

May 7, 1968

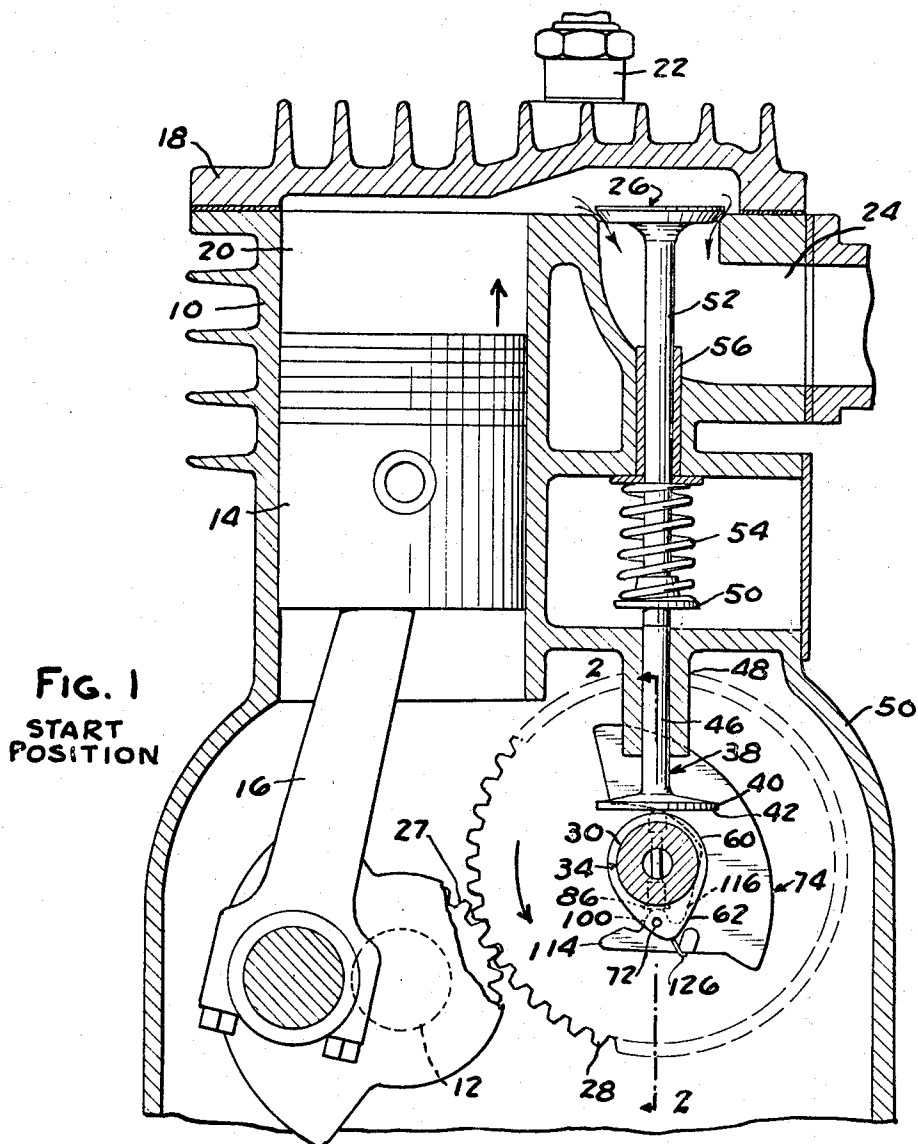
K. W. CAMPEN

3,381,676

COMPRESSION RELIEF MECHANISM

Original Filed Jan. 12, 1965

4 Sheets-Sheet 1



INVENTOR.
KENNETH W. CAMPEN

BY
Barnes, Kuehl, Rensch & Choate
ATTORNEYS

May 7, 1968

K. W. CAMPEN

3,381,676

COMPRESSION RELIEF MECHANISM

Original Filed Jan. 12, 1965

4 Sheets-Sheet 2

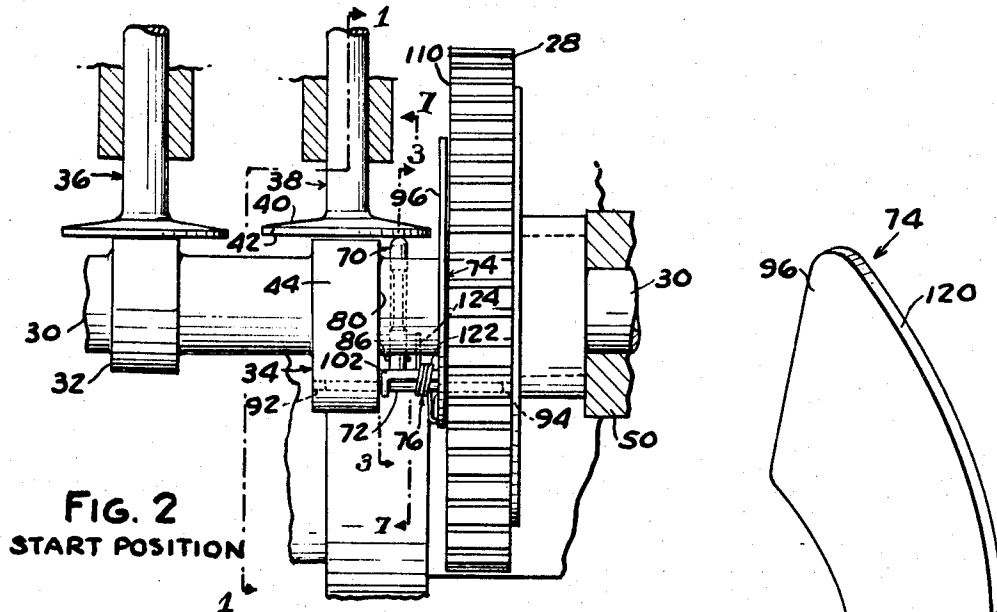


FIG. 2
START POSITION

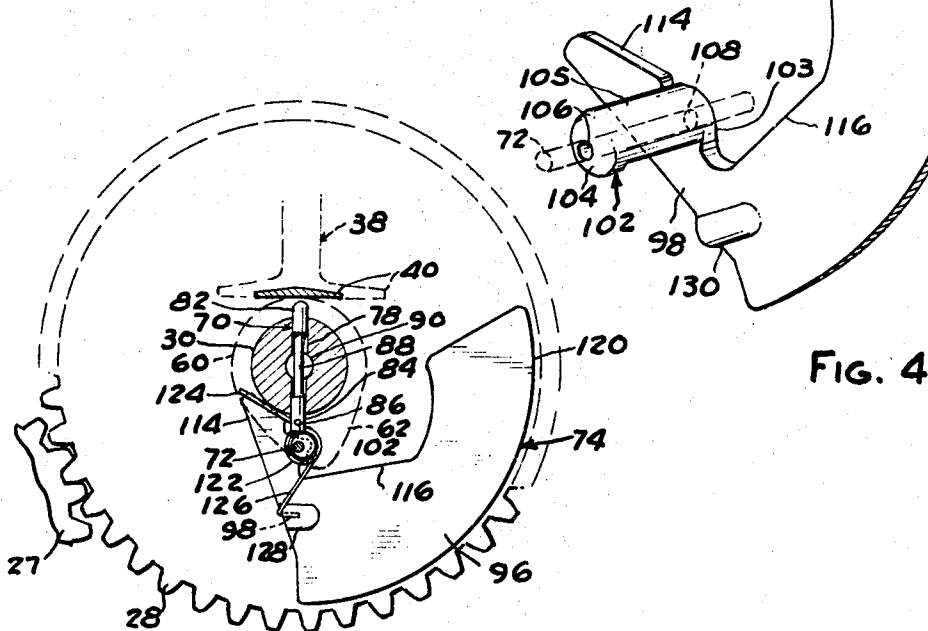


FIG. 3
RUN POSITION

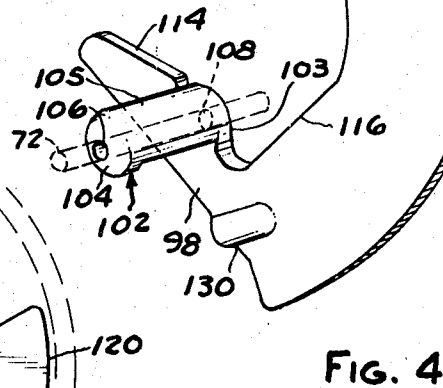


FIG. 4

INVENTOR.
KENNETH W. CAMPEN

BY
Barnes, Kuehler, Reisch & Choate

ATTORNEYS

May 7, 1968

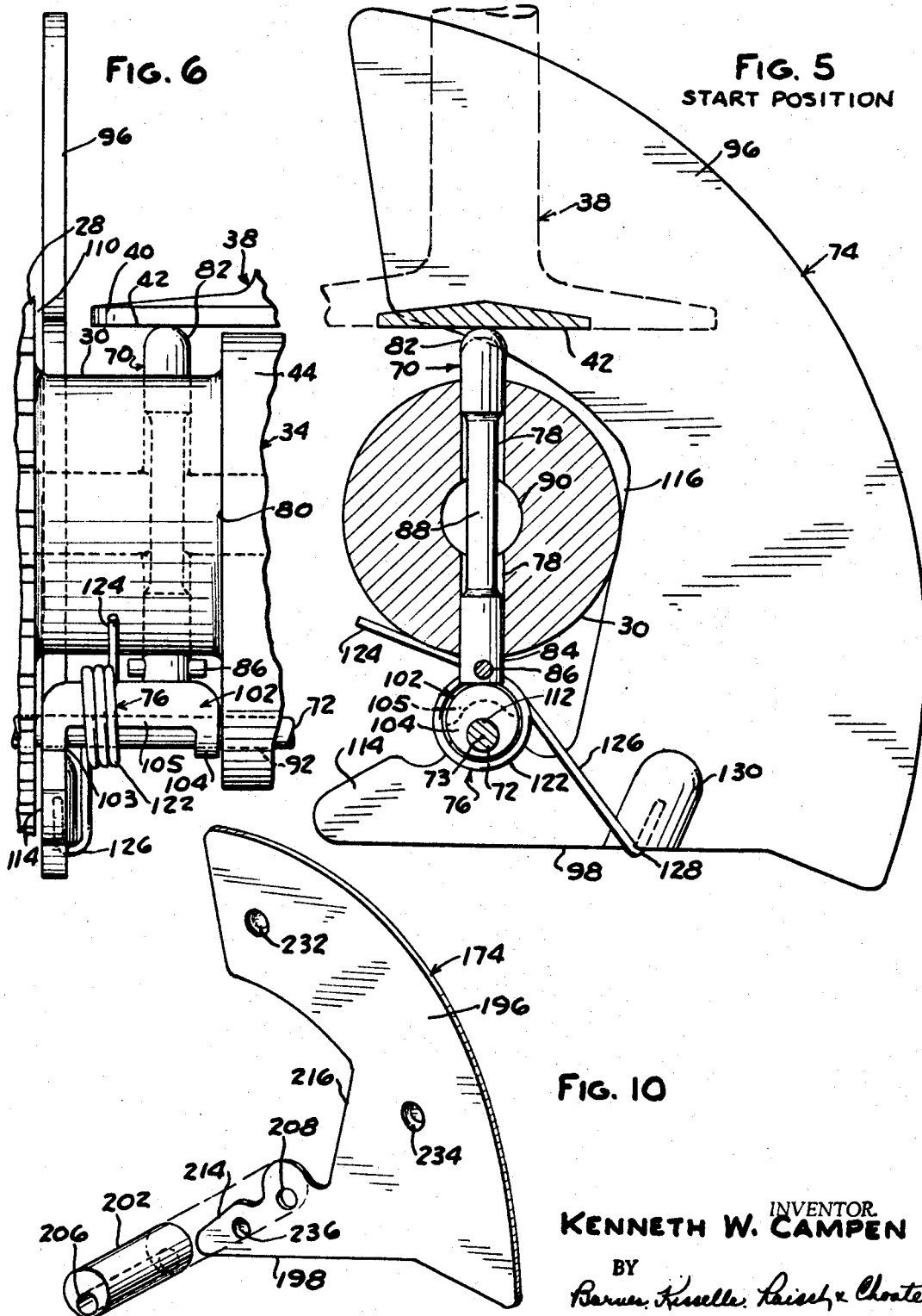
K. W. CAMPEN

3,381,676

COMPRESSION RELIEF MECHANISM

Original Filed Jan. 12, 1965

4 Sheets-Sheet 3



INVENTOR
KENNETH W. CAMPEN

BY
Barnes, Kesselle, Kirsch & Choute
ATTORNEYS

May 7, 1968

K. W. CAMPEN

3,381,676

COMPRESSION RELIEF MECHANISM

Original Filed Jan. 12, 1965

4 Sheets-Sheet 4

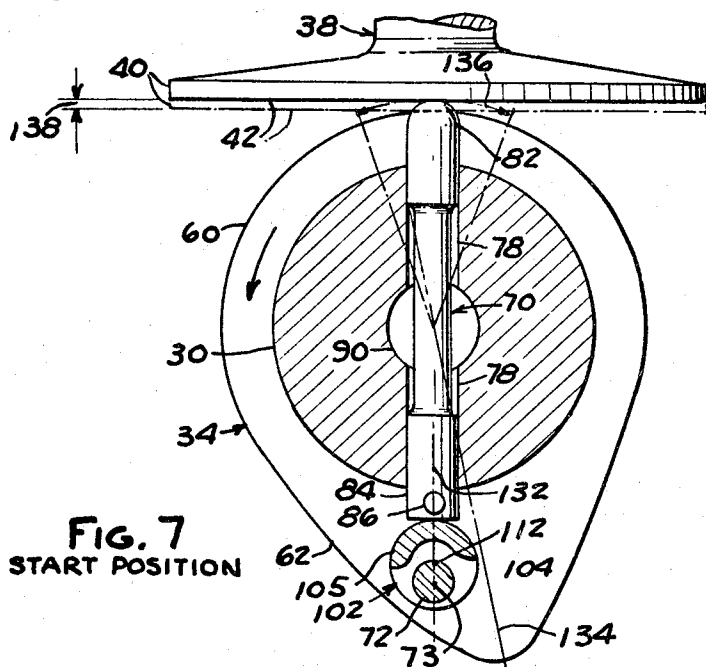


FIG. 7
START POSITION

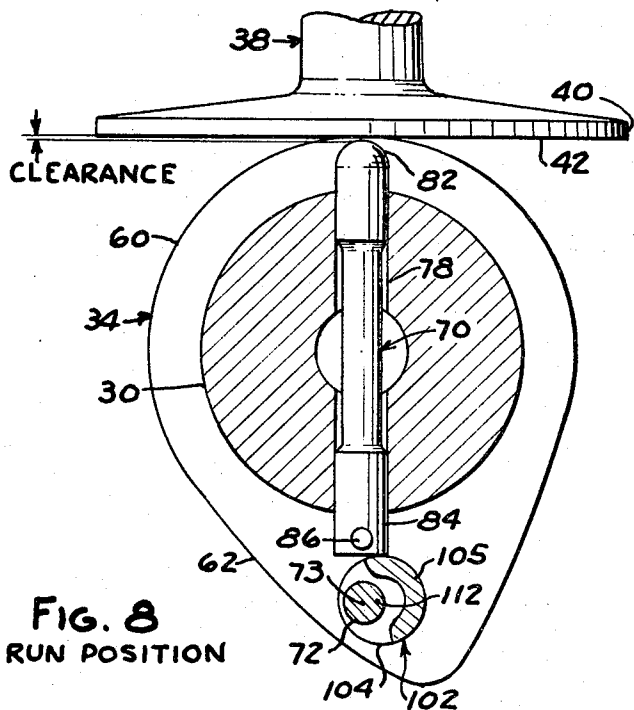


FIG. 8
RUN POSITION

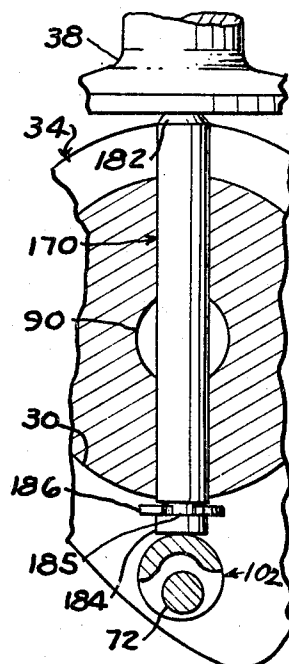


FIG. 9

INVENTOR
KENNETH W. CAMPEN

BY
Barnes, Kisselle, Reich & Choate
ATTORNEYS

1

3,381,676

COMPRESSION RELIEF MECHANISM

Kenneth W. Campen, Kiel, Wis., assignor to Tecumseh Products Company, a corporation of Michigan
Continuation of application Ser. No. 424,915, Jan. 12, 1965. This application Apr. 12, 1967, Ser. No. 630,465
17 Claims. (Cl. 123—182)

This application is a continuation of application Ser. No. 424,915, filed Jan. 12, 1965.

This invention relates to internal combustion engines, and more particularly to an improved compression relief mechanism adapted for use in a single cylinder four-stroke cycle engine.

An object of the present invention is to significantly reduce the cranking effort required to start an internal combustion engine without thereby sacrificing engine power at engine running speeds.

Another object of the present invention is to provide an improved compression relieving mechanism for an internal combustion engine which is automatically controlled by the engine itself to relieve compression only during cranking of the engine to thereby significantly reduce the cranking pull required to start the engine and which is rendered inoperative once the engine is running so that there is no power loss incurred at engine speeds.

Still another object is to provide an improved compression relieving mechanism of the above character which is economical in construction and highly reliable in operation.

A further object is to provide a compression relieving mechanism which is adapted for installation on existing engines without requiring redesign or retooling to modify the engine to accept the parts of the mechanism.

A more specific object of the present invention is to provide a compression relief mechanism of the above character in a compact arrangement which is adapted for installation on the camshaft of a four-cycle engine between the usual exhaust cam and timing gear thereof.

Other objects, features and advantages of the present invention will become apparent from the following detailed description and accompanying drawings wherein:
FIG. 1 is a vertical section taken on the line 1—1 of FIG. 2 through a single cylinder four-stroke cycle internal combustion engine embodying the compression relief mechanism of the present invention, the parts thereof being illustrated in their starting position.

FIG. 2 is a fragmentary side elevational view taken partially in section on the line 2—2 of FIG. 1 illustrating the compression relief mechanism and associated engine parts.

FIG. 3 is a fragmentary sectional view taken on the line 3—3 of FIG. 2 illustrating the parts of the compression relief mechanism in their respective positions at engine running speed.

FIG. 4 is an enlarged perspective view of a flyweight of the compression relief mechanism shown separate from the engine.

FIG. 5 is an enlarged sectional view also taken on the line 3—3 of FIG. 2 but showing the illustrated parts in their start position.

FIG. 6 is a fragmentary end elevational view of the structure shown in FIG. 5 viewed from a direction opposite to that of FIG. 2.

FIG. 7 is an enlarged fragmentary sectional view taken on line 7—7 of FIG. 2 showing the illustrated parts in their start position.

FIG. 8 is an enlarged sectional view similar to that of FIG. 7 but illustrating the parts in their run position.

FIG. 9 is a fragmentary sectional view similar to FIG. 8 illustrating a modified plunger construction also in accordance with the present invention.

2

FIG. 10 is a perspective exploded view of a modified flyweight construction also in accordance with the present invention.

Since this invention is primarily concerned with, but not necessarily limited to, single cylinder four-stroke cycle internal combustion engines, the drawings illustrate the invention as embodied in such an engine. As is customary the engine shown in FIG. 1 has a cylinder 10, a crankshaft 12 and a piston 14 operatively connected with the crankshaft through a connecting rod 16. The piston coacts with the cylinder and a cylinder head 18 to define a combustion chamber 20. A spark plug 22 secured in the cylinder head ignites the fuel charge after it has been drawn into the combustion chamber during the intake stroke and then compressed during the compression stroke of the piston, the spark normally being timed to ignite the fuel charge just before the piston completes its ascent on the compression stroke. The fuel charge is drawn into the combustion chamber from the carburetor of the engine through an intake passage controlled by a conventional intake valve (not shown), and the products of combustion are expelled from the cylinder during the exhaust stroke through an exhaust port 24 controlled by a poppet-type exhaust valve 26.

The conventional parts of the valve operating mechanism include a timing gear 27 mounted on crankshaft 12 for rotation therewith and a timing gear 28 mounted on a camshaft 30 and rotatably driven by gear 27 to thereby rotate the camshaft at one-half crankshaft speed. Camshaft 30 carries conventional pear-shaped intake and exhaust cams 32 and 34 (FIGS. 1 and 2) which rotate with the camshaft to impart reciprocating motion to the intake and exhaust valves via flat-footed push rods 36 and 38 respectively. The complete exhaust valve train is shown in FIG. 1 and includes push rod 38 which has a circular follower 40 with a flat underface 42 adapted to bear tangentially against and track upon the periphery 44 of cam 34. A stem 46 of the push rod slides in a guide boss 48 of crankcase 50 and butts its upper end against the stem 52 of exhaust valve 26. A valve spring 54 encircles stem 52 between a valve guide 56 and a spring retainer 58 carried on the stem, spring 54 biasing valve 26 closed and also biasing push rod 38 into tracking contact with cam 34.

The above-described engine and valve train parts are conventional, as is the fixed profile of exhaust cam 34 which, as best seen in FIGS. 7 and 8, consists of a base circle 60 and a lobe 62. When the compression relief mechanism described hereinafter is in its inoperative or run position, rotation of cam 34 with camshaft 30 causes normal operation of valve 26 so that it opens and closes in timed relation with the travel of the piston 14 according to conventional engine timing practice. Thus cam lobe 62 is adapted to open valve 26 near the end of the power stroke and to hold the same open during ascent of the piston on the exhaust stroke until the piston has moved slightly past top dead center. When follower 40 contacts base circle 60, spring 58 reseats valve 26 and holds the same closed during the ensuing intake, compression and power strokes. Intake cam 32 is likewise of conventional fixed configuration to control the intake valve such that it closes completely shortly after the piston begins its compression stroke and remains closed through the subsequent power and exhaust strokes, reopening to admit the fuel mixture on the intake stroke.

Since in a conventional engine the intake and exhaust valves are normally closed for the major portion of the compression stroke, cranking of the engine would be difficult unless some provision is made to vent the combustion chamber 20 during part or all of the compression stroke during cranking of the engine. However, by

modifying a conventional engine to incorporate the improved compression relief mechanism in accordance with the present invention, compression relief is automatically obtained at cranking speeds to greatly reduce cranking effort and thereby facilitate starting. In addition, the mechanism is responsive to engine speed such that it is automatically rendered inoperative at engine running speeds so that there is no compression loss to decrease the efficiency of the engine when it is running under its own power.

Referring to FIGS. 2 and 3, the compression relief mechanism of the present invention is compactly disposed between exhaust cam 34 and gear 28 and preferably consists of only four parts; plunger 70, pin 72, flyweight 74 and spring 76.

Plunger 70 is slidably disposed in and protrudes from both ends of a diametrical bore 78 formed in camshaft 30 adjacent one side 80 of exhaust cam 34 (FIGS. 2, 5 and 6). As best seen in FIGS. 7 and 8, bore 78 is angularly oriented relative to cam 34 such that one end 82 of plunger 70 protrudes from the bore adjacent base circle 60 and is thus oppositely arranged relative to the valve lifting lobe 62 of the cam. The opposite end 84 of plunger 70 protrudes from camshaft 34 adjacent lobe 62 and carries a pin 86 which extends transversely therethrough and overlaps camshaft 30 to retain the plunger in the camshaft. In the form shown in FIGS. 1-8, end 82 of plunger 70 is spherically shaped and the center section 88 of plunger 70 is reduced in diameter relative to its ends 80 and 82 to minimize obstruction of oil flow in the axial oil passage 90 of camshaft 30.

As shown in FIGS. 2 and 6, hinge pin 72 has one end disposed in a hole 92 extending through lobe 62 of cam 34 and its opposite end secured by a press fit in a hole 94 extending through the sides of gear 28. Holes 92 and 94 are coaxial and are located such that pin 72 is parallel to camshaft 30 with the respective axes of pin 72 and plunger 70 perpendicular to one another.

As best seen in FIG. 4, flyweight 74 comprises an arcuate arm 96 having an integral radially inwardly directed coplanar extension 98. In the embodiment of FIGS. 1-8, flyweight 74 is configured to facilitate manufacture by stamping it from a single piece of sheet metal. In this form, flyweight 74 includes an integral yoke-like cam 102 comprising a pair of spaced parallel ears 103 and 104 joined by a semicylindrical arm 105. Ear 103 is coplanar with extension 98 and arm 105 extends perpendicularly from extension 98. Ears 103 and 104 each have a hole 106 and 108 respectively for receiving pin 72 therethrough to thereby pivotally mount flyweight 74 on the pin. In the assembled position of flyweight 74 as shown in FIGS. 2 and 6, arm 96 is disposed closely adjacent and parallel to the face 110 of gear 28 so that arm 96 clears the outer edge of follower 40. Ear 104 is disposed closely adjacent face 80 of cam 34, cam 102 thereby maintaining arm 96 properly spaced from follower 40.

As best seen in the enlarged views of FIGS. 5, 6, 7 and 8, end 84 of plunger 70 rides upon cam 102. The center 112 of curvature of the semicylindrical circumference of cam 102 is eccentric relative to the axis 73 of pin 72. Thus as flyweight 74 swings outwardly from the start position of FIGS. 1, 5 and 7 to the run position of FIGS. 3 and 8, cam 102 pivots on pin 72 and moves away from camshaft 30, thereby allowing plunger 70 to move in camshaft 30 until end 82 is retracted radially inwardly of base circle 60 of cam 34 (FIGS. 3 and 8).

Outward pivotal movement of flyweight 74 (clockwise as viewed in FIG. 3) is limited by the terminal end 114 of flyweight extension 98 butting against camshaft 30 to thereby determine the run position of the flyweight. In this position arm 96 is still disposed radially inwardly of the outer periphery of timing gear 28. Counterclock-

wise pivotal movement of the flyweight is limited by inner edge 116 of arm 96 butting against camshaft 30 to thereby determine the start position of the flyweight (FIGS. 1 and 5).

Torsion spring 76 comprises a series of convolutions 122 positioned loosely around cam 102 and pin 72 (FIG. 5) and has one end 124 bearing against camshaft 30 and another end 126 bent back at 128 and hooked into a pocket 130 of flyweight 74. When camshaft 30 is stationary or rotating at or below its cranking speed, spring 76 holds flyweight 74 inwardly against camshaft 30 (start position of FIGS. 1 and 5). In start position cam 102 abuts plunger end 84 and projects its rounded end 82 a predetermined distance 138 (FIG. 7) beyond base circle 60. As best seen in FIG. 7, when flyweight 74 is in the start position, cam 102 is preferably on "dead center," e.g., the center 112 of curvature of arm 105 is substantially aligned with a line 132 coincident with the axis of plunger 70 and intersecting the axis 73 of pin 72. Hence when plunger 70 strikes follower 40, the downward force exerted by valve spring 54 is transmitted by push rod 38, plunger 70 and the cam portion 102 of the flyweight along line 132, thereby producing a simple shear loading on the pin 72 and eliminating any torque on the flyweight tending to act against spring 76. In addition, the force of spring 76 in the run position of FIGS. 3 and 8, as it is translated into an upwardly acting force on plunger 70, is multiplied many times (approximately twelve times in the illustrated embodiment) due to the mechanical advantage of the eccentric cam 102 of the flyweight multiplied by the ratio of the moment arms of spring arm 126 and arm 102 about the axis of pin 72. When the flyweight cam 102 reaches the start or dead center position, this mechanical advantage becomes infinite, resulting in a locked relation wherein valve spring 54 cannot produce any unlocking torque of the flyweight. Due to manufacturing tolerances, the start position of cam 102 may vary slightly from dead center but the extremely high mechanical advantage obtained in the vicinity of dead center will accommodate such tolerance variations without thereby hindering operation of the compression relief mechanism. Due to these features, spring 76 may be relatively weak and flyweight 74 in turn made relatively lightweight.

It is also to be understood that spring 76 need not be strong enough to project plunger 70 to start position against the force of valve spring 54. Actually spring 76 need only be strong enough to overcome centrifugal force acting on flyweight 74 at cranking speeds and below due to the fact that for approximately 320° of revolution of camshaft 30 plunger 70 is out of engagement with follower 40 even when plunger end 82 projects beyond base circle 60 of cam 34. Hence spring 76 can effect full retractile movement of flyweight 74 and thus full projection of plunger end 82 beyond the base circle during this period of camshaft rotation without encountering counter-torque resistance from valve spring 54. Thus as the engine comes to a halt, there is sufficient angular travel between contacts of plunger 70 with follower 40 to allow spring 76 to snap flyweight 74 into start position.

The operation of the above-described compression relief mechanism is entirely automatic and determined by engine speed. To start the engine the operator manually cranks the engine in the usual manner, such as with a pull rope starter, to turn the engine over at a relatively low cranking speed. As plunger 70 revolves with camshaft 30, plunger end 82 will strike follower 40 and lift it a predetermined distance (which is a fraction of normal or full valve lift as explained below) off of base circle 60, thereby lifting exhaust valve 26 off its seat for a portion of each compression stroke. Exhaust valve 26 will thus be partially reopened on every compression stroke as long as the engine speed does not exceed cranking speed, thereby venting a portion of the previously inducted fuel-air mixture from the combustion chamber

through exhaust passage 24 to atmosphere to thereby relieve compression during starting.

As soon as the engine has started and is running under its own power, its speed will increase to low idling speed or above, for example on the order of 1200-1500 engine r.p.m. As the rotational speed of camshaft 30 increases above cranking speed, flyweight 74 as it revolves with camshaft 30 overcomes spring 76 and pivots clockwise from the start position of FIG. 1 to the run position of FIG. 3. For example, spring 76 and flyweight 74 may be balanced to produce this movement in the range from 750 to 1000 engine r.p.m. This movement of the flyweight simultaneously rotates cam portion 102 from the start position (FIGS. 1, 5 and 7) to the run position (FIGS. 3 and 8) and plunger 70 shifts radially of camshaft 30, thereby retracting plunger end 82 within the base circle of exhaust cam 34. The plunger is retracted by valve spring 54 which acts through the push rod 38 on the plunger as plunger end 82 strikes follower 40 during revolution of the camshaft. Plunger 70 is thereafter maintained in its retracted position by the spring-biased push rod 38. In the embodiment of FIGS. 1-8, centrifugal force acting on plunger 70 also tends to retain it in retracted position since the center of gravity of the plunger is now disposed between the axis of camshaft 30 and pin 72. Thus after the engine has started and is brought up to idling speed, and so long as it is running at idling speed or above, plunger 82 is rendered inoperative and the opening and closing cycle of exhaust valve 26 is determined solely by the fixed, conventional profile of exhaust cam 34. Hence the exhaust valve will be closed throughout every compression stroke at these speeds so that the engine can develop its maximum rated power output.

As the engine is brought to a stop, spring 76 returns the flyweight to start position (FIGS. 1 and 5), thereby causing cam portion 102 to cam the plunger 70 to the start position (FIG. 7) where it again will be operable to effect compression relief to facilitate starting.

The compression relief mechanism of the present invention thus provides an auxiliary or secondary cam (plunger 70, or 170 as hereinafter described) which is speed responsive and reliable in operation, and which greatly reduces the work required to crank the engine without sacrificing engine performance once the engine begins running. Reliable operation is assured by the aforementioned dead center relationship of plunger 70, cam portion 102 and pin 72 in the start position, as well as by the high mechanical advantage through which spring 76 acts to project the plunger. The mechanism of the invention is simple and compact. Conventional engines may thus be readily equipped with the compression relief mechanism without requiring rearrangement of the existing cams and timing gears or enlargement of the existing radial clearance space between timing gear 28 and crankcase 50.

In addition, plunger 70 may be dimensioned, shaped and/or oriented angularly relative to the associated conventional cam as desired to adjust the extent of valve lift and hence the degree of compression venting during the compression stroke as well as to adjust the duration of the period during which the valve is held open. For example, as shown in FIG. 7 the mechanism may be designed to open the exhaust valve during the compression stroke at approximately 50° after bottom dead center and to close the exhaust valve at approximately 130° after bottom dead center (in terms of crank angle). In the embodiment of FIGS. 1-8 this is accomplished by orienting the axial centerline 132 of plunger 70 about 12° lagging the centerline 134 of cam 34, depending of course on the angular orientation of cam 34 relative to crankshaft rotation. The angle 136 (FIG. 7) of rotation of camshaft 30 during which plunger end 82 contacts follower 40 will be about 40°, which is equivalent to 80° of crankshaft rotation, depending upon shape of plunger

end 82 and the distance 138 (FIG. 7) which plunger end 82 projects beyond base circle 60. Peak valve opening for compression relief venting of the combustion chamber may be on the order of .010-.015". Thus in terms of piston travel during its ascent on the compression stroke, exhaust valve 26 will be opened by plunger 70 when piston 14 has traveled about one eighth from the bottom toward the top of its compression stroke, and will be closed again at approximately three fourths of its total ascent in the compression stroke. These figures are exemplary only and may be varied as desired according to the needs of the particular engine under consideration.

It is also to be understood that the compression relief mechanism of the present invention may be mounted adjacent intake cam 32 to operate on the intake valve rather than the exhaust valve. In this event compression relief is accomplished by the plunger delaying the closure of the intake valve so that the same is held off its seat during the major portion of the compression stroke. Assuming that the intake valve normally closes when piston 14 has traveled one eighth of its total ascent in the compression stroke, plunger 70 is oriented so that plunger end 82 projects adjacent the lagging side of the lobe of the intake cam to produce the requisite lift for holding the intake valve off its seat until piston 14 has traveled say three fourths of its total ascent in the compression stroke. This modification would require some redesign of the camshaft and/or the intake cam so that camming portion 102 and associated structure of the compression relief mechanism clears the follower of intake push rod 36. Hence for sake of economy it is preferred to mount the compression relief mechanism adjacent the exhaust valve 34 as shown herein.

In some applications it may be preferred to provide a third valve the sole purpose of which is to relieve compression during starting, in which case a compression relief mechanism of the present invention may be mounted adjacent a circular rather than pear-shaped cam and valve movement effected solely by the plunger when the same is projected to its operative position.

Referring to FIG. 9, there is shown a modified plunger 170 also provided in accordance with the present invention. Plunger 170 differs from plunger 70 in that its upper end 182 is chamfered instead of being spherically shaped, it is formed as a straight cylindrical piece rather than being relieved in the center and its lower end 184 has a groove 185 for receiving a snap ring 186 in lieu of pin 86 to retain plunger 170 in camshaft 30. These changes reduce manufacturing costs. In addition, the use of snap ring 186 permits plunger 170 to be assembled in camshaft 30 after flyweight 74 has been assembled on pin 72 between cam 34 and gear 28. This in turn permits selective assembly to fit each particular unit, thereby offsetting tolerance stack-ups to give better control of valve opening in applications where this is deemed necessary.

Referring to FIG. 10, there is shown in exploded form a modified flyweight 174 of the present invention which is a two-piece assembly: a stamped sheet metal part comprising arcuate arm 196 and radial extension 198, and a cam 202 comprising a solid cylinder having an axially extending through-bore 206 which is eccentric to the axis of cylinder 202. Cylinder 202 is brazer or otherwise suitably fixed at one end to extension 198 in the position indicated in broken lines in FIG. 10 wherein bore 206 is aligned with a hole 208 in extension 198. Bore 206 and hole 208 receive hinge pin 72 therethrough to pivotally mount flywheel 174 on the camshaft for operation in the manner of the previous flyweight embodiment 74. Another feature of flyweight 174 is the provision of one or more dimples, such as the three dimples 232, 234 and 236, which are stamped from arm 196 to project beyond the side of the arm which is disposed adjacent timing gear 28. Dimples 232, 234 and 236 thus are disposed

to slidably contact face 110 of gear 28 and thereby hold the flyweight spaced from gear 28. This prevents an oil film from forming between the flyweight and gear, thus minimizing surface tension drag. Dimples 232, 234 and 236 eliminate the need for stamped pocket 130 of flyweight 74 since the dimples project a sufficient distance to provide a clearance spaced between the flyweight and gear 110 for reception of the bent back end 128 of spring 122. As an alternative to the aforementioned dimples, other spacing means may be provided such as a bent tab which is struck from arm 196 to project generally perpendicularly from the side of the arm which is disposed adjacent gear 28, or a washer may be assembled on hinge pin 72 between gear 28 and the flyweight. However, a plurality of dimples are preferred since they provide economical spacing structure having smooth rounded surfaces for free sliding contact with face 110 of gear 28 and also provide a stable three point contact with the gear due to their triangular orientation on flyweight 174.

I claim:

1. In an internal combustion engine, a compression relief mechanism comprising a valve controlling a port adapted to connect a combustion chamber of the engine with atmosphere, a cam follower, a camshaft, a primary cam on the camshaft, a valve spring biasing said follower against said primary cam, said primary cam having a fixed profile normally operative on said cam follower to effect cyclical opening and closing of said valve in response to camshaft rotation, a secondary cam supported on said camshaft for movement transversely thereof in a plane intersecting the path of travel of said follower and adjacent said primary cam and means supporting said secondary cam for movement between a run position clear of said follower and a start position where said secondary cam is operative to engage said follower during rotation of said camshaft, said last mentioned means including pivot means carried by said camshaft for rotation therewith and a flyweight pivotable on said pivot means relative to said camshaft to a run position in response to centrifugal force acting on said flyweight when engine speed exceeds cranking speed, spring means biasing said flyweight against centrifugal force to pivot said flyweight to a start position when engine speed equals or is less than cranking speed and means carried on said pivot means and operably connected to said flyweight for rigidly supporting said secondary cam in said start position thereof when said flyweight is in said start position thereof, said last-mentioned means being actuated by movement of said flyweight to its run position to permit movement of said secondary cam to its run position.

2. The combination set forth in claim 1 wherein said means carried on said pivot means and operably connected to said flyweight comprises a member formed as an integral portion of said flyweight and having a surface slidably engagable with said secondary cam during movement of said member with said flyweight between said run and start positions thereof.

3. In an internal combustion engine having a cylinder, a piston reciprocable in the cylinder and defining therewith a combustion chamber, a rotary crankshaft, a connecting rod operably interconnecting said piston and crankshaft, valve train means including inlet and exhaust valves operable to respectively control flow of air to and exhaust of gases from said combustion chamber, a camshaft rotatable about an axis parallel to said crankshaft, a gear train drivingly connecting said crankshaft to said camshaft including a timing gear fixed on said camshaft, and inlet and exhaust cams fixed on said camshaft and having fixed profiles for respectively operating said inlet and exhaust valves, one of said inlet and exhaust cams being disposed adjacent one side of said timing gear, said valve train means further including a follower and a spring associated therewith for biasing said follower into tracking relation with said one cam whereby rotation of

said one cam operates said one of said valves, the combination therewith of a compression release mechanism disposed generally between said timing gear and said one cam comprising a pin supported on said timing gear and extending from said one side thereof toward said one cam parallel to the rotational axis of said timing gear, a flyweight pivotally supported on said pin and responsive to centrifugal force acting thereon as the engine exceeds cranking speed to pivot in a path disposed between said one side of said timing gear and said follower from a start position adjacent said camshaft to a run position spaced outwardly from said camshaft but inwardly of the periphery of said timing gear, a spring biasing said flyweight inwardly to said start position thereof at and below engine cranking speed, and auxiliary cam means supported by said camshaft and timing gear for rotation therewith including follower engaging means movable between a run position thereof disposed inwardly and clear of the path of said follower and a start position protruding outwardly for engagement with said follower during a predetermined angle of rotation of said one cam to thereby hold said one valve open in the compression stroke of said piston, said auxiliary cam means also including support means fixed to said flyweight for movement therewith, said support means being oriented relative to said flyweight and said follower engaging means to engage and support said follower engaging means in said start position thereof when said flyweight moves to said start position thereof and to permit said follower engaging means to move to said run position thereof when said flyweight moves to said run position thereof.

4. The combination set forth in claim 3 wherein said follower engaging means has a center of gravity disposed relative to the rotational axis of said camshaft such that centrifugal force acting on said follower engaging means during rotation of said camshaft tends to maintain said follower engaging means in said run position thereof.

5. The combination set forth in claim 3 wherein said camshaft has a cavity therein receiving said follower engaging means in its run position.

6. The combination set forth in claim 3 wherein said follower engaging means is disposed axially between said one cam and said one side of said timing gear.

7. The combination set forth in claim 3 wherein said support means of said flyweight and said follower engaging means have interengaging surfaces extending in said respective start positions thereof in a direction generally perpendicular to the direction of force exerted by said follower on said follower engaging means and to a line intersecting the point of engagement of said surfaces and the axis of pivotal movement of said flyweight whereby the force exerted by said follower engaging means on said flyweight is ineffective to develop a rotational force on said flyweight sufficient to a pivot the same from its start position toward its run position.

8. The combination set forth in claim 7 wherein said interengaging surfaces are oriented relative to one another such that said surface of said support means has a camming engagement with said surface of said follower engaging means tending to force said follower engaging means toward said start position thereof as said flyweight is moved by said flyweight spring toward said start position thereof.

9. In an internal combustion engine having a cylinder, a piston reciprocable in the cylinder and defining therewith a combustion chamber, a rotary crankshaft, a connecting rod operably interconnecting said piston and crankshaft, valve train means including inlet and exhaust valve operable to respectively control flow of air to an exhaust of gases from said combustion chamber, a camshaft rotatable about an axis parallel to said crankshaft, a gear train drivingly connecting said crankshaft to said camshaft including a timing gear fixed on said camshaft, and inlet and exhaust cams fixed on said camshaft and having fixed profiles for respectively oper-

ating said inlet and exhaust valves, one of said inlet and exhaust cams being disposed adjacent one side of said timing gear, said valve train means further including a follower and a spring associated therewith for biasing said follower into tracking relation with said one cam whereby rotation of said one cam operates said one of said valves, the combination therewith of a compression release mechanism comprising a pin supported on said timing gear and extending from said one side thereof parallel to the rotational axis of said timing gear, a generally flat flyweight pivotally supported on said pin such that said flyweight is pivotable on said pin by centrifugal force acting thereon in a plane perpendicular to the camshaft rotational axis and closely adjacent said one side of said timing gear from a start position adjacent said camshaft to a run position pivoted outwardly away from said camshaft but inwardly of the circumferential periphery of said timing gear, a spring supported on said pin and engaging said flyweight and operable to bias the same inwardly toward said start position thereof at camshaft rotational speeds corresponding to engine cranking speeds or below, and auxiliary cam means supported by said camshaft and timing gear for rotation therewith including follower engaging means movable between a run position thereof disposed inwardly of the profile of said one cam and a start position protruding outwardly a predetermined distance beyond said profile of said one cam for engagement with said follower during a predetermined angle of rotation of said one cam to thereby hold said one valve open during the compression stroke of said piston, said auxiliary cam means also including support means fixed to said flyweight for movement therewith into engagement with said follower engaging means in the start position of said flyweight to support said follower engaging means in said start position thereof against movement thereof toward said run position thereof, said support means being movable by movement of said flyweight to its run position to permit said follower engaging means to move to its run position.

10. In an internal combustion engine, a compression relief mechanism comprising a valve controlling a port adapted to connect a combustion chamber of the engine with atmosphere, a cam follower, a camshaft, a primary cam on the camshaft, a valve spring biasing said follower against said primary cam, said primary cam having a fixed profile normally operative on said cam follower to effect cyclical opening and closing of said valve in response to camshaft rotation, a secondary cam supported on said camshaft for movement transversely thereof adjacent said primary cam and means for projecting and retracting said secondary cam to move it into or out of an operative position relative to said cam follower, said last mentioned means including a flyweight carried on said camshaft for rotation therewith and pivotable relative thereto to a first position in response to centrifugal force acting on the flyweight at a predetermined camshaft rotational speed, spring means biasing said flyweight against centrifugal force to pivot said flyweight to a second position at camshaft rotational speeds less than said predetermined speed and means operably connecting said flyweight and secondary cam such that said pivotal movement of said flyweight between said first and second positions causes movement of said secondary cam between its inoperative and operative positions relative to said follower, said means operably connecting said flyweight and secondary cam comprising a third cam pivotable with said flyweight and having a curved camming surface disposed eccentrically relative to the pivotal axis of said flyweight and contacting said secondary cam to effect said movement thereof in response to said pivotal movement of said flyweight, said third cam being oriented relative to said secondary cam and said flyweight such that the center of curvature of said camming surface is substantially aligned with said flyweight pivotal axis and the

contact of said camming surface and said secondary cam when said secondary cam is in its operative position.

11. The combination set forth in claim 10 wherein said spring means is operably connected between said camshaft and flyweight to act through a moment arm greater than the radial distance between said camming surface and the pivotal axis of said flyweight.

12. In an internal combustion engine, the combination comprising a camshaft having an exhaust cam thereon, an exhaust valve train including a follower biased against the periphery of said cam to track thereon for reciprocating said valve in response to rotation of said cam, said camshaft having a bore extending transversely therethrough adjacent said cam, a plunger slidably disposed in said bore, a flyweight carried on said camshaft for rotation therewith and for pivotal movement in a plane transverse to the axis of said shaft, said flyweight having cam means operably connected to one end of said plunger for shifting the same such that the end of said plunger opposite said one end thereof moves inwardly and outwardly of an imaginary axial extension of the profile of said cam, and spring means operably interconnecting said flyweight and camshaft for biasing the flyweight radially toward said camshaft to a first position whereby said cam means shifts said plunger such that said opposite end thereof projects beyond said cam profile to operably engage said follower, said flyweight being movable under the influence of centrifugal force to a second position radially outwardly from the camshaft in response to the camshaft rotating at a predetermined speed whereby said cam means operably effects shifting of said plunger to retract said opposite end thereof out of operable engagement with said follower.

13. An internal combustion engine having a cylinder, a crankshaft, a piston in the cylinder operatively connected with the crankshaft to define a combustion chamber in which a charge of air-fuel mixture is compressed during the compression stroke of the piston, means defining a passage communicating with the combustion chamber and through which part of the charge in the combustion chamber may escape, a valve for closing said passage, a rotary camshaft having a cam fixed thereon, valve train means including a follower and a spring for biasing said valve to closed position and said follower into tracking relation with said cam, timing gears on said crankshaft and camshaft intermeshed to synchronize the operation of said valve by said cam and valve train means with piston travel, said follower having a portion extending beyond one side of said cam toward said camshaft timing gear, said camshaft having a bore therethrough between said cam and camshaft timing gear aligned with said follower portion, a plunger slidably disposed in said bore and having its opposite ends protruding therefrom, a pin extending between and supported by said cam and camshaft timing gear parallel to the axis of the camshaft adjacent one end of said plunger, a flyweight having a camming portion journaled on said pin engaging said one end of said plunger and an arm extending radially outwardly from the pin adjacent said camshaft timing gear, said flyweight also having a stop portion adapted to abut said camshaft to limit movement of said arm away from the camshaft, and a torsion spring encircling said pin and camming portion and having one end engaging said camshaft and the other end engaging said flyweight to bias said arm radially inwardly into abutment with the camshaft, said flyweight camming portion being shaped to cam said plunger radially of the camshaft to thereby project the opposite end of said plunger beyond the adjacent fixed profile of said cam in response to movement of the flyweight toward said camshaft and to permit retraction of said plunger out of engagement of said follower in response to movement of the flyweight away from said camshaft.

14. The combination set forth in claim 13 wherein said flyweight camming portion has a camming surface con-

11

tacting said one plunger end oriented relative to the plunger and said pin such that the resultant force exerted by said plunger on said camming portion acts substantially through the center of rotation of said camming portion when said flyweight arm is at the limit of its movement toward said camshaft.

15. The combination set forth in claim 13 wherein said flyweight includes means projecting from the side thereof adjacent said camshaft timing gear and adapted to slidably contact the adjacent side of said gear for spacing said flyweight therefrom.

16. The combination set forth in claim 15 wherein said projecting means comprise at least one dimple stamped from said flyweight to provide a rounded projection adapted for smooth sliding contact with said gear.

12

17. The combination set forth in claim 15 wherein said projecting means comprises three dimples each stamped from said flyweight to provide a rounded projection adapted for smooth sliding contact with said gear, said dimples being arranged in a triangular pattern on said flyweight with one of said dimples disposed on the opposite side of the axis of rotation of said flyweight from at least one other of said dimples.

References Cited

UNITED STATES PATENTS

868,765	10/1907	Dock	123—182
3,247,835	4/1966	Weglage	123—182

15 RALPH D. BLAKESLEE, *Primary Examiner*.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,381,676

May 7, 1968

Kenneth W. Campen

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 70, "an" should read -- and --.

Signed and sealed this 23rd day of September 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents