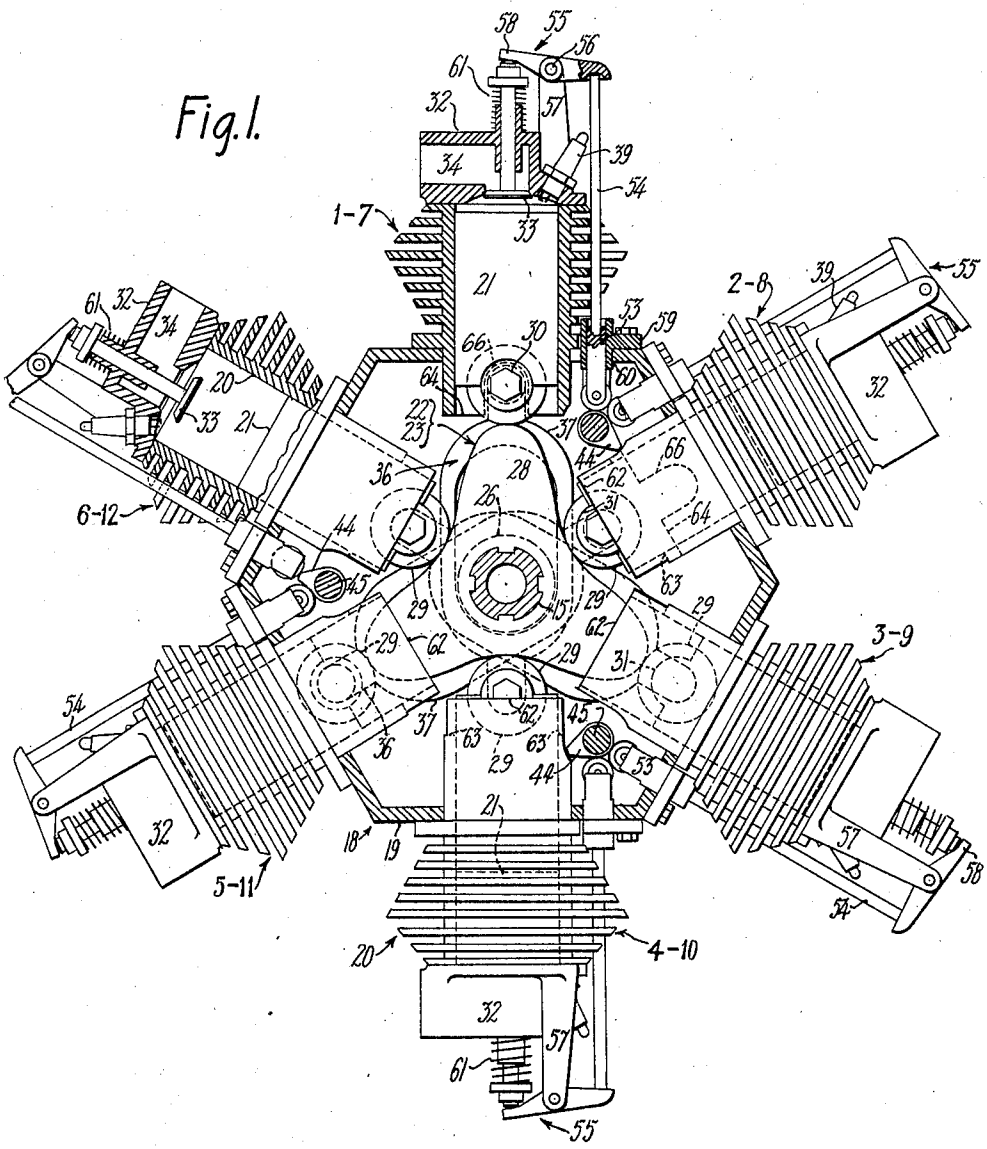
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INTERNAL COMBUSTION ENGINE

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Fig. 1.



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Fig.2.

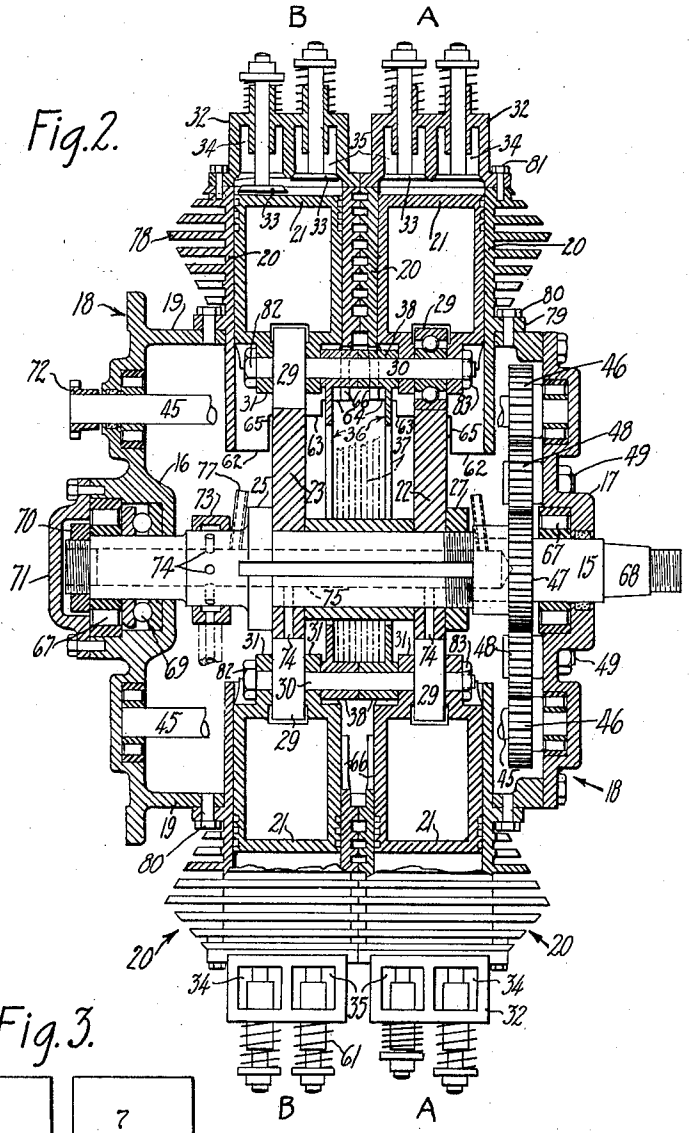
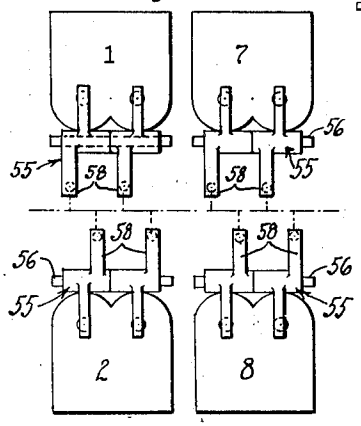


Fig.3.



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Fig. 4.

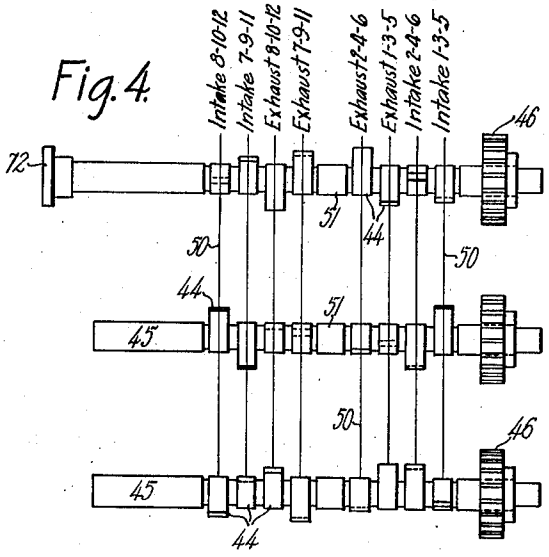


Fig. 5.

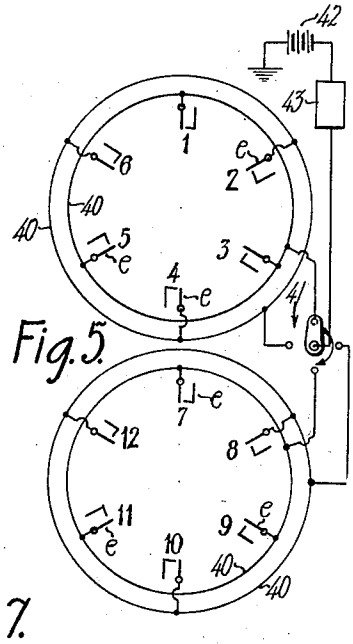


Fig. 7.

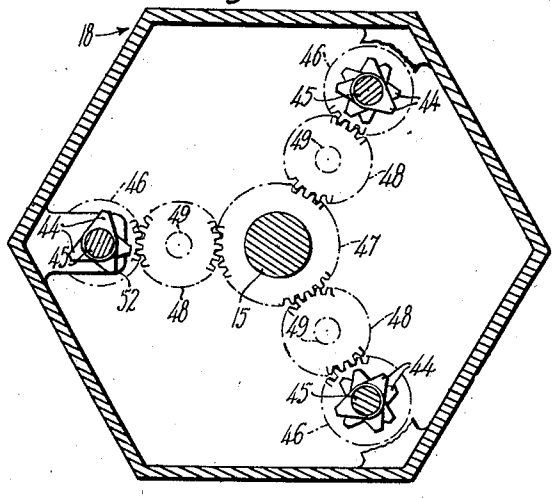
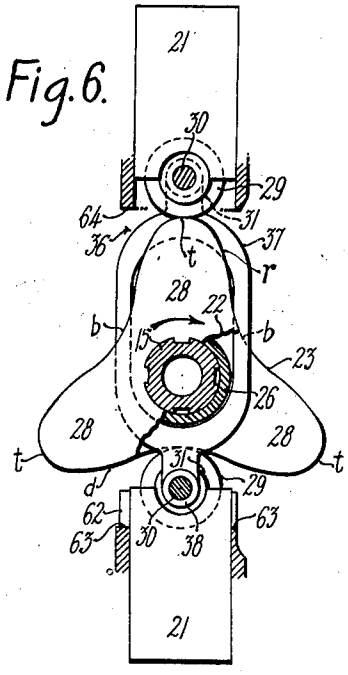


Fig. 6.



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Patented Nov. 3, 1931 1,830,046

UNITED STATES PATENT OFFICE

FRANK WHITE, OF NEW YORK, N. Y.

INTERNAL COMBUSTION ENGINE

Application filed September 28, 1928. Serial No. 308,937.

This invention relates mainly to internal combustion engines, and particularly to those of light weight, as, for example, airplane engines.

It is a feature of the present invention to secure very high speed of the reciprocating pistons of the engine, thereby keeping down the size and weight of the engine, and economizing the fuel for the purpose stated, and moreover, to balance the reciprocating parts of the engine, so as to insure smooth running and also to permit still higher rate of revolution while keeping the propeller-shaft rate down to its aforesaid low limits. The necessity of the use of said train of gearing between the engine and the propeller-shaft is avoided, and the pistons are connected to the propeller-shaft in a way to cause reciprocating parts to be self-balancing. Moreover several reciprocations of each piston are provided for during each single revolution of the shaft.

Other features and advantages will hereinafter appear.

In the accompanying drawings,

Figure 1 is a cross-sectional view of the engine taken transversely of the main shaft and through some of the cylinders.

Figure 2 is a view of a cross-section extending longitudinally of the main shaft and through a group of diametrically opposite cylinders.

Figure 3 is a diagram illustrating an arrangement of valve-operating mechanism.

Figure 4 is a view illustrating the arrangement of the valve-operating cams or camshafts.

Figure 5 is a wiring diagram for the ignition devices to illustrate the concurrent firing of three alternate cylinders.

Figure 6 is a detail view showing diametrically opposite pistons and details of means fixedly connecting and spacing said pistons for making their cam-followers adhere to their respective cam-surfaces.

Figure 7 illustrates three cam-shafts along which the valve-operating cams may be distributed, and also shows the driving connections of said shafts to the main shaft.

The main shaft 15 of the engine is journaled in ends 16—17 of a casing 18, which encloses said shaft and has faces 19 for supporting in radial array around said shaft two groups A and B of cylinders 20, each cylinder having a piston 21. Each group has an even number of cylinders, namely, six spaced 60 degrees apart, and the cylinders of one group are spaced, lengthwise of the main shaft, from the cylinders of the other group as in Figure 2.

The pistons reciprocate in the usual four-stroke cycle for driving the main shaft 15 to which they are operatively connected by novel cams 22—23 and connections, there being one cam for each cylinder group A and B. Said cams may be keyed to the splined main shaft as indicated, and one cam may abut a flange 25 of said shaft and be spaced from the other cam by a sleeve 26; the cams being thus located lengthwise of said shaft, so that each cam is in line with the central plane of its cylinder group A or B. A nut 27 may secure the cams on said shaft.

Each cam has three lobes 28, all of the same contour, spaced 120 degrees apart and forming alternate rises and drops. Cam-rollers 29 for the several pistons are directly mounted on the inner piston ends, and are preferably of roll or ball bearing type. A transverse bolt 30 may connect each two pistons that are in line lengthwise of the main shaft, and may serve as a common stud with journals for the rollers 29 of the pistons thus paired, said bolt passing through spaced-apart ears 31 formed at the inner end of each piston and between which ears a roller 29 is retained. For the six radial planes of cylinders there are six bolts 30.

Each cylinder has a detachable head 32 in which may be fitted poppet-valves 33 for opening and closing fuel intake and exhaust passages 34 and 35, respectively, formed in said head.

From Figures 1 and 2, it will be seen that each piston is opposite another piston diametrically of the main shaft, and that by reason of the odd number (three) of cam-lobes 28 the diametrically opposite pistons always move in the same direction, and hence

may be positively and rigidly connected, the diametrically opposite cam rise and drop contours being to this end made complementary. The space separating the cams 22—23 lengthwise of the main shaft affords room for such connections between the diametrically opposite pistons, and which connections, in the form of links 36, may be attached to the transverse bolts 30. Each link 36 has an elongated loop 37 to clear the main shaft and its surrounding sleeve 26. Each end of a link 36 has a hub 38 in which the bolt 30 is fitted. The length of the link between hubs is such that, in conjunction with the complementary forms of the diametrically opposite cam-surfaces, the rollers 29 of each four pistons thus connected together are always kept in contact with their respective cam-surfaces. Each group of said four pistons may have two links 36 spaced lengthwise of their respective hubs 38 for distributing the pull of the links symmetrically between the cams 22—23, the loops 37 of the several links for the different groups of four connected pistons extending in different planes to clear one another, as indicated by the dot-and-dash lines in Figure 2. For the three groups of four connected pistons three pairs of links 36 are required, as indicated in Figure 1. Each bolt 30 may have a head 82 and a nut 83 to abut the piston ears 31 and keep said bolt in place.

In the drawings, the complementary rise-and-drop cam-contours are represented as corresponding substantially to uniformly accelerated and decelerated reciprocatory piston movement. Referring to Figure 6 and the direction of rotation indicated by the arrow, the cam-surface r between a top t and a bottom b of the cam represents a rise; and the surface d between a top t and bottom b represents a complementary and diametrically opposite drop.

In each main shaft revolution, each piston makes six strokes or two strokes for each cam-lobe. With a cam having three lobes, each piston therefore completes its four-stroke cycle in two-thirds of a main shaft revolution. For balancing all the strokes of said cycle from opposite sides of the main shaft to minimize vibration, three alternate pistons, 120 degrees apart, around said shaft operate concurrently on each stroke in either the A or B group of cylinders. For explaining the cycle sequence, the several pistons with their respective cylinders are numbered from 1 to 6 in group A and from 7 to 12 in group B, as indicated in Figure 1. Thus cylinders 1—3—5 may fire concurrently, then cylinders 8—10—12, then cylinders 7—9—11, and then cylinders 2—4—6, the concurrence of the firing strokes being indicated by the ignition diagram in Figure 5. which represents the electrodes e of ignition plugs 39 for the several cylinders of the two groups A and B, the plugs 39 of every three alternate cylinders being represented as having their undergrounded electrodes connected by a wire 40 for simultaneous sparking. The diagram also represents the connections of the wires 40 to a distributor 41 and spark-generating source, such as a battery 42 and coil 43. The plugs 39 are inserted in the cylinder-heads 32.

Inasmuch as each piston completes its four-stroke cycle in two-thirds of a main shaft revolution, cams 44 for operating the poppet-valves 33 rotate at one and a half times the main shaft speed; that is to say, for two-thirds of a main shaft revolution, the cams 44 make one revolution. The valve-cams 44 are distributed along three cam-shafts 45 journaled in the ends 16—17 of the casing 18 and spaced around and from the main shaft 15 and between adjacent radial planes of cylinders, as indicated in Figures 1 and 7, so that each cam-shaft may serve four cylinders, that is, two cylinders in each group A and B. Each cam-shaft 45 has fastened thereto a pinion 46, and the three cam-shafts are driven by a common gear 47 fastened to the main shaft and which gear 47 may be connected to each pinion 46, through an intermediate gear 48 which may rotate on a stud 49 carried by the casing end 17.

As indicated in Figure 4, each cam-shaft 45 has spaced therealong eight of the cams 44, that is, one intake and one exhaust cam for each of the four cylinders which said each cam-shaft 45 serves. The intake-cams for the alternate cylinders 1—3—5 are time-spaced on their respective cam-shafts 45 to operate their intake-valves concurrently on the concurrent intake-strokes of said cylinders. Similarly, the exhaust-cams for said three cylinders 1—3—5 are also time-spaced to operate the exhaust-valves on the concurrent exhaust-strokes of said cylinders. In like manner are the intake-cams for each of the alternate-cylinder groups 8—10—12, 7—9—11 and 2—4—6 timed to operate their intake-valves concurrently for the intake-strokes of their respective groups, the exhaust-cams for each group 8—10—12, 7—9—11 and 2—4—6 being also timed for concurrence of their valve-operation. Figure 4 indicates by each cross-line 50, timing coincidence of three cams, one on each cam-shaft, for the intake and exhaust strokes of the several alternate-cylinder groups 1—3—5, etc. For additional support each cam-shaft 45 may have a middle portion 51 journaled in a bearing 52 extended from the casing 18, Figure 7.

Each valve-cam 44 operates its valve through a tappet 53, and a push-rod 54 connecting said tappet to a valve-lever 55, rockable on a shaft 56 journaled between bearings 57, which may extend from opposite sides of the cylinder-head 32, each shaft 56 carrying

the valve-levers 55 for both the intake and exhaust valves of said head 32, Figure 3.

As shown in Figure 3, in which for convenience of illustration the cylinders 1—7 are assumed to be parallel to cylinders 2—8, the arms 58 of the four-valve levers for said cylinders 1—7 may be staggered in respect to the similar arms of the four-valve levers for said cylinders 2 and 8, the tappets of cylinders 1 and 7 being thus interspaced with the tappets for cylinders 2 and 8 to present the eight tappets in a line corresponding to the line of eight cams 44 on the cam-shaft which serves said cylinders 1—7 and 2—8. The same arrangement is effected for the connections from the other cam-shafts to their respective cylinder-valves. The tappets 53 may be guided in blocks 59 having tappet guides 60 and being secured to the casing 18, Figure 1. Each valve is closed as by a spring 61.

The two groups of cylinders or pistons, A—B, twelve in all, afford four groups of three alternate pistons each, and the cycles of which four groups may be evenly phased as measured by angular displacement of the main shaft. Inasmuch as a cycle for each of said four groups is completed in two-thirds of a main shaft revolution and the cycles for the several groups are evenly phased, it is evident that, for a whole main shaft revolution, six cycles are evenly phased. Hence there are six evenly phased power-strokes in each main shaft revolution. The adequate number, even phasing, and balancing of the power-stroke from opposite sides of the main shaft, as aforesaid, provide smooth power output and freedom from vibration, the latter being effected not only in respect to the piston-masses and their connections without the use of special counterweights or similar devices, which of themselves contribute no power and reduce the efficiency of the engine and increase its weight, but also in respect to the firing forces, the compression forces, etc., of the four-stroke cycle.

The pistons are of the slipper type, and may be adequately guided to the bottoms of their strokes by extending the cylinder-walls into the casing. To this end, a portion 62 of each cylinder-wall may extend substantially to the inner end of the piston when it is at the bottom of its stroke and may be stepped back as at 63 to clear the tops of the cam-lobes 28 and then stepped back further as at 64 to clear the ends of the loops 37 of the links 36. The portion 62 may be brought close to the adjacent side of the cam 22 or 23 as at 65, Figure 2. The cylinder-wall-portion which is stepped back to 64 may have a notch 66 for clearing the hub 38 of the link 36.

Roller bearings 67 may be provided for the main shaft journals. If a screw-propeller be attached to the main shaft, as at 68, a thrust bearing 69 may be provided adjacent the bearing 67 and retained in the casing-end 16, as shown in Figure 2. A nut 70 threaded on the end of the main shaft serves to transmit the thrust to the thrust bearing 69. A removable cap 71 opposite the end of the main shaft in the casing-end 16 facilitates assembly of the parts enclosed in said casing-end. The casing-end 17 may also be removable to facilitate assembly.

One of the cam-shafts 45 may project through the casing-end 16, and may have a connection 72, Figure 2, to drive the ignition mechanism which includes the distributor 41, Figure 5.

Variations may be restorted to within the scope of the invention, and portions of the improvements may be used without others.

Having thus described my invention, I claim:

1. An internal combustion engine including cylinders, a main shaft, twelve reciprocatory pistons operable in firing and preparatory strokes toward and from said shaft, said pistons disposed in a radial array surrounding said shaft, means inclusive of evenly-spaced cam-lobes and operatively connecting said pistons and main shaft and effective for producing three firing strokes per piston for two main shaft revolutions, whereby the firing strokes in certain pistons on opposite sides of said shaft may take place concurrently, thereby to balance said strokes and minimize vibration, and means for controlling the intake, compression, explosion and exhaust of fuel in each of said cylinders in accordance with its piston-strokes due to co-operation with said cam-lobes seriatim.

2. A four-stroke cycle internal combustion engine including a main shaft, a bank of six power-cylinders and pistons spaced radially around said shaft, a second bank of six cylinders and pistons also spaced radially around said shaft, the second bank being spaced lengthwise of the shaft from the first bank, means operatively connecting said pistons and shaft, and means whereby the cycles occurring in the two banks are phased at even intervals as measured by angular displacement of said shaft.

3. A four-stroke cycle internal combustion engine having a main shaft, twelve radial cylinders surrounding said shaft, a piston in each cylinder, means operatively connecting the pistons and shaft whereby said pistons are reciprocated and said shaft rotated, fuel intake and exhaust valve mechanism, ignition mechanism, the twelve cylinders being arranged to prevent four groups of three cylinders each, said three spaced 120 degrees apart around said shaft, said piston and shaft connecting means and the valve and ignition mechanisms being arranged to effect concur-

rent firing strokes in one group of three cylinders, said strokes repeated in succession in each of the other groups, the other strokes of the four-stroke cycle in each group also being concurrent, said engine being thus balanced in respect to the piston masses and their strokes.

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