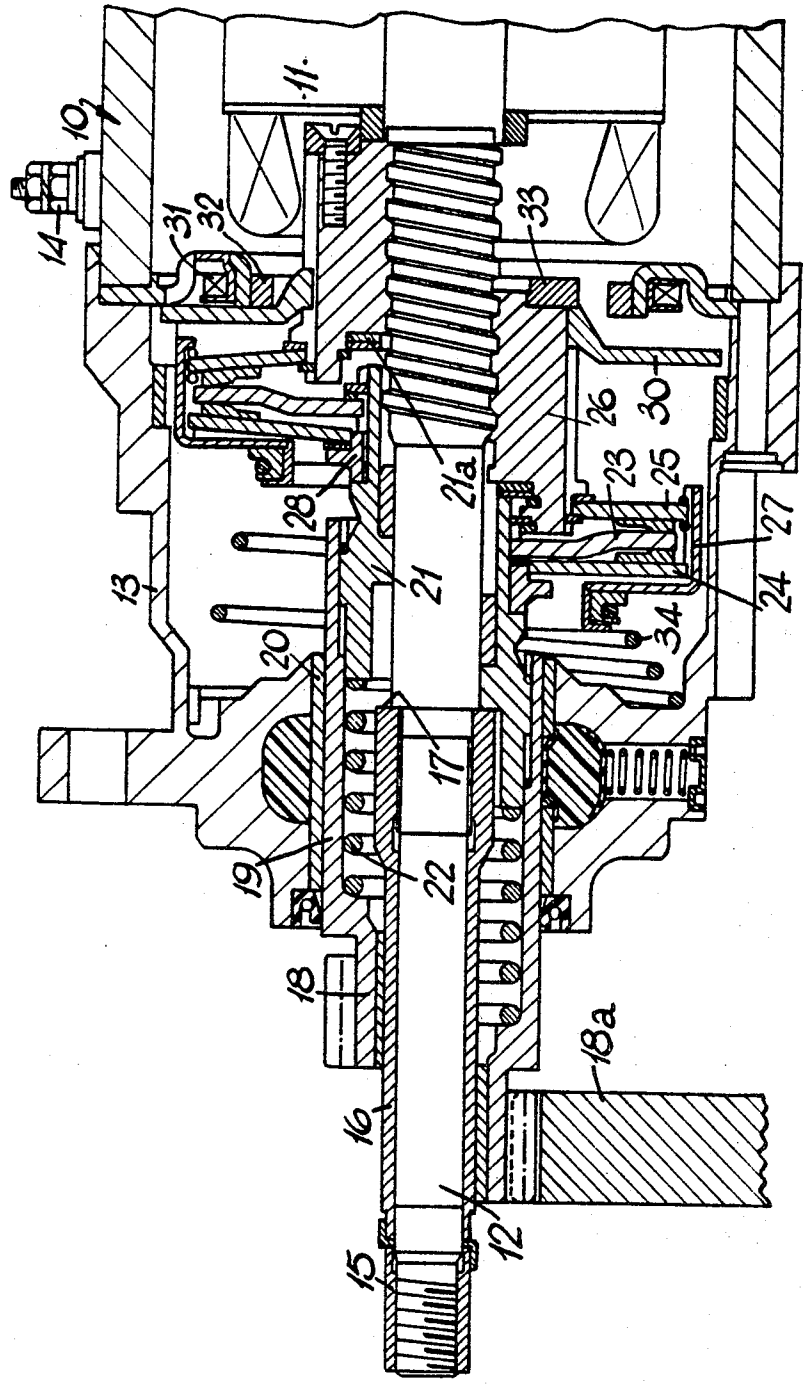
Sept. 3, 1968 A. H. SEILLY ET AL 3,399,575

STARTING MECHANISMS FOR INTERNAL COMBUSTION ENGINES

Filed Oct. 10, 1966



United States Patent Office

3,399,575

Patented Sept. 3, 1968

3,399,575

STARTING MECHANISMS FOR INTERNAL COMBUSTION ENGINES

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Filed Oct. 10, 1966, Ser. No. 585,617
Claims priority, application Great Britain, Oct. 12, 1965, 43,167/65
7 Claims. (Cl. 74—7)

ABSTRACT OF THE DISCLOSURE

A starting mechanism for an internal combustion engine which comprises a motor, a shaft which is arranged to be driven by the motor and an axially movable pinion which is movable from a rest position to an operative position into engagement with a toothed wheel on the engine. The mechanism comprising a driven clutch plate which is connected to the pinion and a driving clutch plate in frictional engagement with the driven clutch plate and a member which is axially movable upon the shaft and which is connected to said driving clutch plate. The member is provided with a quick pitch thread connection with the shaft and means is provided for restraining the angular movement of the member until the pinion has attained its operative position, resilient means being provided which limits the torque which is applied to said pinion until it has reached its operative position.

This invention relates to starting mechanism for internal combustion engines.

A mechanism in accordance with the invention comprises in combination, a motor, a shaft arranged to be driven by the motor, an axially movable pinion which is movable from a rest position to an operative position in which it engages a toothed wheel on the engine to be started, friction clutch means operable upon rotation of the shaft to move the pinion from its rest position to its operative position and to transmit the necessary torque between the shaft and pinion to crank the engine, said friction clutch means being arranged so that in the event of nose to nose engagement of the teeth of the pinion with the teeth of the toothed wheel, the torque which can be transmitted to the pinion from the shaft is limited until the pinion is moved to its operative position.

The accompanying drawing is a sectional side elevation of one example of a starting mechanism in accordance with the invention. The upper and lower halves of the left hand portion of the drawing show parts of the mechanism in their inoperative and operative positions respectively.

Referring to the drawing there is shown in outline at **10**, a motor casing which contains a field assembly not shown. Rotatably mounted within the casing is an armature **11** having a rotor shaft **12** which extends through an end wall of the casing and beyond an extension **13** of the casing. Mounted on the casing is an electrical connector **14** through which the motor can be connected to a source of supply the other connection being taken by way of the casing.

The rotor shaft **12** is stepped at various points throughout its length and on the end thereof remote from the armature is engaged a lock nut **15** which retains upon the shaft a sleeve **16**. The sleeve defines an abutment **17**. Moreover, mounted about the sleeve **16** is a toothed pinion **18** which is formed integrally with a tubular portion **19** which defines an annular space between itself and the sleeve **16**. The tubular portion **19** is supported by a sleeve bearing **20** located in the end of the extension **13**.

Furthermore, slidable within the tubular portion **19** and in spline engagement therewith is a further sleeve **21** this also being slidably mounted on the shaft. Furthermore, located intermediate a step defined on the internal periphery of the tubular portion **19** and the adjacent end of the sleeve **21** is a coiled compression spring **22**.

The end of the further sleeve **21** remote from the pinion has formed on its external periphery axially extending splines which are engaged with a driven clutch plate **23** and for cooperation with this clutch plate are a pair of driving clutch plates **24**, **25** which are disposed on opposite sides of the driven clutch plate and which are provided with a pair of annular linings respectively formed from friction material. The driving clutch plate **25** is non-rotatably engaged upon a nut **26** and is also non-rotatably engaged with an annular clutch shell **27** with which is non-rotatably engaged the driving clutch plate **24**. The inner periphery of the clutch plate **24** is supported about a collar **28** splined upon the further sleeve **21** and which defines a shoulder against which the plate **24** bears as will be described. Furthermore, as shown in the upper half of the drawing when the mechanism is at rest the driving clutch plates **24** and **25** are dished inwardly.

The nut **26** is angularly movable about the shaft and has formed on its internal periphery a quick pitch screw thread which is engaged by a complementary thread formed on the periphery of the shaft. The helix angle of the thread lies between 40 and 60 degrees. Moreover, the end of the nut adjacent the sleeve **21** is provided with a thrust washer **21***a* which when the mechanism is operating can contact the adjacent end of the sleeve **21**. Formed on the periphery of the nut **26** are a plurality of axially extending splines with which are engaged complementary splines formed on the internal periphery of a magnetizable plate **30**. As shown in the upper half of the drawing the plate is attractable towards the annular pole pieces of an annular solenoid winding **31** secured within the casing and when so attracted bears against a brake ring **32** formed from a suitable bearing material. The solenoid is arranged to be energised at the same time as the motor and when the nut is in the forward position as will be described and as is shown in the lower half of the drawing, an abutment ring **33** on the nut urges the plate away from the ring **32**.

The operation of the mechanism will now be described. When the motor is energised the solenoid **31** is also energised so that the plate **30** is held stationary. The result is that as the shaft **12** starts to rotate the nut **26** will be urged in an axial direction away from the armature **11**. Movement of the nut imparts axial movement to the clutch shell **27**, the sleeve **21**, the spring **22** and the pinion **18**. Providing the teeth of the pinion **18** freely engage with the teeth of a toothed wheel **18***a* of the engine this movement will continue until sleeve **21** bears against abutment **17** as shown in the lower half of the drawing. As soon as this occurs further axial movement of the nut **26** is opposed by the resilience of the driving clutch plates with the result that the nut starts to turn with the shaft. During this movement the plate **30** is removed from the ring **32** by the abutment **33**. The angular movement of the nut is now opposed by the load of the engine on the pinion and the nut moves a further amount to load the clutch and to reduce the clearance between the thrust ring **21***a* and the end of the sleeve **21**. With the clutch loaded the nut has no option but to rotate with the shaft and thereby the engine is cranked. The amount of loading of the clutch is sufficient to ensure that the engine is cranked however, if the load imposed by the engine is excessive all the clearance will be taken up and the clutch will slip at a predetermined torque value to minimise the risk of damage to the mechanism and motor.

If the engine fires intermittently, the pinion will be accelerated and owing to the action of the quick pitch thread connection between the nut **26** and the shaft **12**, will tend to be thrown out of engagement with the toothed wheel. When this occurs the disc **30** will contact the ring **32** to slow down the nut to below the speed of the shaft and thereby to cause the nut to be moved away from the motor so that movement of the pinion out of engagement will be prevented. When the engine starts to run properly and the motor and the brake solenoid are de-energised by the operator the pinion will be thrown out of engagement with the toothed wheel as described above and this will be assisted by the action of a return spring **34** mounted intermediate the extension and the clutch shell which spring is stressed during the engaging process of the mechanism.

The operation above described assumes that the pinion engages freely with the toothed wheel, however, this does not always happen. When tooth to tooth engagement of the pinion and toothed wheel occurs the impact loading is cushioned by the action of spring **22** and relative axial movement of the tubular portion **19** and the sleeve **21** occurs.

The extent of such relative axial movement is limited by the spring **22** which as it is compressed imposes an axial load upon the nut **26**. Depending on the helix angle of the quick pitch thread when this axial load achieves a certain value relative angular slip will occur between the plate **30** and the ring **32**. The resulting rotary motion of the nut **26** will be transmitted to the pinion and when the nose to nose engagement is cleared the spring **22** will move the pinion into contact engagement with the toothed wheel, the full engagement being completed as described. By this arrangement the torque applied to the pinion is controlled since if the torque increases the nut **26** will be moved further axially due to the action of the quick pitch thread and against the action of the spring **22**.

In the second example (not shown) the solenoid **31** is omitted and the flux for retaining the plate **30** against the ring **32** is provided by extending the field system of the motor. This having the disadvantage as compared with the provision of a separate solenoid of reducing the power output of the motor. In this construction also the plate **30** is not withdrawn from the ring **32** when the pinion is fully engaged with the toothed wheel. Again this arrangement has disadvantages because mechanical losses are introduced and wear occurs. However, it will be appreciated that the plate may be withdrawn from the ring if desired in the manner described in the illustrated example.

In a third example (not shown) the clutch described in the first example is replaced by a clutch having a driving and a driven plate, however, the mode of operation is exactly the same. In this arrangement the return spring **34** bears, through a suitable thrust arrangement against the driven member of the clutch. However, this particular arrangement has the disadvantage that it is not easy to attain sufficient loading of the clutch to ensure that under all conditions and particularly when the clutch is worn, the clutch will transmit the torque required to start the engine. In this connection it has been found that the rubbing surface of the friction material tends in use, to become glazed so that the friction between the lining and the driven clutch is reduced. One way of alleviating this problem is to provide angularly spaced depressions in the rubbing face of the driven clutch plate to break up the glazing as relative slip occurs.

In a fourth example (not shown) a multi-plate clutch is used and this is housed intermediate the tubular portion **19** of the first example and a sleeve surrounding the shaft. Alternate plates of the clutch being in spline engagement with the sleeve and the tubular portion. Moreover, the sleeve is in spline engagement with one part of a one-way clutch the other portion of which is connected to a sleeve which is in spline engagement with the nut. The return spring may either be positioned between an abutment on the end of the shaft and the pinion or between a wall of the extension and a part secured to said one part of the one-way clutch. As in the previous example a spring is provided to partially load the clutch when the mechanism is at rest, this spring being compressed as the pinion becomes fully engaged with the toothed wheel to load the clutch sufficiently to transmit the torque required to start the engine. When the engine starts the one-way clutch operates to prevent the motor being driven a a speed in excess of the light running speed thereof.

Returning now to the first and second examples, it has been said that when the plate **30** is held in contact with the ring **32** the pinion will be unable to move out of mesh with the toothed wheel. This feature is desirable when starting high compression engines but has the disadvantage that if the operator holds the starting button depressed then the motor can be driven at dangerously high speeds by the engine. In order to overcome this, speed sensitive means may be provided to hold the plate away from the discs when the armature of the motor exceeds a predetermined speed. This speed sensitive means is so adjusted that when the armature is running at its no-load speed, the pinion will be held out of engagement. For this purpose the plate is shaped to define an inclined surface which extends outwardly and in a direction away from the pinion and connected to the armature is a housing having a radial face adjacent the inclined face. In the radial face are formed a plurality of equiangularly spaced radial recesses each of which accommodates a ball. During the starting sequence and whilst the engine is being cranked, the balls lightly engage the base walls of the recesses and the inclined face of the plate and when the engine fires, the nut is retained to allow the plate to bear against the disc as has been described. When however, the engine fires correctly and the pinion is accelerated by the engine, the armature speeds up to said predetermined speed at which speed the axial component of the centrifugal force acting on the balls is sufficient to overcome the magnetic pull on the plate and the latter is moved away from the discs with the result that the drag on the nut is moved and the pinion is ejected. In this manner, wear on the clutch is reduced as also is wear on the bearing surfaces of the mechanism.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. A starting mechanism for internal combustion engines comprising in combination, a motor, a shaft arranged to be driven by the motor, an axially movable pinion which is movable from a rest position to an operative position in which it engages a toothed wheel on the engine to be started, a driven clutch plate operatively connected to said pinion and a driving clutch plate in frictional engagement with said driven clutch plate, a member axially movable upon said shaft and connected to said driving clutch plate, said member having quick pitch thread connection with said shaft, means for restraining the angular movement of said member until the pinion has attained its operative position and resilient means which limits the torque which is applied to said pinion until the latter has reached its operative position, said member acting to move the clutch plates relative to each other into heavy frictional engagement when the pinion attains its operative position.

2. A starting mechanism according to claim **1** including stop means to limit the extent of relative movement of the clutch plates into heavy frictional engagement whereby the clutch constituted by the clutch plates can act as an overload clutch.

3. A starting mechanism according to claim **2** in which the means for restraining the angular movement of said member comprises a disc mounted on and secured against angular movement relative to the member, said disc being permitted axial movement relative to the member, a

brake surface, and electro-magnetic means for urging the disc into contact with the brake surface thereby to restrain angular movement of the disc and member, said disc being allowed to slip relative to the brake surface in the event of end to end engagement of the pinion and toothed wheel.

4. A starting mechanism according to claim 3 including stop means on said member to limit the extent of relative angular movement of the disc and member, said stop means being mounted so as to move said disc out of contact with said brake surface after the pinion has engaged with the toothed wheel but before it moves into full engagement therewith.

5. A starting mechanism according to claim 4 in which a pair of driving clutch plates are mounted on opposite sides respectively of said driven clutch plate, said driving clutch plates being of annular dished form, friction linings mounted on the faces respectively of the driving clutch plates which are presented to the driven clutch plate, the dished form of said driving clutch plates acting to maintain said linings in frictional engagement with said driven clutch plate.

6. A starting mechanism according to claim 5 including a solenoid which is energised when the mechanism is operated, the magnetic field produced by said solenoid acting to maintain said disc in contact with said break surface.

7. A starting mechanism according to claim 1 including a sleeve surrounding the shaft and axially movable thereon, said sleeve being operatively connected to the driven clutch plate so as to rotate therewith, a tubular portion formed integrally with the pinion and extending over said sleeve, spline means interconnecting said sleeve and said tubular portion whereby to permit relative axial movement but at the same time to permit driving torque to be transmitted therebetween, a shoulder defined on the internal periphery of the tubular portion and a coiled compression spring acting intermediate the shoulder and the sleeve, said spring being compressed in the event of end to end engagement of the pinion and toothed wheel and which when such engagement is removed by relative angular movement of the pinion and toothed wheel, urges the pinion into engagement with the toothed wheel.

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