March 19, 1929. R. ABELL 1,705,464

ENGINE STARTER

Original Filed Dec. 14, 1923

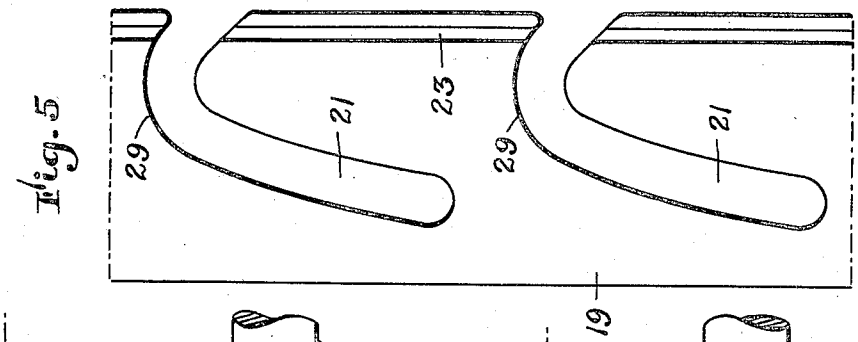


Fig. 5

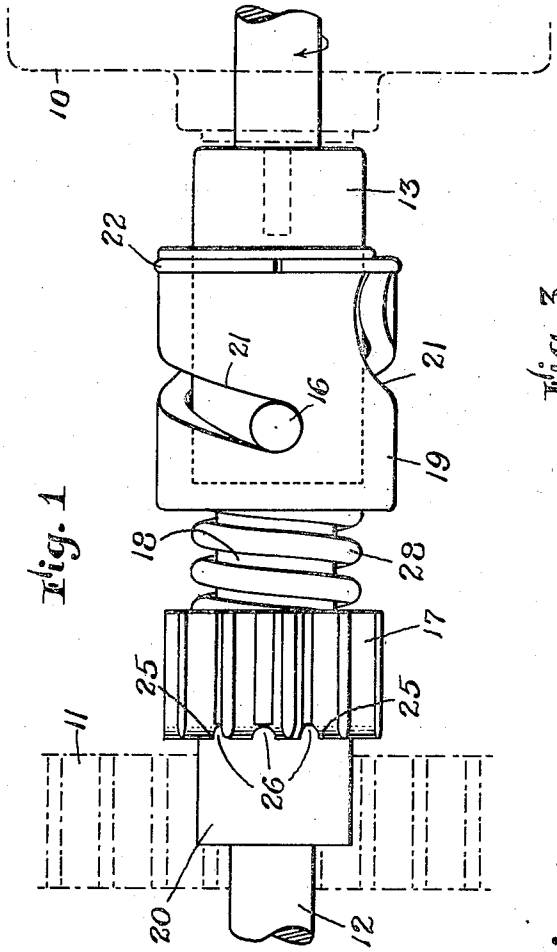


Fig. 1

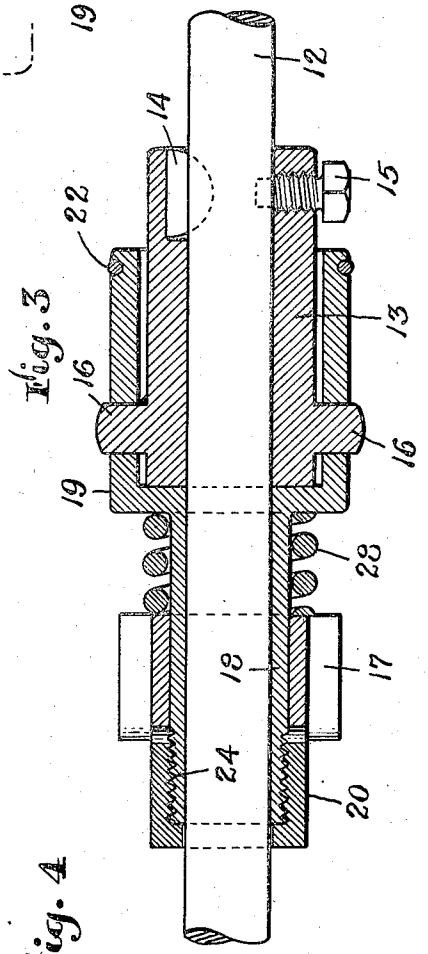


Fig. 3

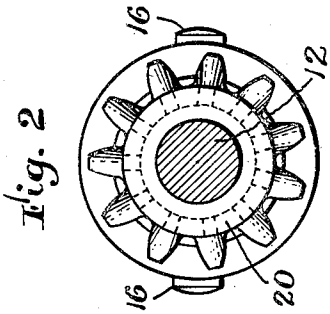


Fig. 2

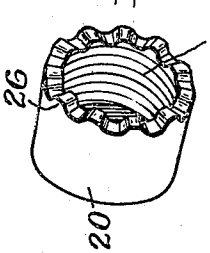


Fig. 4

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UNITED STATES PATENT OFFICE.

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ENGINE STARTER.

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This invention relates to automatic starters for internal combustion engines, and its object is to provide an improved construction and to overcome various faults that exist in the constructions hitherto in use.

For example, one such fault is that when the teeth of the axially movable pinion strike the ends of the teeth of the engine gear one or more teeth become chipped in consequence of failure to mesh properly before the starting torque is applied, and in time the pinion or engine gear or both become so badly mutilated that the mechanism can no longer function.

Again, sometimes the engine backfires when started, and when this occurs the starting mechanism sustains a tremendous reaction which, in many cases, bends or even breaks the shaft of the starting motor, while in other cases it breaks other parts of the starting mechanism or so tightens them that they will not release.

Former constructions also sustain breakage or cause burning out of the starting motor in consequence of accidentally turning on the starting current while the traction wheels are geared and clutched to the engine, and sustain breakage when the starting current is turned on while the engine is running.

In view of these and other causes of trouble the object of the present invention is to provide a starting mechanism that will withstand all possible conditions of use and misuse without damage to itself, the starting motor or other parts of a power organization. In other words, the object is to provide a "fool-proof" starting mechanism.

More specifically, an object of the invention is to provide, in a starting mechanism of the character mentioned, improved means for automatically releasing the axially movable pinion from its source of rotation when its axial movement is arrested by the ends of the teeth of the engine gear, so that it may turn backward, if necessary, far enough to slip into gear before the starting torque is applied to it.

Another object is to provide for relief of the starting mechanism, and particularly of the starting motor, from excessive counter torque so that no damage or undue strains will be sustained when the engine backfires.

A feature of the invention consists in an axially movable transmission unit including an initially coupled toothed clutch arranged to be uncoupled by stoppage of the axial movement of the starting pinion toward its operative position. The immediate effect of such uncoupling is to prevent the development of torque in the pinion. Consequently, when the ends of the teeth of the pinion clash with those of the engine gear in such a way as to arrest the axial movement of the pinion the latter is released from the source of starting torque so that instead of causing mutilation of the teeth it may turn in whichever direction the teeth tend to deflect it and go into gear before the starting torque is applied.

Another feature consists in a transmission unit having automatic releasing means to relieve said unit and the starting motor from excessive torque, as, for example, when the engine is restrained against "turning over" or when it backfires while the starting pinion and engine gear are in mesh. The said releasing means and the aforesaid clutch may be, and preferably are, combined one in the other to make the mechanism simple, compact and efficient. Furthermore, when so combined, a single spring may be utilized both for relieving counter-torque and for automatically resetting or recoupling the clutch after the latter has been uncoupled.

A toothed clutch of the type shown, having beveled or rounded teeth, has proved to be extremely satisfactory under all conditions of use and misuse, since it does not become heated or stick from any cause even when subjected repeatedly to the harshest tests that could be imposed upon it. Furthemore, it is self-cleaning and not affected peceptibly by oil or dirt, though it works better and wears longer if lubricated. In any event, the teeth insure a positive driving connection irrespective of dirt and oil, except when the torque is developed to a predetermined degree at which the clutch automatically releases.

Other features of the invention are hereinafter described and claimed, and are illustrated by the drawings. Referring to the latter,

Figure 1 is a side elevation of a starter mechanism embodying the invention;

Fig. 2 is an end elevation thereof;

Fig. 3 is a longitudinal section;

Fig. 4 is a perspective view of one of the clutch members; and

Fig. 5 is a development of the cam by which the starting pinion is shifted to its working position.

The assemblage shown by Fig. 1 includes a portion of a starting motor 10 and a portion of an engine gear 11 having spur teeth. This gear is usually formed on or fastened to the fly-wheel of the internal combustion engine. The starting shaft 12 forms a part of the rotor of the starting motor and is journaled in the casing of the latter. An outboard bearing (not shown) would preferably be provided to support the shaft near the gear 11.

A hardened steel sleeve 13 is fixed to the shaft by a key 14 and set-screw 15, and is formed with two integral and diametrically opposite cylindric lugs 16. This sleeve and the shaft 12 provide what is hereinafter termed a "rotary operating unit".

A spur pinion 17, hereinafter termed the "starting pinion", is provided to turn the engine gear 11 and is shifted axially to and from the latter by a transmission unit which includes a cylindric hardened steel sleeve 18 and a clutch member 20 of smaller diameter than the pinion to clear the engine gear 11.

The sleeve 18 is arranged to slide axially on the shaft 12 and is free to turn relatively to the shaft within certain limits. Also, the pinion, which has a cylindric bore to fit the sleeve 18, is arranged to slide axially thereon and turn relatively thereto. The sleeves 13 and 18 are formed to be assembled in nested relation, the sleeve 18, as shown, being provided at one end with a barrel portion 19 to receive the sleeve 13. Twin cam slots 21, each double-acting, are formed in the barrel portion 19 to cooperate with the lugs 16. The internal diameter of the portion 19 is preferably larger than the sleeve 13 to provide clearance. This feature avoids the necessity of smoothing and truing the internal surface of the portion 19 and the periphery of the sleeve 13, and prevents sticking of the parts even when they are coated with heavy lubricating oil in cold weather.

The cam-slots 21 are open at the right hand end of the portion 19 to admit the lugs 16 so that the parts 13 and 19 may be assembled, and when the lugs have been placed in the slots the two sleeves may be kept in nested relation by springing an expansible locking ring 22 into a groove 23 (Fig. 5) in the periphery of the portion 19. Moreover, the slots 21 are so shaped near their open ends that the lugs can not run out in operation even if the ring 22 is omitted. In fact, the lugs never advance so far as to touch the ring, since the steep surfaces 29 limit the extent to which the lugs may advance toward the open ends of the slots. As shown, the slots 21 are curved to provide gradually increasing pitch from their closed ends to and including the steep portions 29 which, being hook-shaped, prevent the lugs from advancing so far as to touch the ring 22.

The outboard or front end of the sleeve 18 and the clutch member 20, which is in the form of a collar, have cooperative screw-threads 24 to provide a rigid connection. Before the clutch collar 20 is screwed on, the starting pinion 17 is slipped on the sleeve; then the clutch collar is screwed on as far as it will go.

The front or entering end of the starting pinion and the confronting end of the collar 20 are provided with cooperative clutch formations by which rotation is transmitted from one to the other. The illustrated clutch formations comprise teeth 25 on the pinion and teeth 26 on the collar. These teeth project axially and are preferably rounded or otherwise beveled to effect declutching when the torque is developed to a predetermined degree. As shown, the clutch teeth of the pinion project axially from the hub thereof and merge with the spur teeth respectively, and the front or leading ends of the spur teeth are preferably rounded or beveled to facilitate their entrance between the teeth of the engine gear 11.

Any suitable yielding means may be provided to keep the clutch members normally in cooperative relation, but I prefer for this purpose a compression spring 28 surrounding and carried by the sleeve 18 and held under initial compression. As shown, the spring is seated against the forward end of the portion 19 and the rear end of the pinion. The applied force of the spring is slightly more than enough to prevent declutching under the average torque required to turn the engine gear 11 when conditions are normal, but at the same time limited to permit greater torque of predetermined degree to effect declutching rather than to impose injurious stresses on the mechanism.

Figs. 1 and 3 show the transmission unit in its initial position, the pinion 17 being out of gear but clutched to the collar 20. Upon giving current to the starting motor the shaft 12 turns in the direction indicated by the arrow in Fig. 1. As the lugs 16 act on the cam surfaces the transmission unit is shifted axially, and, if the teeth of the pinion 17 enter readily between the teeth of the engine gear the pinion remains clutched. When the lugs 16 engage the steep portions 29 of the cams the axial thrust becomes negligible but the maximum torque is developed and the transmission unit is rotated positively. If the engine is free, that is, not clutched or geared to the wheels, and not stuck in its bearings, it will be turned over and started without causing declutching of the pinion 17, but if, for any reason, the engine does not respond to the starting torque it will not arrest the shaft 12 because, under these conditions, the clutch teeth 25, 26 will permit, and will be declutched by, relative rotation of the transmission unit and the pinion while the latter remains stationary and in gear.

This relieves the mechanism and the starting motor from excessive torque and avoids burning out the motor.

Sometimes the teeth of the pinion 17, instead of going readily into gear as above suggested, abut the teeth of the engine gear, and in consequence the pinion is arrested. Here, instead of breaking one or more teeth, the transmission unit, by its continued axial movement, declutches itself from the arrested pinion while the spring 28 yields. Thus, the pinion is uncoupled from its source of rotation and relieved from all torque. Being now free to turn in either direction and still under axial thrust of the spring, the pinion teeth slip between the teeth of the engine gear and immediately the pinion is automatically re-clutched to the transmission unit. Then the starter functions just as though no arrest of the pinion had occurred.

When the engine starts to run on its own power it drives the pinion at a faster speed than that caused by the starting motor, and the cam surfaces of the element 19 then react on the lugs 16, with the result that the transmission unit is returned to its initial position with the pinion out of gear.

Let it now be assumed that the engine backfires while the starting mechanism is in gear and operating under the power of the starting motor. With former types of starting mechanism this might force the pinion laterally and bend or break the shaft 12, break teeth from the gear 11 or the starting pinion, split the casing of the starting motor, or cause some other but equally serious damage. But with my improved construction the reaction produced by backfiring merely causes declutching of the pinion from the transmission unit because the teeth 25, 26 do not maintain positive connection when they force themselves apart. They are rounded or otherwise beveled enough to force themselves apart under conditions of abnormal resistance or reaction, and at all times they constitute a safeguard against the development of torque above a predetermined degree. This, of course, is dependent upon two factors, viz, the shape of the clutch teeth and the strength of the spring 28. Thus, even though the pinion is locked against all rotation or turned reversely by the engine gear, the starting motor may continue to take current without danger of burning out and may continue to turn the shaft 12 without doing any harm. The only result will be that the clutch teeth of the collar 20 will click over those of the pinion.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. An engine starter comprising a rotary operating unit and a transmission unit having cooperative portions by which said transmission unit is shifted axially and rotated, a starting pinion arranged to be shifted axially by said transmission unit, said pinion and said transmission unit having cooperative clutch teeth, and a spring arranged to maintain said pinion and said transmission unit normally in clutched relation, said clutch teeth being formed to effect relative axial movement and declutching of said pinion and said transmission unit with a starting torque of predetermined degree but to maintain a substantially positive driving connection with starting torques of lesser degree.

2. An engine starter comprising a rotary operating unit and a transmission unit having cooperative portions by which said transmission unit is shifted axially and rotated, said transmission unit having a toothed clutch portion and having a cylindric sleeve portion between said clutch portion and said operating unit, a starting pinion arranged to slide axially on said cylindric portion and having a toothed clutch portion arranged to cooperate with that of said transmission unit to form a driving connection, and a spring arranged to maintain said pinion and said transmission unit normally in clutched relation, said clutch portions being formed to force themselves apart by relative rotation under torque of a predetermined degree.

3. An engine starter comprising a rotary operating unit and a transmission unit having cooperative portions by which said transmission unit is shifted axially and rotated, a starting pinion rotatable relatively to said transmission unit and arranged to be shifted axially thereby, said pinion having clutch teeth at one end of its hub and said transmission unit having beveled clutch teeth arranged to engage said teeth of said pinion to form a driving connection, and a spring arranged to maintain said pinion and said transmission unit normally in clutched relation.

4. In an engine starter of the type in which a rotary transmission unit is shifted axially and driven by a rotary operating unit, the combination with said transmission unit of a clutch member affixed thereto, a relatively rotatable and axially movable starting pinion carried thereby, and a spring arranged to keep said pinion normally against said clutch member, said pinion and said clutch member having cooperative clutch teeth the driving faces of which are beveled to rupture the starting connection when the starting torque is developed to a predetermined degree.

5. In an engine starter of the type in which a rotary transmission unit is shifted axially by a rotary operating unit, the combination with said transmission unit, of a relatively rotatable starting pinion carried thereby, a clutch member fixed to said transmission unit, said clutch member and one end of said pinion having cooperative clutch teeth formed to repel the pinion axially and de-

clutch the latter under abnormal torque, and a spring arranged to return said pinion to clutching position.

6. An engine starter comprising a rotary operating unit, a transmission unit arranged to be shifted axially and rotated thereby, said transmission unit having a cylindric portion, a starting pinion having a cylindric bore arranged on said portion, said transmission unit and said pinion being relatively rotatable and axially movable, the front end of said pinion having an axially projecting clutch formation, means fixed to said transmission unit and having a complemental clutch formation to cooperate with that of said pinion, and a spring arranged to keep said pinion normally in clutched relation to said means.

7. An engine starter comprising a transmission unit, a rotary operating unit arranged to impart axial movement and rotation to said transmission unit, a starting pinion carried by said transmission unit, said pinion and transmission unit being relatively rotatable and relatively movable axially, the front end of said pinion having clutch teeth, a clutch element fixed to said transmission unit and having clutch teeth to cooperate with said clutch teeth, and a spring arranged to keep said pinion normally in cooperative relation to said clutch element, the driving faces of said clutch teeth being beveled to effect relative declutching movement when the starting movement of the pinion is prevented or arrested.

8. An engine starter comprising a transmission unit, a rotary operating unit arranged to impart axial movement and rotation to said transmission unit, a starting pinion carried by said transmission unit, said pinion and transmission unit being relatively rotatable and relatively movable axially, the front end of said pinion having clutch teeth, a clutch element fixed to said transmission unit to cooperate with said clutch teeth, and a spring arranged to keep said pinion normally in cooperative relation to said clutch element, said clutch teeth and said clutch element being formed to effect declutching of the pinion under excessive torque to relieve the torque.

9. An engine starter comprising a transmission unit, a rotary operating unit arranged to impart axial movement and rotation to said transmission unit, a starting pinion carried by said transmission unit, said pinion and transmission unit being relatively rotatable and relatively movable axially, a collar fixed to said transmission unit to engage the front end of said pinion, and a spring arranged to keep said pinion normally against said collar, said pinion and said collar having cooperative clutch teeth to rotate the pinion under normal torque-load, said teeth being formed to repel and declutch the pinion under an excessive torque-load so that the transmission unit may rotate without rotating the pinion.

10. An engine starter comprising a transmission unit, a rotary operating unit arranged to impart axial movement and rotation to said transmission unit, a starting pinion carried by said transmisison unit, said pinion and transmission unit being relatively rotatable and relatively movable axially, said pinion having spur teeth for meshing with a gear of the engine and having clutch teeth at its front end projecting axially from its hub, a clutch element of smaller diameter than said spur teeth fixed to said transmission unit to cooperate with said clutch teeth of the pinion, and a spring arranged to keep said pinion normally in clutching relation to said clutch element.

11. An engine starter comprising a cylindric operating shaft, an internally and externally cylindric sleeve arranged to slide axially and turn on said shaft, means fixed to said shaft to shift said sleeve axially and transmit rotation thereto, a starting pinion having a cylindric bore coextensive with its length arranged to slide axially and turn on said sleeve, a collar secured on said sleeve to retain said pinion, and a compression spring surrounding said sleeve and arranged to keep said pinion normally pressed against said collar, said pinion and said collar having cooperative external clutching portions to transmit rotation to said pinion, which clutching portions are formed to be declutched by their reaction with starting torque of a predetermined degree.

12. An engine-starter comprising a rotary operating shaft, a driving sleeve affixed thereto, and a driven sleeve provided with a starting pinion arranged to slide axially on said shaft, one end of one of said sleeves being nested in the other one of said sleeves, one of said sleeves being provided with a cylindric operating lug and the other being formed with a cam slot in which said lug operates, said slot being open at one end to permit assembling said sleeves but being shaped near said end to prevent said lug from running out in operation.

13. An engine-starter comprising a rotary operating shaft, a driving sleeve affixed thereto, and a driven sleeve provided with a starting pinion arranged to slide axially on said shaft, one end of one of said sleeves being nested in the other one of said sleeves, one of said sleeves being provided with a cylindric operating lug and the other being formed with a cam slot in which said lug operates, said slot being open at one end to permit assembling said sleeves and having a hook-shape at said end to prevent said lug from running out in operation.

14. An engine-starter comprising a rotary

operating unit and a transmission unit arranged in coaxial relation and provided one with a radial lug and the other with a double-acting cam slot to cooperate with said lug, said cam slot being open at one end to provide for assembling said units and having a steep portion near said open end to prevent the lug from running out in operation, and said transmission unit being provided with a starting pinion.

In testimony whereof I have affixed my signature this fifth day of December, 1923.

ROLLIN ABELL.