Feb. 23, 1960 W. F. ISLEY ET AL 2,926,265

ELECTRIC STARTER

Filed June 24, 1957

FIG.2.

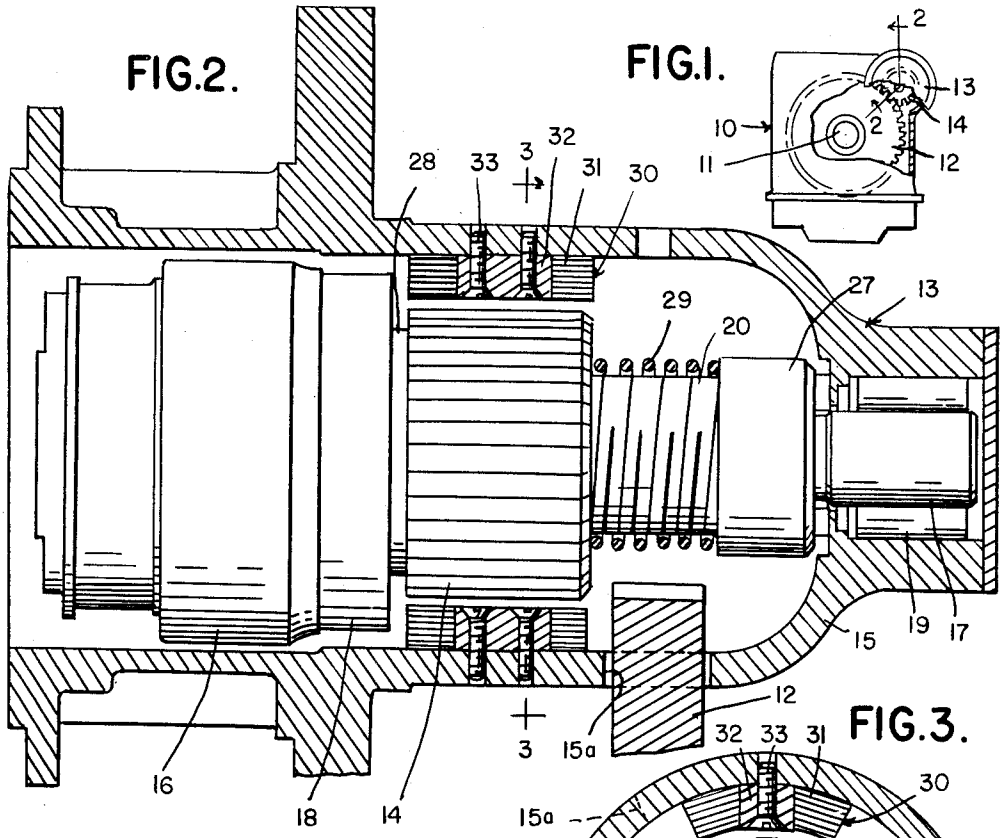
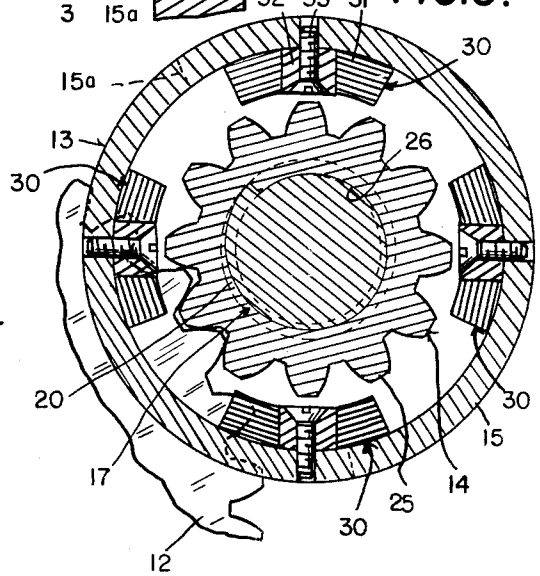


FIG.1.

FIG.3.



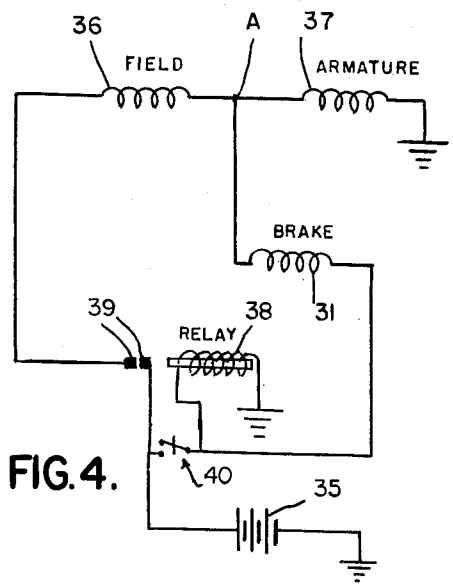


FIG.4.

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ELECTRIC STARTER

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This invention relates to electric starters and more particularly to an improved starter pinion inertia engaging mechanism.

Conventional starter pinion inertia engaging mechanisms comprise a pinion gear of large mass mounted on a worm-type screw machined integral with the armature shaft of the cranking or starting motor. The mass or inertia of the pinion is designed to be sufficiently large so that, upon initial rotation of the worm screw, the pinion inertia force will exceed the frictional force between the pinion and the worm screw. Thus, as the worm screw turns the pinion will advance along the axis of the screw to engage the flywheel ring gear of the engine being started. A stop is provided to limit the axial travel of the pinion and thereby lock the gears in engagement so that the cranking motor is enabled to turn the flywheel ring gear.

At the end of the cranking cycle, or whenever the engine fires, the pinion gear is returned along the worm screw due to the over-speeding of the pinion by the flywheel ring gear and/or by a light return spring provided for this purpose.

However, during cold weather, the lubricant in the mechanism may become so congealed that it effects a binding of the pinion on the worm screw, increasing the frictional force between them to such an extent as to overcome the inertia of the pinion. Thus the pinion will commence rotating with the worm-screw, and will never advance for engagement with the flywheel ring gear. Dirt, sludge, or other existing conditions freezing the pinion to the worm screw may effect this result also. A solution to the problem might be to increase the mass, and thus the inertia, of the piston, but this could only be carried out within certain practical limits.

An object of the present invention is to improve starter operation by providing a simplified means of braking the pinion when the starting motor is energized.

Another object of the invention is to insure cold weather operation of the starter by providing a means for positively releasing a pinion which may have become frozen to the worm screw.

A further object of the invention is to provide a means for braking the pinion of a starter mechanism upon initial rotation of the worm screw to insure axial engaging travel of the pinion by constructing a simplified electromagnetic brake for said pinion and devising a simplified electrical circuit to insure de-energizing of said brake after brief operation.

For a more complete understanding of the invention, reference may be had to the accompanying drawing illustrating a preferred embodiment of the invention in which like reference characters refer to like parts throughout the several views and in which:

Fig. 1 is a fragmentary elevational view of an engine partially in section to illustrate the starter embodying the present invention.

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

Fig. 3 is a cross-sectional view taken substantially on the line 3—3 of Fig. 2, and

Fig. 4 is an electrical circuit diagram illustrating a preferred means of operating the starter.

In Fig. 1, an engine **10** is illustrated as having a crankshaft **11** on which is mounted a flywheel ring gear **12** and a starter **13** having a starter pinion gear **14** arranged to be selectively engaged with the flywheel ring gear **12**.

As illustrated in Figs. 2 and 3, the starter **13** preferably comprises a casing **15** having a slot **15***a* through which projects the flywheel ring gear **12**. An electric starting motor **16** of conventianal construction is carried in the casing **15** and the motor armature preferably drives a shaft **17** through a conventional one-way over-running clutch **18**, the details of which are not illustrated since it may be of any conventional construction. The shaft **17** is preferably rotatably supported in a bearing **19** carried by the casing **15**. A worm-type male screw **20** is provided on the shaft **17**, preferably being integrally machined on same.

The pinion gear **14** is provided with exterior gear teeth **25** arranged for selective engagement with the flywheel ring gear **12** and an internal or female worm screw **26**, arranged to turn on the shaft worm screw **20**. Thus, if the pinion gear **14** is hindered from rotating when the starting motor **16** rotates the shaft worm screw **20**, the pinion gear **14** will advance axially of the shaft **17** and engage with the flywheel ring gear **12**, driving same to start the engine. A stop **27** is provided on the shaft **17**, limiting forward travel of the pinion gear **14**. As long as the starter motor **16** so operates, inertia or load on the pinion gear **14** will tend to retain it in the engaged position. When the engine is started or the starting motor **16** is stopped, the flywheel ring gear **12** will tend to overrun the shaft **17** and the angular momentum of the pinion gear **14** will cause it to travel in the reverse direction, disengaging from the flywheel ring gear. A stop **28** adjacent the overrunning clutch **18** limits reverse movement of the pinion gear **14**. A light spring **29** assists in reversing the pinion gear **14**.

In order to insure relative rotation of the shaft **17** with respect to the pinion gear **14** on initially cranking of the motor **16**, a plurality of electromagnets **30** are annularly spaced around the periphery of the pinion gear **14**. Each electromagnet **30** comprises a coil or winding **31** on a pole element **32** which is preferably secured to the casing **15** by screws **33** or other means. Each pole element **32** is disposed, as shown in Fig. 3, to be aligned with and closely adjacent to one or more of the exterior pinion gear teeth **25**.

Upon energizing the starter motor **16**, the electromagnets **30** are also energized. The electromagnetic attraction between the pinion gear teeth **25** and the pole elements **32** serves to stall the pinion gear **14** during a start, insuring that the pinion gear **14** will travel forward on the shaft worm screw **20**. Any appropriate electrical circuit may be utilized to substantially simultaneously energize the motor **16** and the electromagnets **30**.

In the event the engine starts and the pinion gear **14** disengages from the flywheel ring gear **12** before the starter motor **16** is de-energized, a means must be provided for disconnecting or de-energizing the electromagnets **30**, otherwise the pinion gear **14** will be again braked and forced to travel forward on the worm screw **20**, causing possible damage upon engagement with the moving flywheel ring, gear **12**. Any conventional type of speed-sensitive switch means may be used for the purpose, but a preferred electrical circuit, as shown in Fig. 4, may be utilized.

The circuit comprises a source of electrical power such as a preferred 24 volt D.C. battery **35**, the series field winding **36** and armature winding **37** of the starting

motor 16, the brake electromagnet windings 31 connected in parallel with the field winding 36 and in series with the armature winding 37, a relay solenoid winding 38 connected in parallel with the brake electromagnet winding 31, relay contact points 39, and a single pole, single throw switch 40.

In operation, the switch 40 is actuated, simultaneously energizing the brake electromagnet and the armature windings 31 and 37 respectively to brake the pinion gear 14 and the relay solenoid winding 38 to connect the starter motor field winding 36 with the battery 35. The finite time lapse in the relay provides for positive voltage buildup in the electromagnet windings 31 before the starter motor 16 turns over. Thus at point A in the circuit, the armature windings resistance being negligible, a reading would first indicate voltage drop across the brake winding 31 and then voltage drop across the field and brake windings 36 and 31 respectively. As the starting motor turns over, back E.M.F. induced through the armature winding 37 serves to cause a rapid decay of current through the electromagnet windings 31, so that even if the pinion gear 14 reverses travel before the switch 40 is turned off, the pinion gear 14 will no longer be braked, but will continue to rotate with the worm screw 20.

Although we have described but one embodiment of our invention, it will be apparent to one skilled in the art to which the invention pertains that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. An engine starter mechanism comprising an electric starter motor having a drive shaft provided with a worm screw, a pinion gear having a worm screw meshed at all times with said drive shaft worm screw and arranged to travel axially relative to same only upon relative rotation between said drive shaft and said pinion gear, a driven gear disposed in the path of travel of said pinion gear and adapted for connection to an engine for starting same, said pinion gear being selectively engaged with said driven gear, means axially urging said pinion gear to a position disengaged from said driven gear, and an electromagnet having a pole element disposed closely adjacent at least one tooth of said pinion gear, and means energizing said electromagnet on initial operation of said motor, said electromagnet being operable to produce electromagnetic braking force directly on said pinion gear for insuring axial travel of said pinion gear into driving engagement with said driven gear.

2. In an engine starter mechanism comprising an electric starting motor having a driving shaft, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, means resiliently urging disengagement of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said brake comprising at least one electromagnet having a pole element disposed closely adjacent and aligned with at least one gear tooth of said pinion gear in the disengaged position, said electromagnet being operable to produce electromagnetic braking force directly on said pinion gear.

3. In an engine starter mechanism comprising an electric starting motor having a driving shaft, said shaft provided with a male worm screw, a pinion gear having a female worm screw adapted to turn on said driving shaft

worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, means resiliently urging disengagement of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said brake comprising a plurality of annularly spaced electromagnets disposed closely adjacent the periphery of said pinion gear when same is in the disengaged position, each electromagnet having a pole element arranged to be aligned with one or more gear teeth of said pinion gear when same is at rest.

4. In an engine starter mechanism comprising an electric starting motor having a driving shaft, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, means resiliently urging disengagement of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said brake comprising at least one electromagnet disposed closely adjacent the periphery of said pinion gear in the disengaged position, said electric circuit comprising a source of electric current, starting motor field and armature windings, a brake electromagnet winding, and a selectively actuated circuit connecting means operable to substantially simultaneously energize said windings, and means deenergizing said brake electromagnet winding after brief energizing of same.

5. In an engine starter mechanism comprising an electric starting motor having a driving shaft, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, means resiliently urging disengagement of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said brake comprising at least one electromagnet disposed closely adjacent the periphery of said pinion gear in the disengaged position, said electric circuit comprising a source of electric current, starting motor field and armature windings, a brake electromagnet winding, and a selectively actuated circuit connecting means operable to substantially simultaneously energize said windings, said brake electromagnet winding being arranged in series with said armature to provide for decay of current in said brake electromagnet winding due to reverse electromotive force induced on rotation of said armature in order to deenergize said brake electromagnet winding after brief energizing of same.

6. In an engine starter mechanism comprising an electric starting motor having a driving shaft, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft

and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, means resiliently urging disengagement of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said brake comprising at least one electromagnet disposed closely adjacent the periphery of said pinion gear in the disengaged position, said electric circuit comprising a source of electric current, starting motor field and armature windings, a brake electromagnet winding, and a selectively actuated circuit connecting means operable to substantially simultaneously energize said windings, said brake electromagnet winding being arranged in series with said armature to provide for decay of current in said brake electromagnet winding due to reverse electromotive force induced by rotation of said armature in order to deenergize said brake electromagnet winding after brief energizing of same, said circuit connecting means comprising a relay operable to connect said field and armature windings with said source of electric current and having a solenoid winding arranged in parallel with said field and armature windings and a switch operable to energize simultaneously said brake and relay windings to provide a finite time interval between energizing of said brake winding and said field winding, said brake winding being arranged in parallel with said field and relay windings.

7. In an engine starter mechanism comprising an electric starting motor having a casing and a driving shaft rotatably supported therein, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake supported by said casing and constructed and arranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, stop means disposed at both ends of said driving shaft worm screw to limit axial travel of said pinion gear, means resiliently urging said pinion against one of said stops for disengaging of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said electromagnet having a pole element disposed closely adjacent at least one gear tooth of said pinion gear and being operable to produce electromagnetic braking force directly on said pinion gear.

8. In an engine starter mechanism comprising an electric starting motor having a casing and a driving shaft rotatably supported therein, said shaft provided with a male worm screw, a pinion gear having a female worm screw carried by and adapted to turn on said driving shaft worm screw and to travel axially on same upon relative rotation between said driving shaft and said pinion gear, and a driven gear disposed in the path of travel of said pinion gear to be selectively engaged therewith and drivingly connected with said engine, an electromagnetic brake supported by said casing and constructed and aranged to brake said pinion gear upon initial operation of said motor for insuring axial travel of said pinion gear into driving engagement with said driven gear, stop means disposed at both ends of said driving shaft worm screw to limit axial travel of said pinion gear, means resiliently urging said pinion against one of said stops for disengaging of said pinion gear from said driven gear, and an electric circuit for operating said motor and said brake, said electromagnetic brake comprising a plurality of annularly spaced electromagnets mounted within said casing and disposed closely adjacent the periphery of said pinion gear when same is in the disengaged position, each electromagnet having a pole element arranged to be aligned with a gear tooth of said pinion gear when same is at rest.

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