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[54] **ENGINE STARTER GEARING**

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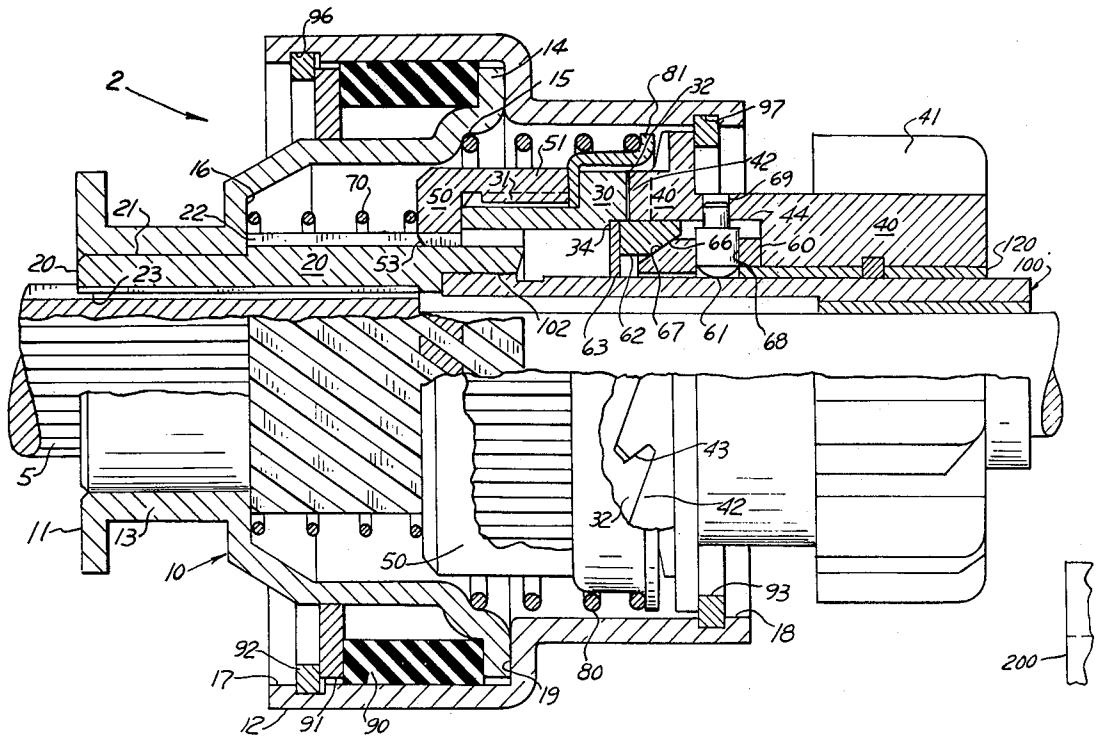
[57] **ABSTRACT**

Engine starter gearing of the positive shift type, including a clutch to provide driving, overrunning, means for automatically separating the clutch teeth at a predetermined speed, and means for keeping the clutch teeth in engagement during the indexing function, thereby allowing full and complete engagement of the starter pinion gear into the engine ring gear to prevent damage to the clutch teeth of the starter and starter motor shaft when the starter motor is energized.

13 Claims, 1 Drawing Figure



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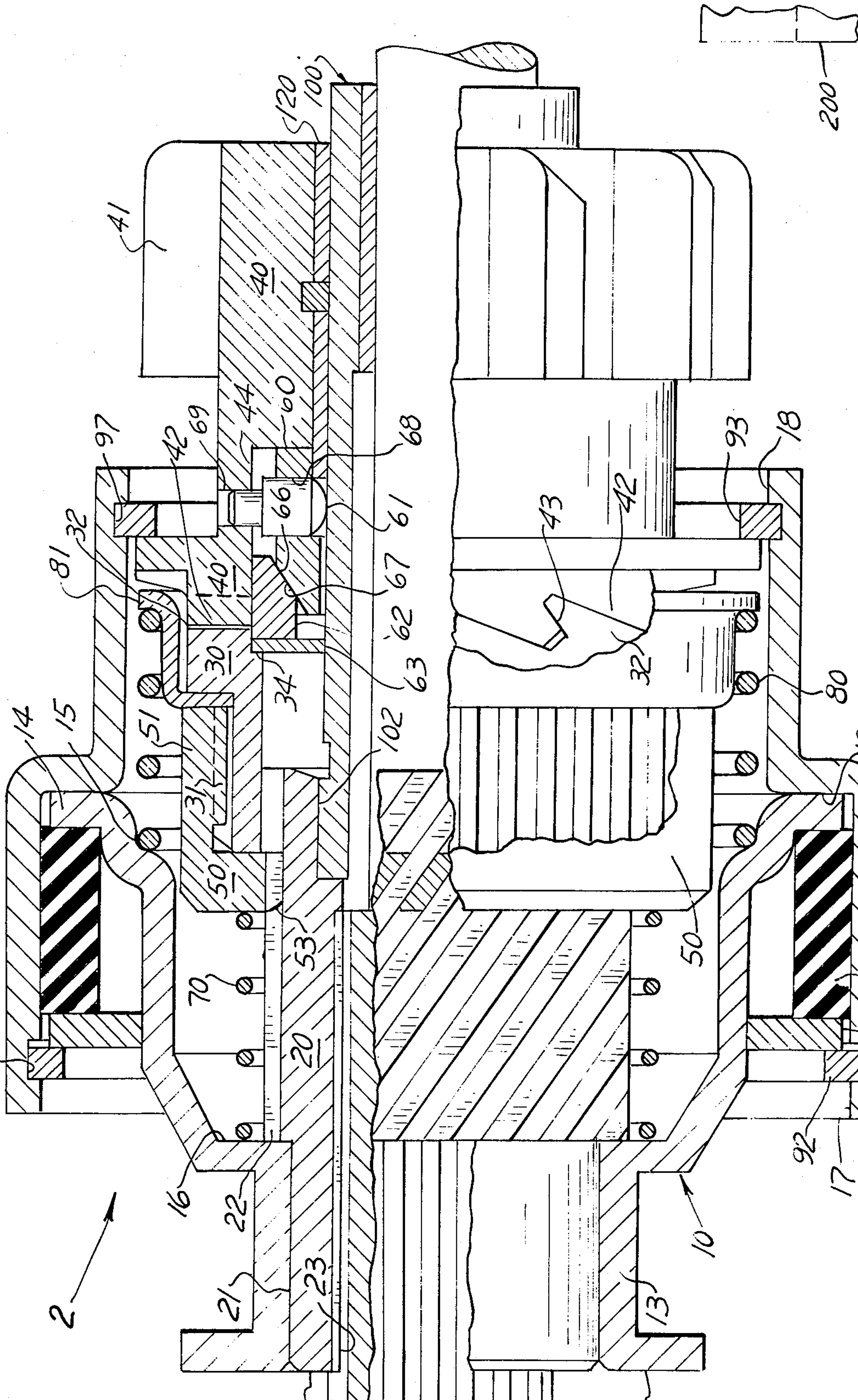

ENGINE STARTER GEARING

BACKGROUND OF THE INVENTION

The present invention relates to engine starter gearing of the positive shift type as described in U.S. Pat. No. **3,263,509,** entitled "Engine Starter Gearing," issued Aug. **2, 1966,** and U.S. Pat. No. **1,892,056,** entitled "Engine Starter," issued Dec. **27, 1932.**

More specifically, the present invention relates to engine starter gearing of the positive shift type which provides means for indexing the starter pinion with respect to the ring gear of the engine to be started.

Prior art developments have resulted in engine starter gearing having a unidirectional torque transmitting clutch which includes means for indexing the pinion gear of the starter with the engine's ring gear when abutting conditions exist between said pinion gear and the engine's ring gear, and means for separating the clutch teeth within the starter when the pinion gear of said starter rotates at a faster speed than the starter motor shaft.

In prior art starters, e.g., U.S. Pat. No. **3,263,509,** a condition occurs where upon shifting the starter along the shaft towards the engine ring gear, the pinion moves axially toward the engine ring gear. When the gear teeth on the pinion gear do not axially align with the spaces between the teeth on the engine's ring gear, the pinion gear will abut the engine's ring gear. After this abutting condition occurs, the starter is designed to move the pinion gear rotatably so that the pinion and ring gear no longer abut and the pinion gear assumes a meshing position with respect to the ring gear. Upon meshing the pinion moves axially forward into the ring gear, while the clutch within the starter moves rotatably and axially forward toward the engine ring gear along a helical spline thereby causing the clutch teeth to separate from each other to a point where they stop on top of each other. At this point the starter motor is energized. Because of the relatively high torque and acceleration of the starting motor, the clutch teeth, which are not completely engaged, cannot mate immediately to carry the torque load developed by the starting motor, and a slipping of the clutch teeth occurs. In some cases, the clutch teeth will only slip one or two teeth and then engage. However, the slipping of the clutch teeth results in excessive wear at the mutually engageable surfaces of the teeth as well as overloading of the starter motor shaft. This overload causes the starter motor shaft to bend and/or twist.

BRIEF SUMMARY OF THE INVENTION

This invention provides engine starter gearing of the positive shift type that permits the starter gearing to complete the indexing of the starter pinion with the engine ring gear without separating the clutch teeth, thereby allowing engagement of the starter pinion gear into the engine ring gear without adverse damage to the clutch teeth of the starter and the starter motor shaft.

The invention is an engine starter assembly characterized by an arrangement of the assembly elements whereby the clutch teeth within the assembly are kept in engagement during the complete indexing of the pinion gear with the engine ring gear while simultaneously permitting rotational movement thereby allowing the pinion of the starter to index and align itself for proper engagement with the ring gear. The starter gearing is further characterized by an intermediate member **50**

which is mounted for rotational and axial movement on a first sleeve **20** and a driving clutch member **30** that is mounted for only axial movement with respect to said intermediate member.

In one embodiment of the invention, the starter gearing comprises: an intermediate member **50** having a forward end and rearward end and a means for mounting said intermediate member on a power shaft **5,** said means including: means for providing axial and rotational movement of said intermediate member **50** mounted on said shaft; and means for biasing **70** said member in the forward direction so that when an axial force is applied in a rearward direction, said member **50** moves axially and rotatably in a rearward direction and when said force is removed, said member returns to its original position; a driving clutch sleeve **30** having a forward and rearward end, said forward end having axially extending clutch teeth **32;** and means for mounting said driving sleeve on said intermediate member, said means including: means for providing axial movement **31** of said driving sleeve **30** with respect to said intermediate member **50;** and means for biasing **80, 81** said driving sleeve in the forward direction so that when a force is applied in a rearward direction, said driving sleeve moves axially in a rearward direction and when said force is removed, said driving sleeve returns to its original position; a driver clutch sleeve **40** having radially extending gear teeth **41** on one end portion and axially extending clutch teeth **42** on the opposite end; and means for mounting said driver sleeve on said shaft for rotational and axial movement with respect to said shaft, said driver sleeve **40** disposed so that the clutch teeth **42** of said driver sleeve engage said driving sleeve clutch teeth **32** for transmitting torque between said driving sleeve and said driver sleeve to rotate said driver sleeve; whereby when a rearward force is applied to said driver sleeve, said driver sleeve **40** and said driving sleeve **30** move axially rearward with respect to said intermediate member **50** and said intermediate member **50** moves axially rearward with respect to said shaft.

Accordingly, it is an object of this invention to provide an engine starter that keeps the clutch teeth of the starter in engagement during the indexing of said pinion gear teeth with the engine's ring gear.

It is another object of the present invention to provide starter gearing for internal combustion engines which is simple, efficient, reliable and economical to manufacture and fabricate.

It is a further object of this invention to provide starter gearing whereby, during the indexing of the pinion gear with the engine's ring gear, the clutch teeth move axially but nonrotatably with respect to each other but together move rotatably with respect to the shaft, so that during the indexing of the starter pinion with the engine ring gear the clutch teeth are kept in engagement.

It is still a further object of the present invention to provide a starter gearing that prevents adverse damage to the clutch teeth of the starter and the starter motor shaft.

The above and other objects and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawing and claims which form a part of the specification. Further, use of numerals is for the pur-

pose of clarification and is not intended to limit the specific embodiment referenced.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawing, there is illustrated a starter drive **2** for an engine, mounted on a power shaft **5** of a starting motor (not illustrated). The drive includes an axially extending first sleeve **20** connected to the power shaft **5** by straight splines **23** on the inside surface of the first sleeve, so as to be axially, but nonrotatably moveable relative to the power shaft. The outside surface of the forward extremity of said first sleeve **20** has helical splines **22** formed thereon to which an intermediate member **50** is moveably mounted. The intermediate member **50** has a passage having a first end portion which includes helical splines **53** mutually engageable with the helical splines **22** of said first sleeve so that said member **50** is rotatably and slidably mounted to said first sleeve **20.** The opposite end portion of the passage of said member has straight splines **51.**

A second sleeve **100** is coaxially mounted to the power shaft adjacent to said first sleeve **20.** Said second sleeve **100** is connected **102** at one end to the forward end of the first sleeve for movement therewith.

A driving clutch sleeve member **30** having straight splines **31** on one portion of the outside surface and axially extending clutch teeth **32** on an opposite end is coaxially disposed with respect to said first **20** and second **100** sleeves. The straight splines **31** on the outside surface are mutually engageable with the straight splines **51** on the intermediate member **50** so that said driving clutch sleeve member **30** is mounted for only axial movement with respect to said intermediate member **50** and mounted for axial and rotatable movement with respect to said first and second sleeves. In its engaged position a portion of the driving clutch sleeve **30** projects past the forward end of sleeve **20** and the rightmost edge of the inside surface includes shoulder **34.**

The barrel shaped housing **10** has a first portion **11** and a second portion **12** axially aligned with respect to said first portion. The first portion **11** of said housing **10** has a first end **14** and an opposite end with a narrowed portion **13** which is mounted to the outside end portion **21** of said first sleeve **20.** The second portion **12** of said housing has a first annular groove **96** adjacent the first end **17** and a second annular groove **97** adjacent the opposite end **18** of the second portion of said housing. The second portion of said housing is provided with an internal shoulder **19** intermediate its extremities to provide an abutment for the first end **14** of the first portion of said housing.

A driven clutch sleeve **40** is coaxially disposed and rotatably mounted to said second sleeve **100** adjacent to the driving sleeve **30.** The driven sleeve **40** has radially extending gear teeth **41** on one end which form a pinion gear, and axially extending clutch teeth **42** on the other end which engage the driving sleeve clutch teeth **32** for transmitting torque so that the driving sleeve **30** may rotate the driven sleeve **40.** The driven clutch sleeve **40** includes an internal circular recess **44.** The opposing or adjacent faces of clutch teeth **32** and **42** are provided with mutually engageable inclined torque transmitting surfaces **43.** The clutch teeth are of a sawtooth variety to provide a unidirectional overrunning clutch connection.

A means for moving the starter gearing assembly **2** toward and away from the engine gear **200** may be comprised of a conventional solenoid, air or hydraulic cylinder actuated lever (not illustrated) connected to the narrowed portion **13** of the first portion of said housing.

An overrunning clutch feature which operates to separate the clutch teeth of the driving sleeve **32** from the clutch teeth of the driven sleeve **42** when the driven sleeve rotates faster than the driving sleeve includes: an annular recess **44** within the driven clutch sleeve **40**; an annular ring **62** having an inner inclined surface **66** is backed by a thrust washer **63,** abuts at its outer edge the shoulder **34** of said driving clutch sleeve **30.** The inner inclined surface **66** of the annular ring is conically formed with respect to the longitudinal axis of the starter gear. A plurality of arcuate centrifugal weight members **60** are annularly arranged adjacent said ring **62.** Each weight has an inclined surface **67** complementary with an abutting inclined surface **66** of the annular ring **62.** The centrifugal weight members **60** are mounted so that the inclined surface **67** of said centrifugal weight members abut the inclined surface **66** of the annular ring **62.** A radial hole **68** is formed in each weight at an intermediate or midpoint closely corresponding with the location of the center of gravity of the weight member and support pin **61** is secured on one end in a radial hole **69** formed in the annular recess of said driven clutch member **40.** The pin projects radially inwardly therefrom into the hole **68** in the weight member. The pin and hole connection restrain the weight members from movement in either the axial or circumferential direction, while permitting radial movement in response to centrifugal force.

A bearing sleeve **120** is coaxially disposed with the second sleeve **100** and projects into the annular recess **44** and provides a radially inward stop for the weight member **60,** thereby establishing clearance between said weight members **60** and said second sleeve **100** to avoid wear of the moving assembly. The assembly for separating the clutch teeth when the driven sleeve rotates faster than the driving sleeve also includes elements for axially biasing the driven **40** and driving **30** sleeves so that their mutually engageable clutch teeth **32, 42** are in an engaged position until said driven sleeve **40** reaches the predetermined speed required to separate or overrun the clutch teeth. The biasing elements include: a lock ring **93** which is located in the annular notch **97** adjacent the opposite end **18** of the second portion of said housing. The lock ring **93** has sufficient radial length to engage the driven clutch sleeve **40** to thereby confine the driven clutch sleeve within the opposite end of said second housing passage; a block of (shock absorbing) resiliently deformable material **90,** such as, rubber, located between the first end of the second portion of said housing and the first end **14** of the first portion of said housing; a lock washer **91** located adjacent the biasing element **90** which abuts a second lock ring **92** located in the annular recess adjacent the first end **17** of the second portion of said housing, so that axial movement in one direction of either portion **10, 12** of the housing with respect to the other will increase the biasing force developed by the material **90.**

An assembly for keeping the clutch teeth **32** of the driving sleeve **30** in engagement with the clutch teeth **42** of the driven sleeve **40** when the driving sleeve moves in the direction of the driven sleeve comprises: a spring **80,** located between the first portion of the

housing and the driving clutch sleeve, which acts upon the driving clutch sleeve **30** through member **81** to exert a force upon the driving clutch member **30** in the direction of said driven clutch sleeve **40**; a second spring **70** located between the first portion **11** of the said housing **10** and the intermediate member **50** which acts upon the intermediate member **50** to exert a force in the direction of said driving member **30** thereby keeping intermediate member **50** in engagement with said driving clutch member **30.** The spring constant k_2 of spring **80** is greater than the spring constant k_1 of spring **70.** It is desirable that k_2 be at least **1.4** times greater than k_1 and preferably k_2 about **2** times greater than k_1. In actual practice, it has been found that the force exerted by spring **80** acting between the driving sleeve and the housing **10** is about **11** pounds, and the force exerted by spring **70,** acting between the intermediate member **50** and the housing **10** is about **5** pounds **2** ounces.

In operation, when it is desired to start the engine, the starter gearing assembly **2** is shifted toward the engine ring gear **200** by a positioning mechanism (not shown) connected to the narrowed portion **13** of the first portion of the housing and along the power shaft **5** so that pinion gear **41** engages the engine's ring gear **200.** The power shaft (**5**) is rotated by a starting motor to transmit torque through straight splines **23** to sleeve **20,** from helical splines **22** to the intermediate member **50,** from the straight splines **51** of intermediate member **50** to the straight splines **31** of the driving sleeve **30,** through the mutually engageable clutch teeth **32, 42** driven clutch sleeve **40** pinion gear **41** and to the engine ring gear **200.** After the engine starts and becomes self-operative, engine ring gear **200** will now drive the driven clutch sleeve **40** at a speed greater than that of shaft **5.** At a predetermined speed, the centrifugal weight members **60** will start to move radially outward along support pins **61.** This radial movement causes an axial thrust on the annular ring **62** through incline surfaces **66** and **67.** The movement of weight members **60** in a radial direction along support pin **61** creates a centrifugal force acting on surfaces **66** and **67** which is sufficient to generate an axial force on annular ring **62** to cause annular ring to move in a direction away from the driven clutch sleeve. Thrust washer **63** is thereby caused to move away from the driven clutch sleeve and through its abutting connection at shoulder **34** causes the driving clutch sleeve to become disengaged and moves against the biasing forces of springs **70** and **80** thereby causing separation of clutch teeth **32** and **42** at the predetermined engine self-operating speed. This action prevents the clutch teeth from being subject to periods of contact while the pinion is rotating at a speed greater than that of the power shaft.

The starter gearing is further designed to provide an indexing function when the pinion gear **41** is moved to the right but abuts one of the teeth of the starter gear **200** thereby preventing engagement of the driven gear's teeth **41** with the ring gear **200.** When abutment occurs axial movement by the driven sleeve is obstructed by the ring gear, but the shifting mechanism, attached at the housing's narrowed portion **13,** will continue to shift housing **10** toward ring gear **200.** In this abutment condition, driven clutch sleeve **40,** driving clutch sleeve **30,** and intermediate member **50** stand still against ring gear **200** while the first sleeve **20,** the second sleeve **100,** and the housing first and second portion **10** and **20** continue to shift towards the engine's ring gear. The continued axial movement of sleeve **20** forces intermediate member **50** to rotate through the interaction of the helical spline **22** on sleeve **20** and the intermediate members helical spline **53.** The rotation of the intermediate member **50** causes driving sleeve **30** also to rotate and since clutch teeth **32** and **42** are in engagement, driven clutch member **40** is also forced to rotate. This rotation during abutment is known as indexing. Indexing will continue until driven sleeve gear teeth **41** rotates sufficiently to clear the engine ring gear teeth. Upon clearing the teeth of the engine ring gear, the gear teeth **41** on the driven clutch member **40** enter into engagement with the teeth on the engine ring gear. At the point of engagement the driving and driven clutch members will be moved axially forward into full engagement with the engine's ring gear. Full engagement of the driven clutch gear teeth with the engine's ring gear is attained by the axial force generated by spring **80** acting upon the driving and driven clutch sleeves to move the clutch sleeves **30, 40** axially, but not rotatably in the direction of the ring gear **200.** The reason that full engagement of the driven sleeve gear teeth with the engine's ring gear can be accomplished without separating the clutch teeth is because spring constant k_2 of the spring **80** is larger than spring constant k_1 of the spring **70.** After the driven sleeve gear teeth are fully engaged into the engine ring gear, the starter motor is activated causing shaft **5** to rotate. The helical spline **22** on the first sleeve **20** in conjunction with the axial force generated by spring **70** now causes intermediate member **50** through helical spline **53** to thread itself forward until it stops against the driving sleeve **30.** Intermediate member **50** maintains this position until the engine is started.

The starter gearing mechanism accomplishes all of the normal functions of impact cushioning, indexing, overrunning, automatic clutch teeth separation, and in addition, keeps clutch teeth **32** and **42** in full engagement during the complete indexing function, thereby greatly increasing the life of the starter gearing.

While a preferred embodiment of the invention has been disclosed, it will be apparent to those skilled in the art that changes may be made to the invention as set forth in the appended claims and, in some instances, certain features of the invention may be used to advantage without corresponding use of other features.

Accordingly, it is intended that the illustrated and descriptive materials herein be used to illustrate the principles of the invention and not to limit the scope thereof.

Having discribed the invention, what is claimed is:

1. Starter gearing comprising:

a shaft;

a intermediate member having a forward end and a rearward end;

means for mounting said intermediate member on said shaft, said means including:

means for providing axial and rotational movement of said member mounted on said shaft; and

means for biasing said member in the forward direction so that when a force is applied in the rearward direction, said member moves axially and rotatably in a rearward direction and when said force is removed, said member returns to its original position;

a driving clutch sleeve having a forward and rearward end, said forward end having axially extending clutch teeth;

means for mounting said driving sleeve on said intermediate member, said means including:

means for providing axial movement of said driving sleeve with respect to said intermediate member; and

means for biasing said driving sleeve in the forward direction so that when a force is applied in the rearward direction, said driving sleeve moves axially in a rearward direction and when said force is removed, said driving sleeve returns to its original position;

a driven clutch sleeve having radially extending gear teeth on one end portion and axially extending clutch teeth on the opposite end; and

means for mounting said driven sleeve on said shaft for rotational and axial movement with respect to said shaft, said driven sleeve disposed so that the clutch teeth of said driven sleeve engage said driving sleeve clutch teeth for transmitting torque between said driving sleeve and said driven sleeve to rotate said driven sleeve;

whereby when a rearward force is applied to said driven sleeve, said driven sleeve and said driving sleeve move axially rearward with respect to said intermediate member and said intermediate member moves rotatably and axially rearward with respect to said shaft, so that when said rearward force is removed said driving clutch sleeve moves in a direction of said driven clutch sleeve while said mutually engageable clutch teeth are maintained in full engagement.

2. The starter gearing recited in claim **1** wherein the means for biasing said intermediate member includes a spring having a spring constant k_1 and wherein the means for biasing said driving sleeve includes a spring having a spring constant k_2, which is greater than k_1.

3. The starter gearing recited in claim **2** wherein k_2 is between **1.5** and **2.7** times the magnitude of k_1.

4. The starter gearing as recited in claim **3** wherein the means for mounting the intermediate member on the shaft for axial and rotational movement of said member includes a helical spline on one portion of said member.

5. The starter gearing as recited in claim **4** wherein the means for mounting said driving sleeve on said intermediate member for axial movement of said driving sleeve with respect to said member includes a straight spline on said driving sleeve that mates with a straight spline on a portion of said member.

6. The starter gearing as recited in claim **5** including:

means for separating the clutch teeth of said driving sleeve from the clutch teeth of said driven sleeve by moving said driving sleeve in a first direction away from said driven sleeve when said driven sleeve rotates above a predetermined speed.

7. Starter gearing comprising:

a barrel shaped housing having a central axis and a passage therethrough, said housing having a first portion and a second portion axially aligned with said first portion; said second portion having a first end and an opposite end; said first portion having a first end and an opposite end having a narrowed portion; and

a first sleeve having an outside end portion mounted to the narrowed portion of said housing, said first sleeve having a helical spline on the other outside end portion, and a straight spline on the inside surface of said sleeve;

a second sleeve axially aligned with and adjacent to said first sleeve; said second sleeve connected at one end to one end of said first sleeve;

a driving sleeve coaxially disposed with respect to said first and second sleeve, said driving sleeve having a straight spline on one portion of the outside surface and axially extending clutch teeth on one end;

a driven sleeve coaxially disposed and mounted to said second sleeve adjacent to said driving sleeve, said driven sleeve having radially extending gear teeth on one end and axially extending clutch teeth on the other end which engage said driving sleeve clutch teeth for transmitting torque between said driving and driven sleeves to rotate said driven sleeve, said driven sleeve having an annular recess formed on the inside surface of said other end;

a member moveably mounted on said first sleeve, said member having a first end portion, a second opposite end portion, a passage therethrough, a helical spline at said first end portion of said passage and a straight spline at the other opposite end portion of said passage, the helical spline of said member engaging the helical spline of said first sleeve so that said member is rotatably and slidably mounted to said sleeve, said straight spline of said member engaging the straight spline of said driving sleeve, so that said driving sleeve is slidably but nonrotatably mounted to said member;

means for separating the clutch teeth of said driving sleeve from the clutch teeth of said driven sleeve by moving said driving sleeve in a first direction away from said driven sleeve when said driven sleeve rotates above a predetermined speed, said separating means including:

an annular ring having an inner inclined surface;

means for mounting said ring to said one end of said driving sleeve;

a plurality of arcuate centrifugal weight members disposed adjacent said ring, each of said weight members having an inclined surface; and

means for mounting said centrifugal weight members so that said inclined surfaces of said centrifugal weight members abut said inclined surfaces of said annular ring, said inclined surfaces operative to axially displace said annular ring and said driving sleeve in the direction of said narrowed portion of said housing when said driven sleeve rotates above said predetermined speed;

means for axially biasing said driven and driving sleeve so that their teeth are in an engaged position until said driven sleeve reaches said predetermined speed, said biasing means including:

means for connecting the first end of said housing first portion to the first end of said housing second portion, said connecting means including:

a biasing element disposed between the first end of said housing second portion and the first end of said housing first portion; and

means for retaining said biasing element between said first and second housing portion so that axial movement one direction of either portion

of the housing with respect to the other will increase the biasing force;

means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve when said driving sleeve moves in the direction of said driven sleeve, said means including:

a first means for biasing said member in the direction of said driving sleeve, said biasing means including a first spring axially disposed between said housing and said member, said spring having a spring constant (k_2); and

a second means for biasing said driving sleeve in the direction of said driven sleeve, said second biasing means including a second spring axially disposed between said housing and said driving sleeve, said spring having a spring constant (k_2) which is greater than (k_1);

whereby when an axial force is applied to the driven sleeve gear teeth, in a first direction of the narrowed portion of said housing, said driven sleeve, said driving sleeve and said member move axially and rotatably in said first direction, said driving sleeve moving axially along the straight spline on said member and also following the movement of said member which follows the helical spline of said first sleeve causing said first spring and said second spring to compress so that when said axial force is removed, said second spring, having the greater spring constant (k_2), will force said driving sleeve to move axially but nonrotatably in a second opposite direction along said straight spline on said member thereby allowing the driving and driven sleeves to keep the clutch teeth in engagement before the first spring, with the lower spring constant, forces said members to move axially and rotatably in said second direction along the helical spline on said first sleeve.

8. In combination with an internal combustion engine of the type having a gear for starting rotation of the engine crankshaft and a starter for rotating said engine gear, said starter including: a rotatable power shaft; a first sleeve coaxially, slidably and rotatably mounted on said shaft, said first sleeve adapted to operatively engage said power shaft and rotate therewith; a driven clutch sleeve coaxially, slidably and rotatably mounted on said first sleeve, said driven sleeve having radially extending gear teeth on one end and axially extending clutch teeth on the other end; a driving clutch sleeve coaxially, slidably and rotatably mounted on said first sleeve adjacent said driven sleeve, said driving sleeve having axially extending clutch teeth on one end which include surfaces engageable with said driven sleeve clutch teeth for transmitting torque between said driven and driving sleeves; means for separating the clutch teeth of said driving sleeve from the clutch teeth of said driven sleeve by moving said driving sleeve in a direction away from said driven sleeve when said driven sleeve rotates above a predetermined speed; wherein the improvement comprises:

means for keeping the clutch teeth of said driven sleeve in engagement with the clutch teeth of said driving sleeve when said driving sleeve moves in a direction of said driven sleeve.

9. The combination as recited in claim **8** wherein the means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve when said driving sleeve moves in the direction of said driven sleeve comprises:

a first means for biasing said driving sleeve in the direction of said driven sleeve; and

a second means for biasing said driving sleeve in the direction of said driven sleeve, said second biasing means exerting a greater biasing force on said driving sleeve than said first biasing means exerts on said driving sleeve,

whereby when an axial force is applied to the driven sleeve gear teeth, in a first direction, said driven and driving sleeves move axially and rotatably; and when said force is removed, said second biasing means having the greater biasing force causes said driven and driving sleeves to move axially but nonrotatably with respect to said first sleeve in a second opposite direction before moving rotatably by action of said first biasing means thereby allowing the driving and driven sleeves to keep the clutch teeth in engagement when said driving sleeve moves in the direction of said driven sleeve.

10. Starter gearing comprising:

an elongated member having a central axis, an outside surface, and driving means on one portion of said outside surface;

a driven clutch sleeve coaxially, slidably and rotatably mounted on said member, said driven sleeve having radially extending gear teeth on one end and axially extending clutch teeth on the other end;

a driving sleeve coaxially disposed with respect to said member adjacent said driven sleeve, said driving sleeve having axially extending clutch teeth on one end which include surfaces engaged with said driven sleeve clutch teeth for transmitting torque between said driven and driving sleeves;

means for mounting said driving sleeve for biased axial and rotational movement with respect to said member;

means for separating the clutch teeth of said driven sleeve from the clutch teeth of said driving sleeve by moving said driving sleeve in a first direction away from said driven sleeve when said driven sleeve rotates above a predetermined speed; and

means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve when said driving sleeve and said driven sleeve, which have been axially disposed in said first direction, move in a direction opposite said first direction.

11. The combination as claimed in claim **10** wherein said means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve when said driving sleeve moves in a direction of said driven sleeve includes:

a housing having a passage therethrough, said passage having a narrow portion at one end, said narrow portion coaxially mounted to one end of said elongated member;

a cup shaped member having a central axis and an inside surface, said inside surface having a first portion coaxially disposed with said central axis and a second portion transverse to said central axis, said second portion having a first means for receiving the driving means on one portion of the outside surface of said elongated member, said first receiving means coaxially disposed with the driving

means on one portion of the outside of said elongated member for communication therewith, said first portion having second means for receiving said mounting means of said driving sleeve for biased axial and rotational movement with respect to said elongated member and for axial but nonrotatable movement with respect to said driving sleeve;

a first means for biasing said cup shaped member into engagement with said driving sleeve; and

a second means for biasing said driving sleeve into engagement with said driven sleeve.

12. Starter gearing comprising:

an elongated member having a central axis;

a driven clutch sleeve coaxially, slidably and rotatably mounted on said member, said driven sleeve having radially extending gear teeth on one end and axially extending clutch teeth on the other end;

a driving clutch coaxially and slidably mounted on said member for limited and biased rotatable movement therewith, said driving sleeve disposed adjacent said driven sleeve and having axially extending clutch teeth on one end which include surfaces engaged with said driven sleeve clutch teeth for transmitting torque between said driven and driving sleeves; and

means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve when said driving sleeve moves in a direction of said driven sleeve.

13. Engine starter gearing as recited in claim **12** wherein the means for keeping the clutch teeth of said driving sleeve in engagement with the clutch teeth of said driven sleeve includes:

means for biasing said driving sleeve in the direction of said driven sleeve, said biasing means including a first spring having a spring constant k_1 and a second spring having a spring constant k_2 which is at least **1.5** times greater than k_1.

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