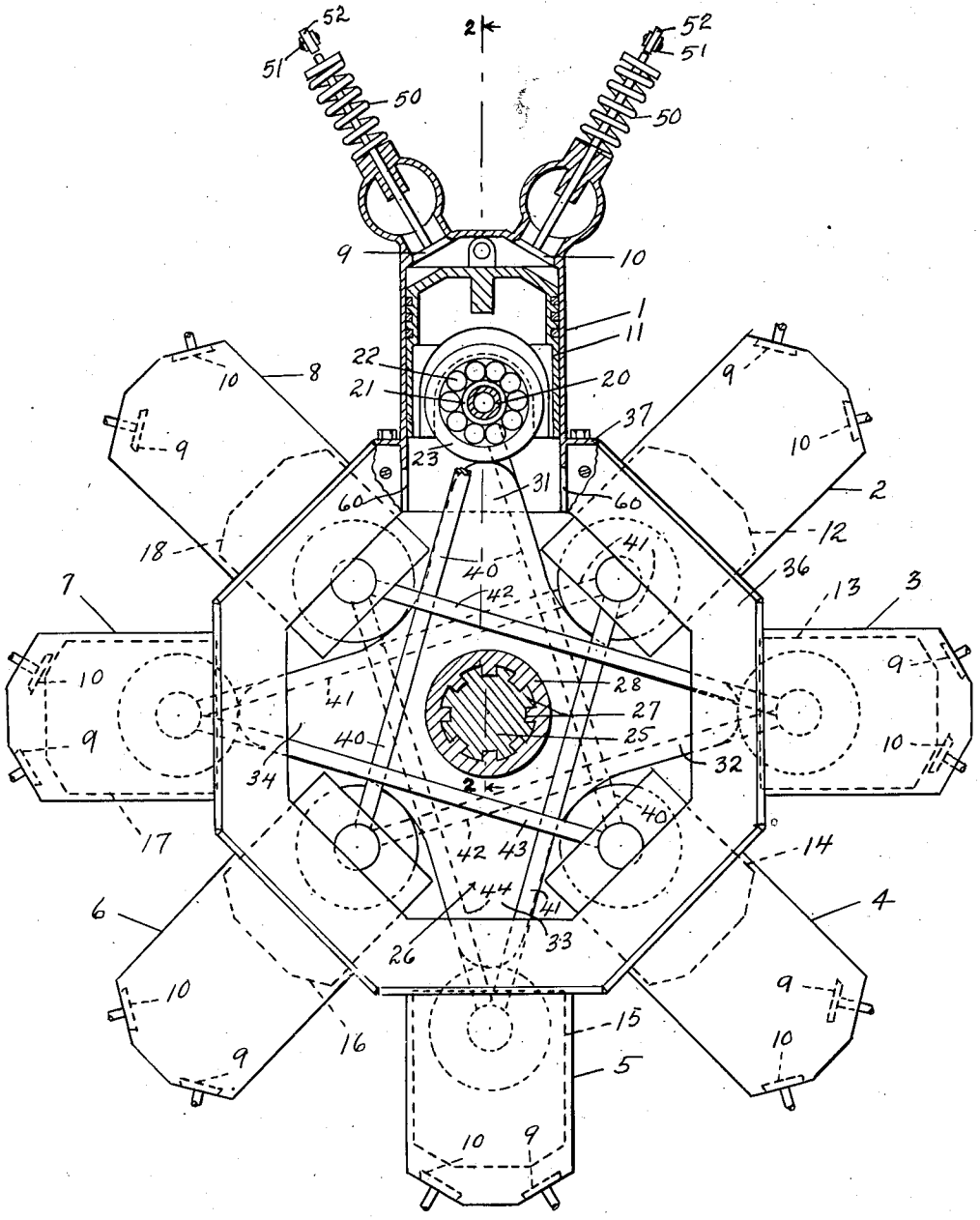
July 26, 1949. O. E. IRVING 2,477,061

RADIAL ENGINE

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Fig. 1.



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Fig. 2.

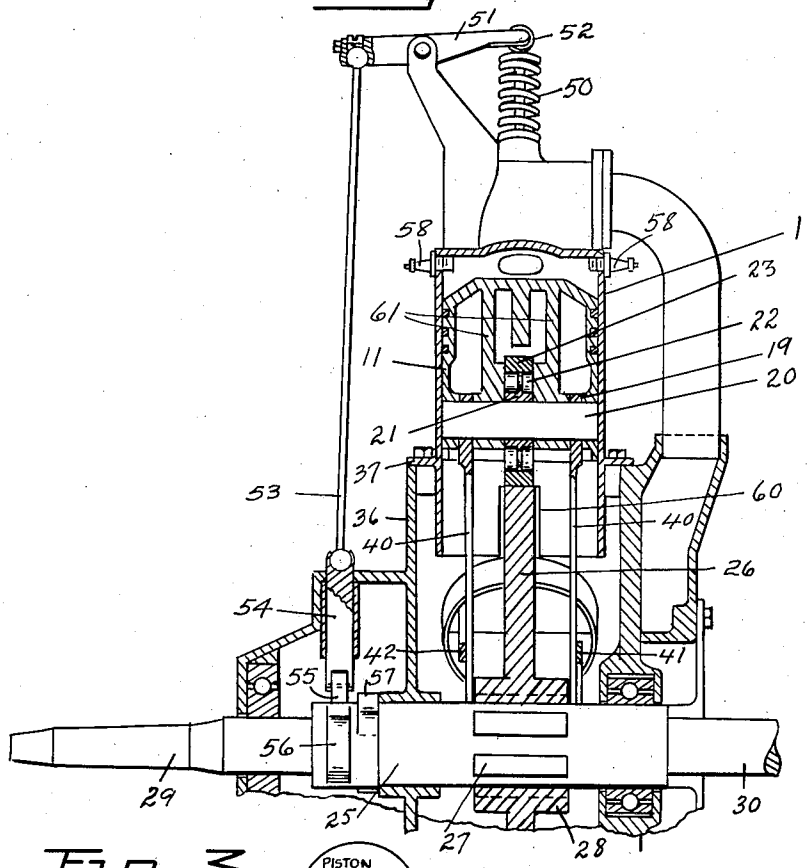
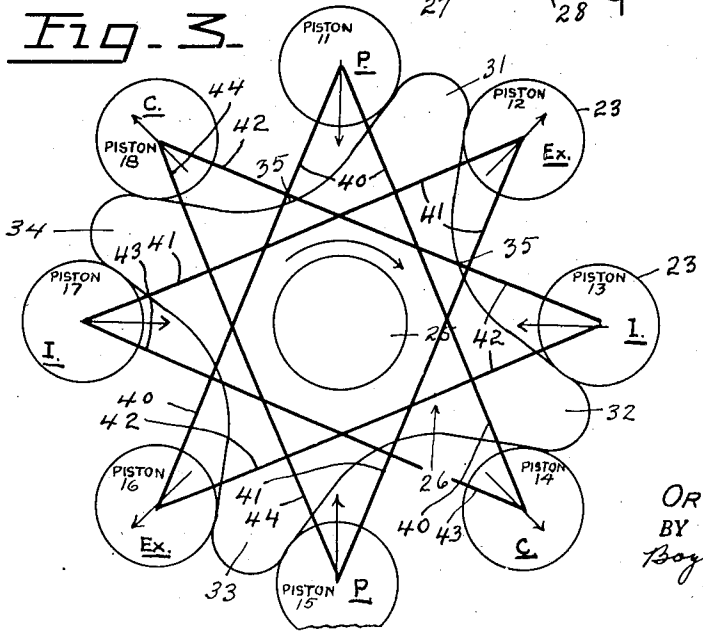


Fig. 3.



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RADIAL ENGINE

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This invention relates to radial engines and has for one of its objects the provision of an improved internal combustion radial engine that is adapted to produce more horse power per pound of weight than conventional radial engines heretofore made, and which engine is of relatively simple construction and utilizes many elements common to conventional radial engines.

Another object of the invention is the provision of an internal combustion four-cycle radial engine having an even number of cylinders that are adapted to be fired twice for each complete revolution of the drive shaft to which the power from the pistons during their power strokes is directly transmitted.

In most static four-cycle radial engines heretofore made an odd number of cylinders has been employed, such as nine, and the fuel has been ignited in every second cylinder around the engine as it rotates. Thus all cylinders have been fired once during each two complete revolutions of the engine. With my engine an even number of cylinders is used and all cylinders are fired twice during each complete revolution of the engine, and the firing of the cylinders is in pairs instead of singly, the firing pair being preferably axially aligned and at opposite sides of the drive shaft to which they transmit their power on the power stroke. Thus my structure provides an engine that is balanced with respect to torque forces developed during the power strokes of each pair of pistons in the firing cylinders, while the structure also makes possible greater horse power per pound of weight.

Other structure hereinafter described more in detail will show other objects and advantages of the invention.

In the drawings,

Fig. 1 is a semi-diagrammatic view of an engine, part in section and part in elevation.

Fig. 2 is a fragmentary sectional view through one cylinder of the engine of Fig. 1 as seen from line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic view of the central cam in one of the positions during driving thereof by the pistons.

It will clarify the description to explain that many of the elements of my engine are conventional or substantially so, such as the cylinder barrels, cylinder heads, poppet valves and valve actuating mechanism, crank case, and manner of mounting the cylinders on the crank case. Also, the crank case may be of the type that has a nose section, power sections (carrying cylinders), mounting section (for securing to usual engine

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mounting ring), and super-charger, pumps, tachometer, gun synchronizers, etc.). These various sections are well known in the art and are not all indicated in Fig. 2, it being understod that no claim is being made to any of such sections in themselves.

Eight equally spaced cylinders are indicated in Fig. 1 and are numbered 1 to 8, inclusive, cylinder 1 being the uppermost, and the others being numerically in order from 2 to 8 in a clockwise direction as seen in Fig. 1. The conventional cooling fins are not shown on the cylinders for the sake of clarity in the drawings.

Each cylinder has a conventional head with the usual poppet valves 9, 10 therein, the valve 9 being the intake valve, and valve 10 being the exhaust valve.

Pistons 11 to 18 are respectively in the cylinders 1 to 8, each piston having the conventional sealing rings thereon, and each being formed with bosses 19 (Fig. 2) in which a wrist pin 20 is supported. In the drawings an inner race 21 is supported on the wrist pin 20 centrally thereof, and roller bearings 22 rotatably support an outer annular race 23 thereon concentric with the axis of pin 20. The rollers 22 may be centrally grooved and inner race 21 may be formed with an annular ridge extending into the grooves in said rollers as seen in Fig. 2, if desired.

A central drive shaft 25 carries the main cam 26, the hub 28 of the latter being splined to the shaft as at 27.

Where the engine is used in an aircraft, the one end 29 of the shaft 25 may be the propeller shaft, unless it is found desirable to provide a gear connection between the propeller and shaft 29, while the other end 30 of shaft 25 may be for driving accessories such as a super-charger, pumps, etc., not shown.

For an eight cylinder engine, as shown in the drawing, the central cam is formed with four equally spaced lobes 31, 32, 33, 34 (Figs. 1, 3), the peripheral outline of the cam being convexly curved at the outer ends of the lobes and concavely curved at the low points 35 between adjacent pairs of lobes. The lobes are identical with each other in size and contour and the cam is symmetrical at opposite sides of a plane bisecting it through lobes extending oppositely from each other relative to the axis of the central shaft 25.

The cylinders 1 to 8 may be secured in the usual manner to a conventional crank case 36 by means of bolts extending through mounting flanges 37 on said cylinders, and which crank

case is provided with the usual bearings rotatably supporting shaft 25 (Fig. 2).

The cam 26 is supported on shaft 25 in a position so that the outer race 23 in each of the pistons will roll on the peripheral surface of the cam. As each of the said races 23 is virtually a roller, the term roller will be used hereafter to designate the said races.

The rollers 23 are held in engagement with the peripheral surface of the cam 26 at all times by means of a pair of arms extending divergently from the wrist pin in each cylinder to the wrist pins of a pair of other cylinders. For example, in the eight cylinder engine of Fig. 1 there are, all told, eight arms. From the wrist pin of piston 11, a pair of arms 40 extend to the wrist pins of piston 14, 16, the latter being in the cylinders at opposite sides of the cylinder 5 that is opposite cylinder 1. From the piston 12 a pair of arms 41 extend divergently to the pistons 15, 17 and from piston 13 arms 42 extend divergently to pistons 16, 18. As one end of arm 40 connects piston 11 with piston 14, a second arm 43 connects piston 14 with piston 17. Piston 15 is connected with piston 12 by one of the arms 41, therefore a second arm 44 connects piston 15 with piston 18. By this arrangement each piston is connected with those pistons of the pair that are at opposite sides of the piston directly opposite thereto.

The peripheral contour of the cam 26 is such that the arms connecting the pistons will hold all the rollers 23 against the said contour, and when any one roller 23 is positioned at the outer end of one of the cam lobes, the rollers in the pistons directly connected thereto by a pair of the arms above described will be positioned at the low points on the cam at the opposite sides of the lobe directly opposite the one over which the roller is passing.

The compression, power, exhaust and intake strokes of the pistons are controlled by the actuation of the valves, ignition, etc., in the usual manner.

The intake and exhaust valves 9, 10 are each held closed by a valve spring 50. To each valve is a rocker arm 51 carrying a roller 52 at one end for actuating the valve. The opposite end of the rocker arm is connected by a push rod 53 with a tappet 54 that carries a roller 55. Cams 56, 57 carried by shaft 25 actuate the tappets for actuation of the intake and exhaust valves in proper order and timing. Spark plugs 58 in the cylinder heads are actuated in the conventional manner for firing the cylinders. All these elements are conventional, although the cams 56, 57 are designed for opening and closing the valves in the eight cylinder engine herein illustrated, instead of being for the ordinary nine cylinder engine.

In Fig. 3, the rollers 23 represent those indicated in Fig. 1 and the pistons to which they are connected are indicated thereon. Also on each roller is indicated its stroke; for example, "P" means power stroke, "Ex." means exhaust stroke, "I" means intake stroke, and "C" means compression stroke. The central cam 26 in Fig. 3 has rotated clockwise one sixteenth of a revolution from the position in Fig. 1. This view being understood, the actual operation of the engine through the four cycles of piston 11 may readily be followed. A one-eighth revolution of cam clockwise from the position of the cam in Fig. 1 will complete the power stroke of said piston, or another sixteenth of such revolution of the cam Fig. 3 will complete such stroke. Another

eighth of a revolution of cam 26 will complete the exhaust stroke of piston 11 and the next eighth of a revolution will complete the intake stroke. After the intake stroke, the next eighth revolution of cam 26 will complete the compression stroke and the four cycles are completed. In all, cam 26 will have rotated clockwise only a half revolution during the four cycles of each cylinder.

It is pertinent to note that piston 15, which is directly opposite piston 11, is actuated to go through its power, exhaust, intake and compression strokes simultaneously with piston 11. When the cylinder 1 (carrying piston 11) is fired, the cylinder 5 (carrying piston 15) is also fired. Thus these pistons move toward and away from each other simultaneously. It will be observed that the movement of piston 11 in its power stroke will cause outward movement of pistons 14, 16, the former being on its compression stroke and the latter on its exhaust stroke, while the movement of piston 15 in its power stroke causes outward movement of pistons 13, 12, the former being on its compression stroke (and diametrically opposite piston 14) while the latter will be on its exhaust stroke (and diametrically opposite piston 18). This movement of pistons 14, 16 by piston 11 is by reason of arms 40 that connect them, together with the power transmitted through lobes 32, 33 of cam 26, while the movement of pistons 12, 18 is by reason of arms 41, 44, together with the power transmitted through lobes 31, 34 of the cam.

The remaining two diametrically opposite pistons 13, 17 are respectively connected to pistons 16, 18 (by arms 42), and 12, 14 (by arms 41, 43) and which pistons 13, 17 are caused to move inwardly on intake strokes by reason of the outward movement of pistons 16, 18 and 12, 14. Each diametrically opposite pair of cylinders is fired twice during each complete revolution of the cam 26, and these diametrically opposite pairs of pistons always have the same stroke. The firing order of the cylinders of the particular engine illustrated in Figs. 1, 3 is 11, 15—14, 18—13, 17—and 12, 16. Two opposite cylinders are always fired simultaneously.

The shape of cam 26 may be slightly modified according to the diameter of the rollers 23 and desired stroke of the pistons. In Figs. 1 and 2 it will be seen that the cylinders are slotted at 60 to pass the cam lobes. The pistons themselves are formed with brace and guide members, as at 61 (Fig. 2) and one of the arms 40, 41, 42, and arms 43 are at one side of the cam 26, while the other of arms 40, 41, 42 and arm 44 are at the opposite side of said cam. This arrangement could be modified to provide for positioning all of the arms between a pair of spaced cams similar to cam 26, and by providing a pair of rollers in each piston, but it is intended that such modification shall come within the scope of the claims.

In Fig. 3 it will be seen that as soon as the rollers 23 pass the outer ends of the lobes of the cam on the power strokes of the pistons, the initial radially inward movement of the rollers delivers the maximum power to the cam, which power progressively becomes less until the rollers are at the low points between lobes. Thus the timing of the firing is such as to take advantage of the full power of the power strokes where there is the maximum efficiency in transfer thereof to the cam.

The invention hereinbefore described is in-

tended as illustrative of the invention and not restrictive thereof.

Having described my invention, I claim:

1. In a radial internal combustion engine having a rotatable central shaft, an even number of not less than eight equally spaced stationary cylinders radially positioned around said shaft, a piston reciprocable within each cylinder, a cam follower carried by each piston and reciprocable therewith, a cam on said shaft having radially extending equally spaced similar lobes equal to one-half the number of said cylinders, said cam followers being in engagement with the cam surfaces of said cam, the improvement that comprises; a pair of arms extending divergently from each piston and past opposite sides of said shaft connecting each piston with a pair of different pistons that are equally spaced therefrom by intervening pistons and cylinders and which latter pair are spaced from each other by a single intervening piston and cylinder only.

2. In a radial internal combustion engine having a rotatable central shaft, an even number of not less than eight equally spaced stationary cylinders radially positioned around said shaft, a piston reciprocable within each cylinder, a cam follower carried by each piston and reciprocable therewith, a cam on said shaft having radially extending equally spaced similar lobes equal to one-half the number of said cylinders, said cam followers being in engagement with the cam surfaces of said cam, the improvement that comprises; a pair of arms extending divergently from each piston and past opposite sides of said shaft connecting each piston with a pair of different pistons that are equally spaced therefrom by intervening pistons and cylinders and which latter pair are spaced from each other by a single intervening piston and cylinder only, each of the arms of each pair extending across an arm of another pair in close relationship thereto.

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