

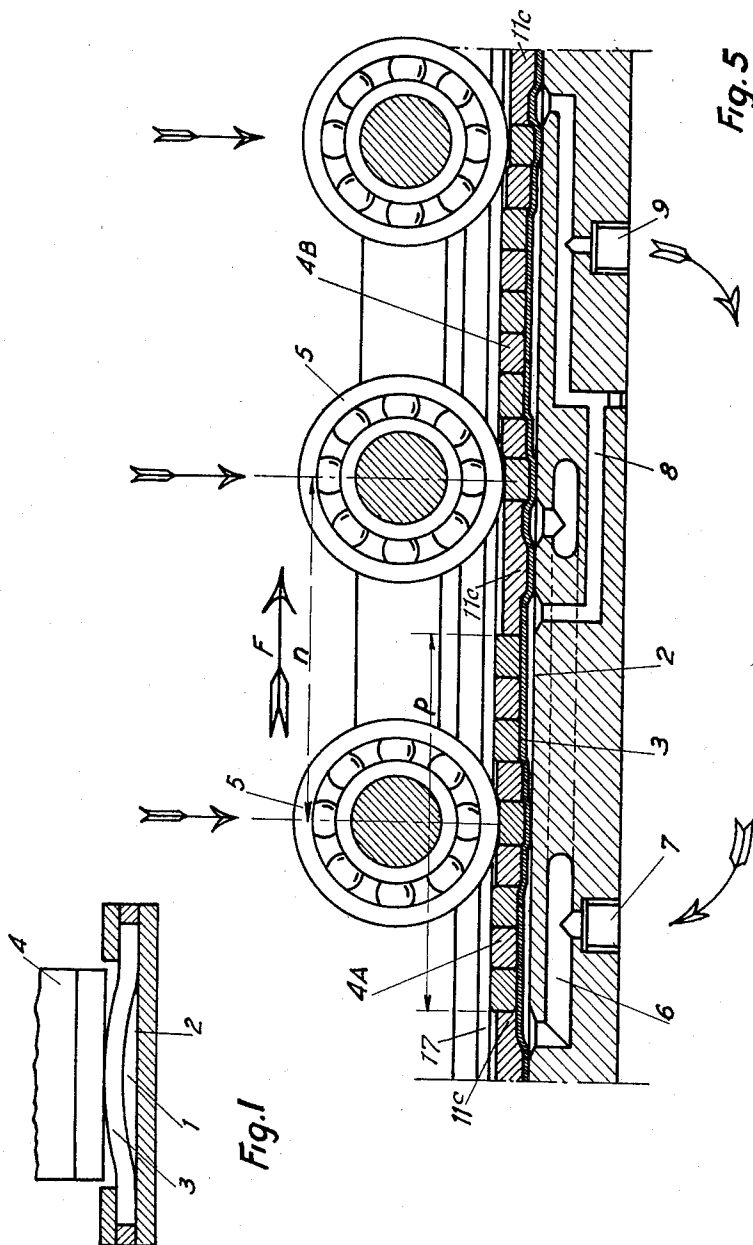
Nov. 8, 1955

L. A. MAILLOT
COLLAPSIBLE CHAMBER PUMP

2,722,893

Filed Jan. 5, 1951

7 Sheets-Sheet 1



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7 Sheets-Sheet 2

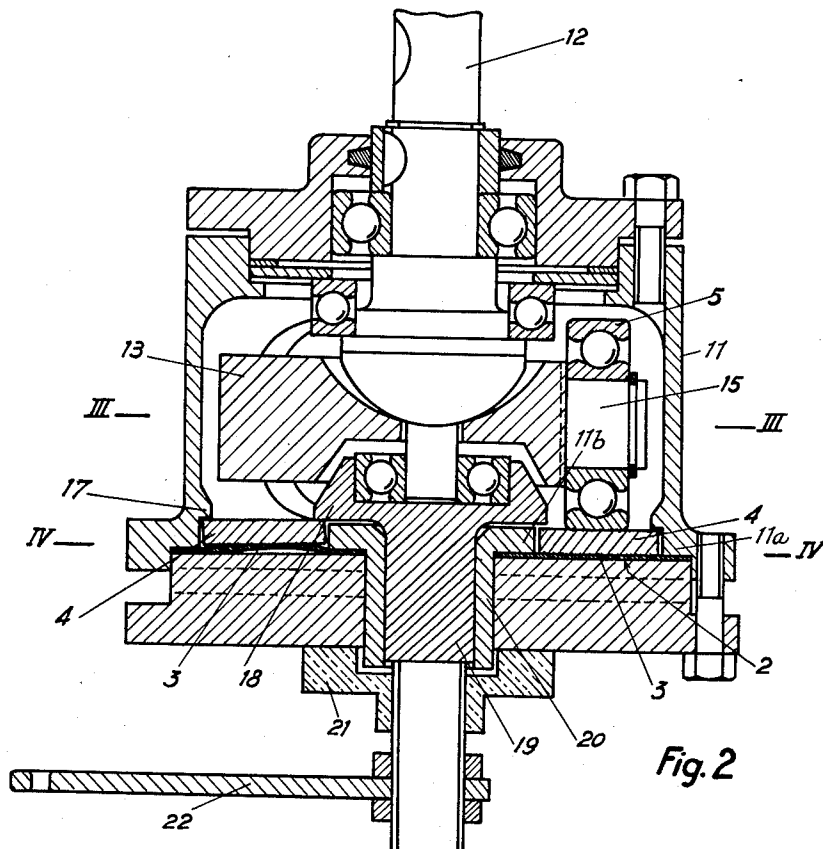


Fig. 2

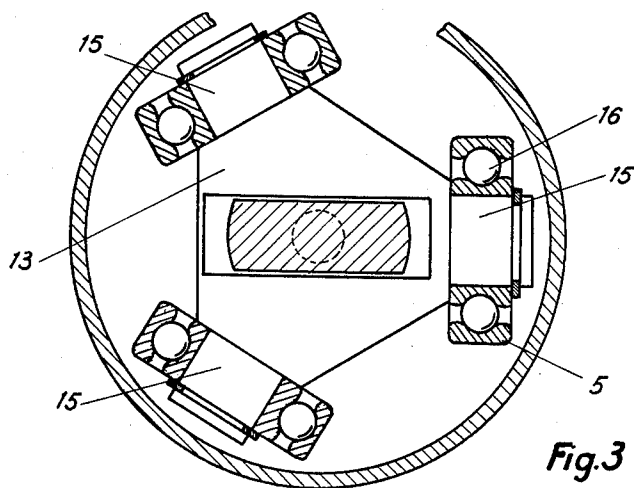


Fig. 3

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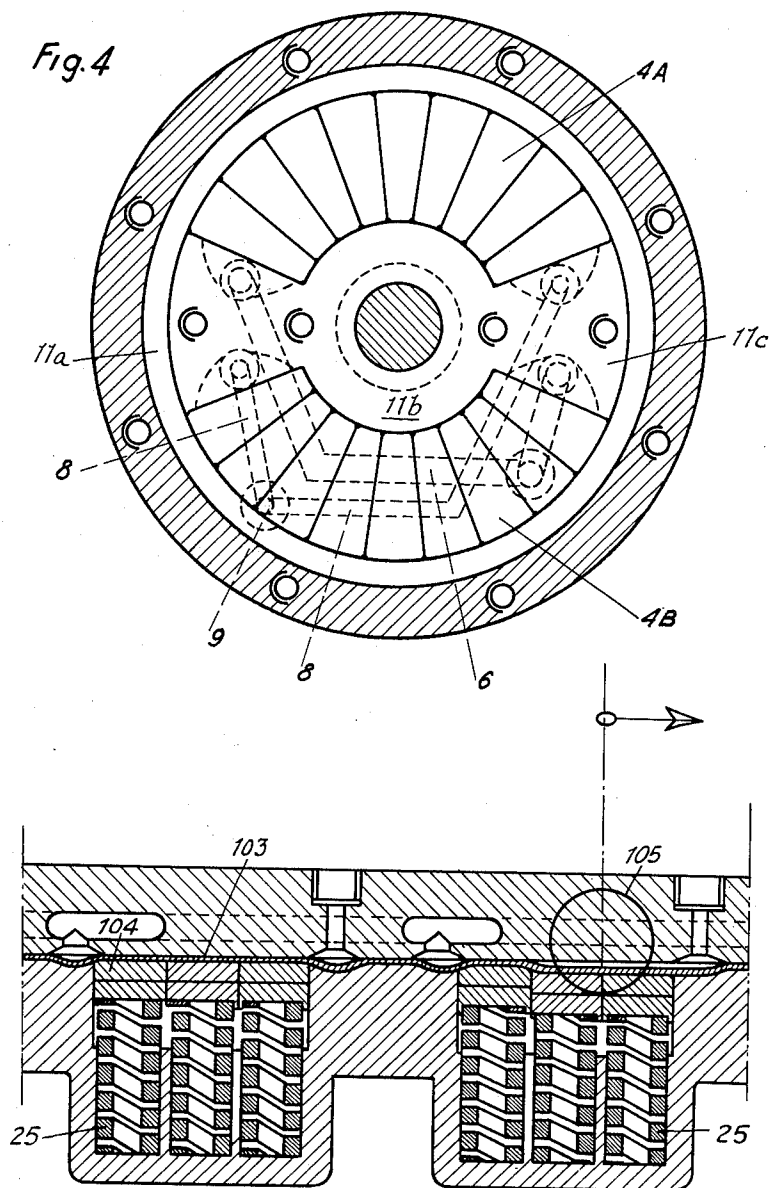
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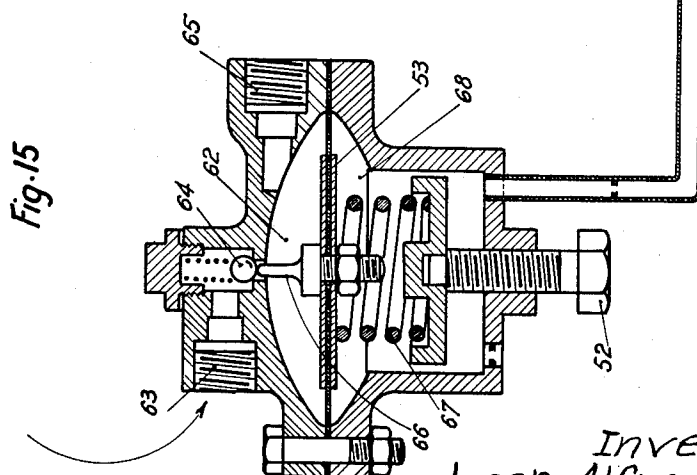
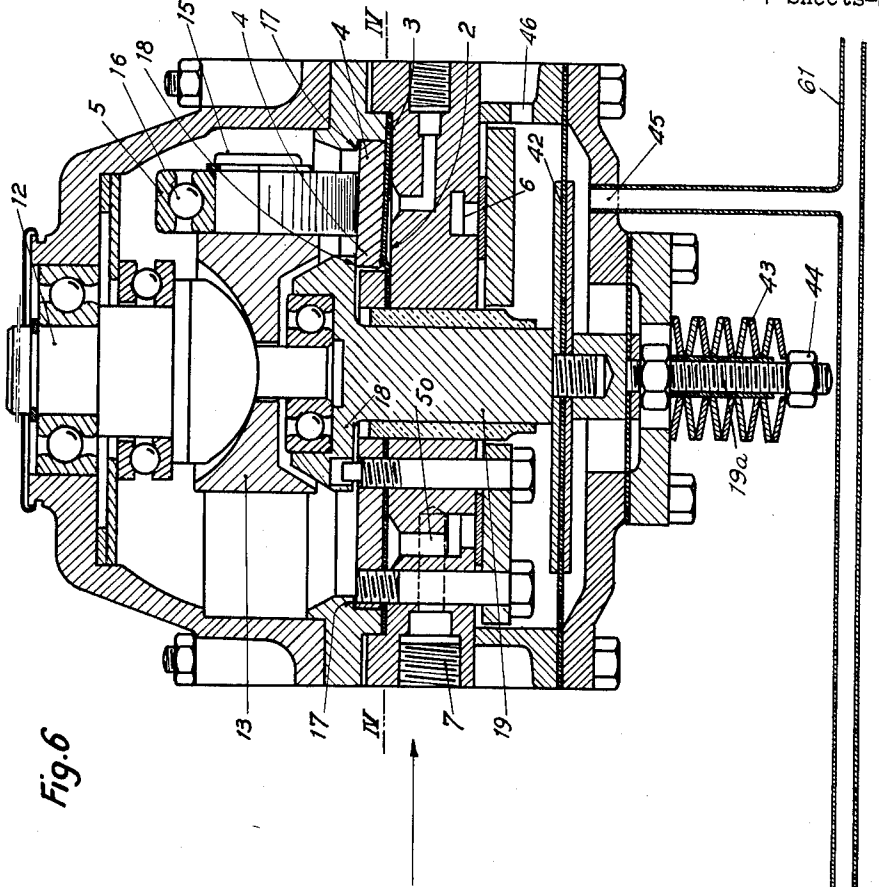
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Fig. 7

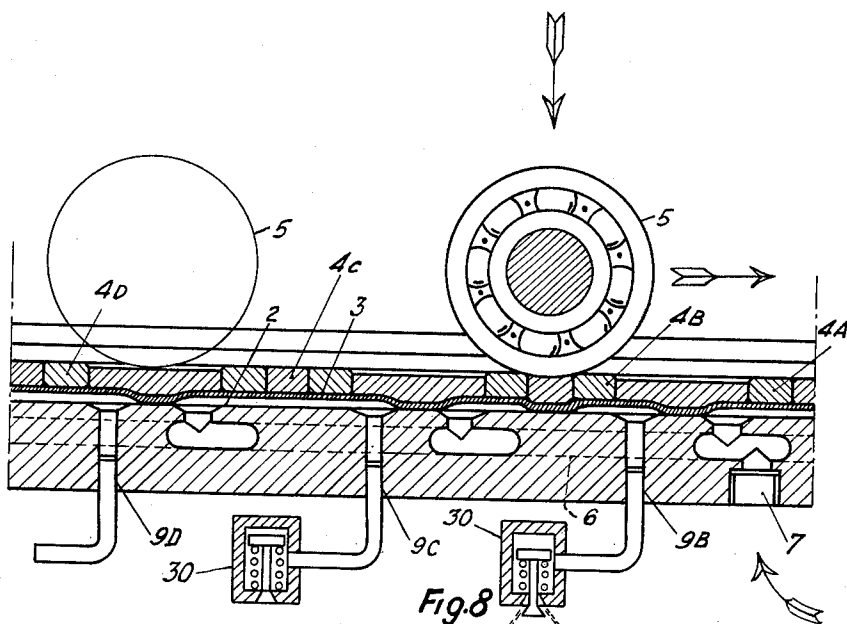
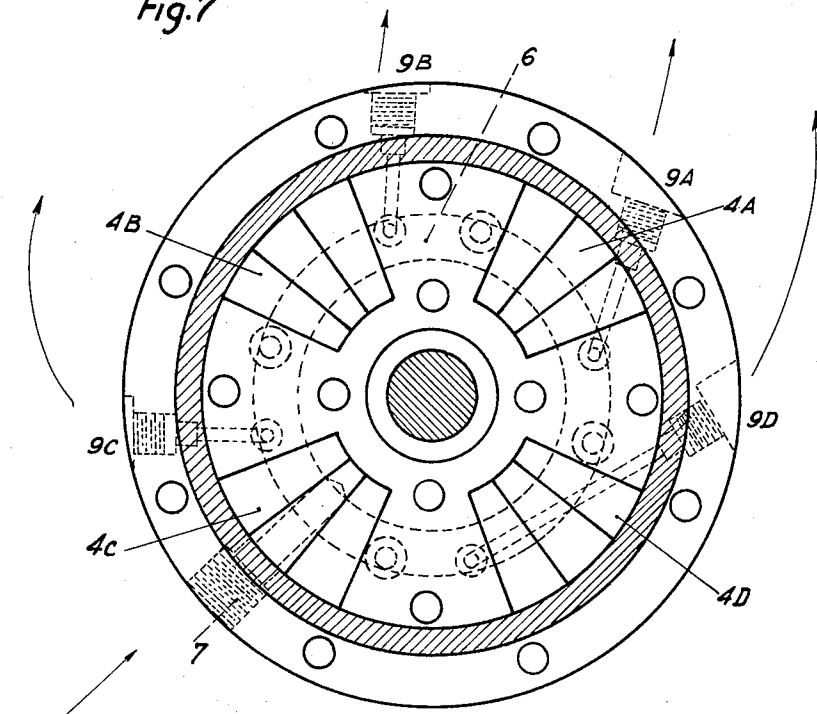


Fig. 8

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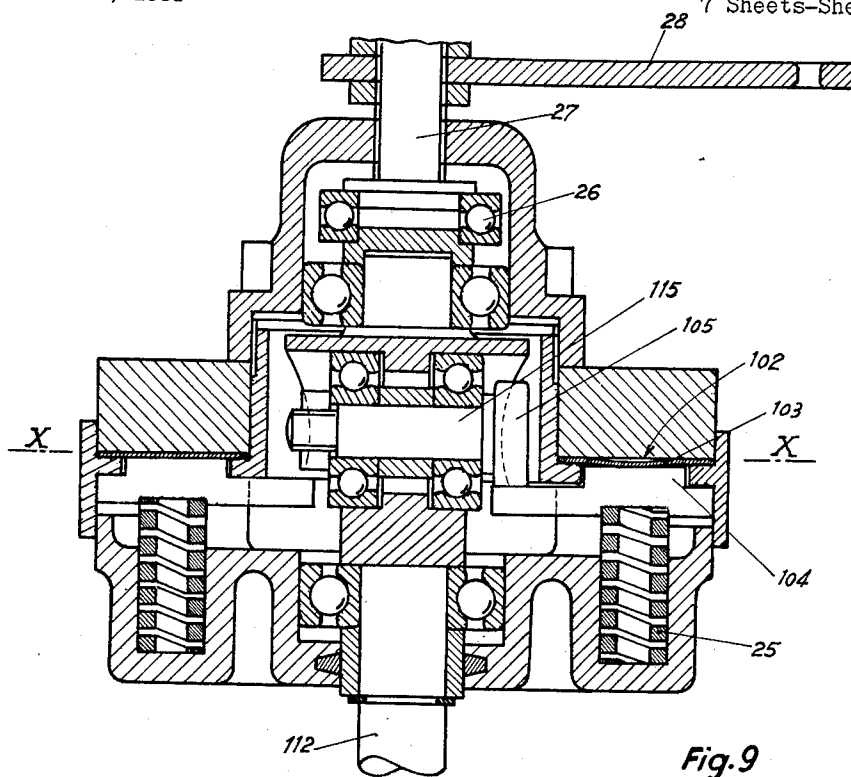


Fig. 9

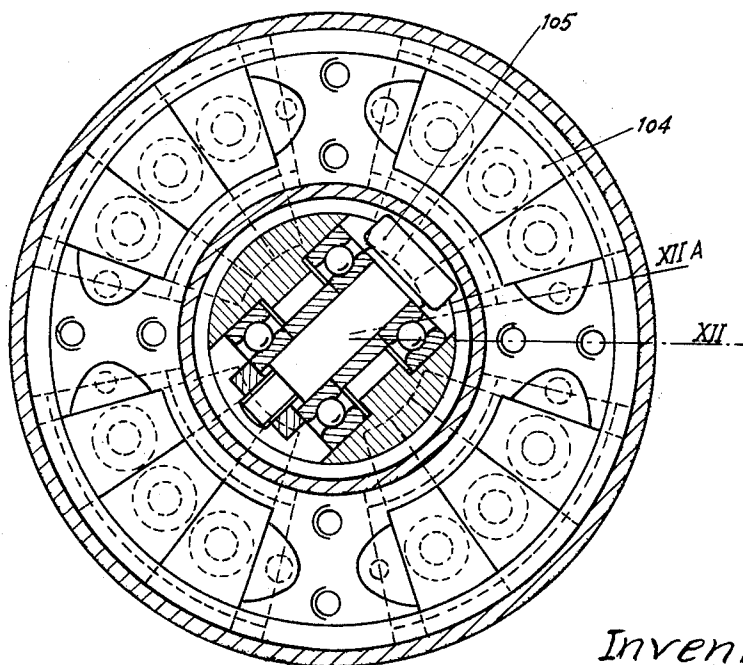


Fig. 10

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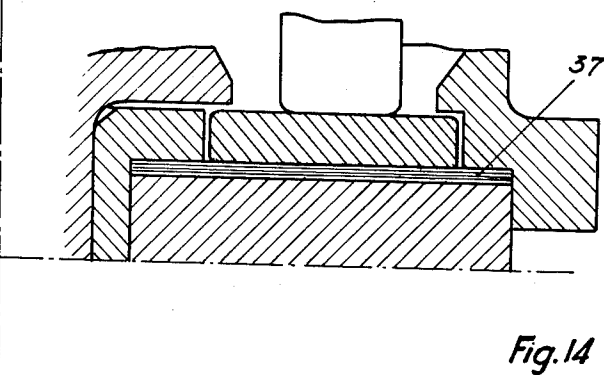
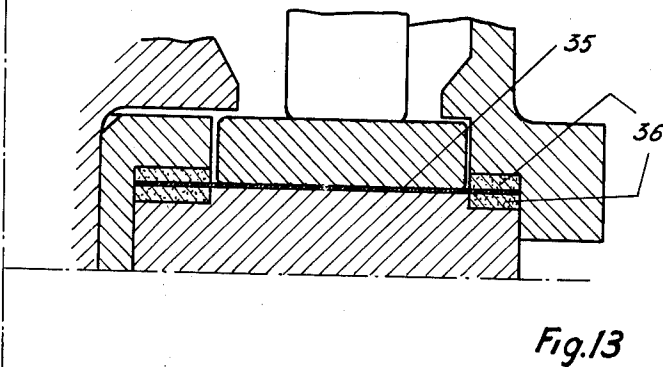
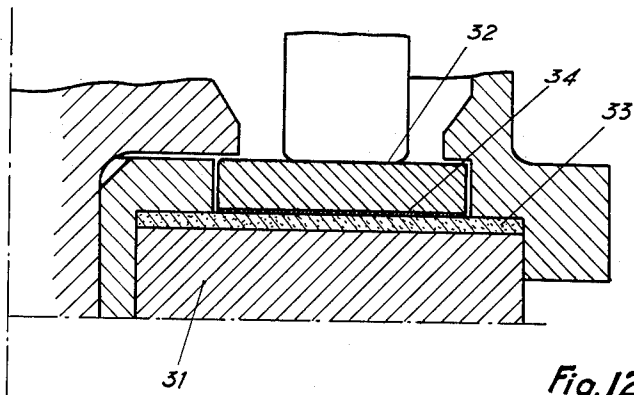
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Filed Jan. 5, 1951

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2,722,893

COLLAPSIBLE CHAMBER PUMP

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Application January 5, 1951, Serial No. 204,648

Claims priority, application France January 17, 1950

10 Claims. (Cl. 103—148)

It is known to use pumps whose principal member consists of a deformable elongated tubular enclosure and a device for locally tightening the tube so as to produce an obturation displaceable along the enclosure. The fluid to be pumped is sucked up upstream from the obturation and discharged downstream therefrom. Such pumps, which have considerable advantages of simplicity in construction, absence of valves, accurate operation (for they are exactly volumetric under certain conditions) and complete separation of the fluid to be pumped from lubricants, are frequently used mainly for medical purposes, such for example as blood transfusions, but they have not found extensive use industrially. On one hand, the rubber tubes used as the elongated tubular enclosure, deteriorate rapidly and hence are unsatisfactory to meet conditions of an industrial plant on account of the amplitude and the frequency of the required deformation. On the other hand, the means employed for producing the obturation of these tubes and displacing the region of obturation along the tube exert on the tubes not only transverse stresses but also longitudinal stresses that fatigue the tube rapidly.

The present invention remedies the above inconveniences. It consists essentially in employing, instead of a complete elastic tube, such as a rubber tube, an elongated enclosure of very flat section, of which one wall only is deformable with a very small amplitude of deformation, whereby considerably longer life for the tube and accuracy of operation are obtained. Moreover, the deformations of said wall are produced by adjacent elementary pushers which exert their action perpendicularly to the longitudinal axis of the elongated enclosure. These pushers, which do not form any seal, do not need to be made with the accuracy required, for example, in making pistons.

In order to obtain a compact construction and simplify the control of these pushers, it is expedient to arrange the elongated tubular enclosure circularly in a plane disposed at right angles to the pump drive shaft, which carries rollers or rolls adapted to act upon the pushers whose displacement, in principle substantially normal to the enclosure surface, is limited by an adjustable external abutment.

According to the present invention, it is preferable to substitute for the displacement of the pushers, normally the enclosure surface a tilting motion relative to a stationary abutment that maintains in place, with very little play, one side of the pusher, while a second abutment, which is an adjustably movable abutment, permits a limited movement of the other side of the pusher. Preferably, the adjustable abutment is an internal abutment the adjustment of which may be controlled during the pump operation by means of a controlling device concentric with the pump shaft.

In the present case, there are shown two forms of pump which have proven very efficient. One of these forms is a continuous flow pump with a varying feed and with a single discharge under high pressure. Such a

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pump is suitable for all uses where an accurate discharge is desired, to be varied at will during the pump operation, without relative displacement of metallic parts in the liquid handled and without the use of valves, for example, in the case when different reagents in chemical plants or injecting gasoline, water or antidetonating products into internal explosion engines are continuously handled.

The other of these forms is concerned with a discontinuous flow pump having a single feed and having a number of independent discharge ports, namely for injecting directly into the cylinders of an engine an exact quantity of liquid fuel.

There has further been provided a pump in which the flat tube that constitutes the principal member, is constantly maintained obturated by spring-loaded pushers whose successive rising, results in disengaging or liberating only the tube region subjected to the action of a determined pusher, the pump being herein called a reverse control pump.

In view of the fact that these pumps operate with a very small deformation of the membrane, there has been provided a membrane consisting of one or more very thin metal foils, preferably combined with a membrane of plastic material, for example the plastic material formed from polymerized fluorinated hydrocarbons.

Finally, various improvements according to the invention have been applied to pumps for feeding internal combustion engines, more particularly those operating on the "Beau-de-Rochas" cycle.

An intricate problem occurring in the operation of these engines is that of metering air-and-gasoline.

As a first approximation, it is necessary to send into the cylinders a weight of gasoline in proportion to the weight of air. The weight of gasoline will be almost proportionate to its volume. The weight of air will be proportionate to its volume, its absolute pressure and its temperature.

The speed of rotation of the engine is directly related to the volume.

The absolute pressure and the temperature are those prevailing between the throttle and the valves (pressure at the valves).

There are thus available three parameters to define the weight of air; it is therefore necessary to utilize them in order to measure the weight of gasoline to be supplied.

In the fuel injecting pump according to the invention the device for regulating the height of elevation of the pushers is made dependent on a member whose displacements are automatically determined by a pressure parameter, namely by the pressure at the valves of the engine to be fed, and preferably also by a temperature parameter.

Several forms of pumps designed according to the invention will now be described, by way of example, with reference to the accompanying, more or less schematic, drawings in which:

Fig. 1 is a transverse section of the tubular enclosure according to the present invention;

Fig. 2 is a longitudinal axial section of a continuous pump according to the present invention, showing on the left a pusher raised and on the right a pusher depressed;

Fig. 3 is a transverse section through the line III—III of Fig. 2;

Fig. 4 is a schematic plan view taken substantially along the line IV—IV of Fig. 2;

Fig. 5 is an evolution along the mean line of the pushers of the pump;

Fig. 6 is a longitudinal axial section of a discontinuous pump for injecting gasoline into the cylinders of an engine;

Fig. 7 is a schematic sectional plan view corresponding to Fig. 6;

Fig. 8 schematically shows an evolution along the mean line of the pushers of a pump that is the same as that of Fig. 6 except that there are several rollers;

Fig. 9 is a longitudinal axial section of a reversed control pump for fuel injection;

Fig. 10 is a transverse section through the line X—X of Fig. 9;

Fig. 11 shows an evolution of the kind shown in Figs. 5 and 8;

Figs. 12, 13, 14 schematically show various modified forms of membrane of the tubular enclosure; and

Fig. 15 shows, in axial section, a pressure governor that may be interposed between an ordinary gasoline supplying pump and the injection pump according to invention.

Similar numerals refer to similar parts throughout the several views.

Schematically (Figs. 1 and 5), the tubular enclosure 1 forming pump chamber, is defined, on one hand, by a plane metallic surface 2 which is polished or glazed and, on the other hand, by a thin membrane of deformable material 3. This membrane may be made for example of synthetic rubber unaffected by gasoline (if the liquid to be handled is gasoline). I may use also a plastic material, for example the plastic material formed from polymerized fluorinated hydrocarbons. The membrane 3 is clamped between the surface 2 and a frame having spaced lateral edge portions 11a and 11b (Fig. 2) parallel to the longitudinal axis of the frame and one or more transverse portions 11c (Fig 5). The term "parallel" is used in the sense of equidistant without being limited to straight lines. In the embodiment illustrated in Figs. 2 to 5, the tubular enclosure is annular so that its longitudinal axis is arcuate. The lateral edge portion 11a of the frame is formed by an annular shoulder of a casing 11 while the opposite lateral edge portion 11b is formed by a flange on a stationary sleeve 20. The lateral edge portions 11a and 11b of the frame define the lateral edges of the enclosure 1 while the ends of the enclosure are closed by the transverse portion or portions 11c. By providing a plurality of transverse portions 11c, the enclosure is divided into a number of separate chambers.

Along the length of the enclosure there are disposed a series of adjacent pushers 4 guided in a manner to exert only a force normal to the longitudinal axis of enclosure 1. The pushers 4 are acted upon by rollers 5 (Fig. 5) adapted to rotate on their axles and to have a motion of translation parallel to the longitudinal axis of enclosure 1, for example in the direction of the arrow F. It will be seen that the successive displacements of the pushers cause the successive obturation of the enclosure from the left to the right, with the result that, for each chamber of the enclosure 1, there occurs suction upstream from the obturation through the passages 6, 7 and a discharge downstream therefrom through the passages 8 and 9.

In order that the obturation may be maintained constant, it is evidently necessary that a pusher 4 acts before the next upstream pusher stops its action, that is to say that the roller 5 has a sufficient diameter. It is further necessary, when the roller 5 reaches the right end of the chamber, that the next roller has commenced the obturation, that is to say (Fig. 5) that the distance n between the inlet and outlet passages of a chamber must be less than or equal to the distance p between centers of successive rollers.

The seal constituted by the obturation may correspond to a number of depressed pushers above the unit. In order to determine the length of this seal it is evidently necessary to take into account two considerations: on one hand, to have an absolutely efficient seal, which would necessitate a seal as long as possible and, on the other hand, to obtain a discharge as great as possible, which would lead to a seal as short as possible.

The pump shown in Figs. 2 and 3 has a shaft 12 ro-

tating the disc 13 ball-mounted thereon. The disc 13 carries axle ends 15 located 120° apart from one another and on which there may rotate ball bearings 16 whose outside races perform the role of rollers 5 which bear on the pushers 4 acting upon the circular membrane 3 maintained by its two sides on the surface 2 of the machine framework, and which may be detached from the surface. The surface 2 and membrane together form the flat tubular enclosure constituting the essential member of the pump proper. Each pusher is retained, on one hand, by a stationary outer abutment rim 17 leaving a very small clearance to the pusher edge and, on the other hand, by an inner abutment rim 18 whose axial position may be modified. Indeed, this abutment rim 18 is rigid with a shaft end 19 centered in the stationary sleeve 20 and which carries threads cooperating with a nut 21. This shaft end is, on the other hand, rigid with a lever 22 and it is clear that the displacement of the lever 22 in one or the other sense lowers or raises the abutment 18. It is further clear that the pusher, which oscillates practically about its setting on the stationary abutment 17, may thus be given a tilting motion from zero (the membrane 3 applied completely against the glaze surface 2) to a maximum, thereby varying the volume under the membrane 3 and the discharge of the pump.

The ball-mounting of the disc 13 permits the latter to apply evenly against all the rollers 5.

In the case of a continuous pump (Figs. 4 and 5) there exist on each half-circumference two sets of pushers 4A, 4B (or two working chambers), to cooperate with the three rollers 5 spaced 120° apart from one another. The discharge ends of each set are interconnected, through passages 8, and connected to the outlet 9, the passages 8 being made in the pump body. The feed ends are connected, through the passages 6 of somewhat larger diameter, with the inlet 7.

The operation of the pump is readily understandable by referring in particular to Fig. 5 which illustrates the sequence of operation. The rollers 5 are supposed to move in the direction of the arrow F. It will be seen that there is always at least one roller which obturates a pusher of a working chamber. In the position shown, the right-hand roller is about to leave the pushers of the set 4B. The second roller has already obturated the passage so that no communication can take place between the discharge and the obturation. At this moment, the discharge of the chamber corresponding to the pushers 4B stops during a fraction of revolution, but the third roller (the left-hand one) causes full discharge of the chamber corresponding to the set of pushers 4A. The cyclic oscillations of the instantaneous discharge are thus very small.

The discharge will be still more regular if the number of working chambers and number of rollers are increased.

The speed of rotation of such a pump may be selected at will: no synchronization being necessary, and in all cases for which the use of the pumps is foreseen a series of speeds may be combined at best with the angle of lever 22 and the feed pressure, in order to obtain the desired results.

Figs. 6 and 7 show a pump for direct injection, for example, into the cylinders of an internal combustion engine, for example a four cylinder diesel engine. The number of working chambers here is therefore equal to the number of cylinders. Each of these working chambers has a set of pistons, such as 4A, 4B, 4C, 4D. It is further supposed that there exists only one roller 5 mounted on the disc 13. In this case the ball is discarded and the mounting of the disc 13 is rigid. All the admissions are interconnected, as previously, through passages 6 while the inlet is designated by reference 7. There are as many discharge ports 9A, 9B, 9C, 9D as there are chambers, their discharge ports not being interconnected. A reduced number, at least two, of pushers are sufficient in each set thereof. It is however preferable

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to employ three or four pushers (three in the case shown in Figs. 7, 8) in order to obtain a less abrupt rise of pressure and a more regular jet proceeding from the working chamber.

The various discharge ports are connected each to the injector of a cylinder.

It is very necessary that the speed of the pump (and hence the drive speed of the roller) be synchronized with that of the engine to be fed. In the case of a single roller this speed must be that of the camshaft. For two revolutions of the engine crank-shaft, that is to say for the time of the cycle, the roller attacks successively, as can be seen in Fig. 8, the sets of pushers 4A, 4B, 4C, 4D, the discharges of the corresponding chambers being connected to the cylinders in the desired order.

The time of injection is determined by the pump. In the case of Fig. 7 where the sides of the three pushers form with one another an angle of about 15° , the time of injection may be evaluated in the following way: when the roller 7 attacks the first pusher, nothing occurs but an obturation of the feed and a confinement, under the two next pushers, of the liquid to be injected. When the roller attacks the second pusher (the position in Fig. 8) and then the third one, the injection occurs, that is to say during about 15° angle that separates two successive edges of pushers or during 30° on the crank-shaft, which is a good time of injection for a diesel engine. This time may easily be varied by changing the number, and hence the angle, of the pushers.

The shifting of the pump shaft with respect to the crank-shaft determines the beginning of the injection in the cycle. This shifting may be modified in the course of running, if the piping is flexible enough, by rotating slightly the pump body.

When the injection is not for an engine of the diesel type but for a four-stroke explosion engine, it would be inadvisable to shorten the time of injection in order that the latter might occur only upon a rotation of the crank-shaft through 30° , since the injection may thus be operated during a good portion of the suction stroke. On the other hand, as these engines have high speeds, it is not expedient to subject the pump to useless stresses. It is therefore of advantage to employ several rollers, as indicated schematically in Fig. 8. If there are three in number (as in the case of Figs. 2 and 3), the speed to be imparted to the pump will be equal to the third of the speed of the camshaft, that is, to the sixth of the speed of the crank-shaft. The time of injection, multiplied by three, then becomes in the order of 90° that will be placed at best into the angle of 180° representing the suction time.

It will be seen that, while a roller presses down the pushers of a working chamber, all the pushers of the other chambers are raised and consequently both the feed and the discharge are in communication. All the non-working circuits are therefore under the feed pressure up to the injectors. This does not present any inconvenience, for the usual injectors 30 (Fig. 8) are maintained closed, or opened and protected by a check-valve. In contrast, it is an important advantage, especially for the injection of gasoline, that the chambers be well filled up, which permits the maintenance with greater facility of the volumetricity of the pump for carrying out air-and-gasoline metering.

It is sometimes preferred that the non-working circuits should be normally obturated by the pump. This can be attained by means of the pump shown in Figs. 9 to 11, where the membrane is normally applied against the support surface, this pump herein being called a reversed control pump. As shown in these drawings, the parts corresponding to those of Figs. 2 and 4 are designated by the same numerals with addition of a hundred. It will thus be seen that the membrane 103 is normally applied against the surface 102 by the pushers 104 subjected each to the action of a strong spring 25. The

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pushers are released successively by the roller 105 mounted on the shaft 115, the whole assembly being rotated by the shaft 112. The height of the release of the pusher-pistons may be regulated in the course of running by means of the thrust ball bearing 26, screw-threaded part 27 cooperating with the pump body and lever 28 permitting of rotating this screw-threaded part. It is clear that the spring 25 raises the pusher 104 immediately after the roller 105 passes.

The chambers fill up during only a very short interval prior to the discharge. It is therefore to be expected that this filling, for a given feed pressure and for a given shifting of the lever 28, should decrease with the speed of the pump and that, consequently, the characteristic of the discharge in function of revolutions is not a straight line but is a convex curve that becomes inflected when the speed increases. This is, however, without importance since no metering is to be effected; it will be sufficient to increase a little the elevation of the pushers, by acting upon the lever 28 for example with the aid of an accelerator attached to this lever. In this way there will even be obtained an advantage in that the engine will not speed up untimely, the pump being, in effect, auto-regulating.

In Figs. 12 to 14 there are shown some modified forms of membrane.

It will be seen in Fig. 12 that between the surface 31 and the pusher 32 there is interposed, as described above, a plastic non-metallic membrane 33, and that between this membrane 33 and the pusher there is interposed a metal disc 34 sufficiently flexible to follow the deformations of the membrane 33, and sufficiently strong to protect the membrane from the edges of pushers 32 during the operations.

In Fig. 13 the plastic membrane is removed and replaced by an all-metal membrane 35 jammed between two plastic washers 36 to form a thoroughly tight outward joint, in such a way as to allow the membrane to move upwards a few tenths of a millimeter required for its operation. This upward displacement necessitates, in fact, a slight pull on the outer and inner joints. These lateral joints, however, may be avoided by replacing the membrane, constituted by a thin metallic foil of Figs. 12 and 13, by an assembly of thin metallic foils 37 (Fig. 14).

Referring now to Figs. 6 and 15, it will be seen how, in the case of an explosion engine operating on "Beau-de-Rochas" cycle, it is possible automatically to take in account the pressure of the intake manifold, and also the temperature, in a manner to ensure a correct air-and-gasoline ratio.

A membrane piston 42 is mounted on the shaft 19 and a nut 44 is screwed onto a threaded extension 19a of the shaft and applied against one end of a set of Belleville washers 43 acting as a spring the other end of which bears against the pump body.

The membrane 42 receives, on its lower side, the absolute intake manifold pressure through the port 45 and, on its upper side, atmospheric pressure through the port 46. By changing the number of Belleville washers it is possible to modify the flexibility of the spring. By tightening or loosening the nut 44 the initial tension is changed.

If it is assumed that the intake manifold pressure prevailing in piping 61 is equal to the atmospheric pressure (this is the case of full load of the engine), the membrane 42 subjected to the same pressure on both sides does not come into action; the equilibrium establishes itself between the load of pushers 4 (depending only upon the injection pressure selected so as to be constant) and the compression load of spring 43. A height of elevation of the pushers is then well defined.

If the gas throttle is closed, the intake manifold pressure decreases and the membrane 42, under the influence of the atmospheric pressure which becomes preponderant, transmits to the system in equilibrium a downward stress that breaks the previous equilibrium. The downward

displacement thus produced releases the spring 43, its contraction decreases and the system becomes stabilized to a new position of equilibrium such that the height of elevation of the pushers is lesser than previously. The discharge of gasoline has diminished as a function of the pressure parameter.

The change in the number of washers of the spring 43 permits of adjusting the variation in the discharge in exact function of the variation of the pressure parameter, this being obtained by adjustment in the workshop.

The tightening of the nut 44, which also modifies the equilibrium, may be effected on the engine in operation. This nut may be actuated by hand or by means of a thermostat adapted to introduce a correction of temperature or else concurrently with a possible manual correction. This manual correction may be justified for example by a desire to increase the feed at starting.

For aircraft (or automobile in mountains) it is possible automatically to make the system responsive to altitude by substituting, at 46, a vacuum for the atmospheric pressure, either by vacuum pump or by means of a vacuum capsule.

Gasoline flows in through a port 7 and flows along an annular passage 50. The discharge passages 9A, 9B, 9C, 9D (see also Fig. 7) have their outlet ends disposed on the external cylindric surface of the pump and oriented so that the discharge pipes may rapidly take parallel directions.

It is of advantage to feed the pump according to the invention at a regular and controlled pressure since it is clear that the admission pressure influences the filling of the cylinders and that the variation in admission pressure provides additional means for acting upon the discharge. This is why a pressure governor (Fig. 15) is interposed between the usual feed pump (which is for example a membrane auto-regulating pump that supplies the fuel at a pressure in the order of 1 kg./cm.²) and the pump according to the invention.

This governor is of a well known type having a membrane 53 by which it is separated into two chambers. Into the upper chamber 62 gasoline flows in through a fitting 63, passes through a ball-valve 64 and flows out through a fitting 65 to pass into a fitting 7 of the pump according to the invention. The membrane carries a needle-valve 66 which raises the ball and permits gasoline to flow into the chamber 62. A screw 52 is adapted to act, through the intermediary of a spring 67, upon the membrane and, consequently, to define the pressure selected for the admission of gasoline into the pump according to the invention. This device has also the advantage of damping pulsations of the feed pump.

According to the invention, while the gasoline feed pressure prevails in the upper chamber 62, the lower chamber 68 is connected, for example through pipes such as 61, to all or a portion of the pressure at the distributing valves, whereby it is possible to vary the supply of gasoline as function of this pressure.

It will be understood that the pump described for a four-cylinder engine may easily be modified and adapted for an engine having any number of cylinders.

The injectors hereinabove referred to are shown schematically in Fig. 8. The arrangements provided according to the invention may have applications to all installations, it being immaterial whether the injectors be placed in a combustion chamber itself or ahead of the admission valve. It is preferable to employ closed rather than open injectors, in order to render the injection pressure independent from the discharge, but this is not absolutely necessary.

What is claimed is:

1. A pump of the character described comprising a support having a plane surface, a plane elastic element adapted to rest upon said surface when no pressure is exerted between said elastic element and said support, a frame having a longitudinal axis, spaced lateral edge

portions parallel to said longitudinal axis and portions substantially transverse with respect to said longitudinal axis, said lateral edge portions and transverse portions tightly pressing said elastic element against said surface so as to define between said surface and an intermediate portion of said element a tubular enclosure having spaced lateral edges bounded by said lateral edge portions of the frame and closed ends bounded by said transverse portions, admission and discharge ducts extending through said support and opening into opposite end portions of said enclosure, the admission of fluid under pressure through said admission duct separating said intermediate portion of the elastic element from said surface, a plurality of adjacent pushers mounted on said frame tiltably about an axis parallel to the lateral edges of said enclosure and adapted to press said elastic element inwardly against said surface, and actuating means movable parallel to the lateral edges of the enclosure and successively acting on the pushers to cause the successive tilting of said pushers.

2. A pump according to claim 1 in which the actuating means are rolling means acting on the pushers.

3. A pump according to claim 2 comprising a plurality of said tubular enclosures the admission ducts of which are united together to form a common admission and the discharge ducts of which are also united together to form a common discharge.

4. A pump according to claim 2 comprising a plurality of said tubular enclosures the admission ducts of which are united together and the discharge ducts of which are separately connected to the points of utilization.

5. A pump according to claim 1 in which the actuating means comprises two successive means acting on the pushers, the distance between said successive means being smaller than the distance between the ends of the tubular enclosure.

6. A pump according to claim 1 in which the actuating means comprises two successive means acting on the pushers, the distance between said successive actuating means being greater than the distance between the ends of the tubular enclosure, said pump working against a predetermined pressure which is at least equal to the admission pressure.

7. A pump according to claim 1 comprising a rotating shaft and in which the longitudinal axis of the said frame is curved according to an arc concentric to the axis of said rotating shaft and in which the means acting on the pushers is carried by said shaft.

8. A pump of the character described comprising a support having a plane surface, a plane elastic element adapted to rest on said surface when no pressure is exerted between said elastic element and said support, a frame having a longitudinal axis, lateral edge portions parallel to said longitudinal axis and portions substantially transverse with respect to said longitudinal axis, said lateral edge portions and transverse portions tightly pressing said elastic element against said surface so as to define, between said surface and an intermediate portion of said element, a tubular enclosure having spaced lateral edges bounded by said lateral edge portions of the frame and closed ends bounded by said transverse portions, admission and discharge ducts extending through said support and opening into opposite end portions of said enclosure, the admission of fluid under pressure through said admission duct separating said intermediate portion of the elastic element from said surface, a plurality of adjacent pushers mounted on said frame tiltably about an axis on one side of said enclosure and parallel to the lateral edges of said enclosure, said pushers extending transversely across said enclosure and being tiltable about said tilt axis to press said elastic element inwardly against said surface, means mounted on said frame on the opposite side of said enclosure from said tilt axis and adjustably limiting the tilt of said

pushers, and actuating means movable parallel to the longitudinal axis of the frame and successively acting on the pushers to cause the successive tilting of said pushers.

9. An intermittent discharge pump comprising a housing, a pump shaft rotatively mounted in said housing, a stationary support fixed to said housing and having a plane surface perpendicular to the axis of said shaft, a membrane resting on said surface, a frame having radially spaced inner and outer arcuate portions concentric with said shaft and circumferentially spaced radial portions, said arcuate and radial portions tightly pressing said membrane against said surface so as to define between said surface and intermediate portions of said membrane bounded by said frame a plurality of circumferentially extending tubular enclosures having closed ends, admission and discharge ducts extending through said support and opening into opposite end portions of each of said enclosures, the admission ducts of said enclosures being connected to a common inlet passage, a plurality of sets of adjacent pushers mounted on said frame between said radial portions, said pushers extending radially across said enclosures and being tiltably supported at one end by said frame, said pushers being tiltable to press said membrane against said surface, a common non-rotating circular abutment mounted in the housing concentrically with said shaft, said abutment being movable axially and being engageable with said pushers to limit variably the tilting movement of said pushers

and actuating means carried by said shaft for successively tilting said pushers as said shaft is rotated.

10. A pump according to claim 9 further comprising an enclosure provided in said housing, a diaphragm dividing said enclosure into two chambers, fluid connections respectively from said chambers to two points of different pressure, connections between said diaphragm and said abutment limiting the tilting of the pushers and means biasing said abutment and diaphragm toward a selected position, whereby said abutment is movable against said bias by differences of pressure in said chambers, thereby controlling the amount of tilting of said pushers.

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