

A. R. CURTIS.
 STARTING MECHANISM FOR INTERNAL COMBUSTION ENGINES.
 APPLICATION FILED OCT. 12, 1908.

1.064,132.

Patented June 10, 1913.

3 SHEETS—SHEET 1.

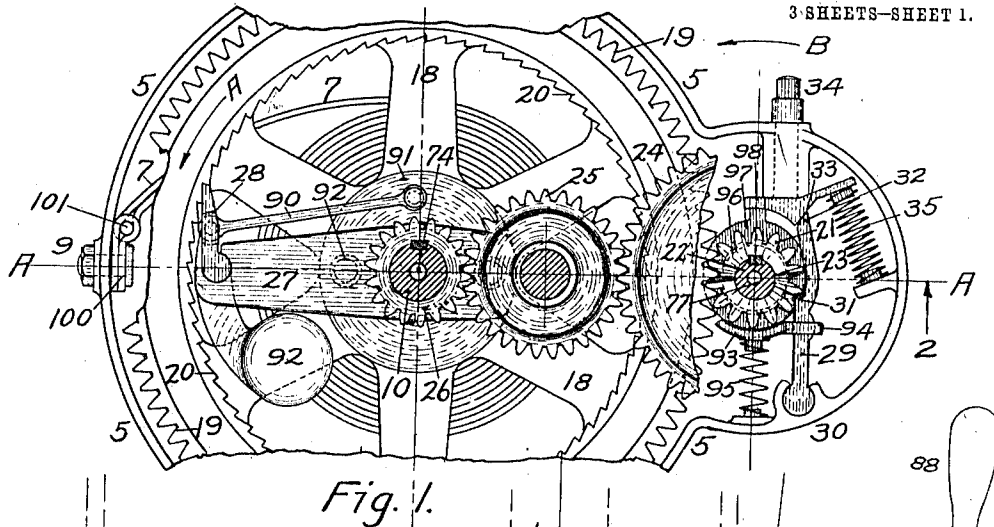


Fig. 1.

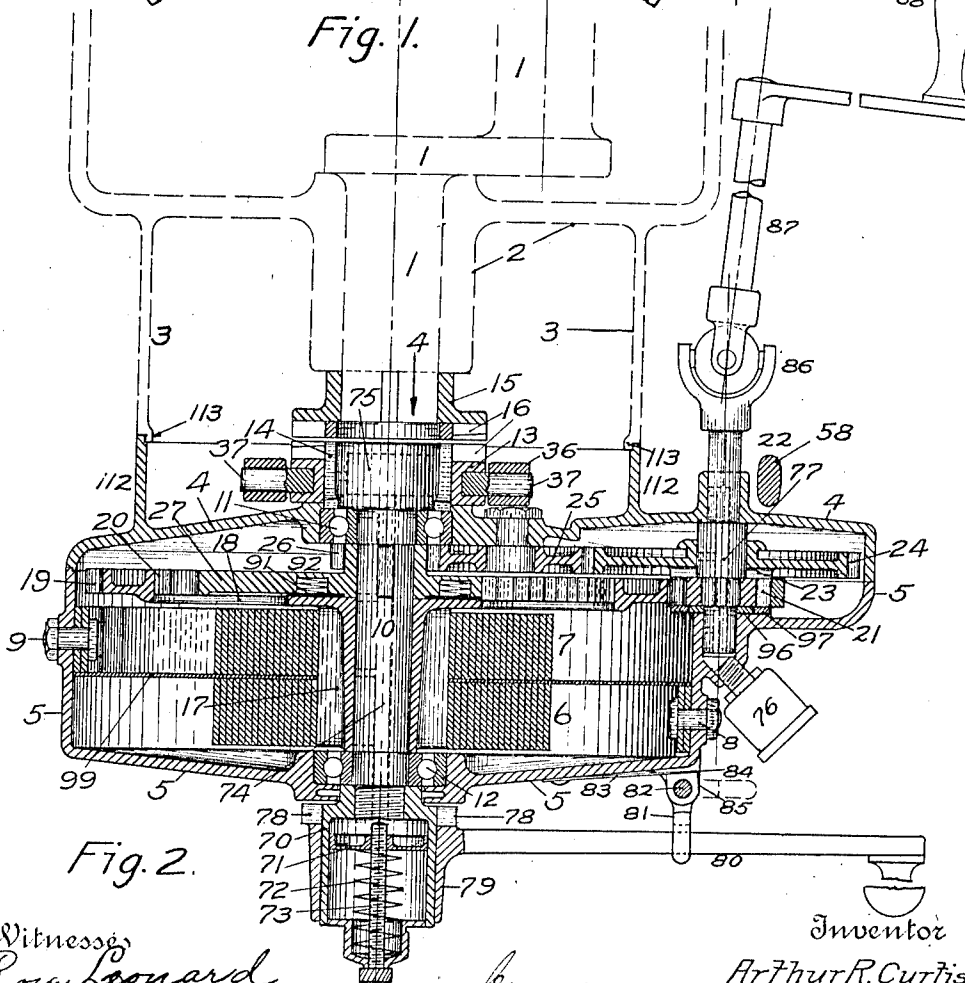


Fig. 2.

Witnesses
 Ross Leonard
 Louis Cosner

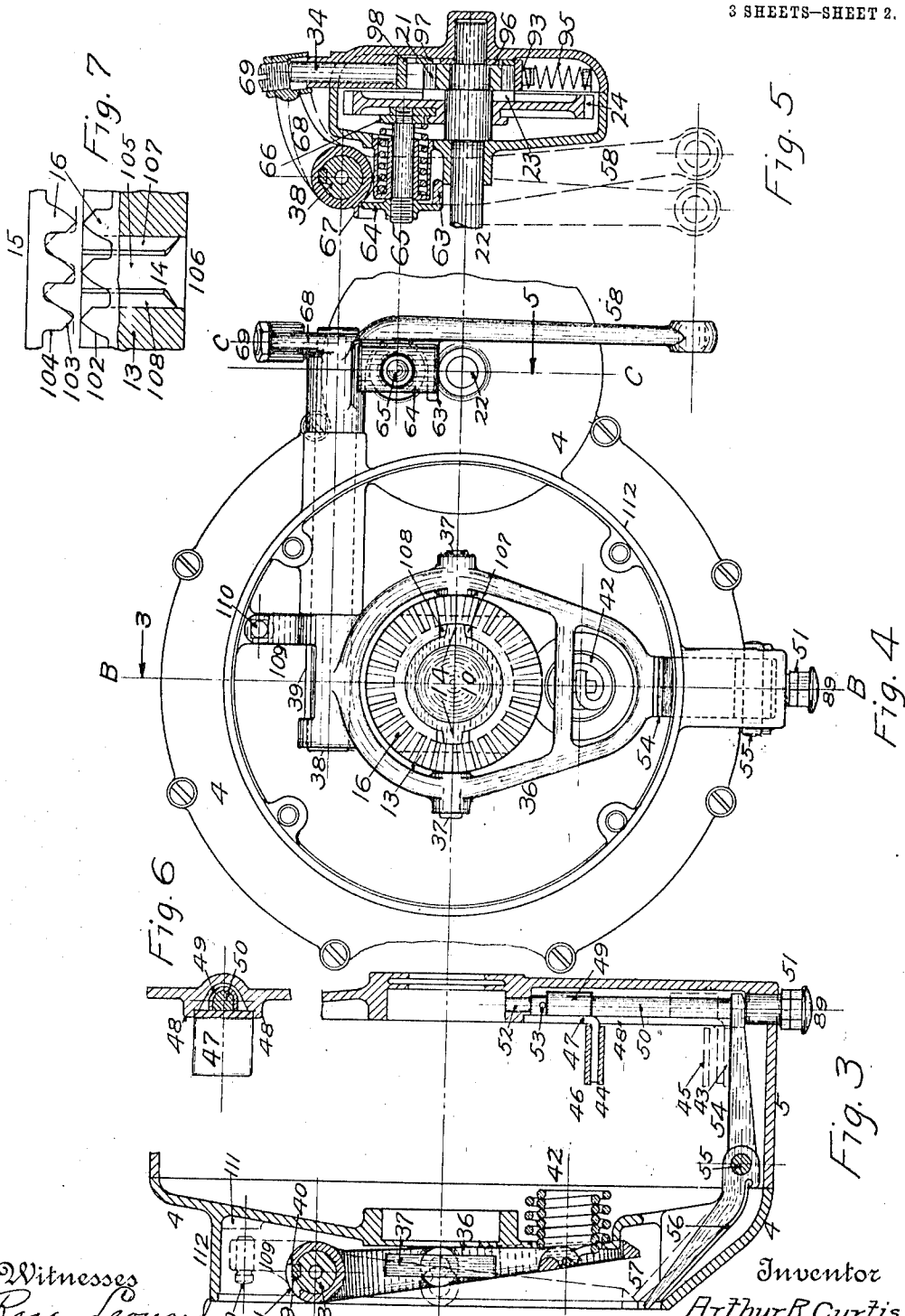
Inventor
 Arthur R. Curtis
 by *Arthur R. Curtis*
 Attorney

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UNITED STATES PATENT OFFICE.

ARTHUR R. CURTIS, OF DENVER, COLORADO.

STARTING MECHANISM FOR INTERNAL-COMBUSTION ENGINES.

1,064,132.

Specification of Letters Patent.

Patented June 10, 1913.

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To all whom it may concern:

Be it known that I, ARTHUR R. CURTIS, a citizen of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Starting Mechanism for Internal-Combustion Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in mechanism for starting or cranking internal combustion engines, and is particularly adapted for use in connection with engines of this character when used in connection with automobiles or motor vehicles.

My invention belongs to that class of starting mechanism in which a spring of the clock-spring type, is used to give the initial turn or turns to the ordinary internal combustion engines, particularly when such engine is used in an automobile as hereinafter explained.

The operations or movements provided for in my starter, assuming that the spring is wound up, are as follows: Pressure of the foot on the operating lever, makes connection between the starter and the engine, disconnects the apparatus for winding the spring, and releases the spring, allowing the latter to turn the engine shaft until its energy is exhausted, or partially exhausted, or the same is run down. This action takes place no matter whether the engine starts or not. However, an engine in starting order will be started by this operation and at any time after starting, the engine will be able to rewind the spring and thus bring the starter as a whole, back to the condition before the operations here enumerated were inaugurated. Upon releasing the operating lever the connection between the starter and the engine is not broken, this engagement being locked by a tripping device which is later operated by the spring itself. However, the releasing of the lever puts in operation the apparatus for winding the spring, which, changing in shape as it is wound, acts at the point when it is completely wound up, to release the connection between the starter and the engine, thus bringing the

starter to its original condition and leaving the engine absolutely free from any connection with the starter. In other words, the starter shaft and the engine shaft are two separate and distinct devices and when the engine is running, assuming that the starter spring is wound up, these two shafts are completely separated the one from the other, though their adjacent extremities are equipped with clutch-members which are readily caused to engage by the movement of one member in the direction of the other.

Having stated the essential operations to be provided for in my starter I will proceed to describe in detail the means for effecting the same, reference being made to the accompanying drawings, in which—

Figure 1 is an elevation viewed from the engine side of the starter and with the inclosing case and all attached parts removed from that side. Fig. 2 is a sectional plan, the section being taken on the line A—A Fig. 1, viewed in the direction of arrow 2. Fig. 3 is a section taken on the line B—B Fig. 4 looking toward the left, or in the direction of the arrow, showing the operating mechanism only, the clutch member and the starter shaft being omitted to facilitate clearness of illustration. Fig. 4 is an elevation looking from the engine side or in the direction of arrow 4 Fig. 2, showing only those parts which are on the outside of the inclosing case. Fig. 5 is a section taken on the line C—C Fig. 4 looking toward the left or in the direction of arrow 5. Figs. 6, 7 and 8 illustrate details of the mechanism. Fig. 9 shows in outline a portion of an automobile with my improved starter attached, the latter together with its controlling means being shown in full lines. In this view the starter mechanism is shown on a greatly reduced scale.

The same reference characters indicate the same parts in all the views.

Referring first to Figs. 1 and 2, let the numeral 1 designate the crank shaft of the engine, and 2 a part of the crank case, which is rigidly attached to the lid part of the inclosing case 4 by means of a flange 3. 5 is the body of the inclosing case to which are attached the two main springs 6 and 7 by means of the bolts 8 and 9. 10 is the main shaft of the starter and is supported in the outer casing by two ball bearings 11 and 12. On its enlarged rear end is slidably mounted the engaging clutch 13 held from rotation

on the starter shaft by keys 14 and arranged to engage with a corresponding member 15 keyed to the front end of the engine shaft 1, by means of teeth 16, thus making connection between the starter shaft and the engine shaft. Mounted loosely on the shaft 10 is the spring center 17 to which the inner ends of the springs 6 and 7 are rigidly attached in the usual manner. This center 17 carries, by means of radial arms 18, gear teeth 19 and ratchet teeth 20. Meshing with the teeth 19 is a pinion 21 which is keyed to a winding shaft 22 and bears on its side two spiral jaws 23 which are shown engaged with corresponding jaws on a winding gear 24, the two sets of jaws forming the winding clutch. Meshing with the gear 24 is an idler gear 25 which in turn meshes with a pinion 26 which is keyed to the main shaft 10 so that gears 24, 25 and 26 are always turning when the shaft 10 is turning. Formed integral with the pinion 26 is a ratchet arm 27, carrying a pawl 28 which engages with the ratchet teeth 20. The gear 19 and the pinion 21 always being in rigid connection with the inner ends of the main springs 6 and 7 either one may be used as a ratchet wheel in connection with a pawl to hold the spring when wound. Since this pawl must be withdrawn from the teeth under pressure, which necessitates hardened surfaces, I have used the pinion 21 for this purpose. 29 is the pawl which is fulcrumed at 30 and engages with the teeth of the pinion at 31. For disengaging, this pawl has an extension terminating in a face 32, which slides on an incline face 33 of a plunger 34. Pressure on this plunger will force the pawl 31 to the right (see Fig. 1), and release the pinion 21, after which the plunger 34 is returned to its original position by a spring 35. The foregoing description covers all of the parts which transmit power either from the starter or the engine, and I will now proceed to describe the parts comprising the operating mechanism whose movements are brought about either by the operator or automatically.

Referring to Figs. 2, 3 and 4, the engaging clutch 13 is controlled by a lever 36 by means of sliding blocks 37. The lever 36 is mounted loosely on the main operating shaft 38, but the latter is provided with a key 39 which, when the shaft 38 is turned clockwise (see Fig. 3), will engage a shoulder 40 in the hub of the lever 36 and thus turn this lever to the position shown in broken lines, but the slot 41 in the hub of the lever 36 will not permit the shaft to carry the lever 36 back with it on its return movement, the spring 42, cooperating with the action of teeth 16 causing such return, being provided for this purpose. According to the general outlines of movements given, the engaging clutch 13 must be held in engage-

ment through all movements, and released only when the main springs 6 and 7 are completely wound. To arrange for this, advantage is taken of the fact that when a spring of this sort is being wound up it grows less in diameter, the outermost layer of the spring being the last to come in and engage the other layers. If, however, a slide be arranged to be controlled by this outermost layer and so constructed as to impinge upon some moving part of a tripping device (arranged to hold the lever 36 in its engaged position), when said outermost layer has reached its smallest diameter, the desired control of the lever 36 will be accomplished.

Referring to Fig. 3, the numeral 43 represents the outer layer and 44 the innermost position of the outermost layer of the main spring 6, that is to say, the positions of this outermost layer corresponding to the unwound and wound conditions of the main springs 6 and 7. The numerals 45 and 46 represent the corresponding positions of the next layer of the spring 6, lying inside of the outermost layer. Lying between these two layers is one leg of a slide 47 which is guided by ways 48 formed in the main case 5. This slide is provided with a sleeve 49 slidably mounted on a guide rod 50. This rod is guided at its outer end by the bearing of an adjusting nut 51 in the main casing, and at its inner end by a bearing 52 also in the main casing 5. The sleeve 49 of the slide 47 engages with a pin 53 in the rod 50, thus drawing the said rod in toward the shaft of the starter as the main spring thus grows smaller in diameter. This movement is communicated to a trip lever 54 by means of the adjusting nuts 51. The trip lever 54 is fulcrumed on a pin 55 which has secured to it a flat spring 56 which always acts to push the upper end 57 of the lever 54 into the position shown by dotted lines in Fig. 3. In this position the trip lever 54 is shown supporting the lever 36 in its engaged position. Thus it will be seen that by properly adjusting the nuts 51 the operation of the trip lever 54 can be so timed that just as the outermost layer of the main spring 6 reaches the position 44, the end 57 of the lever 54 will be withdrawn from the lever 36 and the latter will be brought to its disengaged position by the spring 42.

Referring to Figs. 4 and 5, the main operating shaft 38 is operated by a lever 58 which in turn is connected by means of a rod 59 (see Fig. 9), with a foot lever 60 which should be placed at a point convenient for the operator of the vehicle in which the engine is placed. The foot lever 60 has a foot-pad 61 provided with an extension which engages with fixed ratchet teeth 62, which are intended for locking the operating mechanism in the engaged position. For operating the winding clutch 23 the lever

58 has a lug 63 projecting laterally under an adjusting nut 64 on the outer end of a stem 65. At the inner end of the stem 65 is a clutch yoke 66 which engages with the groove in the hub of the gear 24; and as the clutch 23 is a part of this gear, the winding clutch 23 is controlled. A spring 67 acts to hold the clutch 23 in the engaged position. Formed integral with the lever 58 is a trip lever 68 having at its end an adjusting screw 69 which in turn engages the plunger 34 of the spring-releasing mechanism.

Having now described all of the parts necessary to a proper understanding of the operation of the starter, I will describe these operations more in detail. All of the parts are shown in the disengaged position. The main springs 6 and 7 are shown wound up and everything in readiness for starting the engine. This is accomplished by pushing the foot lever 60, whereby the main operating lever 58 is drawn to the position shown by dotted lines farther to the left in Fig. 5. The results of this movement are as follows: The key 39 in the shaft 38 engages with the shoulder 40 turning the lever 36 and carrying its clutch 13 into engagement with its cooperating clutch member 15, on the adjacent extremity of the engine shaft, thus rigidly connecting the main shaft 10 of the starter with the crank shaft 1 of the engine. The lug 63 on the lever 58 engages with the nut 64 and thus pulls the winding clutch 23 out of engagement, thus freeing the train of gears 24, 25 and 26 from action. The screw 69 of the lever 68 engages with the plunger 34 pushing it in and by means of the face 32 withdraws the lip 31 of the pawl 29, and releases the pinion 21 which in turn releases the spring center 17 together with the ratchet teeth 20 which are connected therewith as heretofore explained. The springs 6 and 7 will now turn the teeth 20 in the direction of arrow A (Fig. 1) so that the pawl 28 will engage these teeth and thus transmit this turning movement through the arm 27 to the main shaft 10. In other words, the spring center 17 and all parts mounted on the main shaft 10 turn as a whole on ball bearings 11 and 12 and through the engaging clutch 13 turn the engine shaft. Assuming now that the engine is running and the main springs 6 and 7 are run down we have the following existing conditions: The spring center 17 together with the pinion 21 and ratchet teeth 20 are stationary, the pawl 28 freeing the arm 27 which is still turning in the direction of arrow A, but is now being driven by the engine shaft instead of the springs 6 and 7. The layers 44 and 46 of the spring 6 have moved out to their unwound positions 43 and 45 carrying the slide 47 with them and thus releasing the rod 50 allowing the spring

56 to push the trip lever 54 over so that its end 57 engages the lever 36 ready to lock it in its engaged position. These conditions may be maintained as long as the operator may wish with no harm resulting to the starter. To rewind the spring the operator releases the foot lever 60 and the following movements take place. The trip lever 54 holds the lever 36 so that the engaging clutch 13 is still in engagement with the clutch 16 of the engine shaft the key 39 simply moving through the slot 41. The spring 35 pushes the plunger 34 back to its original position thus allowing the lip 31 on the pawl 29 to again engage the teeth of the pinion 21. The spring 67 pushes the winding clutch 23 back into engagement when power will be transmitted through the gears 26, 25, 24, 21 and 19 to the spring center 17, and by virtue of the idler 25 the spring center 17 will be driven in the direction of arrow A (Fig. 1), and thus wind the springs 6 and 7. As the spring 6 is wound up, its outer layer will approach the position 44 (Fig. 3), drawing the slide 47 with it, and at that position the sleeve 49 will engage with the pin 53 moving the rod 50, thus pushing the end 57 of the trip lever 54 out of engagement with lever 36, when the latter will be drawn to its original position by the spring 42 and pressure on the teeth 16, thus disengaging the clutch 13 from the cooperating clutch on the engine shaft, leaving the engine perfectly free and bringing the starter back to its original position ready for another start.

The foregoing description covers the main operations of the starter, but there are several points of construction that need special attention.

Automobile work in general, requires more or less automatic lubrication of all the bearings. Again, machinery as here shown inclosed, is difficult to lubricate in the ordinary way. To meet these conditions, I have made the following provision: Screwed onto the front end of the main shaft 10 is the body of a compression grease-cup 70 provided with the usual piston 71 and spring 72, and an adjusting screw 73. Leading out of the grease-cup 70 is a duct 74 running through the middle of the shaft 10 and ending in the cavity 75 at the enlarged front end of the shaft 10. Radiating from this duct and cavity are ducts (shown by dotted lines) leading to the parts along this shaft that need lubrication. Similarly for the shaft 22 I have provided a grease-cup 76 and a duct 77 with radiating ducts leading to the parts to be lubricated along the shaft 22. Similar provision may also be made for the main operating shaft 38 although not here shown.

Provision must be made for cranking the engine in the ordinary way and for winding

the springs 6 and 7 by hand. For this purpose I equip the grease-cup body 70 with two or more lugs 78 which are shown in engagement with corresponding lugs made a part of a hub 79 of a starting crank 80, said lugs being of the ordinary form used on starting cranks. The starting crank 80 may be removed from its bearings on the grease-cup 70 when not in use, or may be left hanging in place. When left on the starter it must be held in some way and I have provided a clip 81 fulcrumed on the main case 5 by means of a pin 82 and held in place in its in and out positions by a flat spring 83 bearing on two flat faces 84 and 85 of the hub 81. The action of this hand crank upon the starter is as follows: If the operating mechanism is in the disengaged position, turning the crank 80 will turn the shaft 10 just the same as if the engine were turning it by means of the engaging clutch 13, so that all gearing being as shown in Fig. 2, the springs 6 and 7 will be wound up through the gears 26, 25, 24, 21 and 19, thus winding through all of the winding gears. If the operating shaft is in the engaged position, and the springs 6 and 7 are completely run down, since the winding clutch 23 is then out and engaging clutch 13 is in, turning the crank 80 will turn the engine shaft directly, with no winding of the spring, so that the engine can then be cranked in the ordinary way with no action taking place in the starter. If the operating mechanism is in the engaged position, but the spring is only partly run down, then the action is the same as just described, but whatever force is left in the spring will be added to what is being done by the crank 80. The winding of the springs by the method just described requires that the operator be at the point where the starter is located on the car, which could probably never be so arranged that he could sit in his seat and wind up the springs. Again, winding through all the winding gears is too slow and tedious so that I have provided another way of winding which is as follows: The shaft 22 is provided at its outer end with a universal coupling 86 to which a winding shaft 87 is attached, which shaft may run to any point convenient to the operator when in his seat (see Fig. 9). At the end of the shaft 87 is a crank 88. The action is as follows: Set the operating mechanism in the disengaged position. Then the turning of the crank 88 will turn the pinion 21 directly, thus winding the springs 6 and 7 through the gear reduction caused by the pinion 21 and the gear 19 only, instead of through all of the winding gears.

If the winding clutch 23 is in the engaged position during the above movements, it would appear that this would cause interference, but the jaws of the clutch 23 are

of the so-called spiral type, as shown by the shading on the same, as shown in Fig. 1 and in detail in Fig. 8. It is well known that such jaws will drive positively in one direction and will slip in the reverse direction. It will thus be seen that when the gear 24 is driving the gear 21 through the clutch 23, the jaws of 23 are positively engaged; but if the gear 24 is stationary and the gear 21 is turned ahead by turning crank 88, the jaws will simply ride up on each other, compressing springs 67 and slide by. In certain applications of the starter a simple shaft such as 87 might not enable one to reach a satisfactory position for the crank 88 in which case some other form of gear might have to be introduced between the shaft 22 and the shaft 88.

If the operating mechanism is once placed in the engaged position, the engaging clutch 13 cannot be released in the ordinary working of the starter, except by winding the spring up, thus causing the tripping devices to act, and in order to put the starter in the disengaged position under these circumstances, I have provided the means shown in Fig. 3 for tripping the lever 36 by hand. As here shown, nuts 51 project through the main casing 5 and have a rounded head 89. It will be seen that the applying of pressure to the head 89 at any time, will withdraw the end 57 of the tripping lever from the lever 36 and thus release it.

Internal combustion engines when being cranked always oscillate backward more or less, and may actually run backward for several turns, and provision must be made to prevent injury to the main springs 6 and 7 or any of the mechanism of the starter from this cause. There are two conditions to be considered: First, when the springs are wound up and the starter is placed in the engaged position, if the engine attempts to start backward, its power will be immediately choked by the springs 6 and 7 since the effect of running backward is to wind up these springs more and it has been found by experiment that springs that are powerful enough to start a given sized engine properly, will have sufficient power to immediately stop said engine, if it starts to run backward, under the conditions here stated; second, when the springs 6 and 7 are run down and the engaging clutch 13 is in the engaged position, if an attempt is made to start the engine by cranking and it starts backward, the following operations will result: The pawl 28 on the arm 27 will engage with the ratchet teeth 20 and thus drive the spring center 17, the gear teeth 19 and the pinion 21 in the proper direction for winding, but at the same time the gears 26, 25 and 24 will be driven in the opposite direction for winding, and thus if the jaws 23 forming the winding clutch, would drive in the

wrong direction of turning, there would be interference. As heretofore explained, the jaws 23 will slide by each other if the gear 24 turns backward. Thus the net result of the engine running backward, if the springs run down, is to wind the springs up directly, through the arm 27 and pawl 28.

Internal combustion engines are all inclined to be noisy when starting, so that it is very desirable not to add any noise at this time due to operations taking place in the starter. For this reason I have made the two ratchets shown of the so-called silent type.

Referring to Figs. 1 and 2 the pawl 28 is connected by means of a rod 90 with a circular disk or washer 91 which washer is pressed into frictional contact with the flanged hub of the spring center 17, by coil springs 92, so that if relative motion takes place between the arm 27 and the spring center 17, the disk 91 tends to move or remain with the spring center 17. The action is as follows: When the spring center 17 moves in the direction of the arrow A (Fig. 1) or the arm 27 moves in the opposite direction, the ratchet teeth 20 and the pawl 28 should engage with each other, and it will be seen that the disk 91 adhering to the spring center 17 will push the pawl 28 into engagement through the rod 90. When the spring center 17 moves in the direction opposite to the arrow A, or the arm 27 moves in the direction of arrow A, the ratchet teeth 20 and pawl 28 should be held out of engagement if no noise is to be made. It will be seen that the disk 91 adhering to the spring center 17 will draw and hold the pawl 28 out of contact with the teeth 20 by means of the rod 90. The pawl 28 and the rod 90 will be acted upon by centrifugal force, which might interfere with the action just outlined. To prevent this, a counterweight 92 is connected with the pawl 28 as shown, which will act against any centrifugal action set up in the pawl 28 and the rod 90.

The pawl 29 is controlled by exactly the same principle namely, by friction, decidedly different mechanism, however, being employed. Referring to Figs. 1, 2 and 5, 93 is a friction shoe having the curvature of the outside of the pinion 21, and having a loop 94 at its end, which loop surrounds the pawl 29 as shown, and rather loosely fits the same. The shoe 93 is pushed into frictional contact with the periphery of the pinion 21, by a spring 95. The action is as follows: Starting with all parts as shown in Fig. 1, if the pinion 21 turns in the direction of arrow B, the pawl 29 will have its lip 31 pushed out of engagement with the tooth of the pinion 21, and the friction between the pinion 21 and the shoe 93 will keep the pawl 29 out of contact and thus prevent any noise. When the pinion 21 moves in a direction opposite

to the arrow B the friction of the shoe will draw the pawl 29 back into engagement. The action here described takes place no matter whether the pinion 21 is being driven by the power of the engine or by the power from the springs 6 and 7. However, when the pinion 21 is driven by the springs, it will turn at considerable speed and, as all of the power of the springs is wanted to turn the engine, the drag set up by the frictional contact of the shoe 93 is objectionable. I have, therefore, arranged to hold the shoe 93 out of contact with the pinion 21, during the time when the pawl 29 is held released by the plunger 34, when the latter is held down by the operating lever 68.

The numeral 96 designates a tight round washer mounted on the shaft 22 and is surrounded by a loose washer 97 which is made with a vertically slotted opening (see dotted lines in Fig. 1), so that it can have vertical motion. The loose washer 97 has a lug 98 at the top fitting into a slot made on the back-side of the head of the plunger 34, to keep the washer 97 from turning. This washer fits and rests on the shoe 93, the latter being made wider than the pinion for this purpose. It will now be seen that as the plunger 34 is pressed in or downwardly, forcing out of engagement the lip 31 of the pawl 29, its lower end will impinge upon the top of the loose washer 97 and thus push the shoe 93 out of contact with the pinion 21. As soon as the plunger 34 is released and returns to its original position, the spring 95 will again act to put the shoe 95 in frictional contact with the pinion 21.

Single springs of dimensions to give strength enough for starting engines as now found in the market, are hard to obtain, difficult to handle, and produce great side strain on the outer casing, and more especially on the bearings of the spring center 17, and the main shaft 10. To overcome these difficulties I use two or more springs instead of a single spring to get the necessary power. To neutralize the side pull two springs have their inner and outer ends fastened 180° apart as here shown; if three springs are employed, their corresponding outer extremities would be 120° apart and so on, although more than three springs would probably never be found necessary. Where more than one spring is used, a separating disk must be placed between each pair of springs as shown at 99, Fig. 2. With these heavy springs it is difficult to get them in and out of the inclosing case if there are fastening lugs of any kind projecting inside of the case. Again, with the light construction of case that must be used, lugs cast with it of allowable size do not give a reliable fastening for the outer ends of the springs.

Referring to Figs. 1 and 2, the spring 7 has formed on its outer end of substantially

the same material as itself, a hinged piece 100, 101 being the pin of the hinge. The piece 100 has the bolt 9 running through it and the outer case 5. By using special nuts or suitable washers, enough area on the case 5 may be covered and clamped to make a secure fastening in the thin material, and when the bolt 9 is removed, the case is left perfectly smooth for the insertion or removal of the springs.

The clutch that makes connection between the main shaft of the starter and the engine shaft must be of a type that will admit of engagement when both shafts are stationary as this is the condition just before making a start. A friction clutch of any of the well known forms would fulfil this condition admirably but would be altogether too cumbersome and would require adjustment from time to time. On the other hand, with the usual forms of jaws or positive clutches, there would be certain angular positions of the engaging jaws when the jaws would strike and prevent engagement. Again, it will be found that when the springs 6 and 7 are driving the engine, the pressure is on one side of the jaws or teeth 16, and on the other side of these teeth when the engine is driving the starter, so that both sides of the teeth must be properly shaped for transmitting power.

Referring now to Figs. 2, 4 and 7, it will be seen that teeth 16 come to an edge on a radial line and are provided with sloping faces 102 extending all the way from this edge, whereas the opposite face of each tooth is made up of the sloping face 103 and the perpendicular face 104. The faces 102 are in contact when the engine is driving and the faces 104 are in contact when the starter is driving. I have found that teeth coming to an edge in this manner, will engage readily at all angular positions, if the engine shaft 1 and the starter shaft 10 are in line, and if one of the clutch members, such as 13, is free to turn a distance equal to one-half of the pitch of the teeth from their initial positions, when the teeth start to engage. I have provided for this movement as follows: Referring particularly to Fig. 7, the key 14 is made with a narrow portion 105, and at its back end a wider portion 106. The key way in the clutch member 13 is made in width to fit this wider portion so that when the member 13 is back in its disengaged position, it is held securely in a central position with reference to the keys 14, leaving equal spaces 107 and 108 on either side of the narrow portion 105. As the member 13 is moved forward into engagement with the member 15, either of the faces 102 come into contact turning the member 13 to the right as shown, space 108 making this possible; or the faces 103 come into contact turning the member 13 to the

left, the space 107 making this possible. Should it ever occur that the edges of all of the teeth should exactly meet and stop the engagement, a slight movement of the member 13 back and forth will jar it to one side or the other, as it is seen that member 13 is perfectly free to turn through a small angle when brought forward for engagement.

When the starter is driving there should be no force tending to separate members 13 and 15, as this would tend to develop friction which would waste the energy of the springs and for this reason the faces 104 which are in contact then, are made straight and perpendicular. On the other hand, when the engine is driving and the faces 102 are in contact, there is ample power available whereby there is sufficient thrust to separate the members 13 and 15 and to neutralize all friction of these parts so that the instant the trip lever 54 released the lever 36 the members 13 and 15 will be separated by the very driving force they are transmitting independently of the spring 45. This forms a safe-guard against the possible sticking of the engaging clutch 13 which would cause the springs to be over-wound and perhaps broken. It is for this reason that the faces 102 are made sloping.

It has already been pointed out that the time of tripping the lever 36 may be adjusted by the nuts 51. It is equally important that relative movements of the lever 36, the plunger 34 and the yoke 66 operating respectively, the engaging clutch 13; the spring-release pawl 29 and the winding clutch 23, be accurately timed constantly to establish and maintain their proper sequence. The movement of the lever 36 must first be adjusted and the other movements regulated with reference thereto. The lever 36 is stopped in its engaged position and is adjusted for this position by a screw 110 passing through a lug 109 which is a part of the hub of the lever 36, said screw impinging on a lug 111.

The movement of the plunger 34 must be so timed by adjusting the screw 69 that the pawl 29 is released just as the lever 36 is stopped, thus insuring that the springs 6 and 7 are not released until full engagement has been established between the starter and the engine.

The movement of the yoke 66 must be timed by adjusting the nut 64 so that the jaws of the winding clutch 23 are fully separated, before the plunger 34 releases the pawl 29.

For the purpose of holding the starter in proper alinement and more especially to make it possible to remove and replace the starter and have it come to the same place, I provide the lid 4 with a flange 112 which may form a complete circle as here shown, or form only a part of a circle as outside

conditions may demand. Such circular portions of the flange 112 must be recessed to receive a corresponding flange or rim 113 of a cooperating flange on the supporting member which is here shown as made a part of the engine casing 2.

Having thus described my invention what I claim is:

1. In a starter for internal combustion engines, the combination with the engine shaft and a starter shaft normally, wholly disconnected from the engine shaft, of a device journaled co-axially with said starter shaft, a spring having one extremity attached to said device, the other extremity being fixed, a gear fixedly attached to the movable device, a ratchet and pawl connection between said gear and the starter shaft whereby the movement of the gear in response to the tension in the spring actuates the shaft, and an operative connection between the starter shaft and the engine shaft.

2. A starter for internal combustion engines comprising a starter shaft, a spring center journaled co-axially with said shaft, the said center being provided with a gear forming a rigid part of said spring center, and a ratchet and pawl connection between the gear and the starter shaft whereby the power of the spring may be exerted to rotate the shaft.

3. A starter for internal combustion engines comprising a starter shaft, a spring, a spring center journaled co-axially with said shaft and provided with a gear, means engaging the teeth of said gear for normally locking the spring-actuated parts against movement, and means acting on said gear teeth whereby the latter are utilized to transmit power for winding the spring.

4. A starter of the class described comprising a shaft, a spring center loose on the shaft, said center being provided with a gear, a ratchet and pawl connection between the gear and the shaft whereby the power of the spring may be exerted to rotate the shaft, a winding pinion meshing with the said gear, means acting directly on the pinion for normally locking the spring-actuated parts against movement, and a gearing connection between the winding pinion and the shaft, including a reversing idler, whereby the rotation of the shaft may be utilized to wind the spring.

5. A starter of the class described comprising a starter shaft, a spring center loose on the shaft, said center being provided with a gear, a pinion fast on the starter shaft, a ratchet and pawl connection between the gear and the shaft, whereby the power of the spring may be exerted to rotate the shaft, a winding pinion meshing with the said gear, means engaging the pinion for

normally locking the spring-actuated parts against movement, and a gearing connection between the winding pinion and the shaft pinion including a reversing idler whereby the rotation of the shaft may be utilized to wind the spring, and means for breaking the gearing connection between the two pinions to permit the power of the spring to act to turn the shaft.

6. The combination with a shaft, of a device rotatably mounted, a spring connected with the rotatable device at one extremity its opposite extremity being fixed, a train of winding gears interposed between the spring center and the shaft whereby the rotation of the shaft winds the spring, means for breaking the connection between the train of gears at a suitable intermediate point, and a hand operated shaft connected with one of the intermediate gears on the spring center side of the break in the train of gears whereby the spring may be wound without actuating the entire train of gears, substantially as described.

7. The combination with a shaft, of a device rotatably mounted co-axially with the shaft, a spring connected with the rotatable device at one extremity its opposite extremity being fixed, a gear connected to move with the rotatable device, a ratchet and pawl connection between the said gear and the shaft whereby the power of the spring acts through the gear to turn the shaft, a train of gears interposed between the first named gear and the shaft whereby the spring may be wound by the operation of the shaft, means for disconnecting the train of winding gears at a suitable intermediate point, and a hand operated shaft connected with the gears at a point between the break in the train of gears and the spring, for winding the latter by hand, substantially as described.

8. A starter for internal combustion engines comprising in combination with the engine shaft, a starter shaft, an engaging device arranged to connect the two shafts in operative relation, a spring connected with the said starter shaft, a suitable device for normally locking the spring-actuated parts against movement, a device for releasing said locking device, and means for controlling said engaging and said releasing devices to cause them to act substantially simultaneously, and means for locking said controlling means when said engaging and releasing functions have been performed.

9. The combination of a starter shaft, a power spring, a connection between the shaft and the spring whereby the latter is adapted to give power to and receive power from the said shaft, a hand crank for winding the spring mounted loosely on said shaft, suitable means for connecting said crank with

the shaft, and suitable means for locking said hand crank against rotation when not connected.

10. A starter of the class described comprising a shaft, a spring center loose on the shaft, said center being provided with a gear, a ratchet pawl arranged to engage with said gear and connected with said shaft so that the power of the spring may be exerted to rotate the shaft, means for automatically bringing said pawl into arrangement with said gear when the gear moves in the power transmitting direction, and for automatically disengaging and holding said pawl from all contact with said gear when the motion is reversed.

11. A starter for internal combustion engines comprising a starter shaft, a spring, a spring center journaled co-axially with said shaft and provided with a gear, means engaging said gear for winding the spring, a pawl engaging said gear for holding the spring when wound, means for automatically bringing said pawl into engagement with said gear when the gear moves in a direction opposite to that for winding, and for automatically disengaging and holding said pawl from all contact with said gear when the motion is reversed.

12. A starter for internal combustion engines comprising a starter shaft, a spring, a spring center journaled co-axially with said shaft and provided with a gear, means engaging said gear for winding the spring, a pawl engaging said gear for holding the spring when wound, means for automatically bringing said pawl into engagement with said gear when the gear moves in a direction opposite to that for winding, and for automatically disengaging and holding said pawl from all contact with said gear when the motion is reversed, and means for withdrawing said pawl from engagement with said gear and simultaneously withdrawing said automatic means from action.

13. A starter for internal combustion engines comprising in combination with the engine shaft, a spring-actuated starter shaft, distinct and separate from the engine shaft, and means for connecting the two shafts in operative relation for turning the engine shaft, said means for connecting the two shafts consisting of a jawed member on the starter shaft arranged to engage with a corresponding jawed member on the engine shaft, one of said members being free to rotate in either direction through a small predetermined angle.

14. A starter for internal combustion engines, comprising in combination with the engine shaft, a spring-actuated starter shaft, distinct and separate from the engine shaft, and means for connecting the two shafts in operative relation for turning the engine shaft, said means for connecting the two

shafts consisting of a jawed member on the starter shaft arranged to engage with a corresponding jawed member on the engine shaft, each of said engaging jaws being formed with sloping engaging faces meeting on a radial line passing through the center of said shafts, and one of said members being free to rotate in either direction through a small predetermined angle.

15. The combination with a shaft to be operated, of a spring-actuated starter shaft distinct from the first named shaft, means for connecting the two shafts in operative relation for starting purposes, means for locking the two shafts in the connected position, and means for automatically releasing the locking mechanism, said means for connecting the two shafts consisting of a jawed member on the starter shaft arranged to engage with a corresponding jawed member on the engine shaft, the engaging faces of said jaws being sloped, so that when said releasing means act to release the locking mechanism the sloping faces cause said jawed members to disengage.

16. The combination with an engine shaft, of a starter shaft, a spring for actuating the latter, a spring center coaxially journaled with the starter shaft and to which one extremity of the spring is attached, a gear connected with the spring center and movable therewith under tension of the spring acting on the latter, a connection between the said gear and the starter shaft for actuating the latter, means for connecting the two shafts in operative relation for utilizing the power of the spring to start the engine, and means acting on the teeth of the said gear for utilizing the power of the engine shaft for winding the spring, substantially as described.

17. The combination with an engine shaft, of a starter shaft, a spring for actuating the latter, a spring center coaxially journaled with the starter shaft and to which one extremity of the spring is attached, a gear fixedly connected with the spring center, a pawl and ratchet connection between the said gear and the starter shaft, means for connecting the two shafts in operative relation for turning the engine shaft, and means acting on the teeth of the said gear for utilizing the power of the engine shaft to rewind the spring after the starter shaft has performed the starting function, substantially as described.

18. The combination with an engine shaft, of a starter shaft, a spring for actuating the latter, a connection between the two shafts, whereby the starter shaft first acts to operate the engine shaft after which the latter serves to rewind the spring, a lever in operative relation with the connection between the two shafts, and a slidably mounted member engaged by the spring and

in operative relation with the said lever for automatically disconnecting the two shafts after the spring has been wound to a predetermined tension, substantially as described.

19. A starter for internal combustion engines, comprising in combination with the engine shaft, a casing, a starter shaft journaled in the said casing, a spring center journaled coaxially with the said starter shaft, a spring having one extremity attached to the casing, while the other extremity is connected with the casing, an operative connection between the starter shaft and the spring center, whereby the tension of the spring serves to rotate the shaft, means for connecting the starter shaft and the engine shaft in operative relation, whereby the power of the spring may be utilized to rotate the engine shaft, a lever for locking the two shafts in operative relation, and a slidably mounted member acted on by the spring for actuating the said lever to bring the same in the locking position when the spring has been unwound, substantially as described.

20. A starting device for internal combustion engines, consisting in combination with an engine shaft, a fixed casing, a movable part free to rotate within the said casing, a spring secured at one end to the casing and at the other end to the movable part, a connection between the said movable part and the engine shaft, suitable means for applying the power of the said spring when wound to the said movable part, means for winding the said spring by power taken from the engine shaft, a lever in operative relation with the connection between the movable part and the engine shaft for stopping the said winding, a movable member engaged by the spring and in operative relation with the said lever, whereby when the spring has been wound to a predetermined position, the said movable member is shifted to release the lever from engagement with the connection between the said movable part and the engine shaft, and means acting on the movable part for breaking the connection, substantially as described.

21. A starter for internal combustion engines, comprising in combination with an engine shaft, a starter shaft, an operative connection between the engine shaft and the starter shaft, a spring center loose on the starter shaft, the said center being provided with a gear, a pawl and ratchet connection between the starter shaft and the said gear, whereby the power of the spring is exerted to rotate the starter shaft, means for automatically bringing the said pawl into engagement when the said gear moves in the direction transmitting the power from the spring to the starter shaft, means for automatically disengaging and holding the said

pawl from contact with the said gear when the motion is reversed, whereby the power of the engine is used for rewinding the spring, substantially as described.

22. A starter for internal combustion engines, comprising in combination with an engine shaft, a starter shaft, a gear journaled coaxially with the said shaft, a spring connected with the said gear means engaging the said gear for winding the spring, a pawl engaging the said gear, for holding the spring when wound, means for automatically bringing the said pawl into engagement with the said gear when the gear moves in a direction opposite to that for winding, and for automatically disconnecting and holding the said pawl from all contact with the said gear when the motion is reversed, and an operative connection between the said starter shaft and the engine shaft, whereby the starter shaft acts to impart power to the engine shaft when the spring is being unwound, and the engine shaft acts to impart power to the starter shaft in the reverse direction for rewinding the spring, substantially as described.

23. A starter of the class described, comprising a shaft, a gear coaxially journaled on the shaft, a spring for actuating the said gear, a pawl and ratchet connection between the said gear and the shaft, so that the power of the spring may be exerted to rotate the shaft, means carried by the said shaft for automatically bringing the said pawl into engagement with the said gear, when moving in the power-transmitting direction, and for automatically disengaging and holding the said pawl from all contact with the said gear when the motion is reversed, and means acting on the said gear teeth, whereby the latter are utilized for transmitting power for winding the spring, substantially as described.

24. A starter for internal combustion engines, comprising a starter shaft, a spring, a gear journaled coaxially with the said shaft, means engaging the teeth of the said gear for normally locking the spring-actuated parts against movement, and means acting on the said gear teeth, whereby the latter are utilized to transmit power for winding the spring, substantially as described.

25. A starter for internal combustion engines, comprising a starter shaft, a spring, a spring center journaled coaxially with the said shaft, and provided with a gear, means engaging the teeth of the said gear for normally locking the spring-actuated parts against movement, and means acting on the said gear teeth, whereby the latter are utilized to transmit power for winding the spring, and means for releasing the locking means to allow the power of the spring to act upon the shaft, substantially as described.

26. The combination with the engine shaft, of a starter shaft alined therewith, a spring for actuating the latter, a reversible connection between the two shafts whereby
5 the starter shaft first acts to operate the engine shaft after which the latter rewinds the spring, and mechanism for automatically disconnecting the two shafts after the spring has been wound to a predetermined tension,

the action of the spring performing the initial step in the disconnecting operation. 10

In testimony whereof I affix my signature in presence of two witnesses.

ARTHUR R. CURTIS.

Witnesses:

LOUISE COSNER,

A. EBERT O'BRIEN.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."
