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TIMING MEANS

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2 Sheets-Sheet 1

Fig. 1.

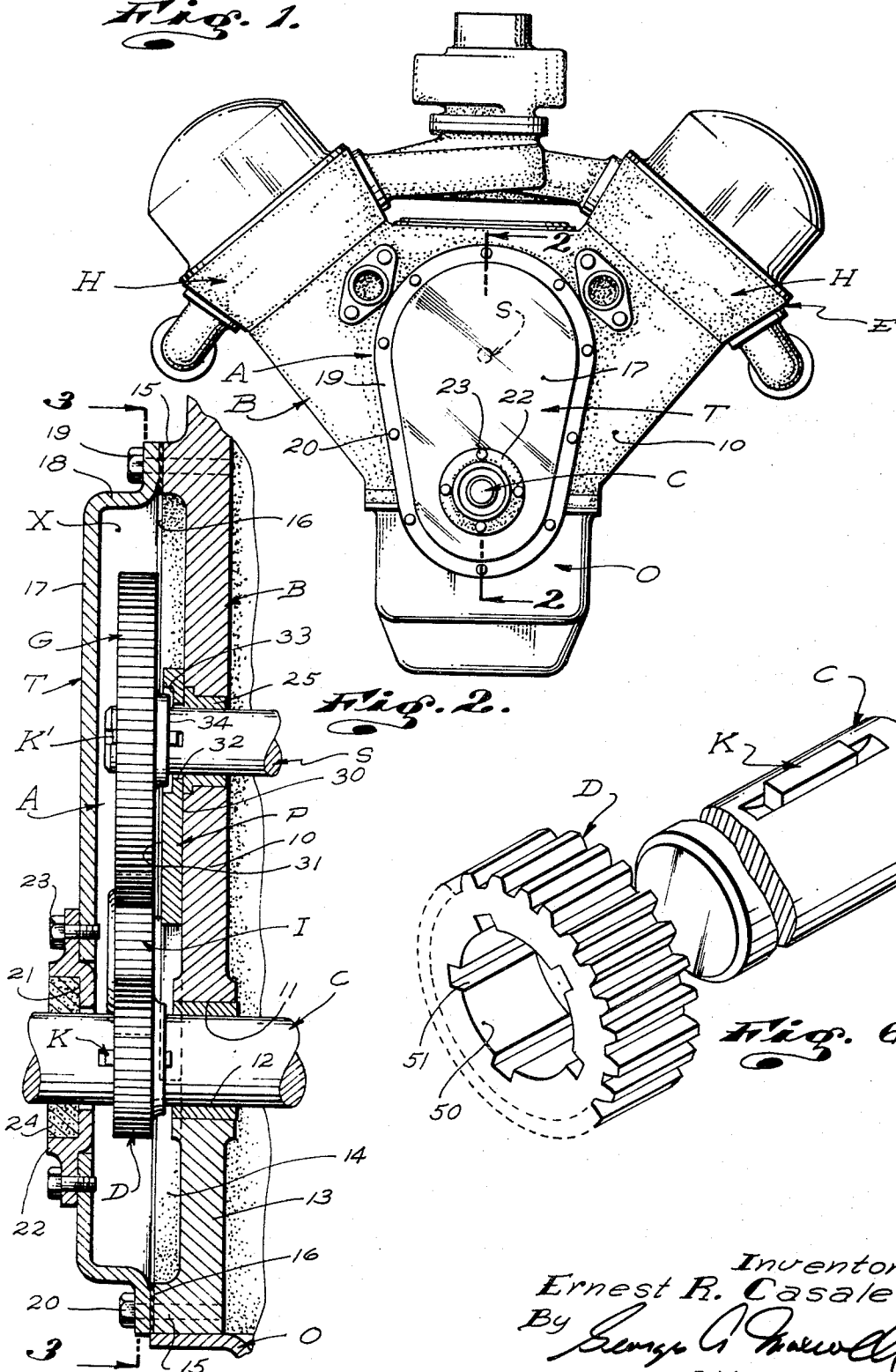


Fig. 2.

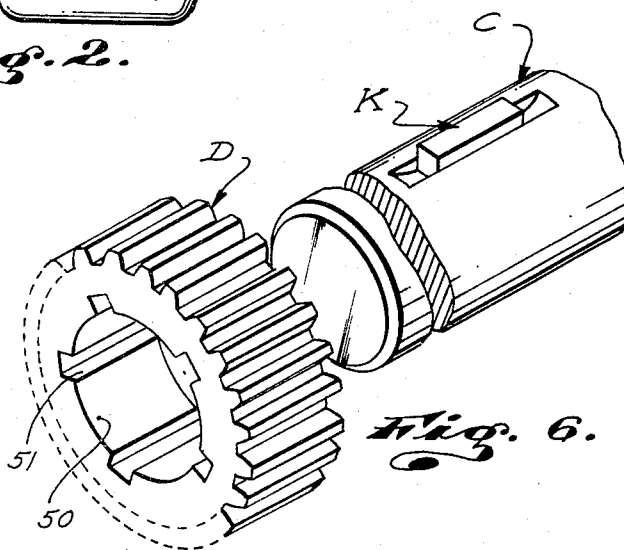


Fig. 6.

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3,415,137

TIMING MEANS

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ABSTRACT OF THE DISCLOSURE

A valve timing gear train structure for replacement of sprocket and chain timing means of a stock engine has a crank shaft gear which has a plurality of keyways to engage selectively a key disposed on the crank shaft so that the gear may be rotated with respect to the crank shaft a predetermined fraction of the circumferential extent of one gear tooth.

In the art of reciprocating or piston type internal combustion engines, such as are employed throughout the automotive art, timing of the opening and closing of the intake and exhaust port valves relative to the position of the pistons of the engine is extremely critical. Adjustment of valve timing represented by one or two degrees of rotation of the crank shaft relative to the cam shaft can change the character of the engine from one which is suitable for driving a passenger car on city streets to a high performance engine suitable for racing and the like.

In high speed or so-called high performance engines, a small adjustment in valve timing represented by a fraction of one degree of rotation of the crank shaft relative to the cam shaft can result in a loss or gain of twenty-five percent or more of possible maximum horsepower output and speed of the engine.

In low speed, low performance engines, such as stock automobile engines, the valve timing is, as compared with high performance engines, not critical, since the maximum operating speed of such engines is relatively low and well below a speed where timing becomes critical. In such engines a variation in timing represented by as much as two degrees of rotation of the crank shaft relative to the cam shaft is permissible without material adverse effects.

As a result of the above, stock sprocket and chain type timing means such as is employed in the ordinary automobile engine is quite adequate and the variations in timing resulting from the necessary running slop and/or play in the chains is within allowable tolerances.

Stock sprocket and chain type valve timing means are designed to adequately handle the loads and forces imparted into and through the means, when employed in stock, low performance engines, without failure and without excessive stretching of the chain. Such means, however, cannot dependably and effectively handle the materially greater loads and forces encountered in high performance engines with the result that the chains stretch excessively and to an extent as to upset the timing and frequently stretch to a point where they jump the teeth on the sprockets and/or break.

As a result of the above, when modifying a stock engine for high performance, it is common practice to replace the stock sprockets and chain with heavy duty sprockets and chain which are adequate to handle the greater loads and forces to be encountered. While such heavy duty equipment effectively eliminates the problem of chain stretching and failure, it does not eliminate and carries with it the inherent slop and play of a chain drive and the resulting very loose tolerances in timing.

Another notable reason for the adoption of sprocket and chain type valve timing means by the automotive art resides in the fact that the timing of an engine with such

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equipment can be changed and adjusted by simply shifting the chain, one tooth at a time about one of the sprockets. Such adjustment can be easily and quickly performed as it does not require removing or pulling and remounting the sprockets on their related shafts.

It has been recognized that in high performance engines, a gear train type valve timing means is much more effective and dependable than the stock sprocket and chain type means, as slop and/or play in such a gear means can be reduced to such fine tolerances that it ceases to be an effective factor. Further, such gear type means can be easily established to withstand the loads and forces to be encountered and at the same time effect a reduction in weight and in friction loss.

The principal difficulty in employing gear train type valve timing means in stock engines in place of standard sprocket and chain type means, resides in the fact that the cam shafts are ground and arranged or positioned in the engine to rotate in the same direction as the crank shaft. Accordingly, gears on the two shafts cannot be directly engaged with each other and an idler gear must be provided between them. Unfortunately, the ordinary or stock automobile engine is not provided with means for mounting such an idler gear and substitution of a gear means for a sprocket and chain means cannot be made without special and costly modification of the engine block to facilitate mounting an idler gear. Such modifications, when made, have generally been of a makeshift nature and are of questionable soundness.

Another difficulty or shortcoming to be found in the use of gear train valve timing means resides in the fact that to effect a change in timing, the drive gear on the crank shaft or the driven gear on the cam shaft must be such that it can be rotatively adjusted relative to its related shaft.

In standard or ordinary engine constructions, since the cam shaft is rotated at one half the speed of the crank shaft, the driven or cam sprocket is considerably larger than the drive or crank sprocket. The sprocket in such engines are slidably engaged on the front ends of their related shafts and are keyed thereto against rotation. The shafts with the sprockets fixed thereto project forwardly from the forward end of the block and are housed by a shell-like timing cover plate coupler bolted to the block. The crank shaft extends forwardly from the drive sprocket through an oil seal mounted in an opening in the cover and carries a sheave about which a drive belt is engaged for driving such accessories as a fan, generator, and water pump.

When such an engine is modified for high performance and a gear drive is substituted for the stock sprocket and chain drive, provision must be made for rotating one of the gears relative to its related shaft for the purpose of adjusting the timing. Since the crank shaft is a large, costly and difficult-to-make part and the drive gear is relatively small and since the cam shaft is an easier to make and less costly item and the driven gear is relatively large, it has been the common practice, in the automotive art, to replace the cam shaft with an especially made cam shaft having an enlarged mounting flange at its forward end to engage the hub portion of the larger driven gear and to secure the driven gear to the cam shaft flange by a plurality of circumferentially spaced bolts. By providing a suitable pattern of bolts and bolt holes in the mounting flange and driven gear hub, desired rotative adjustment of the driven gear relative to the cam shaft can be effected.

When such a modification is made, adjustment of the timing is accomplished by first removing the sheave from the crank shaft (if such a sheave is employed), second, removing the cover from the block and, next, removing the several screw fasteners or bolts securing the driven

gear to the cam shaft flange, next removing the driven gear from the cam shaft, reorienting it in the desired rotative position relative thereto, and then re-assembling the entire structure. This procedure is, at best, a time-consuming and troublesome task.

An object of my invention is to provide a novel valve timing gear train for easy, convenient and effective installation in a stock engine in place of a standard sprocket and chain type timing means.

Another object of my invention is to provide a means of the character referred to including drive and driven gears engageable on and with the stock crank and cam shafts of the engine, an idler gear for engagement with and between the drive and driven gears and novel mounting means for the idler gear including a carrier plate releasably secured to the engine block, wholly within and clear of the cover plate.

It is an object of this invention to provide a mounting or carrier plate of the character referred to which has a portion remote from the idler gear engaged about the cam shaft whereby said plate serves as a radius arm and maintains the idler gear in proper radial position relative to the driven gear at all times and prevents the idler gear from being urged into binding engagement with the drive or driven gears as the construction is operated.

Still another object of the present invention is to provide fastening means in the plate, remote from the axis of the cam shaft and engageable with the block to fix the plate in set circumferential relationship relative to the axis of the cam shaft so that the idler establishes proper driving engagement with the driven gear.

It is another object of this invention to provide a structure as set forth above wherein the radial position of the axis of the idler gear can be varied or adjusted relative to the axis of the drive gear to establish accurate and proper engagement of the idler gear with the drive gear and, if desired, to make fine adjustment in timing by adjusting the depth of engagement of the teeth of the drive and idler gears and in such a manner as to vary the effective diameter of the drive gear.

Yet another object of my invention is to provide a novel drive gear having improved means to facilitate easy and convenient circumferential adjustment and positioning of the gear on the crank shaft whereby the rotative position of the crank shaft relative to the cam shaft can be varied distances equal to fractions of the circumferential extent of a single tooth of one of the gears to vary the valve timing, as desired or as required.

The foregoing and other objects and features of my invention will be fully understood from the following detailed description of the invention, throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is a front elevational view of an internal combustion engine with my timing gear related thereto;

FIG. 2 is a sectional view taken as indicated by line 2—2 on FIG. 1;

FIG. 3 is a sectional view taken as indicated by line 3—3 on FIG. 2;

FIG. 4 is a view taken as indicated by line 4—4 on FIG. 3;

FIG. 5 is a view taken as indicated by line 5—5 on FIG. 4; and

FIG. 6 is an isometric view of my new drive gear.

In FIG. 1 of the drawings, I have illustrated the front end of a typical V-type internal combustion engine E with the structure A that I provide related thereto. The engine E is characterized by an elongate cast iron block B with a substantially flat, axially forwardly disposed front end 10, a pair of heads H with related fuel and air intake means, exhaust means, valve covers and the like related thereto, and a pan O.

The engine E has an elongate central longitudinally extending crank shaft C arranged at the lower portion of the block and projecting forwardly from the block. The engine further includes an elongate central longitudinally

extending cam shaft S spaced vertically above the crank shaft and having a forward end projecting from the block.

The lower edge of the front of the block is provided with a semi-circular seat 11 to receive the upper half of a front main crank shaft bearing 12 and has a pillow block or cap 13 fixed to it to engage and support the lower half of the bearing 12. The cap which cooperates with the block to keep the front main bearing and the crank shaft is, in effect, a continuation of the front wall of the block and will be considered as a part thereof for the purpose of this disclosure.

The front wall 10 of the block, including the bearing cap referred to above, is provided with a forwardly opening recess 14 into which the shafts C and S project. The sides of the recess are defined by a forwardly projecting rib 15 on the block, the forward edge of which is milled flat to cooperatively receive a gasket 16 and is provided with a plurality of fasteners receiving openings to facilitate securing the timing gear cover T to the block. The sides of the recess are spaced radially outward from the shafts C and S a sufficient distance to accommodate a suitable gear or sprocket and chain drive means engaged on and between the shafts.

The cover T is a simple shell-like structure with a flat front wall 17 overlying the recess in axial, spaced, forward relationship from the front wall 10 of the block, a rearwardly projecting side wall 18 about the perimeter of the front wall and an outwardly projecting flange 19 about the rear edge of the side wall to establish flat bearing engagement with the gasket on the front surface of the rib 15 and having openings therein to register with the openings in the rib and through which suitable fastening bolts 20 are engaged.

The forward wall 17 of the cover T is provided with an opening 21 in axial alignment with the crank shaft C. An apertured plate-like closure 22 is releasably secured to the cover T by screw fasteners 23 to overlie the opening 21 therein. The plate 22 carries a suitable annular oil seal 24 through which the forward end of the shaft C projects.

With the above relationship of parts, it will be apparent that the recess 14 defined by the front wall 10 and the rib 15 cooperate with the cover T to define a chamber X into which the forward end of the cam shaft S projects and through which the forward end of the crank shaft C projects.

The portion of the shaft C which projects through the chamber X is provided with a radially outwardly projecting, axially extending key K suitably fixed with or to the shaft in accordance with common practice and which is adapted to establish driving engagement with a drive gear D of my construction.

The forward end of the cam shaft S is a stock shaft or a special shaft with a standard or conventional front end portion projecting from the block B into the chamber X and like the shaft C is provided with and carries a key K' to establish driving engagement between the shaft and a driven gear G which is slidably engaged on the shaft.

The shaft S terminates in the chamber X and is rotatably supported by a suitable bearing 25 carried by the front wall 10 of the block B through which the shaft projects.

The structure provided by this invention further includes a carrier plate P adapted to be carried by the front wall 10 of the block B, within the chamber X, in predetermined relationship to the shafts and the drive and driven gears and which carries an idler gear I for engagement with said drive and driven gears.

The carrier plate P is a flat, vertical plate-like part having a flat, rearwardly disposed rear surface 30 establishing substantially flat bearing engagement on the front wall 10 of the block and a flat front surface 31. The plate is established of plate stock the thickness of which is such that the plate can be advantageously arranged adjacent the front wall 10 of the block to occur between said front

wall of the block and the gears carried by the shaft, in running clearance with said gears.

In practice, in the case of certain makes of engines, the front wall 10 may be provided with forwardly projecting ribs and the like, which ribs and the like have milled front faces upon which the plate P is mounted.

The upper portion of the plate is provided with an opening 32 through which the forward end of cam shaft S projects with running clearance. The opening 32 is such that the fit established with the shaft S is not a bearing fit, but is of sufficient close tolerance that the shaft S constitutes a pivot for the plate and prevents radial displacement of the plate relative to the axis of the cam shaft S. In practice, a bearing, such as an anti-friction ball bearing (not shown), could be provided between the plate and the cam shaft without departing from the spirit of this invention.

In practice and as illustrated, the forward end of the opening 32 in the plate can be provided with a counter-bore or annular recess 33 to accommodate a rearwardly projecting hub 34 on the driven gear C.

The lower portion of the plate P occurs below the gear G and carries a forwardly projecting cylindrical trunnion 35 about which an anti-friction roller bearing 36 is engaged. The roller bearing 36 rotatably carries the idler gear I. The forward end of the trunnion is provided with a radially outwardly projecting retaining flange 37 to overlie the forward end of the bearing and the inner peripheral portion of the front end of the idler gear to hold the bearing and gear captive on the cylindrical portion of the trunnion and to prevent forward displacement of said bearing and gear.

The trunnion is a simple cylindrical body having a flat rear end 38 establishing flat bearing engagement on the front surface 31 of the plate P. The trunnion is provided with a central rearwardly projecting orienting pin 39 engaged in a pilot opening 40 in the plate and is provided with three circumferentially spaced axially extending, rearwardly opening fastener receiving openings 41 registering with three openings 41' spaced circumferentially about the pilot opening. The rear ends of the openings 41' are countersunk as at 42 and cooperatively receive flat head screw fasteners 43, which fasteners project forwardly into the openings 41 to hold and maintain the trunnion fixed to the plate.

It will be apparent that the head of the fasteners 43 are flush with the rear surface 30 of the plate and do not prevent or interfere with positioning the plate P flat against the front wall 10 of the block and that when the plate is in position adjacent the block, the block serves to hold the screws captive in their related openings and prevents said screws from working out, and becoming loose.

The arrangement of the orienting pin 39 and circumferentially spaced screw fasteners 43 effectively orient the trunnion, prevent rotation of the trunnion, eliminate the possibility of the trunnion from becoming loose and provide an extremely strong and stable support for the idler gear I.

The bearing 36 is a simple or conventional roller bearing construction having an inner race snugly engaged about the trunnion and an outer race snugly engaged in a central opening 45 in the idler gear I.

The upper end of the plate is provided with two or more fastener receiving openings 46, the forward ends of which are countersunk as at 47 and in which flat head mounting screws 48 are engaged. The openings 46 preferably occur above and radially spaced from the opening 32 and register with existing or specially drilled and tapped openings 49 in the front wall 10 of the block and into which the fasteners 48 are engaged to hold the plate tight against the wall 10 of the block.

The lower portion of the plate projects radially from the axis of the shaft S beyond the idler gear and its mounting means a sufficient distance to accommodate an

accessible countersunk opening 46' which opening is registered with an opening 49' in the block and in which a flat head fastener 48' is engaged to secure the lower end of a plate to and against the wall 10.

It is to be noted that the trunnion 35 supports the idler gear I in predetermined radial position relative to the axis of the cam shaft and that the idler gear is therefore at all times maintained in proper radial and driving engagement with the driven gear G.

The plate P, with several openings therein, is arranged so that the idler gear I is properly positioned to establish proper and desired driving engagement with the drive gear D. In the case illustrated, the idler gear I, viewing the construction from the front, is offset laterally to the left of the central vertical plane of the engine and occurs at and engages the lower left quadrant of the driven gear and the upper left quadrant of the drive gear.

In addition to the foregoing, the plate can, when necessary, be provided with oil openings or ports to register with the outlet ends of forwardly opening timing gear lubricating oil galleries in the front wall 10 of the block B (not shown).

The plate, to clear the drive shaft, to properly fit within the confines of the chamber X, to establish flat bearing engagement with the front wall 10 of the block B, to assure proper alignment of the openings in the plate with the existing and especially established openings in the front wall 10 of the block, and to reduce the weight of the construction, is especially shaped and designed. In the instant case it will be noted that the plate is substantially triangular in shape or plane configuration. In practice, the shape or plane configuration of the plate and the placement of the several openings therein can and must be varied to adapt it for use in connection with engines of different design. Such variations are easily made and do not affect the novelty of the instant invention.

It is to be noted that the wide spacing of the several fasteners securing the plate flat against the wall 10 of the engine establishes an extremely strong, rigid and stable mounting for the plate which effectively supports the trunnion and idler gear against the lateral bending and/or turning forces encountered when the construction is in operation.

The drive gear D on the crank shaft C is a simple spur gear with a central opening 50 to slidably receive the front end portion of the crank shaft C. The gear D distinguishes from standard or conventional gears in that it is provided with a plurality of circumferentially spaced, axially extending radially inwardly opening keyways 51, each of which can be selectively cooperatively engaged with the key K on the shaft C.

The ratio of the number of keyways 51 to the number of teeth on the gear is extremely important. If the number of teeth on the gear is an even number, the number of keyways 51 must be an uneven number. Whereas, if the number of teeth is uneven, the number of keyways must be even. In practice, the minimum number of keyways, when an uneven number of such keyways is called for, is three. Whereas, when an even number of keyways is required, two is the minimum number of such ways.

With the above relationship of parts, it will be apparent that the gear D engaged on the shaft C with the key K engaged in one keyway 51, is shifted axially forward out of engagement with the key K, is rotated and then shifted axially rearward with the key K engaged in another of the keyways 51, the effective rotative position of the gear C on the shaft C is varied a distance unequal to the circumferential extent of one tooth or a multiple thereof. Accordingly, the gear is rotated on the shaft a fraction of the circumferential extent of one tooth of the gear.

For example, if the gear D has 36 teeth, each effectively 10 degrees in circumferential extent, and there are five

keyways spaced equally on 72 degrees about the circumference of the opening in the gear, rotating the gear one keyway or 72 degrees relative to the shaft and key results in effective rotative adjustment of the gear on the shaft one-fifth ($\frac{1}{5}$) of one tooth, or two degrees. Rotating the position of the gear in the shaft two or more of the five keyways effects an adjustment of 4, 6 or 8 degrees.

It will be noted that after rotating the gear four times, rotation of the gear, in the same direction another 72 degrees results in an adjustment of 10 degrees or one full tooth.

It will be further noted that the direction in which the gear is moved relative to the shaft determines whether the adjustment affects advancement or retarding of the valve timing.

Greater or coarser rotative adjustment of the gear D relative to the crank shaft can be effected by eliminating certain intermediate keyways 51 so that every other of the above-noted variations can be obtained or a lesser number of equally spaced keyways can be provided, for example, three keyways spaced 120 degrees apart. Finer rotative adjustment can be obtained by employing an increased number of keyways, say, for example, seven keyways spaced 51.44 degrees apart.

Since the ratio between the drive and driven gears D and G is two to one (the cam shaft turning one-half the speed of the crank shaft), the above-noted adjustments being made at the smaller of the two gears E and G effects a relative rotative adjustment between the shafts C and S of one-half the adjustment of the gear D on the shaft C. Referring to the first example given above, the rotative adjustment of the gear D on the shaft C of two degrees would result in a relative adjustment of one degree between said shafts and, therefore, an adjustment of valve timing of one degree.

In light of the above, it will be apparent that with the structure that I provide, the relative rotative position of the crank and cam shafts C and S can be advantageously varied fractions of degrees as circumstances required or as desired.

In adjusting and setting the timing of the engine E with my structure related thereto, the timing gear cover T need not be removed and the gear G and plate P with the idler gear I related thereto need not be worked upon. Rather, the cover plate 22 is removed from the cover T and the forward end of the shaft C. With the cover plate 22 removed, the gear D is accessible through the opening 21 in the cover T. The gear D is manually engaged and pulled forwardly on the shaft to a point where it disengages the key K, is rotated as desired and is urged rearwardly and back into engagement with the key K.

By providing a multitude of keyways 51, it is possible for the person setting the timing to disengage the gear D as set forth above, rotatively adjust the crank shaft and the cam shaft as desired, in accordance with common practice, and then urge the gear D rearwardly on the shaft C and at the same time rotate the gear until the key K registers with one of the keyways 52 and the teeth on the gear D register and mesh with the teeth on the idler gear I.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any modifications and/or variations that may appear to those skilled in the art and which fall within the scope of the following claims:

Having described my invention, I claim:

1. In an internal combustion engine having an elongate block with a flat, forwardly disposed front wall, an elongate crank shaft with a forward end portion projecting from the front wall and an elongate cam shaft spaced from the crank shaft, and having a forward end portion projecting from the front wall, a timing gear means including, a drive gear on the forward end portion of the

crank shaft, a driven gear on the forward end portion of the cam shaft, a carrier plate releasably fixed to the front wall rearward of the drive and driven gears, a forwardly projecting trunnion on the carrier plate, and an idler gear rotatably carried by the trunnion and meshed with the drive and driven gears.

2. A structure as set forth in claim 1 wherein said carrier plate has a portion arranged between the front wall and the drive gear, with an opening through which the cam shaft projects with running clearance.

3. A structure as set forth in claim 1 wherein said plate has a plurality of fastener receiving openings, each with a forwardly opening countersink spaced radially from the axis of the trunnion and flat head screw fasteners engaged in said fastener receiving openings and extending rearwardly from the plate and into registering openings in said front wall.

4. A structure as set forth in claim 1 wherein said plate has a plurality of fastener receiving openings with a forwardly opening countersink spaced radially from the axis of the trunnion and flat head screw fasteners engaged in said fastener openings and extending rearwardly from the plate into registering openings in said front wall, said carrier plate having a portion arranged between the front wall and the driven gear, with an opening through which the cam shaft projects with running clearance.

5. A structure as set forth in claim 1 wherein said forward portion of the crank shaft has a radially outwardly projecting longitudinally extending key and said drive gear has a central opening slidably receiving the forward portion of the crank shaft and a plurality of circumferentially spaced, radially inwardly opening, longitudinally extending keyways to selectively slidably receive the key, the number of keyways being such that upon circumferential shifting of the drive gear on the crank shaft and engagement of the key from one keyway to another, the relative rotative position of the teeth of the gear and the shaft is varied a predetermined fraction of the circumferential extent of one tooth.

6. A structure as set forth in claim 1 wherein said forward portion of the crank shaft has a radially outwardly projecting longitudinally extending key and said drive gear has a central opening slidably receiving the forward portion of the crank shaft and a plurality of circumferentially spaced, radially inwardly opening, longitudinally extending keyways to selectively slidably receive the key, the number of keyways being such that upon circumferential shifting of the drive gear on the crank shaft and engagement of the key from one keyway to another, the relative rotative position of the teeth of the gear and the shaft is varied a predetermined fraction of the circumferential extent of one tooth, said plate having a plurality of fastener receiving openings, each with a forwardly opening countersink spaced radially from the axis of the trunnion and flat head screw fasteners carried in said fastener receiving openings and extending rearwardly from the plate and engaged in registering openings in said front wall.

7. A structure as set forth in claim 1 wherein said forward portion of the crank shaft has a radially outwardly projecting longitudinally extending key and said drive gear has a central opening slidably receiving the forward portion of the crank shaft and a plurality of circumferentially spaced, radially inwardly opening, longitudinally extending keyways to selectively slidably receive the key, the number of keyways being such that upon circumferential shifting of the drive gear on the crank shaft and engagement of the key from one keyway to another, the relative rotative position of the teeth of the gear and the shaft is varied a fraction of the circumferential extent of one tooth, and a cover plate fixed to the front wall to occur forward of the carrier plate and the several gears and having an access opening larger than the drive gear in axial alignment with the crank

shaft, a closure plate with a central opening, an oil seal in said opening and normally engaging and sealing about the forward end portion of the crank shaft and a plurality of screw fasteners releasably securing the closure plate to the cover plate to close the access opening.

8. A structure as set forth in claim 1 wherein said forward portion of the crank shaft has a radially outwardly projecting longitudinally extending key and said drive gear has a central opening slidably receiving the forward portion of the crank shaft and a plurality of circumferentially spaced, radially inwardly opening, longitudinally extending keyways to selectively slidably receive the key, the number of keyways relative to the number of teeth being such that upon circumferential shifting of the drive gear on the crank shaft and engagement of the key from one keyway to another, the relative rotative position of the teeth and the shaft is varied a predetermined fraction of the circumferential extent of one tooth, said plate having a plurality of longitudinally extending fastener receiving openings with forwardly opening countersinks spaced radially from the axis of the trunnion and flat head screw fasteners in said fastener receiving opening and extending rearwardly and engaged in registering openings in said front wall, and a cover plate fixed to the front wall to occur forward of the carrier plate and the several gears and having an access opening larger than the drive gear in axial alignment with the crank shaft, a closure plate with a central opening, an oil seal in said opening and normally engaging and sealing about the forward end portion of the crank shaft forward of said cover plate and a plurality of screw

fasteners releasably securing the closure plate to the cover plate to close the access opening.

9. A structure as set forth in claim 1 wherein at least one of said shafts has a radially outwardly projecting longitudinally extending key and the gear related to that shaft has a central opening slidably receiving the shaft and has a plurality of radially inwardly and axially outwardly opening longitudinally extending keyways arranged in circumferentially spaced relationship in said central opening, adjacent keyways being spaced equidistant from each other, the circumferential distance between adjacent keyways, or a multiple thereof, being unequal to multiples of the circumferential extent of each tooth of the gear, whereby selectively engaging the key in predetermined keyways varies the relative rotative position of the gear teeth relative to the shaft a predetermined fraction of the circumferential extent of one tooth.

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