Oct. 27, 1931. R. ABELL 1,829,624

ENGINE STARTER

Filed April 3, 1924

Fig. 1

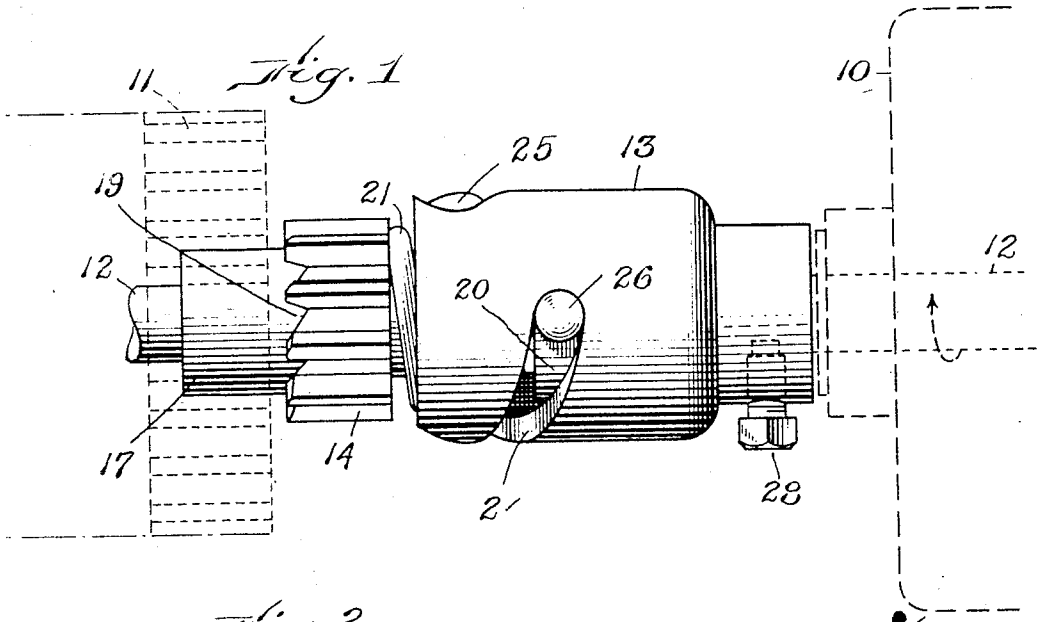


Fig. 2

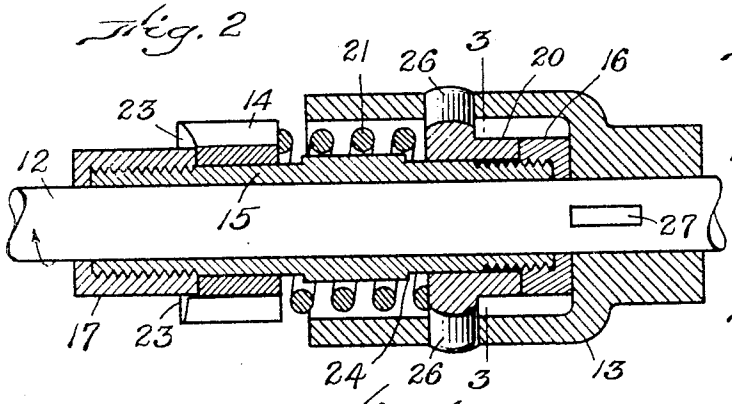


Fig. 3

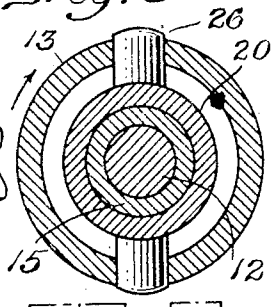


Fig. 4

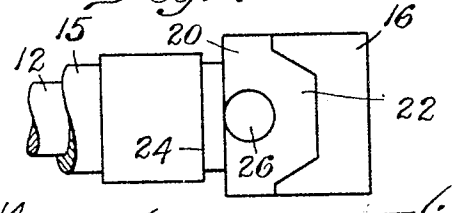


Fig. 6

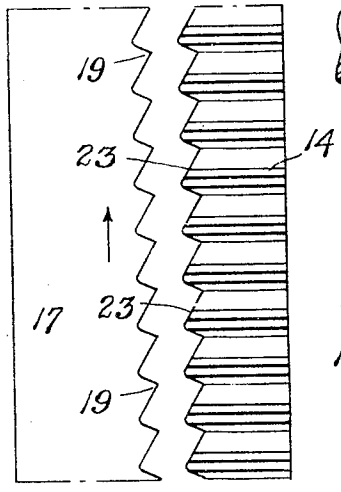


Fig. 5

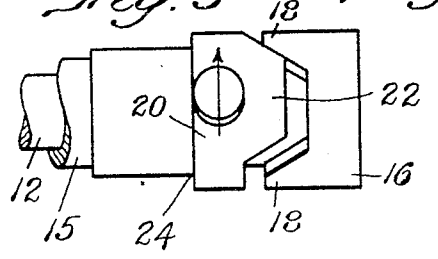
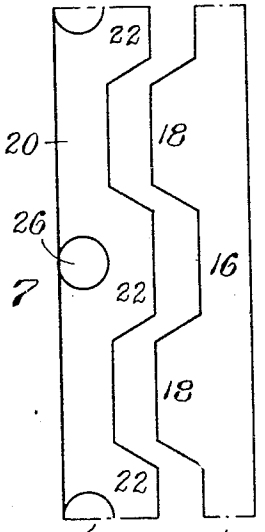


Fig. 7



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UNITED STATES PATENT OFFICE

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ENGINE STARTER

Application filed April 3, 1924. Serial No. 703,935.

This invention relates to starters for internal combustion engines, and particularly to the type of starter in which a starting pinion is shifted axially to engage a gear of the engine and then rotated to start the latter.

A starting mechanism of this type is disclosed in my copending application filed December 14, 1923, Serial No. 680,681. In that case the transmission means by which rotation is communicated to the starting pinion includes an overrunning toothed clutch which is normally maintained in clutched condition by a spring but declutched automatically by reaction of its inclined teeth whenever the torque exceeds a certain degree. As a safeguard to prevent damage to the starting equipment under abnormally difficult conditions the said former construction has proven entirely satisfactory, but it does not provide for a yielding application of torque of any degree less than that required to effect declutching. In other words, the transmission is positive up to that degree of torque required to rupture the starting connection by effecting declutching. Consequently, said former construction affords these two alternatives without compromise, viz., first, giving the clutch a driving capacity powerful enough to overcome all ordinary resistance to starting, and, second, giving it a less powerful driving capacity to soften the application of torque and thereby depriving it of sufficient power to overcome factors of resistance such as cold weather, tight bearings and extremely high compression in the cylinders of the engine.

According to the first of said alternatives the starting action is comparatively harsh or non-resilient, while according to the second it not only sacrifices the ability to overcome the more difficult conditions of resistance but produces a noisy though harmless clicking of the clutch teeth whenever one clutch member overruns the other.

In view of the conditions above explained an object of the present invention is to provide an improved starting mechanism by which the application of torque will be softened and at the same time developed to a degree high enough to overcome the more difficult conditions of resistance without sacrificing the former feature of automatic declutching to prevent the development of torque to a degree that would cause damage.

A feature of the invention consists in an engine-starter comprising a cushioning clutch and an overrunning releasing clutch arranged in series to transmit rotation to a starting pinion.

Another feature consists in a starting mechanism comprising a cushioning clutch of which the driving and driven members are organized to provide a positive transmission when the cushioning effect has been developed to a predetermined degree.

Still another feature consists in a starting mechanism comprising a cushioning clutch, an overrunning releasing clutch and a single spring organized to utilize the spring to control both clutches.

Other features of the invention are hereinafter described and claimed and are illustrated by the accompanying drawings, in which—

Fig. 1 is an elevation of a preferred form of my improved starting mechanism in its initial or non-working position;

Fig. 2 is a longitudinal section therethrough;

Fig. 3 is a cross-section on line 3—3 of Fig. 2.

Figs. 4 and 5 are elevations of the cushioning clutch in each of its two extreme positions;

Fig. 6 is a development of the two disconnectible clutch members; and

Fig. 7 is a development of the two cushioning clutch members.

The showing in Fig. 1 includes broken lines representing the casing 10 of an electric starting motor and broken lines representing the usual fly-wheel gear of an engine, said gear having spur teeth. The armature shaft 12 of the starting motor, hereinafter termed the starting shaft, serves as a support for the starting mechanism, and may have an outboard bearing (not shown) in addition to the bearings afforded by the casing 10.

The starting mechanism includes a cam member 13, a starting pinion 14, and trans-

mission means by which the pinion is shifted axially and rotated. The transmission means includes a unit comprising, in the form shown, three members, viz., a sleeve 15, a wedge toothed clutch member 16 and a wedge toothed clutch member 17. These clutch members are screwed on to the ends of the sleeve and remain tight under all conditions. The clutch teeth 18 of the member 16 confront the clutch teeth 19 of the member 17 and the space between the two sets of teeth is occupied by the pinion 14, a clutch member 20 and a compression spring 21 under initial compression. Clutch teeth 22 formed on the member 20 mate the teeth 18 to form the cushioning clutch, while teeth 23 formed on the pinion 14 mate the teeth 19 to form the overrunning clutch. The spring 21 maintains the members 16 and 20 initially in fully interengaged relation as shown by Figs. 2 and 4, and maintains the pinion initially in clutched relation to the member 17 as shown by Figs. 1 and 2. The driving train formed by the described elements is as follows:—shaft 12, cam member 13, wedge-toothed member 20, wedge-toothed member 16, sleeve 15, clutch member 17 and pinion 14. Although the spring 21 does double duty by maintaining the member 20 against the member 16 and by maintaining the pinion normally in clutching relation to the member 17, it is not an element of the driving train in the sense that the rotational effort is transmitted through it. In other words, no torsional stress is ever applied to the spring.

As in my former construction shown in my application Serial No. 680,681 the starting pinion and the sleeve by which it is carried are capable of relative axial movement to permit declutching of the pinion, this result being brought about automatically when the applied torque is developed to a degree beyond which it would not be safe or desirable to maintain the starting connection.

The cushioning clutch provided by the members 16 and 20 constitutes a lost-motion connection and is a feature disclosed for the first time in the present application. This connection functions to soften the application of torque as follows: Since the members 16 and 20 are non-resilient and are initially maintained in the relation shown in Fig. 4, by the initial compression of the spring their initial driving effect is positive and continues so until torque is developed to a degree sufficient to compress the spring further. This further compression is effected by the inclination of the operative faces of the teeth 18 and 22. Consequently, when torque has been developed to a point at which the further compression begins, the driving effect ceases to be positive and becomes yielding, thus softening the starting action. The clutch member 20 now slides axially on the sleeve 15 until it is arrested, as shown by Fig. 5, by a shoulder 24 formed on the sleeve. Now the driving action again becomes positive, since the range of relative axial movement of the clutch member 20 is not great enough to permit declutching of the members 20 and 16. Thus the final starting connection is established, and, if the engine responds as it should under normal conditions, the pinion 14 will remain clutched to the member 17.

It should be noted that the driving faces of the teeth 19 and 23 (the more abrupt faces shown in Fig. 6) are inclined less than those of the teeth 18 and 22. This difference is necessary to utilize the cushioning effect of the members 16 and 20 as a condition precedent to declutching action of the pinion. It should also be noted that the further compression of the spring developed by the cushioning clutch gives the disconnectible clutch members 14 and 17 increased clutching power to overcome resistance of the engine to starting. If, however, the engine does not turn over when the starting torque has been developed to the maximum degree determined by the applied force of the spring and the effective inclination of the teeth 19 and 23, the latter will react to declutch the pinion. This affords a complete release of the starting connection and permits the teeth 19 to click over the teeth 23 until the starting current for the motor 10 is turned off.

The rotation of the shaft 12 is communicated to the member 20 by the cam member 13. Twin cam slots 25, both of which are partly shown in Fig. 1, are occupied by lugs or followers 26 formed on the member 20. The cam member 13 is secured to the shaft by a key 27 and set-screw 28.

The mechanism operates as follows: Assuming that the parts are in their initial positions as shown by Fig. 1, and that starting current is supplied to the motor 10, the shaft turns in the direction indicated by arrows in Figs. 1, 2, 3 and 5. The cams 25 operate initially to shift the transmission unit axially to the left for the purpose of shifting the pinion 14 into meshed relation with the engine gear 11. As usual, the inertia of the transmission means resists rotation sufficiently to give precedence to the axial movement. If the spur teeth of the pinion 14 happen to butt the teeth of the engine gear instead of entering between the latter teeth the spring 21, now under relatively low compression, yields to permit the transmission unit to continue its axial movement while the pinion is momentarily arrested. This action avoids damage to the spur teeth of the pinion and engine gear. The pinion is thus declutched and may turn forward or backward relatively to the transmission unit and slip into mesh while declutched but still impelled axially by the spring. As it goes into mesh it also goes into clutched relation with the member 17, and the driving connection is

automatically restored. The cam slots 25 are so curved that their rotative driving effect finally becomes positive.

When the driving connection is fully established the torque is first positively applied as hereinbefore explained, the clutch members 16 and 20 operating initially in the relation shown by Fig. 4. The torque is applied with a cushioning effect while the teeth 18 and 22 react to shift the member 20 to the position shown in Fig. 5. The shoulder 24 marks the elastic limit of the cushioning clutch which thereafter operates without further lost motion and with a positive driving effect. The clutch members 14 and 17 also operate with a positive driving effect if the engine gear 11 responds to the starting action, but if it does not respond, or if the engine backfires the inclined driving faces of the teeth 19 and 23 react to declutch the pinion while the applied torque is within the limit of safety. When the engine operates by its own power it drives the pinion at a faster speed than the starting shaft 12, and as a consequence the lugs 26 react with the cam slots 25 to shift the pinion out of gear.

Although the spring 21 is utilized to give a cushioning effect to the driving action of the clutch members 16 and 20 it is not torsionally flexed under any conditions. I regard this as a point of advantage, since the stress to which it is subjected simply by axial compression does it no harm, whereas if it had to carry the torque it would soon crystallize and break.

I do not consider the invention limited to the illustrated arrangement of the two clutches, since it would be possible to make a construction in which their positions would be reversed, that is, interchanged. The claims are therefore to be construed to afford protection to a reversed arrangement wherever the language permits.

I claim:

1. An engine-starter comprising a rotary transmission unit, two pairs of clutch members arranged thereon in series, the two outer clutch members being rigidly related to said unit and the two inner clutch members being loose relatively thereto, a compression spring arranged between the two inner clutch members to keep them against the outer clutch members respectively, and means for driving one of said inner clutch members, the other one of said inner clutch members having gear teeth to engage a gear of the engine, said clutch members having cooperative clutch teeth formed to develop end-thrust against said spring and one of said pairs of clutch members being organized to be declutched automatically.

2. An engine-starter comprising a rotary transmission member, cushioning means arranged to impart rotation thereto with yielding torque, an abutment arranged to limit the cushioning effect of said means and furnish a positive driving action to supplement the cushioning action, a starting pinion carried by said transmission member to engage a gear of the engine, said pinion and said transmission member having cooperative clutch teeth to transmit rotation from the latter to the pinion, and a spring arranged to maintain said pinion and said member normally in clutched relation, said teeth being formed to effect declutching after the torque has been developed to the point where said positive driving abutment is brought into action.

3. An engine starter comprising a rotary transmission unit, a starting pinion carried thereby, said unit and said pinion having cooperative inclined driving surfaces forming an overrunning clutch, a rotary driving member in coaxial relation to said transmission unit, said driving member and said unit having interengaged driving parts forming a lost-motion connection, and a spring arranged to be deflected by lost motion between said driving member and said unit and to apply the stored energy of such deflection to said pinion axially thereof so as to develop the clutching power of said overrunning clutch.

4. An engine-starter comprising a rotary transmission unit, a starting pinion carried thereby, said unit and said pinion having cooperative inclined teeth forming an overrunning clutch, rotary means arranged to shift said unit axially and drive it rotatively, said means including relatively movable members forming a lost-motion connection, and a spring arranged to resist lost motion between said members and maintain said pinion and said unit normally in clutched relation.

5. An engine-starter comprising a rotary transmission member having two sets of clutch teeth confronting each other but spaced apart axially, the teeth of both of said sets being inclined but those of one set being inclined more than the others, a starting pinion and a collar arranged on said member between said sets of teeth and having clutch teeth to cooperate with said sets of teeth respectively, a compression spring arranged between and acting against said pinion and collar to maintain the two latter against said sets of teeth respectively, and means for imparting rotation to said collar, the elements having the teeth of lesser inclination being organized to be automatically declutched by torque of predetermined degree, and said transmission member having an abutment to prevent declutching of the elements that have the teeth of greater inclination.

6. An engine-starter comprising a starting pinion, a rotary operating member, and mechanism arranged to be rotated and moved axially by said operating member to shift said pinion axially and to transmit rotation thereto, said mechanism including an over-

running toothed clutch and resilient means arranged to cushion the torque.

7. An engine-starter comprising a starting pinion, a rotary driving member, and transmission means including an overrunning toothed clutch and cushioning means arranged in series to transmit rotation from said rotary member to said pinion, said cushioning means including relatively movable parts forming a lost-motion connection and a spring arranged to resist lost motion between said parts.

8. An engine-starter comprising a rotary driving member and transmission means one of which has a cam surface engaging the other to shift axially and rotate said means, a starting pinion carried and driven by said means, said means including a sleeve and a collar capable of relative turning and relative axial movement, said sleeve and said collar having abutting camming faces, and a compression spring by which said camming faces are maintained against each other to transmit rotation and to cushion the starting action.

9. An engine-starter comprising a starting pinion, a rotary driving member, and transmission means arranged to transmit rotation from said driving member to said pinion, said means including an overrunning toothed clutch and a cushioning clutch each having inclined clutch teeth, and a compression spring arranged to maintain said overrunning clutch normally in clutched relation and to furnish resilience to said cushioning clutch for softening the starting operation.

10. An engine-starter comprising a starting pinion, a rotary driving member, and transmission means arranged to cooperate with said member and including an axially movable unit by which said pinion is shifted into and out of meshed relation with a gear of the engine, said unit including a cushioning clutch and a releasing clutch arranged in series, and a compression spring arranged between said clutches to make them both effective, said pinion being one member of one of said clutches and said spring being arranged to cushion the axial movement of the pinion when said unit is advancing to carry the pinion into gear.

11. A transmission mechanism comprising a sleeve adapted to slide on a shaft, said sleeve being provided with two confronting abutments spaced apart axially, a pinion and a driving collar arranged on said sleeve between said abutments, said pinion and one of said abutments having cooperative wedge teeth forming an overrunning clutch, said collar and the other one of said abutments having cooperative wedging portions arranged to move said collar toward said pinion, and a compression spring between and abutting said collar and said pinion to render the driving action of said collar resilient and to develop increasing clutching pressure of said pinion against the abutment first specified.

12. A transmission mechanism comprising a sleeve adapted to slide on a shaft, said sleeve being provided with two confronting abutments spaced apart axially, a pinion and a driving collar arranged on said sleeve between said abutments, said pinion and one of said abutments having cooperative wedge teeth forming an overrunning clutch, said collar and the other one of said abutments having cooperative wedging portions arranged to move said collar toward said pinion, and a compression spring between and abutting said collar and said pinion to render the driving action of said collar resilient and to develop increasing clutching pressure of said pinion against the abutment first specified, said sleeve having a third abutment arranged to limit the axial movement of said collar toward said pinion.

13. A transmission mechanism comprising a sleeve adapted to slide on a shaft, said sleeve being provided with two confronting abutments spaced apart axially, a pinion and a driving collar arranged on said sleeve between said abutments, said pinion and one of said abutments having cooperative wedge teeth forming an overrunning clutch, said collar and the other one of said abutments having cooperative wedging portions arranged to move said collar toward said pinion, the effective pitch of said clutch teeth being steeper than that of said wedging portions, and a compression spring between and abutting said collar and said pinion to render the driving action of said collar resilient and to develop increasing clutching pressure of said pinion against the abutment first specified.

14. An engine-starter comprising a rotary driving member and a driven member one of which has a camming surface engaging the other to shift axially and rotate said driven member, a transmission unit on which said driven member is movably mounted, a starting pinion mounted on said unit and spaced from said driven member, and a compression spring acting in one direction against said pinion and in the opposite direction against said driven member, said transmission unit having an overrunning clutching surface against which said pinion is maintained by said spring, said unit also havng a camming surface against which said driven member is maintained by said spring and by which said driven member is caused to increase the pressure of said spring against said pinion.

In testimony whereof I have affixed my signature this 29th day of March 1924.

ROLLIN ABELL.