Sept. 23, 1958 L. J. FAGEOL 2,852,837

INTERNAL COMBUSTION ENGINES AND METHODS
OF MANUFACTURING SUCH ENGINES

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Fig. 1

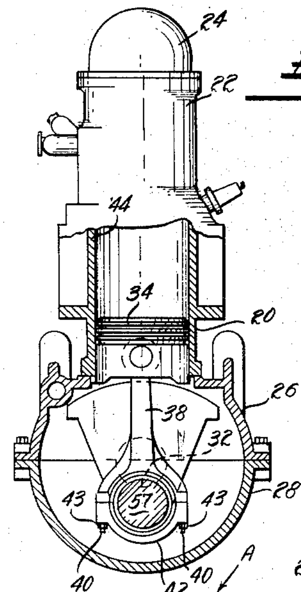


Fig. 2

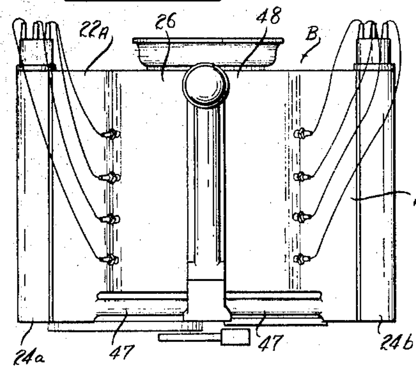


Fig. 4

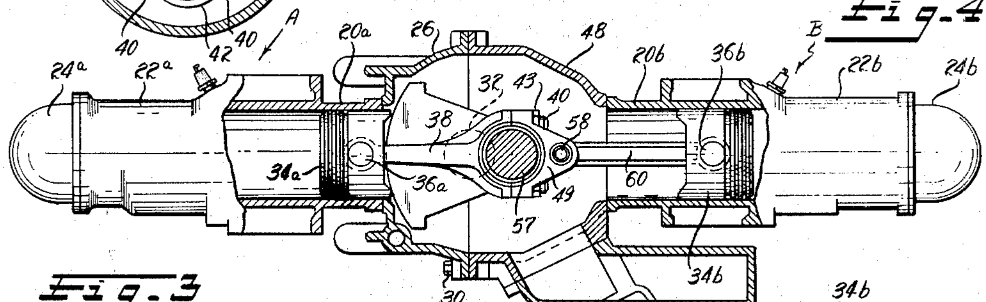
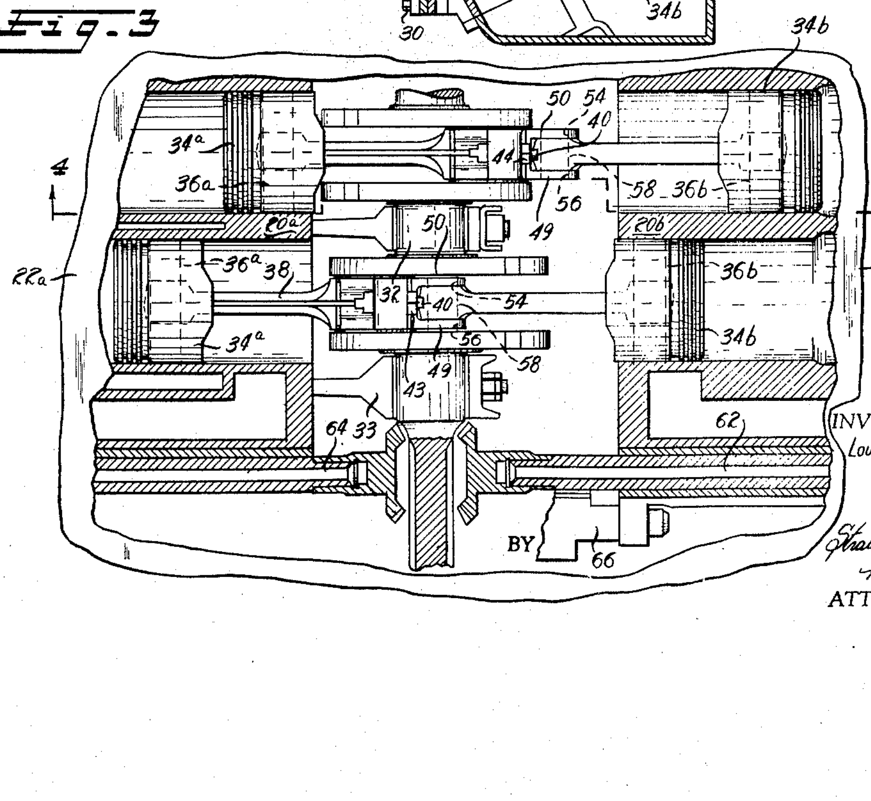


Fig. 3



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INTERNAL COMBUSTION ENGINES AND METHODS OF MANUFACTURING SUCH ENGINES

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2 Claims. (Cl. 29—156.4)

This invention relates to improvements in internal combustion engines and components thereof and to novel methods for manufacturing and assembling internal combustion engines.

The need has long existed in many military and commercial applications for engines of standard design employing interchangeable components for installations in vehicles having widely differing power requirements. It has long been recognized particularly in connection with military vehicles that the use of a specific engine for each class of vehicles increases the original vehicle development cost and increases the cost and difficulty of servicing and maintaining the vehicles in the field.

In accordance with the present invention a basic engine adapted for use with vehicles of a given size is combined with a substantially identical engine in a novel manner to produce an engine which has at least twice the power of the original engine and is thus suited for installation in larger vehicles. The invention thus provides two engines which are substantially different ratings and which utilize the same basic major components including cylinder blocks, crankshafts, pistons, camshafts and valves. In view of the interchangeability of these major components, the costs of manufacturing and servicing the two engines are substantially below the cost of manufacturing two entirely different engines in accordance with prior practice.

For purposes of illustration, the invention will be disclosed as applied to an eight-cylinder engine of the so-called "flat" or "pancake" type in which one bank of cylinders is directly opposed to and in-line with the other bank of cylinders. Preferably the engine is assembled from components of four-cylinder in-line engines of conventional construction. However, it is to be understood that the invention is of broader application and may be successfully utilized in connection with other engines.

The construction of the connecting rod and the crankshaft is such that the cylinders of one bank are coaxial with the respective cylinders of the opposite bank. The effective bearing area for each cylinder is the same in the eight-cylinder engine as in the four-cylinder engine. Accordingly, despite the fact that the original crankshaft used in the four-cylinder engine transmits the power developed by eight cylinders in the converted engine the original bearing loads at the connecting rods and the crankshaft are not increased.

It is also a feature of the present invention that one cylinder in one bank is fired simultaneously with a cylinder of the opposite bank. Thus the power impulses are substantially completely balanced. Also since the pistons in the opposite banks are always reciprocating oppositely oppositely and the crankshaft is fully balanced, the engine is unusually smooth, quiet and efficient in operation.

Essentially the eight-cylinder engine of the present invention provides the same torque as a four-cylinder engine of equal displacement (which is substantially greater than the torque produced by a conventional eight-cylinder engine) but with much smoother and better balanced operation than the equivalent four-cylinder engine.

The high torque characteristics of the eight-cylinder engine also permit the use of a fly-wheel of the same size and weight as that used in the original four-cylinder engine thus permitting rapid acceleration and a flexibility of operation not previously associated with comparable prior engines.

It is a particular feature of the present invention that the eight-cylinder engine employs the same crankshaft as the original four-cylinder engine. Accordingly, a standard crankshaft serves for both engines and the length of the eight-cylinder engine is the same as the length of the four-cylinder engine. This unique advantage and other advantages of the present invention are made possible in large measure by a connecting rod of novel construction which thus also forms an important feature of the present invention.

With the foregoing considerations in mind it is an important object of the present invention to provide improved internal combustion engines and improved methods of manufacturing such engines.

It is also an object of the present invention to provide novel methods of combining at least two engines of a given displacement to provide a single larger engine having a displacement equal to the combined displacement of the original engines and having a horsepower greater than the sum of the horsepower produced by the original engines individually.

It is a more specific object of the invention to provide novel methods for converting a pair of four-cylinder engines into an eight-cylinder engine of the flat or pancake type having an overall length no greater than the length of the original four-cylinder engine.

It is also an important object of the present invention to provide improved novel connecting rod assemblies which permit the displacement of a pair of opposed cylinders directly in line with each other and the connection of each of the opposed pistons to a crank pin journal having a width no greater than that used in connection with a single piston.

Additional objects and advantages will become apparent as the description proceeds in connection with the accompanying drawings in which:

Figure 1 is an end elevation with parts broken away of a conventional four-cylinder in-line internal combustion engine;

Figure 2 is a top plan view of the novel eight-cylinder pancake engine of the present invention;

Figure 3 is an enlarged fragmentary top plan view of the engine of Figure 2 with parts broken away; and

Figure 4 is a fragmentary vertical section taken along line 4—4 of Figure 3.

As stated above certain of the basic concepts of the present invention are applicable to a variety of engines. In practice the invention has been successfully applied to engines of the type shown in the drawings which are water cooled internal combustion engines of the type generally employed for automotive use. The particular engine shown in Figure 1 is a four-cylinder in line overhead cam engine and includes a cylinder block **20** having an integral cylinder head **22** and a cam cover plate **24**. The crankcase is of the split type and comprises the upper half **26** and the lower half of oil pan **28**, the parts **26** and **28** being secured together by the usual bolts **30** substantially at the center line of the crank shaft **32** which is supported by main bearings **33** rigidly mounted on the upper crankcase half **26**. The pistons **34** carry wrist pins **36** which support connecting rods **38**, the lower ends of which carry studs **40** on which the caps **42** are mounted, the latter being held in place by nuts **43**. Spark plugs **44** are conventionally mounted at one side of the block, the opposite side of which carries intake and exhaust manifolds 45 and 46, respectively. Since the engine of Figure 1 is in all respects conventional it is not believed that further detailed description is required.

One important aspect of the present invention involves the conversion of two engines of the type shown in Figure 1 into a single flat eight opposed engine as shown in Figure 2. It is a feature of the invention that the conversion may be effected simply and in a manner to permit the utilization of a maximum number of the basic components of the original engine. In Figure 2 the original engine designated A appears at the left side of the figure and the duplicate original engine designated B appears at the right side of the figure. Before installation the cylinder block 20*b* is reversed end for end to dispose the number one cylinder of engine B opposite number four cylinder of engine A to thereby dispose the intake and exhaust manifolds of the two blocks at the same side of the engine of Figure 2. Because of this reversal the tower shaft housing 47 of block 20*b* is relocated. Otherwise, the two cylinder blocks 20*a* and 20*b* and all of the mechanisms associated therewith are identical. It will be noted that the original crankcase half 26 is retained in the engine of Figure 2. In the second engine the entire crankcase pan is removed and the cylinder block 20*b* is bolted directly to a crank case adapter section 48 which thus serves as the added crankcase half for engine B and the added crankcase half for engine A.

It is also an important feature that the original crankshaft 32 of engine A is retained in the converted engine of Figure 2 with the result that the engine of Figure 2 is the same length as the engine of Figure 1 and the pistons of the two engines are directly in line. In both engines the main bearings 33 support the crankshaft. This unique construction is made possible in large measure by a novel piston rod construction to which detailed reference will now be made. It will be noted that the connecting rods 38 of engine A are retained in the final engine. However, the connecting rod caps 42 used in the original engine are replaced by caps 49. The caps 49 are provided with a pair of spaced ears 50 and 52, the ears having aligned bores 54 and 56, respectively, formed about a center disposed in a plane containing the center of the crank pin 57 and the center of the wrist pin 36. Press fitted into the bores 54 and 56 is a pin 58 on which one end of a modified connecting rod 60 is mounted. The pin 58 is preferably interchangeable with the original wrist pins 36*a* and 36*b*, the latter supporting the outer end of the modified connecting rod 60 in the usual manner.

It will be noted that because of the displacement of the axis of pin 58 from the center of the crank pin 57 the angular movement of the piston rod 60 during a single revolution of the crankshaft is somewhat greater than the angular movement of the connecting rod 38. To reduce this angular differential the length of the connecting rod 60 is such that the wrist pin 36*b* is somewhat farther from the center of the crank pin 57 than the wrist pin 36. In a specific example, the distance between the center of crankpin 57 and the center of wrist pin 36*a* is equal to the distance between the center of pin 58 and the center of wrist pin 36*b*. In this example, the angular movement of the connecting rod 38 is 5 degrees less than the angular movement of the connecting rod 60. It is for this reason that the depth of the crankcase adapter section 46 is somewhat greater than that of the original upper crankcase section 26. In the illustrative example given above, the bottom of the cylinder block 20 is 2⅜ inches from the crankshaft center line and the bottom of the cylinder block 20*b* is 3¾ inches from the crankshaft center line. While it is necessary to move the pistons 36*b* relatively away from the axis of the crankshaft the exact amount of the movement is not critical.

Actual tests have demonstrated conclusively that despite the asymmetrical arrangement of the engine it operates smoothly and with full efficiency. In fact tests have demonstrated that the horsepower of the engine of Figure 2 exceeds the combined horsepower of two of the engines shown in Figure 1 by approximately 10 percent.

This result is due to the relatively reduced friction losses brought about from the use, in the engine of Figure 2, of a single crankshaft, one set of main bearings and one set of connecting rod bearings. In the latter respect the engine of Figure 2 has a significant advantage over the usual opposed cylinder engine in which separate sets of connecting rod bearings are used. Also the weight of the engine of Figure 2 is considerably less than twice the weight of the engine of Figure 1 so that the engine of Figure 2 has a substantially better power weight ratio than the engine of Figure 1.

Since the particular engine shown is of the overhead cam design, the drive or tower shafts 62 for the cams of engine B are somewhat longer than the shafts 64 designed for the original engine 20. Apart from the substitution of longer tower shafts and an asymmetrical tower casting 66, no other modification in the valve actuating mechanism need be made.

The original carburetion system and intake manifold system may be retained if desired with appropriate linkage to permit simultaneous control of the carburetors. Preferably the original exhaust manifolds of the individual engines are retained in the converted engine of Figure 2. The manifolds may be positioned either above or below the crankshaft center line.

The conventional ignition system for the four-cylinder engine of Figure 2 may be replaced by an ignition system suitable for an eight-cylinder engine or the original distributors 68, coils 70 and harness 72 may be used in the eight-cylinder engine.

In either case the distributors are timed so that each cylinder in one block fires simultaneously with a cylinder in the other block.

The firing order of the cylinders of one block is retained. The firing sequence of the cylinders of the other block is retained but the firing order is shifted to avoid firing directly opposite cylinders simultaneously. In a specific case the firing order of engine A may be 1, 3, 4, 2. The opposite bank has a firing order of 3, 4, 2, 1. However, other arrangements may be used, if desired.

No other significant changes, additions or modifications are required to complete the conversion.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A method of converting an internal combustion engine having one or more cylinders to an engine having twice as many cylinders, said engine having a split crankcase supporting a crankshaft and having pistons in said cylinders and capped connecting rods connecting said pistons and said crankshaft, comprising the steps of replacing the lower half of said split crankcase with an adapter section, replacing the caps of said connecting rods with cap assemblies each adapted to support an additional connecting rod, installing said additional connecting rods on said cap assemblies, connecting said additional connecting rods to additional pistons, and assembling a cylinder block to said crankcase adapter section in a manner to dispose the cylinders of said cylinder block in alignment with the cylinders of said engine.

2. A method of converting an internal combustion engine having one or more cylinders to an engine having twice as many cylinders, said engine having a split

crankcase supporting a crankshaft and having pistons in said cylinders and capped connecting rods connecting said pistons and said crankshaft, comprising the steps of replacing the lower half of said split crankcase with an adapter section, said adapter section being of greater depth than the upper half of said crankcase, replacing the caps of said connecting rods with cap assemblies each adapted to support an additional connecting rod, installing said additional connecting rods on said cap assemblies, connecting said additional connecting rods to additional pistons, assembling a cylinder block to said crankcase adapter section in manner to dispose the cylinders of said cylinder block in alignment with the cylinders of said engine and further from the center of crankshaft than the original cylinder block sufficiently so the angularity

of the additional connecting rods is low enough to effect smooth and efficient operation of the engine.

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