Dec. 30, 1941. J. H. GOODMAN 2,268,532

INTERNAL COMBUSTION ENGINE

Filed Feb. 12, 1941 4 Sheets-Sheet 1

FIG. 1

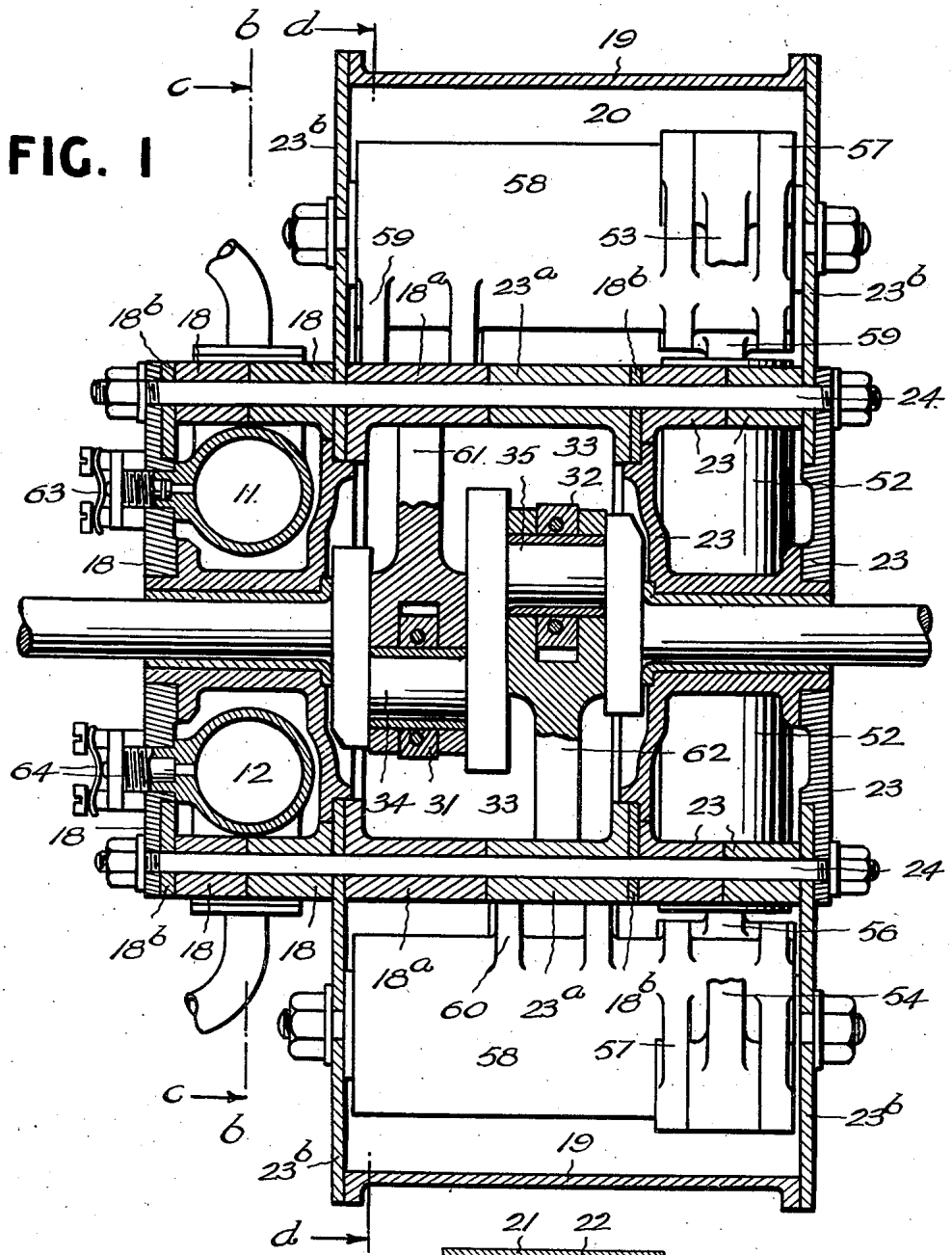

FIG. 4

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INTERNAL COMBUSTION ENGINE

Filed Feb. 12, 1941 4 Sheets-Sheet 2

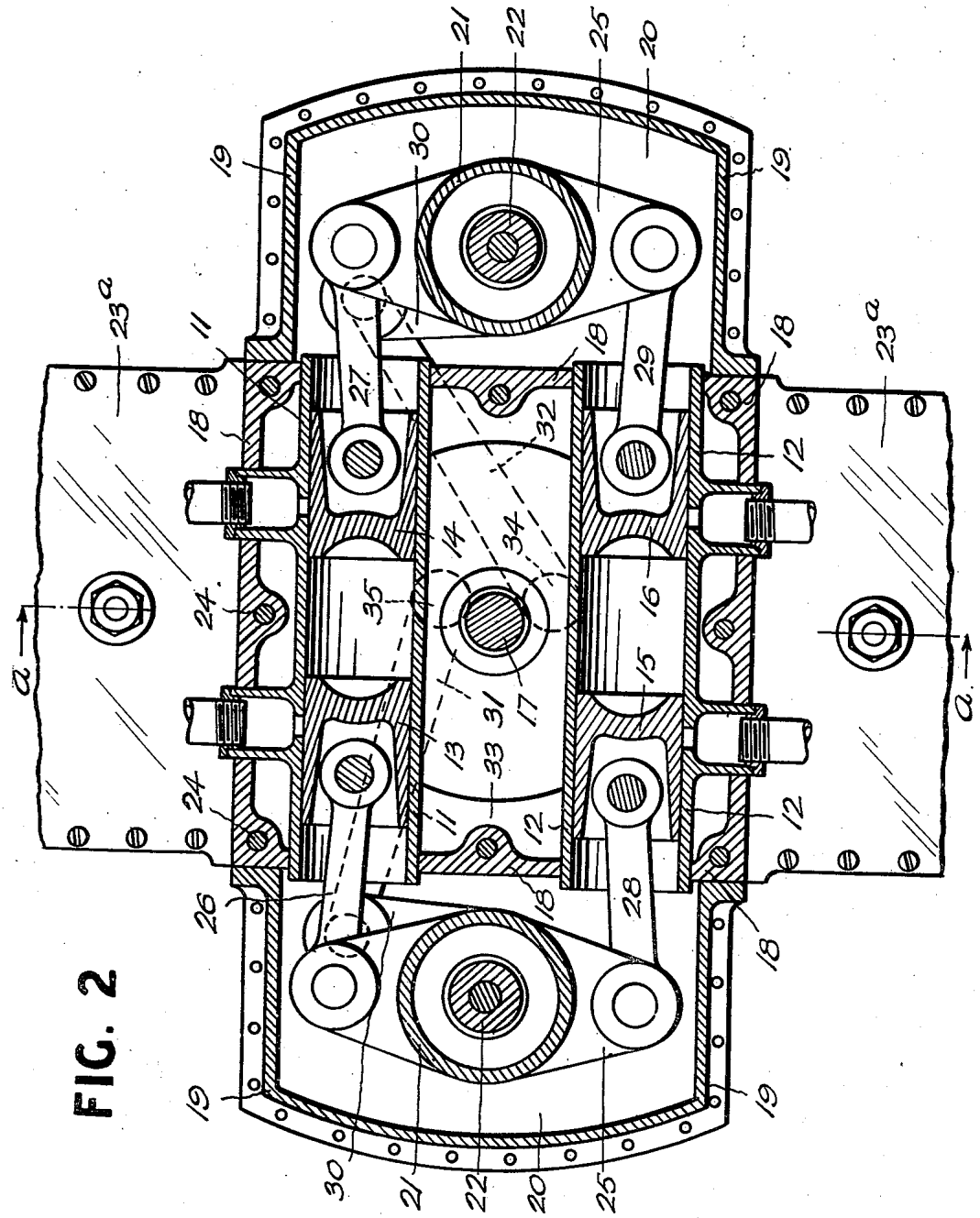

FIG. 2

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Dec. 30, 1941. J. H. GOODMAN 2,268,532

INTERNAL COMBUSTION ENGINE

Filed Feb. 12, 1941 4 Sheets-Sheet 3

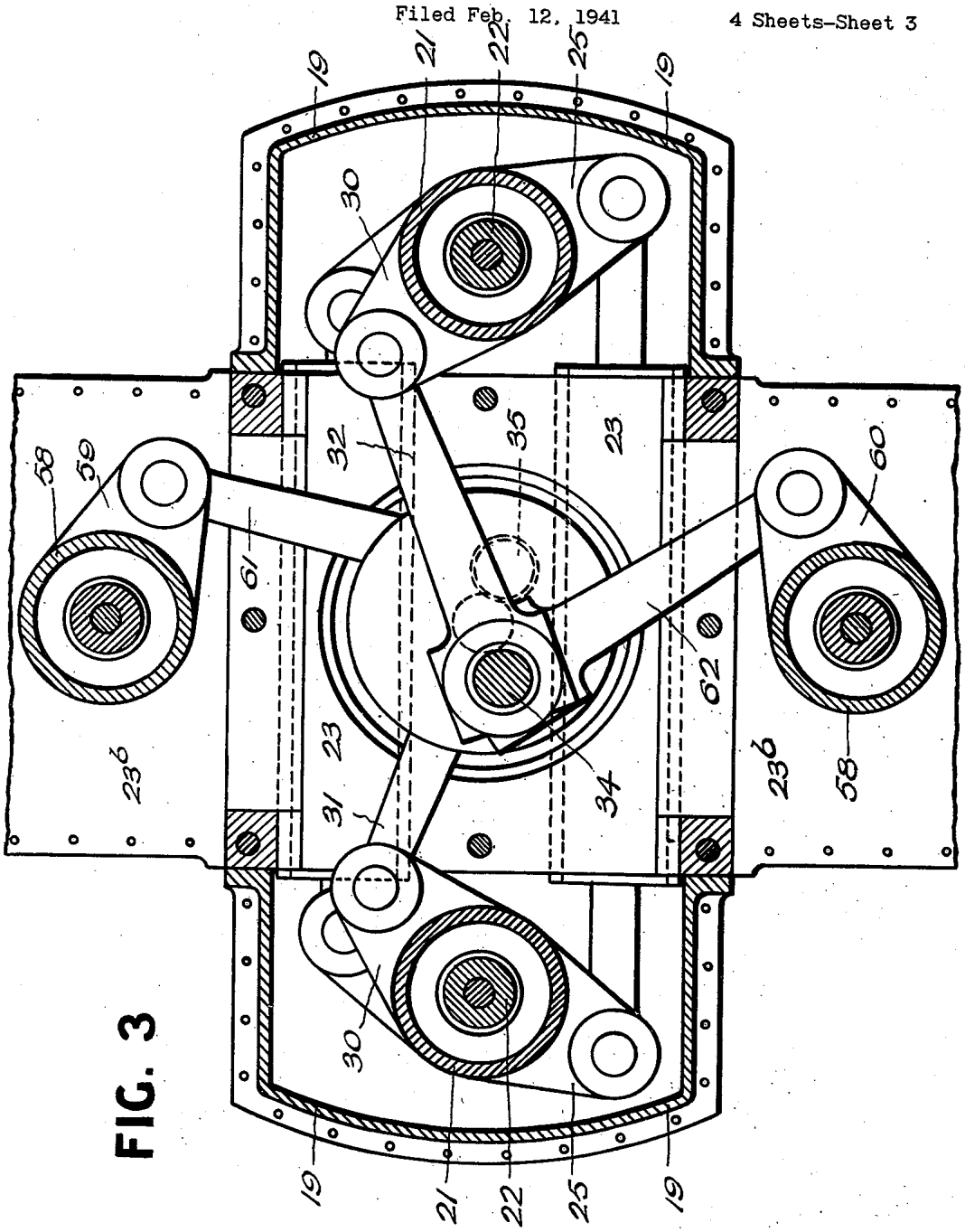

FIG. 3

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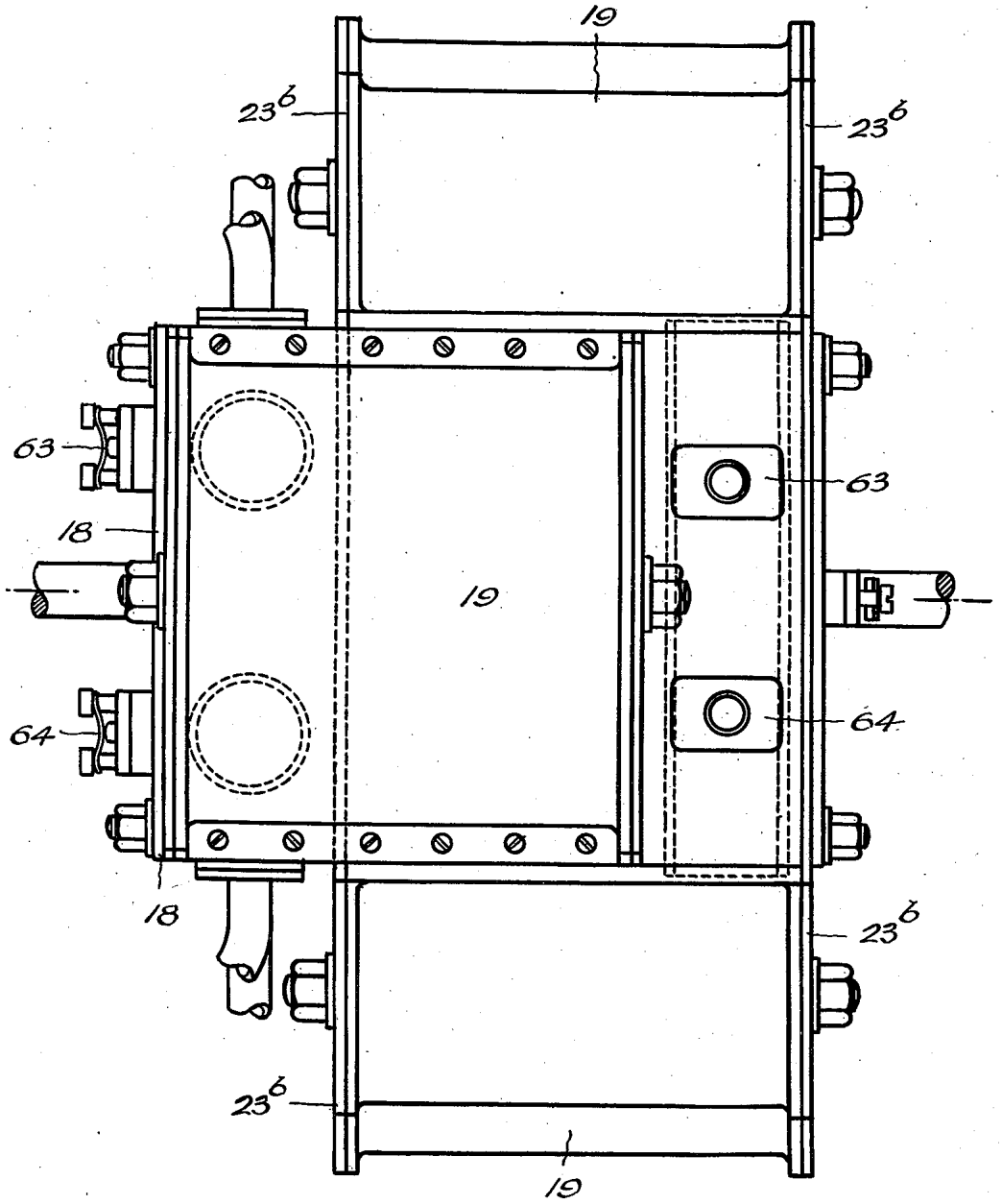
Dec. 30, 1941. J. H. GOODMAN 2,268,532

INTERNAL COMBUSTION ENGINE

Filed Feb. 12, 1941 4 Sheets-Sheet 4

FIG. 5



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UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

John Howard Goodman, Edgbaston, Birmingham, England

Application February 12, 1941, Serial No. 378,639
In Great Britain January 30, 1940

4 Claims. (Cl. 123—51)

This invention relates to internal combustion engines having cylinders containing opposed pistons. In a British patent specification No. 513,381 I described an engine of this kind in which the pistons are operatively connected to rockshafts arranged at the ends of the cylinders and these rockshafts are operatively connected to two cranks geared together arranged between the cylinders.

In the United States patent specification 2,067,049 diagonally opposed rocker beam ends are connected to a common crank pin on the main shaft.

The object of the present invention is to provide an engine of the opposed piston type having greater simplicity in design, low manufacturing cost, improved balance, lighter weight and more compact dimensions for any given power. It is also an object to increase mechanical efficiency by reducing the number of main bearings required for a given number of cylinders. When the invention is applied to compression ignition engines it has the further object of relieving the main bearings of most of the usual high pressure.

An internal combustion engine in accordance with the present invention has at least one pair of cylinders each cylinder containing opposed pistons with their piston rods connected to a pair of rock shafts on which rock shafts connecting rods to a crank shaft are provided said connecting rods from the rock shafts being arranged on the same side of a central plane containing the axes of the said rock shafts and of the crank shaft and being connected to two cranks on opposite sides of the shaft.

According to a preferred embodiment of the invention a number of open ended cylinders, i. e. cylinders open at both ends, are arranged in one or more groups of four, consisting of two pairs each one of a pair having its axis parallel to the other of the same pair, each pair of a group has its axis at right angles to the axes of the other pair of the same group; all these cylinders are arranged tangentially around a single central crank shaft, the axis of which is at right angles to the axes of the cylinders. The plane containing the axes of one pair of cylinders is spaced apart from, but parallel to, the plane containing the axes of any other pair of cylinders which are in effect duplicates of the first pair.

All the cylinders have two pistons each connected to rock shafts which are arranged equidistantly around the crank shaft, with their axes parallel to the same.

The crank shaft has two cranks (set at an angle which is less than 180°) for each group of four cylinders and each crank pin is operatively connected to four pistons, two of which work in cylinders located towards one side of the crank and the other two work in cylinders on the other side of the said crank.

The rock shafts are each provided with one double arm and one single arm, the double arm being preferably in one plane containing the axes of a pair of cylinders and the single arm working in another plane off-set far enough to enable connection to be made with the crank pin in the space between the pairs of cylinders of each group of four.

The appended drawings illustrate this convenient example in which groups of four pistons connected to two rock shafts are arranged about a single crank shaft with one group at right angles to the adjacent group.

Figure 1 is a central section with the two rock shafts and arms shown in full; it is taken on the line *a*—*a* of Figure 2.

Figure 2 is a section on the line *b*—*b* of Figure 1 looking in the direction of the arrows *c*.

Figure 3 is a section on the line *d*—*d* of Figure 1 looking in the direction of the arrows *c*.

Figure 4 is an axial section showing a mounting of one of the rock shafts.

Figure 5 is an elevation looking from the right in Figure 2.

So far as many of the parts of the engine such as the casings and main shaft bearings are concerned these drawings are merely indicative and all parts may follow approved design. The present invention concerns the grouping of the cylinders with their opposed pistons around the shaft and the connection of the rocker arms or beams from opposed pistons to the shaft. Fuel pump or supply means and scavenging means are omitted from the drawings.

A pair of cylinders 11, 12, are arranged parallel to each other. The opposed pistons in cylinder 11 are marked 13, 14 and the pistons in cylinder 12 are marked 15, 16. Between the cylinders is the crank shaft 17 at right angles to the axes of the cylinders 11, 12. The cylinders 11 and 12 are secured in a narrow square built up casing referred to generally by the numeral 18, and a second pair of cylinders, of which only one cylinder 52 is shown, are secured in a similar square casing 23 parallel to 18 but with its cylinders disposed at right angles to 11 and 12. Between these casings 18 and 23 are distance

members 18a, 23a, enclosing a crank chamber. Four frame plates 18a and 23a of stout construction complete the main parts of the assembly which is bolted together by a series of bolts 24.

Covers 19 are fitted to the ends of these two casings 18 and 23, each cover extending not only over the casing containing the cylinders but also over the part facing the crank chamber. Under each cover 19 is a space 20. The spaces 20 at the ends of cylinders 11 and 12 provide room for the rock shafts 21 around the sleeves 22 and for the working of the rocker arms or beams 25 to which are connected the piston rods 26, 27, 28 and 29 from pistons 13, 14, 15 and 16 respectively. In the part over the crank chamber 33 further arms 30 are carried from each rock shaft 21 and on these the connecting rods 31, 32 are hinged and enter the chamber 33 where the two crank pins 34 and 35 are mounted on the crank shaft 17.

In the second pair of cylinders is another group of four pistons corresponding exactly with 26 to 29 so that there is no need to particularise them or illustrate them. Their piston rods 53, 54, 55, 56 are seen in Figure 1 connected to the rocker arms 57 on the barrel shaft 58. Further along the rock shafts 58 are the arms 59 and 60 on which the two connecting rods 61 and 62 for connecting the rock shafts with the crank pins 34 and 35 are mounted.

The cranks are preferably set at an angle of about 140 degrees. The actual angle depends on the distance apart of the cylinders, the length of stroke and the positions of the rock shafts, but it is determined by the fact that the arrangement is such that both cranks are in the dead centre positions simultaneously. The crank shaft pins 34 and 35 are each made long enough to take two connecting rods, one of the rods on each pin having a forked end and the other working in between the fork as seen in Figure 1, where the ends of the rods 31 and 32 are received in the ends 63 of the rods 61 and 62. The rock shaft 58 at one end of the second pair of cylinders is connected by the forked connecting rod 61 to the first crank pin 34 and the rock shaft at the opposite end of these cylinders is connected by the other forked connecting rod 62 to the second crank pin 35. The rock shafts 21 at the two ends of the other pair of cylinders 11 and 12 are similarly connected by the non-forked connecting rod 31 to the first crank-pin 34 and by the other connecting rod 32 to the second crank-pin 35. Thus it will be seen that the four connecting rods work at approximately right angles to each other, see Figure 3.

Due to the fact that the two connecting rods from the one pair of cylinders and their respective arms on the rock shafts (e. g. rods 31, 32 and arms 30, Figure 2) are both arranged on the same side of the central plane containing the rock shafts 21 and the crank shaft 17, better relative movements of the opposed pistons and a better balance are obtained. The same is true of the connecting rods 61, 62, from the arms 59, 60 and rock shafts 58 of the other pair of cylinders as the arrangement is similar to that of the first pair turned through a right angle.

Owing to the connecting rods being arranged so that the one from the rock shaft at one end of a pair of cylinders leads to the first crank pin while that from the other end leads to the other crank pin, each crank pin is only subjected to the maximum pressure from one piston at a time, thus effecting a considerable saving in the stress imposed on the pin and the bearing pressures.

In the illustrated construction the cylinders are formed by wet liners held in a block built up from a number of square frames held together by the long bolts 24.

The parts shown at 63, 64, in Figure 1 are approximated representations of oil pressure injectors to the cylinders but form no part of the present invention.

The engine is economical in weight, is easily made and constructed and as far as possible provides good balance with a single crank shaft while having all the thermodynamic advantages of opposed pistons; thus it is very suitable for use in aircraft.

I claim:

1. An internal combustion engine comprising in combination a pair of cylinders arranged parallel to each other with one of the pair on each side of a crank shaft; a similar pair of cylinders arranged one on each side of the said crank shaft but with their axes at right angles to those of the first mentioned pair, two opposed pistons in each of said cylinders and a rod from each piston to an arm on a rock shaft at the end of the cylinder, the rock shafts being four in number disposed equally around said crank shaft at the ends of the cylinders; two crank pins on said crank shaft and a connecting rod from each of the four rock shafts to said crank shaft, two of said connecting rods being mounted on each crank.

2. An internal combustion engine comprising at least one pair of cylinders each cylinder provided with oppositely working piston rods from the pistons therein to rock shafts at the ends of the cylinders, a single crank shaft between the cylinders with two cranks at an angle to each other of approximately 140 degrees, a connecting rod from each rock shaft to the crank shaft, said connecting rods from two diametrically opposed rock shafts being connected one to each crank and being connected to the rock shafts on the same side of a plane containing the axes of the rock shafts and the crank shaft axis.

3. An internal combustion engine having at least two pairs of cylinders each of which pairs is spaced from the other pairs, each of said cylinders containing opposed pistons having piston rods, the cylinders of each pair being parallel to each other and on opposite sides of the crank shaft and the cylinders of one pair being at right angles to those of the adjacent pair, the axes of all of the cylinders being at right angles to the axis of the crank shaft, four rock shafts each of which is at one end of a pair of cylinders, said rock shafts being spaced at equi-distant points around the crank shaft, a rocker arm on each of the said rock shafts extending to both sides thereof, each rock shaft being connected by said rocker arms to two pistons which are at corresponding ends of the cylinders of one of said pairs, additional rocker arms connecting the rock shafts to the crank shaft, all of said additional rocker arms being arranged in the space between the two pairs of cylinders.

4. An internal combustion engine having at least two pairs of cylinders each of which pairs is spaced from the other pairs, each of said cylinders containing opposed pistons having piston rods, the cylinders of each pair being parallel to each other and on opposite sides of the crank shaft and the cylinders of one pair being at right angles to those of the other pairs, the axes of all of the cylinders being at right angles to the axis

of the crank shaft, four rock shafts each of which is at one end of one of the pairs of cylinders, said rock shafts being spaced at equi-distant points around the crank shaft, a rocker arm on each of the said rock shafts extending to both sides thereof, each rock shaft being connected by said rocker arms to two pistons which are at corresponding ends of the cylinders of one of said pairs, additional rocker arms connecting the rock shafts to the crank shaft, all of said additional rocker arms being arranged in the space between the two pairs of cylinders, the crank shaft ends of two of said connecting rods being forked and the corresponding ends of the other two connecting rods being connected to the crank shaft inside said forked ends.

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