June 16, 1931. J. B. DYER 1,810,393

ENGINE STARTING APPARATUS

Filed Feb. 29, 1928 3 Sheets-Sheet 1

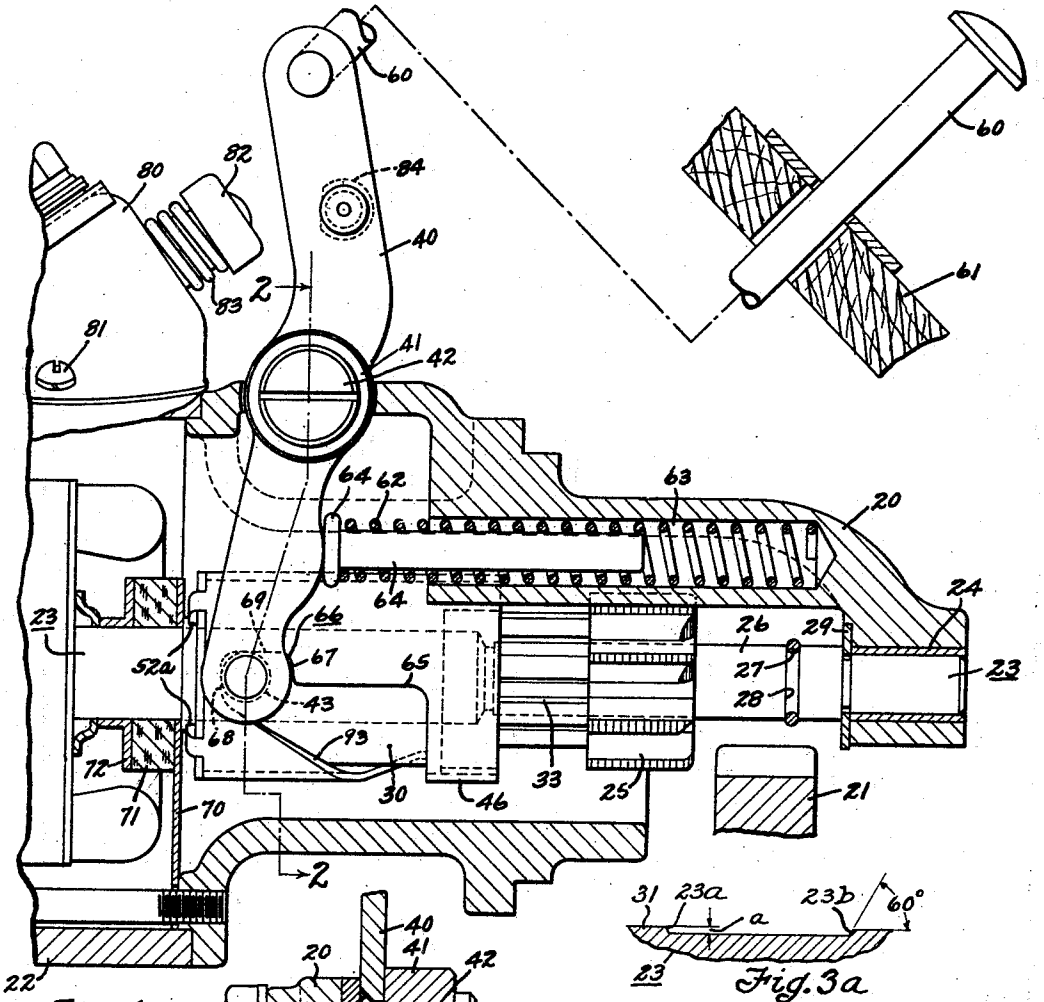


Fig. 1

Fig. 3a

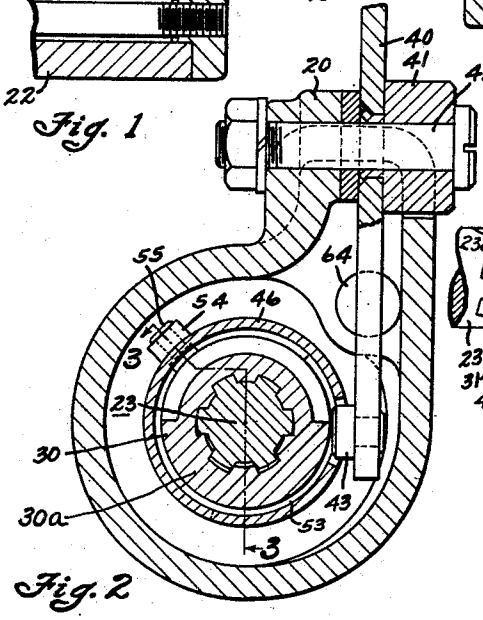


Fig. 2

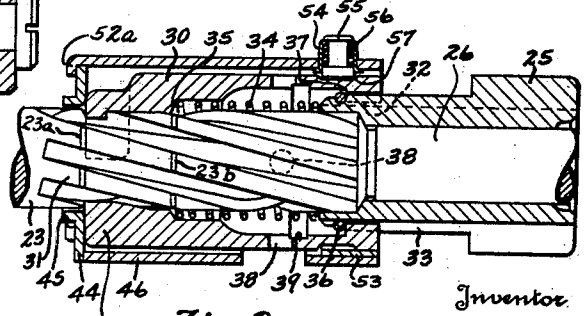


Fig. 3

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ENGINE STARTING APPARATUS

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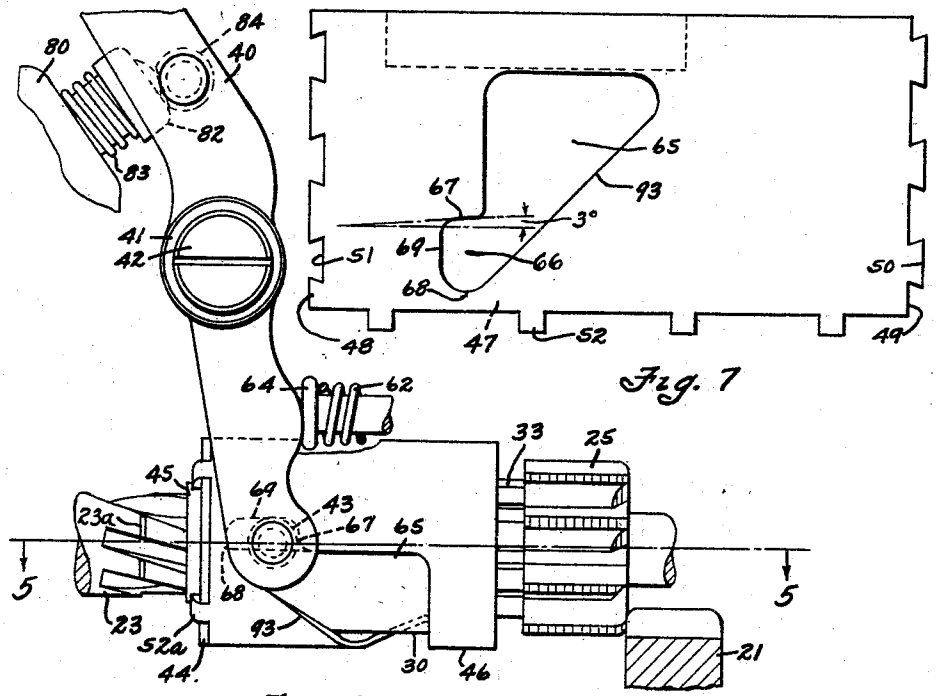


Fig. 7

Fig. 4

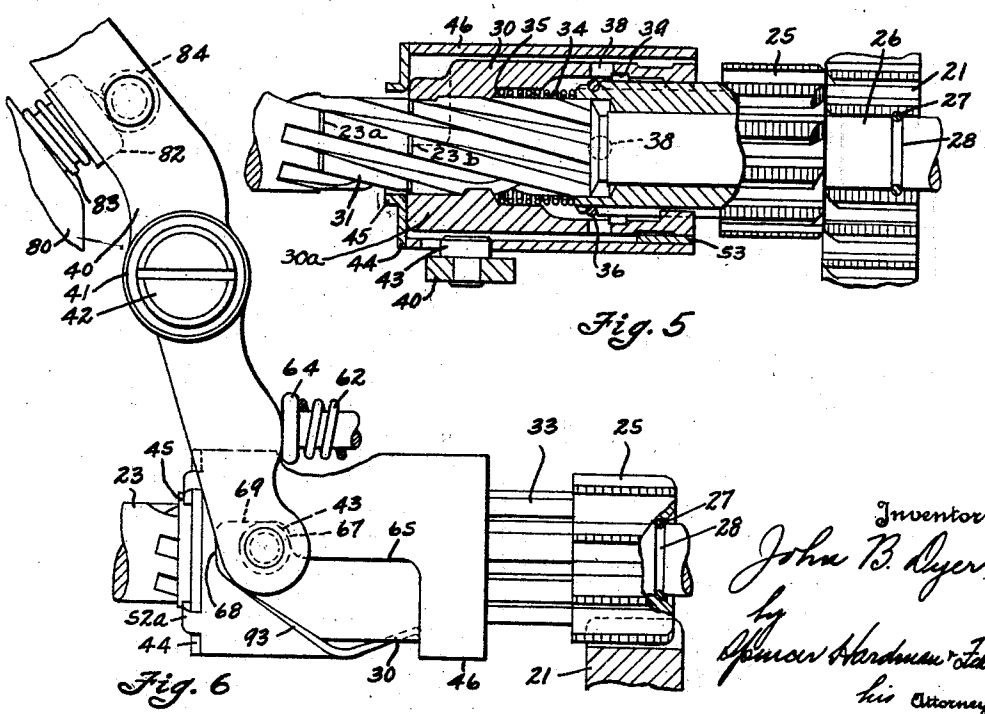


Fig. 5

Fig. 6

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ENGINE STARTING APPARATUS

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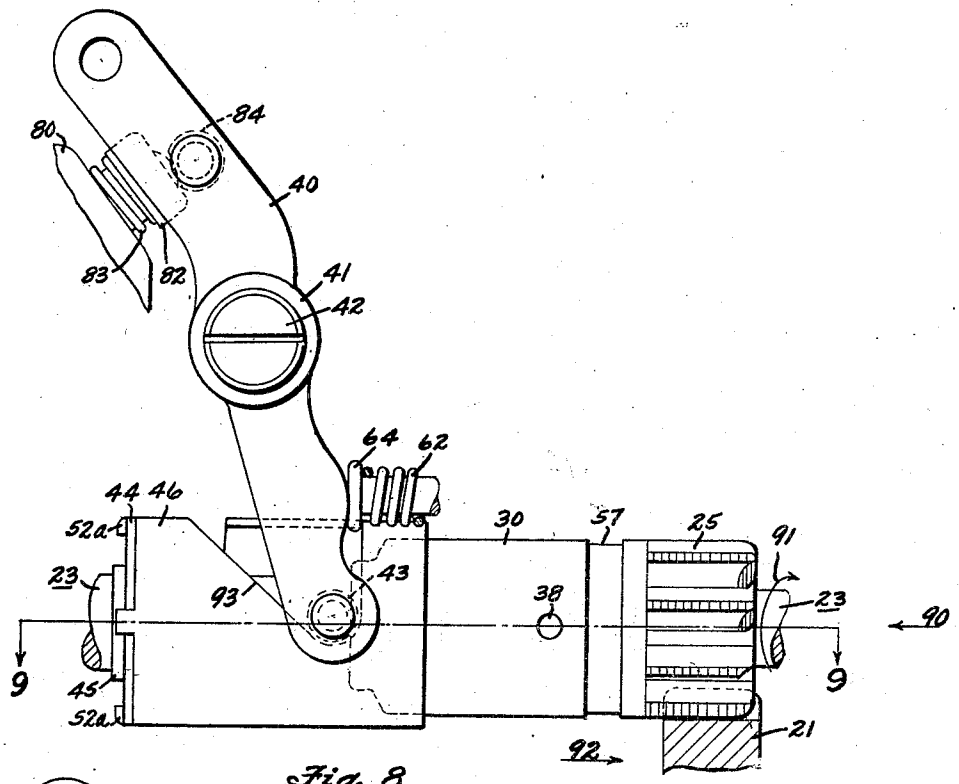


Fig. 8

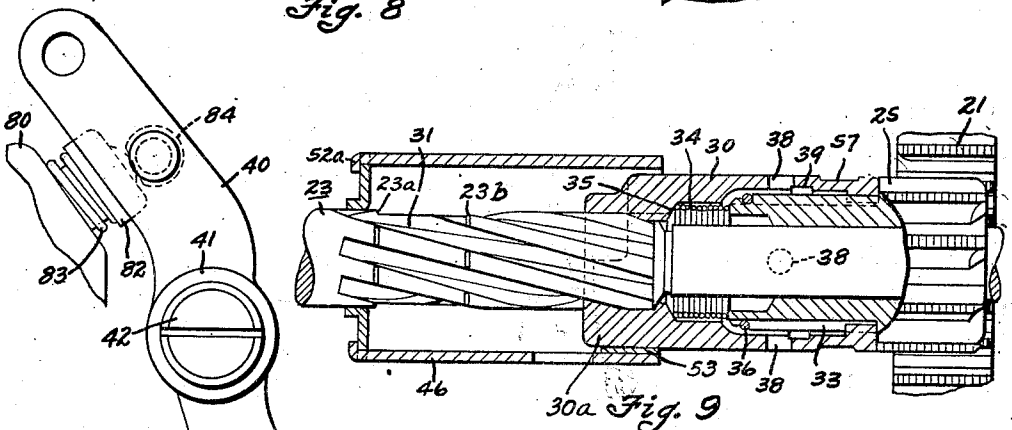


Fig. 9

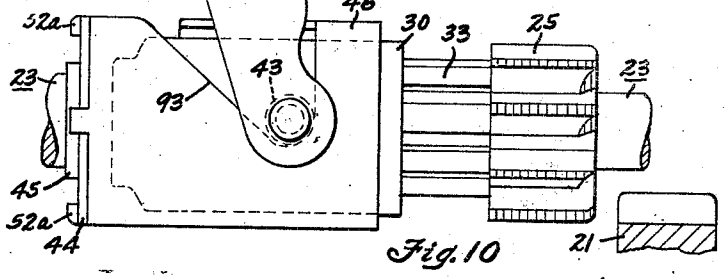


Fig. 10

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UNITED STATES PATENT OFFICE

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ENGINE STARTING APPARATUS

Application filed February 29, 1928. Serial No. 258,071.

This invention relates to apparatus for starting internal combustion engines, and particularly to the type of apparatus which includes a gear or pinion operated by an electric motor and movable by manual operation into mesh with a gear connected with the engine to be started, and means whereby the pinion will be automatically demeshed from the engine gear when the engine becomes self-operative.

The present invention constitutes improvements in manually operable mechanisms for rotating the pinion, in case of its abutment with the engine gear teeth, into meshing registration with the engine gear in order that the pinion may be brought into substantially full meshing relation with the engine gear before the motor is operated. In this way breakage of the teeth of the pinion and gear is reduced to a minimum.

In one of its aspects, the present invention constitutes improvements in the form of engine starting apparatus described and claimed in the copending application of F. J. Hardman, Serial No. 728,531, filed July 28, 1924 and in my copending application, Serial No. 245,886, filed January 9, 1928. These applications disclose engine starting apparatus comprising a motor, a shaft operated thereby, means for connecting the shaft with the gear of an engine to be started and including a pinion movable endwise into mesh with the gear of an engine to be started and including provisions whereby the pinion will be automatically demeshed from the gear when the engine starts, a device movable with the pinion for moving the pinion and for rotating it prior to meshing in case of abutment with the engine gear while the pinion is being pressed yieldingly against the engine gear, a manually operable actuator for operating said device, and means for automatically disconnecting the manually operated actuator from said device after the pinion has been meshed with the gear and before the engine starts so that the pinion may be automatically demeshed, regardless of the fact that the operator has not released the actuator. In these applications there are disclosed disconnectible elements operatively connected respectively with the actuator and pinion shifting device, and means for automatically moving the element operatively connected with the actuator out of operative relation to the element operatively connected with the pinion shifting device, and means for automatically restoring these elements to their operative relation when the actuator is returned to normal position. The apparatuses shown in these applications compel the operator to release the actuator so that it may be returned by spring operation to normal position before a starting operation may be repeated.

My present invention differs from those shown in these other applications in that the element which is operatively connected with the pinion shifting and meshing device is moved automatically away from the path of movement of the element operatively connected with the actuator. Preferably I employ an element moved by the actuator longitudinally of the pinion and normally engageable with an element operatively connected with the pinion shifting and meshing device and mounted to rotate between certain limits due to frictional connection between the motor shaft. When the motor operates to crank the engine, the second mentioned element will be moved away from the operative connection with the actuator or first mentioned element so that the pinion may be automatically demeshed when the engine starts regardless of the status of the actuator element. The return of the actuator element to normal position will operate means for automatically rotating the second mentioned element to normal position and into the path of movement of the first mentioned or actuator element. Thus the operation of the starting device cannot be repeated unless the actuator has been released and restored to normal position. In this way the starting apparatus is rendered fool-proof against a manipulation which would place the gear shifting mechanism in such condition that the motor could be operated before the pinion is meshed with the engine gear.

Further objects and advantages of the present invention will be apparent from the fol-

lowing description, reference being had to the accompanying drawings, wherein a preferred form of embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a fragmentary longitudinal sectional view of the starting apparatus embodying the present invention, and shows the apparatus in normal condition.

Fig. 2 is a sectional view on the line 2—2 of Fig. 1.

Fig. 3 is a sectional view on the line 3—3 of Fig. 2.

Fig. 4 is a diagrammatic side elevation showing certain parts of the starter mechanism at the instant just before bringing the pinion into meshing registration with the engine gear.

Fig. 5 is a sectional view on the line 5—5 of Fig. 4.

Fig. 6 is a diagrammatic view showing the position of the mechanism at the instant the pinion has been moved into mesh with the engine gear and just before the motor switch has been closed.

Fig. 7 is a plan view of a blank of sheet metal which is formed into a cylindrical body constituting the intermediate element between the manually operated element of the mechanism and the sleeve which provides the driving connection between the pinion and the helically splined shaft.

Fig. 8 is a diagrammatic side elevation showing the position of the mechanism during the cranking of the engine.

Fig. 9 is a sectional view on the line 9—9 of Fig. 8.

Fig. 10 is a diagrammatic side elevation showing the positions of parts of the mechanism after the pinion has been demeshed from the engine gear and before the manually operable member has been released.

In the drawings, 20 designates a mounting bracket and gear housing member by which the starting apparatus is attached to the frame of an engine not shown but represented by a flywheel gear 21. The frame 20 supports a motor field frame 22 and an armature shaft 23 journalled in a bearing 24 provided by the frame 20 and in a bearing not shown provided by the frame 20 and in a bearing not shown provided by the frame 22. A motor pinion 25 is slidable along a smooth portion 26 into and out of engagement with the engne flywheel gear 21. Motion of the pinion toward the right into mesh with the engine gear is arrested by a stop provided by a split wire ring 27 occupying a groove 28 in the shaft 23. End thrust of the shaft 23 toward the right is taken up by a thrust washer 29 bearing against a machined surface provided by the frame 20.

Motion is transmitted from the shaft 23 to the pinion 25 through a sleeve 30 threadedly engaging the helical splines 31 provided by the shaft 23. The sleeve 30 is provided with internal straight splines 32 which are drivingly connected with longitudinal straight splines 33 provided exteriorly by the hub of the pinion 25. Thus the driving connection between the sleeve and pinion provides for relative endwise movement between these elements. A spring 34 located between the hub of the pinion 25 and an internal shoulder 35 of the sleeve 30 tends to separate the pinion from the sleeve, but this movement of separation is limited by a split wire ring 36 engaging a groove in the hub of the pinion and bearing against the inner faces 37 of the internal splines 32 of the sleeve. The sleeve 30 is provided with holes 38 through which suitable tools may be manipulated for holding the ring 36 while it is being sprung over the pinion hub so that it may be entered in the groove of the pinion hub and for removing the ring 36 from the pinion so that the pinion may be removed from the sleeve. The internal annular groove 39 provided by the sleeve provides clearance for entrance and removal of the ring 36 from the groove of the pinion hub.

The manually operated mechanism for moving the sleeve 30 and pinion 25 toward the engine gear 21 comprises a manually operated member or lever 40 attached to a hub 41 which is pivoted upon a bolt 42 supported by the gear housing 20. The lever 40 carries a stud or pin 43 which is movable longitudinally of the shaft 23. The manually operated mechanism includes also an intermediate member for transmitting motion from the lever 40 to the sleeve 30. This motion transmitting member includes a disc 44 having a flange 45 slidable along the shaft 23 and engageable with the end of the sleeve 30 so as to push the same toward the engine gear. The disc 44 provides a support for one end of a sleeve or tube 46 which is formed by bending the blank 47 shown in Fig. 7 into a cylindrical form and by joining the abutting edges 48 and 49 by means of an interlocking joint including dovetail tangs 50 which engage dovetail notches 51. The blank 47 provides tangs 52 which, after the blank 47 is bent into cylindrical form, are interlocked with suitable notches adjacent the periphery of the disc 44 and are bent against the disc 44 as indicated by numeral 52*a*. The right hand end of the tube 46 is supported by the sleeve 30 by providing the tube 46 with an arcuate friction plate 53 preferably spot-welded upon the inner side of the tube and having a thickness approximately equal to the width of the annular space between the sleeve and tube when these parts are located concentrically. The wall of the tube opposite the friction plate 53 carries a plunger guide sleeve 54 for guiding a plunger 55 which is urged by a spring 56 against the sleeve 30. The plunger 55 is adapted to press

against the cylindrical periphery of the sleeve 30 but does not press against the bottom of an annular groove 57 provided by the sleeve 30.

The lever 40 is operated by a pedal 60 extending through the floorboard 61 of the vehicle and the lever 40 is maintained normally in the position shown in Fig. 1 by a spring 62 which is expandable and contractable within a recess 63 provided by the housing 20 and which urges a plunger 64 against the lever 40 so as to urge the pin 43 toward the left. The pin 43 is received by an aperture 65 in the tube 46. This aperture is generally triangular in shape but includes a notch 66 defined by edges 67, 68 and 69. Normally the spring 62 urges the pin 43 against the edge 68 as shown in Fig. 1 thereby urging the flange 45 of the collar 44 against a floating brake plate 70 and the plate 70 against a floating cork disc 71 surrounding the shaft 23, and the disc 71 against a plate 72 which is attached to the shaft 23. In this way the spring 62 serves to return the manually or pedal operated lever 40 to normal position and to apply a brake for bringing the armature 23 of the starting motor quickly to rest after a starting operation. This feature is advantageous in case the engine makes a false start, that is, it operates sufficiently to demesh the pinion from the flywheel gear but does not continue to be self-operated. The brake will bring the motor quickly to rest so that the operator may repeat the starting operation promptly without having to wait a substantial length of time for the pinion to come to rest before moving it again into engagement with the engine gear.

The motor is caused to operate by the closing of a starting motor switch which is housed within a case 80 attached by screws 81 to the motor field frame 22, and is operated by a plunger 82 which is normally held in switch open position by spring 83. The plunger 82 is located in the path of movement of a stud 84 attached to the lever 40. As shown in Fig. 1, the stud 84 is spaced from the head of the plunger 82 sufficiently to permit the operation of the manually operated mechanism to move the pinion into mesh with the engine gear before the motor switch is closed.

The mode of operation of this invention is as follows:

To start the engine the operator will press the pedal rod 60 to cause the lever 40 to move counterclockwise and to move the pin 43 into engagement with the edge portion 67 of the tube 46. Continuing the movement of the lever 40 in this direction the tube 46 will pull the collar 44 against the sleeve 30 to cause it to move in a helical path relative to the shaft 23. Since the spring 34 transmits endwise motion from the sleeve 30 to the pinion 25, the pinion 25 will likewise move in a helical path toward the engine gear 21. Due to the frictional drag between the sleeve 30 and the tube 46 there is a tendency for the tube 46 to move in a helical path but it is not free to do so because the edge portion 69 which defines the notch 66 in the tube 46 bears downwardly against the pin 43. Therefore the pin 43 will remain within the notch 66 until the cranking operation begins. In case the pinion is not immediately brought into meshing registration with the teeth of the engine gear 21 by the helical movement referred to but the teeth of the pinion abut the teeth of the engine gear, by continuing the movement of the lever 40 in a counterclockwise direction the sleeve 30 will continue to move in a helical path while compressing the spring 34 and while simply rotating the pinion 25 into meshing registration with the engine gear. Due to the yielding connection provided by the spring 34 whereby the pinion 25 is yieldingly pressed against the end faces of the teeth of the gear 21, the pinion 25 is free to move endwise along the shaft portion 26 so that it may accommodate itself to any irregularities in the end faces of the pinion and gear teeth which would require the pinion to back off from the flywheel gear before the pinion can be registered for meshing with the flywheel gear. When the pinion is rotated into meshing registration with the gear 21, the spring 34 will be released in order to move the pinion 25 into mesh with the engine gear. Figs. 4 and 5 show positions of the starting mechanism just prior to meshing the pinion with the engine gear. It will be noted that the sleeve 30 has been moved endwise relative to the pinion 25 and that the spring 34 has been compressed. Fig. 6 shows positions of the starting mechanism after the spring 34 has been released to move the pinion 25 into mesh with the gear 21.

As stated before the motor switch cannot be closed before the pinion 25 is meshed with the engine gear. After the mechanism has been placed in position shown in Fig. 6, the motor switch may be closed by a motion of the pedal which will cause the stud 84 to move the plunger 82 into switch closing position. Then the cranking operation will begin. The shaft 23 is rotated clockwise as viewed in the direction of the arrow 90, in Fig. 8, or as indicated by the arrow 91 in order to rotate the engine flywheel gear 21 clockwise as viewed from the front of the engine or as looking in the direction of arrow 92 in Fig. 8. Due to the end thrust toward the right between the splines 31 of the shaft 23 and the internal splines of the sleeve 30, the sleeve 30 is moved toward the right until it engages the backs of the teeth of the pinion 25 and thereupon the pinion 25 is forced drivingly against the stop ring 27 and the pinion is caused to rotate to turn

the gear 21. While the engine is being cranked, the tube 46 will be moved from the position shown in Fig. 6 to that shown in Fig. 8. This relative motion between the sleeve 46 and the pin 43 and the sleeve 30 takes place due to the friction drag between the sleeve 30 and the tube 46 tending to rotate the latter in the direction of the arrow 91. Since the tube 46 is free to turn in this direction, it will move its notch portion 66 and hence the portion 67 away from the pin 43 and will move its oblique edge 93 of the opening 65 against the pin 43 whereupon the sleeve 46 will be moved endwise toward the left due to the camming operation which takes place between the edge 93 and the pin 43. Therefore the parts of the mechanism referred to will be located as shown in Figs. 8 and 9 before the engine becomes self-operative.

When the engine becomes self-operative, the sleeve 30 will be moved from the position shown in Fig. 9 to that shown in Fig. 10 due to the fact that the flywheel gear 21 tends to drive the pinion 25 faster than the shaft 23 can turn it. When this occurs there is a reversal of thrust between the helical splines of the sleeve and shaft which tends to move the sleeve 30 toward the left into the position shown in Fig. 10. This same operation causes the pinion 25 to be withdrawn from the engine gear 21. Movement of the pinion and sleeve toward the left may take place although the operator fails to release the pedal 40. During the cranking operation the tube 46 and flange 44 will have moved sufficiently to clear a path for the demeshing movement of the sleeve and pinion. After the engine becomes self-operative and before the pedal 60 is released, the starting mechanism will be in the position shown in Fig. 10. Before the starting operation can be repeated the operator is compelled to release the pedal 60 so that the notch 66 may again receive the pin 43 attached to the lower end of the lever 40. During the restoration of the lever 40 by the operation of the spring 62 the tube 46 will be rotated from the position shown in Fig. 10 to that shown in Fig. 1 due to the camming action between the oblique edge 93 defining the opening 65 in the tube 46 and the pin 43. Therefore it is useless for the operator to attempt a trick manipulation of the starting device by trying a repeat operation before the pedal has been entirely released. It is apparent that unless the notch edge 67 is located in the path of movement of the pin 43 no movement of the pinion toward the engine gear can take place.

The plunger 55 attached to the tube 46 cooperates with the side walls of the groove 57 of the sleeve 30 for the purpose of preventing the accidental drifting of the pinion 25 into mesh with the gear 21 while the starting apparatus is in normal condition and also tends to overcome a tendency of the pinion to rebound into mesh with the engine gear directly after being demeshed. Tendency of the sleeve 30 to rebound toward the gear 21 is hindered also by making the outside diameter of that splined portion of the shaft 23 which normally engages the sleeve 30, less than the outside diameter of the remainder of the splined portion (.020 inch less for a ¾ inch shaft). The reduced poriton is shown between the interrupted shoulder portions 23*a* and 23*b* of the shaft 23 as shown in Fig. 3. The sleeve 30 is provided with an eccentrically located weight 30*a* located adjacent the splined portion of the sleeve. The shoulder 23*b* is made somewhat abrupt, preferably a taper at about 60 degrees to horizontal as viewed in Fig. 3. Therefore when the pinion is demeshed and the sleeve 30 is thrown back into the position shown in Fig. 10, the sleeve will be prevented from rebounding since its splined hub is retained between the shoulders 23*a* and 23*b*. The shoulder 23*b*, being fairly steep, tends effectively to hinder the rebounding of the sleeve toward the engine gear. At the time of demeshing the pinion, the sleeve 30 is rotating at highest speed and the unbalanced centrifugal force acting upon the eccentric mass 30*a* is the maximum. Therefore the tendency to rebound is counteracted by the fact that the hub of the sleeve 30 is held against the shoulder 23*b* and prevented from riding over the shoulder by the unbalanced centrifugal force referred to. In other words, as the pinion is going out of mesh with the gear, the sleeve 30 is rotating while sliding toward the left along the shaft 23, and, upon arriving at normal position, its hub will snap into the reduced shaft portion and will be held there due to the unbalanced centrifugal force referred to.

It is therefore apparent that my invention comprises a pinion shifting and meshing device (the sleeve 30), a manually operated actuator for operating the device (the lever 40), disconnectible elements (the pin 43 and the edge surface 67 of part 46) for transmitting motion from the actuator 40 to the device 30, means for automatically moving the element 67 away from the path of movement of the element 43 (the tube 46 which is frictionally connected with the motor shaft so that the tube 46 will turn when the motor cranks the engine), and means for restoring the operative connection between the elements 43 and 67 when the actuator 40 is returned to normal position (the edge surface 93 of tube 46 cooperating with pin 43).

In case the pedal 60 is pressed while the engine is running, the pinion 25 will be moved against the rotating gear 21 and will be rotated thereby in such direction as to cause the notch 66 to move almost instantly away from the pin 43 so that the pin 43 may move with-

out producing any further movement of the pinion 25 toward the gear. The engine may restore the pinion 25 to normal position as shown in Fig. 10 while the lever may be moved freely into position for closing the switch. Although the switch be closed, the pinion cannot move into contact with the engine gear because any tendency it might have to move toward the gear would be resisted by the effort necessary to lift the hub of the sleeve 30 from the reduced shaft portion between shoulders 23*a* and 23*b* and by the resistance afforded by the plunger 55 engaging a side wall of the groove 57. The tendency of the tube 46 to move endwise while the shaft 23 is rotating clockwise as viewed in the direction of arrow 90 in Fig. 8, is to move endwise toward the left in Fig. 10 due to the cooperation between the pin 43 and the notch 65 but not toward the right.

While the form of 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. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; a device for moving the pinion endwise and operating in case of abutment with the engine gear for rotating the pinion while it is pressed against the engine gear; a manually operable actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and the shifting device; means for automatically moving the element connected with the shifting device away from the path of movement of the element connected with the actuator before the engine starts; and means for restoring the operative connection between these elements.

2. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; a device for moving the pinion endwise and operating in case of abutment with the engine gear for rotating the pinion while it is pressed against the engine gear; a manually operable actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and the shifting device; means responsive to the operation of the starting motor for automatically moving the element connected with the shifting device away from the path of movement of the element connected with the actuator before the engine starts; and means for restoring the operative connection between these elements.

3. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; a device for moving the pinion endwise and operating in case of abutment with the engine gear for rotating the pinion while it is pressed against the engine gear; a manually operable actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and the shifting device, the element operatively connected with the shifting device being mounted for limited rotation as well as movement axially of the pinion; means frictionally connecting said last mentioned element with the shaft whereby the element will be rotated away from the path of movement of the actuator element; and means for restoring the operative connection between the elements.

4. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and the sleeve; means for automatically moving the element connected with the sleeve away from the path of movement of the actuator element before the engine starts; and means for restoring the operative connection between these elements.

5. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually op-

erated actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and sleeve; means responsive to the operation of the starting motor for automatically moving the element connected with the sleeve away from the path of movement of the actuator element before the engine starts; and means for restoring the operative connections between these elements.

6. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; disconnectible motion transmitting elements operatively connected respectively with the actuator and sleeve, the element operatively connected with the sleeve being supported by the shaft; means frictionally connecting the last mentioned element with the shaft whereby the element will be rotated away from the path of movement of the actuator element; and means for restoring the operative connection between these elements.

7. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; an element moved by the actuator longitudinally of the shaft; a device rotatably supported by the shaft and frictionally connected therewith and adapted to move the sleeve endwise to mesh the pinion with the engine gear; an element provided by said device and normally in the path of movement of the actuator element but moved out of the path of movement of the actuator element when the motor operates; and a cam-element provided by said device and engageable with the actuator element and cooperating therewith to effect the return of the device to normal position when the actuator is returned to normal position.

8. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; an element moved by the actuator longitudinally of the shaft; a device rotatably supported by the shaft and frictionally connected therewith and adapted to move the sleeve endwise to mesh the pinion with the engine gear; an element provided by said device and normally in the path of movement of the actuator element but moved out of the path of movement of the actuator element when the motor operates; and a cam-element provided by said device and coacting with the actuator element to cause the device to be retracted from the engine gear due to rotation of the device by the shaft when the motor operates, and also coacting with the actuator element to effect the rotation of the device to normal position when the actuator is returned to normal position.

9. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; a pin element moved by the actuator along the shaft; and a cylindrical device rotatably supported by the shaft and frictionally connected therewith and movable against the sleeve to move the pinion toward the engine gear, said device having a recess for receiving the pin and so shaped as to provide a surface normally located in the path of movement of the pin but moved out of the path of movement of the pin when the motor operates, and so shaped as to provide a surface oblique to the shaft and coacting with the pin to cause the device to be retracted from the engine gear due to rotation of the device by the shaft when the mo-

tor operates, and also coacting with the pin to effect the rotation of the device to normal position when the pin is returned to normal position.

10. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a pinion movable along the shaft into mesh with the gear of the engine to be started; a pinion shifting sleeve movable along the shaft and having driving connections with the shaft such that endwise movement of the sleeve will cause it to turn relative to the shaft; driving connections between the sleeve and pinion permitting relative endwise movement between the sleeve and pinion so that the pinion may be turned by endwise movement of the sleeve while the pinion is pressed against the engine gear in case of abutment therewith; a manually operated actuator; a pin element moved by the actuator along the shaft; and a tubular member movable along the shaft and surrounding the sleeve and frictionally connected with the sleeve and movable against the sleeve in order to move the pinion toward the gear, and having an opening in its cylindrical wall so shaped as to provide a surface normally located in the path of movement of the pin but moved out of the path of movement of the pin when the motor operates, and so shaped as to provide a surface oblique to the shaft and coacting with the pin to cause the tubular member to be retracted from the engine gear due to rotation of the tubular member by said sleeve when the motor operates and also coacting with the pin to effect rotation of the tubular member to normal position when the actuator is returned to normal position.

11. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; means for connecting the shaft with the gear of an engine to be started and including a pinion movable endwise into mesh with the engine gear and provisions whereby the pinion will be automatically demeshed from the gear when the engine starts; manually operable means for moving the pinion into mesh with the engine gear and including an actuator and disconnectible elements operatively connected respectively with the actuator and pinion; and means for preventing the meshing of the pinion with the gear by the manually operable means while the engine is running, said means including provisions for automatically disconnecting said elements in response to rotation of the pinion in case it is moved against the rotating engine gear.

12. Engine starting apparatus comprising, in combination, a motor; a shaft driven by the motor; a sleeve and a pinion slidable along the shaft toward an engine gear; driving connections between the sleeve and shaft which will produce relative rotary movement between the sleeve and shaft when the sleeve is moved toward the engine gear; means for drivingly connecting the pinion and sleeve while permitting relative endwise movement between the sleeve and pinion; means for moving the sleeve and pinion toward the gear; and means tending to retain the sleeve in normal position.

13. Engine starting apparatus according to claim 12 in which the sleeve is retained in normal position by reducing the outside diameter of that portion of the shaft which is normally engaged by the hub of the sleeve so that the hub is normally located beyond a shoulder portion provided by the shaft on the side thereof remote from the engine gear.

14. Engine starting apparatus according to claim 13 in which the sleeve is retained in normal position by reducing the outside diameter of that portion of the shaft which is normally engaged by the hub of the sleeve so that the hub is normally located beyond a shoulder portion provided by the shaft, the hub of the sleeve having an eccentric mass whereby the unbalanced centrifugal forces acting upon the hub assist in maintaining the hub, while rotating, in engagement with shaft portion of reduced diameter.

15. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; manually operable means for moving the pinion toward the gear and including an actuator and disconnectible motion transmitting elements movable axially of the shaft, one being connected with the actuator and the other operatively associated with the pinion; means for automatically moving the element associated with the pinion away from the path of movement of the actuator element before the engine starts; and means for restoring the operative connection between these elements.

16. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; manually operable means for moving the pinion toward the gear and including an actuator and disconnectible motion transmitting elements movable axially of the shaft, one being connected with the actuator and the other operatively associated with the pinion; means responsive to the operation of the motor for automatically moving the element associated with the pinion away from the path of movement of the actuator element before the engine starts; and means for re-

storing the operative connection between these elements.

17. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provision whereby the pinion will be automatically demeshed when the engine starts; manually operable means for moving the pinion toward the gear and including an actuator and disconnectible motion transmitting elements movable axially of the shaft, one being connected with the actuator and the other operatively associated with the pinion, the latter element being mounted also for limited rotation; means frictionally connecting said last mentioned element with the shaft whereby the element will be rotated away from the path of movement of the actuator element; and means for restoring the operative connection between the elements.

18. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; a manually operated actuator; an element moved by the actuator longitudinally of the shaft; a device rotatably supported by the shaft and frictionally connected therewith and adapted to move the pinion endwise toward the engine gear; an element provided by said device and normally in the path of movement of the actuator element but moved out of the path of movement of the actuator element when the motor operates; and a cam element provided by said device and engageable with the actuator element and cooperating therewith to effect the return of the device to normal position when the actuator is returned to normal position.

19. Engine starting apparatus comprising, in combination, a motor; a shaft operated thereby; means for connecting the shaft with the gear of an engine to be started and including a pinion meshing endwise with the gear and provisions whereby the pinion will be automatically demeshed when the engine starts; a manually operated actuator; a pin element moved by the actuator along the shaft; and a cylindrical device rotatably supported by the shaft and frictionally connected therewith and movable endwise so as to move the pinion toward the engine gear, said device having a recess for receiving the pin and so shaped as to provide a surface normally located in the path of movement of the pin but moved out of the path of movement of the pin when the motor operates, and so shaped as to provide a surface oblique to the shaft and coacting with the pin to cause the device to be retracted from the engine gear due to rotation of the device by the shaft when the motor operates, and also coacting with the pin to effect the rotation of the device to normal position when the pin is returned to normal position.

In testimony whereof I hereto affix my signature.

JOHN B. DYER.