W. J. STILL.

INTERNAL COMBUSTION ENGINE.

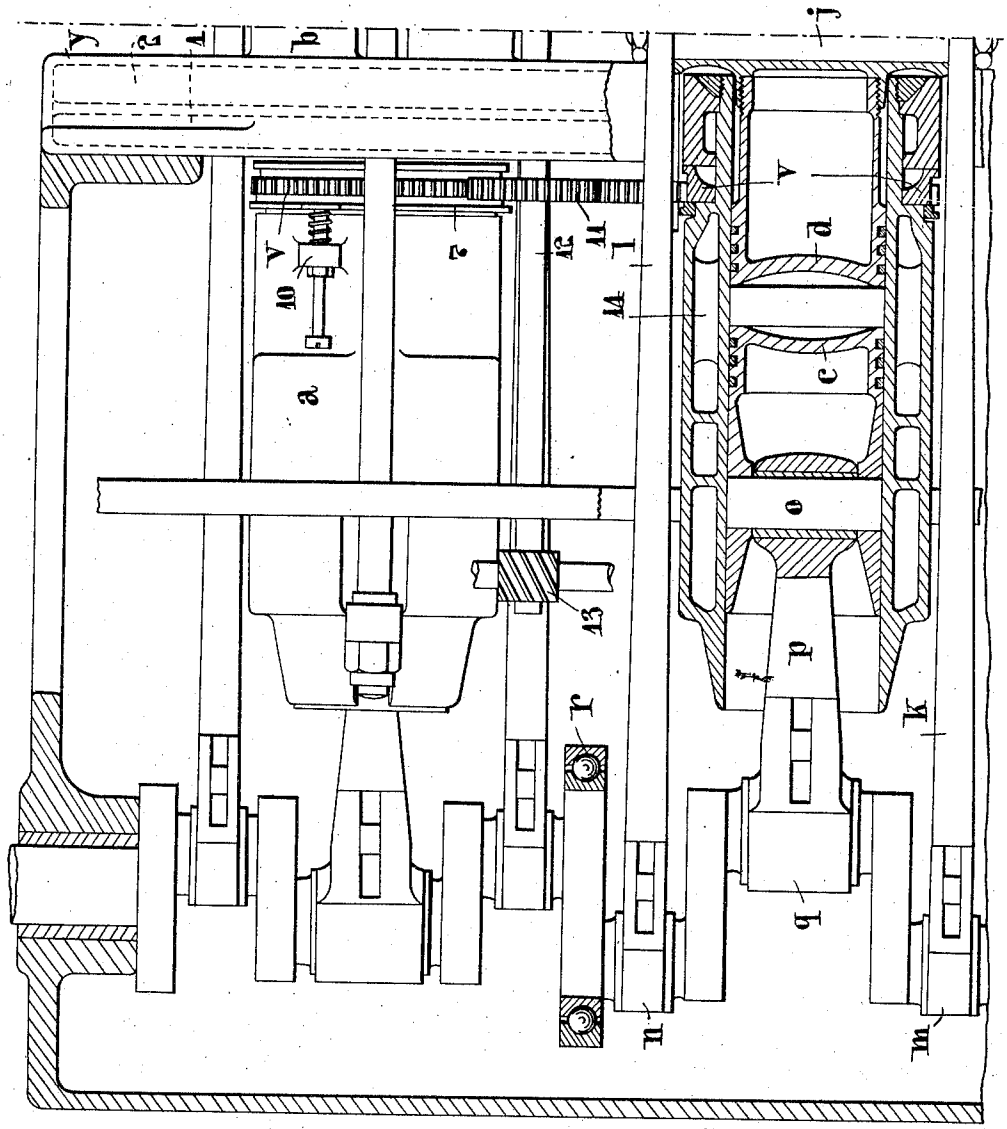
APPLICATION FILED APR. 14, 1911.

1,015,216.

Patented Jan. 16, 1912.

4 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
Bent, Th. Stahl,
Edward N. Sutton

Inventor
William J. Still.

By Spear, Middleton, Donaldson & Spear
Attys

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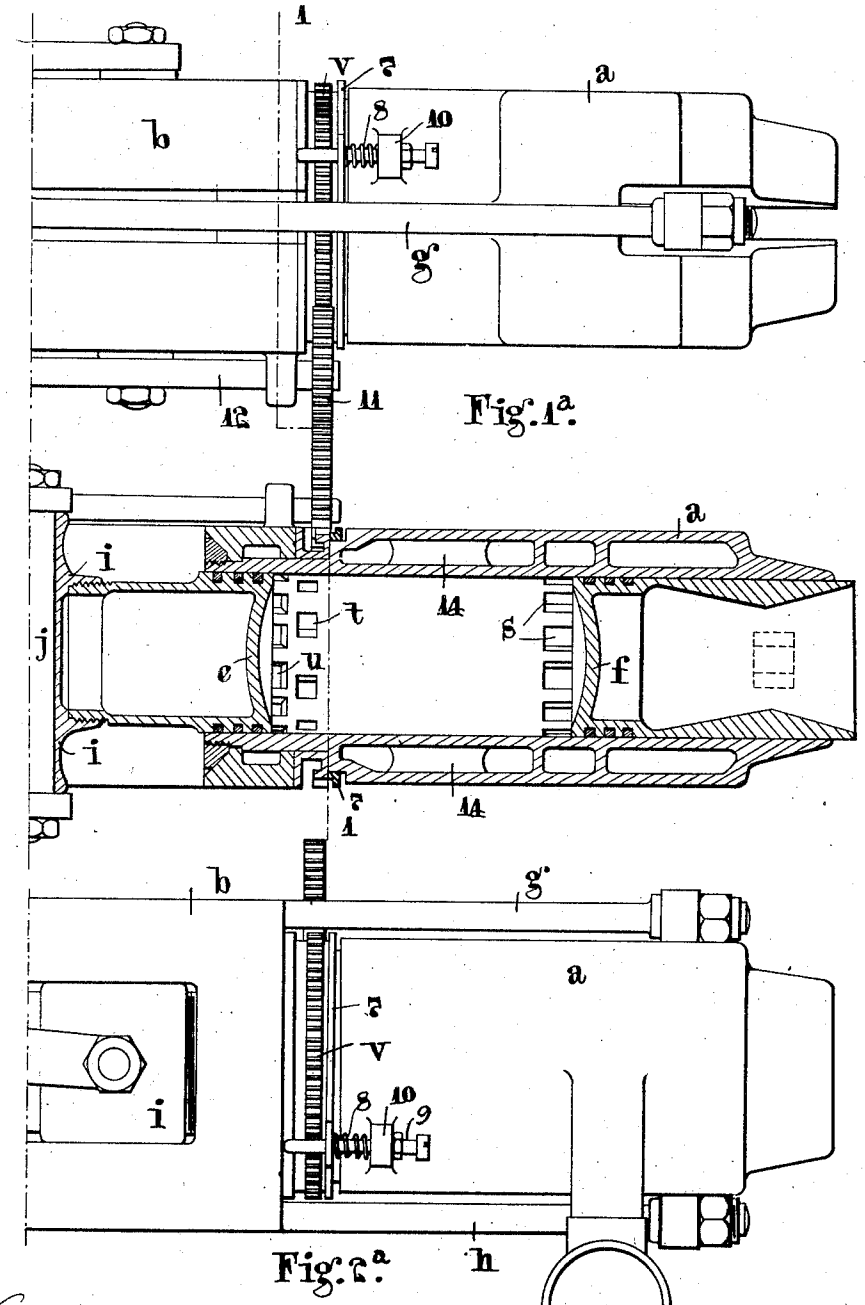

Fig. 1a.

Fig. 2a.

Attest.
Bent, Mr. Stahl,
Edward N. Sutton

Inventor.
William J. Still.
By Spear, Middleton, Donaldson & Spear
Attys.

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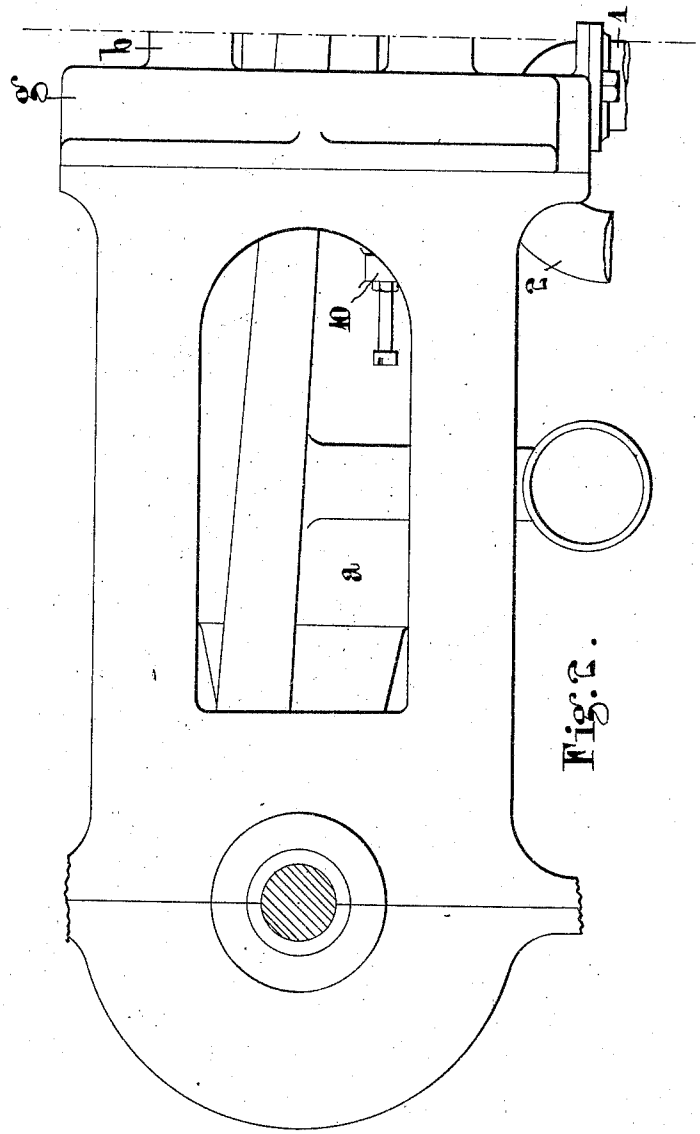

Fig. 2.

Attest:
Bent, Wood & Stahl
Edward A. Sarton

Inventor.
William J. Still.
By Spear, Middleton, Donnelly & Spear
Attys.

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4 SHEETS—SHEET 4.

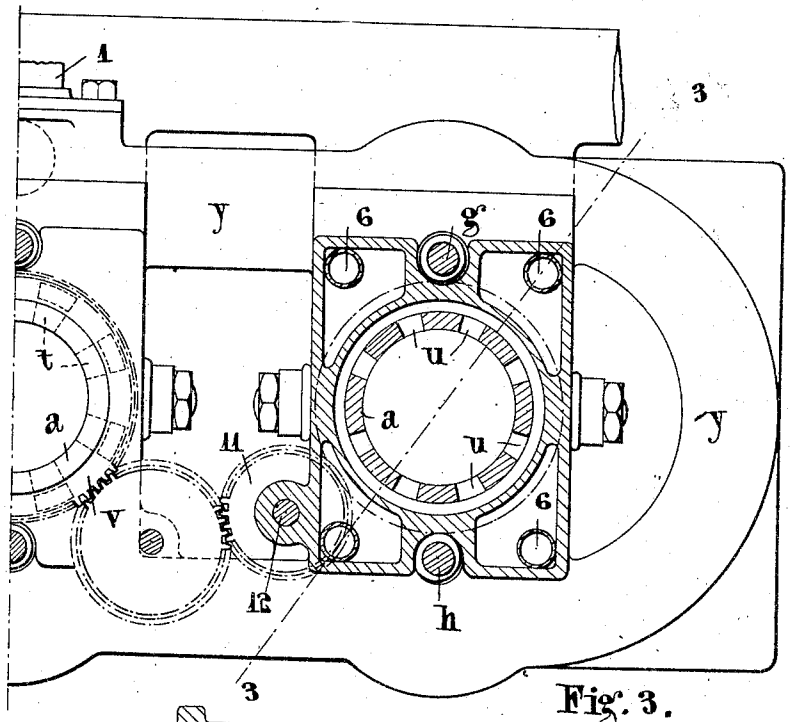

Fig. 3.

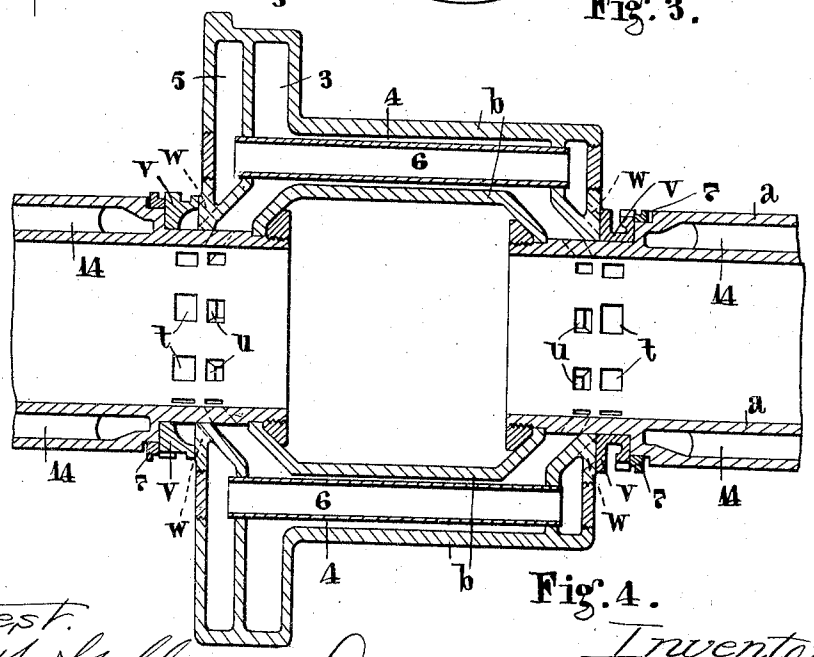

Fig. 4.

Witnesses:
Bentley W. Hall
Edward A. Seiter

Inventor
William J. Still.
By Spear, Middleton, Donnelly & Spear
Attys.

UNITED STATES PATENT OFFICE.

WILLIAM JOSEPH STILL, OF SOUTHALL, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

1,015,216. Specification of Letters Patent. **Patented Jan. 16, 1912.**

Application filed April 14, 1911. Serial No. 621,164.

To all whom it may concern:

Be it known that I, WILLIAM JOSEPH STILL, a subject of the King of Great Britain and Ireland, and residing at 15 Avenue road, Southall, in the county of Middlesex, England, have invented certain new and useful Improvements in and Relating to Internal-Combustion Engines, of which the following is a specification.

In another application filed by me on the 14th day of April, 1911, Serial No. 621,165, certain claims are made for subject matter disclosed in this application and not claimed herein.

This invention relates to internal combustion engines and to constructions and arrangements of rotary valves for the same, of the kind which embrace the cylinder.

This invention relates more particularly to engines operating on the two stroke cycle and of the kind in which two cylinders each containing a pair of pistons (the two spaces between which form combustion chambers) are placed end to end and the inner pair of pistons are rigidly connected to one crank on a crank shaft placed at the end of the combination and the other pair to other cranks on the shaft.

The object of the present invention is to provide improvements resulting in the obtaining of more complete and economical scavenging than heretofore and allowing of variation of the compression as desired during running or at any other time. Also an engine can be produced in which none of the ports or valves are subjected to the heat of the explosion and in which the number of wearing parts, weight per horse power, cost and space occupied are reduced to a minimum.

This invention has also for its object to provide an improved valve of the type referred to above.

This invention consists in a scavenging internal combustion engine in which the inflow of the combustible to the cylinder is controlled with respect to the scavenging air flow by a rotary valve embracing the cylinder.

This invention also consists in a rotary valve for internal combustion engines embracing the cylinder which has one or more passages joining faces on the valve in planes practically perpendicular to each other which faces co-act with ports connected on the one hand with the cylinder and on the other with gas ducts.

In applying this invention in one form to a gas engine as referred to above each cylinder may have in it three rings of ports, one ring at one end and two at the other. Of these the former will act as exhaust ports and of the two latter that nearest the center of the cylinder will act as gas and air mixture inlet and the other as the scavenging air inlet. The gas and air inlet is controlled by a rotary valve which embraces the cylinder and is adapted to remain closed until the piston has just closed the scavenging air ports and the exhaust ports are just closing at which moment it commences to open. Part therefore of the charge enters by displacement of the air remaining and part by virtue of the inlet pressure and it therefore becomes practicable to employ a greater charge than the content of the cylinder at atmospheric pressure. Furthermore by retarding the opening of this inlet valve with relation to the closure of the exhaust valve a greater proportion of the mixture can be caused to enter by virtue of its pressure and the compression of the charge may therefore be varied during running of the engine or at any other time means only being required for allowing alteration of the timing of the valve in such a case.

A particular advantage of this arrangement lies in that the maximum period is given by the disposition of the scavenging air inlet at the extreme end of the cylinder for the pressure in the cylinder to fall by exhaustion before scavenging commences this leading to economical scavenging since air at a lower pressure can be used and less of it is necessary. As an example of such an arrangement of the periods may be given one in which commencing at the dead center of one of the cranks the exhaust valve opens after 120° rotation, and remains open for 120°, the scavenging air ports are uncovered 15° after the exhaust ports and remain open until 15° before the exhaust ports close at which moment the charge inlet valve opens and remains so for 35° when it is closed and compression commences.

A further feature of the present invention resides in an engine of the kind described

having in conjunction with rings of ports concaved heads to the pistons of such curvature that eddy currents in the cylinder are avoided. I have observed by experiment that if the head of the piston which co-acts with the scavenging air ports is suitably concaved the inrush of air by these ports occurs in a uniform mass which does not mingle with the products of combustion but acts as a solid mass or wall to expel the same by pushing them along the cylinder, and there being no eddies much less air is required for complete scavenging by using this feature than is required where ordinary pistons are employed. It does not appear to be essential for both pistons where two pistons in a common cylinder are used to be so shaped. The preferred curvature is such that the radius of curvature of the head is the bore of the cylinder. Using the two features above set out I have succeeded in producing complete scavenging of a tandem engine of the kind indicated with air compressed only to two pounds to the square inch.

This invention also consists in the improved internal combustion engine and improved rotary valve hereinafter described.

In the accompanying drawings are shown one manner of carrying the present invention into effect.

Figures 1 and 1ª, together illustrate in sectional elevation two units of a multi-unit two-cycle engine having tandem cylinders. Figs. 2 and 2ª together show a side elevation of the same; and Fig. 3 a plan sectional view on the section line 1—1 of Fig. 1. Fig. 4 shows a sectional view of the middle part of one of the cylinder pairs of the units on the section line 3—3 of Fig. 3.

Referring to these figures, *a* represents the cylinder castings which are connected together as shown in Fig. 4 by an intermediate member, *b*. Each cylinder contains two pistons which are indicated in Fig. 1 by the reference letters *c*, *d*, *e* and *f*. The outer pistons, such as *c* and *f*, are rigidly connected together by a framework composed of rods *g* and *h*. The inner pistons such as *d* and *e* are both screwed into an intermediate casting *i*, through which passes a shaft *j* connected to rods *k* and *l*. These rods *k* and *l* are connected to cranks *m* and *n*, while the end piston, such as the one *e*, is connected by a gudgeon pin *o* and connecting rod *p* to a crank *q* on the crank shaft. An intermediate ball race *r* acts to support the crank shaft, and to prevent whipping of the same. Each cylinder is provided with three rings of ports, an exhaust ring such as *s* in Fig. 1, a ring of combustible inlet ports *t* and scavenging air ports *u*. The compressed gaseous combustible and the compressed air for scavenging are supplied to these ports. The exhaust ports are uncovered by the motion of the pistons, as are the combustible and air inlet ports; but the combustible inlet ports are controlled by a rotary valve such as is shown at *v* in the drawings. This valve consists of a ring embracing the cylinder about the combustible inlet ports, and provided with a series of passages in it co-acting on the one hand with the ports in the cylinder, and on the other hand with ports *w* (see Fig. 4) formed in the combustible supply duct. The combustible and air supply ducts comprise a hollow casting *y* forming part of and passing around the engine, having passages in it for the air and for the mixture which enter the same by the air inlet 1 and the combustible inlet 2, having been previously compressed to the desired pressure. The air passes along the duct 3 in the hollow casting *y* and is distributed by an annular passage 4, to the air ports of each of the cylinders, as is shown in Fig. 4. The gas which enters at the inlet 2 passes along the passage 5, and directly through the ports *w*, and the perforations in the rotary valve, which is suitably situated, into one of the cylinders, passing also by way of the ducts 6 and the ports *w* of the other cylinder when the other valve is in suitable position. In this way, by the use of a single hollow casting and ducts such as are indicated both cylinders are supplied by only the two combustible and air inlets 1 and 2. The rotary valve, the essential of which is that it shall have maximum port area with minimum waste of combustible due to clearance losses obtainable by a valve embracing the cylinder consists merely of the ring provided with gear teeth on its exterior surface. It is provided at suitable intervals with passages which curve through 90 degrees, so that they pass from one surface of the ring, which co-acts with the ports *w* to the other surface, which co-acts with the ports *t* of the cylinder, with a minimum of constriction and with a minimum of volume, so that no appreciable quantity of gas is wasted or lost as the result of becoming trapped in it when the valve closes. The rotary valve is caused to set firmly by the pressure of a ring 7 which presses against it under the action of a spring 8, wound around a pin 9 rigid in a lug 10 on the cylinder casting. By accurately surfacing the member 7 upon the surfaces which bear upon the rotary valve, and upon the cylinder, an accurate and gas-tight fit can be obtained.

It will be seen that many different ways of constructing a rotary valve of this nature are practicable, provided always that it has the essentials above indicated, which are apparently most satisfactorily brought about by having a series of small ducts in the rotary valve which turn through 90 degrees, and co-act on the one hand with the ported

surface of the cylinder, and on the other hand with a ported surface of a combustible trunk.

A particular advantage of the rotary valve with two surfaces at right angles lies in the ease with which gas tightness is maintained by pressing the ring well into the angle of the cylinder walls which respectively bear the ports into the cylinder and the ports in the gas duct.

In the form shown in the drawings the valve is rotated by co-action of its geared surface with gear wheels 11 mounted upon a lay shaft 12, operated by worm gearing 13. In the form of power unit described, the gas or combustible or inlet ports have been described as disposed at the inner extremities of the cylinders. This is, however, only employed in as far as it is advantageous as allowing simplified constructions of combustible and air trunks, and reducing the length and number of the same.

It will be understood that the application of the rotary valve is not limited to a power unit of the kind illustrated, but may, as before indicated, be applied in many different ways.

The water jackets which are provided around the cylinders and exhaust valve ports may be of any suitable type, and are preferably constructed where they surround the cylinder with cooling ribs, which act not only to distribute the cooling medium more effectively, but act to assist cooling by conduction through them. Such ribs are indicated at 14 in Figs. 1 and 4, and are preferably composed of a multi-thread spiral of high pitch. They may be formed by casting them upon the cylinder.

The operation of the engine is as follows:—Assuming the unit shown in section in Fig. 1 to be considered, and an explosion to have occurred in the lower cylinder, the pistons are moved apart, this motion acting to compress the charge which is in the cylinder nearest the top of the sheet, and after a short travel, the piston *c* will uncover the exhaust ports, and exhaustion will commence. The continued motion of the upper piston will uncover the combustible inlet port, but no mixture will enter, owing to the valve not yet being open. Further motion of the upper piston uncovers the scavenging air ports, and scavenging ensues and continues until return of the piston cuts off the scavenging supply at this moment, and just as the exhaust ports are being covered, the rotary valve opens, and compressed rich mixture enters. Continued motion of the piston closes the mixture inlet ports, compression ensues, and explosion, when the cycle re-commences.

It will be seen that the cycle of operations in the two cylinders of each unit is displaced by 180 degrees, as also is the opening of the rotary valve. It will be seen that in this cycle, the cushion of air is introduced between the incoming charge and the outgoing exhaust products which must be effective in avoiding loss of mixture and premature ignition, by contact with the burned charge. The piston heads in the form of engine illustrated are both concaved, and have the radius of curvature above referred to, for the purpose of avoiding eddies, although, as indicated, only the piston *d* is essentially so formed.

An engine as shown is particularly advantageous, as being one in which the construction and arrangement of the operations of the cycle are such that stresses and variations of stress transmitted to the crank shaft are as small as possible, the reactions due to acceleration and retardation of moving parts are balanced, and negative work is practically avoided.

It will be understood that several power units, such as are indicated, may be combined, as for marine purposes, to act in any number desired upon the same crank shaft, such combinations producing remarkably balanced power systems, in which the variation of crank effort is reduced to a minimum.

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

A scavenging internal combustion engine having a cylinder, with a ring of exhaust ports at one end of the same, and a ring of gaseous combustible and a ring of scavenging air inlet ports at the other end, two pistons adapted to move oppositely in said cylinder, and the one adapted to uncover the exhaust ring of ports, and the other to uncover the two other rings of ports aforesaid, a rotary ring valve embracing the ring of said two rings of ports nearer the center of said cylinder, and having a surface substantially perpendicular to the surface which embraces the cylinder ports, these two surfaces being connected by ducts, and a gas duct in proximity to said cylinder provided with a ring of ports, said ring valve being adapted by angular movement to place the ring of ports which it embraces on the cylinder in communication with the ring of ports in the gas duct; as set forth.

In testimony whereof, I affix my signature in presence of two witnesses.

WILLIAM JOSEPH STILL.

Witnesses:
CYRIL F. L. NURSEY
R. A. OUTHWAITE.