Nov. 16, 1943. H. A. THORNBURG 2,334,657

ENGINE STARTING MECHANISM

Filed July 30, 1942 4 Sheets-Sheet 1

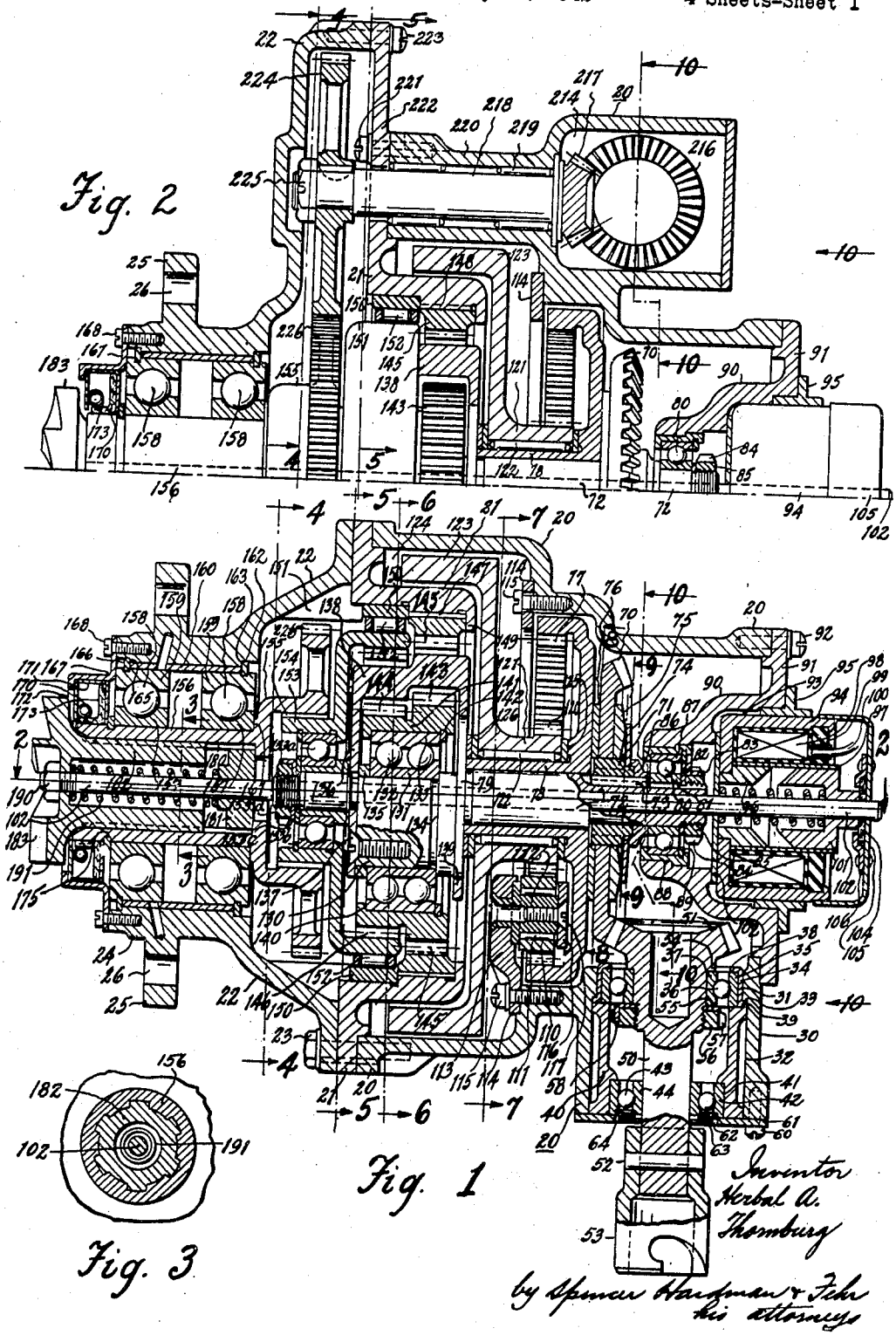


Fig. 1

Fig. 3

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ENGINE STARTING MECHANISM

Filed July 30, 1942 4 Sheets-Sheet 2

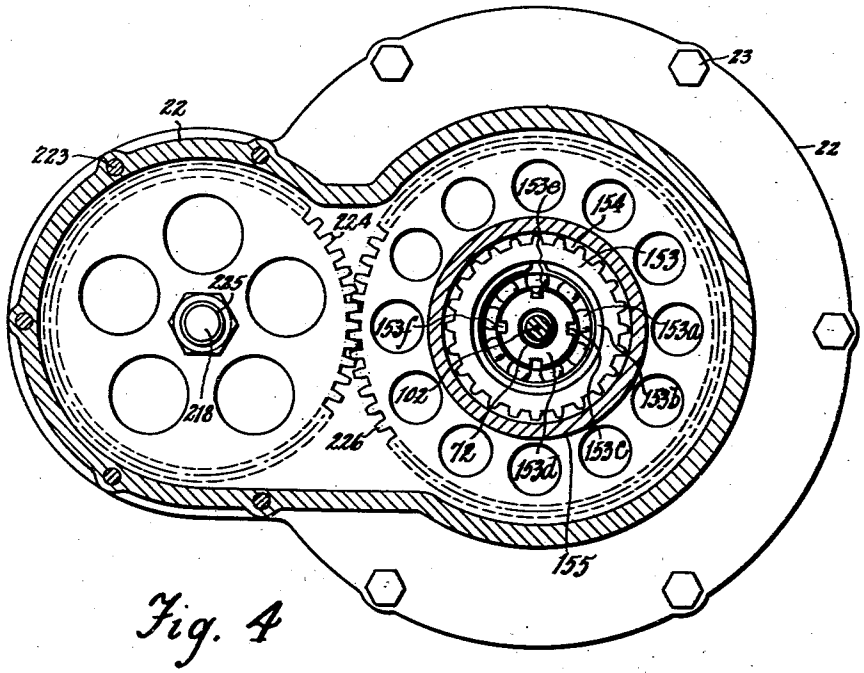


Fig. 4

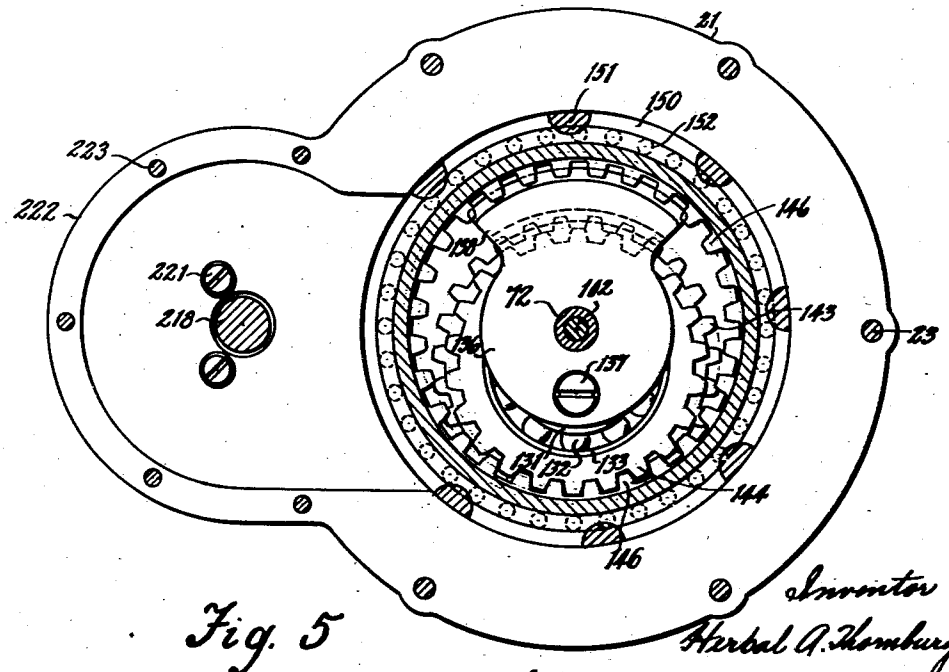


Fig. 5

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Nov. 16, 1943. H. A. THORNBURG 2,334,657

ENGINE STARTING MECHANISM

Filed July 30, 1942 4 Sheets-Sheet 3

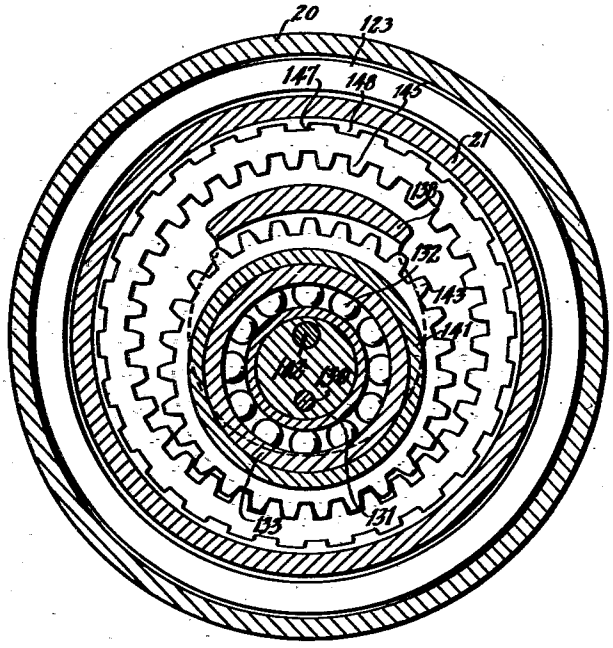


Fig. 6

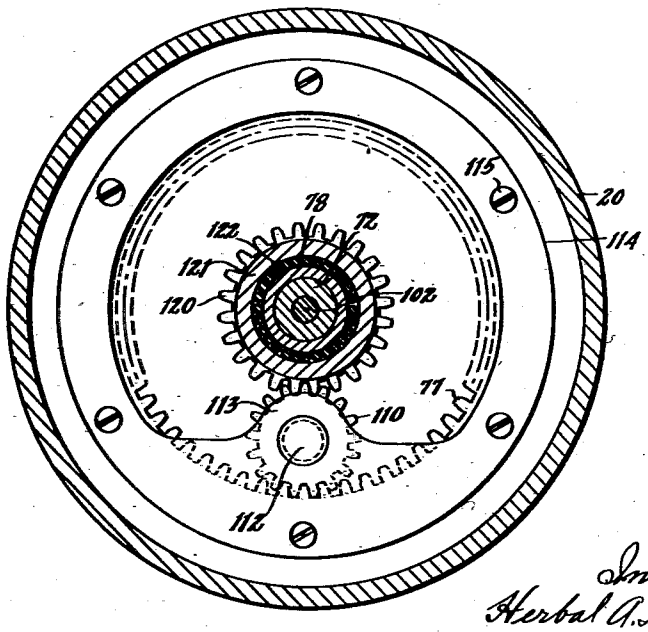


Fig. 7

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Nov. 16, 1943. H. A. THORNBURG 2,334,657

ENGINE STARTING MECHANISM

Filed July 30, 1942 4 Sheets-Sheet 4

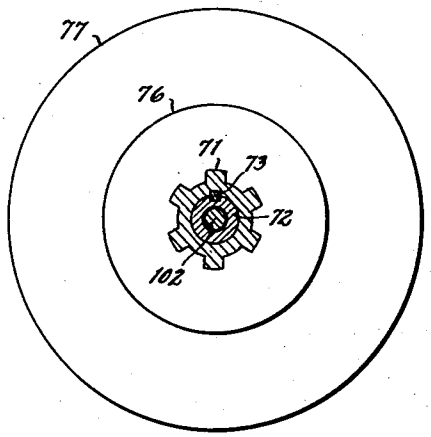


Fig. 8

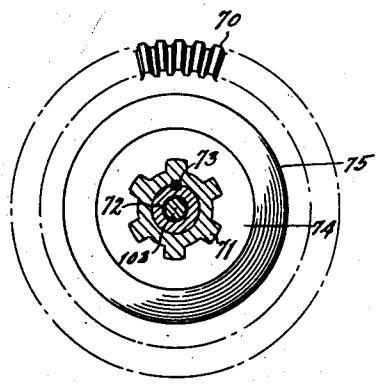


Fig. 9

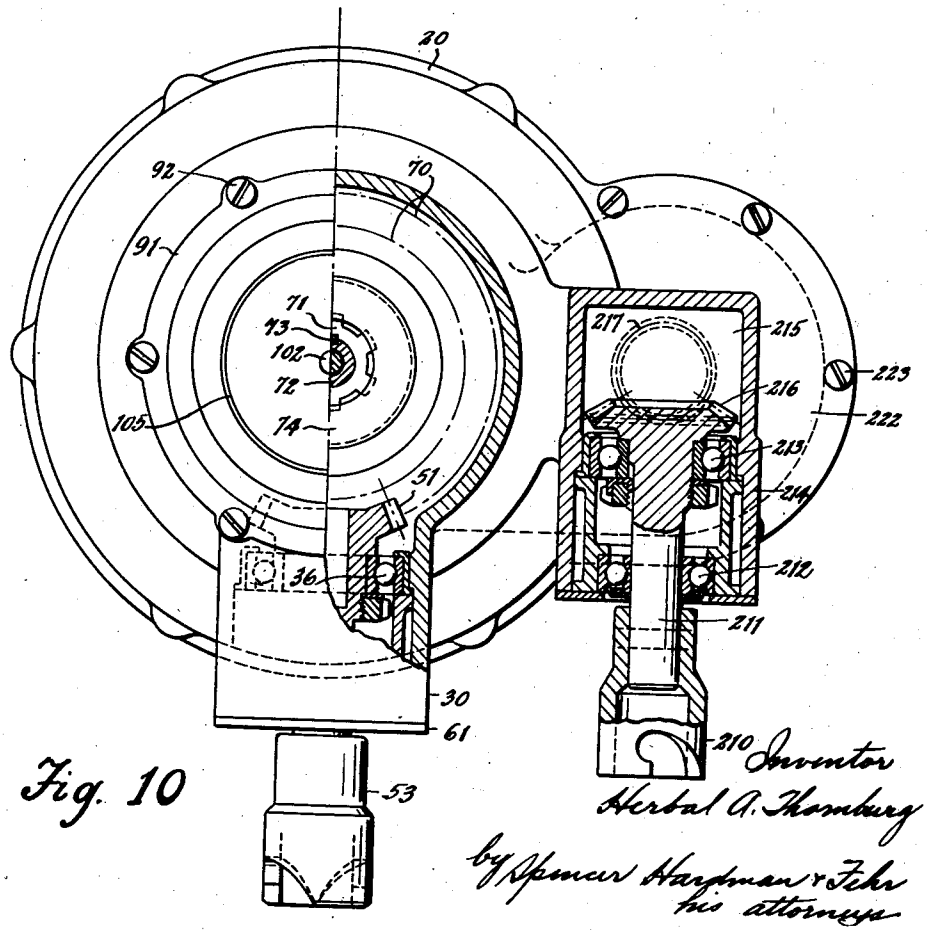


Fig. 10

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UNITED STATES PATENT OFFICE

2,334,657

ENGINE STARTING MECHANISM

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Application July 30, 1942, Serial No. 452,833

14 Claims. (Cl. 123—179)

This invention relates to a mechanism for starting an internal combustion engine, particularly aircraft engines.

It is an object of the present invention to provide for the starting of the engine either by electric motor or by hand-cranking, the effectiveness of either of these instruments being augmented by the release of energy stored in a flywheel which is caused to rotate rapidly before the starter mechanism is coupled with the engine to be started. More particularly it is an object to minimize the strain upon the starting mechanism at the time it is coupled with the engine; and this object is accomplished by providing means for yieldably connecting the flywheel with the coupling so that the flywheel may gradually take up its burden of supplying additional power for starting the engine.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the invention is shown.

In the drawings:

Fig. 1 is a longitudinal sectional view of an engine starter mechanism embodying the present invention.

Fig. 2 is a fragmentary, longitudinal, sectional view on line 2—2 of Fig. 1.

Figs. 3, 4, 5, 6, 7, 8 and 9 are sectional views taken respectively on lines 3—3 of Fig. 1, 4—4 of Figs. 1 and 2, 5—5 of Figs. 1 and 2, 6—6, 7—7, 8—8 and 9—9 of Fig. 1.

Fig. 10 is an end view looking in the direction of arrow 10 of Figs. 1 and 2, the part shown in section being taken on line 10—10 of Figs. 1 and 2.

The starter mechanism is enclosed by a housing comprising a right end part 20, an intermediate part 21 and a left end part 22, these parts having abutting flanges clamped together by screws 23. Housing 22 has a cylindrical portion 24 adapted to extend through a hole, not shown, in the frame of an engine, said hole being concentric with respect to a coupling member, not shown, carried by the engine. Housing 22 provides a flange 25 having holes 26 for receiving screws by which the housing 22 and the entire starting unit is attached to the engine frame.

Housing 20 has a tubular part 30 having stepped bore portions 31 and 32 joined by shoulder 33. The bore 31 receives a ring 34 which encloses an outer bearing race 35 supporting bearing balls 36 which support an inner bearing race 37. Race 35 engages a flange 38 of ring 34, and flange 39 of ring 34 engages the shoulder 33 of part 30. Flange 39 is held in engagement with shoulder 33 by a spacer sleeve 40 which is counterbored at 41 to receive the outer race 42 of a bearing which includes bearing balls 43 and an inner race 44. These ball bearings support a shaft 50 integral with a bevel gear 51 and connected by pin 52 with a coupling 53 adapted to be connected with a flexible shaft driven by an electric motor, not shown. The inner race 37 is secured between a shoulder 54 of shaft 50 and a washer 55 by a nut 56 threadedly connected with the shaft 50 and having a plurality of notches 57 each for receiving a tang 58 of the washer 55 which is bent around the nut and into one of the notches in order to prevent the nut from turning. A plurality of screws 60 secure to the housing part 30 a circular plate 61, which retains the spacing sleeve 40 and the bearing race 42. Plate 61 has an aperture 62 to provide clearance for an oil seal disc 63 which is press-fitted into the race 42 and which is provided with a central aperture through which the shaft 50 projects. The plate 63 retains a felt ring 64 against the bearing race 44.

Gear 51 meshes with gear 70 which is splinedly connected with a hub 71 which is axially adjustable along the shaft 72 and which is drivingly connected therewith by key 73. The hub 71 is splinedly connected with a dished washer 74 of resilient metal engaging the crown of an anvil or fulcrum washer 75 (Fig. 9) which is not splined to the hub 71. Due to the action of the resilient washer 74 the anvil washer 75 is caused to bear frictionally against the right face of gear 70, and the left face of gear 70 is caused to bear against a washer 76 (Fig. 8) which is splined to the hub 71 and which bears frictionally against the right face of a ring gear 77 having a hub 78 surrounding the shaft 72. The washer 74 urges the left end of hub 78 against a shoulder 79 of shaft 72. The right end of shaft 72 is supported by a ball bearing 80, the inner race 81 of which is located against a washer 82 having a tang 83 adapted to be bent into one of plurality of notches 84 of a nut 85 threaded upon the right end of shaft 72. A spacer sleeve 86 separates the inner race 81 from the hub 71. The tightening of nut 85 causes the shaft 72 to be urged toward the right relative to the bearing race 81, thereby in effect urging the resilient disc 74 toward the left to cause the gear 70 to be resiliently connected with the gear 77 through frictional resistance. The nut 85 is secured in the desired position of adjustment along the shaft 72 by bending the tang 83 of washer 82 into one of the notches 84 of the nut.

The outer race 87 of ball bearings 80 is received by a sleeve 88 and is retained therein by a resilient split washer 89. Sleeve 88 is pressed into the tubular extension 90 of a cover plate 91 for covering a hole in the right end of housing 20. Plate 91 is secured to housing 20 by a plurality of screws, one of which is shown at 92.

Cover 91 provides a recess 93 for receiving a solenoid unit comprising a magnetizable housing 94 attached to a flanged ring 95 which is secured to the cover 91 in any suitable manner. The magnetizable solenoid housing 94 supports a magnetizable core 96 which supports a non-

magnetizable tube 97. Between the tube 97 and the housing 94 is located an annular magnet coil 98 which is insulated from these parts. Coil 98 is retained by non-conducting disc 99 apertured to receive the leads from the coil, one of which is shown at 100. The non-magnetizable tube 97 supports and guides for sliding movement an armature 101 attached to a rod 102 which is slidable within the central bore of the shaft 72. Solenoid housing 94 is attached to a plate 102. Between plate 102 and armature 101 there is located a compression spring 103 which urges the armature 101 toward the right so that it engages a felt or leather bumper disc 104 located against a cup-shaped member, attached to housing 94 by a retainer disc 106. When solenoid coil 98 is connected with a current source, armature 101 moves toward core 96 to cause rod 102 to move toward the left for the purpose of coupling the starter mechanism with the engine to be started, as will be explained in detail later. When the solenoid 98 is disconnected from the current source, spring 103 returns the armature 101 and the rod 102 to the position shown in the drawing.

The ring gear 77 meshes with an idle gear 110 journalled on needle bearings 111 which are journalled on a stud 112 attached to a bracket arm 113 integral with a ring 114 attached by screws 115 to the housing 20. Idle gear 110 is retained upon the stud 112 by washer 116 attached to stud 112 by screw 117. Idle gear 110 meshes with a gear 120 integral with a hub 121 journalled on needle bearings 122 supported by the hub 78 of gear 77. Hub 121 is integral with flywheel rim 123 rotatable in an annular pocket 124 located between housing parts 20 and 21. A washer 125 spaces the right end of hub 121 from the left face of gear 77. Washers 126 space the left end of hub 121 from shoulder 79.

Shaft 72 has an eccentric portion 130 which receives an inner bearing race 131 of bearing balls 132 having an outer race 133. Race 131 is confined between a shoulder 134 and a washer 135 retained by a plate 136 attached to the eccentric by screw 137. Plate 136 is integral with an eccentric counter-balance 138 integral with a plate 139 apertured to receive the shoulder 77. Outer race 133 is located between a shoulder 140 of a hub 141 and is retained by resilient split ring 142.

The hub 141 is integral with epicyclic gears 143 and 144 meshing respectively with ring gears 145 and 146. Gear 145 has splines 147 engaging similar splines 148 (Fig. 6) provided by frame member 21. Gear 145 is retained against a shoulder 149 of member 21 and a spacer ring 150 which is retained by a plurality of spacer lugs 151 integral with frame member 22. Ring 150 is the outer bearing race of a roller bearing 152, the inner race of which is provided by ring gear 146 which has a hub 153 splinedly connected at 154 with a cup-like rotary member 155 which is integral with a tubular extension or sleeve 156 fitting within inner race 157 of ball bearings 158 whose outer races 159 are supported by a sleeve 160 carried by frame 22. The part 155 provides a shoulder 161 engageable with bearing race 157 and limiting its movement toward the right. Movement of bearing race 159 toward the left is limited by the engagement with a shoulder 163 provided by frame 22 of a resilient wire snap ring 162 received by a groove in the race 159. Movement of the left outer bearing race 159 toward the right is limited by the engagement with a shoulder 165 of frame 22 with a snap ring 166 secured to said left outer bearing 159. Movement of said left outer race 159 toward the left is limited by a retainer 167 attached by screws 168 to frame 22. Retainer 167 carries an oil seal comprising parts 171 and 172 enclosing a felt seal ring 170 urged by a garter spring 173 against the sleeve 156. Movement of left inner bearing race 157 toward the left is limited also by a resilient split ring 175 engaging a groove in the sleeve 156.

Sleeve 156 is internally splined at 180 and receives an externally splined stop block 181. Spline 180 also engages similar splines of the hub 182 of a jaw clutch 183 or driving member for engaging a driven jaw clutch, not shown, connected with the engine to be started. The location of the clutch 183 relative to the sleeve 156 is determined by the adjustment of a nut 190 threaded on rod 102, the sleeve 182 being urged against the nut 190 by compression spring 191 bearing also against the block 181.

Referring to Figs. 1 and 4, the hub 153 is journalled on shaft 72 by a ball bearing 153*a* retained in hub 153 by a resilient split ring 153*b* and upon shaft 72 by a washer 153*c* and a nut 153*d* (threaded on shaft 72) having notches 153*f* one of which received a tang 153*e* of washer 153*c*.

When the solenoid is energized, the rod 102 moves toward the left to permit the jaw clutch 183 to move toward the left under the action of spring 191 in order to engage a companion jaw clutch member of the engine to be started. When the engine becomes self operative so that the driven jaw clutch member with which it engages tends to run ahead, the jaw clutch member 183 is disengaged drivingly from the engine and merely snaps back and forth under the action of spring 191. When after starting the engine, the solenoid is deenergized, spring 103 within the solenoid unit restores the jaw clutch 183 to normal position.

The mechanism which has been described and its enclosed housing constitute a unit which is mounted upon the vehicle propelled by the engine to be started. Preferably the unit is mounted upon the frame of the engine. The starting motor, which may be carried on a small truck together with its current source such as a storage battery, is connected with the starter mechanism by means of a flexible shaft and a coupling which engages the coupling 53. Before the solenoid is energized the electric motor is connected with its current source and is caused to rotate the driving clutch member 183 and the flywheel 123. After the flywheel has attained a certain high speed, resulting in the storing of kinetic energy therein, the circuit between the current source and the solenoid magnet 98 is completed, thereby causing the rod 102 and the driving clutch 183 to move toward the left to connect with the driven clutch, not shown. At the instant these two clutch members become engaged, there is a tendency to reduce the speed of the starter drive mechanism, but the flywheel 123 tends to continue to rotate and its frictional connection with the mechanism to the ring gear 77, washer 76 and bevel gear 78 provides means for yieldably transmitting kinetic energy from the flywheel to the driving clutch 183. As the driving clutch 183 picks up speed following the instant of its engagement with the driven clutch member, the slippage of the friction clutch between the flywheel 123 and the shaft 72 gradually diminishes, during which time the flywheel is imparting

stored energy to the shaft 72 gradually to increase its speed. The nut 85 at the right end of shaft 72 is so adjusted that a limited amount of torque is transferred from the flywheel 123 to the shaft 72 by the friction clutch between gears 77 and 70. Thus the shaft 72 is allowed to receive a limited amount of energy from the flywheel; and, therefore, the mechanism is not stressed abnormally at the instant the driving clutch member 183 becomes drivingly connected with its companion clutch member of the engine to be started. The torque which is initially transmitted is only sufficient when combined with the torque of the starting motor to gradually increase the speed of the driving clutch 183. As acceleration of that member proceeds, more and more of the kinetic energy of the flywheel is given up to assist the starting motor in increasing the speed of the starting mechanism.

In case an electric motor is not available, the engine may be started manually by hand crank which can be connected with a coupling 200, Fig. 10, attached to a shaft 211 journalled in bearings 212 and 213 supported by tubular portion 214 of frame member 20 which provides a housing 215 for a gear 216 integral with shaft 211 and driving a gear 217. The manner of supporting and retaining the bearings 212 and 213 of the shaft 211 is exactly similar to the manner of supporting the bearings 36 and 43 of shaft 50, shown in Fig. 1. Gear 217 is integral with a shaft 218 supported by needle bearings 219 in a tubular portion 220 of frame 20. The left end of portion 220 is attached by screws 221 (Fig. 2) to a pad 222 which is integral with frame member 21. Pad 222 is secured by screws 223 to an extension of frame 22. The space between frame 22 and pad 222 (Fig. 2) receives a gear 224 driven by shaft 218 and retained thereon by nut 225. Gear 224 meshes with gear 226 which is integral with the cup-shaped part 155 which provides the sleeve 156. By turning a hand crank (not shown) connected with coupling 200, the starter drive mechanism and the flywheel 123 are caused to rotate; and, when a certain flywheel speed has been attained, the solenoid is energized so as to connect the hand crank and the flywheel with the engine through the driving clutch member 183.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. An engine starter mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, a flywheel, speed reducing gearing connecting the shaft with the driving member, a ring gear having a hub journalled on the shaft, a flywheel having a hub journalled on the ring gear and provided with a gear, an idle gear connecting the ring gear with the flywheel-hub gear, a friction clutch connecting the shaft with the ring gear, said clutch including a driven friction element provided by the ring gear, and means for driving the shaft.

2. An engine starter mechanism comprising a shaft, a driving member for engaging a driven member, of the engine to be started, a flywheel, speed reducing gearing connecting the shaft with the driving member, a ring gear having a hub journalled on the shaft, a flywheel having a hub journalled on the ring gear and provided with a gear, an idle gear connecting the ring gear with the flywheel-hub gear, a friction clutch connecting the shaft with the ring gear, said clutch including a driven friction element provided by the ring gear, and driving friction element splinedly connected with the shaft and a spring for urging the friction elements into engagement under yielding pressure, and means for driving the shaft.

3. An engine starter mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, a flywheel, speed reducing gearing connecting the shaft with the driving member, a ring gear having a hub journalled on the shaft, a flywheel having a hub journalled on the ring gear and provided with a gear, an idle gear connecting the ring gear with the flywheel hub gear, a friction clutch connecting the shaft with the ring gear, said clutch including a driven friction element provided by the ring gear, a gear for driving the shaft and splinedly connected therewith, a clutch driving element splinedly connected with the shaft and located between the ring gear and the shaft driving gear, and a spring for urging the shaft driving gear against the clutch driving element and the latter into engagement with the clutch driven element provided by the ring gear.

4. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, a flywheel, speed reducing gearing connecting the shaft with the driving member, a ring gear having a hub journalled on the shaft, a flywheel having a hub journalled on the ring gear and provided with a gear, an idle gear connecting the ring gear with the flywheel hub gear, a hub surrounding the shaft and splinedly connected therewith, a friction clutch connecting the hub and ring gear and including a clutch driving plate splinedly connected with the hub, a clutch driven plate provided by the ring gear, a spring disc secured by the hub and arranged to urge the clutch plates together, means for effecting relative axial movement between the shaft and hub in order to adjust the pressure effected by the spring disc, and means for driving the shaft.

5. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, a flywheel, gearing for connecting the shaft with the driving member, means supporting the shaft for axial movement, means for adjusting the shaft axially, means for connecting the shaft and flywheel and including a friction clutch having driving and driven plates which are movable axially with the shaft when the latter is adjusted, a spring having a part fixed against movement with the shaft and a part for exerting pressure on the clutch plates, said pressure being varied when the shaft is axially adjusted, and means for driving the shaft.

6. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, gearing for connecting the shaft with the driving member, means supporting the shaft for axial movement, means for adjusting the shaft axially, a flywheel movable axially with the shaft, means for connecting the shaft and flywheel including speed increasing gearing and a friction clutch having driving and driven plates movable with the shaft, a spring having a part fixed against movement with the shaft and a part for exerting pressure on the clutch plates, said pressure being varied when the shaft is axially adjusted, and means for driving the shaft.

7. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, a gearing for connecting the shaft with the driving member, means supporting the shaft for axial movement, means for adjusting the shaft axially, a flywheel movable axially with the shaft and rotatable thereon, speed increasing gearing for connecting the shaft and flywheel and including a gear movable axially with the shaft and rotatable thereon, a friction clutch having a driven plate provided by the gear and a driving plate connected with the shaft, a spring having a part fixed against movement with the shaft and a part for exerting pressure on the clutch plates, said pressure being varied when the shaft is axially adjusted, and means for driving the shaft.

8. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, gearing for connecting the shaft with the driving member, means supporting the shaft for axial movement, means for adjusting the shaft axially, a flywheel movable axially with the shaft and rotatable thereon, speed increasing gearing for connecting the shaft and flywheel and including a gear movable axially with the shaft and rotatable thereon, a friction clutch having a driven plate provided by the gear and a driving plate connected with the shaft, a hub splinedly connected with the clutch driving plate and splinedly connected with the shaft and fixed against axial movement, a spring washer having its central part supported by the hub and its peripheral part exerting pressure upon the clutch plates, said pressure being varied when the shaft is axially adjusted, and means for driving the shaft.

9. An engine starting mechanism comprising a shaft, a driving member for engaging a driven member of the engine to be started, gearing for connecting the shaft with the driving member, means supporting the shaft for axial movement, means for adjusting the shaft axially, a flywheel movable axially with the shaft and rotatable thereon, speed increasing gearing for connecting the shaft and flywheel and including a gear movable axially with the shaft and rotatable thereon, a friction clutch having a driven plate provided by the gear and a driving plate connected with the shaft, a hub splinedly connected with the clutch driving plate and splinedly connected with the shaft and fixed against axial movement, a spring washer having its central part supported by the hub and its peripheral part exerting pressure upon the clutch plates, said pressure being varied when the shaft is axially adjusted, and a gear for driving the shaft and connected with the hub.

10. An engine starting mechanism comprising a shaft, means for adjusting the shaft axially, a member driving the shaft, an engine driving member for engaging a driven member of the engine to be started, a rotary member fixed against axial movement and supporting the engine driving member, speed reducing gearing for connecting the shaft and rotary member and including rotatable members movable axially with the shaft when the latter is adjusted and having a spline connection with the first mentioned rotary member, a flywheel, a friction clutch for connecting the flywheel with the shaft, and means for varying the torque transmitted by the clutch in response to axial adjustment of the shaft.

11. An engine starting mechanism comprising a shaft, means for adjusting the shaft axially, a member for driving the shaft, an engine driving member for engaging a driven member of the engine to be started, a rotary member fixed against axial movement and supporting the engine driving member, speed reducing gearing for connecting the shaft and rotary member and including epicyclic gears eccentrically driven by the shaft and ring gears meshing therewith, one of the ring gears being fixed and the other rotatable around the shaft, said epicyclic gears and the rotatable ring gear being axially movable with the shaft when the latter is adjusted, a bearing supporting the ring gear and permitting axial movement thereof, a bearing supported by the ring gear and supporting the shaft and movable axially therewith, a spline connection between said first mentioned rotary member and the rotatable ring gear, a flywheel, a friction clutch for connecting the flywheel with the shaft, and means for varying the torque transmitted by the clutch in response to axial adjustment of the shaft.

12. In an engine starting mechanism the combination of a shaft, means for driving the shaft, a member connected with the engine to be started, speed reducing gearing connecting the member with the shaft and comprising adjacent epicyclic gears driven eccentrically by the shaft, adjacent ring gears meshing respectively with the epicyclic gears, a fixed annular member surrounding the ring gears and supporting one for non-rotary and the other rotary movement, a flywheel having a hub supported by the shaft coaxially therewith and having a rim surrounding a portion of the fixed annular member, and means for connecting the flywheel with the shaft.

13. In an engine starting mechanism the combination of a shaft, means for driving the shaft, a member connected with the engine to be started, speed-reducing gearing connecting the member with the shaft and comprising adjacent epicyclic gears driven eccentrically by the shaft, adjacent ring gears meshing respectively with the epicyclic gears, a fixed annular member surrounding the ring gears and supporting one for non-rotary and the other rotary movement, a flywheel having a hub supported by the shaft coaxially therewith and having a rim surrounding a portion of the fixed annular member, a speed increasing gearing for connecting the shaft with the flywheel and including a ring gear driven by the shaft and surrounding the hub of the flywheel and having a hub located within the hub of the flywheel and surrounding the shaft, a housing surrounding the flywheel and ring gear, a bracket supported by the housing in the plane of the hub of the flywheel, an idle gear connected with the second mentioned ring gear and a gear on the flywheel hub meshing with the idle gear.

14. In an engine starting mechanism the combination of a shaft, means for driving the shaft, a member connectible with the engine to be started, a flywheel coaxial with the shaft and comprising a disc, a rim extending from one side of the disc and a hub extending from the other side of the disc, speed-reducing gearing at least partly surrounded by the flywheel rim and connecting the said engine-connectible member with the shaft, and speed increasing gearing at least partly surrounding the hub of the flywheel for connecting the flywheel with the shaft.

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