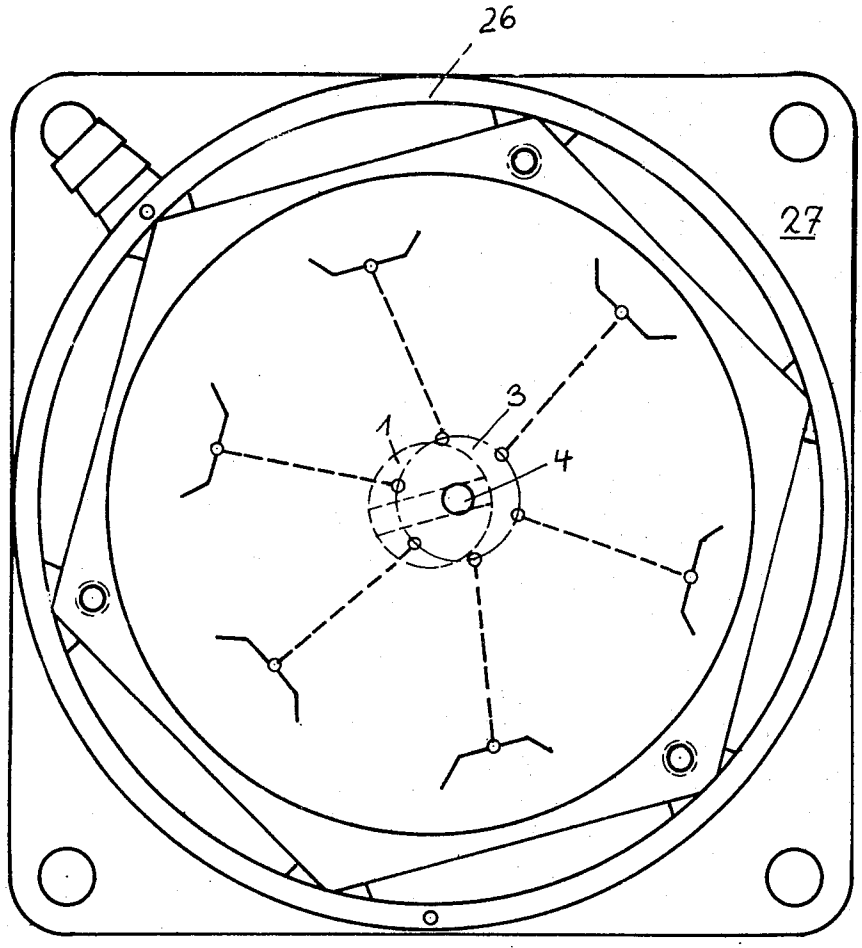

Fig. 3

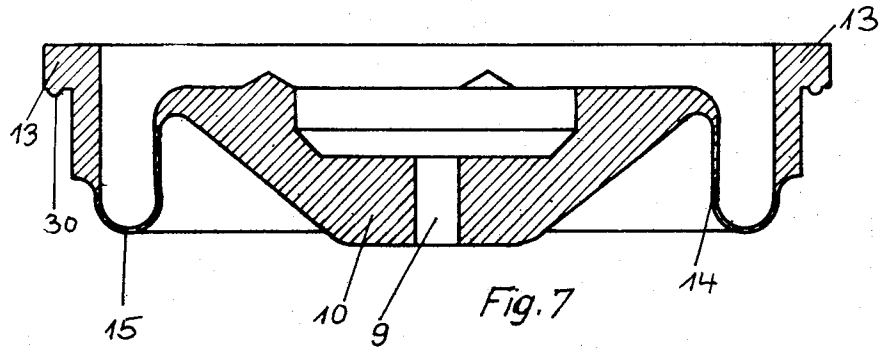

Fig. 7

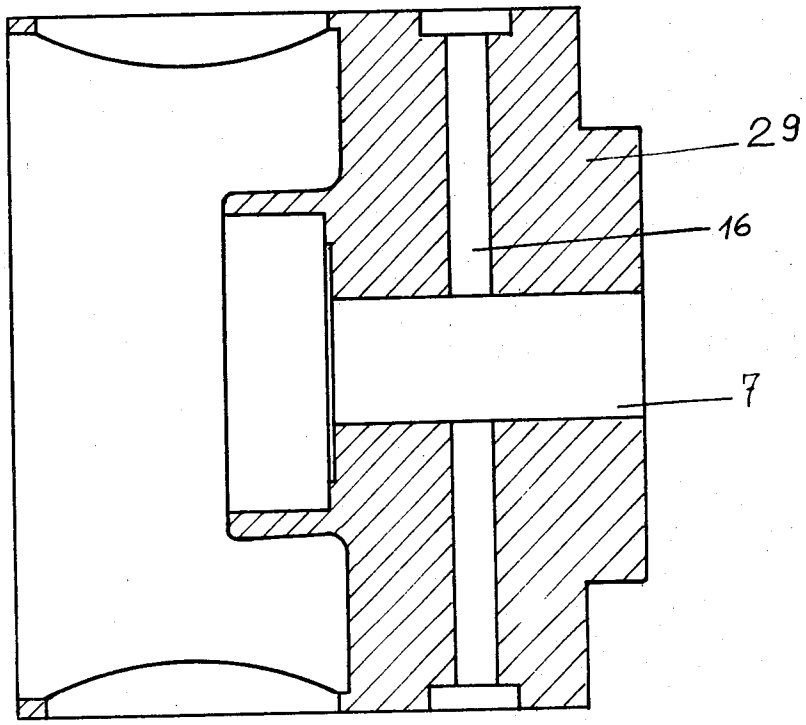

Fig. 4

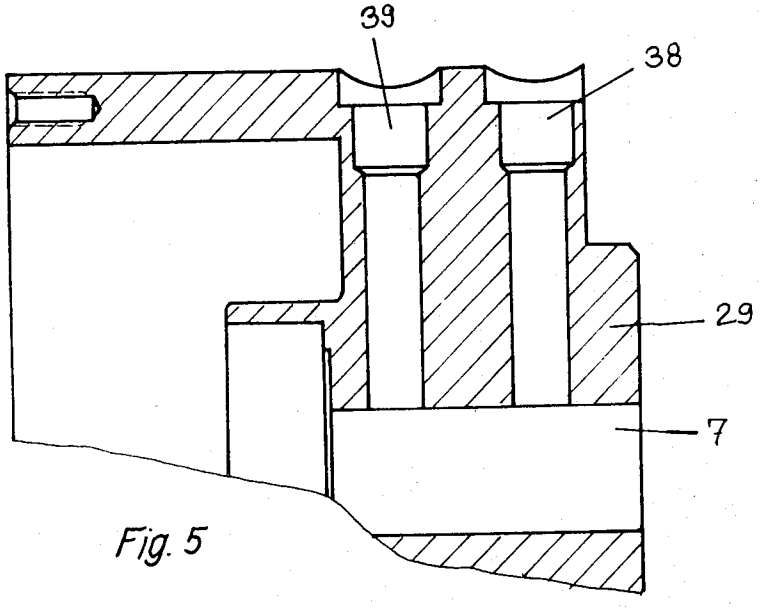

Fig. 5

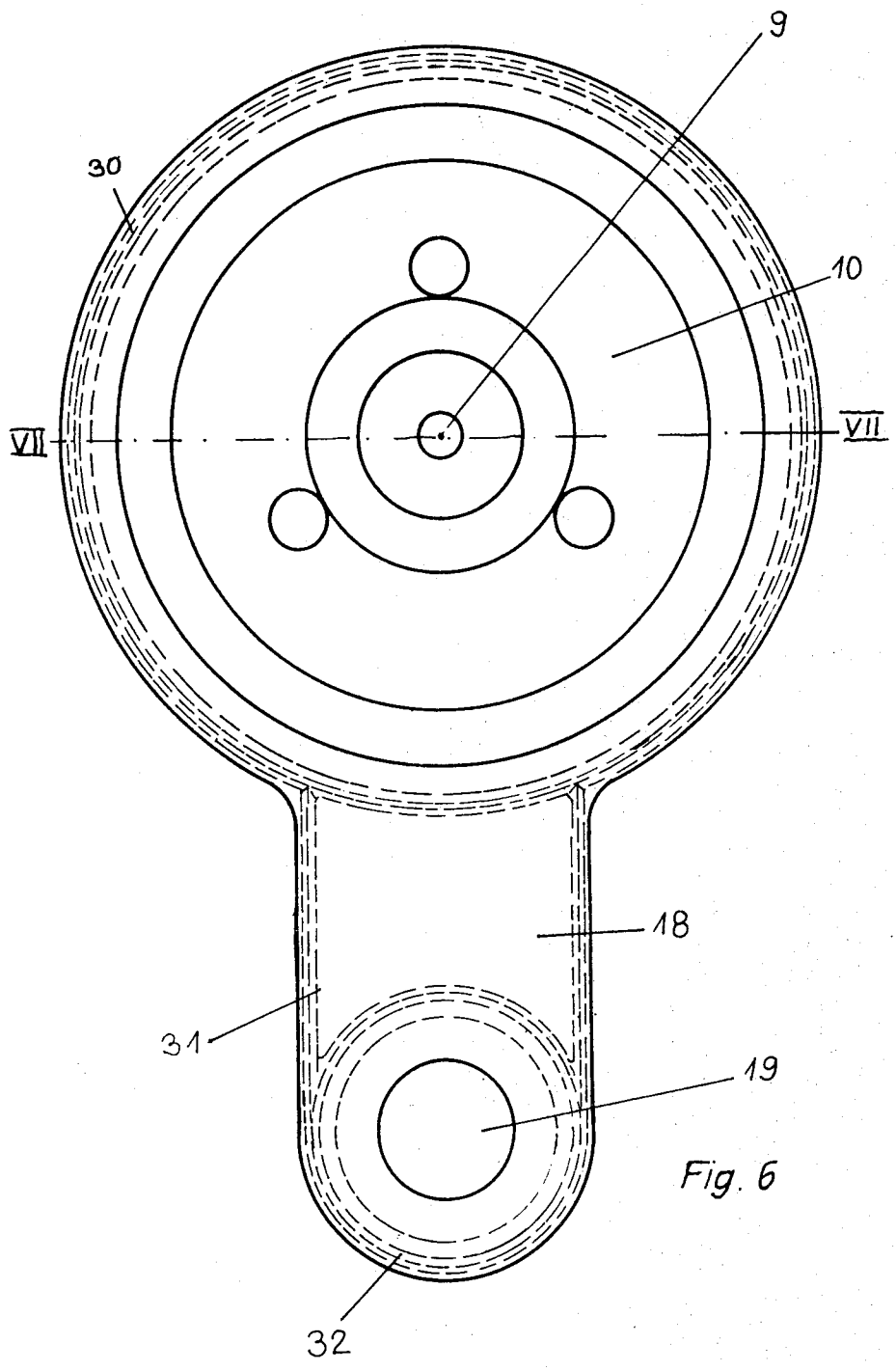

Fig. 6

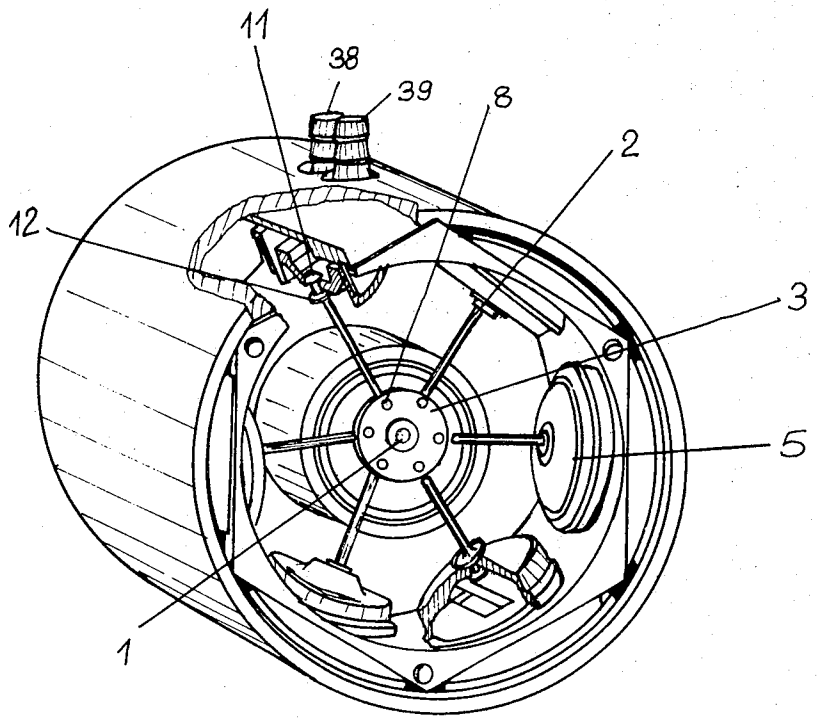

Fig. 11

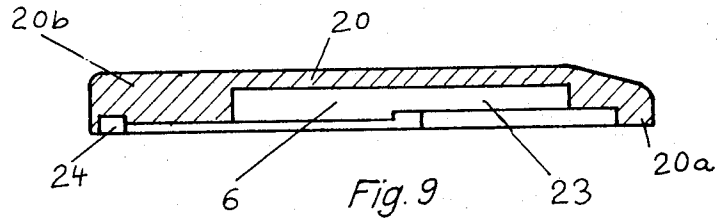

Fig. 9

PRIME MOVER OF THE RADIAL ENGINE TYPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an engine of the radial type, the shaft of which is driven by a plurality of radially arranged and equally spaced driving elements of the pistonacting type, which are eccentrically linked to the shaft or one of the members connected thereto and whose oscillating movements are directed radially towards or away from the shaft.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an engine of the kind described herein which, operating pneumatically, is of simple design and low cost and operates with a minimum of losses.

To achieve the object aforementioned the invention provides that a pneumatic medium is employed to actuate the driving elements of the new engine and that for this purpose each of the driving elements is provided with a radially arranged transmission element, which may be of the rod type, and which is connected directly or indirectly to the shaft at the end facing the interior part of the housing while its end facing away from the shaft is connected to the central part of a bellows type diaphragm whose collar is clamped to the housing and which encloses towards the interior part of the housing a pressure chamber which is alternately filled with pneumatic medium and vented, depending on the movement of the shaft and conveniently also depending on the control movement of a centrally located valve type distributor.

The engine according to the present invention operates in a way similar to the system of the two-stroke engine, one of its special features being the practically frictionless form of operation (which is due to the use of the bellows type diaphragms as closed pressure chambers instead of the piston-cylinder units) and that there are practically no clearance or leakage losses, which can also be attributed to the design features described hereinbefore. The engine is both explosion and short-circuit proof, so that it will not suffer damage even when operated under heavy overload conditions. Above all its direction of rotation is fully reversible at any desired frequency, for example at a frequency of 15 cps. Further advantages of the engine according to the invention are that it can be started up quickly and that its speed is variable practically steplessly over a wide range, for example a range of 1 : 100. The new engine is of very simple design, its assembly is also very simple. It is assembled by handling only a few parts and in addition the engine practically requires no maintenance. The engine can be operated at smallest pressures, it is primarily intended for smaller capacity ranges. The new engine may be used as a stationary drive in any form desired, as a prime mover for toys, as a prime mover for laboratory type mixers in the chemical industry, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing shows a form of construction of the object of the invention, in which

FIG. 1 shows a general view of an engine according to the invention in a side elevation in an axial section,

FIG. 2 shows the arrangement according to FIG. 1 in a section according to the line II—II of FIG. 1,

FIG. 3 shows the arrangement according to FIG. 1 in a section according to the arrow III of FIG. 1,

FIG. 4 shows the main body of the engine according to the invention in a side elevation in a vertical section,

FIG. 5 shows the main body shown in FIG. 4 in a side elevation in a section, with this section following a line which is transposed by 30° in relation to the section shown on FIG. 4,

FIG. 6 shows a bellows type diaphragm of the engine according to the invention in a plan view in an enlarged scale,

FIG. 7 shows the arrangement as shown in FIG. 6 in a lateral view in an axial section along the line VII—VII of FIG. 6 on a reduced scale,

FIG. 8 shows a diaphragm holding device of the engine according to the invention on a reduced scale,

FIG. 9 shows the diaphragm holding device according to FIG. 8 in a side elevation in a vertical section,

FIG. 10 shows a valve type distributor of a first embodiment of the engine according to the invention in a side elevation partically sectionalized, and

FIG. 11 shows the engine according to the invention as seen from the front end in perspective illustration, with the front cover removed, to show the details inside the engine housing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The engine according to the invention is designed according to the socalled radial type system and works similarly to the two-stroke engine. The shaft **1** of the engine is driven by a plurality, in the embodiment of the invention shown in the illustrations six, piston-type driving elements equally spaced in a circular manner around the driving shaft. These driving elements are designed as rod-type transmission elements of the connecting rod type, as shown in the illustration at **2.** The driving elements are radially arranged, thus extending outwardly from the shaft like the arms of a star, connecting to the shaft or the circumference of the eccentric disc **3** which is coupled to the front end of the shaft and connected to the same, for example by the bolt **4.** At the end opposite to the shaft the rod type transmission elements or connecting rods **2** are connected to the central part of a bellow type diaphragm whose collar is tightly clamped to the housing, which seals off towards the interior part of the housing a pressure chamber **6,** which is alternately filled and evacuated by a pressure medium as controlled by the movement of the centrally located valve type distributor **7.** Five of the six rod type transmission elements of the embodiment of the invention shown in the illustration are connected flexibly to the shaft, the connection being effected by the free ends of the transmission elements engaging freely in the groove *7a* of the eccentric disc and connected pivotally within this groove and its surrounding walls by a pin **8** around the axis of the same, which is arranged parallel to the longitudinal central axis. The flexible connection between the rod type transmission elements and the eccentric disc may also be effected in a number of other ways, for example by a socalled ball end. One of the transmission elements, identified in FIG. 1 as position *2a*, is rigidly connected to the shaft or eccentric disc, which connection is ef-

fected by its free end being fixed firmly to the groove **8***a*, for example because the free end extends to the bottom of the groove.

The collar of the bellows type diaphragm **5** is clamped tightly to the housing, thus forming with said housing a totally enclosed pressure space which only communicates with the valve type distributor, while its central part **10** is connected to the corresponding rod type transmission element by a bore **9** through which passes the free end of the transmission element which is thus connected to the wall surrounding the bore by providing, for example, a rivet type head **11** at one side and a collar **12** at the other side. FIGS. **6** and **7** show that the said central part **10** is shaped like a cup, with the opening according to FIG. **1** directed towards the pressure chamber **6** while its bottom part is connected to the transmission element. A ring shaped connecting part **14** is provided between the central part of the diaphragm and its holding collar **13,** forming a kind of intermediate area while the diaphragm is operated which, while the diaphragm is in its neutral position, as indicated in FIG. **1,** has a U-shaped cross section, with its opening towards the pressure chamber and whose cross-section **15** almost follows a circular arc.

The diaphragm is characterized by an exceptionally good bending property as well as elasticity because the central part **10** of the diaphragm is considerably thicker than the ring shaped connecting part **14** — it may be 10 to 15 times thicker than the latter — and because the ratio of the thickness of the central part of the diaphragm to the total height of the cup is about 2 – 4 : 1, while the relation of the diameter of the central part to that of the entire part is about 1 : 1.25 – 1.75, thus affording an extraordinarily long useful life of the engine, even under heaviest load conditions. The use of a bellows type diaphragm to actuate the transmission elements results in obtaining a considerably larger stroke as compared to conventional arrangements, which permits a larger eccentricity, which in turn helps to obtain a higher torque.

The input lines **16** to the individual pressure chambers **6** are each contained in a main body **17,** which is arranged inside the engine housing and which serves as a bearing for the shaft and which is shaped like a cast member with a hexagonal cross section through which the driving shaft passes in an axial direction and the input lines for the pressure medium in a radial direction. The pressure chambers are, however, situated outside the main body **17,** advantageously in axial direction in front of the main body **17** by being arranged within a hollow space, which also contains the eccentric disc, provided in the housing situated in front of the main body, this hollow space being situated at that side of the main body which is turned away from the driving end of the main body. The pressure chambers are in this way connected with the input lines by projecting parts or extensions. For this reason the diaphragms of the pressure chambers include a flap type extension **18** which is situated at the projecting part or extension of the pressure chamber and which constitutes, observed in top view, a narrow elongated extension of the circular diaphragm body **10** at the end of which a bore **19** is situated through which the input line communicates with the pressure chamber. The ratio of the diameter of the circular diaphragm body to the width of the extension is about 2.5 – 3.5 : 1 and to its length like about 1.5 – 2 : 2, while the ratio of the thickness of the cup of the diaphragm body to that of the extension is about 1.25 : 2 – 1. The pressure chambers are each arranged between the bellows type diaphragm **5** at the side facing the input lines **16** for the pressure medium and a coresponding diaphragm holder **20,** which may be of metal or a plastic material, situated at the side facing the housing.

The diaphragm and the diaphragm holder are braced to each other by the relative position of the housing and main body, as will be explained more fully below. The diaphragm holder includes an extension **21,** which corresponds to the flap type extension **18** and is situated facing it, which extends to the opening **22** of the input line **16** for the pressure medium and which contains, at the side facing the diaphragm, a recess **23** arranged at about right angles to the corresponding input line **16** and effecting the communication between the same and the actual pressure chamber. From this it results that the recess **23** practically forms a channel which forms an extension of the input line **16** running, however, at right angles to the same and extending to the actual pressure chamber **6.** The diaphragm holder includes at its periphery at the side facing the diaphragm a circular recess **24** into which is fitted the peripheral portion **13** of the diaphragm, which may be held in position by a check piece **25** or something similar. According to the rrangement shown in FIG. **1** the diaphragm holder is fixed with the side facing away from the diaphragm to the inner surface of the housing **26,** which is shaped like a cylinder sleeve, open at both axial ends, and, for example, a screwed-on cover **28** and whose internal diameter corresponds to the diameter of the main body. The diaphragm body is further braced at its peripheral parts **20***a*, **20***b* protruding into the inside of the housing and the engine to the main body **29** or perhaps to a protruding part **27***a* of the housing cover **27.** Inside the engine the diaphragm body is free as far as the central portion is concerned and the compensating part, the peripheral part is partly situated between part **20***b* of the diaphragm holder and the check piece **25,** the extension **18** of the diaphragm body fitting to the side of the main body of the engine facing away from the diaphragm holder and/or its extension where the peripheral part is contained and retained between this main body **29** and part **20***a* of the diaphragm holder. With this type of design of the parts there results a very simple form of assembly, which may be carried out by hand in a few minutes, for example two minutes. All that is now required is to take the main body and attach the pressure chambers which are formed by the diaphragms holder and the diaphragm fixed thereto to the positions corresponding to the sides of the hexagon, fixing them with the aid of pins or bolts and obtaining the necessary bracing and the necessary unity by covering the whole with the sleeve or housing **26.** It is also possible to fix the diaphragm to the diaphragm holder in such a way that the former is attached to the latter and that its peripheral part is beaded over the diaphragm body thus holding the diaphragm body, between it and the diaphragm holder, with a corresponding groove being provided for passing the flap type extension. This type of embodiment has the advantage that it permits an even quicker assembly, it may also result in advantages relative to the finishing of the main body as the portion **29***a* will then not be required so that the main body can be made by machin-

ing and does not require manufacture by injection moulding.

To ensure proper mating and considerable tightness the diaphragm has been fitted in several parts with a supporting rim at the points where it mates with other parts. This rim has the shape of a triangle pointing outwardly and away from the diaphragm. Such supporting rims are, for example, shown in FIG. 7 at reference numeral **30,** where they serve to mate with the ring disc or the diaphragm holder. These supporting rims are also provided as indicated at reference numerals **31, 32** of FIG. **6,** where they serve to mate with the main body **29.**

Generally speaking, then, the arrangement is such that the main body **29** which in its cross section has the shape of a hexagon is covered by the cylindrical sleeve **26** in such a manner that spaces **33** (FIG. **2**) are formed between the circumference **29***c* of the main body and the inside wall of the cylindrical sleeve **26** at each of the positions corresponding to the sides of the hexagon. Each of these spaces contains a pressure chamber with input lines **16** for the pressure medium passing radially to the outside from each of the pressure chambers, the input lines ending in the central bore **7** of the main body. The pressure chambers which are each formed by the diaphragm and the diaphragm holder are kept in position by bolts **34.** The whole housing is completed by the two bearing covers **27** and **28** (FIG. **1**), where the bearing cover **28** has a central bore **35** so that the end of the shaft **1** may pass through it. At the end of the engine facing away from the eccentric disc a flywheel **36** is provided, which is removable. It it is desired to obtain an exceptionally easy and quick high frequency reversibility of the engine this flywheel may be removed. The cover **28** of the engine may, for example, be replaced by a different cover which contains a brake or a gearing, thus obtaining constructionally most simply a stepdown or adjustability of the engine speed. In this case the barke serves primarily to stop the engine, the regulation of the engine speed is preferably effected by throttling the exhaust.

From FIG. **1** it can be seen that the housing includes an input line **38** for the compressed air as well as an exhaust line **39,** which pass through the housing in radial direction ending in the central bore **7** which takes the shaft. With this type of arrangement the reversibility may be effected by reversing the connections for the air intake and exhaust, i.e., in this case the exhaust will be effected through **38** and the input through **39.** The direction of rotation of the engine may, however, also be reversed by feeding the engine across line **38** either with compressed air or connecting the line to a vacuum. With this arrangement the input line **38,** the input lines **16** for the pressure medium and the exhaust line **39** are located in three planes which are parallel to each other, situated at right angles to the longitudinal central axis of the shaft **1** and situated, as viewed from the driving side A, at the side of the shaft facing away from the eccentric disc, one behind the other and each at a distance to the other. The central portion of the shaft is designed as a valve type distributor, as indicated at item **40,** which facilitates on the one hand the air intake through the input line **38** and at the same time the exhaust through the exhaust line **39** while the shaft rotates through the input lines **16.** This central portion **40** of the shaft **1** which is designed as a valve type distributor is separated at its two axial ends from the other parts of the shaft by one labyrinth packing each. For this reason the shaft is provided at the relevant points with a collar **41** or **42** the external circumference of which mates with the internal circumference of the casing the bore and which has, at its outside several, for example two or three parallel annular grooves **43.** In this way an almost perfect and for the present purposes fully sufficient sealing of the valve type distributor is obtained, which is also characterized by its very simple design as it is integral with the shaft.

According to the design input line **38** for the compressed air, input lines **16** and exhaust line **39** terminate in the housing within the area which corresponds to the central part designed as the valve type distributor. This central part is subdivided by two parallel collars **44, 45,** which are advantageously spaced at essentially equal distances from each other, into three axially consecutive sections **46, 47** and **48** — the collars **44, 45** being positioned at right angles to the longitudinal center axis **1** — with the two external sections **46, 48** corresponding to the orifices of the input line **38** for the compressed air intake and the exhaust line **39,** while the central section **47** communicates with the orifices of the input lines **16** leading to the individual pressure chambers. The central section is subdivided by two partitions **49, 50,** arranged in the longitudinal direction of the shaft and equally spaced in the peripheral direction of the shaft, i.e., situated diametrically opposite each other, into two sections or parts, of which one part communicates through the opening **51** of the relevant partition with that section which effects the communication with the compressed air intake line which comes from the source of the compressed air source, while the other part communicates through an opening **52** of the other partition, staggered at about 180° with regard to the other opening, with the exhaust line. With such an arrangement the input lines **16** will be connected consecutively to the input line **38** while the shaft rotates, thus supplying compressed air to the corresponding pressure chambers (three pressure chambers of a total of six) while at the same time the subsequent channels are connected to the exhaust line **39,** thus permitting the exhaust of the compressed air remaining there from the previous working stroke. In this way the pressure chambers are consecutively filled with compressed air thus causing the diaphragm to expand in a direction towards the inside of the housing so that the rod type transmission elements **2** move like connecting rods in the direction towards the shaft indicated by the arrow **55,** thus causing the shaft to revolve, as they are connected to the same eccentrically by the eccentric disc. It follows that by suitable arrangement and design of the distribution channels **46, 47, 48** at the same time three pressure chambers are filled with compressed air and three are exhausted. The elasticity required, especially when the engine is operated at high speed, is obtained by the connecting rods or rod type transmission elements **2** at one end being connected to the diaphragm and — with one exception — at the other end resting flexibly or being articulated in the eccentric disc. The rigid connection of one of the rod type transmission elements with the eccentric disc ensures the necessary stability of the whole arrangement, the necessary movement transverse to the feed movement is assured by the connection with the diaphragm.

Instead of using the valve type distributor described above, which acts like a commutator, it is possible to

use different arrangements for the distribution of the compressed air to the individual pressure chambers or for the venting of said pressure chambers. In such a case the shaft is fitted with a disc concentric to the same which is fitted with bore holes parallel to shaft axis situated in the peripheral part of the same, these bore holes being spaced equally and corresponding in number to the number of pressure chambers and actuating elements. These bore holes may be loaded in a non-contact way by discharge nozzles facing the same whereby a corresponding element, such as a valve, will be actuated by releasing a signal, thus loading the bellows type diaphragm of the corresponding pressure chamber. With such an arrangement only the normal bearing friction results, there are no pressure losses or losses of volume in the annular clearances, as the valves may be hermetically sealed, especially if these are of the bellows type, too. The efficiency is very much better than with comparable arrangements. The number of pressure chambers and the corresponding elements is then not limited.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. In a prime mover of the radial engine type having a housing, a shaft rotatably mounted in the housing, a plurality of driving elements extending substantially radially with respect to the shaft axis thereof, means forming a plurality of chambers for fluid fixed with respect to the housing and means to connect said fluid chambers to pressure and exhaust, said chamber forming means including a diaphragm forming the wall of each chamber nearest the shaft axis and means operatively connecting each diaphragm with one of the driving elements, each diaphragm having a relatively thicker central portion of large area acting as a piston and a relatively much thinner outer portion of substantially less radial extent than the inner portion, said means connecting the diaphragm to the driving element covering only a small part of the central portion, said means for connecting the fluid chambers to pressure and exhaust including passages extending substantially parallel to the shaft axis, said diaphragms having lateral extensions integral therewith forming the walls of such passages nearest the shaft axis.

2. In a prime mover as claimed in claim **1**, distributor valve means turnable with the shaft and radially extending passages connecting the distributor valve means with said passages parallel to the shaft.

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