C. A. HULT.

FOUR-CYCLE INTERNAL COMBUSTION ENGINE.

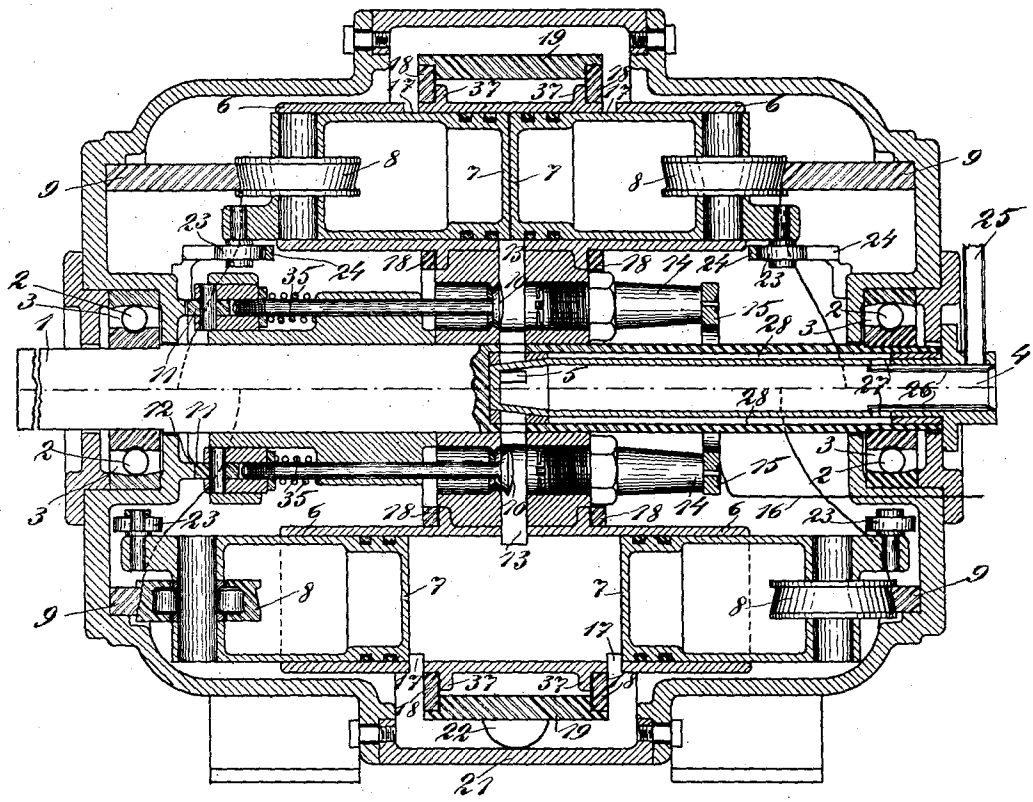
APPLICATION FILED SEPT. 9, 1919.

1,389,873.

Patented Sept. 6, 1921.

3 SHEETS—SHEET 1.

Fig. 1.



Inventor
C.A.Hult,
By H. R. Kerslake
Attorney

C. A. HULT.

FOUR-CYCLE INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 9, 1919.

1,389,873. Patented Sept. 6, 1921.

3 SHEETS—SHEET 2.

Fig. 2.

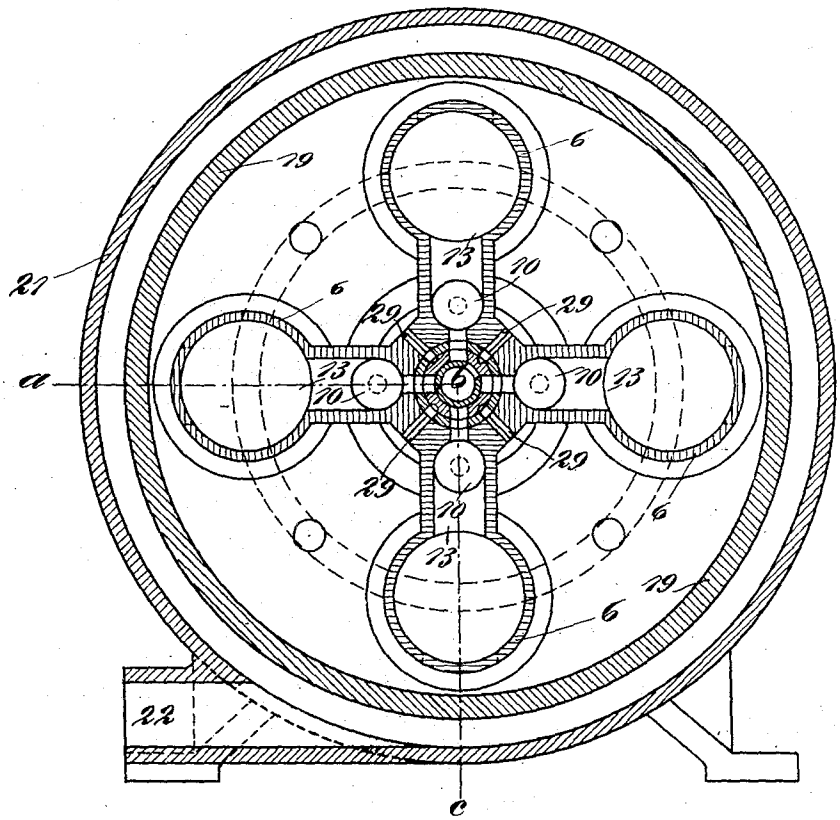
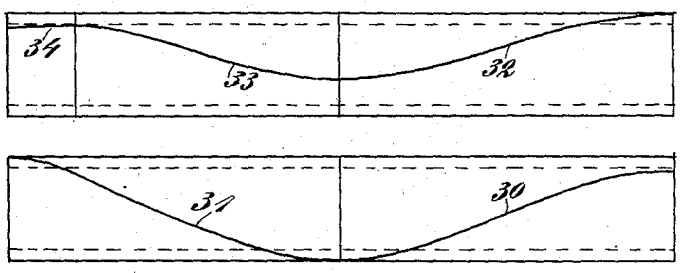


Fig. 3.



Inventor
C. A. Hult,
By H. R. Kerslake.
Attorney

C. A. HULT.

FOUR-CYCLE INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 9, 1919.

1,389,873.

Patented Sept. 6, 1921.

3 SHEETS—SHEET 3.

Fig. 4.

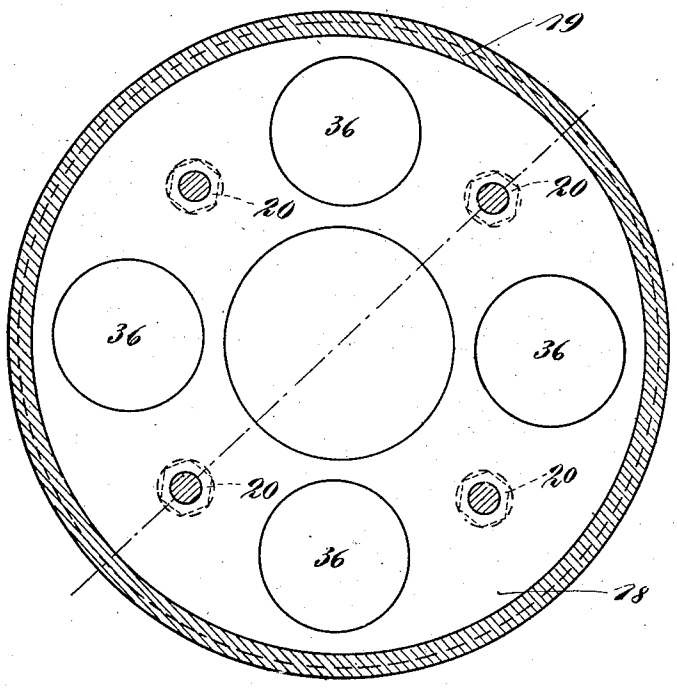
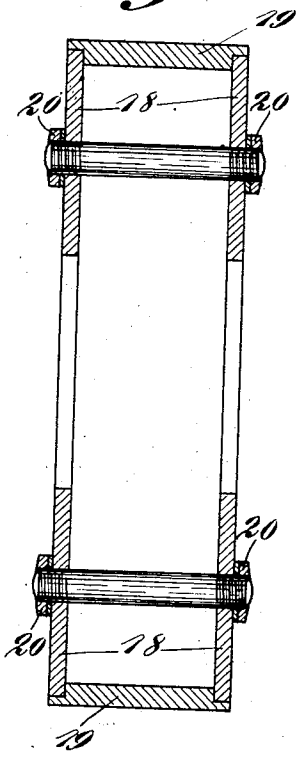


Fig. 5.



Inventor
C. A. Hult,
By H. R.
Attorney

UNITED STATES PATENT OFFICE.

CARL ALRIK HULT, OF STOCKHOLM, SWEDEN.

FOUR-CYCLE INTERNAL-COMBUSTION ENGINE.

1,389,873. Specification of Letters Patent. Patented Sept. 6, 1921.

Application filed September 9, 1919. Serial No. 322,754.

To all whom it may concern:

Be it known that I, CARL ALRIK HULT, a subject of the King of Sweden, and resident of Torsgatan 4, Stockholm, in the Kingdom of Sweden, have invented certain new and useful Improvements in Four-Cycle Internal-Combustion Engines, for which I have filed an application for patent in Sweden, Oct. 20, 1916; 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 drawing, and to figures marked thereon which form a part of this specification.

In internal combustion engines of the common four cycle type it is usual to have all the strokes of the pistons of the same lengths during the different operations of expansion, exhaust, suction and compression and this can not be otherwise, when common crank shafts are used to transmit the motions of the pistons.

By the equal lengths of the strokes during the cycle the different operations are limited to work in a way that is by no means correct, if a good result of the heat units spent to run the engine is to be attained.

In the exhaust stroke, the burnt gases will not be driven out entirely, but a great per cent. will remain in the cylinder after the stroke is done and then mix with the fresh gases, sucked in during the following stroke. In a benzin motor where the ratio of compression generally is not above four to one the explosive gas mixture will thus be composed of about 25 per cent. already burnt exhaust gas and 75 per cent. fresh gas, the whole constituting a bad explosive gas which occupies 25% more room than otherwise would be needed. The walls of the room in the cylinder containing the compressed gas mixture will, consequently, be a great deal larger than otherwise would be necessary, and as about 45% of the heat units from the explosions escape through the walls of the cylinder and the greatest per cent. thereof, from the walls of the chamber of compression, a proportional saving of heat units would be attained, if the room of compression was limited to contain only the pure gas mixture.

Theoretically the best way to obtain a good result of the exploded gases in an engine of four cycle type would be to drive the burnt gases out of the cylinder entirely, by running the piston up the entire length of the cylinder and then to give the suction stroke such a limited length that only so much pure gas would be admitted that could be entirely, or nearly so, expanded during the expansion stroke. It would further be the best way not to ignite the gases during the last period of compression, as is now done, but let the ignition take place first when the compression is entirely done, but still in a sufficient time before the stroke of expansion is to begin. Also it would heighten the efficiency of a combustion engine, if the compression of the gases could begin at full atmospheric pressure, instead of below that point, as is now generally the case.

The object of this invention is to produce a four cycle combustion engine, in which the different strokes of the pistons are regulated, so that the operations practically come very near to the theoretically best way of running such an engine.

To obtain these results the pistons work in combination with curved tracks shaped in such a way that, during the exhaust stroke, the pistons are brought to run up at the entire length of the cylinder and at the suction stroke run outward only long enough to take in as much pure gas as can be almost expanded during the stroke of expansion.

During the compression stroke, the pistons are given such lengths of stroke as to cause a suitable compression to the charge reduced to pure gas. At the end of this stroke the pistons will be brought to a standstill, or nearly so, during a period of time corresponding to the time, in which the electric ignition of the gases takes place. The next stroke, in which the exploded gases expand is given such a length compared to the suction stroke, that the expansion comes very near to the atmospheric line and the burnt gases escape without the usual noise. In order to get full atmospheric pressure of the gases, at the beginning of the compression stroke, the suction stroke works in combination with the centrifugal force, to fill the engine cylinder, this being caused by let-

ting the cylinders rotate around a central hollow shaft, through which the fresh gases are admitted on their way to the cylinders.

The improvements are shown on the annexed drawing wherein Figure 1 shows an engine in longitudinal section along the broken sectional line *a—b—c* in Fig. 2, of which the section above the line *a—b* is shown above the central line in Fig. 1, showing the position of a cylinder and its piston at the end of the exhaust stroke, together with the part of the cam tracks that belongs to that stroke, and the section on the right hand side along the line *b—c* is shown below the central line in Fig. 1, showing a cylinder and its pistons at the end of the expansion stroke and the portion of the cam track that belongs to that stroke. Fig. 2 shows the engine in transversal section. Figs. 4 and 5 show details of the water jacket which contains the different cylinders. Fig. 3 shows the different curves of the track, that regulates the different operations and strokes of the pistons.

1 designates the engine shaft. 2 and 3 the ball bearings thereof. 4 the inlet pipe for the fresh gases. 5 the opening in the same that regulates the inlet. 6 are the cylinders. 7 the pistons. 8 the rollers connected to the pistons. 9 are the annular tracks on which the rollers run. 10 are the exhaust valves. 11 the rollers actuating the valves. 12 the cam track which actuates the valve rollers. 13 are the channels leading from the inlet pipe to the cylinders. 14 are the spark plugs and 15 is a ring uniting the spark plugs. 16 is the cable leading the electric sparks from a magneto or the like. 17 are openings in the cylinders, from whence the exhaust gases escape. 18 are circular flanges of the water jacket which hold the cylinders in their position, as they are clamped together with an annular ring 19 by means of bolts 20. 21 is the outside casing of the motor and 22 an opening in said casing, through which the exhaust gases and water may escape. 23 are rollers united to the pistons and 24 are stationary cams or guides on which said rollers are actuating, during the suction stroke. 25 is a pipe for cooling water and 26 a liner leading the water through holes 27 into an annular space 28, outside of the inlet pipe, to holes 29, from whence the water is thrown into the water jacket. 30 in Fig. 3 shows the shape of curve of the annular track for the period of expansion, 31 for the period of exhaust, 32 for the period of suction, 33 for the period of compression, and 34 for the period of ignition.

The engine shown in Figs. 1 to 5 has four open cylinders 6 placed parallel to the shaft 1, and each of these cylinders has two pistons 7 working to and from each other at an equal distance from the transversal center of the cylinder. The rooms of suction, compression and expansion are constituted by the cylinder and the two pistons. Naturally the number of cylinders can be more than four, but ought not to be less than two in order to keep the balance of the rotating parts of the motor.

The motor works in the following manner:

When the motor is put in rotation and the gases have been sucked in through the inlet channels 4 and 5 and suitably compressed between the closed ends of the pistons and then ignited by the spark plug the expansion takes place, forcing the two pistons with the rollers 8 outward. The rollers 8 in the pistons run at the time on the part 30 of the track 9. The pressure from the explosion, on the pistons and rollers, forces the latter to run down to the deepest point of the track, thereby actuating the cylinders to move sidewise and thus to rotate about one fourth of a revolution around the center of the motor shaft 1. At a certain period before the end of the outward motions of the pistons, the openings 17 in the cylinder are uncovered by the former and the burnt exhaust gases escape out into the casing 21 of the motor and then through the hole 22. But at the same time as the openings 17 begin to uncover by the pistons, on their way outward, the valve 10 actuated by the cam roller 11 and the cam track 12, opens, leaving a free passage for the air to run in through the channel 13 and into the cylinder. The cam track 12 is so shaped as to keep the valve 10 open during the whole period of the time, during which the pistons, on their way outward and inward, keep the apertures 17 open and then still further until the piston cans on their return stroke of exhaust have met at the middle of the cylinder by means of the rollers and the part 31 of the track.

By letting the exhaust gases out through the openings 17 no heated exhaust gases will have to go through the valve 10, but instead of this, the fresh air actuated by the centrifugal force caused by the rotation of the motor will run through the valve opening into the motor cylinder and out through the openings 17, thereby causing the room in the cylinder to be cooled and swept completely free from all burnt exhaust gases. On their return stroke of exhaust, the pistons drive the fresh air remaining in the cylinder out through the valve opening 10, thereby causing a further cleaning and cooling of the cylinder. When the pistons guided and actuated by the rollers 8, part 32 of the track 9, rollers 23 and guides or tracks 24 are on their next stroke outward, the valve 10 actuated by the spring 35 closes and pure gas mixture is sucked in through the inlet pipe 4 and the opening 5 in same, which latter, by the rotation of the motor,

has just come in position to communicate with the opening or channel 13 running out into the cylinder. The part 32 of the track 9, which regulates the suction stroke, is so shaped as to limit the length of stroke and thereby the quantity of gas sucked in, to a portion as large as can be expanded, or nearly expanded, during the expansion stroke.

By this shortened stroke the openings 17 are not uncovered and the charge of gases is kept in the cylinder for the next return stroke in which it is compressed. During the suction stroke, when the cylinder has been in open communication with the inlet pipe for gas mixture 4, the centrifugal force caused by the rotation of the motor cylinders, has, in combination with the suction caused by the outward movements of the pistons, also caused the cylinder to be entirely filled with gas mixture at the atmospheric pressure. The rotation of the motor causes the opening 5 of the inlet pipe to be automatically closed at the end of the suction stroke.

In the return stroke of the pistons, the rollers 8 meanwhile running on the parts 33 of the tracks 9, the gas mixture is suitably compressed, which operation is now limited to compress pure gases only, whereby the room of compression can be kept about 25 per cent. smaller than otherwise would be necessary.

When the compression is fully complete the ignition takes place, while the rollers run over the parts 34 of the tracks 9. These parts of the tracks may run at equidistance from the transversal center of the cylinders and, consequently, the pistons will be at a complete standstill in their axial direction during the time the gases are fully ignited, or they may be a little inclined, as shown in the drawing, so that a small expansion of the gases may take place. By these means, the ignition which requires a certain time to reach all the gases and, therefore, must commence a certain time before the expansion stroke begins, to obtain, already at the beginning of the stroke, the full pressure on the pistons, does not cause the pressure of the explosion to work before the compression is complete and thus it does not work to repress the inward movements of the pistons during that period, as in common motors.

The cycle described works naturally by all the cylinders in the same way, and if four cylinders are used, as shown in the drawing, one stroke of expansion, exhaust, suction and compression will always be under operation during the same time, by one of the different cylinders, as there are four curves on the track 9, actuating the different pistons. The strokes of expansion will thus succeed one another, so that the impulse of rotation given therefrom will be continual during the whole of a revolution, causing a steady and equal running without the aid of a heavy fly wheel.

The weight of the rotating parts, inclusive the water in the water jacket, is quite sufficient to equalize the fluctuation of the pressure on the pistons.

The cylinders are preferably cooled by water, although even air may be used for that purpose. The water is led by the pipe 25 into the sleeve 26 and out through the holes 27. The water is thus caught by the rotating hollow shaft outside of the inlet pipe and thrown by holes 29 out in the water jacket which surrounds the cylinders. By means of the centrifugal force the water will, while the motor runs, stand in the water jacket in equal distance from the center of the motor shaft. When the water jacket has been filled in to the central openings of its walls 18, the water led in afterward will run over the edges of these central openings and be thrown out in the casing, wherefrom it may run out from the opening 22.

The ring that unites the spark plugs is naturally constructed from electrically non-conducting material, so that the electric spark does not run over from one plug to another, but each plug receives an electric spark in the right moment from the sliding contact between the plugs and the electro-cable 16.

By adapting open cylinders placed parallelly and symmetrically and of equal weights around a common shaft and causing the pistons to work two and two in each cylinder in symmetrical movements, at equidistance from the transversal center of the cylinders and actuating two annular tracks of equal constructions, the engine can be made to run at a great speed with a complete running balance.

The water jacket is so constructed that it also serves to unite and hold the cylinders together and in the right position around the shaft. The flanges 18 of the water jacket have openings 36, in which the cylinders are fitted, and the latter have flanges 37 which are clamped tightly together to the flanges 18 by means of the bolts 20.

The annular cam tracks may naturally be provided with more than five curves and still work in the manner described, although with the difference that, if ten, fifteen, twenty or twenty-five curves are provided, the whole cycle will be done in one half, one third, one fourth or one fifth of a revolution of the engine shaft.

It is not essential to the invention to have the cylinders placed in the way described and shown in the drawing, open at both ends, with two pistons in each cylinder, actuating two cam tracks, by means of rollers, but the contrivance whereby different and

suitably regulated lengths of the different piston strokes in the cycle are obtained, so as to practically reach the theoretically best way of working the different operations of expansion, exhaust, suction, compression and ignition, in a four cycle motor, is the main object aimed at. This is attained, even if the cylinders are closed at one end, as is most usual, with one piston in each cylinder, coöperating with one cam track only, by means of a roller or otherwise by a sliding contact and even if the cylinders are situated in a radial direction to the engine shaft or are otherwise inclined to the same, or if the annular cam tracks, united to the engine shaft, rotate and the cylinders are stationary, because the same regulated movements of the different piston strokes in the cycle, will be at hand in all cases. But by the construction described and shown in the drawing, the engine is given a complete running balance and the pressure in the cylinders, during the expansion and compression strokes, is equalized and balanced, so as not to give any end pressure to the engine shaft. Neither is it essential that the coöperations between the pistons and the cam tracks are done by means of rollers, as shown and described. These coöperations can be done by other means, such as sliding shoes or the like, united to the pistons and sliding on rollers or balls, running on the cam tracks in endless series.

During the strokes of expansion, exhaust and compression the gases inclosed between the pistons tend to keep the latter and their rollers pressed outward against the curves of the cam tracks, but during the stroke of suction, the atmospheric pressure on the outside of the pistons and the vacuum inside of the cylinder, caused by the suction, would, if not prevented, stop the outward movements of the pistons. In order to prevent this and to give the pistons the outward movements needed, during that operation, the small rollers 23 united to the piston cans, run on the inner guides or tracks 12 formed in curves equal to the part 32 of the cam track 9.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a four cycle internal combustion engine in combination, a plurality of cylinders placed symmetrically around and parallel to the engine shaft and open at both ends, two pistons in each cylinder, working to and from each other at the same time and at equidistance from the transversal center of the cylinder, each piston being provided with a roller or the like, two annular tracks placed concentrically around the engine shaft against which the piston and rollers work, the rollers running on the annular tracks and coöperating with curves so shaped as to actuate and guide the in and outward movements of each piston into one long stroke of expansion, one still longer stroke of exhaust, one short stroke of suction, one still shorter stroke of compression and one slight movement at the time of ignition, during at least one turn of the engine shaft, openings (17) for the exhaust gases, so placed in the cylinders as to be automatically uncovered by the pistons near the end of the expansion stroke, valves (10) coöperating with said openings, leaving a free passage for the air to sweep through the cylinders during a part of the expansion- and exhaust strokes, a cam track (9) actuating the valves (10) by means of the rollers (8), a guide or cam track (12) guiding the outward stroke of suction, by means of the rollers (23), an inlet pipe (4) for the gas mixture with an opening (5), channels (13) leading from the inlet pipe to the cylinders, spark plugs situated in said channels, a ring (15) composed of electrically non-conducting material and uniting the spark plugs, and an electric cable (16) sliding on said ring.

2. In a four cycle internal combustion engine in combination, a plurality of cylinders placed symmetrically around and parallel to the engine shaft and open at both ends, two pistons in each cylinder, working to and from each other at the same time and at equidistance from the transversal center of the cylinder, each piston being provided with a roller or the like, two curved annular tracks placed concentrically around the engine shaft and against which the pistons and rollers work, the rollers running on the annular tracks and coöperating with curves so shaped as to actuate and guide the in and outward movements of each piston can, into one long stroke of expansion, one still longer stroke of exhaust, one short stroke of suction, one still shorter stroke of compression and one slight movement at the time of ignition, during at least one turn of the engine shaft, openings (17) for the exhaust gases, so placed in the cylinders as to be automatically uncovered by the pistons near the end of the expansion stroke, valves (10) coöperating with said openings, leaving a free passage for the air to sweep through the cylinders during a part of the expansion and exhaust strokes, a cam track (9) actuating the valves (10) by means of the rollers (8), a guide track (12) guiding the outward stroke of suction, by means of the rollers (23), an inlet pipe (4) for the gas mixture with an opening (5), channels (13) leading from the inlet pipe to the cylinders, spark plugs situated in said channels, a ring (15) composed of electrically non-conducting material and uniting the spark plugs, an electric cable (16) sliding on said ring, a water jacket composed of a ring (19) and

two flanges (18) kept together by bolts (20), circular openings (36) in said flanges, corresponding to the outside diameter of the cylinders, and in which the cylinders are fitted and kept in position around the shaft, flanges (37) on the cylinders, tightening against the flanges (18) of the water jacket and by which the cylinders are kept in their axial position, a water pipe (25), a liner (26) and holes (27) leading water into an annular space (28) to holes (29) and then to the water jacket by means of the centrifugal force.

In witness whereof, I have hereunto signed my name.

CARL ALRIK HULT.