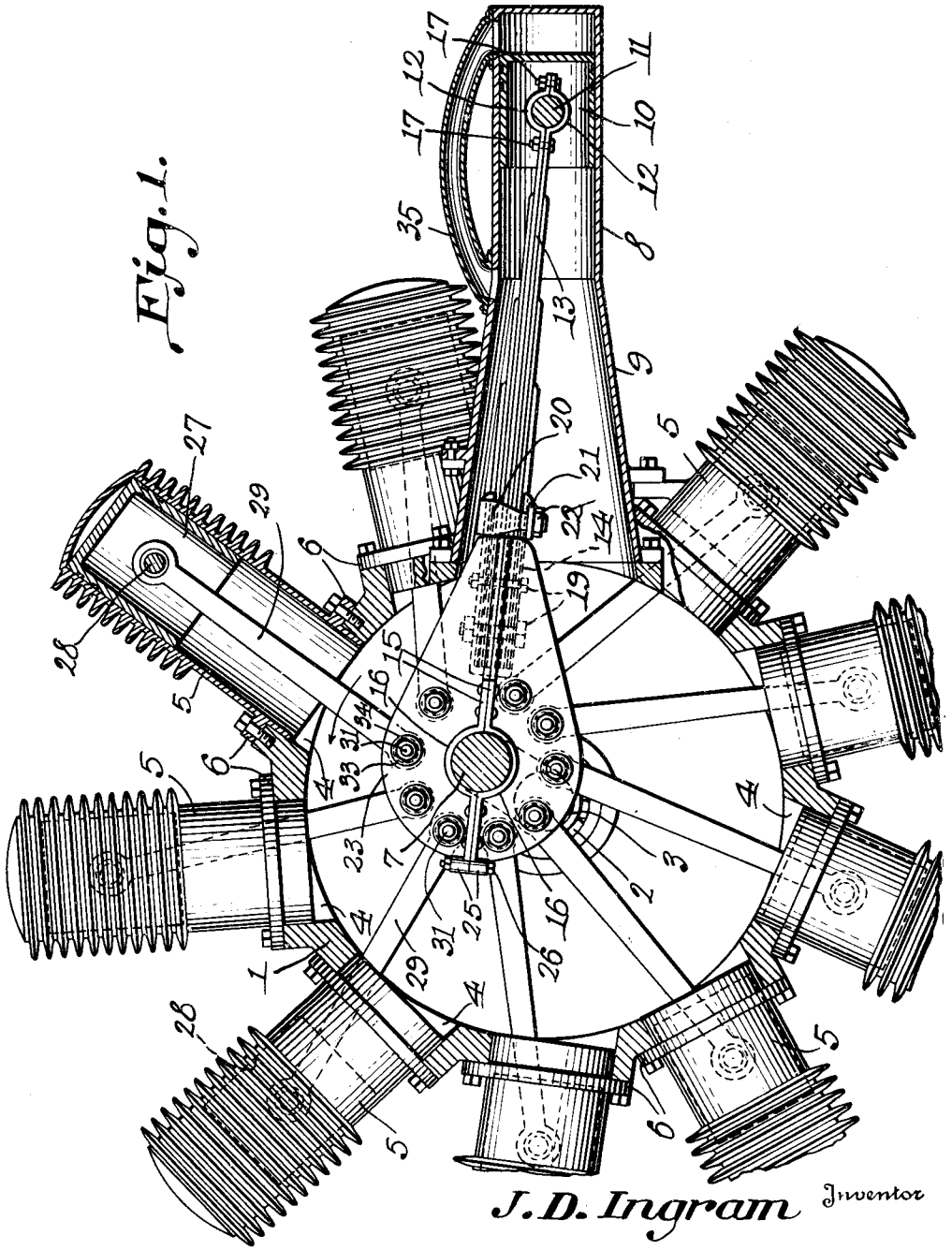
May 1, 1934. J. D. INGRAM 1,956,922

INTERNAL COMBUSTION ENGINE

Filed April 25, 1932 2 Sheets-Sheet 1

Fig. 1.



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INTERNAL COMBUSTION ENGINE

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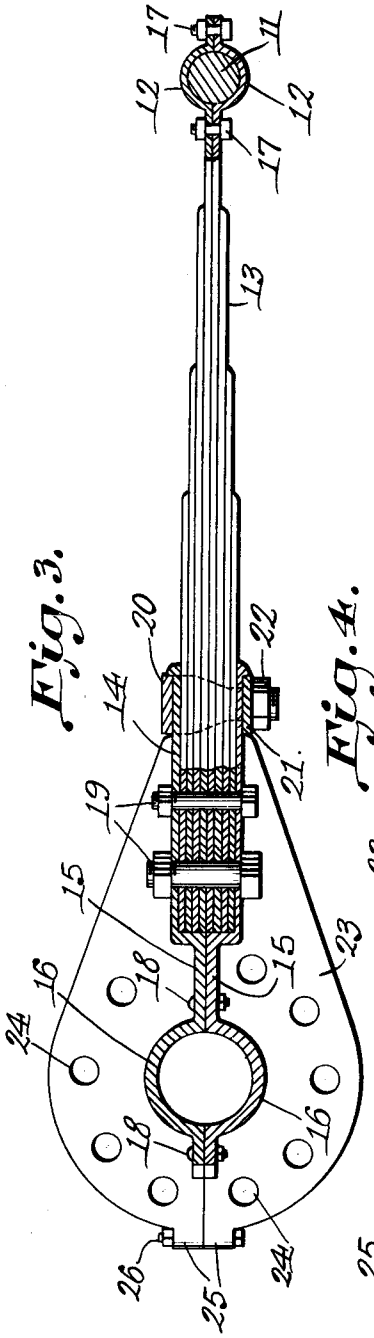


Fig. 3.

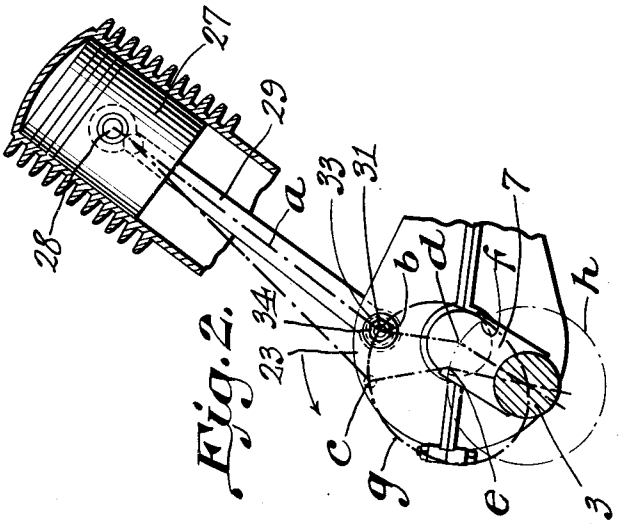


Fig. 2.

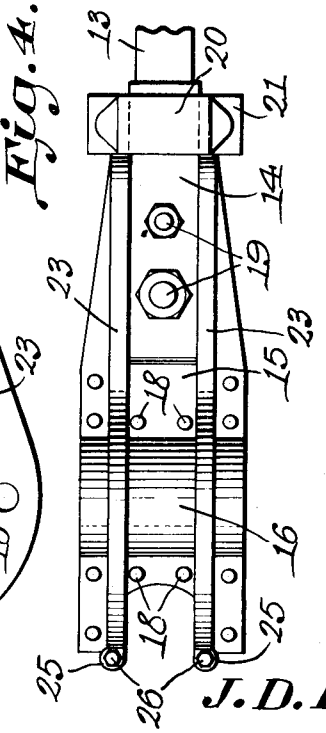


Fig. 4.

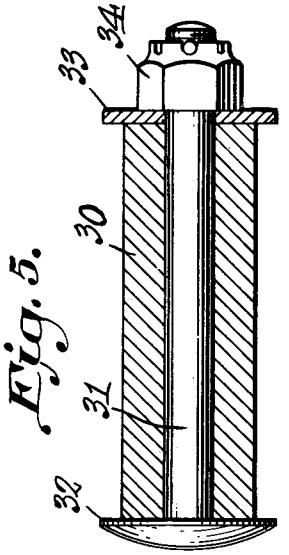


Fig. 5.

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UNITED STATES PATENT OFFICE

1,956,922

INTERNAL COMBUSTION ENGINE

Joseph D. Ingram, La Jolla, Calif.

Application April 25, 1932, Serial No. 607,388

6 Claims. (Cl. 123—54)

This invention relates to internal combustion engines of that type utilizing a plurality of cylinders extending outwardly from a crank case whereby the connecting rods of the pistons in the cylinders can all be mounted so as to exert successive driving forces upon the crank in the case.

One of the objects of the invention is to increase the leverage exerted from each piston upon the crank without necessitating the lengthening of the crank.

A further object is to so arrange the cylinders that their longitudinal axes will be along lines extending in advance of the axis of rotation of the crank whereby the crushing and crystallizing effect resulting from firing on dead centers is practically overcome.

A still further object is to utilize a resilient master connecting rod joining the crank to a guide piston at one end and to the several driving connecting rods at its other end whereby a cushioning action is set up for relieving side thrusts upon the guide piston resulting from the successive applications of power to the crank end of the resilient master rod.

A further object is to provide a novel form of yoke-head on the resilient master rod to which the connecting rods of the power piston are connected, the points of connection being so located as to insure maximum leverage upon the crank before the initial force of the explosion in each cylinder is expended.

Another object is to lighten the motor, increase the life thereof by eliminating many of the strains to which a motor of this general type is subjected and to reduce the amount of fuel required for operation.

With the foregoing and other objects in view which will appear as the description proceeds, the invention resides in the combination and arrangement of parts and in the details of construction hereinafter described and claimed, it being understood that changes in the precise embodiment of the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

In the accompanying drawings the preferred form of the invention has been shown.

In said drawings:

Figure 1 is a central vertical section through the motor, some of the cylinders being in elevation and some of them being broken away.

Figure 2 is a view showing in diagram the action of each power piston in exerting a thrust in advance of the dead center so as to vary the leverage upon the crank shaft.

Figure 3 is an enlarged view partly in central vertical section and partly in side elevation of the resilient master rod.

Figure 4 is a plan view of the yoke-head of the master rod the coupling pins being removed.

Figure 5 is a section through one of the yoke pins.

Referring to the figures by characters of reference, 1 designates a crank case concentric with the bearings 2 of a crank shaft 3 and this crank case is provided at intervals in its periphery with openings 4 in which are mounted the inner ends of cylinders 5. These cylinders can be secured to the crank case by bolting flanges 6 thereto. When the cylinders are properly located their longitudinal axes will be out of line with the axis of rotation of crank shaft 3 and, as indicated particularly in Figure 2, each longitudinal axis a is extended in advance of the axis of rotation of the shaft and at no time alines with crank 7.

An elongated cylinder 8 is extended from the crank case 1 and has its inner portion preferably flared toward the crank case, as shown at 9. In this cylinder 8 is mounted a guide piston 10 the pin 11 of which is embraced by opposed yokes 12 each located at one end of a laminated spring 13. The other ends of the two springs are extended into a socket 14 formed by opposed plates 15 and these plates, in turn, are provided with opposed semi-cylindrical portions 16 which cooperate to form a bearing sleeve.

In addition to the bolts 17 which are used for holding the yokes or split sleeve 12 in engagement with pin 11, the plates 15 are bolted together close to opposed portions of the sleeve 16, as shown at 18. Additional bolts 19 are extended through the socket 14 and those portions of the springs therein. As an additional means for holding the plates 15 together they are straddled by a clip 20 the threaded ends of which are extended through a clamping plate 21 and engaged by nuts 22.

Split sleeve 16 is mounted on the crank 7 and each of the plates 15 is provided adjacent to its sides with parallel flanges 23 provided with openings 24 adjacent to their outer edges, these openings being disposed in a circular series concentric with sleeve 16. If desired those ends of the flanges remote from socket 14 can be formed with alining sleeves 25 for receiving tie bolts 26 which thus constitute a further means for preventing spreading of sleeve 16.

Sleeve 16, plates 15 and flanges 23 form a yoke

and the laminated springs 13 constitute a resilient master rod which connects this yoke to the pin 11 in piston 10.

Each of the cylinders 5 has a power piston 27 mounted for reciprocation therein and the pin 28 in each cylinder has a connecting rod 29 which extends inwardly from its cylinder and into a space between the flanges 23 of the yoke. The openings 24 in these flanges provide seats for the ends of tubular bearing members 30 through which pins 31 are extended, these pins having heads 32 at one end and washers 33 at their other end for laping the outer sides of the flanges and holding the sleeves 30 against displacement. Each pin 31 and its washer 33 can be fastened in place by a nut 34.

Each of the bearing sleeves 30 is engaged by one of the connecting rods 29 and, as shown particularly in Figure 2, when a connecting rod is extended axially of its cylinder, as at the instant of firing, the center line thereof is not on a dead center with the crank 7 but extends in advance of the crank so that the explosive force will not exert a crystallizing or crushing effect upon the parts but will, on the contrary, be expended with a powerful leverage effect on the crank, which leverage will increase as the force of the explosion diminishes. For example, as the piston 27 moves inwardly the point of connection 31 with the yoke will move with gradually increasing speed in the direction of rotation of the crank. For example, should the pin 31 move from point *b* to point *c*, the distance thus travelled would be twice the distance from *d* to *e* travelled by the crank 7. Thus the leverage exerted is much greater than that which could be obtained by any direct connection between the connecting rod 29 and the crank 7 because the thrust is along lines more remote from the dead center.

The several pistons operate in rapid succession, the action of each piston being duplicated by that of the others. Obviously the exertion of thrust along lines in advance of the point of connection between the yoke and the crank will tend to set up an excessive transverse pressure or whipping action upon the guide piston 10. This is greatly reduced, however, by utilizing the resilient master rod 13 which acts as a shock absorber and insures smooth and quiet operation. It is evident that by using a long master rod the movement of the yoke out of the plane of its piston will be correspondingly reduced, thereby reducing the elliptic circles and side thrust that destroy balance at high speed. The average service plane wears out three motors, due mostly to the fact that the yoke is attached to a short power rod.

The pin 31 is located at a distance from the point *d* equal to the distance of said point *d* from the axis of shaft 3 and the distance between point *d* and the nearest point *f* of the path *g* described by pin 31 is one-fourth of the smallest diameter of said path. See Figure 2. The path *g* intersects circle *h* described by point *d*, as shown in Figure 2. Consequently the back pressure set up by those pistons 27 where exhaust and compression is taking place will be greatly reduced as compared with engines in which the connecting rods are attached directly to the crank shaft.

In an engine constructed as described, at least two pistons will constantly transmit power in substantially the same direction to drive the crank shaft and to exert a lateral thrust against the master connecting rod 13 and its piston 10. Thus there is no danger of this master rod exerting a whipping or slapping action such as would occur should the power be transmitted abruptly and intermittently from the pistons to the yoke

Importance is attached to the fact that while pin 31 travels in a path which is eccentric to shaft 3 the group of paths and piston assembly are balanced exactly off center of the crank shaft. A by-pass 35 is mounted in cylinder 8 so as to permit free reciprocation of piston 10 when desired.

What is claimed is:

1. An engine of the class described including a crank case, a crank shaft therein, cylinders extending outwardly from the case with their longitudinal axes out of line with the axis of rotation of the shaft, pistons mounted for reciprocation in the cylinders, a yoke mounted on the crank of the shaft, connecting rods joining the pistons to the yoke, the point of connection between each rod and the yoke being in advance of the dead center of the crank shaft, and resilient shock absorbing means for restraining the yoke against rotation upon the crank.

2. An engine of the class described including a crank case, a crank shaft therein, cylinders extending outwardly from the case with their longitudinal axes out of line with the axis of rotation of the shaft, pistons mounted on the crank of the shaft, connecting rods joining the pistons to the yoke, the point of connection between each rod and the yoke being in advance of the dead center of the crank shaft, shock absorbing means for restraining the yoke against rotation upon the crank, including a stationary cylinder, a piston mounted for reciprocation therein and a resilient master rod rigidly connected to the yoke and pivotally joined to said piston.

3. In an engine of the class described the combination with a shaft having a crank, a crank case housing the crank and cylinders extending outwardly from the case, of power pistons mounted for reciprocation in the cylinders along lines out of line with the dead center of the crank, a yoke mounted on the crank, a resilient shock absorbing master rod rigidly connected to the yoke and mounted to oscillate and reciprocate, and rods connecting the power pistons to the yoke at points spaced from the center of the crank a distance equal to that between the center of the crank and the axial center of the shaft, each of said points being in advance of dead center of the crank whereby the point of connection between the connecting rod and the yoke will travel at twice the speed of the axial center of the yoke, during the power stroke.

4. An engine of the class described including a shaft having a crank, a split yoke carried by the crank, a resilient master rod fixedly connected to the yoke, a cylinder, a piston in the cylinder and connected to the master rod whereby reciprocation and oscillation of the yoke is set up by rotation of the crank, fixed cylinders, power pistons therein, connecting rods extending from said pistons, and means joining each connecting rod to the yoke at a point out of line with the dead center of the crank and in the direction of rotation of the crank when the piston of said rod is at its point of maximum compression whereby said point of connection is caused to travel in a path intersecting the path of movement of the crank.

5. An engine including a shaft having a crank, radial cylinders, pistons in the cylinders, connecting rods, and means movable with and adapted to oscillate upon the crank for connecting

said rods at points in advance of the dead center of the crank and guiding the points of connection in paths eccentric to the shaft thereby to increase crank vantage on the power strokes and reduce back pressure vantage by each piston during its exhaust and compression strokes, said means including a yoke on the crank, a resilient master rod fixed to and extending from the yoke and mounted for oscillation and reciprocation, and a stationary guide for the outer end of the master rod.

6. An engine including a shaft having a crank, radial cylinders, pistons in the cylinders, connecting rods, and means movable with and adapted to oscillate upon the crank for connecting said rods at points in advance of the dead center of the crank and guiding the points of connection in paths eccentric to the shaft thereby to reduce back pressure vantage by each piston during its exhaust and compression strokes, said means including a yoke on the crank, a master rod fixed to and extending from the yoke, a piston pivotally connected to the outer end of the master rod, and a stationary guide cylinder for the piston.

JOSEPH D. INGRAM.