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REVOLVER-TYPE RECIPROCATING PISTON ENGINE

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Fig. 1.

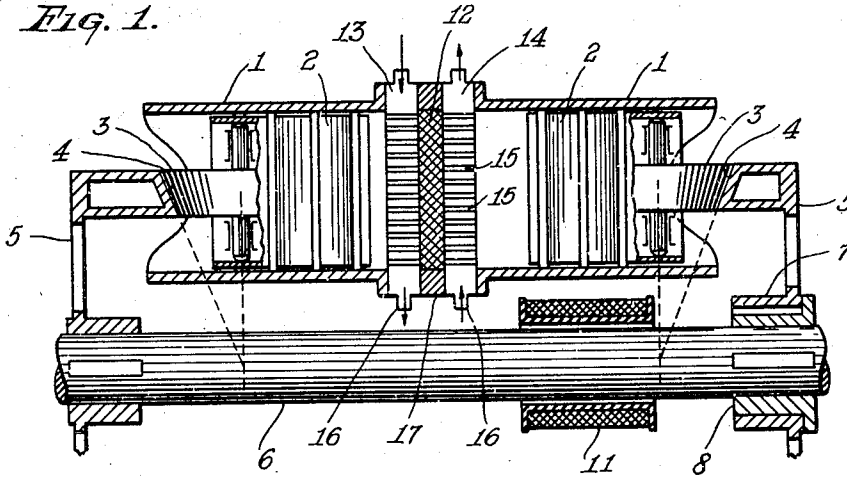


Fig. 2

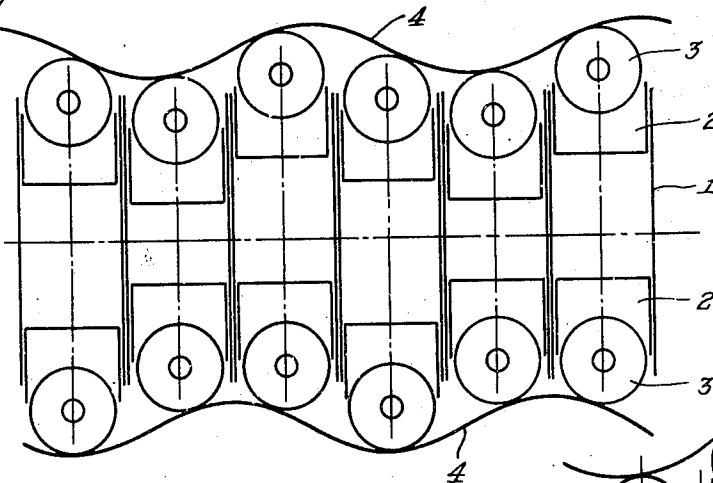
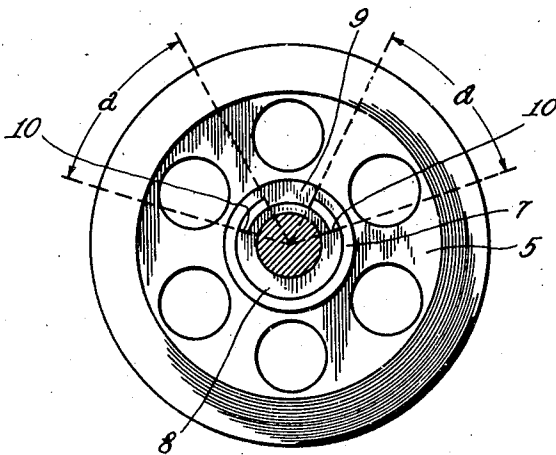
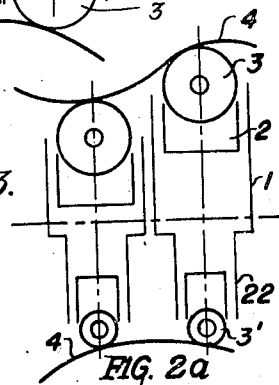


Fig. 3.



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REVOLVER-TYPE RECIPROCATING PISTON
ENGINE

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4 Claims. (Cl. 60—24)

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This invention relates to a piston engine of the type in which the reciprocating movement of the pistons is converted into a rotating movement by means of one or more sinusoidally arched tracks on a disc mounted normally to the shaft, the ends of the pistons rolling or sliding on these tracks. In a well-known engine of this kind the cylinders are arranged in two rims around the shaft on either side of such a disc mounted on the shaft.

According to the invention, an engine of this type is given a modified construction by which various advantages are offered and new possibilities are created.

According to the invention, the cylinders are mounted in pairs in line with each other between two discs fast on the shaft at some distance and the relative angular position of these discs and also the variation of the pressure in the cylinders are adjusted in such manner that complete or else partial balancing of the axial pressure and/or acceleration forces is obtained.

Preferably, the cylinders of each pair are caused to be in open communication and the pistons in said cylinders are given equal but opposite movements.

If the pairs of cylinders are diametrically arranged by twos, for example by mounting an even number of pairs of cylinders uniformly around the shaft, and if also an even number of sinusoids is chosen on each disc, it may be ensured that at any one moment, in addition to the effective torsional stress, the shaft will only be subjected to longitudinal stresses which are moreover compensated in the said shaft. The engine is thus enabled to run perfectly free from vibration and the bearings have no other pressure to absorb than the weight of the shaft and of the parts fixed thereto. It will appear hereinafter that even the said weight may still be neutralised, if desired.

Beside the advantage of quiet running, this arrangement provides a compact design, saving in material and weight, and the use of one common distribution and ignition mechanism.

In those cases in which longitudinal stresses occur in the shaft, for example with air-craft or ships, the construction according to the invention permits of the effective load forces being absorbed entirely or substantially entirely by the pistons so that the use of heavy collar blocks and the friction losses occurring therein, may be obviated, since it is possible to choose the mean piston force to be greater to any desired extent in one direction than that in the other di-

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rection, either by admitting a higher gauge pressure in the cylinders of one rim than in those of the other rim, or by giving a greater cross section to the first-mentioned cylinders than to the others.

This arrangement may also be used to advantage with an engine comprising a vertical shaft since the weight of the moving parts are compensated. With a given difference in diameter of the cylinders the resulting axial pressure depends on the mean gauge pressure on the pistons, hence automatic compensation of the axial load pressure (or load traction) may be obtained by causing the mean gauge pressure in the cylinders to be regulated by the axial pressure.

In the engine according to the invention, care will have to be taken that the members, for example rollers, forced by the pistons against the sinusoidal tracks at any one moment engage the said tracks at least with a slight force in order that "beating" may be avoided. In engines having a steady gauge pressure behind the piston this is ensured automatically, whereas in engines in which there is periodically no gauge pressure but even sub-atmospheric pressure, the above condition must be satisfied in some suitable manner unless the sub-atmospheric pressure periods coincide with the periods in which the pistons are subjected to an acceleration of sufficient value directed from the track.

Since this cannot always be assured continuous engagement between the pistons and the tracks may be ensured electromagnetically in a simple manner by arranging an energizing coil between the discs to surround the shaft, the magnetic circuit being short-circuited across the two discs, the pistons and the cylinders. In this case, the shaft must of course be journaled with a non-magnetic material so that a magnetic short-circuit across the frame is avoided.

An example of an engine having continuous gauge pressure is a hot-gas engine. The use of the invention with such an engine offers particular advantages, apart from the general advantages mentioned before.

For example, the reversal of movement with such an engine is particularly simple since with one sense of rotation the pistons of one of the two cylinder rims lead by a given phase angle relatively to the corresponding pistons of the other rim, and with the other sense of rotation, lag to the same extent.

The relative phase ratio of these two groups of pistons is governed by the relative angular position of the two discs so that it is only nec-

essary to, change the position of one disc relatively to the other through double the angle of lead or lag in order to reverse the direction of movement of the engine. The disc leading (in both directions of rotation) is preferably mounted on the shaft so as to be capable of rotating between two stationary stops, the other disc being in this case rigidly secured. The angle through which one of the discs must be rotated depends not only on the desired phase difference between the pistons but also on the number of sinusoids on each disc. If this number is, for example 4, during each complete piston stroke the shaft makes one quarter of a revolution, and if the pistons of one rim have to lead by $\frac{1}{4}$ cycle relatively to those of the other rim, reversal of the movement will require the adjustable disc to turn through an angle of $\pi/4$. Generally, the lead and hence also the angle of rotation is chosen to be slightly smaller.

In order that the invention may be clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which a hot-air engine is illustrated.

Fig. 1 is a longitudinal sectional view of a hot-gas engine in accordance with the invention.

Fig. 2 shows a diagram of the cylinders, pistons and sinusoidal tracks of same in the developed condition.

Figure 2a shows a diagram of a modification of the arrangement shown in Figure 2. In Figure 2a the opposed cylinder sections are shown of different diameters, only two complete cylinders being shown for illustrative purposes.

Fig. 3 is an elevation of the disc whose position can be changed for the purpose of reversal of movement.

The hot-gas engine part of which is shown in longitudinal section in Fig. 1 comprises two rims of six cylinders 1 which are pair-wise in line with each other. Within each of these cylinders a piston 2 is adapted to move and its free end is provided with a roller 3. These rollers engage a sinusoidally arched track 4 which is carried by a disc 5. One of these discs, in the case shown the left hand one, is fast on the motor shaft. The right hand disc 5 is so journaled that its boss 7 rotates through a given angle about a sleeve 8 rigidly secured to the shaft 6 and provided with two stops on which a projecting lug of the boss 7 is caused to bear in the two extreme positions of the disc. This is shown in Fig. 3 in which the projecting lug is designated 9 and the two stops are designated 10. For the sake of clearness the disc is shown in Figure 3 in its central position from which it can be moved by rotation to the left or to the right through an angle "a" equal to the angle of lead into the position "ahead" or "back."

An energising coil 11 surrounding the shaft brings about a magnetic flux in the closed iron circuit formed by the shaft 6, the two discs 5 with their tracks 4, the rollers 3, the pistons 2 and the cylinders 1. The energisation flux is adjusted in such manner that under all conditions the rollers 3 continue to engage the tracks 4. If there is never a sub-atmospheric pressure in the cylinders 1 a low energization will therefore suffice. The current required may be supplied on starting by the starting battery or by a small generator (not shown) to be assembled in known manner with the engine. Use may also be made of a line voltage to energize the coil.

In order to avoid sliding friction the rollers 3 may be constructed in the form of bevel gears.

This has the disadvantage that apart from the tangentially directed reaction force, which of course is unavoidable, the rollers 3 also exert a pressure on the pistons, and hence on the cylinder wall, which is radially directed outwards. If desired, this pressure may be absorbed by special runways, as otherwise is the case with the tangential pressure referred to. It is essential that the pistons 2 have no lateral strain since, the cylinders would be worn out-of-round.

Between each pair of cylinders 1 in line with each other there is an aggregate comprising a regenerator 12, a heater 13 and a cooler 14. The regenerator must preferably be made from porous material of good heat conductivity and of high heat capacity, which with a maximum surface offers a minimum resistance to the medium flowing through.

The heater 13 and the cooler 14 are shown in the form of metal drums having, in the axial direction, a large number of fine tubes 15 which are open on both sides. The interior of these drums communicates by in- and outlet ports 16 with the supply and discharge means (not shown) of a heating and cooling medium respectively. The cooling medium may be, for example, air or water.

In Fig. 2 is shown six pairs of cylinders with their pistons and rollers in the developed state, the rollers engaging the tracks, it being assumed that the pistons of one rim lead by exactly 90° relatively to those of the other rim and in addition that each disc contains two complete sinusoids so that the shaft 6 makes one revolution only on every two complete piston strokes. This ratio number may, of course, be greatly increased if desired, particularly when the cylinders are mounted in a wide rim around the shaft. This may be done, for example, in cases in which the speed of the shaft should be comparatively low such, for example, as is the case of screw shafts of ships, driving shafts of locomotives, motorcars, and so forth. For high-speed shafts such, for example, as shafts of air-screws the ratio 2:1 will generally be sufficient, there being in this case, if a four stroke cycle internal combustion engine is concerned, the supplementary advantage that the motor shaft itself can be used directly for driving the valve- and ignition mechanism.

In addition to the advantage already mentioned of the possibility of a great reduction in speed the arrangement of a large number of cylinders in a wide rim around the shaft has still further advantages. First of all, the slope of the tracks 4 decreases in a radial sense so that the detrimental radial pressure towards the outside on the rollers 3 becomes little (and may be assisted also by making the rollers 3 as small as possible). Secondly, at least in many cases, much annular space is available between the shaft 6 and the insides of the cylinders 1 so that the above-mentioned heating and/or cooling means can be housed in this space resulting in a construction which is exceedingly compact.

Obviously, it is not necessary that the same section should be given to all cylinders, as shown. Wherever this method is adopted the forces acting axially on the discs 5 will be at any one moment equal but oppositely directed and thus neutralise each other in the shaft 6. If, however, in contradistinction to this a resulting axial force such, for example, as with a screw shaft is desired either the "hot" or the "cold" cylinders may have a greater cross-sectional area than the other, according to circumstances. Such modification is

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shown in Figure 2a wherein the cylinders 1 are constructed similarly to those shown in Figure 2, with like parts being designated by like reference characters, but with the difference that one section of each cylinder is of smaller cross-section at 22' than is the other. A smaller roller 3' for the piston in section 22' is shown riding in track 4. In such a case the value of the resulting axial force is proportional to the mean pressure in the cylinders and this pressure may be regulated as desired. Hence, the axial displacements which the shaft will perform, may be used for so influencing one or more of the said factors that equilibrium is restored. Thus a light collar block may suffice which must be strong enough for maximum conditions, such as for example failure of any automatic control devices of the engine.

It will be observed that in the engine shown and described the phase difference of about 90° between the pistons of each pair is responsible for the compensation of the axial acceleration forces being incomplete, at least within each pair of cylinders. Due to this, vibrations may still occur at high speeds. This may be obviated by the cylinders in line with each other not being made in open communication with each other pairwise, but by having one of the cylinder rims and the associated disc being turned relatively to the other to such extent that in the oppositely arranged cylinders the pistons are given opposite sense of movement. In this case, however, the construction of the engine becomes more complicated since it is necessary for regenerator to be housed in the inclined connecting pieces between the thermally associated cylinders. In addition, in this construction there is no longer within each pair of cylinders absolute compensation of the axial piston pressure on the discs. It will therefore depend on conditions as to which of the two systems is to be used.

In other engines, for example steam engines and internal combustion engines in which with each pair of pistons the phase difference may be exactly 180°, this difficulty is obviously not encountered and quiet running of such engines is obtained.

The use of the invention in steam engines and internal combustion engines avoids the need for more than one distribution and, as the case may be, for more than one ignition mechanism for each pair of cylinders, which are driven from an adequate set of cams on the middle of the shaft. In such a case, regulation of the degree of filling and of the sense of rotation may be effected by regulation of the angular position of the said cams on the shaft. In an internal combustion engine according to the invention, the valves, the sparking plugs etc., can be arranged about the shaft in a rim so that they can be operated by one common set of cams by means of short and light connecting members with the avoidance of the need for separate cam shafts or the like.

What I claim is:

1. A hot-gas engine comprising a shaft member, a plurality of cylinder means positioned about said shaft member and being arranged substantially parallel therewith, said cylinder means each having two sections, each said section containing a reciprocable piston slidably arranged therein, said pistons each having a roller means coupled thereto, a plurality of assembly means each comprising a heater, a cooler, and a regenerator interposed between said heater and said cooler, one of said assembly means interposed between said two sections of each of said cylinder

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means, and a pair of discs each having a sinusoidal arched track, one of said discs being fixed to said shaft member and being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at one end of said cylinder means, the other of said discs being movably secured to said shaft member and being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at the other end of said cylinder means and being further arranged so that said disc can be rotated with respect to said shaft member to either of two limiting positions.

2. A hot-gas engine as claimed in claim 1 wherein all the cylinder sections arranged toward one end of said shaft member have a cylinder and piston diameter greater than the cylinder and piston diameter of all the cylinder sections arranged toward the opposite end of said piston member.

3. A hot-gas engine comprising a shaft member, a plurality of cylinder means positioned about said shaft member and being arranged substantially parallel therewith, said cylinder means each having two sections, each said section containing a reciprocable piston slidably arranged therein, said pistons each having a roller means coupled thereto, a plurality of assembly means each comprising a heater, a cooler, and a regenerator interposed between said heater and said cooler, one of said assembly means interposed between said two sections of each of said cylinder means, a pair of discs each having a sinusoidal arched track, one of said discs being fixed to said shaft member and being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at one end of said cylinder means, the other of said discs being movably secured to said shaft member and being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at the other end of said cylinder means and being further arranged so that said disc can be rotated with respect to said shaft member to either of two limiting positions, and an electromagnetic coil surrounding said piston to establish a magnetic field maintaining engagement between said roller means and said sinusoidal arched track portions of said discs.

4. A hot-gas engine comprising a shaft member, a plurality of cylinder means positioned about said shaft member and being arranged substantially parallel therewith, said cylinder means each having two sections, each said section containing a reciprocable piston slidably arranged therein, said pistons each having a roller means coupled thereto, said roller means having bevel gear type contact surfaces, a plurality of assembly means each comprising a heater, a cooler, and a regenerator interposed between said heater and said cooler, one of said assembly means interposed between said two sections of each of said cylinder means, and a pair of discs having sinusoidal arched tracks in the form of bevel gear surfaces, one of said discs being fixed to said shaft member and being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at one end of said cylinder means, the other of said discs being arranged to engage operatively the sinusoidal arched track of said disc with said piston roller means at the other end of said cylinder means and being further arranged so that said

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disc can be rotated with respect to said shaft member to either of two limiting positions.

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