July 31, 1923. 1,463,646

C. CHILOWSKY

APPARATUS FOR PERFORMING CYCLES OF COMPRESSION, EXPANSION, COMBUSTION, SUCTION, EXHAUST, AND THE LIKE

Filed March 6, 1923 4 Sheets-Sheet 1

FIG. 1

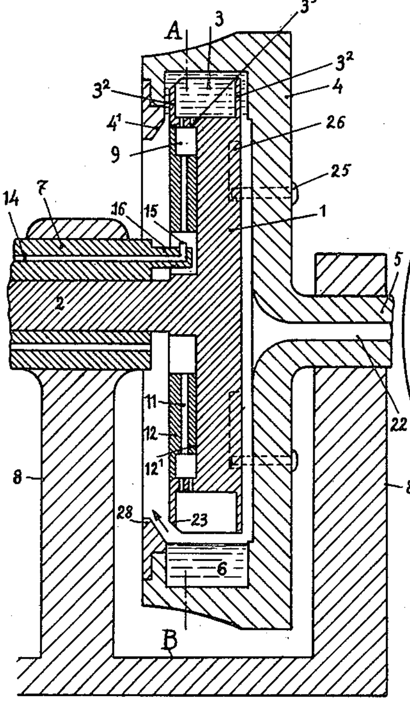


FIG. 2

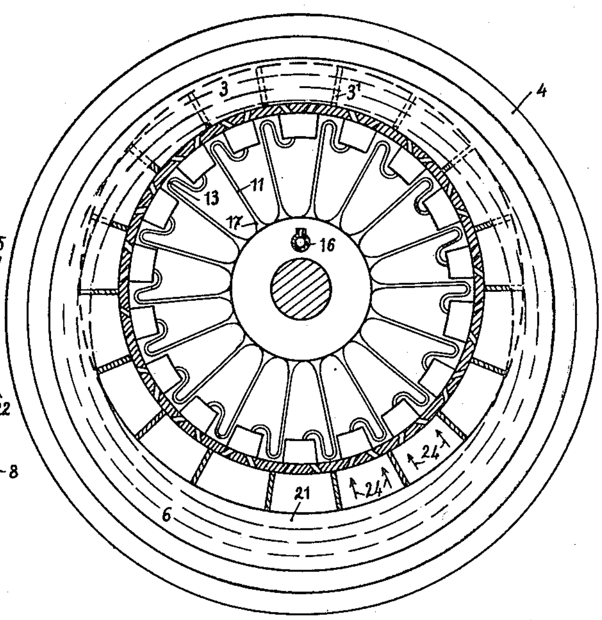


FIG. 3

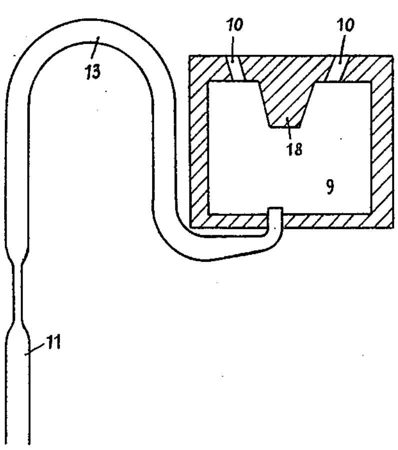
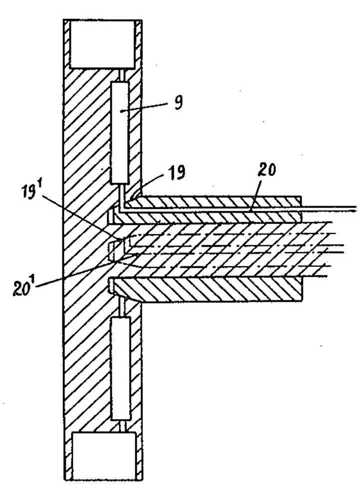


FIG. 4



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Filed March 6, 1923 4 Sheets-Sheet 2

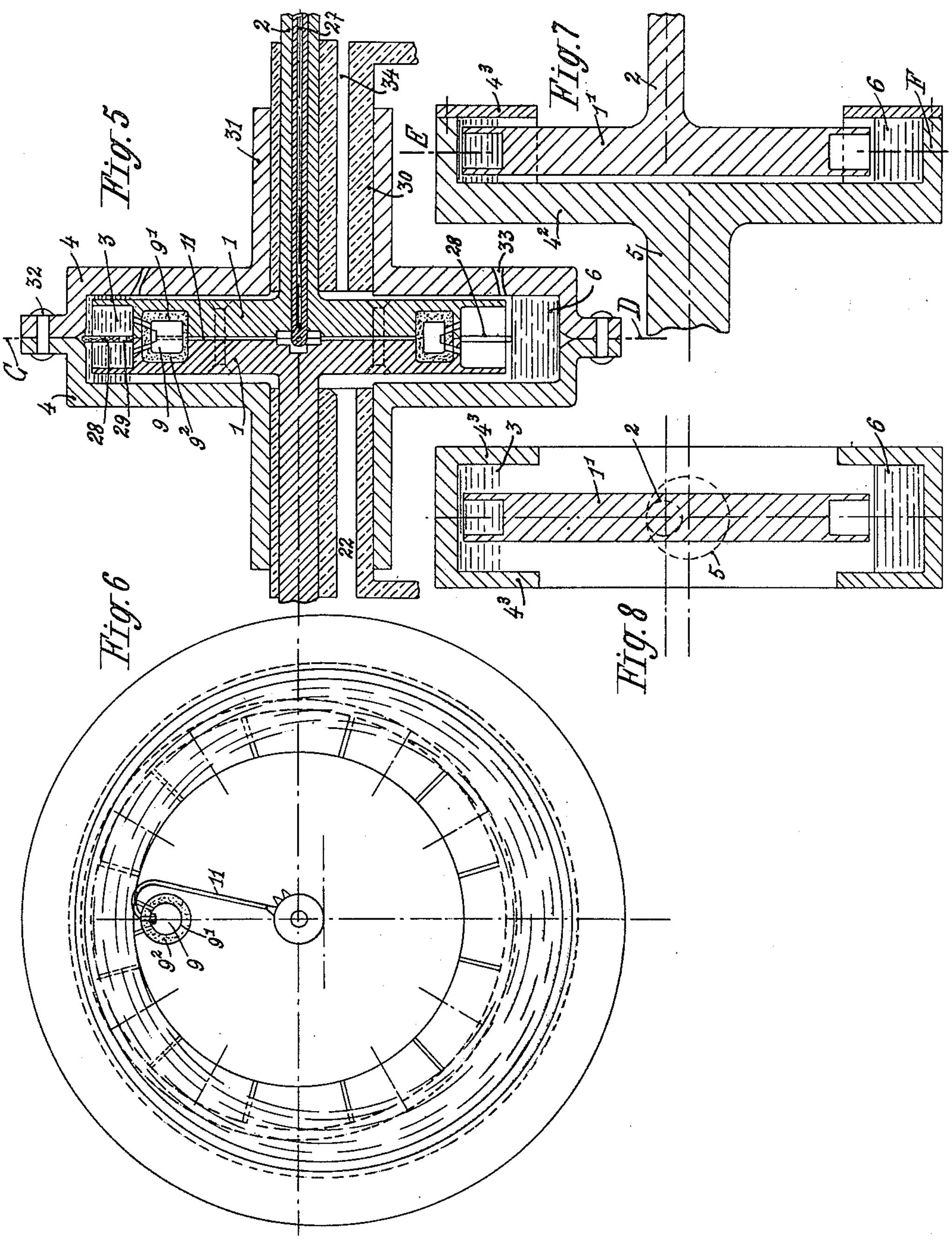

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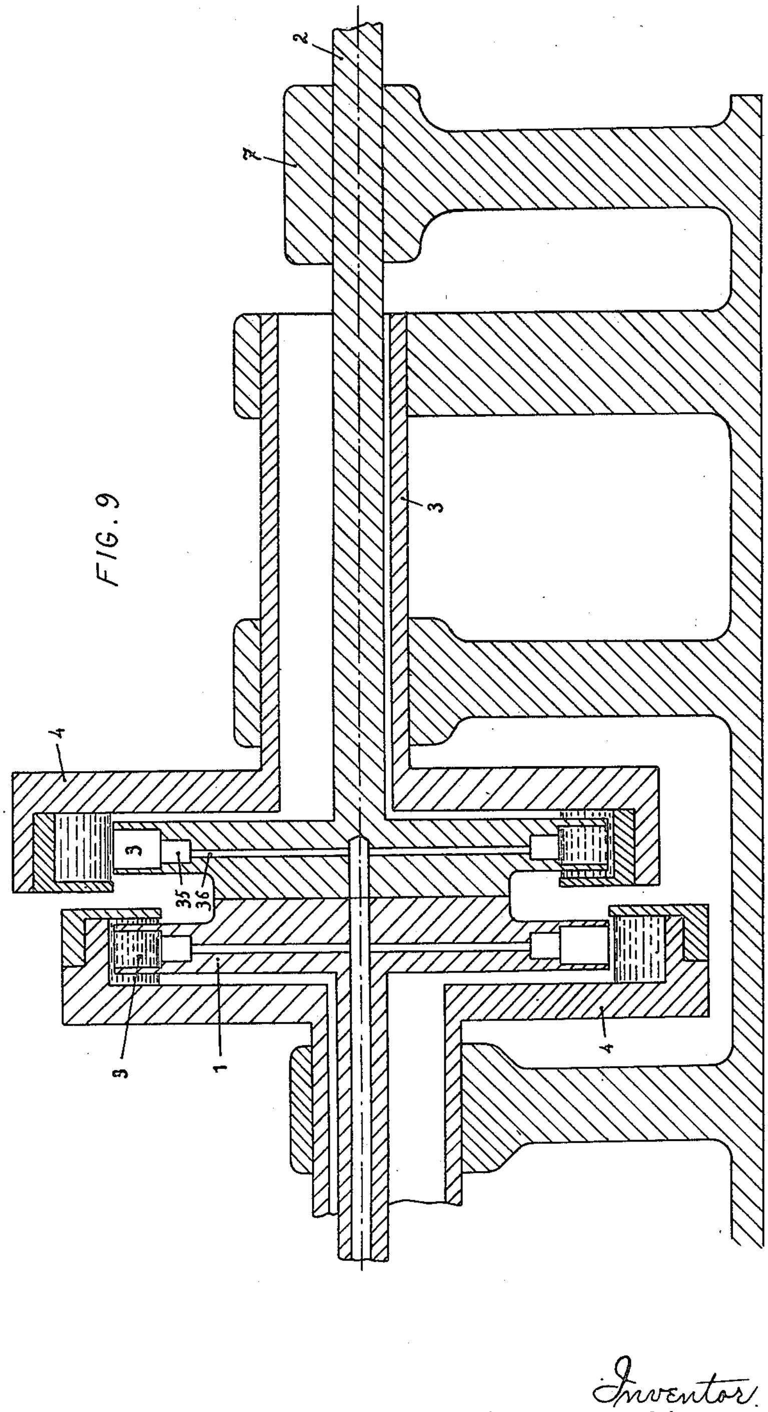
FIG. 9



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APPARATUS FOR PERFORMING CYCLES OF COMPRESSION, EXPANSION, COMBUSTION, SUCTION, EXHAUST, AND THE LIKE

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FIG. 11

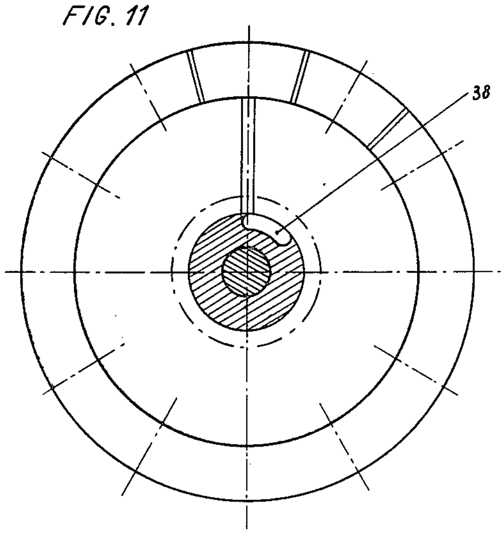


FIG. 10

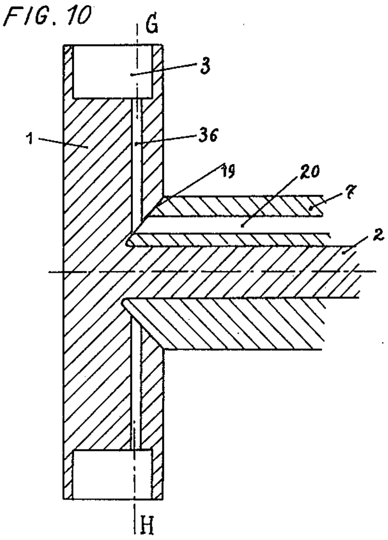
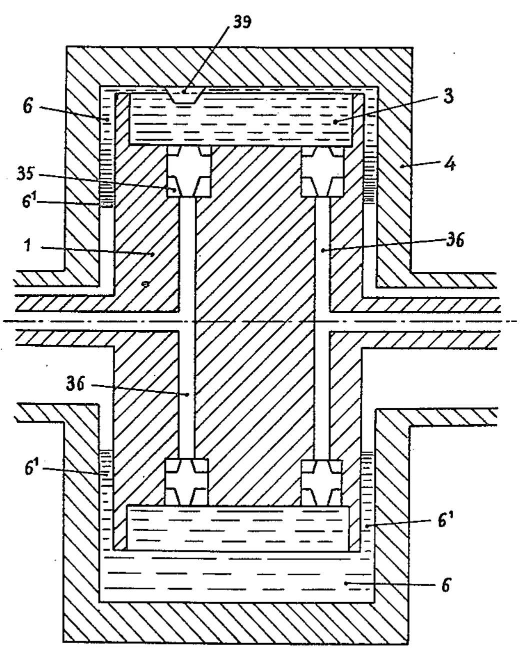
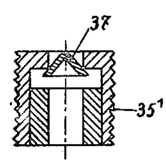
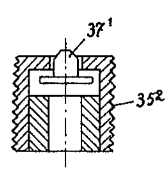
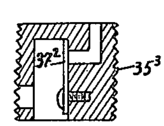


FIG. 12









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By Henry Orth, Jr. Atty.

Patented July 31, 1923. 1,463,646

UNITED STATES PATENT OFFICE.

CONSTANTIN CHILOWSKY, OF PARIS, FRANCE.

APPARATUS FOR PERFORMING CYCLES OF COMPRESSION, EXPANSION, COMBUSTION, SUCTION, EXHAUST, AND THE LIKE.

Application filed March 6, 1923. Serial No. 623,275.

To all whom it may concern:

Be it known that I, Constantin Chilowsky, a citizen of Russia, and a resident of Paris, France, have invented certain new and useful Improvements in Apparatus for Performing Cycles of Compression, Expansion, Combustion, Suction, Exhaust, and the like; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

All machines provided with a piston such as air compressors, internal combustion and explosion engines, steam engines, pumps, and the like, have their life, their speed and their output restricted by the friction of the piston in cylinder, the wear of walls, the effects of the inertia of masses in reciprocating movement and, also by an often delicate construction; the rotary engines with blades or paddles have the same disadvantages (although to a less extent).

On the other hand, the different systems of turbines, steam turbines, centrifugal turbo-compressors, gas-turbines, and the like, are free from these disadvantages but have others among which are too great speeds of rotation (which are however often insufficient for a good output) blades exposed to too high temperatures, small compression and necessity of compressing and expanding in several stages, and the like. These disadvantages become considerable in the case of a gas-turbine.

The present invention has for its object to avoid these disadvantages by means of an apparatus which constitutes a new kind of machine in which is effected the different cycles as: compression of a gas or of a liquid, expansion of a compressed and incandescent gas, suction, exhaust, and the like with the same efficiency as the usual piston and cylinder but without the inconveniences and restrictions inherent to the latter.

This apparatus can also constitute a turbo-motor or a motor-turbine having great speed of rotation and capable of performing the cycles and the rates of compression of the Diesel, half-Diesel and explosion engines.

This invention consists in an apparatus which permits the substitution for the usual solid piston of a liquid piston.

To this purpose an annular layer of a liquid has imparted thereto a very rapid rotary motion in and with a circular cavity opening inwardly, provided in the wall of a rotor having a high speed of rotation. Under the action of a considerable centrifugal power, this liquid layer assumes the form of a liquid ring which is pressed with a great force against the inner wall of said cavity. At same time this liquid ring under centrifugal action comes to a state in which it is difficult (or even almost impossible) to distort it and which is also elastic, that is to say that it opposes a considerable power (similar to hydrostatic power) to every body or volume which one would try to immerse or dip into its mass. On the other hand the ring may be considered in a perfect state of elasticity due to the fact that the work required to immerse a body into its mass is entirely recovered when this body emerges from the liquid. According to these properties, the liquid of the ring becomes capable of acting as a liquid piston in the wall of the cavity, chamber, or box, which is immersed into its mass at its opened side; the gas contained in such a cavity will be compressed, and a liquid may be forced under pressure.

In order to practically obtain this result there is introduced inside the rotor (called external rotor) another rotor (called internal rotor) of smaller size, provided on its periphery with a crown of cavities or chambers opening outwardly and arranged in such a way that the edges of these chambers dip into the surrounding liquid ring for instance for half their depth.

The two rotors and the liquid ring inclosed between them are set into a rapid rotary motion at about the same angular speed and in the same direction, and the shafts or axes of the two rotors are excentric with reference to one another. By virtue of the excentricity, the chambers of the internal rotor dip and emerge periodically at every revolution, into and out of, the liquid of the ring, thus creating in these chambers a periodical and very rapid to and fro motion of the ring which effects in a perfect manner, without leakage and almost without friction, the operations of compression, expansion, and the like, and this by virtue of the comparative rigidity of the ring level which is maintained everywhere at the same thickness by the centrifugal force.

In order to obtain sufficient centrifugal force and to have rings which cannot be easily distorted and capable of effecting within the chambers compressions as high as several tens of thousands of atmospheres without causing the level of the ring to yield in an exaggerated and troublesome manner under such a pressure, it is necessary for example: to make use of tangential speeds varying between 150 and 200 meters per second with liquids the density of which is near 2.

We shall mention by way of example that a liquid ring formed of a concentrated solution of 72 gr. of chloride of zinc in 100 gr. of water, the density of which is 1,95, having 10 centimeters of diameter, 1 centimeter of thickness and having a tangential speed of 200 meters per second, would only have about 2,5 millimeters of its thickness under a gas pressure of 40 atmospheres in the compression chamber.

The ring would therefore already be capable of acting as a piston performing the cycle of compression, combustion, expansion of the Diesel, and half-Diesel motors, also we would still be far from the limit-tangential speed allowable in modern constructions; the speeding up of the ring liquid in the above mentioned case reaches about 80.000 times that of the gravity.

Different liquids can be used in starting from the water: hydrocarbons, oils, and the like, liquids having a density of 2 to 3 such as saturated aqueous solutions of chloride of zinc (72 gr. per 100 gr. of water) of chloride of tin (67 gr. per 100 gr. of water), tetra-chloride of tin (100 gr. per 100 gr. of water, density 2,23), solutions of mercury salts and up to the metals and alloys which are fusible and molten such as: mercury, alloys of lipowet (4 parts of tin — 8 of lead — 15 of bismuth — 3 of cadmium) maintained at a temperature of more than 60°, and others known alloys having a low melting point.

The liquid ring can also be composed of two different liquids which are maintained separated by the centrifugal force, for example a ring of mercury or fusible alloy, and a ring of oil and water, this latter ring protecting against any oxydation, the surface of the ring made of liquid metal.

Of course a ring of mercury for example would require only a tangential speed of about 75 meters per second, in order to afford the same resistance as a ring made of a solution of chloride of zinc. On the other hand, a mercury ring maintained at a tangential speed of 200 meters per second, would compress the gases to pressures which would be about 6.8 times greater, that is to say at about 270 kg.

These figures show the whole range for the degrees of compression which can be obtained according to above indicated process, either in motors or in — compressors, steam motor-turbines, and the like.

As above indicated, the work involved in dipping into the liquid ring, the metal walls (which are supposed to be sufficiently thin) of the crown of chambers is recovered during their emergence. In the same manner, the work involved for producing small variations of speeds of the different parts of the ring is also largely recovered, the corresponding forces being symmetrically arranged and in a reverse direction.

The invention which has just been described allows the construction of different machines which all run at high speeds, performing considerable compressions and having consequently a high output. These different machines are obtained in combining with the two above described rotors suitable devices which are generally known.

For the motors or turbo-motors: fuel supplying device, eventually sparking, exhausting, scavenging, and the like, devices; for the compressors and steam turbo-motors: valves, and admission, exhaust, and the like devices: for the forcing pumps: the use of liquid rings which are denser than the liquid to be forced is required.

The ways in which this invention can be carried out can of course vary, according to circumstances and the purpose to be obtained. We give (Figs. 1 to 12), by way of example only a few forms for carrying out the invention with different modifications which show the features of the process and the operation of the apparatuses.

Figs. 1 to 12, show schematically, by way of example, a few types according to the invention.

Figs. 1 and 2 show transverse and axial sections of an internal combustion, two stroke turbo-motor or motor-turbine, in which the fuel is sprayed into the combustion chambers.

Fig. 3 shows a fuel spraying device.

Fig. 4 shows a modified form of the fuel spraying device.

Figs. 5 and 6, show in transverse and axial sections, a modified form of turbo-motor.

Figs. 7 and 8 show a modified form of construction with the use of turnstiles.

Fig. 9, shows the process as applied to a compressor.

Figs. 10 and 11 show a steam admission device to a steam turbo-motor.

Fig. 12 is a section of forcing pump.

In Fig. 1: I is a metallic discoidal rotor (internal rotor) with its shaft 2;

3, a crown of chambers or cavities connected with the rotor;

3^2 side walls of the chambers parallel with the plane of the disc;

3^3, walls of the chambers at right angles with the plane of the disc, every chamber having in the example as described, four walls 3′, 3′, 3^2, 3^2 and a bottom 3^3 constituted by the periphery itself of the disc I, each chamber being open on the external side opposite to the shaft; through this side the liquid can enter to the chamber.

The ring 4′ connected to the external rotor 4, being removed, the part I can be introduced inside the body 4 constituting the external rotor.

The periphery of the body 4, with the adjoined ring 4′, constitutes the walls of a circular cavity, forming a crown opening towards the middle of the body I. This cavity is filled with a suitable quantity of liquid which under the action of centrifugal force assumes the form of a liquid ring 6, the section of which is almost rectangular in the arrangement shown, but which can be of any section.

Also, in the arrangement shown in the drawings, the chambers or cavities have substantially the form of an inverted frustum of a pyramid with a quadrangular base, but they can also have any other geometrical shape such as: a cylindrical frustum, half-spherical, and the like, shapes.

5 is the axis or shaft of the discoidal body 4.

7 is the bearing supporting the shaft 2.

8 is a frame supporting the axis 5 and the bearing 7.

The chambers 3 are preferably connected through a series of holes 10 with small chambers 9 which constitutes the extension thereof.

In these small chambers takes place the combustion or explosion of the fuel with compressed air, which is forced therein by the liquid when the latter enters the chamber 3. These small chambers 9 are connected with the discoidal body I and can be either cut, screwed, or formed therein or connected thereto as is the case in Fig. 1.

A suitable fuel for example: heavy oil, paraffin, or petrol is sprayed into the chambers 9. Different processes and devices can be used for this spraying, but it has been especially provided for that this spraying is effected under the action of the centrifugal power of the system itself.

A spraying device is shown in Fig. 1 in which a thin tube 11 is radially embedded into the mass of the body I.

In Fig. 1, this tube is embedded between two discs 12 and 12′ which are on their turn imbedded into the mass of the body 1. The chamber 9 is itself formed by a cavity partly in the body 1, and partly in the discs 12 and 12′.

The tube 11 joins the chamber 9 only after having described a bend 13 Figs. 2 and 3 which is a sort of inverted U. The fuel delivered by a dosing device or a delivery pump (preferably a continuous and adjustable one) passes through the channel 14 provided in the bearing 7 and comes out in the form of a jet through the opening 15 of a projection 16 of the bearing 7.

The channel of the tube 11 is widened, in its part which is nearer the axis 2, into a sort of conical cavity 17 Fig. 2; and it is into the almost continuous crown of these cavities 17 that strikes or impacts this spray or jet coming out of 15 at the moment where the cavities pass in front of the jet.

The fuel thus sprayed fills under the action of centrifugal force, the channel or duct of tube 11 in forming a somewhat long column of liquid. The length of this liquid column exceeding the height of the hook or of the U-shape tube, creates under the action of centrifugal force, a considerable overpressure through which the fuel is sprayed into the chamber 9 in overcoming the gas back-pressure in the chamber.

However after this spraying there always remains in the bend 13 of the tube 11, a double column of liquid which the gas pressure in the chamber 9 cannot drive out. The pipe for the liquid fuel thus remains automatically closed to the incandescent gases under pressure as soon as the spraying is finished.

Fig. 3 shows on a larger scale a small chamber having several holes 10 for communication with the chamber 3, and the spraying tube 11 with the bend 13. It is obvious that in suitably modifying the section of channel of tube 11, it is easy to obtain spraying suited to the selected combustion cycle. The spraying can be effected through a single small orifice and be directed either against the hot walls of the chamber or for example against a projection 18 where this spray is pulverized by impact.

In the same way, different known modes of pulverization under pressure similar for example to those which are used in the Diesel motors can be employed (the spraying can also be effected through the top and be directed towards the axis, as such is the case in Fig. 6).

Another mode of spraying is given in Fig. 4 in which a cone connected for example with the bearing is formed in the body 1; the fuel is sprayed (through a channel 20 provided in the bearing) into a combustion chamber of elongated form 9. Fig. 4 shows in dotted lines a modified form in which a rod with channel 20′ introduced through the hollow shaft 2 is provided with a cone 19′ formed in the body 1. This device can be substituted for the cone 19 and the channel or duct 20.

The device shown in Figs. 1 and 2 gives an example of application of the invention to a turbo-motor or a motor-turbine, that is to say to a machine in which are combined at same time the features of a turbine (great speed, absence of solid friction, continuous operation, the chambers being similar to the blades) with those of a motor (cycle of the Diesel motor, half-Diesel motor, working through expansion inclosed chambers under high pressures, cooling of the chambers through a liquid).

Its operation is as follows: The two shafts 2 and 5 being excentric, the one with reference with the other, the chamber which is the nearest to the shaft 5 (in Figs. 1 and 2, the bottom one), emerges from the liquid and in connection with the air layer 21, this air entering in the apparatus for instance through the channel 22 of the hollow shaft 5. When said chamber in following the arrow indicating the direction of revolution, is slightly shifted, the edges of its walls dip into the liquid ring and the air contained in the chamber is therefore included.

In the position of the chamber which is the most remoted from the shaft 5, this air is pressed and forced, either entirely or partially into this chamber 9, by the liquid of the ring 6, which invades the chamber 3 according as to this chamber is immersed into the liquid (it may be advantageous to cause the liquid to come down to the bottom itself of the chambers 3 so as to leave no free space between this bottom and the liquid).

The chamber is at this moment (Figs. 1 and 2) in the highest position, when or at a suitable proceeding moment the fuel is sprayed, for example, through described devices 11, 13, 15, 16, into the chamber 9 where it burns either as in the Diesel motor with the compressed hot air, or on being vaporized and ignited by the incandescent walls of the chamber 9, as in the half-Diesel motors (as shown in Figs. 5 and 6), or at last ignited through a suitable spark-plug or through igniting or sparking processes which will be hereinafter described. A suitable advance of the fuel spraying can be obtained in making the bearings 7 supporting the shaft 2, movable and in directing this movable part and the projection 16 (with the hole 15) so as to introduce the spray of fuel into the channels or ducts 17 and 11 before their respective chambers 9 have reached the extreme maximum immersion position.

The combustion (or explosion) and the expansion then take place in the chambers 3 and 9 when the same are moving out the liquid (Fig. 2) up to the moment where the wall edges of the chamber 3 leave the liquid. At this moment the gases which have worked in the chamber escape. During the period of expansion (work), the thickness of the liquid ring included in the chamber where the combustion takes place is but very slightly reduced by yielding slightly to the gas pressure and is substantially maintained by reason of the great centrifugal force which opposes every difference of level of the liquid ring. The resultant of forces for example the gas pressure and the like, acting upon the body 1 has a component normal to the line connecting the axes 2 and 5, this component is applied lower than the center of the axis 2 at the point where the center of the axis 5 intersects the body 1 and it is this component which transmits to the body 1 the expanding work of the gases.

The shaft of rotor 1 is the working shaft which can be used either by direct coupling or through gearing.

The escape of gases which takes place in the narrow meniscus of free space 21 can be directed on one side by suitably shaping the edges of the walls of chambers 3. In Fig. 1 the straight edge of chamber 3 is bevelled and the corresponding wall 3^2 is shorter (lower). It accordingly emerges from the liquid and opens the way to the escape, which takes place on the right hand side through the slot which forms itself in the direction indicated by the arrows 24.

The edges emerging from the liquid can therefore be replaced by outlet holes provided in the sides of the walls emerging from the liquid. The edges remaining continuously immersed in this liquid. As soon as the exhaust has come to an end and generally a little before the chamber 3 occupies its lowest position, this scavenging of chamber 3 automatically begins and is continued as long as these chambers remain in contact with the free meniscus.

This scavenging is effected through the air which enters from the side opposite to the escape, particularly for example, through a channel 22 provided in the shaft 5.

This air is driven along into a rotary motion through the bodies 1 and 4 provided for instance with suitable blades or through the body 4 only, the walls of which can contain radial channels forming a sort of turbo-compressor. The air is thus compressed by the action of centrifugal force and the scavenging thus takes place under pressure; this pressure can still be increased by the addition of a convenient air compressor.

In order to start the apparatus, the body I is set into a rapid rotary motion. The body 4 is carried along into the rotary motion, either by friction of the liquid interposed between the two bodies or through a solid friction or through a suitable coupling. This coupling is shown schematically in Fig. 1 by pins 25, entering into cavities 26 of the body 1.

The liquid of the ring 6 which enters periodically into the chambers 3 receives periodical speeding up impulses from the walls of the chamber 3. But the small periodical variations of speed of the liquid thus caused are provided symmetrically with reference to the dead point (maximum immersion) of the chambers and are directed in a reverse direction. The greater part of the kinematic energy which is lost during one phase is recovered in the opposite phase. The energy of immersion of the walls in the liquid and the energy of the radial shifting of the liquid are recovered in the same way.

Figs. 5 and 6 show another example of a turbo-motor which is capable of working like a half-Diesel motor.

The oil used as a fuel is introduced therein through the channel or duct 27 of a stationary tube passing through the axis with a hole 15 for the spray. The body I is supposed to be made of two discs bolted together between which is located the pipe II with the bend 13 which ends at the top into the combustion chamber 9. The expansion chamber 3 is formed of two juxtaposed chambers separated by a discoidal partition 28 which is higher than the walls 3^2. The edge of the wall 28 remains continuously immersed in the liquid in the low position in which the edges 3^3 emerge from the liquid. The two chambers 3 arranged side by side thus remain always separated the one from the other. They are connected together only through the holes 10 which lead into the common chamber 9 or through holes 29 of the partition 28. The scavenging air is thus caused to pass entirely, from the top to the bottom, through the two juxtaposed chambers and also through the small chambers 9. The bearing 30 carries the shaft 2 and supports at the same time the two tubular shafts 31 of the body 4. The latter can be formed of two annular shafts bolted together at their periphery by bolts 32. The scavenging air can enter either through a channel 34 provided in a bearing 30 or into the shaft 2. The exhaust takes place through a series of nozzles 33 provided in the walls of the body 4. Provisions are also made so that these nozzles may be directed in such a manner that they can expel the waste gases almost tangentially in the direction reverse to the direction of rotation of the turbo-motor thereby using as work the reaction of these gases; provisions are also made so that these waste gases may do double work and after having been sufficiently cooled and slowed so that they can be conveniently used with reference to other turbine wheels.

The turbo-motor of Figs. 5 and 6 operates similarly to the cycle of the half-Diesel motor. To this purpose, the walls of the chambers 9 can be made of a heat-insulating coating or layer, for instance, mica, asbestos, molten corundum, and the like, preferably supported by an internal metal casing (chambers surrounded by air can also be employed) the internal wall of the chamber being thus brought easily to incandescence or to a glowing point.

Suitable devices prevent the bearing 30 from rotating.

Means are also specially provided in order to give to the bearing 30 the possibility of rotating with the whole of the system about the axis 2 at a predetermined speed, which is always inferior to the speed of the latter. This means allows of entirely destroying the parasitical loads which are exerted by the body 4 upon the bearing 30 in the direction of the line connecting the two excentric axes or shafts, since these forces are always opposed to the direction of excentricity of the body 4 with reference to the axis 2. If the whole of the system is revolving about the axis 2 centrifugal force will act upon the body 4 in a direction which is always opposed to the parasitical power (caused for instance by the immersion of the walls of chambers 3 into the liquid ring). It is even possible to balance according to this method the side strains which are perpendicular to the parasitical powers, in causing the whole of the system to revolve not about the axis 2 but about another excentric axis with reference to the axis 5 and also with reference to the axis 2, but this is not so practical as the working axis 2 does not in this case remain fixed in the space.

The starting (setting into motion) of the turbo-motor can be effected by a small air turbine for example or any other suitable means. For example it is possible to set the engine in rotation in a non-excentric state and adjust the excentricity only after it has been set in motion. The engine can also be set in rotation after it has been placed in excentric position but without liquid (in the ring) and then introduce this liquid for example through a channel 34 provided in the bearing 30. Through this same channel the liquid of the ring can be compensated for evaporation.

The cooling of the system can be effected by different well known means, but the simplest way seems to be the use of vaporization of the liquid of the ring to which the walls of the chambers 3 impart their heat.

The turbo-motor can also be supplied with carburetted air instead of the fuel which is sprayed, said carburetted air entering for instance through the channel 22 of Fig. 1 and effecting also the scavenging of the chambers.

The sparking or ignition can be effected either by means of suitable spark-plugs or through any other devices (for example the heat of the walls, the heat of compression, and the like).

It has also been provided that the fuel (for example the petrol) can be sprayed by means of a suitable pipe through the meniscus 21 upon the surface of the ring 6 where its vaporization is effected by the heat of the liquid ring and by the action of the heat of compression of the air in the chambers.

During the starting and the operation the sparking or ignition cannot take place regularly. A special recess is provided to facilitate the starting of the apparatus. It consists in injecting during this period, instead of the ordinary fuel, pyrophoric fuels which ignite themselves instantaneously in contact with air, and particularly solutions of white phosphorus in sulphuret of carbon. As soon as the combustion chambers become hot, and the running is regular, the ordinary fuels are used.

Provision has also been made so that the small quantities of pyrophoric fuels may be sprayed, not only during the critical periods of starting but also during the normal operation for securing the ignition of ordinary fuels instead of plugs.

Another mode of carrying out the process is also provided. It consists in giving to the revolving bodies 1 and 4 the form of turnstiles instead of discs, with a continuous crown of chambers. This case is schematically shown in Figs. 7 and 8 in which a turnstile 1′ revolves, at its chamber ends 3, about the axis 2, while another turnstile 4^2 provided with receptacles 4 open towards the axis and containing the liquid revolves about another excentric shaft 5. The receptacles 4 are sufficiently broad to allow to the chambers 3 to move periodically in the liquid 6.

The process such as it has been described can also be used in connection with turbines, steam turbo-motors and also with air or gas compressors, liquid pumps, in providing the chamber 3 with suitable pipes and valves or side-valves allowing at the convenient moment the admission of fluid, forcing, exhaust, and the like.

Fig. 9 shows in vertical section a double air compressor formed of two discoidal bodies I and I′ bolted together having the same shaft 2 carried by bearings placed at a convenient distance apart. Two bodies 4 containing the liquid rings 6 and within which are the bodies I and I′ are excentric with reference to the axis or shaft 2 in opposite directions. Thus the pressures exerted from the liquid ring and the compressed gases upon the two crowns of chambers 3 are of opposed direction and counterbalance themselves to a large extent; accordingly, the remote bearings have only a small torque to bear. This torque can disappear entirely in case more than two elements are used. The rotors I and I′ can therefore turn if necessary about a free and flexible shaft.

The two external rotors 4 turn by means of their shaft in separate bearings. The chambers 3 are provided with valves 35, the air being forced through these valves for example into channels 36, exhausted through a hollow shaft or through channels provided in the bearings. The suction of air takes place generally at the moment when the chamber 3 emerges from the liquid and is connected with the air meniscus 21, but it can also take place through suitable suction valves.

On the same drawing, 35 shows separately an exhaust valve simply constituted by a flat strip or a cone 37, made of very thin sheet-iron and pressed upon its seat by the centrifugal power; 35^2 shows the same valve formed of sheet-iron pressed into the shape of a cylindrical cap 37^1, the cylindrical part of which is projecting into the chamber 3. The liquid of the ring coming near the bottom of the chamber 3 bears upon this cap and assists in opening the valve.

Finally, there is shewn in the drawings, a valve 35^3 in which the channel is closed by means of a flexible blade 37^2 which is located in a radial or almost radial position so as to utilize eventually a small component of the centrifugal power which maintains the same on its seat.

Figs. 10 and 11 show an example of a device for the admission of steam into a steam or compressed air turbine or turbo-motor.

The internal rotor I is applied upon the bearing 7 by means of a cone 19 acting as the rotary slide-valve of a steam-engine and insuring the admission of steam into the chambers 3 through the rings 20 and 36, the direction of the admission into the cavity 38 provided in the cone 19 of the bearing and limiting the duration of contact between the ducts 20 and 36.

Several other means of steam admission can be employed. For instance, one can make use of valves operated by cams or by the liquid of the ring itself. The exhaust of steam can take place either through similar slide valves or at the dead point at the moment the liquid comes out of the chamber 3. The energy of the steam exhaust can be recovered in directing the same in a direction which is the reverse to that of revolution and in then utilizing the same on the blades or paddles of ordinary turbines.

The whole of the two rotors are preferably enclosed within a closed space in connection with a condenser.

Fig. 12 shows an example of a pump driving a liquid.

The chambers 3 of the internal rotor are each provided with two valves 35, the one serving for the suction and the other for the exhaust, which connect these chambers, through pipes 36 for example, with the hollow shafts of the rotor I.

The valves can be replaced by rotary slide-valves like those which are used in rotary pumps with continuous delivery.

The liquid ring 6 is constituted by a very dense liquid, mercury for instance, which is heavier than the liquid to be forced and its thickness in the radial direction must be sufficiently great to counterbalance the centrifugal stresses of the liquid to be forced which is contained in the columns 36. The chambers 3 never emerge entirely from the liqiud ring.

This ring can of course be formed of two different liquids, for example, mercury 6 and a somewhat thick layer of the liquid to be forced 5^1. Fig. 12 also shows the possibility of obtaining the driving along of the rotor 4 through the walls of chambers of rotor I by means of a series of projections 39 arranged in the form of a crown on the internal periphery of rotor 4.

In the apparatuses as described, the excentricities of the shafts of the two rotors can vary within large limits, for example between 5 and 20% of the radius; the thickness of the liquid ring in the radial direction can also vary to a great extent in a corresponding proportion; its width parallel to the axis is not limited.

The diameters of the rotors can vary between a few centimeters and a few meters. The process can supply if needed, in a single element, a power of several tenths of thousands of H. P.

The number of chambers 3 can considerably vary; it varies generally between 12 and 35 per rotor.

Of course, the arrangements which have just been described are only given by way of example and do not in any way limit the invention to which many alterations may be brought.

What I claim is:

1. In a rotary apparatus, an external and an eccentric internal rotor having peripheral pockets thereon, a liquid held by centrifugal force in the external rotor and capable of entering the outer open ends of said pockets and working chambers in the internal rotor communicating with said pockets.

2. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions forming pockets thereon, a liquid held by centrifugal force in the external rotor and capable of entering the outer open ends of said pockets and a working chamber for each peripheral division and communicating therewith, and means to supply fluid to such chambers by centrifugal force.

3. In a rotary apparatus an external and an excentric internal rotor having peripheral divisions forming pockets thereon, a liquid held by centrifugal force in the external rotor and capable of entering the outer open ends of said pockets a chamber carried by said internal rotor, for each peripheral division and communicating therewith, a radial duct communicating with the inner end of each chamber.

4. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions forming pockets thereon, a liquid held by centrifugal force in the external rotor, capable of entering said pockets and out of contact with the periphery of the internal rotor at one point to admit air between said liquid and pockets, an explosion chamber carried by the internal rotor for each peripheral division and communicating therewith, a radial fuel supply tube for each chamber and means passed by the inner ends of said tubes to supply fuel thereto.

5. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions and a peripheral rib dividing the divisions into pockets, said rib projecting beyond the open end of said pockets, a chamber for each division carried by the rotor, each chamber communicating with the pockets of a division, a centrifugally maintained liquid ring into which said rib projects under all conditions of operation, there being a space between the inside of the ring and the edges of said pockets at one point of the periphery, a radially disposed tube communicating with each chamber and means to supply motive fluid to the inner ends of said tubes.

6. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions forming pockets, an explosion cylinder carried by the internal rotor for each pocket and communicating therewith, a centrifugally maintained liquid ring between the rotors, a radial fuel supply pipe connected to each chamber and having a U-shaped bend near its outer end adjacent the point of connection with its chamber, said pipes having juxtaposed widened inner ends and a fuel supply pipe to supply fuel to said ends.

7. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions forming pockets, a centrifugally maintained liquid ring between said rotors capable of entering said pockets, means to supply carburetted mixture between the rotors to said pockets, at one side, and means to supply scavenging air between

the rotors at the other side, said air and mixtures entering the pockets under centrifugal action where they leave the liquid during their rotation.

8. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions forming pockets, a centrifugally maintained liquid ring between said rotors capable of entering said pockets, means to supply carburetted mixture between the rotors to said pockets, at one side, and means to supply scavenging air between the rotors at the other side, said air and mixtures entering the pockets under centrifugal action, where they leave the liquid during their rotation, radially arranged liquid fuel supply tubes carried by the internal rotor and means to supply fuel to said tubes in succession.

9. In a rotary apparatus, an external and an excentric internal rotor having peripheral divisions, a centrifugally maintained liquid ring between the rotors, a partition dividing the divisions into pairs of pockets and means to provide communication between the pockets, said partition projecting beyond the pockets and contacting with said liquid under all conditions of operation, means to supply a combustible mixture to one side of said portion where the edges of the pockets leave the liquid and means to similarly supply scavenging air to the other side of said portion.

10. In a rotary apparatus, an external and an internal rotor having peripheral divisions, a centrifugally maintained liquid ring between the two rotors, a peripheral partition dividing said divisions into pairs of pockets, a combustion chamber for each pair of pockets carried by said internal rotor and communicating with each pocket, said partition contacting with said ring under all conditions of operation, a radial fuel supply for each chamber, means to successively supply fuel to said tubes, means to supply a carburretted mixture between the ring and pockets on one side of said partition and means to similarly supply scavenging air to the other side of said partition and exhaust ports in the external rotor operative when the pockets leave said ring.

11. In a rotary machine, a plurality of excentric external rotors and a plurality of concentric internal rotors having peripheral pockets and each internal rotor being arranged excentric to an external rotor, a centrifugally maintained liquid ring between each pair of external and internal rotors and means to supply fluid to the pockets.

In testimony that I claim the foregoing as my invention, I have signed my name hereto.

CONSTANTIN CHILOWSKY.