1,198,378

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,198,378

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COMPLETE SPECIFICATION

Opposed-piston machine, preferably an opposed-piston engine, with a hydraulic transmission

We, FRIED. KRUPP GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, of 103 Altendorfer Strasse, 43 Essen, Federal Republic of Germany, a German Body Corporate, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to opposed-piston machines, i.e. machines having two counter running pistons in the same cylinder, having a hydraulic transmission between reciprocating displacer pistons linked to the counter running pistons and a rotary displacer mounted on a shaft. Such a machine can be constructed as an internal combustion engine utilising the space between the counter running pistons as the combustion chamber and the shaft carrying the rotary displacer as the driven shaft. Alternatively it can be used as a pump or compressor, in which case the rotary displacer drives the counter running pistons through the hydraulic transmission.

Figure 1 of the accompanying drawings shows in axial section a known form of two-cylinder opposed-piston internal-combustion engine having a hydraulic transmission similar to that described in Specification No. 894227.

In the following description of the mode of operation of this known engine only the left hand working cylinder will be considered, All the operations of the right hand working cylinder are the same with the exception that its displacer pistons lag behind or lead the displacer pistons on the left-hand side with a phase displacement of one stroke.

A rotor 2, which is secured to a driven shaft 3, rotates in the housing 1 of the hydraulic transmission. Slidably mounted in the housing 1 are four vanes 4 which bear against the rotor and form four working chambers. The working chambers 5 and 6 associated with the left-hand working cylinder 4*a* are disposed diametrically opposite one another.

The two opposed working pistons 7 and 8 of an opposed piston internal-combustion engine are connected, through piston rods 9 and 10, to reciprocating displacer pistons 11 and 12 which deliver the liquid pressure medium. The upper piston 11 forces the liquid pressure medium through a pipe-line 13 into the working chamber 5 and the lower piston 12 forces the liquid pressure medium through a passage 14 into the working chamber 6.

It is necessary that the inertia forces of the opposed pistons 7 and 8 should be equal and also that the hydraulic losses in the pipeline 13 and in the passage 14 should be equal in order that the same pressure conditions may prevail at all times in the working chambers 5 and 6, to ensure that all the radial and axial forces exerted on the rotor by the liquid will be mutually balanced. It is also necessary in this known transmission that the pressures in pipeline 13 and in the passage 14 should bear the same ratio to the gas pressure in the combustion chamber 20. Having regard to the fact that the gas pressure acts against the weight of the piston 7, the piston rod 9 and the piston 11, it is generally necessary to achieve this equality of ratio by making the piston 12 slightly smaller than the piston 11, which is inconvenient.

It has also been found that the pistons 11 and 12 are liable to oscillation. If the piston 11, the piston rod 9 and the piston 7 should tend to oscillate at a natural frequency different from the piston 12, the piston rod 10 and the piston 8, they will generate pressure oscillations of different frequencies and often of different intensity in the associated working chambers 5 and 6. If these pressure oscillations are not in phase and are of the same intensity, the rotor is no longer free of radial and axial forces so that it run unevenly and transmits forces to its bearings. It is the object of the invention to overcome these disadvantages.

The invention provides an opposed-piston machine which includes two counter running pistons reciprocable in a cylinder, first and second reciprocating displacer pistons respectively connected to move each with one of the counter running pistons, and each having a smaller piston area at one side that at the other, the first displacer piston acting through a column of liquid on the smaller piston area of the second displacer piston, a rotary liquid displacer, and passages between the larger piston area of the second displacer piston and the rotary displacer for conveying liquid displaced by the second displacer piston to the rotary displacer, the streams of liquid flowing through the passages so acting on the rotary displacer that the radially acting forces exerted by the liquid on the rotary displacer are mutually balanced.

This construction has the advantage that it is no longer necessary for the two displacer pistons to oscillate only jointly and in the same phase because these oscillations no longer have a disturbing effect on the hydraulic transmission. Only the oscillations of the second displacer piston act on the hydraulic transmission and the liquid displaced by this piston does not exert any unbalanced axial or radial forces on the rotary displacer.

Furthermore, with the construction according to the invention it is no longer necessary for the pressures of the liquid displaced by the two displacer pistons to be equal. Differences in pressure which result from different inertia forces, from different transmission ratios between the working pistons and the displacer pistons or from different flow losses, no longer influence the operation of the hydraulic transmission.

It is a further advantage that the strokes of the two opposed working pistons need not be equal. The stroke of the second displacer piston and of the associated working piston is determined by the swept capacity of the rotary displacer. The stroke of the other working piston, however, is determined by the stroke of the first-mentioned working piston and by the ratio of the effective areas of the displacer pistons which enclose a liquid column between them. If importance is attached to complete balancing of the masses, the produce of the weight and stroke of each of the displacer pistons should be equal.

Two embodiments of the invention as applied to a diesel engine are illustrated respectively in Figures 2 and 3 of the drawings. Figure 2 shows the first embodiment in axial section and Figure 3 shows part of the second embodiment also in axial section.

As in the description of Figure 1, the mode of operation of the left hand working cylinder alone will be explained.

The rotor 2 is again mounted on the driven shaft 3 and rotates in the housing 1. Four vanes 4 are mounted for radial displacement in the housing and carry sealing strips, not described in detail, which bear against the outer circumference of the rotor 2. The ends of the vanes 4 form seals with the end walls of the cavity in the housing 1, which accommodate the rotor 2. Four working chambers are again formed between the vanes 4.

The admission of liquid to the opposed working pressure chambers is different from that in Figure 1. In Figure 1 the working chamber 5 is acted upon by the upper piston 11 through the pipeline 13 and working chamber 6 by the lower position 12 through the passage 14. In the construction shown in Fig. 2, however, the working chambers 5 and 6 associated with the left-hand working cylinder 4*a* are both acted upon through liquid columns by the lower piston 12, the chamber 5 through a passage 17 and the chamber 6 through a passage 14. The passages 17 and 14 terminate in the cavity in the housing 1 which accommodates the rotor 2 at diametrically opposite points so that the radial pressures of the liquid in these passages on the rotor balance one another. The liquid pressure medium delivered by the upper piston 11 is conveyed through a passage 18 to a chamber at the upper side of the lower piston 12 and acts on an annular surface of the piston 12 which is equal in area to the difference between the area of the lower piston 12 and the cross-sectional area of the piston rod 10. When ignition occurs in the combustion chamber 20, the two engine pistons 7 and 8 are driven apart and both act through the piston 12 on the rotor 2.

The lower piston 12 is normally held by the gas pressure and by gravity in contact with the liquid pressure medium. Under certain operating conditions this, however, is not assured. For example, during starting, when the speed of rotation is still very low, the force of gravity is not sufficient, in the region of the lower dead centre, to urge the lower piston 12 reliably against the liquid pressure medium. In the construction of Figure 1, adequate contact pressure can be assured by applying a gaseous or liquid pressure medium to the upper side of the lower piston 12 through a pipeline 15.

A gaseous or liquid pressure medium must always be applied to the underside of the upper piston 11 at slow running through a pipeline 16 provided for the purpose and shown in Figures 1 and 2 because the pressure of the upper piston on the pressure medium is always less than that of the lower piston, because the weight of the upper piston tends to retract it from the liquid pressure medium.

Since it is a requirement of the construction shown in Figure 1 that the liquid pressure should always be equal in the passages 13 and 14 and therefore in the working chambers 5 and 6, it is necessary that a pressure medium should act at all times on the upper piston 11 through the pipeline 16 in order to compensate for double the actual weight of the piston.

This is unnecessary in the construction shown in Figure 2 because the liquid pressure in the pipeline 18 need not be anything like as large as the liquid pressure in the passages 14 and 17. To ensure that both the upper and the lower piston are in contact with the liquid pressure medium during starting, it is sufficient in the case of Fig. 2 for the upper piston 11 only to be subjected to a liquid or gaseous pressure medium at its lower end through the pipline 16 and to be pressed thereby against the liquid pressure medium in the pipeline 18. The liquid pressure medium subjected to the action of the piston 11 actually acts directly on the upper surface of the lower piston 12 and presses it against the liquid pressure medium in the passages 14 and 17. The necessity for separate admission of pressure medium to the upper end of the lower piston 12 through the pipeline 15 provided in Figure 1 is elimimated in the case of Figure 2.

In the construction shown in Figure 3, in contrast to that shown in Figure 2, the upper opposed piston 7 is no longer directly connected by its piston rod 9 to a piston for displacing the liquid pressure medium but is connected by a yoke 21 and two piston rods 22 and 23 to two differential displacer pistons 24 and 25 which act on the upper surface of the piston 12 through the liquid pressure medium in the chamber 19. In order to ensure that the pistons 24 and 25 are maintained in contact with the liquid pressure medium under all operating conditions, a gaseous or liquid pressure medium can be applied to the lower surfaces of the pistons 24 and 25 through pipeline 26 and 27 in this example.

The invention may be used both in opposed-piston internal-combustion engines and in opposed-piston compressors and pumps. In the case of an internal-combustion engine two-stroke operation is preferred. Nevertheless, the invention may be applied in some circumstances to four-stroke machines.

The rotor may be provided with axially displaceable vanes instead of with radially displaceable vanes, for example as shown in German Specification No. 1,179,778.

It is also possible to connect the reciprocating displacement pistons and the opposed gas pistons by members which affect the transmission ratio of the piston movements, for example lever systems or gears.

WHAT WE CLAIM IS:—

1. An opposed-piston machine which includes two counter running pistons reciprocable in a cylinder, first and second reciprocating displacer pistons respectively connected to move each with one of the counter running pistons and each having a smaller piston area at one side than at the other, the first displacer piston acting through a column of liquid on the smaller piston area of the second displacer piston, a rotary liquid displacer, and passages between the larger piston area of the second displacer piston and the rotary displacer for conveying liquid displaced by the second displacer piston to the rotary displacer, the streams of liquid flowing through the passages so acting on the rotary displacer that the radially acting forces exerted by the liquid on the rotary displacer are mutually balanced.

2. A machine according to Claim 1, which includes piston rods respectively connecting the displacer pistons with the counter running pistons, and a chamber adjacent to and communicating with the smaller piston area of the second displacer pistons and also communicating by a passage with the larger area of the first displacer pistons.

3. A machine according to Claim 1, having two differential first displacer pistons having their smaller piston areas in hydraulic communication with each other and with the smaller area of the second displacer piston and connected by a yoke and piston rods with the associated counter running piston.

4. A machine according to Claim 2, which includes a conduit communicating with the smaller piston area of the first displacer piston and adapted for connection to a source of pressure fluid.

5. A machine according to Claim 1, substantially as described herein with reference to Fig. 2 of the accompanying drawings.

6. A machine according to Claim 1, substantially as described herein with reference to Fig. 3 of the accompanying drawings.

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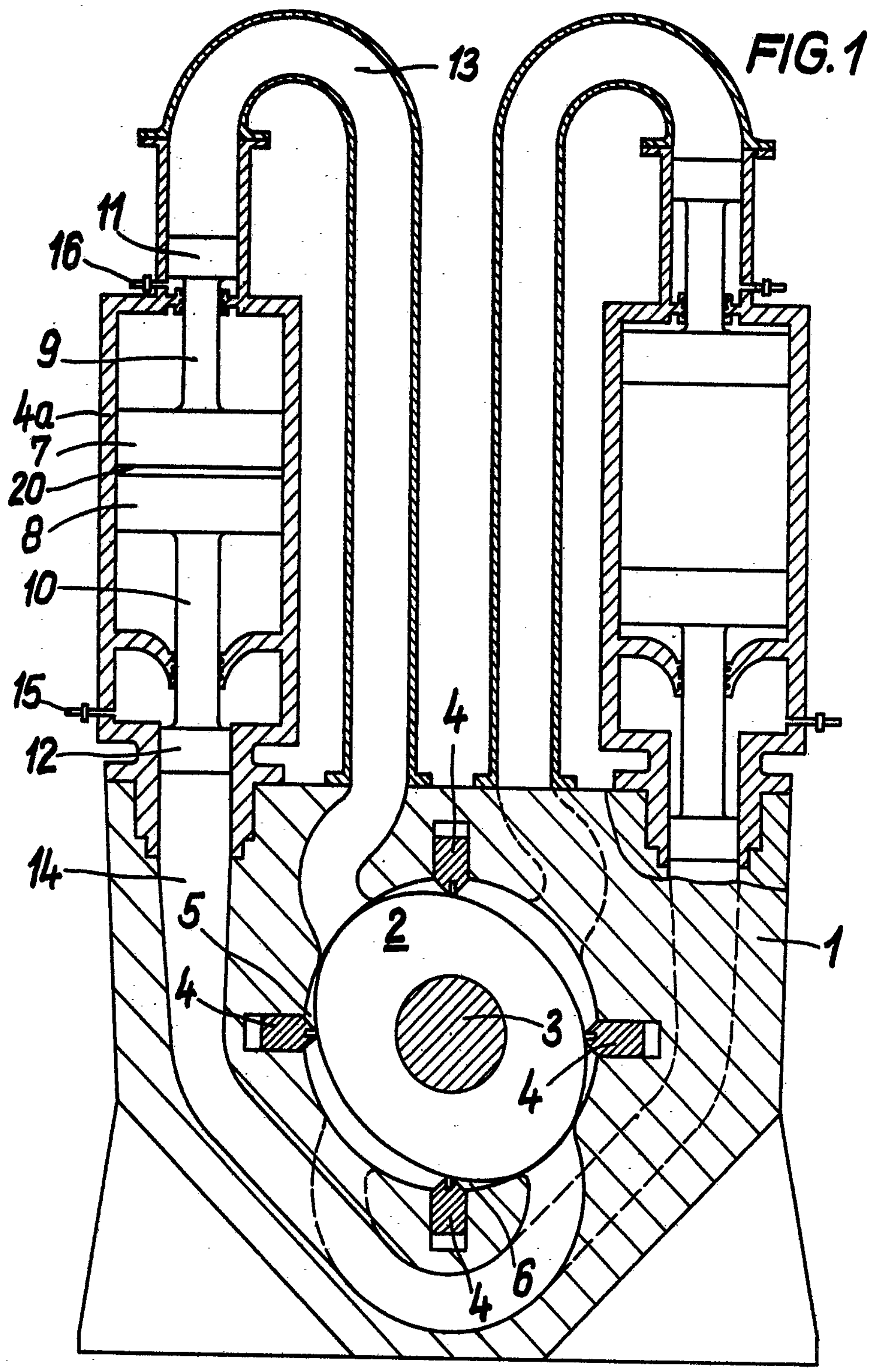
SHEET 1

FIG.1



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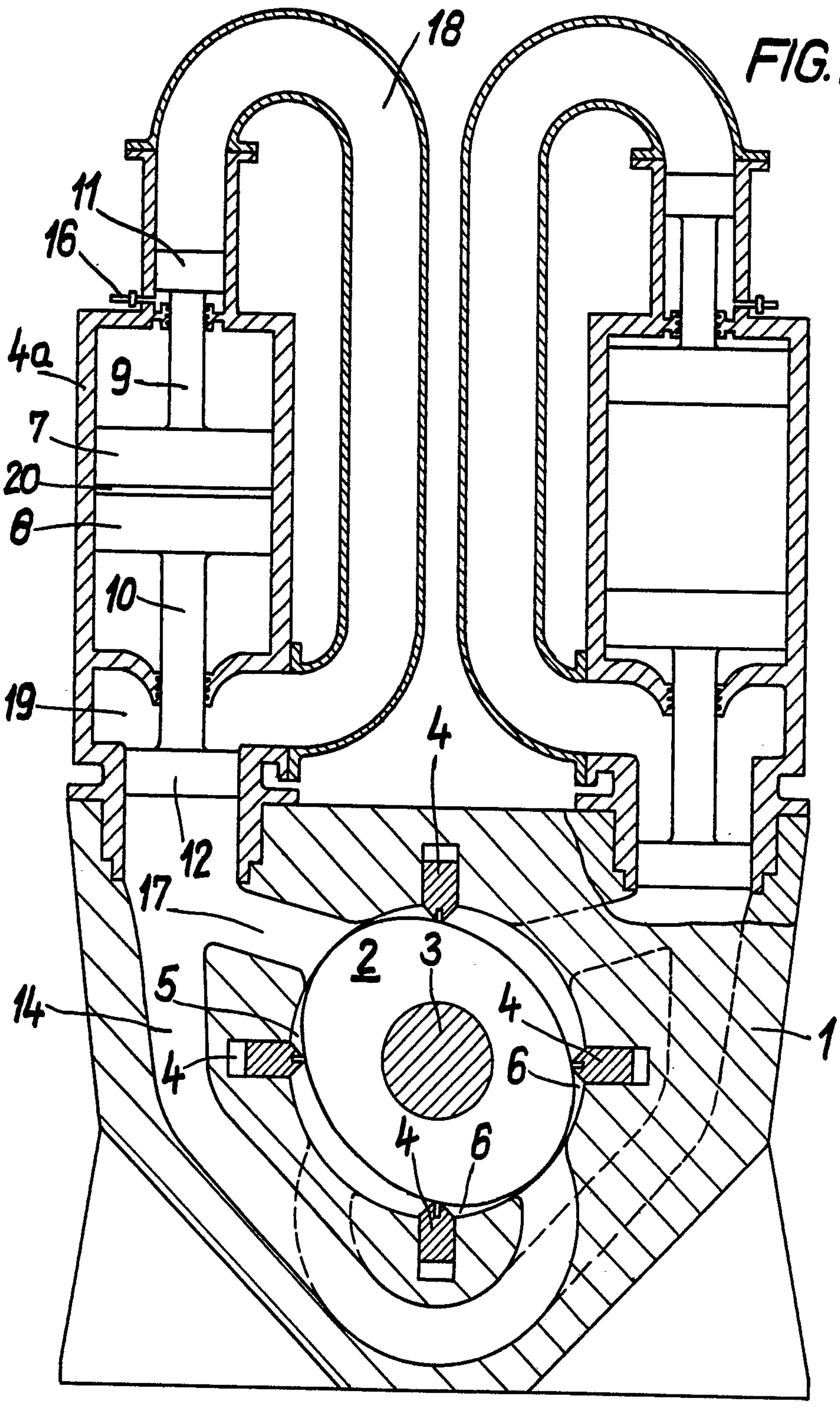
SHEET 2

FIG. 2



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SHEET 3

FIG. 3