J. KELLER.

STARTING MECHANISM FOR MOTORS.

APPLICATION FILED NOV. 14, 1912.

1,135,694. **Patented Apr. 13, 1915.**

6 SHEETS—SHEET 1.

Fig. 1.

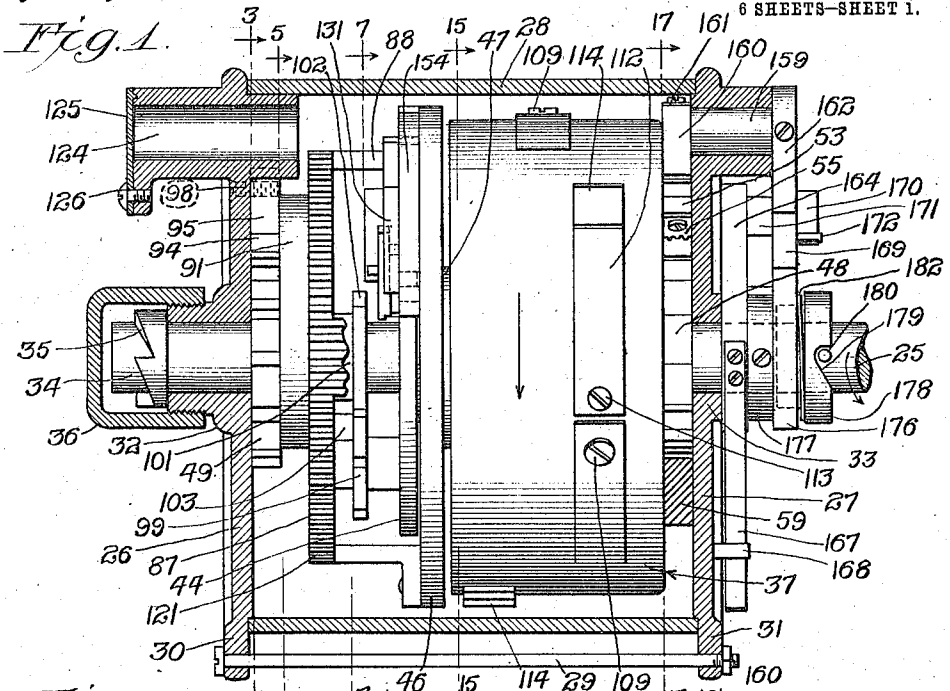
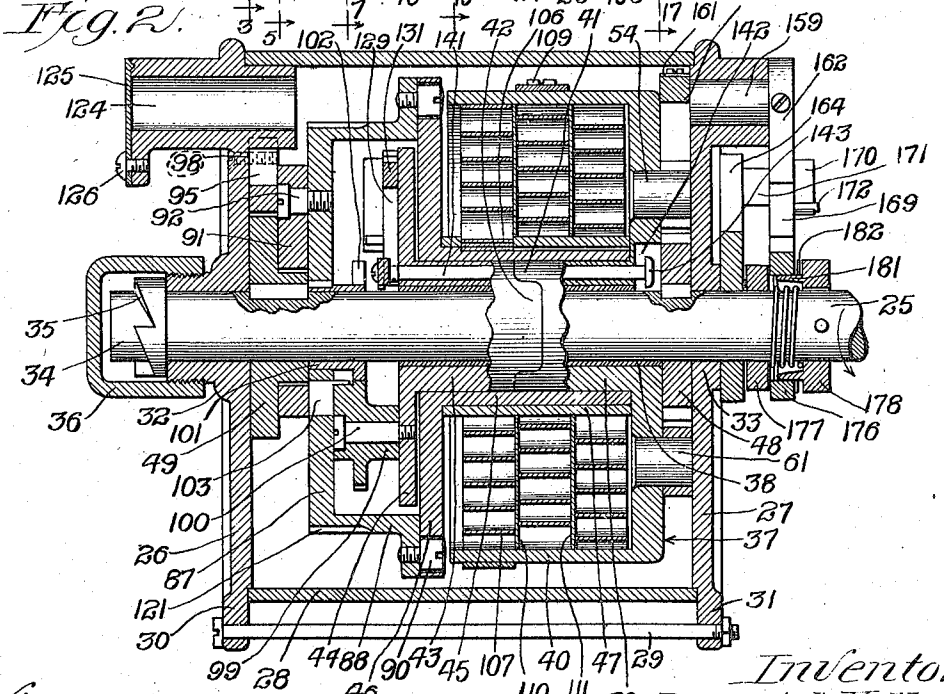


Fig. 2.



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6 SHEETS—SHEET 2.

Fig. 5.

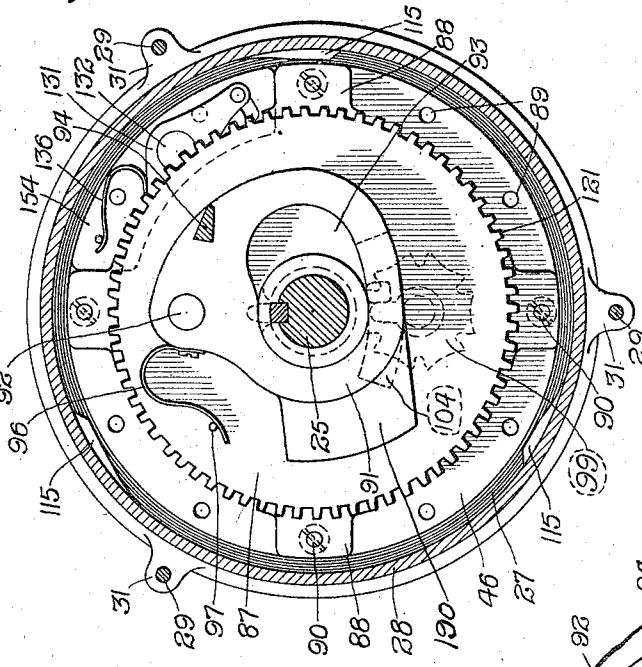


Fig. 6.

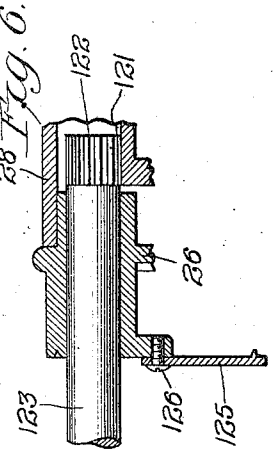


Fig. 4.

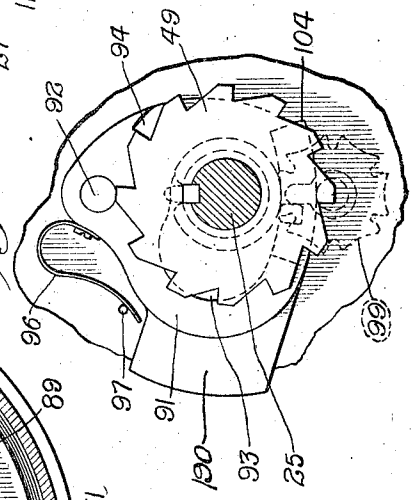
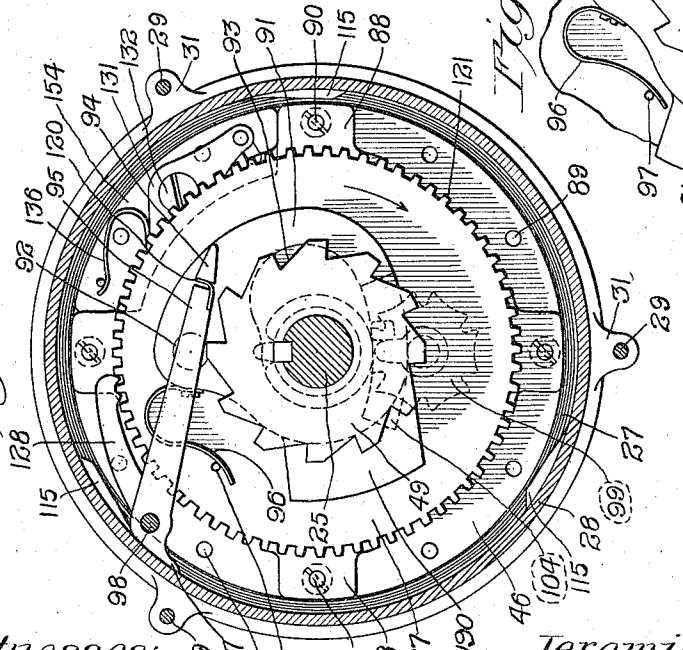


Fig. 3.



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6 SHEETS—SHEET 3.

Fig. 9.

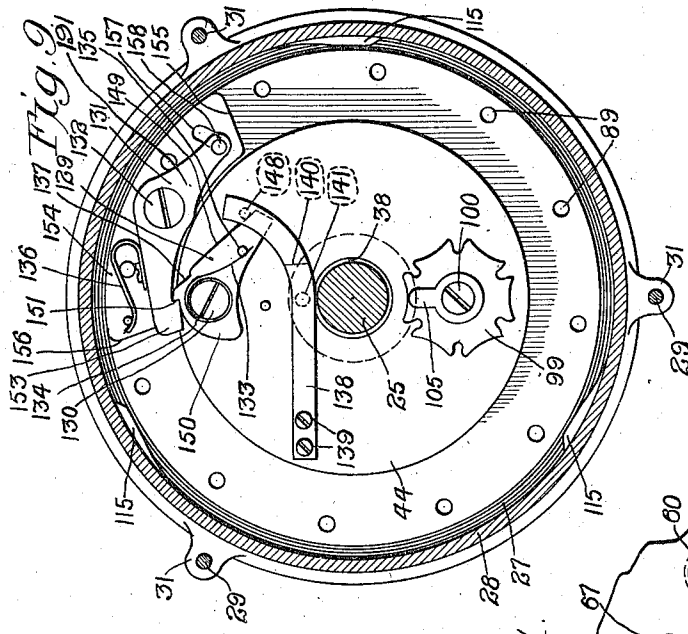


Fig. 10.

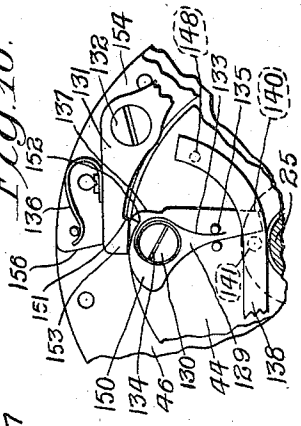


Fig. 11.

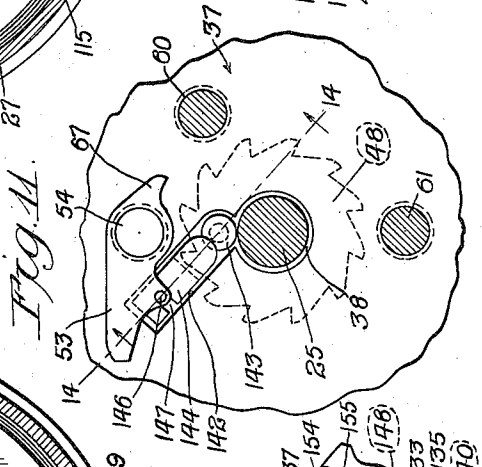


Fig. 7.

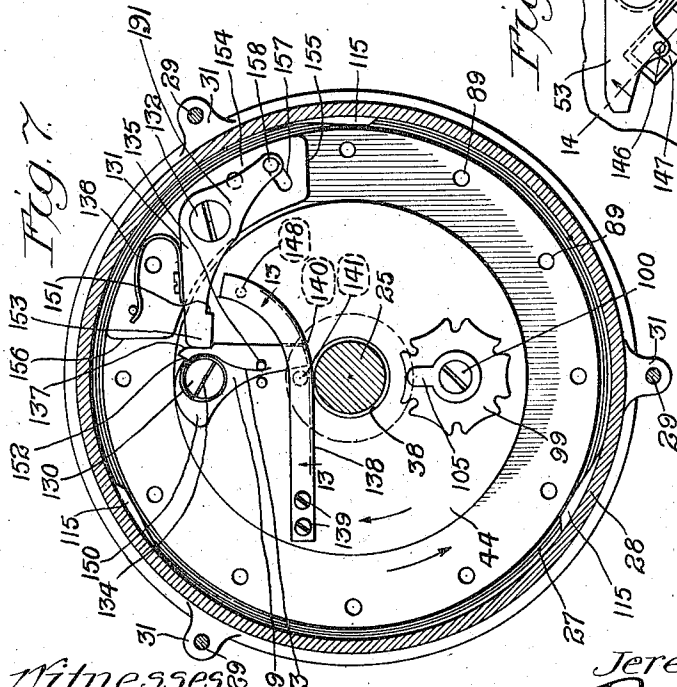
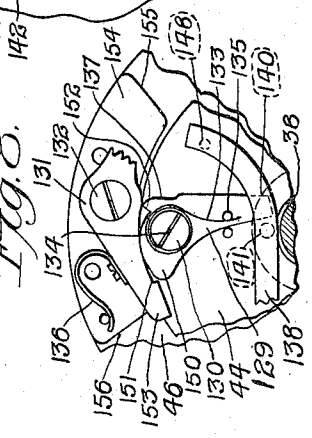


Fig. 8.



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Fig. 16.

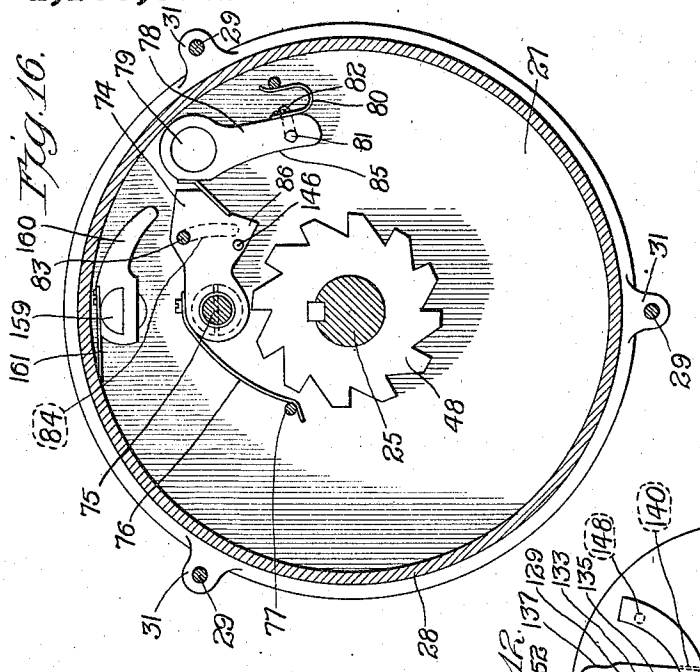


Fig. 14.

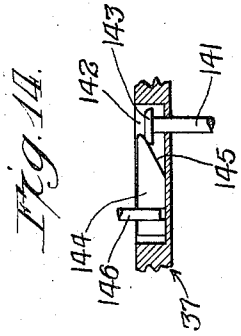


Fig. 12.

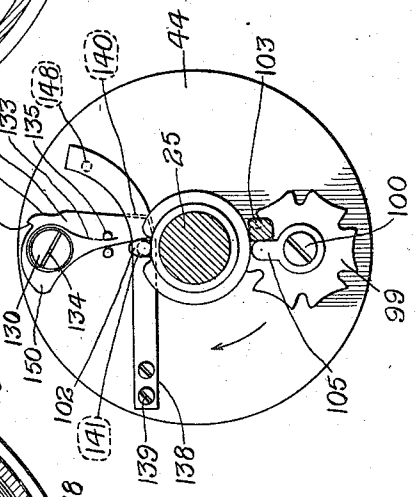


Fig. 15.

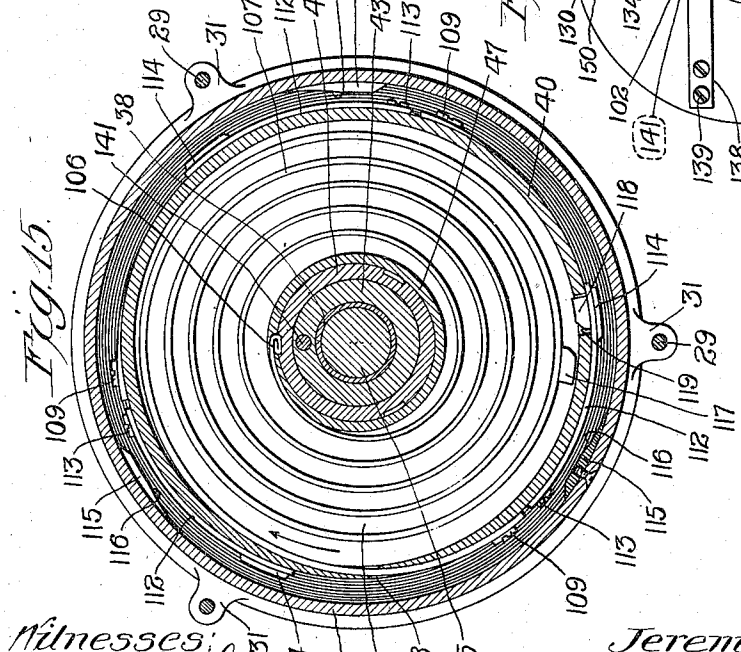
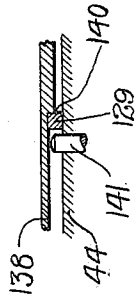


Fig. 13.



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6 SHEETS—SHEET 5.

Fig. 18.

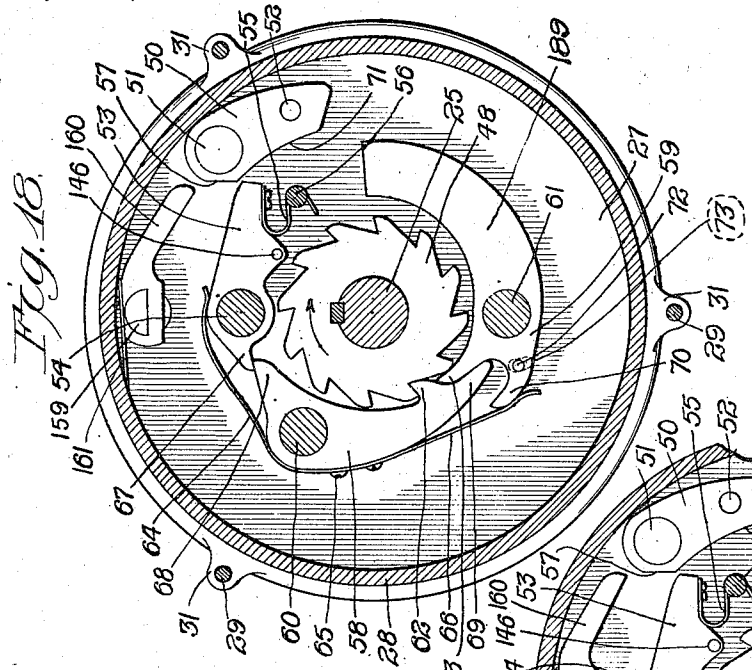


Fig. 19.

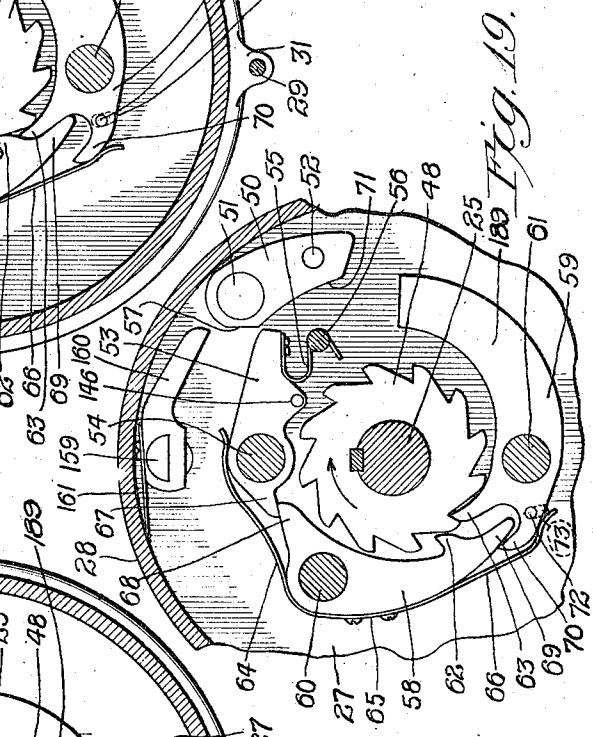
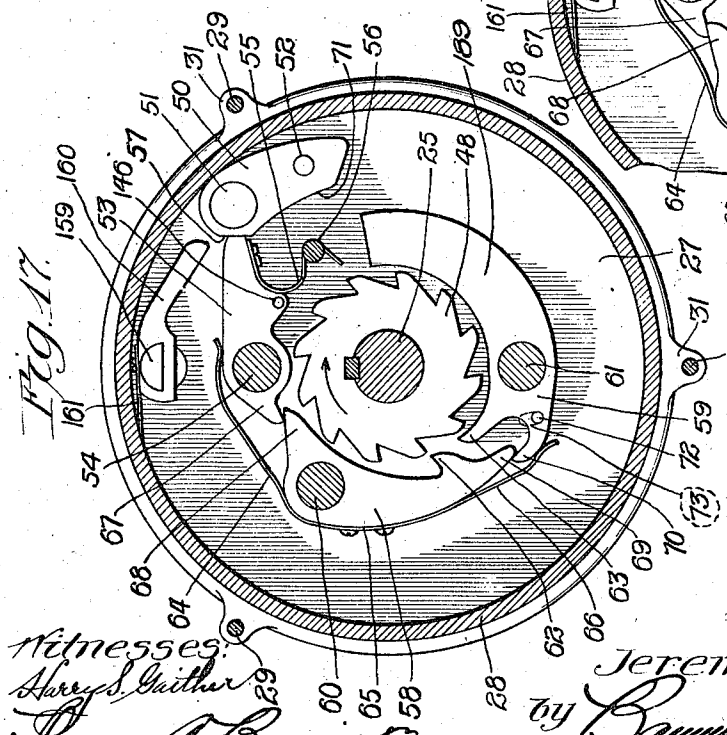


Fig. 17.



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6 SHEETS—SHEET 6.

Fig. 20.

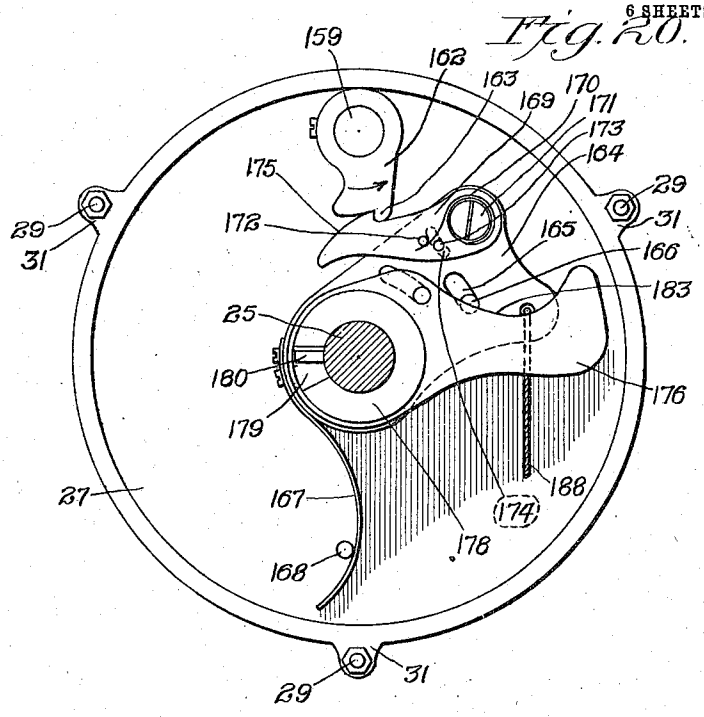
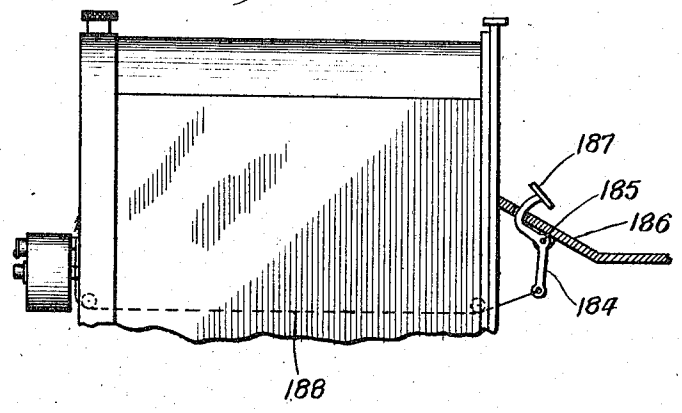


Fig. 21.



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UNITED STATES PATENT OFFICE.

JEREMIAH KELLER, OF CHICAGO, ILLINOIS.

STARTING MECHANISM FOR MOTORS.

1,135,694. Specification of Letters Patent. Patented Apr. 13, 1915.

Application filed November 14, 1912. Serial No. 731,457.

To all whom it may concern:

Be it known that I, JEREMIAH KELLER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Starting Mechanisms for Motors, of which the following is a specification.

The present invention relates to certain new and useful improvements in starting mechanisms for non-self-starting motors, such as gasolene engines, synchronous motors, etc. Such motors must be started by some external force in order to commence the cycle of operations through which they work. For example, to place a gasolene engine in operation, it is necessary to turn the same over once or twice, or at least a fraction of a revolution, before the motor will "pick up" or "take hold" and continue to operate under its own power.

Various forms of starting mechanism have been devised. The mechanism of the present invention relates to that general class in which a suitable amount of energy or work is stored up in the form of an elastic resiliency in a spring or the like, so that when the proper time arrives this work may be made available for turning over the motor shaft in the proper direction.

More particularly, the present invention relates to a mechanism of the above general class, in which mechanism the motor serves to rewind the spring after the motor has commenced to operate under its own power, so that the spring will be wound up and will remain in such condition preparatory to a subsequent starting operation.

Still more particularly the present invention relates to a mechanism of this general class in which the motor is turned over a predetermined number of times and thereafter rewinds the spring an equal number of times.

It has been found by experience that the amount of work necessary to start a motor of moderate size is such that the springs of a spring actuated starter must be fairly large, and that when fully wound up they must exert a very large twisting or turning force. If the springs be not worked to a relatively high percentage of their resiliency, the amount of space occupied by them will be undesirably large, and the starter will be unduly bulky and cumbersome. For this reason, the forces to be handled in a mechanism of this kind are very large, and the spaces available for the elements through which these forces must be transmitted are comparatively small, so that heretofore it has been a difficult matter to so design and relate the various parts that these forces can be economically and safely transmitted without imposing undue friction and wear on the various parts.

One of the main objects of this invention is to so relate the parts that the forces will be transmitted with the greatest possible directness from point to point, thereby making it possible to design each part in such way as to be best able to carry the loads imposed on it.

Another object of the invention is to so arrange the parts which must be tripped off during the starting operation that these parts will start off with a rolling action as contra-distinguished from a sliding one, thereby performing the starting operation with the greatest possible ease and quietness, and imposing the least possible amount of wear and tear on the several mechanisms.

Another object of the present invention is to provide a starter in which the spring, after being completely wound up, will be entirely disconnected from the frame or casing of the machine; this result being accomplished by automatically connecting the ends of the springs together and retaining them in such condition until the time arrives for the next starting operation. In this way any undue friction and strain, both on the casing and on the shaft itself, are eliminated, and the friction of operation is very materially reduced.

Another object of the present invention is to provide a starting mechanism of such construction that by a very simple process it can be so changed or set that it will turn the motor shaft over any predetermined number of times, and will be rewound an equal number of times during the rewinding operation. In this way a starting mechanism of great range of utility is provided for the reason that some motors require to be turned over a greater number of times than others in order to insure a satisfactory start.

In order to still further increase the range of usefulness of the mechanism of the present invention, the same is so constructed that one or more springs of standard size can be very easily and readily connected into it,

without the necessity of changing any other parts, thereby increasing the range of power of the starter according to the size and characteristics of the motor with which it is to be used. This feature of the invention will be readily appreciated when it is understood that the cost of manufacture is very largely affected by the number and size of parts which must be kept in stock for different machines.

Still another object of the present invention is to provide a starter of such construction that, as soon as the springs have been rewound, the starter shaft will be entirely disconnected from the other mechanisms of the starter, thereby allowing said shaft to rotate freely and unimpeded by the other mechanisms, so that during the entire interval while the motor is running under its own power the starter will not interfere with nor affect such running. At the same time that this result is accomplished, I accomplish another desirable result, in that I provide a mechanism of such construction that the spring can be wound by hand entirely independent of the motor shaft. This is a very desirable object for the reason that in case the motor should fail to "take hold" or "pick up" when turned over by the starter, so that the starter would not be rewound by the motor, it would become necessary to rewind the starter by hand.

In all present forms of starter construction with which I am familiar, the starter cannot be entirely disconnected from its shaft, and consequently when it becomes necessary to rewind the starter by hand the engine shaft must also be turned over, so that a double burden is thrown upon the operator, in that it is necessary for him to turn the engine over at the same time that he is storing energy in the starter springs. On the other hand, in the mechanism of the present construction the starter can be wound independently of the engine shaft, so that the only burden thrown upon the operator is that of rewinding the spring. This burden is still further reduced by the provision of a construction such that the rewinding can be effected through a reduction gearing.

A further object of the present invention is to provide a construction of mechanism such that the starter cannot be tripped off while the motor shaft is rotating. This feature of the invention obviates the possibility of tripping off the starter at unnecessary times, and thus serves as a safeguard for the protection of the starter against unnecessary wear and tear. Nevertheless, if desired, this feature of the invention may be left off, in which case the starter could be tripped off while the engine shaft was running.

Other objects and uses will appear from a detailed description of the invention, which consists in the features of construction and combination of parts hereinafter described and claimed.

In the drawings: Figure 1 shows a cross-section through the casing of the starter, but showing the internal mechanisms in elevation, one of the feet of the bridge plate being broken away for the purpose of revealing the mechanism behind it; Fig. 2 is a view similar to that of Fig. 1 with the exception that the internal mechanisms are shown in cross-section; Fig. 3 is a section taken on the line 3—3 of Fig. 1, looking in the direction of the arrows; Fig. 4 shows a detail of the central portion of Fig. 3, the pawl-latch being swung over into rewinding position; Fig. 5 shows a section taken on the line 5—5 of Fig. 1, looking in the direction of the arrows; Fig. 6 shows a detail section through the rewinding port with a rewinding crank in position; Fig. 7 is a section taken on the line 7—7 of Fig. 1, looking in the direction of the arrows; Fig. 8 is a detail of the interlocking latch and hook of Fig. 7, showing how the interlocking latch clears the hook during the rewind; Fig. 9 is a view similar to Fig. 7 at the instant prior to the latching of the hook; Fig. 10 is a detail view similar to Fig. 9 at the instant that the hook is locked; Fig. 11 is a detail of a portion of the back end of the spring barrel, the driving ratchet being shown in dotted lines; Fig. 12 is a detail of the flange plate of the spring barrel, showing the hook latched in position and showing the tooth which engages the star wheel, lying above the hook; Fig. 13 is an enlarged detail taken on the line 13—13 of Fig. 7, looking in the direction of the arrows; Fig. 14 is a detail taken on the line 14—14 of Fig. 11, looking in the direction of the arrows; Fig. 15 is a section taken on the line 15—15 of Fig. 1, looking in the direction of the arrows; Fig. 16 is a view looking at the interior of the back head of the casing, showing one form of a ratchet, abutment, trip-off finger, and driving pawl; Fig. 17 is a section taken on the line 17—17 of Fig. 1, looking in the direction of the arrows; Fig. 18 is a view similar to Fig. 17, showing the finger tripped off and one pawl locked in on the driving ratchet; Fig. 19 is a view similar to Fig. 18 with the exception that the other pawl is locked in on the driving ratchet; Fig. 20 is a back view of the casing showing one form of trip-off mechanism; and Fig. 21 is a diagram showing one manner of attaching the starter to an automobile engine housing.

Referring to the several figures, the starter shaft is designated by the numeral 25. This shaft may be a continuation of the motor shaft, or it may be secured or geared to the motor shaft in any suitable

manner for transmitting forces to and receiving them from the motor shaft. The casing comprises the front head 26 and the back head 27, which heads are fitted on to a cylindrical casing 28 and are held together in any suitable way, as, for example, by bolts 29 extending through ears 30 and 31 of the front and back heads respectively. Manifestly, any other desirable form of attachment may be used. However, it is preferred that the casing should be oil-tight as at times it would be desirable to have the starter operate in oil.

The shaft finds bearings at the points 32 and 33 in the front and back heads, and extends clear through the starter from front to rear. The shaft preferably terminates in a head 34 having the cam surfaces 35 of the usual form, so that a crank or the like can be directly applied to the shaft for the purpose of turning it over under certain circumstances. A cap 36 normally closes in the front end of the shaft, so as to thoroughly protect the same from the ingress of dust and the like.

A spring barrel 37 is mounted for free rotation on the shaft within the casing. This spring barrel is preferably mounted on a bushing 38, which bushing may be of any suitable bearing metal. An advantage following from the use of this bushing will presently appear. The spring barrel is provided with a barrel hub 39 mounted on the bushing, and with the outside inclosing flange or barrel 40 to which the outer ends of the power spring and certain other mechanisms are secured. The barrel hub 39 terminates at its front end in clutch faces 41 which engage corresponding clutch faces 42 of a flange hub 43 which latter carries an outwardly extending flange 44 on which certain mechanisms are mounted. It will be observed from the foregoing that the flange 44 is rigidly secured to the inclosing flange or barrel 40, so that said flange 44 must rotate with the spring barrel, and so that the stresses or forces exerted by the outer ends of the springs may be transmitted to the flange 44 under certain circumstances.

A flange sleeve 45 is mounted for rotation on the hubs 39 and 43, said flange sleeve 45 terminating at its front end in the outwardly extending flange 46 which lies immediately behind the flange 44 and projects somewhat behind the periphery of the same. A sleeve 47 is mounted on the flange sleeve 45, said sleeve being provided with one or more perforations to accommodate the inner ends of the springs as is well shown in Fig. 15. From the foregoing, it will be seen that the inner ends of the springs are secured to the sleeve 47 and transmit their stresses directly to and from it. By keying together the sleeve 47 and the flange sleeve 45, these two will be so joined together that the stresses from the inner ends of the springs will be directly transmitted through the flange sleeve 45 to the flange 46. This keying function may be accomplished by the inner ends of the springs themselves as is well shown in Fig. 15. As therein shown, the inner end of each spring is doubled one or more times, so that, when said ends have been extended through the perforations of the sleeve 47, the flange sleeve 45 may be slipped into place, said flange sleeve being provided with keyways for the accommodation of the doubled-over ends of the several springs. Manifestly, it will be very difficult to attach the inner end of each spring directly to the flange sleeve 45, for the reason that said sleeve would have to be slid out along the barrel hub 39 and flange sleeve 43, in order to provide a sufficient space between the flanges 46 and 40 to permit of the insertion of the springs between said flanges. Sliding the flange sleeve 45 out in this manner would make it necessary to distort the springs to such an extent as to make the attaching of the springs a very difficult matter. However, by means of the present or an equivalent construction, the springs can have their inner ends slipped through the sleeve 47 without the necessity of distorting them materially, and before the flange sleeve 45 with its flange 46 is set into place. Then said flange sleeve 45 may be put in place to close up the spring barrel, which operation will simultaneously key the ends of the springs to the flange sleeve 45.

In order to cause a mechanism of this kind to function properly, means must be provided for connecting one end of each spring to the shaft while the other end of the spring is held stationary during the starting operation, and for reversing said connections during the rewind. Then after the springs have been rewound, means must be provided for securing both ends of the springs to some common element, such as the casing, or for joining them together, and maintaining them in such condition until the time arrives for tripping off to perform a new starting operation. To accomplish these several results, I provide the ratchets 48 and 49 which are keyed to the rear and front ends of the shaft respectively. The teeth of said ratchets are set to drive in opposite directions, so that one of said ratchets can be used to drive the shaft during the starting operation, the other one coming into play for the rewind when the shaft is being driven under the power of the engine. In the present instance, the ratchet 48 is used for the starting operation and will be called the driving ratchet, while the ratchet 49 is used for the rewind and will be called the winding ratchet.

In Fig. 16, I have shown one form of construction for connecting the outer end of

the spring to the driving ratchet for starting purposes, but a preferred form of construction is shown in Figs. 17, 18, and 19. I will first describe the latter construction. The power springs are set into the mechanism illustrated in the drawings in such way as to tend to turn the shaft and spring barrel over in the direction illustrated by the arrows. An abutment 50 is carried by the rear head, said abutment being preferably slipped into place on a pair of pins 51 and 52 which are secured to the rear head. On account of the small clearance provided, this abutment will be securely held in place in this manner, but in case of its wear or injury it can be easily removed and another one inserted in its place. The rear end of the spring barrel carries a stop finger 53 which is pivoted on the stud 54 of the spring barrel, so that said finger can be swung down into the position shown in Figs. 18 and 19. However, a stiff spring 55 having one end secured to the finger and the other end pressing against a stud 56 on the spring barrel, tends at all times to hold the finger up into the position shown in Fig. 17, in which position the finger will rest squarely against the arresting face 57 of the abutment at a point substantially on the tangent line extending through the stud 54 and drawn to a circle about the shaft as a center. By allowing the finger 53 to normally stand in such position, it will receive a direct thrust and firmly lock the spring barrel, and consequently the outer ends of the power springs against rotation in the direction of their tendency.

One or more pawls are pivotally mounted on the end of the spring barrel in position to hook to the driving ratchet when the finger 53 is forced down away from the arresting face 57. In the present case I have shown two pawls for this purpose, the same being carried by the arms 58 and 59. Said arms are carried by the studs 60 and 61 of the spring barrel, respectively. These arms have their pawls 62 and 63 set apart a distance approximately equal to one-half a tooth of the driving ratchet. In this manner one or the other of these pawls will engage a tooth of the driving ratchet depending upon the exact position of the shaft at the instant when the mechanism is tripped off. A spring 64 secured to the arm 58 at the point 65 bears against some other element in such way as to tend at all times to throw said arm in toward the ratchet for the purpose of causing its pawl to engage the same. In like manner a spring 66 tends to throw the arm 59 in toward the ratchet at all times. A lug 67 on the finger 53 engages a similar lug 68 on the arm 58, so that, as long as the finger 53 is held out into the position shown in Fig. 17, the arm 58 will be disengaged from the ratchet. In like manner a lug 69 on the arm 58 engages a lug 70 on the arm 59, so that when the arm 58 is forced out away from the ratchet, the arm 59 will be also forced out. By means of this construction, both of the arms 58 and 59 will be held away from the ratchet as long as the finger 53 stands in its normal position, so as to allow the ratchet to rotate freely with the shaft. But the instant the finger 53 is forced down, as shown in Figs. 18 and 19, either the arm 58 or the arm 59 will engage the ratchet depending upon the exact position of the teeth of the latter at the instant of tripping off.

Although the springs 64 and 66 tend, as above explained, to force the arms 58 and 59 in toward the ratchet, and thus to depress the finger 53 into the position shown in Figs. 18 and 19, still the spring 55 is purposely made of such stiffness as compared to the springs 64 and 66 that it will overcome the tendency of said last mentioned springs, and will force the finger 53 out into the position shown in Fig. 17, thus disengaging both of the pawls, and holding them in disengaged position until some external force is applied to the finger 53 for the purpose of tripping off.

On account of the very large force that is exerted by the power springs when they are brought into play, either the one or the other of the arms 58 and 59 will grip the ratchet and be held to the same even against the restoring tendency of the spring 55. Therefore, the finger 53 will be held in the position shown in Figs. 18 and 19, until the power springs have completely unwound, or if the mechanisms are not so proportioned as to allow a complete unwinding of the power springs, then until some other force is brought into play to allow the motor to drive its shaft and ratchet ahead of the pawls. Thereupon they will immediately disengage from the ratchet and swing out into the position shown in Fig. 17, thus simultaneously allowing the finger 53 to swing out into such position that said finger will strike the arresting face 57 the next time it comes around, thus again locking the spring barrel and the outer ends of the power springs to the casing.

The above described mechanisms should be so arranged that slightly before the finger 53 leaves the arresting surface 57, the pawls will be resting against the ratchet under the force of their respective springs, so that the instant the finger 53 trips off and the spring barrel commences to rotate under the force of the power springs, one or the other of such pawls will be in position to engage a tooth of the ratchet, and thus lock the spring barrel to the shaft, with a minimum amount of free movement on the part of the spring barrel. This is desirable for the reason that, on account

of the large forces which are acting in the power springs, a comparatively small amount of free movement would allow the spring barrel to attain a high speed, so that a very large impact would be produced between the teeth of the pawls and the ratchet. For this reason, I prefer to use two or more pawls arranged in such a manner that one or the other of them will be in position to engage a tooth of the driving ratchet the instant the spring barrel is tripped off, it being manifest that, by multiplication of the pawls in this manner, the amount of free movement of the spring barrel may be decreased. However, under any circumstances, the maximum movement that could occur with a single pawl would be the length of one tooth of the driving ratchet.

It is desired to hold the finger 53 down a sufficient length of time, and during a sufficient amount of travel of the spring barrel, to insure that one or the other of the pawls will engage the ratchet. For this purpose, I have provided the surface 71 on the inner side of the abutment 50, which surface is preferably formed on the arc of a circle drawn to the shaft as a center. With this arrangement, the finger 53 will be held depressed, and consequently the pawls will be held up against the ratchet to engage one or the other of its teeth during a certain amount of travel of the spring barrel. The length of the surface 71 can be proportioned according to the requirements, but ordinarily an extremely short surface will be sufficient. However, in case the finger 53 should be tripped off while the shaft was rotating rapidly in the direction shown by the arrow, a certain amount of extra movement of the spring barrel would be necessary in order to allow the same to speed up under the influence of the power springs, and overtake the ratchet in its rotation. For this reason, the surface 71 can be made any length desired, and in the drawings I have shown it as being of a length equal to approximately two teeth of the ratchet.

For the purpose of limiting the amount of throw of the pawls and the finger 53, I have provided the pin 72 on the arm 59, said pin riding in the slot 73 of the spring barrel, and having its movement limited by such slot.

It will be noted that in the above described construction, two separate elements are provided for engaging the abutment and for hooking in on the ratchet. By providing two separate elements in this manner, I can so associate them that one of them will be in position to engage the ratchet prior to the actual instant of tripping off. By so doing, assurance is had that the spring barrel will not be allowed to run free for a considerable interval between the tripping off and the engaging of the ratchet. In Fig. 16, I have shown an alternative construction in which one and the same pawl performs the two functions of engaging the abutment or the ratchet, depending upon the position of said pawl. This is the pawl 74. It is pivoted on the stud 75 carried by the spring barrel, and it is provided with a spring 76 engaging the pin 77 of the spring barrel, which spring normally holds the pawl out in the position shown in Fig. 16, where it will engage the abutment 78. This abutment is swingingly mounted on a stud 79 of the back head, a spring 80 tending to force the abutment into the position shown in Fig. 16. A pin 81 on the abutment works in a slot 82 of the back head and serves to limit the swinging motion of the abutment. A pin 83 on the pawl 74 rides in a slot 84 of the back end of the spring barrel to limit the movement of the pawl. The surface 85 of the abutment is formed in such a manner that, when the pawl is tripped off from the abutment, it will ride along said surface 85, and on account of the spring tension exerted by the spring 80, the abutment will tend to push the pawl in toward the ratchet and cause the tooth 86 of the pawl to hook into one of the teeth of the ratchet. It will be seen that when this construction is used, a considerable movement of the spring barrel is liable to take place before the pawl will be forced in by the abutment surface 85 a sufficient distance to cause the tooth 86 to engage the ratchet. Therefore, this mechanism might be subject to the objection that a considerable impact and jarring would take place at the instant of tripping off. On account of the large forces being exerted by the power springs, this free movement might in time injure the parts or at any rate cause their rapid wear. However, there might be circumstances in which this mechanism would be desirable to use.

A bridge plate 87 is carried by the flange 46, and is forced to rotate with the same, so that said bridge plate is adapted to receive forces from and to transmit them to the inner ends of the power springs. As is well shown in several figures, this bridge plate is supported by a number of feet 88 which in turn are carried by the flange. As is well shown in Figs. 3, 5, 7, and 9, the flange 46 is provided around its periphery with a number of equally spaced holes 89, which holes are suitably positioned to receive the securing means from several feet of the bridge plate. For the purpose of making adjustments, the bridge plate may be set at different positions on the flange, depending upon the stiffness with which the power springs are to be wound, and upon other factors. The bridge plate is so located that it is unnecessary to press the same up toward

the flange, and consequently the only forces which have to be transmitted through the feet 88 are forces for the purpose of causing the bridge plate to rotate with the flange 46. Therefore, as a simple means of attachment, I provide the pins 90 on the several feet, said pins having their inner ends slightly enlarged, but of such size that they may be slipped through the perforated holes of the flange. These pins are rigidly secured to the feet, so that, when it is desired to set the bridge plate into any given position, the several pins 90 are forced through the corresponding holes of the flange where they will remain. From the above, it will be seen that this bridge plate is connected to the inner ends of the power springs, and consequently rotates with them and receives and transmits the several forces to and from them. During the starting operation, the inner ends of the power springs are to be held stationary while the spring barrel is allowed to rotate, having been previously connected to the shaft through the medium of the driving ratchet 48, as hereinbefore explained, while on the rewinding operation the inner ends of the power springs are to be rotated, the spring barrel being held stationary, as also previously explained. To accomplish these results, I provide a pawl latch 91, the same being pivoted to the bridge plate by being mounted on the stud 92 thereof, so that the said pawl-latch can swing to one side or to the other through a predetermined angle. This pawl-latch has the slot 93 through which the shaft extends, so that the swinging of the latch can take place without interference from the shaft. This pawl-latch carries a winding pawl 94, which winding pawl can be thrown to stand in position to engage an abutment 95 or to engage one of the teeth of the winding ratchet 49, depending upon the position of the pawl latch.

During the starting operation, the pawl-latch stands in the position shown in Figs. 3 and 5 where its winding pawl engages the abutment, but during the rewinding operation said latch stands in the position shown in Fig. 4, where it will engage the winding ratchet. When in this last mentioned position, the winding ratchet 49 by engaging the winding pawl 94 will cause the pawl-latch, bridge plate, and inner ends of the power springs to rotate, provided the motor be driven under its own power at such time, thus rewinding the power springs. A spring 96 secured to the pawl-latch engages the pin 97 of the bridge plate in such way that the pawl-latch is normally thrown into the position shown in Figs. 3 and 5, in which position its winding pawl 94 stands ready to engage the abutment 95. This abutment is swingingly mounted on the casing at the point 98, so that, under certain circumstances, the bridge plate can be rotated in the direction of the arrows for the purpose of winding the power springs even while the pawl latch stands in the position shown in Figs. 3 and 5. Under such conditions, it will, of course, be necessary for the winding pawl 94 to pass beneath the abutment 95.

Means must be provided for controlling the position of the pawl-latch, so as to either hold the inner ends of the power springs stationary while driving the shaft for starting purposes or to rotate said inner ends for the rewind. Owing to the presence of the spring 96, there is a normal tendency for the pawl latch to stand in the position shown in Figs. 3 and 5, which might be the starting position, and consequently said pawl-latch must be thrown over at the end of the starting operation so as to cause the winding pawl 94 to be engaged by one of the teeth of the winding ratchet for the rewind. For this purpose, I have adapted a star wheel or equivalent construction, whereby after the spring barrel has made a predetermined number of revolutions during the starting operation, the pawl-latch will be switched over to rewind the power springs an equal number of revolutions. For this purpose, a star wheel 99, having the desired number of teeth is rotatably mounted on a stud 100 carried by the flange 44, so that said stud must travel in a circle about the shaft as a center as long as the spring barrel is rotating during the starting operation. A sleeve 101 is keyed to the bridge plate and extends inwardly therefrom, said sleeve being forced to rotate or stand idle according to the condition of the bridge plate. This sleeve carries a tooth 102 which extends out into position to engage the notches of the star wheel, so that the latter will be rotated on the stud 98 in the well known manner.

The pawl-latch is provided with a downwardly projecting finger 103 which works in a slot 104 of the bridge plate, so that by operating on said finger the pawl latch will be swung to the one position or the other. This finger extends through the slot 104 a sufficient distance to be engaged at times by a lug 105 of the star wheel, so that under certain conditions the star wheel lug will engage the finger 103, to force the same to one side, thereby swinging the pawl-latch and reversing the position of the winding pawl 94.

The relationship of the star wheel, tooth 102, and finger 103, is well shown in Fig. 12. The finger 103 normally stands at the right hand side of the lug 105 of the star wheel, as therein illustrated, and the tooth 102 stands at a position somewhat above the star wheel—in the arrangement shown at a point diametrically above the same. As soon as the spring barrel is tripped off in the manner hereinbefore described, it commences to

rotate and causes the flange 44 to rotate with it. This causes the stud 100 to travel around in the direction shown by the arrow of Fig. 12, and as the star wheel passes the tooth 102, it will be notched over thereby. Then as it comes past the finger 103, its lug 105 will clear such finger, and will continue to clear such finger each time it passes the same until a predetermined number of revolutions about the shaft have been completed, whereupon the next time the star wheel with its lug 105 comes around, it will strike the finger 103 on the opposite side from that shown in Fig. 12, and will drive such finger over to the left. This will swing the pawl-latch from the position shown in Fig. 3 to that shown in Fig. 4, and the winding pawl 94 will be immediately carried over into position to hook in on a tooth of the winding ratchet 49. The instant that this takes place, assuming that the motor is now driving the shaft under its own power, the winding ratchet will hook in against the winding pawl 94 and drive the pawl latch, bridge plate, and inner ends of the power springs over in the direction of the arrows to rewind said springs. In the mean time, of course, the spring barrel will have been locked to the casing in the manner previously described.

By reason of the fact that the sleeve 101 with its tooth 102 is keyed to the bridge plate, said sleeve will now rotate and carry its tooth 102 around with it, while the flange 44 with its stud 100 will remain stationary. Therefore, as the bridge plate rotates during the rewinding operation, the tooth 102 will engage the star wheel in such a manner as to rotate the same over in the opposite direction from that in which it previously rotated, with the consequence that after the bridge plate has completed a predetermined number of rotations, the lug of the star wheel will stand in the position shown in Fig. 12, so that the next time the bridge plate with the pawl latch comes around, the finger 103 will strike against the lug 105 and have its movement arrested thereby, so that any continued rotation of the bridge plate will simply serve to swing the pawl latch on its stud 92, thus freeing the winding pawl 94 from the winding ratchet 49, and thus allowing the spring 96 to swing the pawl-latch clear out, so that by a slight backward movement the winding pawl 94 will run into and be arrested by the abutment 95. Thereupon, the power springs will be completely rewound, and their inner ends will be disconnected from the shaft and hooked in behind the stationary abutment.

From the above, it will be seen that the number of revolutions which the spring barrel will make, both unwinding and rewinding, depends entirely on the characteristics of the star wheel. Therefore, the capacity of the starter measured in revolutions of its shaft may be readily changed by changing the characteristics of the star wheel.

It is evident that one or more independent power springs may be used as desired. Under ordinary circumstances, however, it would be preferable to use a number of independent power springs for the purpose of storing a certain total amount of work for a number of reasons. In the first place, on account of the very large forces which must be handled in a machine of this kind in order to store up a suitable amount of work within a reasonably small space, it would be very difficult to handle a single power spring of sufficient size and contour to store this work. On the other hand, a number of smaller power springs can be handled independently with great ease. Furthermore, where smaller power springs are used the size of the spring barrel and other parts can be standardized, and then one, two, three, or more power springs can be connected into the spring barrel depending upon the service to which the starter is to be put and the amount of work which it must store. In other words, by using small units their number can be adjusted to the particular requirements of the individual starter.

There is still another reason why it is desirable to use two or more power springs. As shown particularly in Fig. 15, these power springs are spirals having their inner ends connected to the flange sleeve 45 and their outer ends connected to the periphery of the spring barrel. This being the case each power spring has a tendency to exert a considerable thrust on the spring barrel, to draw the same down against the shaft and thus create a considerable friction between the spring barrel and the shaft. On the other hand, where a number of individual power springs are used they can have their points of attachment to the flange sleeve 45 and to the spring barrel stepped or offset in such a manner that these side forces will balance each other, so that the result will be zero as far as any thrust on the shaft itself is concerned.

It was previously explained how the inner ends of the power springs can be easily attached to the sleeve 47 and keyed to the flange sleeve 45. This construction is shown particularly in Fig. 15 where the inner end 106 of the spring 107 is doubled over one or more times to provide an enlargement which will seat into a keyway of the flange sleeve 45.

The outer end of each power spring is carried out through a hole 108 and laid down on out through a hole 108 and laid down on the outside of the spring barrel for a short distance, being secured thereto in any suitable manner, as by means of a screw 109. In order to separate the individual power springs from each other, plates 110 and 111

are set between them. These plates prevent the convolutions of the several springs from hooking together or interfering during the winding and unwinding operations.

A study of the machine, as thus far described, will show that, when it is tripped off at the back end, the outer ends of the power springs being secured to the spring barrel, they are thereby connected to the driving ratchet 48, while the inner ends of the power springs being connected to the bridge plate are held against rotation by the engagement of the winding pawl 94 with the abutment 95. These conditions are maintained during a predetermined number of revolutions depending upon the characteristics of the star wheel, so that the shaft is turned over the desired number of times. In the meantime, the prime mover, for example, the gasolene motor, will "pick up" or "take hold", so that when such predetermined number of revolutions have been completed, the motor will be running under its own power and will be able to rewind the starter. Therefore, when the predetermined number of revolutions have been completed, and the pawl latch 91 is thrown over to carry the winding pawl 94 down into engagement with the winding ratchet 49 the motor will commence to drive the inner ends of the power springs with it. Unless the pawls at the back end of the machine have disengaged from the driving ratchet 48, and unless the spring barrel is locked against rotation, this driving of the inner ends of the power springs by the motor will not effect any rewind, as under such circumstances both ends of the power springs would be simultaneously connected to the shaft. Therefore, means should be provided for insuring that the pawls on the spring barrel will disengage from the driving ratchet, and that the spring barrel itself will be locked against rotation. These results should take place before the pawl-latch is swung over.

In the construction illustrated in the drawings, I have provided a brake mechanism on the spring barrel which is automatically brought into play at the proper instant, so as to arrest the movement of the spring barrel a short interval before the pawl latch is swung over, thereby allowing the motor to drive the shaft and the driving ratchet 48 ahead of the pawls on the spring barrel. The instant that the motor starts to run ahead of the spring barrel and driving ratchet the pawls will disengage from the latter, and the finger 53 will swing out under the influence of the spring 55, thereby positively arresting the movement of the spring barrel and locking the same to the casing.

The brake mechanism shown in the drawing comprises a series of shoes secured to the outer surface of the spring barrel and adapted to be forced out a slight amount at the proper time to engage cam blocks secured to the casing of the machine. I have taken advantage of certain characteristics of the spiral spring for the purpose of bringing these brakes into play at the proper time. Corresponding to each of the spiral power springs, there is provided a brake spring 112 secured to the outer face of the spring barrel by a screw 113 and normally lying flat against the surface of the spring barrel immediately in line with the corresponding power spring. Each of these brake springs 112 carries a brake shoe 114 which normally clears a corresponding cam stop block 115 carried by the casing of the machine, said stop block having the braking surface 116 of the desired inclination. Under ordinary circumstances, the spring barrel can rotate freely, the brake shoes clearing the several stop blocks 115, but when the proper time arrives the several brakes will be forced out, so that, as the spring barrel completes its rotation, the brake shoes will ride on the surfaces 116 and thus be arrested, or at any rate retarded sufficiently to permit the shaft and driving ratchet to run ahead of the spring barrel, so that the pawls will disengage from the driving ratchet and allow the finger 53 to swing out and lock the spring barrel against further rotation. The rotation of the spring barrel is in the direction indicated by the arrow in Fig. 15.

It is a well known fact that, during the process of unwinding a spiral spring, the outside convolutions travel more rapidly than those farther in toward its inner end. For example, in the present case when the inner ends of the power springs are held stationary during the starting operation, the spring barrel will travel more rapidly than any particular convolution closer in toward the shaft. For this reason, the spring barrel will turn more rapidly than the outer convolutions of the power spring, so that a slight relative movement will take place between points on such convolutions and the spring barrel. For example, in the present case a block 117 secured to a power spring approximately one turn from the outer point of support of the same, and slightly in advance of the brake shoe 114, will be approached by said brake shoe as the spring unwinds, until finally when the spring is practically unwound the brake shoe 114 will lie at a point practically above the block 117. At the same time that the power spring is unwound, its various convolutions are expanding out toward the periphery of the spring barrel, so that when the spring is completely unwound, or at any rate unwound as far as will be permitted by the spring barrel, the outer convolution will exert a considerable pressure against the spring barrel in an effort to expand still further.

I take advantage of both of the above described characteristics, namely, the expanding force of the power springs, and the tendency for the spring barrel to approach any given point on a convolution of a power spring during the unwinding, for the purpose of actuating the spring barrel brakes and insuring an exact timing of such actuation. To this end, I attach a block 118 to the inner face of each brake spring 112, said blocks preferably being underneath the brake shoes 114. These blocks 118 extend down through holes 119 to points just inside of the spring barrel where they can be engaged by the blocks 117 on the outer convolutions of the power springs when the time arrives. Preferably the adjacent faces of the blocks 117 and 118 are beveled, as shown, so that they will not lock when they come together.

With the above described arrangement, the operation is as follows, it being understood that Fig. 15 shows the parts in the position which they occupy near the end of the unwinding process; as the unwinding continues, the outer convolution of each power spring will commence to lay out against the periphery of the spring barrel, so that the blocks 117 will be forced out with a considerable pressure against the spring barrel. However, said blocks will not be in registry with the holes 119, and consequently will not engage the brake shoe blocks 118. As the unwinding continues, the blocks 118 and holes 119 carried by the spring barrel will gain upon the blocks 117 until finally at the proper instant said blocks 117 will engage the blocks 118, and the forward corners of the blocks 117 will clear the edges of the holes 119 allowing the blocks to snap into said holes and suddenly exert the maximum pressure against the blocks 118. The instant this takes place, the brake springs 112 will be forced outward, so that the brake shoes will engage the corresponding blocks 115 as the spring barrel comes around in its rotation.

On account of the very large force exerted by each of the brake shoes in its engagement with the corresponding stop blocks, a very large side thrust would be exerted upon the shaft if said thrusts were not balanced. However, in the present case, by reason of the fact that a number of comparatively small power springs are used, the same being set at different points of angularity with respect to the spring barrel, the amount of side thrust exerted by the brake shoes is balanced all of the brake shoes coming into action at the same time, so that the shaft is relieved of all side thrust, and a uniform braking effort is produced around the entire periphery of the spring barrel.

It is found that the above described mechanism or its equivalent works with extreme accuracy, and that the spring barrel will invariably be arrested in its movement at the proper time to allow the pawls to disengage from the driving ratchet, and to allow the finger 53 to move out and engage the stationary arresting surface 57, for the purpose of locking the spring barrel against further rotation. As a matter of fact the braking arrangement above described can be made to operate in such a way that the spring barrel will be completely arrested in its movement and held by the brakes before the finger 53 engages the arresting surface 57, but, of course, as soon as the rewinding commences, the convolutions of the power springs will move in toward the shaft, so that the expanding forces of the blocks 117 will be removed, and the brakes will be allowed to seat in against the spring barrel, thus removing the braking effort and allowing the spring barrel to creep up until the finger 53 engages the arresting surface 57.

It was previously explained that, as the rewinding operation is completed, the pawl-latch will travel around with the bridge plate until the winding pawl 94 stands at a point just in advance of the abutment 95, whereupon the pawl-latch will be swung out into its initial position, thereby disengaging the winding pawl 94 from the winding ratchet, and allowing said winding pawl to run back against the abutment 95. In order to accomplish these results, it is evident that the winding pawl 94 must stand a certain distance in advance of the abutment 95 before it disengages from the winding ratchet. Consequently, as it disengages from the winding ratchet, it will drop back against the abutment 95 with a force and impetus derived from the entire force exerted by all of the power springs. Under these circumstances, a considerable blow would be delivered when the winding pawl 94 engaged the abutment 95, and the parts might be injured. In order to reduce this blow as much as possible, a spring 120 may be secured to the end of the abutment 95 which spring will yield a slight amount to take up the impact delivered by the winding pawl 94.

It has been previously stated that one of the objects of the present invention was to provide a starter of such construction that the same can be wound independently of the motor shaft. It will be noted that, during the rewinding process, the rewinding force is delivered to the bridge plate by means of the pawl-latch. The bridge plate being connected to the inner ends of the power springs it is evident that any force which will serve to turn the bridge plate over will effect the rewinding. I take advantage of this fact by forming the teeth 121 on the periphery of the bridge plate, said teeth being in the po-

sition to be engaged by the inner end 122 of a rewinding crank 123 which may be inserted through the port 125, which port is normally closed by means of a cap 124 pivoted at the point 126. It will be noted that, in rewinding in this manner, the pawl-latch 91 is held in the position indicated in Figs. 3 and 5 by means of the spring 96. Under these circumstances, the winding pawl 94 must pass beneath the abutment 95 each time a revolution of the bridge plate is effected. For this reason, I have pivoted the abutment 95 at the point 98, as previously stated, so that when rewinding by hand in the manner just described the winding pawl 94 can pass beneath said abutment, the latter dropping back into place as each revolution is completed. A heel 127 on the abutment 95 limits the amount of drop of the same, so that it normally rests slightly above the rewinding ratchet. This obviates the possibility of friction and wear which would be incurred if the abutment 95 rested directly on the teeth of the ratchet.

In order to obviate the possibility of the bridge plate dropping back under the influence of the power springs when being rewound by hand, I have provided the dog 128. This is also pivoted on the point 98, and has teeth which engage the teeth of the bridge plate, so that the latter cannot drop backward. Of course, under no circumstances could the bridge plate drop back a distance greater than that necessary to bring the winding pawl 94 up against the abutment 95, but if this distance were a considerable portion of revolution a very heavy blow would be delivered which might injure or even destroy some of the parts. This danger is obviated by the provision of the dog 128.

With the mechanisms thus far described, it will be seen that when the power springs have been completely wound up, so that the winding pawl 94 has moved into engagement with the abutment 95, the finger 53 in the meantime engaging the abutment 50, the entire force of the power springs wound to their maximum capacity is exerted on these abutments. By reason of the fact that these two abutments are a considerable distance apart measured along the length of a shaft, it will be seen that a considerable twisting force is produced which tends to throw the axis of the spring barrel out of line from the axis of the shaft. This force is so very considerable that a large friction is thus produced. It will be understood that, after the motor has completed a rewinding operation, the spring barrel stands entirely disconnected from the shaft, which latter continues to rotate within the bushing 38. Therefore, as long as the aforementioned friction exists, there would be a wastage of energy at this point, and a heating would probably take place which might in time become a serious matter. In order to overcome the above objections, I have provided means for locking the two ends of the power springs together, independently of the inclosing casing, so that the abutments on the casing are only brought into play for any considerable amount of work during the processes of starting the motor and of rewinding the starter, after which the casing abutments are not relied upon to withstand the forces exerted by the power springs.

It will be noted that the flange 44 is connected to the spring barrel to which are connected the outer ends of the power springs, while the flange 46 is connected to the inner ends of the power springs. This being the case, any mechanism which will lock these two flanges together will effect the desired result of taking up the forces exerted by the power springs without the necessity of transmitting said forces into the casing.

In Figs. 7 to 11 inclusive, I have shown the preferred form of mechanism for locking these two flanges together after the power springs have been completely wound, and for tripping off at this point, as well as at the rear end of the spring barrel when it is desired to start the motor. For this purpose, an interlocking latch 129 is pivoted on a pin 130 carried by the flange 44, while an interlocking hook 131 is pivoted on a pin 132 secured to the flange 46. When the power springs have been wound up, there is a tendency for the two flanges to rotate in the directions shown by the arrows of Fig. 7, so that, if the head of the interlocking hook be allowed to stand in the position shown in said figure against the interlocking latch, the two flanges will be locked together. A spring 133 has its inner end extended through a slot 134 of the pin 130, and is wrapped a number of times around said pin, and then engages a pin 135 on the interlocking latch. This spring has a tendency to swing the interlocking latch over toward the right in Fig. 7. A spring 136 tends to hold the interlocking hook down in the position shown in Fig. 7. When the power springs have been wound up and the flanges are to be locked together, the interlocking hook stands with its head against a flattened portion 137 of the interlocking latch, and at a point almost directly in line between the points 130 and 132. It is preferred that the point of contact be slightly above the line between said pins, so that there is a constant tendency for the interlocking latch 129 to swing over, for the purpose of tripping off the interlocking hook even in addition to the tendency of the spring 133. Therefore, unless some other mechanism were provided, the interlocking latch would swing over toward the right in Fig. 7, thus allowing the said latch to pass underneath the interlocking hook 131 and allowing the flange 44 to rotate, for the purpose

of unwinding the power springs. For the purpose of resisting such tendency, I have provided a hook spring 138 which is secured to the flange 44 by means of the screw 139. This hook spring has the hooking edge 140, best shown in Fig. 13, and normally engages the lower end of the interlocking latch to hold the same in the position shown in Fig. 7. Manifestly, means must be provided for unhooking this hook spring when it is desired to trip off the mechanism for starting purposes. In the construction illustrated, I have effected a connection between the tripping finger 53 and the hook spring 138. It is desired to force said hook spring away from the flange plate 44 at the same time that the finger 53 is depressed. For this reason, I carry a rod 141 through the barrel hub 39 from one end thereof to the other, the front end of said rod resting beneath the hook spring, and the other end lying in a recess 142 at the back end of the spring barrel. Said end also is enlarged to provide the button 143.

As shown particularly in Figs. 11 and 14, a sliding bar 144 is mounted to slide within the recess 142, said bar having its lower end beveled as at 145, so that when forced down toward the shaft it will simultaneously force the rod 141 inward, thus causing the spring hook to be raised for the purpose of unhooking the interlocking latch 129, and allowing the same to trip off. I provide a pin 146 on the finger 53, said pin engaging a slot 147 of the bar 144, so that, as the finger 53 is depressed, the bar 144 will also be actuated to accomplish the desired result. The lower end of the bar 144 rests against the inner face of the drive ratchet 48, while the upper end of said bar rests against the inner face of the finger 53, and thus said bar is forced to travel up and down without working out of the slot 142. The parts should be so proportioned that the finger 53 will disengage from the arresting face 57 slightly before the spring hook disengages from the interlocking latch 129, so that the instant such disengagement takes place the spring barrel will be free to rotate under the influence of the power springs, and thus cause the arms 58 and 59 to take hold of the drive ratchet 48. By so proportioning the parts, any wear and tear on the corner of the finger 53 will be obviated, which wear and tear is very considerable and will be appreciated when it is remembered that a force of several hundred pounds on the power springs is being dealt with. The construction and arrangement of the interlocking latch and the interlocking hook are such, however, that they are well adapted to trip off under such pressure, because the tripping which takes place is more in the nature of a rolling action than the disengagement of a hook. This will be readily appreciated by an examination of the several figures, from 7 to 10 inclusive, where it will be seen that the instant the spring hook is tripped off, the interlocking latch, by swinging over to the right in Fig. 7, will tend to raise the head of the interlocking hook which is already slightly off center, and the interlocking latch can then pass beneath the said head, as the flange 44 commences to rotate. When the interlocking latch has thus been tripped off, it will swing clear out until arrested by means of a pin 148, as shown in Fig. 9. When lying in this position, this interlocking latch can pass beneath the interlocking hook each time the flange 44 completes a rotation during the starting operation, the surface 149 of the interlocking latch being formed so that it will lie at an angle with respect to the interlocking hook, and thus cause the interlocking hook to slide or ride up as the interlocking latch passes beneath it.

After the flange 44 and spring barrel have completed the specified number of revolutions for starting purposes, the spring barrel and flange 44 will come to rest, and the bridge plate and flange 46 will commence to rotate for the rewind. As soon as this takes place, the interlocking hook 131 will commence to travel around. Toward the end of the completion of the first revolution, it will ride up on a projecting portion 150 of the interlocking latch, as shown in Fig. 8, and as it continues to advance its hook surface 151 will engage the hook 152 of the interlocking latch, as shown in Fig. 9, to swing the latter back into its initial position and cause it to latch in under the spring hook. In order to cause the hook surface 151 to disengage from the hook 152 in the easiest and best manner, I place the hooking surface of the interlocking hook far enough in from the end 153 thereof, so that the instant the interlocking latch has been hooked in, said surface will cause the hooks to disengage, thus allowing the flange 44 to continue its travel unimpeded. As the flange 46 continues to rotate during the rewind, the interlocking hook 131 will ride over the interlocking latch 129 each time a revolution is completed, until finally just before the completion of the last revolution on the rewind, it will run past the interlocking latch a slight distance, so that the instant the winding pawl 94 is forced out of the winding ratchet, the interlocking hook will stand in position to engage the interlocking latch, as shown in Fig. 7, when the flange 46 drops back the slight distance necessary to permit such engagement. Furthermore, the parts should be so proportioned that the interlocking hook will engage the interlocking latch before the winding pawl 94 engages the abutment 95, and the finger 53 the arresting surface 57. With the construction as above set forth, or its equivalent, the only

duties which the winding pawl 94 and finger 53 have to perform are those which come upon them during the starting and rewinding operations. During the starting operation, the winding pawl 94 is in engagement with the abutment 95, and during the rewinding operation the finger 53 is in engagement with the arresting surface 57, but as soon as the rewind has been completed the entire force of the power springs is taken up by the engagement of the interlocking hook 131 with the interlocking latch 129. Thereafter, the only force which the finger 53 would be called upon to carry would be the slight pressure exerted by reason of the friction of the spring barrel on the shaft. In other words, after the power springs have been completely wound up the only function of the finger 53 until the next tripping operation would be that of retaining the spring barrel positioned properly within the inclosing casing.

It was previously stated that the bridge plate could be set at a number of different positions with respect to the flange 46, and that for this reason a number of holes 89 are provided around the periphery of said flange. It will now be seen that, in order to secure the proper operation, the interlocking hook 131 should always maintain a given position with respect to the bridge plate and pawl-latch. Furthermore, the interlocking hook must be raised above the flange 46 a sufficient distance to bring said interlocking hook into alinement with the interlocking latch. In order to accomplish this last result, and also to accurately position the interlocking hook with respect to the bridge plate, I mount the said interlocking hook on a short plate 154, the ends 155 and 156 of which seat nicely between two of the feet of the bridge plate. This plate 154 can be held in position by screws extended through the holes of the flange 46. This plate 154 is also provided with a slot 157, in which works a pin 158 carried by the interlocking hook 131, which pin serves to limit the amount of throw of the said hook, and thus hold the same to properly engage the interlocking latch 129.

A stub shaft 159 is extended through the back head of the casing, and at its inner end carries a finger 160 which may be swung down to and engage the finger 53 for the purpose of tripping off. A spring 161 normally holds the finger 160 up in the position shown in Figs. 17, 18, and 19, thus swinging the stub shaft 159 back to its normal position. Outside of the casing said stub shaft carries a depending hook finger 162 which has the hook 163. For the purpose of tripping off, it is desired that the finger 162 should be swung in the direction of the arrow of Fig. 20 just far enough to cause the finger 160 to trip off the finger 53, and then be released, dropping back to its initial position, so as to obviate any dangers that might follow from having the finger 160 depending down in the line of travel of the finger 53 after the spring barrel had commenced to rotate. In Fig. 20, I have shown a mechanism for accomplishing this result of tripping off the finger 160, and then immediately allowing said finger to return to normal position. Said mechanism comprises a plate 164 mounted on the main shaft, and adapted to swing a slight distance with respect to the casing. Said plate is provided with a slot 165, in which works a pin 166 carried by the casing for limiting the amount of throw of the plate. A spring 167 carried by the plate engages a pin 168 on the casing for normally holding the plate up in the position shown in Fig. 20. This plate 164 carries a hook 169 which is adapted to engage the hook 163, so that when the plate 164 is forced down the hook 169 will be drawn to the right, thus also swinging the hook 162 to the right and causing the finger 160 to trip off. A spring 170 secured to the pin 171 on which the hook 169 is mounted, and wrapped around the same the desired number of turns, engages a pin 172 on said hook for the purpose of holding it up toward the hook 162. The hook 169 carries a pin 173 working in the slot 174 of the plate 164, which pin limits the swinging movement of the hook 169.

With the above described arrangement, it will be found that when the plate 164 has been swung a certain distance the hook 169 will trip off from the hook 163, and allow the same to drop back into initial position entirely disconnected from the hook 169. Then when the plate 164 is allowed to move up again under the influence of the spring 167 the surface 175 of the hook 169 will ride beneath the hook 163 to again cock both of the hooks ready for another tripping operation.

It was previously stated that, in case the starter should be tripped off while the shaft was rotating under the power of the motor, a slight additional amount of travel of the spring barrel might be necessary in order to permit the same to catch up with the driving ratchet, so as to engage one or the other of the arms 58 and 59 into said ratchet. It was stated that, for this purpose, the surface 71 of the abutment 50 could be made of any desired length. However, under certain circumstances, it may not be desirable to allow the mechanism to be tripped off at all after the motor has once been started. I have, therefore, provided a locking mechanism, whereby the parts can not be tripped off after the motor shaft commences to rotate. For this purpose, I have mounted the plate 176 on the shaft between a collar 177 which is secured to the shaft and a collar 178 which

is free to move on the shaft either for rotation or axially thereof. The collar 178 is provided with a cam groove 179 which can be engaged by a pin 180 of the shaft, so that, as soon as the shaft commences to rotate, said pin by engaging said cam groove will force the same in toward the fixed collar 177, and thus tend to clamp the plate 176 between the fixed and movable collars. If such clamping operation were not limited, the parts might jam and become broken. However, I have provided a sleeve 181 on the collar 178, said sleeve extending through the plate 176 and being adapted to engage the fixed collar before the parts could lock; a spring 182 is interposed between the collar 178 and the plate 176, so that, as soon as said collar begins to move in, the plate 176 will be forced against the fixed collar 177. By reason of the rotation of the latter collar with the engine shaft, the plate 176 will be swung up. Said plate is provided with a curved seat 183, so that, when the plate has risen a predetermined amount, said seat will engage the lower face of the hook 169.

The operation of this device is as follows: As soon as the mechanism is tripped off and before the plate 164 has a chance to swing back to its normal position, so as to hook in the hook 169 behind the hook 163, the plate 176 will swing up and is curved surface will engage the lower surface of the hook 169 to prevent the latter from dropping down under any circumstances. Then, as soon as the plate 164 commences to rise in order to latch the hook 169 in under the hook 163, said hook 169 will not be able to depress by reason of its engagement by the surface 183 of the plate 176, and therefore the hook 169 will not latch under the hook 163 in order to engage the same. Therefore, if the plate 164 were to be pulled down under these circumstances, the starter would not be tripped off because of failure of the hook 169 to engage the hook 163. As a simple means for actuating the plate 164 at the desired time, I have shown diagrammatically in Fig. 21 one manner of attaching the same to a foot pedal on the dash board of an automobile. In this case, a bell crank 184 is pivoted at the point 185 to the dash board 186, the upper arm of said bell crank passing through an opening in the dash board and terminating in a pedal 187. The other arm of the bell crank connects by means of a chain or the like 188 passing over pulleys or suitable openings, and connecting into a hole of the plate 164. By pressing down on the foot pedal 187, the necessary pull will be exerted on the chain 188 to pull down the plate 164 and trip off the starter.

With a mechanism constructed as above illustrated and described, it will be evident that the engagement of the pawls 62 and 63 of the arms 58 and 59 with the driving ratchet 48 is dependent upon the driving force exerted by the power springs during the starting operation. When either one of these pawls is hooked into the driving ratchet, the finger 53 is held down in a position such as that illustrated in Figs. 18 and 19, so that it will clear the arresting face 57. This position must be maintained by the finger 53 during the entire starting operation, or at least until the rotation of the spring barrel is arrested or retarded, as, for example by the braking mechanism, so as to insure that when said finger does finally engage the arresting surface 57 such engagement will be at low speed and with a minimum of impact.

It will be remembered that the spring 55 constantly exerts a force on the finger 53 tending to throw said finger out into the position shown in Fig. 17. From an examination of Figs. 18 and 19, it will also be evident that, during the rotation of the spring barrel in the starting operation, centrifugal forces are exerted on the arm 58 and on the finger 53, which forces tend to swing said arm and finger out away from the shaft, and to disengage the pawls 62 and 63 from the driving ratchet. This centrifugal force acts in addition to the force of the spring 55. Means should, therefore, be provided for insuring that, during the entire starting operation, the one or the other of the pawls 62 and 63 will maintain its engagement with the driving ratchet. This necessity will be better realized when it is considered that, during this starting operation, the motor is supposed to "pick up" and commence to drive the shaft 25, and when it is realized that at times the motor may deliver a very sudden turning effort to said shaft. In order, therefore, to insure a more perfect engagement of the pawls 62 and 63 with the driving ratchet, I prefer to undercut the teeth of said ratchet, as is well shown in Figs. 17, 18, and 19. However, at times even such undercutting might be insufficient to accomplish the desired result, and therefore I have provided other means for insuring a proper engagement during the entire starting operation. For this purpose, I take advantage of the fact that the spring barrel is rotating during the starting operation, and I employ such rotation for the production of a centrifugal force to balance or even overpower the forces exerted by the arms, finger 53, and spring 55. For this purpose, I provide an extension 189 on the arm 59, which extension is of sufficient mass to produce the desired amount of centrifugal action during the unwinding rotation of the spring barrel. This centrifugal action will tend to throw the mass of the extension 189 out away from the shaft, thus preventing the

arm 58 and the finger 53 from flying out. The mass of this extension 189 and the location of its center of gravity should be such that it will fully over-power the centrifugal tendencies of the arm 58 and the finger 53, as well as the force of the spring 55. With the parts thus proportioned, there will be no tendency for either of the pawls to disengage from the driving ratchet as long as the spring barrel is rotating. However, as soon as the spring barrel comes to rest, or is sufficiently retarded by the brakes, the spring 55 will act to throw the finger 53 outward to occupy a position where it will engage the arresting face 57 at the completion of the last revolution of the spring barrel. Of course, the extension 189 should be so shaped that it will clear the abutment 50 at all times, so as to prevent any possible interference therewith.

From a study of the pawl-latch construction at the front end of the machine, it will be seen that the spring 96 tends at all times to restore said pawl-latch from the position shown in Fig. 4 to that shown in Figs. 3 and 5. This restoring tendency must be resisted during the process of winding the power springs, and such resistance may be effected by the engagement of the winding pawl 94 with one of the teeth of the winding ratchet 49. Therefore, I prefer to undercut the teeth of said winding ratchet and the winding pawl 94 for a reason similar to that explained in connection with the arms 58 and 59. However, in the present case also, I desire to reinforce such engagement by other means, and therefore I take advantage of the centrifugal force which may be exerted by reason of the rotation of the bridge plate and pawl-latch during the winding operation. For this reason, I provide the extension 190 on the pawl-latch, said extension being so placed and of such mass as to produce the necessary centrifugal tendency during the winding process, to retain the pawl-latch over in the position shown in Fig. 4, until it is forced away from such position by the action of the star wheel after the proper number of winding revolutions have been effected. The centrifugal tendency of this extension 190 should be sufficient to overpower the restoring tendency of the spring 96 under normal conditions, so as to insure the proper engagement of the winding pawl 94 with the winding ratchet regardless of other conditions.

It was previously explained that the interlocking hook 131 carries the pin 158 which rides in slot 157 of the plate 154. This pin 158 is mounted in an extension 191 of the interlocking hook, which extension will exert a centrifugal tendency during the rewinding process which will tend to balance that of the head 153 of said interlocking hook, so that reliance does not have to be placed entirely upon the spring 136 for assurance that the interlocking hook will properly engage the interlocking latch in the manner previously described.

From the foregoing description, the construction and operation of the particular mechanism illustrated in the drawings will be readily understood, but I desire more particularly to point out certain features not heretofore dwelt upon. In order to set together the various mechanisms, the driving ratchet 48 may first be keyed to the shaft. Thereafter, the spring barrel with the rod 141 in position and including the bushing 38 may be slipped down over the shaft, the beveled bar 144 being previously inserted in the recess 142. The sleeve 47 may then be set in place, and the power springs successively wound into the spring barrel, the outer end of each power spring being connected to the flange 40, and the inner end thereof being passed through a perforation of the sleeve 47. The flange sleeve 45 with the flange 46 may then be slipped in between the barrel hub 39 and the sleeve 47, care being taken to have the several keyways of the flange sleeve 45 registering with the inner ends of the several power springs. Thereafter, the flange hub 43 with the flange 44 may be slipped down into place, care being taken to register up the rod 141 with a perforation in said flange hub and to properly engage the clutch faces 42 and 41. The above operations will result in a mechanism in which the inner ends of the power springs are connected to the flange 46 and the outer ends to the flange 44.

When the interlocking latch, hook spring, and star wheel have been mounted on the flange 44, and the plate 154 with the interlocking hook 131 has been mounted on the flange 46, the bridge plate, including the sleeve 32 and tooth 102, may be slipped into place and locked to the flange 46, by passing the pins 90 through the desired perforations 89. Thereafter, the pawl-latch 91 may be swung on the bridge plate, and the winding ratchet 49 keyed in place. The driving and winding ratchets will serve to lock all of the intermediate elements in position, thus making it unnecessary to permanently connect together the clutch faces 41 and 42, and making it unnecessary to connect the bridge plate to the flange 46 in any manner other than that necessary to effect a driving connection between them.

Having completed the assemblage up to the point above described, the finger 53 and the arms 58 and 59 may be slipped into place on the studs 54, 60, and 61 of the spring barrel. Thereafter, the back head 27, including the tripping mechanisms on its exterior, and the abutment 50 on the pins 51 and 52, may be set in place. On account of the small clearance between this back

head and the rear end of the spring barrel, the arms, finger 53, and abutment 50 will remain properly positioned without the necessity of effecting any other connection than that above described. Having set the inclosing casing 28 against the back head, the front head 26, including the abutment 95, may next be slipped into place, and finally the front and back heads may be connected together by the rods 29 or in any other desired manner.

When the power springs have been fully rewound, and while their outer ends are sustained by the spring barrel and their inner ends are held by the flange sleeve 45, whether the finger 53 be engaging the arresting face 57 and the winding pawl 94 by engaging the abutment 95, or whether the interlocking latch be locked against the interlocking hook, both ends of the power springs will be entirely disconnected from the shaft, so that the latter will be free to rotate under the power of the motor which will therefore have no burden to carry except the comparatively small friction of the several bearings through which the shaft extends. This friction will be negligible when the interlocking latch engages the interlocking hook, because the two flanges 44 and 46 are practically in line, and in fact the interlocking latch is exactly in line with the interlocking hook. Therefore, when the power springs have been wound up, as above stated, the motor shaft can be cranked in the usual manner by engaging a crank with the head 34. When so doing, the only burden thrown on the operator will be that necessary to turn over the motor itself, because the shaft will be free to rotate without the necessity of turning over the starter mechanisms. On the other hand, if, for any reason, the motor should fail to pick up during the starting operation, as, for example, on account of the failure of the operator to throw on spark or gas mixture, the starter springs can be rewound by the insertion of a rewinding crank through the port 124, for the purpose of turning over the bridge plate. When so doing, the only burden thrown on the operator will be that necessary to wind up the power springs, because at such times the arms 58 and 59 will be disengaged from the driving ratchet 48, and the finger 53 will be in engagement with the arresting face 57 for the purpose of holding the outer ends of the power springs. I wish also to point out the fact that, if desired, the casing may be entirely or at least partly filled with oil or other lubricant, so that the entire starting mechanism will operate in oil. This can be done for the reason that all of the operative parts are fully and completely incased, the only connections to the interior being in the form of the bearings which accommodate the shaft and the stud shaft 157, the port 124 remaining normally closed. This is an important advantage, for the reason that a mechanism of this kind will ordinarily be so mounted on the frame of the automobile or other vehicle to which it may be attached as to be liable at times to be subjected to clouds of dust and splashes of mud.

I claim:

1. In a starter the combination of a driving or driven shaft, a power spring, a pair of abutments, means for connecting both ends of the power spring to the abutments when the power spring is wound, means for connecting one end of the power spring to the shaft for starting purposes, means for connecting the other end of the power spring to the shaft and the first end of the power spring to an abutment for winding purposes, and means for connecting the last mentioned end of the power spring back to an abutment after the winding is completed, substantially as described.

2. In a starter, the combination of a driving or driven shaft, a power spring, a pair of abutments, means for connecting one end of the power spring to the shaft for starting purposes, means for connecting said end of the power spring to an abutment for winding purposes, means for connecting the other end of the power spring to an abutment for starting purposes, means for connecting said end of the power spring to the shaft for winding purposes, and a star wheel for controlling said end of the spring to determine the number of revolutions effected by the shaft in starting and winding, substantially as described.

3. In a starter, the combination of a driven or driving shaft, a power spring, a pair of abutments, means for connecting one end of said power spring to the shaft for starting purposes, means for connecting said end of the power spring to an abutment, for winding purposes, the other end of the power spring being free for connection either to an abutment for starting purposes or to the shaft for winding purposes, and a star wheel for effecting the connection of said end of the power spring to the shaft after a predetermined number of revolutions in starting, and for connecting said end of the power spring to an abutment after a predetermined number of revolutions are performed in winding, substantially as described.

4. In a starter, the combination of a driving or driven shaft, a power spring, a pair of abutments, means for connecting one end of said power spring to the shaft for starting purposes, a brake for retarding the movement of said end of the power spring after a predetermined number of revolutions, means for connecting said end of the power spring to an abutment after the brake has retarded the movement thereof,

means for connecting the other end of the power spring to an abutment for starting purposes, and means for connecting said end of the power spring to the shaft for winding purposes, substantially as described.

5. In a starter, the combination of a driving or driven shaft, a power spring, a pair of abutments, means for connecting one end of the power spring to the shaft for starting purposes, a brake for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, means for connecting said end of the power spring to an abutment after its movement has been retarded, means for connecting the other end of the power spring to an abutment for starting purposes, means for connecting said end of the power spring to the shaft for winding purposes, and means for controlling the number of revolutions effected by the shaft in starting and in winding, substantially as described.

6. In a starter, the combination of a driven or driving shaft, a power spring, means for connecting one end of said power spring to the shaft for starting purposes, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, means for connecting said end of the power spring to an abutment after its movement has been retarded, the other end of the power spring being free for connection either to an abutment or to the shaft, and a star wheel for effecting the connection of said end of the power spring to the shaft after a predetermined number of revolutions have been effected, and for effecting the connection of said end of the power spring to an abutment after a predetermined number of additional revolutions have been effected, substantially as described.

7. In a starter the combination of a driving or driven shaft, a power spring, a pair of abutments, means for connecting one end of said power spring to the shaft for starting purposes, a brake for retarding the movement of said end of the power spring after a predetermined number of revolutions in starting have been effected, means for connecting said end of the power spring to an abutment after its movement has been retarded, the other end of the power spring being connectable either to the shaft or to an abutment, and a star wheel for effecting the connection of said end of the power spring to the shaft for winding purposes after a predetermined number of starting revolutions have been effected, and for connecting said end of the power spring to an abutment after a predetermined number of winding revolutions have been effected, substantially as described.

8. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a pair of abutments, a power spring, a pawl connected to one end of the power spring, means for engaging said pawl with the driving ratchet for starting purposes, means for connecting said end of the power spring to an abutment for winding purposes, a pawl connected to the other end of the power spring, means for engaging said pawl with the winding ratchet for winding purposes, and means for connecting said end of the power spring to an abutment after the winding is effected, substantially as described.

9. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto a power spring, a pair of abutments, a pawl connected to one end of the power spring, means for engaging said pawl with the driving ratchet for starting purposes, means for connecting said end of the power spring to an abutment for winding purposes, a pawl connected to the other end of the spring, and a star wheel for engaging said pawl with the winding ratchet after a predetermined number of revolutions have been effected, and for engaging said end of the power spring with an abutment after a predetermined number of winding revolutions have been effected substantially as described.

10. In a starter, the combination of a driving or driven shaft, driven and winding ratchets secured thereto, a power spring, a pair of abutments, means for connecting one end of the said power spring to the driving ratchet for starting purposes, means for connecting said end of the power spring to an abutment for winding purposes, a pawl connected to the other end of the power spring, and a star wheel for engaging said pawl with the winding ratchet for winding purposes after a predetermined number of revolutions have been effected, and for connecting said end of the power spring with an abutment after a predetermined number of revolutions have been effected in winding, substantially as described.

11. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pair of abutments, a pawl connected to one end of the power spring and adapted for engagement with the starting ratchet, means for connecting said end of the power spring to an abutment for winding purposes, means for connecting the other end of the power spring to the winding ratchet or to an abutment, and a star wheel for controlling the connection of said end of the power spring either to the winding ratchet or to the abutment, substantially as described.

12. In a starter, the combination of a driving or driven shaft, starting and winding ratchets secured thereto, a pair of abut-

ments, a pawl connected to one end of the power spring and adapted to engage the driving ratchet for starting purposes, a spring tending to disengage said pawl from the driving ratchet, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, to thereby allow said pawl to disengage from the driving ratchet, means for thereafter connecting said end of the power spring to an abutment for winding purposes, a pawl connected to the other end of the power spring and adapted to engage either an abutment or a winding ratchet and a star wheel for controlling the position of said pawl to throw the same either into engagement with the abutment or the winding ratchet, substantially as described.

13. In a starter, the combination of a driving or driven shaft, starting and winding ratchets secured thereto, a power spring, a pair of abutments, a pawl connected to one end of said power spring and adapted to engage the driving ratchet for starting purposes, means tending to disengage said pawl from the driving ratchet, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, means for thereafter connecting said end of the power spring to an abutment, a pawl connected to the other end of the power spring, and adapted to engage either an abutment or the winding ratchet, and means for controlling the engagement of said pawl with either the winding ratchet or said abutment, substantially as described.

14. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pair of abutments, a pawl connected to one end of said power spring and adapted to engage the driving ratchet for starting purposes, means tending to disengage said pawl from the driving ratchet, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, a pawl connected to the other end of the power spring and adapted to engage either an abutment or the winding ratchet, and a star wheel for carrying said pawl into engagement with the winding ratchet after a predetermined number of starting revolutions have been effected, and for carrying said pawl into engagement with said abutment after a predetermined number of winding revolutions have been effected, substantially as described.

15. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pair of abutments, a pawl connected to one end of said power spring and adapted to engage the driving ratchet for starting purposes, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, an element connected to said end of the spring adapted to engage an abutment after the movement of said end of the spring has been retarded, a pawl connected to the other end of the power spring and adapted to engage the winding ratchet or an abutment, and a star wheel for carrying said pawl into engagement with the winding ratchet after a predetermined number of starting revolutions are effected and after the first mentioned pawl is disengaged from the driving ratchet, and for subsequently carrying said pawl into engagement with said abutment after a predetermined number of winding revolutions have been effected, substantially as described.

16. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pair of abutments, a pawl connected to one end of said power spring and adapted to engage the driving ratchet for starting purposes, means tending to disengage said pawl from the driving ratchet, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected, means for connecting said end of the power spring to an abutment after its movement has thus been retarded, a pawl connected to the other end of the spring and adapted to engage either the winding ratchet or an abutment, and means for carrying said pawl into engagement with the winding ratchet after a predetermined number of starting revolutions have been effected, and for carrying said pawl into engagement with said abutment after a predetermined number of winding revolutions have been effected, substantially as described.

17. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pawl connected to one end of said power spring, and adapted to engage the driving ratchet for driving purposes, a finger also connected to said end of the power spring, an abutment which is adapted to be contacted by said finger for arresting the movement of said end of the power spring, means for tripping off said finger from said abutment and for engaging the pawl with the driving ratchet, a pawl connected to the other end of the power spring, an abutment which said pawl is adapted to at times engage, and means for swinging said pawl after a predetermined number of revolutions of the shaft have been effected, for the purpose of engaging said pawl with the winding ratchet or with said abutment, substantially as described.

18. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, a pawl connected to one end of the power spring, and adapted to engage the driving ratchet for driving purposes, a finger also connected to said end of the power spring, an abutment which said finger is adapted at times to engage, means for engaging said pawl with the driving ratchet for the purpose of connecting said end of the power spring to the shaft, and for disengaging said finger from the abutment to leave said end of the power spring free to rotate, and means for connecting the other end of the power spring either to an abutment or to the shaft, substantially as described.

19. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured to the same, a power spring, a pawl connected to one end of the power spring and adapted to engage the driving ratchet for driving purposes, a finger also connected to said end of the power spring and adapted to engage an abutment for the purpose of locking said end of the power spring against movement, an interconnection between said pawl and said finger, a spring which tends to force said pawl into engagement with the driving ratchet, a spring which tends to force said finger out into position to engage the abutment to thereby disengage said pawl from the driving ratchet, means for retarding the movement of said end of the power spring after a predetermined number of revolutions are effected, a pawl connected to the other end of the power spring and adapted to engage either an abutment or the winding ratchet, and means for shifting the position of said pawl after a predetermined number of revolutions of the shaft have been effected for starting, substantially as described.

20. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a pawl connected to one end of the power spring and adapted to be engaged with the driving ratchet, an abutment, a finger also connected to said end of the power spring and adapted to engage said abutment for the purpose of locking said end of the power spring against rotation, a spring which tends to disengage the pawl from the driving ratchet, an interlocking connection between the pawl and the finger, a second over-powering spring which tends to force the finger out into position to engage the abutment, means for retarding the movement of said end of the power spring after a predetermined number of revolutions have been effected to thereby permit disengagement of the pawl from the driving ratchet and to permit engagement of the finger with the abutment, means for connecting the other end of the power spring to an abutment for starting purposes, means for connecting said end of the power spring to the shaft after a predetermined number of revolutions have been effected and after the pawl has disengaged from the driving ratchet, and means for subsequently again connecting the last mentioned end of the power spring with its abutment, substantially as described.

21. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, a plurality of pawls connected to one end of the power spring and adapted to engage the driving ratchet for driving purposes, said pawls being offset with respect to the driving ratchet, whereby the one or the other of said pawls will engage said ratchet, springs tending to disengage said pawls from the driving ratchet, a finger connected to said end of the power spring, an abutment, said finger being adapted to engage said abutment when in one position, an interlocking connection between the pawls and the finger, an overpowering spring connected to the finger and tending to throw the same out into position to engage the abutment, and to disengage the pawls from the driving ratchet, and means for connecting the other end of the power spring either to an abutment or to the shaft, substantially as described.

22. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, a plurality of pawls connected to one end of the power spring and adapted to engage the ratchet for driving purposes, interlocking connections between said pawls, whereby the one or the other may engage the driving ratchet, a spring tending to disengage all of said pawls from the driving ratchet, an abutment, a finger also connected to said end of the power spring, an interlocking connection between said finger and the pawls, an overpowering spring connected to said finger and adapted to force the same out into position to engage the abutment, and to thereby disengage the pawls from the driving ratchet, a centrifugal element connected to the pawls, and adapted to overpower the force of the last mentioned spring and retain the pawls in engagement with the driving ratchet during the rotation of said end of the power spring, and means for connecting the other end of the power spring, either to an abutment or to the shaft, substantially as described.

23. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to one end of the power spring and adapted to engage the driving ratchet for driving purposes, an abutment, an element

connected to said end of the power spring adapted to engage said abutment for the purpose of locking said end of the power spring against rotation, a spring which tends to disengage said pawl from the driving ratchet, a centrifugal element connected to said pawl and acting in opposition to the said spring to retain the pawl in engagement with the driving ratchet, said centrifugal element being of suitable proportion to retain said pawl in engagement with the driving ratchet during the rotation of said end of the spring in the starting operation, another abutment and means for connecting the other end of the power spring either to said last mentioned abutment for starting purposes or to the shaft for winding purposes, substantially as described.

24. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to the power spring and adapted to engage the ratchet for driving purposes, an abutment for the purpose of locking said end of the power spring against rotation, a spring which tends to disengage the pawl from the driving ratchet, a centrifugal mechanism connected to the pawl which tends to oppose said spring and retain the pawl in engagement with the driving ratchet, mechanism for retarding the rotation of the said end of the power spring after a predetermined number of revolutions thereof have been effected, whereby the speed of rotation of said end of the power spring is reduced until the aforesaid spring overpowers the centrifugal mechanism to disengage the pawl from the driving ratchet, another abutment and means for connecting the other end of the power spring either to said abutment for starting purposes, or to the shaft for winding purposes, substantially as described.

25. In a starter, the combination of driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to one end of the power spring and adapted to engage the driving ratchet for driving purposes, a spring which tends to disengage said pawl from the driving ratchet, a centrifugal mechanism connected to the spring which acts in opposition thereto during the rotation of said end of the power spring, to thereby overpower said spring for retaining the pawl in engagement with the driving ratchet, and means for retarding rotation of the said end of the power spring after a predetermined number of revolutions have been effected, substantially as described.

26. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to one end of the power spring and adapted to engage the driving ratchet for driving purposes, a spring tending to disengage said pawl from the driving ratchet, a centrifugal element connected to said pawl acting in opposition to said spring for the purpose of holding the pawl in engagement with the driving ratchet during the rotation of said end of the power spring, and a braking mechanism for retarding the movement of said end of the power spring after the same has effected a predetermined number of revolutions, whereby the said pawl is allowed to disengage from the driving ratchet, substantially as described.

27. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to one end of the same and adapted to engage the driving ratchet for driving purposes, a spring which tends to force said pawl into engagement with the driving ratchet, a finger connected to said end of the power spring, an abutment which said finger is adapted to at times engage for arresting the movement of the said end of the power spring, an interconnection between said pawl and said finger, a spring which tends to force said finger out into position to engage the abutment and thereby disengage the pawl from the driving ratchet, there being a guiding surface on said abutment for the purpose of retaining said finger in depressed position during the first movement of said end of the power spring to thereby allow said pawl to engage the driving ratchet, another abutment, and means for connecting the other end of the power spring either to said abutment or to the shaft for winding purposes, substantially as described.

28. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected at one end thereof, and adapted to engage the driving ratchet for driving purposes, a spring tending to force said pawl out from engagement with the driving ratchet, a centrifugal element tending to overpower said spring and hold said pawl in engagement with the driving ratchet when said end of the power spring is rotating for starting purposes, and means for retaining the pawl in engagement with the driving ratchet during the first stages of the driving operation, substantially as described.

29. In a starter, the combination of a driving or driven shaft, a driving ratchet secured to the same, a power spring, a pawl connected to one end thereof and adapted to engage the driving ratchet for driving purposes, a spring tending to force said pawl out from the engagement with the driving ratchet, and means for holding the said pawl in engagement with the driving ratchet against the force of the said spring

during the early stages of the driving operation, substantially as described.

30. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, means for connecting one end of said power spring either to said abutment during the starting operation or to the shaft for winding purposes, and means for controlling the connection of said end of the power spring either to the abutment or to the shaft, substantially as described.

31. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, means for connecting one end of the power spring either to an abutment for driving purposes, or to the shaft for winding purposes, and a star wheel for controlling the engagement of said connecting means either with the abutment or with the shaft, substantially as described.

32. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a connecting mechanism secured to one end of the power spring and adapted to engage either the abutment for driving purposes, or the shaft for winding purposes, and a star wheel for reversing the position of said connecting means after a predetermined number of revolutions have been effected, substantially as described.

33. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a swinging pawl connected to one end of the power spring and adapted when in one position to engage the abutment for driving purposes, and when in the other position to engage the shaft for winding purposes, a star wheel connected to the other end of the power spring, a tooth connected to the first mentioned end of the power spring for engaging said star wheel, and an interlocking connection between the star wheel and said swinging pawl for the purpose of shifting the position of said pawl according to the relative positions of the two ends of the spring, substantially as described.

34. In a starter, the combination of a driving or driven shaft, a winding ratchet secured thereto, a power spring, a swinging pawl connected to one end of the power spring, an abutment, said swinging pawl adapted to engage either the abutment or the winding ratchet depending upon its position, a star wheel connected to the other end of the power spring and adapted to travel therewith, a tooth connected to the first mentioned end of the power spring and adapted to engage the star wheel, and an interlocking connection between the star wheel and the swinging pawl for the purpose of shifting the position of the latter to carry the same into engagement with the winding ratchet after a predetermined number of revolutions, during the driving operation, and for shifting the swinging pawl to normal position after a predetermined number of revolutions during the winding operation, substantially as described.

35. In a starter, the combination of a driving or driven shaft, a winding ratchet secured to the same, a power spring, an abutment, a pawl latch swingingly connected to one end of the power spring, a star wheel connected to the other end of the power spring and adapted to travel therewith, a tooth connected to the first mentioned end of the power spring and adapted to travel therewith and to engage the star wheel, and an interlocking connection between the swinging pawl latch and star wheel, whereby the position of the former is dependent upon the relative positions of the two ends of the power spring, substantially as described.

36. In a starter, the combination of a driving or driven shaft, a winding ratchet secured to the same, a power spring, an abutment, a swinging pawl latch connected to one end of the power spring, a star wheel connected to the other end of the power spring and adapted to travel therewith, a tooth connected to the first mentioned end of the power spring and adapted to travel therewith and to engage with the star wheel, and a lug on the star wheel adapted to engage the pawl latch for the purpose of shifting the latter into position to engage either the abutment or the winding ratchet depending upon the relative positions of the two ends of the power spring, substantially as described.

37. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, an abutment, a bridge plate secured to one end of the power spring, a swinging pawl latch pivoted on the bridge plate and having a portion adapted to engage either the abutment or the winding ratchet depending upon its position, a star wheel connected to the other end of the power spring and adapted to travel therewith, a tooth connected to the first mentioned end of the power spring and adapted to travel therewith, and an element on the star wheel adapted to engage a portion of the pawl latch for the purpose of swinging the latter to bring its lug into engagement either with the abutment or with the winding ratchet depending upon the relative positions of the ends of the power spring, substantially as described.

38. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a shiftable engaging mechanism connected to one end of the power spring and adapted to engage either the abutment for driving purposes, or the shaft for winding purposes depending upon its position, an interchangeable star wheel connected to the other end of the power spring and

adapted to travel therewith, a tooth connected to the first mentioned end of the power spring and adapted to engage the star wheel, and an interconnection between the star wheel and the shiftable member, whereby the position of the latter is dependent upon the relative positions of the two ends of the power spring, substantially as described.

39. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a flange plate connected to one end of the power spring, a bridge plate adapted for connection to said flange plate, a swinging pawl latch on the bridge plate, said pawl latch being adapted to engage the abutment for driving purposes, or the shaft for winding purposes according to its position, a flange plate secured to the other end of the power spring, a star wheel carried by said last mentioned flange plate, and adapted to travel with said end of the power spring, a tooth connected to the bridge plate and adapted to engage the star wheel, and a lug on the star wheel adapted to engage a portion of the swinging pawl latch whereby the position of the pawl latch is dependent upon the position of the star wheel, substantially as described.

40. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a flange plate secured to one end of the power spring, and adapted to rotate therewith, there being a plurality of perforations around the periphery of said flange plate, a bridge plate, a plurality of pins on said bridge plate adapted to engage perforations of the flange plate according to the relative positions of the bridge and flange plates, a swinging pawl latch mounted on the bridge plate and adapted to engage the abutment or the shaft according to its position, a flange plate secured to the other end of the power spring and adapted to rotate therewith, a star wheel carried by said flange, a tooth carried by the bridge plate and adapted to engage the pawl latch for the purpose of shifting the same according to the position of the star wheel whereby the bridge plate may be adjusted with respect to the first mentioned flange plate to thereby adjust the position of the pawl latch with respect to the star wheel, substantially as described.

41. In a starter, the combination of a driving or driven shaft, a power spring, an abutment, a flange plate secured to one end of the power spring and adapted to rotate therewith, there being a plurality of perforations in said flange plate, a bridge plate, pins on the same adapted to engage the perforations of the flange plate, whereby the bridge plate may be adjusted angularly with respect to the flange plate, a swinging pawl latch on the bridge plate, adapted to engage either the abutment or the shaft according to its position, a second flange plate secured to the other end of the power spring, a star wheel carried by said last mentioned flange plate and adapted to travel therewith, a tooth carried by the bridge plate and adapted to engage the star wheel, and a lug on the star wheel adapted to engage a portion of the swinging pawl latch for the purpose of shifting the position of the latter, substantially as described.

42. In a starter, the combination of a driving or driven shaft, a winding ratchet secured to the same, a power spring, an abutment, a swinging pawl latch secured to one end of the power spring, and adapted to engage either the abutment or the winding ratchet according to its position, a spring for normally swinging the pawl latch into position to engage the abutment, means for swinging the pawl latch against the force of its spring into engagement with the winding ratchet after a predetermined number of revolutions have been effected, and a centrifugal element connected to the pawl latch and adapted to retain the same in engagement with the winding ratchet during the rotation of the end of the spring to which the pawl latch is secured, substantially as described.

43. In a starter, the combination of a driving or driven shaft, a winding ratchet secured to the same, a power spring, an abutment, a swinging pawl latch connected to one end of the power spring and having a portion adapted to engage either the abutment or the winding ratchet according to the position of the pawl latch, a spring which normally tends to throw the pawl latch into position to engage the abutment for the purpose of locking said end of the power spring thereto, and a centrifugal mechanism for counteracting the effect of the said spring during the rotation of the end of the power spring to which the pawl latch is connected for the purpose of retaining the pawl latch in engagement with the winding ratchet during such rotation, substantially as described.

44. In a starter, the combination of a driving or driven shaft, a winding ratchet secured to the same, a power spring, an abutment, a swinging pawl latch connected to one end of the power spring and adapted to engage either the abutment or the winding ratchet according to its position, a spring which normally retains the pawl latch in position to engage the abutment for driving purposes, mechanism for swinging the pawl latch to bring the same into engagement with the winding ratchet after a predetermined number of revolutions have been effected, and a centrifugal mechanism for holding the pawl latch in engagement with the winding ratchet during the rotation

of that end of the power spring to which the pawl latch is connected, substantially as described.

45. In a starter, the combination of a driving or driven shaft, a winding ratchet secured thereto, a power spring, a bridge plate secured to one end of the power spring, means for retaining the other end of the power spring stationary during the winding process, a swinging abutment, a swinging pawl latch mounted on the bridge plate adapted to engage the abutment or the driving ratchet, teeth on the periphery of the bridge plate, and an element on the swinging pawl latch adapted to engage the abutment after the winding is completed, whereby the teeth of the bridge plate may be engaged to rotate the same for winding purposes, the lug on the pawl latch being adapted to pass beneath the swinging abutment, substantially as described.

46. In a starter, the combination of a driving or driven shaft, a power spring, a flange plate secured to one end thereof, another flange plate secured to the other end thereof, an interlocking latch mounted on one flange plate, an interlocking hook mounted on the other flange plate, and means for retaining one end of the power spring stationary while the other end thereof is rotated during the winding process, whereby said interlocking hook and latch serve to lock the two ends of the power spring together after the same has been wound, substantially as described.

47. In a starter, the combination of a driving or driven shaft, a power spring, a flange plate secured to one end of the power spring, another flange plate secured to the other end of the power spring, an interlocking latch pivotally mounted on one flange plate, an interlocking hook pivotally mounted on the other flange plate, and means for tripping the interlocking latch and hook for the purpose of allowing the power spring to unwind during the driving operation, substantially as described.

48. In a starter, the combination of a driving or driven shaft, driving and winding ratchets secured thereto, a power spring, a flange plate secured to one end of the power spring, another flange plate secured to the other end of the power spring, an interlocking latch on one of said flange plates, an interlocking hook on the other of said flange plates, an abutment adjacent the driving ratchet, another abutment adjacent the winding ratchet, means for connecting one end of the power spring to the first mentioned abutment or to the driving ratchet, means for connecting the other end of the power spring to the second mentioned abutment or to the winding ratchet, and means for tripping the interlocking latch and hook during the process of connecting the first mentioned end of the power spring to the driving ratchet, substantially as described.

49. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, a flange plate secured to one end of the power spring, another flange plate secured to the other end of the power spring, an interlocking hook on one of said flange plates, an interlocking latch on the other flange plate, said interlocking hook and latch being adapted to lock the two ends of the power spring together, means for connecting one end of the power spring to the driving ratchet, and means for simultaneously tripping the interlocking latch and hook, substantially as described.

50. In a starter, the combination of a driving or driven shaft, a power spring, means for connecting either end of the power spring to the shaft while the other end of the power spring is held stationary, a flange plate secured to one end of the power spring, another flange plate secured to the other end of the power spring, an interlocking latch pivotally mounted on one of said flange plates, a spring normally tending to throw said latch into tripping position, an interlocking hook mounted on the other flange plate, and adapted to engage the interlocking latch for the purpose of locking the two ends of the power spring together, means for normally holding the interlocking latch against movement to retain the same in interlocking position, and means for tripping off said interlocking latch at the instant of starting, substantially as described.

51. In a starter, the combination of a driving or driven shaft, a power spring, means for connecting either end of said power spring to the shaft while the other end is held stationary, a flange plate secured to one end of the power spring, a flange plate secured to the other end of the power spring, an interlocking latch pivoted on one of said flange plates, an interlocking hook pivoted on the other flange plate and adapted to engage the interlocking latch at a point slightly off center from a line between the pivotal points of the interlocking latch and hook, means for normally holding the interlocking latch against movement, to thereby lock the two ends of the power spring together, and means for tripping the interlocking latch to permit the same to swing on its pivot under the force of the power spring, substantially as described.

52. In a starter, the combination of a driving or driven shaft, a driving ratchet secured thereto, a power spring, a flange plate secured to one end of the power spring, a flange plate secured to the other end of the

power spring, means for connecting one end of the power spring to the driving ratchet, while the other end of the power spring is held stationary, an interlocking connection between the flange plates for locking the ends of the power spring together, and means for tripping off said interlocking connection and for simultaneously connecting the first mentioned end of the power spring to the driving ratchet, substantially as described.

53. In a starter, the combination of a driving or driven shaft, a power spring, a flange plate secured to one end of the power spring, a flange plate secured to the other end of the power spring, an interlocking latch pivotally mounted on one of said flange plates, an interlocking hook pivotally mounted on the other flange plate, said interlocking hook being adapted to engage said interlocking latch for the purpose of locking the two ends of the power spring together, means for tripping off the interlocking latch to permit the same to ride under the interlocking hook during the starting operation, and a hook on the interlocking latch adapted to be engaged by the interlocking hook for the purpose of cocking said latch during the rewinding operation, substantially as described.

54. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, a connecting device carried by one end of the power spring, and a star wheel carried by the other end of the power spring and operable to carry said connecting device either into operative relationship with respect to the stationary element or into operative relationship with respect to the driving or driven element, whereby the position of said connecting device as dependent upon the operation of the star wheel is determined by the relative positions of the two ends of the power spring, substantially as described.

55. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, a connecting device carried by one end of the power spring, and adapted to engage either the stationary element or the driven or driving element, and means carried by the other end of the power spring and operable according to the relative positions of the two ends of the power spring for determining the connection of the connecting device either with the stationary element or with the driving or driven element, substantially as described.

56. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, and means operable according to the relative position of the two ends of the power spring for connecting one end of the power spring either to the stationary element or to the driving or driven element, substantially as described.

57. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, and means carried by one end of the power spring and operable according to the relative positions of the two ends of the power spring for effecting the connection of one end of the power spring either to the stationary element or to the driving or driven element, substantially as described.

58. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, and adjustable means carried by one end of the power spring, and operable according to the relative positions of the two ends of the power spring for effecting the connection of one end of the power spring either to the stationary element or to the driving or driven element, substantially as described.

59. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, mechanism whereby the ends of the power spring may be connected to the driving or driven element, and means for joining together the two ends of the power spring when the same is in wound condition independent of the stationary element, substantially as described.

60. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, and means for effecting a connection between the two ends of the power spring when the same is in wound condition irrespective of the stationary element, substantially as described.

61. In a starter, the combination with a driving or driven element, of a power spring, a stationary element for each end thereof, and means for joining together the two ends of the power spring when the same is in wound condition irrespective of said stationary elements, substantially as described.

62. In a starter, the combination with a driving or driven element, of a power spring, a pair of stationary elements for the two ends thereof, said stationary elements being displaced axially of the driving or driven element with respect to each other, and means for effecting a connection between the two ends of the power spring when the same is in wound condition irrespective of the stationary elements, to thereby relieve the driving or driven element of twisting forces occasioned by the unwinding forces of the power spring, substantially as described.

63. In a starter, the combination with a driving or driven element, of a power spring, means for joining together the two ends of the power spring when the same is in wound

condition, means for effecting the connection of one end of the power spring to the driving or driven element, and means for correspondingly disengaging the aforesaid connecting means, substantially as described.

64. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, means for connecting the power spring to said stationary element when the power spring is in wound conditions, means for connecting together the two ends of the power springs when the same is in wound condition, means for actuating the first mentioned connecting means to disconnect the power spring from the stationary element, and means for thereafter actuating the last mentioned connecting means to disconnect the two ends of the power spring from each other, substantially as described.

65. In a starter, the combination of a driving or driven element, of a power spring, a connecting device carried by each end of the power spring, means for relatively engaging said connecting devices when the power spring is in wound condition, and means for disengaging said connecting devices for the starting operation, substantially as described.

66. In a starter, the combination with a driving or driven element, of a power spring, a connecting device carried by each end thereof, means for interlocking said connecting devices when the power spring is in wound condition, and means for predetermining the instant of actuation of said interlocking devices to thereby predetermine the amount of wind in the power spring when the interlocking devices are actuated substantially as described.

67. In a starter, the combination with a driving or driven element, of a power spring, means for connecting one end thereof to the driving or driven element for the purpose of winding the power springs, means for disconnecting said end of the power spring from the driving or driven element, and means for predetermining the instant of actuation of said disconnecting means, substantially as described.

68. In a starter, the combination with a driving or driven element, of a power spring, means for connecting one end thereof to the driving or driven element for winding purposes, means for disconnecting said connecting means when the power spring is in wound condition, and adjustable means for determining the instant of disconnection according to the relative positions of the two ends of the power spring, substantially as described.

69. In a starter, the combination of a driven or driving element, of a power spring, means for connecting one end thereof to the driving or driven element for winding purposes, means operable according to the relative positions of the two ends of the power spring for disconnecting said connecting means, and means for adjusting said disconnecting means according to the desired amount of rewind, substantially as described.

70. In a starter, the combination with a driving or driven element, of a power spring, a stationary element, means for effecting a connection between the two ends of the power spring when the same is in wound condition irrespective of the stationary element, means for connecting one end of the power spring to the driving or driven element for winding purposes, means for disconnecting said connecting means after a predetermined amount of rewind has been effected, and means for simultaneously adjusting the disconnecting means and the means for effecting a connection between the two ends of the power spring to thereby predetermine the amount of rewind of the power springs, and to insure a connecting together of the two ends of the power spring when the same is rewound and irrespective of the stationary element, substantially as described.

JEREMIAH KELLER.

Witnesses:
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