June 19, 1923. 1,459,618

E. I. DEUTSCH

ENGINE STARTER

Filed Sept. 25, 1920 4 Sheets-Sheet 1

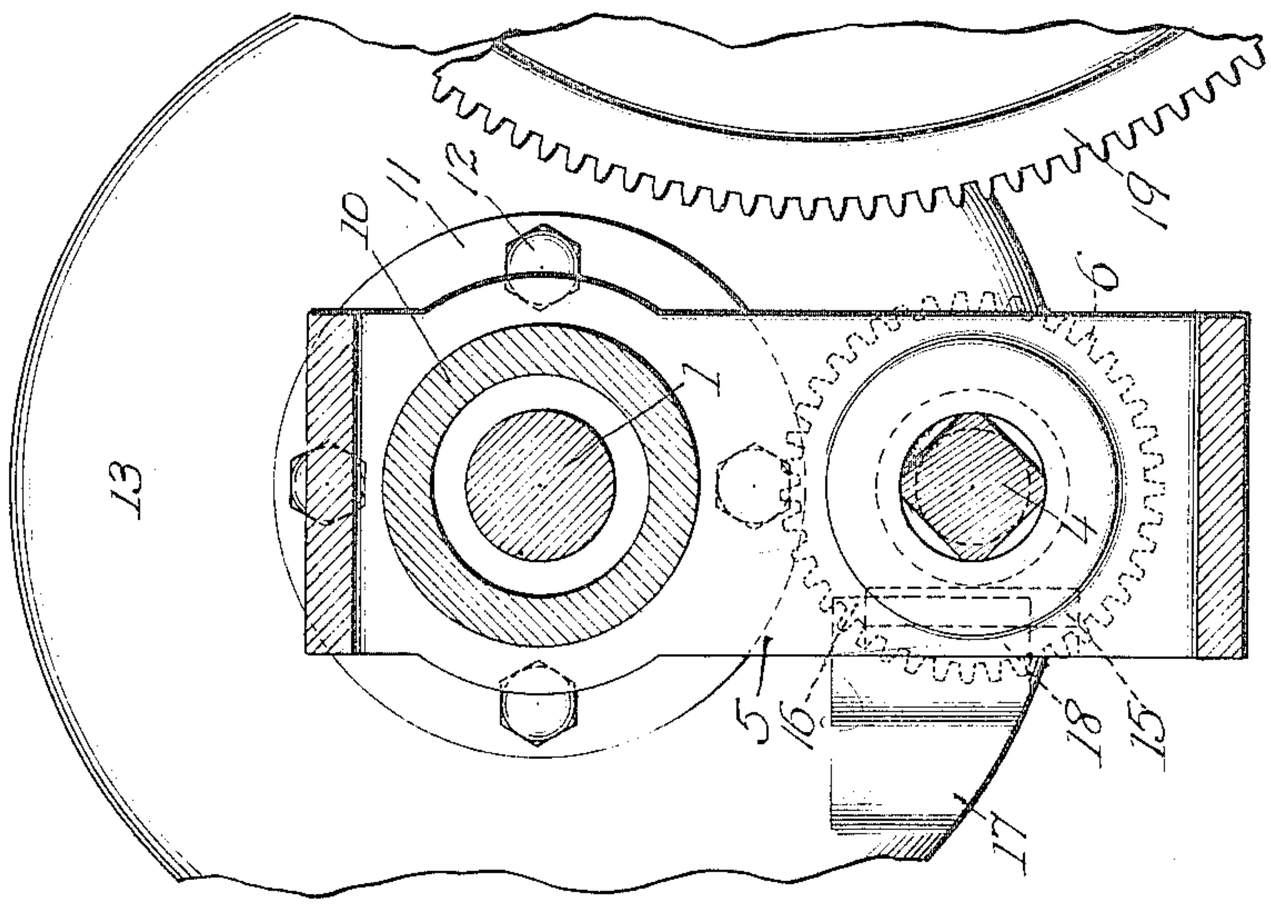

Fig. 2.

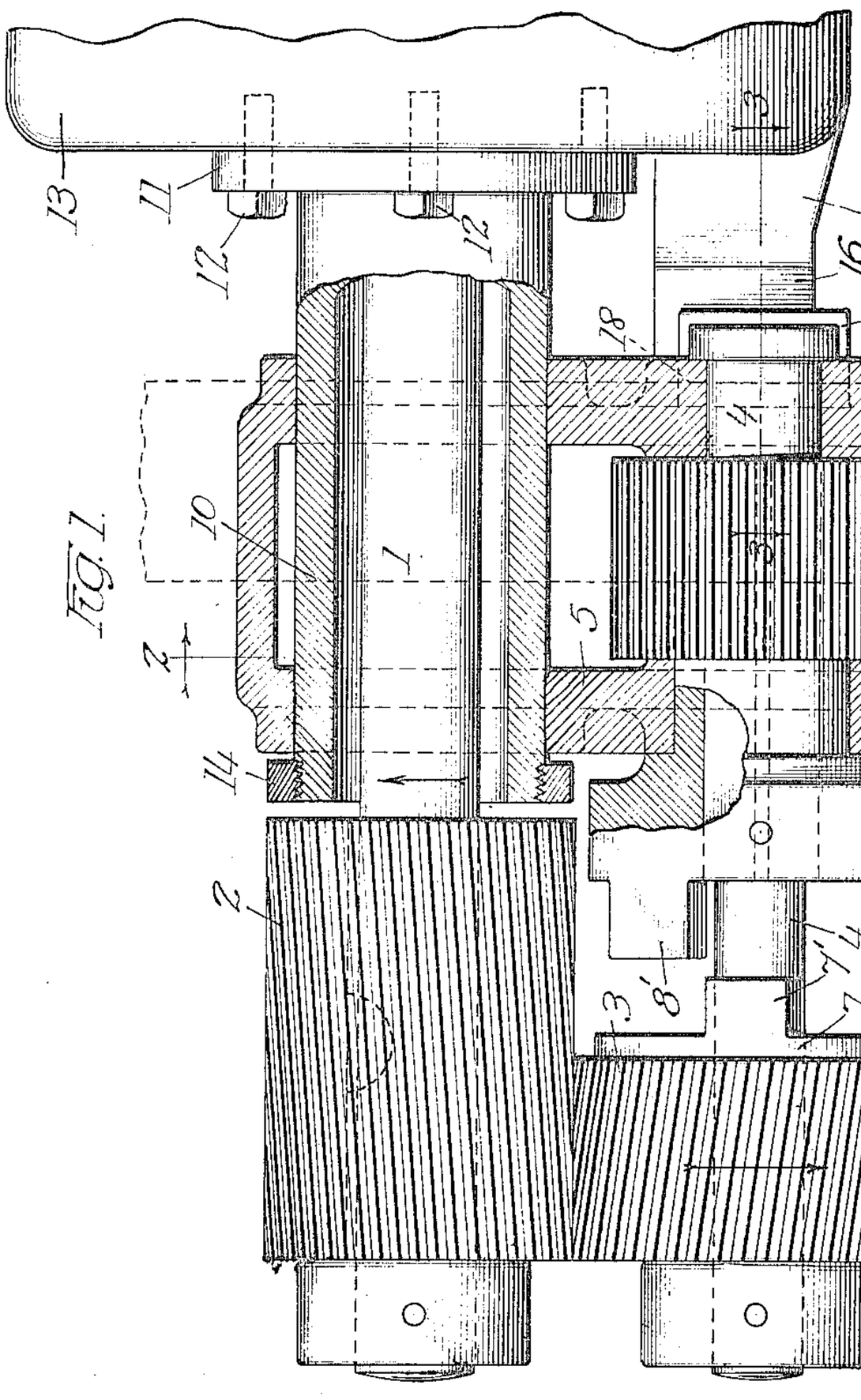

Fig. 1.

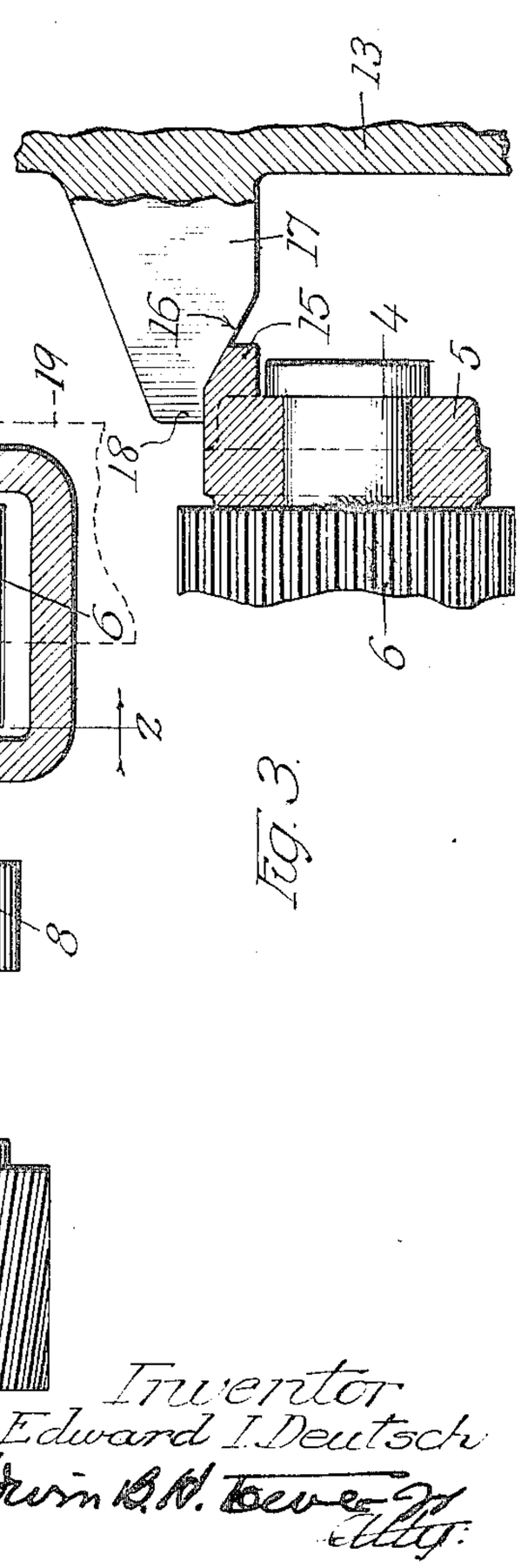

Fig. 3.

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ENGINE STARTER

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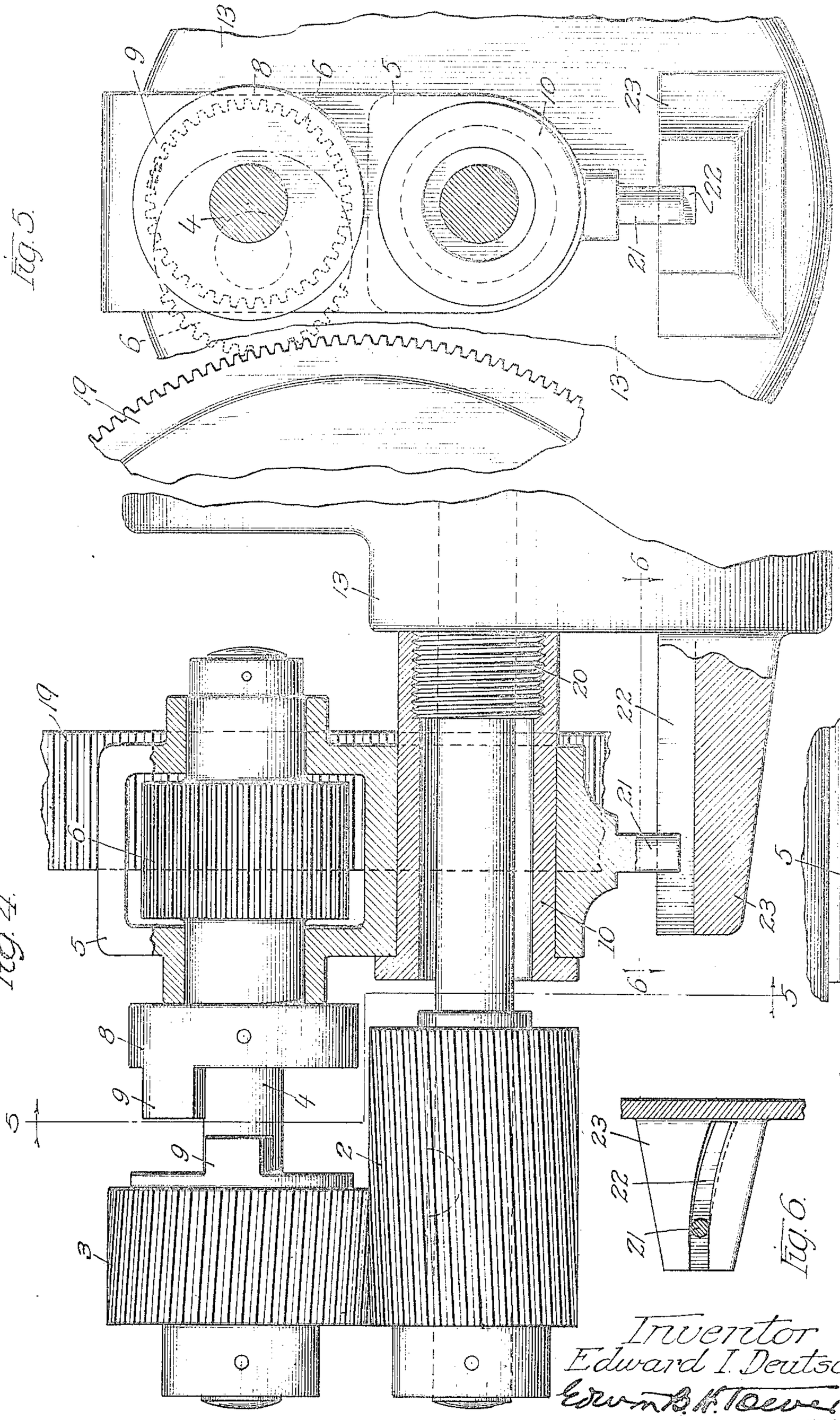

Fig. 5.

Fig. 4.

Fig. 6.

Fig. 6a.

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ENGINE STARTER

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Fig. 7.

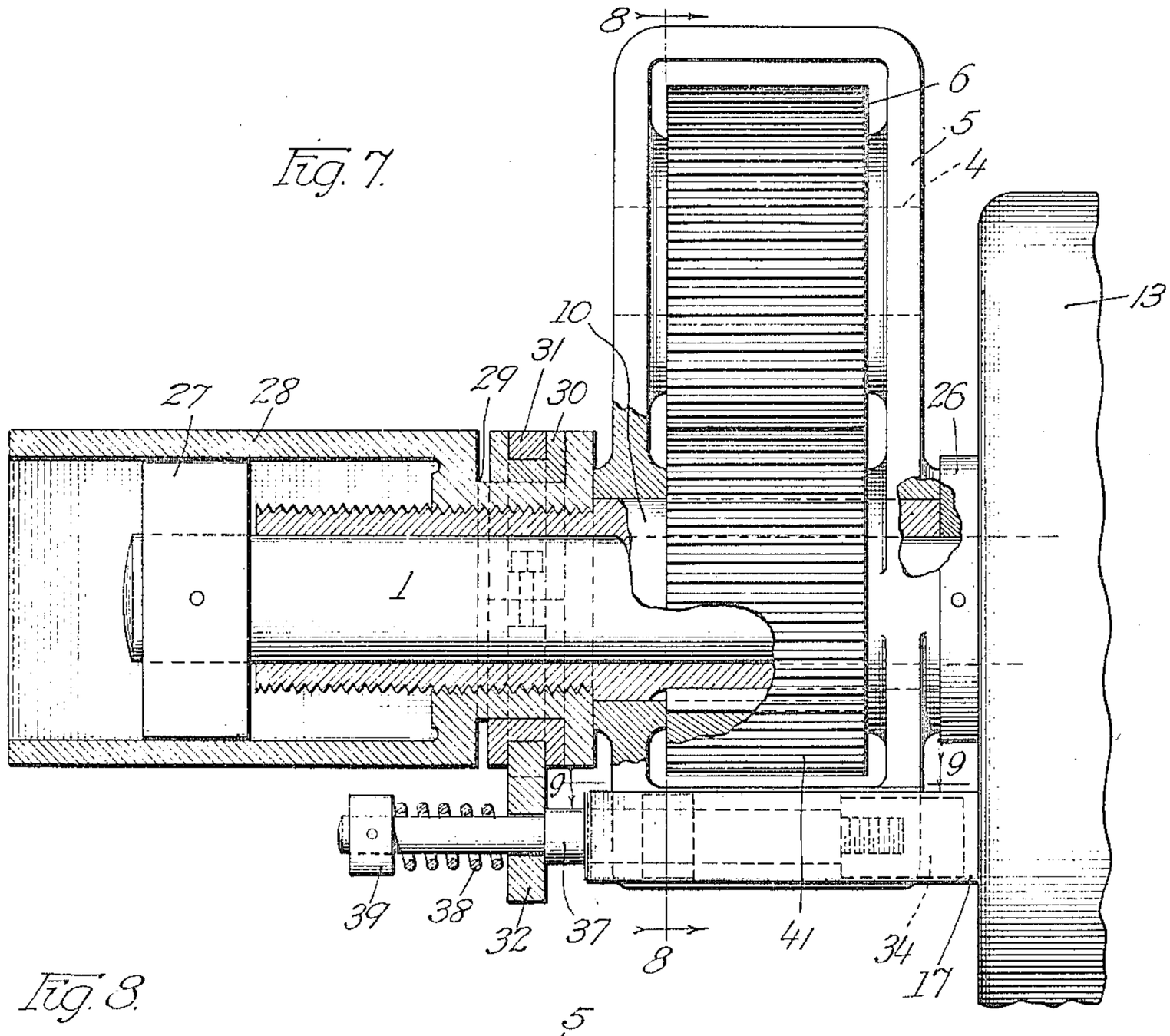

Fig. 8.

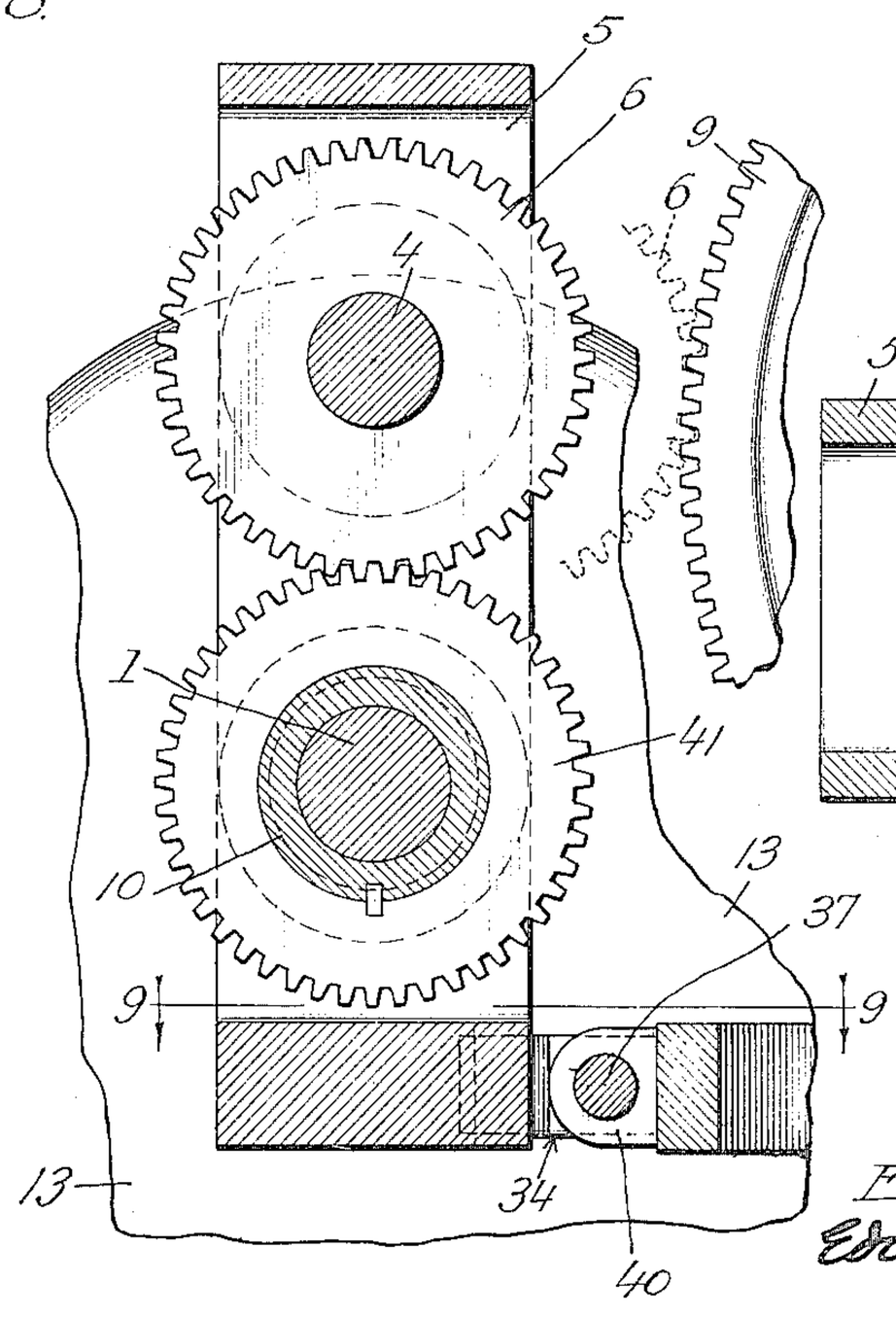

Fig. 9

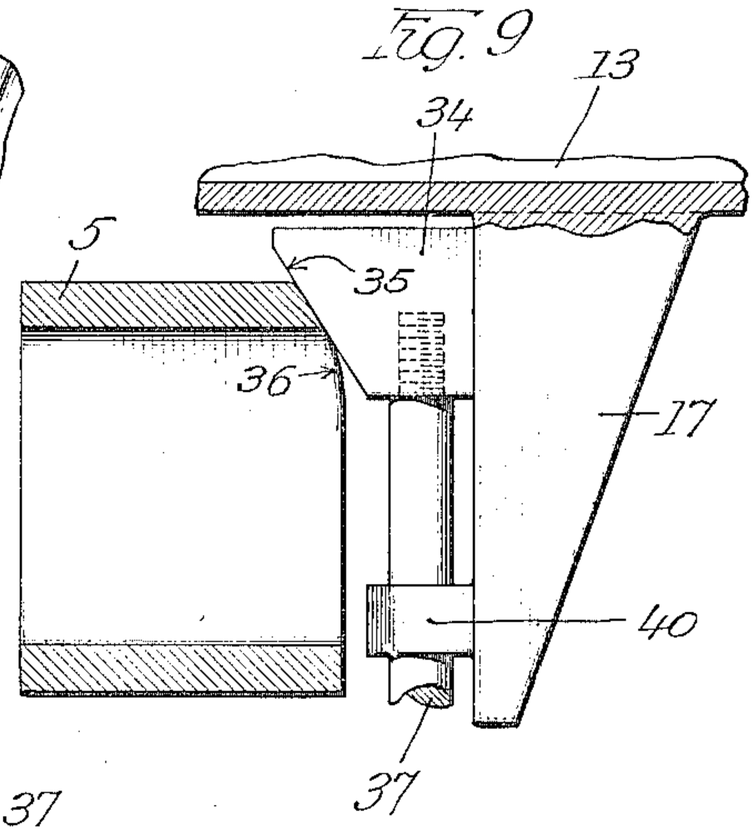

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Fig. 10.

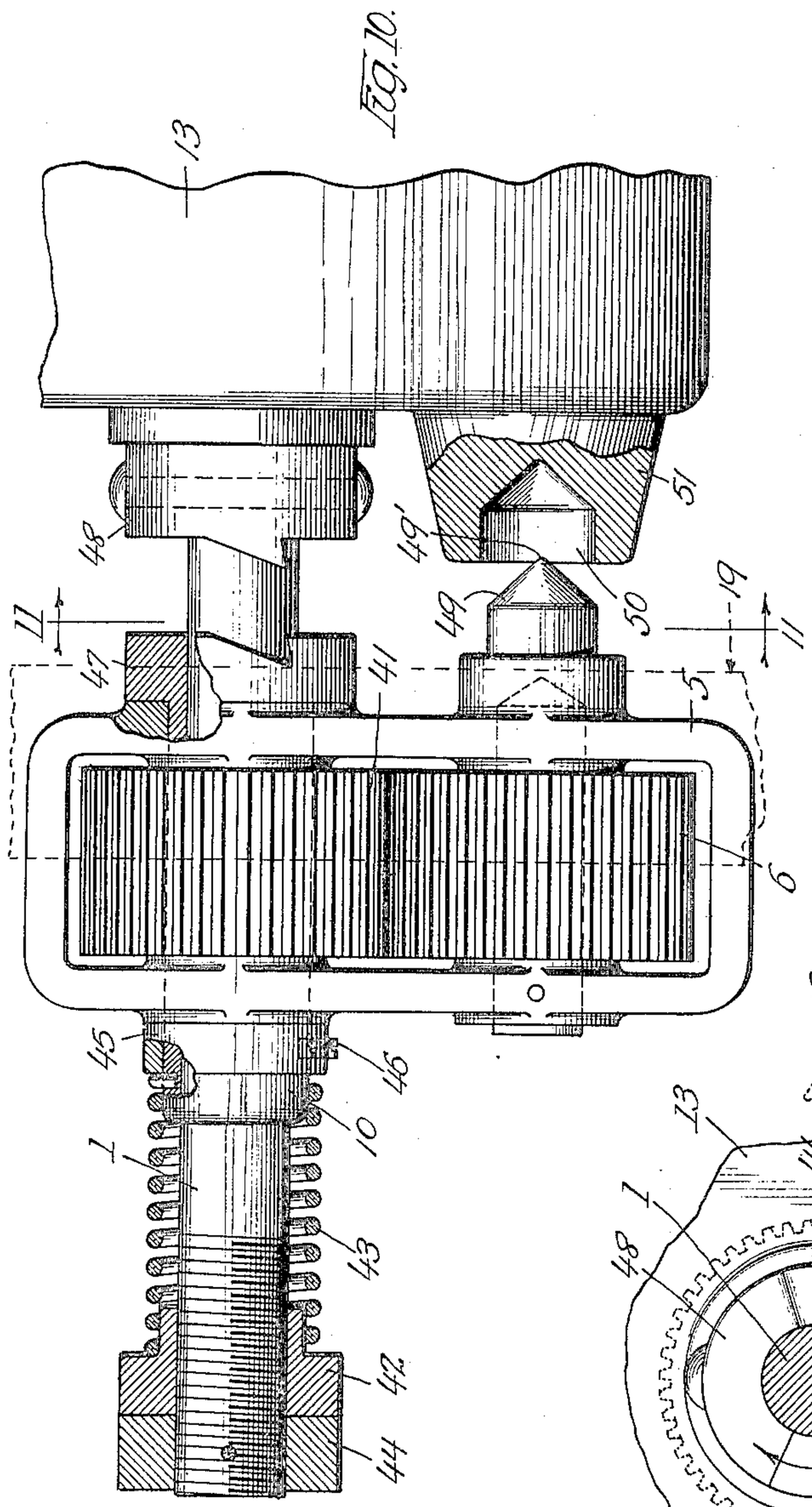
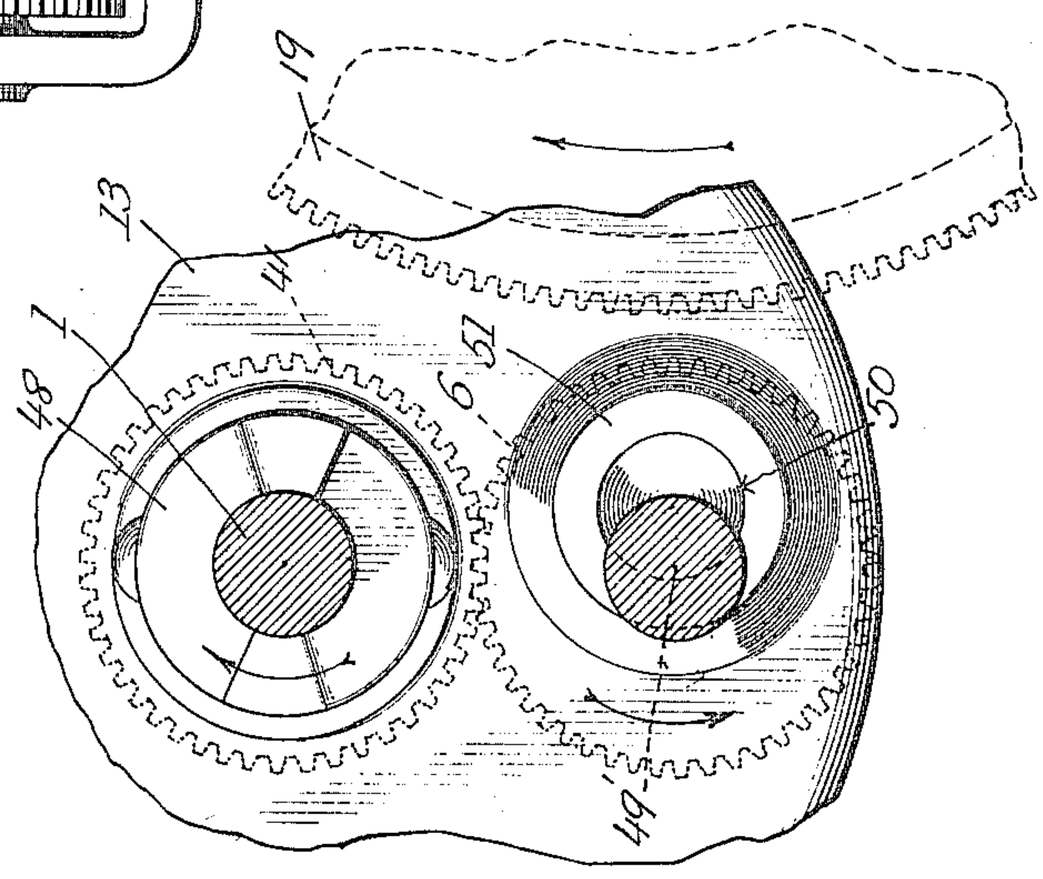


Fig. 11.



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Patented June 19, 1923. 1,459,618

UNITED STATES PATENT OFFICE.

EDWARD I. DEUTSCH, OF MILWAUKEE, WISCONSIN.

ENGINE STARTER.

Application filed September 25, 1920. Serial No. 412,730.

To all whom it may concern:

Be it known that I, EDWARD I. DEUTSCH, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented new and useful Improvements in Engine Starters, of which the following is a specification.

This invention relates to an engine starter.

The engine starter to which the invention particularly applies comprises, in general, a normally disengaged driving pinion which when the starting motor operates is moved into engagement with the engine gear and when the engine is operating under its own power, is thrown out of engagement therewith.

The engine starters now employed have several serious disadvantages. Among these may be mentioned the frequent breakage of the teeth of the engine gear, the wedging of the driving pinion on its threaded shaft at either limit of its movement, and the creepage of the pinion toward the engine gear while the engine is running.

The frequent breakage of teeth is caused by the heavy impact with which the pinion moves against the engine gear. This heavy impact is due to the heavy spring employed between the driving shaft and the pinion. This spring not only serves as a yielding connection for moving the pinion into engagement with the engine gear but forms a driving connection between the driving shaft and the engine and therefore must be made heavy.

The wedging of the driving pinion in driving position is due to the excessive friction between the screw shaft and the pinion resulting from the utilization of the screw threads for establishing a driving connection between the shaft and the pinion.

Even though the spring is made very heavy to afford a driving connection, still there is a partial demeshing of the pinion and engine gear when the engine passes over a compression point. Thus hammering or knocking in the starter results which is not only noisy but is detrimental thereto.

The creepage of the pinion while the engine is running is due to the great pitch of the threads of the screw shaft and to the weighted pinion being free. Various schemes have been devised for preventing creepage of the pinion. These however have not only been unsuccessful but have actually been detrimental to the starter in that they tend to bind the weighted pinion to the screw shaft, while the successful operation of the starter depends upon the pinion being free on the screw shaft.

An object of the invention is to provide an improved engine starter wherein these disadvantages will be overcome.

Another object is to provide an engine starter wherein greater cranking power is available for cranking the engine and the drain on the storage battery is reduced.

Another object is to provide in an engine starter a driving pinion the movement of which from non-driving to driving position is delayed so as to make available for cranking purposes the kinetic energy developed in the motor armature.

Another object is to reduce the stresses upon the driving shaft.

Another object is to reduce the breakage of gear teeth.

Another object is to provide an engine starter which is in running balance.

Another object is to provide an engine starter having inherent characteristics preventing creepage of the driving pinion while the engine is running.

Another object is to provide an engine starter which may be mounted on either side of the engine gear without employing an outboard bearing.

Another object is to provide an engine starter having a relatively low disengaging speed.

Another object is to provide an engine starter in which driving relation with the engine depends upon the acceleration of the driving shaft.

Another object is to provide an engine starter wherein the tendency of the driving pinion to wedge is reduced or eliminated.

Other objects and advantages will appear from the description and claims.

According to the invention, the engine starter comprises a normally balanced pinion adapted to become unbalanced due to operation of the driving shaft and connections therebetween and to be moved into engagement with the engine gear.

The views of the drawings are:

Fig. 1 is a side elevation, partly in section, of an engine starter employing spiral gears between the motor and the driving pinion;

Fig. 2 is a vertical section on line 2—2 of Fig. 1;

Fig. 3 is a section on line 3—3 of Fig. 1;

Fig. 4 is a side elevation, partly in section, of an engine starter wherein the force of gravity is utilized in meshing the driving pinion with the engine gear;

Fig. 5 is a vertical section on line 5—5 of Fig. 4;

Fig. 6 is a section on line 6—6 of Fig. 4;

Fig. 6ª shows a guide for the yoke requiring no external cooperative parts;

Fig. 7 is a side elevation, partly in section, of an engine starter wherein the driving pinion is bodily movable only in a vertical plane to effect engagement with the engine gear;

Fig. 8 is a vertical section on line 8—8 of Fig. 7;

Fig. 9 is a section on line 9—9 of Fig. 7;

Fig. 10 is a side elevation, partly in section, of an engine starter wherein a yielding operating connection is employed to effect a positive or substantially non-yielding driving connection between the motor shaft and the engine gear; and

Fig. 11 is a vertical section on line 11—11 of Fig. 10.

Figures 1 to 3 will first be described.

The motor shaft 1 carries a spiral gear 2 mounted to rotate therewith.

The spiral gear 2 meshes with a spiral gear 3 loosely mounted on a shaft 4 to rotate independently thereof and to travel longitudinally thereon.

The shaft 4 is journalled in a swinging yoke 5. The shaft 4 carries a driving pinion 6 mounted to rotate therewith.

In order that the driving pinion 6 may be driven by the motor shaft 1 through the spiral gears 2 and 3, a clutch is interposed between the spiral gear 3 and the shaft 4.

The clutch comprises a driving member 7 secured to and rotatable with the spiral gear 3 and a driven member 8 mounted on the shaft 4 to rotate therewith.

The driving clutch member 7 has a tooth or projection 7′ adapted to engage a tooth or projection 8′ on the driven clutch member 8 and drive the same as when starting the engine.

Opposite faces of the projections 7′ and 8′ are adapted to engage when the clutch member 8 becomes the driving member thus to drive the clutch member 7 when the engine is started and is operating under its own power as will more fully hereinafter appear.

The yoke 5 is pivotally mounted on a sleeve 10 surrounding but spaced from the motor shaft 1 and having a flange 11 by which through the cooperation of bolts 12 it is fastened to the motor frame 13.

The yoke 5 is adapted to swing in a vertical plane about its pivot—the sleeve 10, and is also adapted to travel longitudinally thereon, the longitudinal movement depending upon the acceleration of the drive shaft.

The flange 11 and bolts 12 limit the longitudinal travel of the yoke 5 in one direction, and the flange 14 in the other. The flange 14 may take the form of a ring having screw threaded engagement with the end of the sleeve.

To effect rotary movement of the yoke 5 and pinion 6 about the sleeve 10, the yoke has a boss 15 adapted to ride along an inclined track 16 on the projection 17 extending from the motor frame 13.

The forward extension 18 of the projection 17 serves as a stop to limit the vertical movement of the yoke 5 in one direction. The boss 15 of the yoke 5 normally rests against the stop 18.

The operation of the engine starter illustrated in Figs. 1 to 3 is:

The motor is started and the motor shaft 1 rotates in the direction indicated by the arrow thereon. The spiral gear 2 mounted thereon also rotates in the same direction.

The spiral gear 3 is driven by the gear 2 in the direction indicated by the arrow thereon.

As the driving motor and its shaft 1 are accelerated the spiral gear 3 is not only rotated but is accelerated, thereby being caused to travel to the right along the shaft 4.

After gear 3 has traveled a short distance along the shaft 4, the tooth 7′ of the driving clutch member 7 engages the tooth 8′ of the driven clutch member 8. The spiral gear 3 clutch members 7 and 8, shaft 4 and driving pinion 6 thereupon rotate as a unit.

The driving pinion 6 upon the engagement of the clutch members is not only rotated, but is accelerated, its rotational velocity changing with the rotational velocity of the driving shaft.

This acceleration of the driving pinion then reacts upon the driving mechanism intermediate the driving shaft and pinion developing biasing forces for causing the movement of the pinion toward the engine gear.

As the longitudinal movement of the spiral gear 3 continues under propulsion of the meshing spiral gear and the biasing forces, the yoke 5 is caused to travel to the right along the sleeve 10 moving the driving pinion therewith and toward the engine gear. During such longitudinal movement of the yoke and the driving pinion and other parts carried thereby the boss 15 on the yoke slides along the relatively stationary track 16 thereby swinging the yoke and driving pinion about the supporting sleeve 10.

Thus the yoke is caused to travel longitudinally along the supporting sleeve 10 in a horizontal plane and to swing about the same in a vertical plane.

From this description of the engine starter and the operation thereof it will be evident that the movement of the driving pinion into engagement with the engine gear depends

upon the acceleration of the driving shaft; also since the yoke 5 is caused to travel both longitudinally and rotatively with respect to the supporting sleeve 10, and since the driving pinion moves therewith, it will travel in a plane oblique to its axis of rotation.

The engine gear 19 of the engine to be started is positioned in front and to the right of the driving pinion 6.

The pinion 6 is moved in both a horizontal and a vertical plane into engagement with the engine gear 19.

When the pinion 6 is in engagement with the engine gear 19, there is a positive or substantially non-yielding driving connection between the motor shaft 1 and the engine gear 19 through the meshing spiral gears 2 and 3, the clutch members 7 and 8, the shaft 4 and the pinion 6.

Thus the engine is driven by the motor in starting.

When the engine operates under its own power, the speed of the engine gear 19 exceeds that of the motor shaft 1 and drives back through the pinion 6, shaft 4 and clutch to the spiral gears.

The speed of the driven clutch member 8 exceeds that of the driving clutch member 7, so that the tooth 8′ of the member 8 moves away from the tooth 7′ of the other clutch member 7; it rotates until it has gained substantially a complete revolution on the clutch member 7 and then engages the opposite face of the tooth of the clutch member 7. The clutch member 8 now becomes the driving member, and the clutch member 7 the driven member.

Thus the speed of the spiral gear 3 increases because driven by the engine gear 19. Consequently, the spiral gear 3 becomes the driving gear with respect to the gear 2.

The spiral gear 3 being driven at high speed by the engine will be caused to move to the left along the shaft 4 and with respect to the spiral gear 2. At the moment the clutch members disengage, the spiral gear 3 has sufficient velocity to cause the continued movement thereof along the shaft 4 until it engages the nut or collar at the end of the shaft. At such time the velocity of the spiral gear 3 is still sufficient to cause it to carry along with it the shaft 4 and yoke 5.

Thus the yoke 5 is caused to travel to the left along the supporting sleeve 10. During this longitudinal movement, the yoke rides down the track 16 and swings about the supporting sleeve 10.

Thus the driving pinion 6 is moved out of engagement with the engine gear 19, and, the motor having been stopped, the starter is restored to its normal position of rest.

The thrust between the spiral gears 2 and 3 is a function of the rate of acceleration of the driving shaft 1, the angle of the teeth of the spiral gears, and the inertia of the parts to be accelerated.

Since each of these factors can be determined readily when designing an engine starter, it is possible to predetermine the thrust between the spiral gears of the required starter for an engine of a known rating. Thus in such starters, it will be impossible to exert a meshing thrust greater than the predetermined thrust. Furthermore the starter may be so designed and constructed as to have a low meshing thrust.

A starter of low meshing thrust has the advantage that the breakage of teeth on the engine gear is reduced. This breakage of teeth, which is a serious disadvantage of previous starters, is caused by the great impact of the driving pinion against the engine gear when moving into engagement there with. The impact is a function of the weight of the pinion and the force or meshing thrust required to move it into engagement with the engine gear. Thus the low meshing thrust of the present starter reduces breakage of teeth of the engine gear.

Due to the low meshing thrust between the spiral gears wedging of the pinion and of the spiral gears at either limit of movement—the meshing and demeshing positions—is reduced or eliminated.

During the movement of the pinion from non-driving to driving position it rotates and is accelerated, there being a difference in angular velocity of the accelerating driving pinion and shaft. The longitudinal movement of the pinion from non-driving to driving position being a function of this difference in angular velocity, the pinion will have but little longitudinal movement for each revolution of the driving shaft as compared to the longitudinal movement thereof in case the pinion is prevented from rotating; consequently, the pinion does not reach driving position until the driving motor has attained considerable speed.

Thus, when the pinion reaches driving position the motor armature has acquired considerable kinetic energy commonly known as "fly wheel effect," which is available for cranking the engine.

This "fly wheel effect" is in addition to the normal torque of the motor.

By thus utilizing the "fly wheel effect" of the motor armature to assist in cranking the engine, there is less drain on the storage battery from which the motor is operated and greater cranking power is available.

Figures 4 to 6 show an engine starter which differs from that shown in Figs. 1 to 3 merely in that the weight of the yoke 5 and the parts carried thereby is utilized to assist in moving the driving pinion into mesh with the engine gear, and a grooved guide is employed for determining the rotary movement of the yoke

The sleeve 10 carrying the yoke 5 is internally threaded at its inner end and engages a supporting cylindrical threaded boss 20 on the motor frame 13.

The yoke 5 has a projection 21 forming a pin which travels in an angularly disposed guide slot 22 provided in the boss or projection 23 on the motor frame 13. Thus when the yoke travels to the right along the sleeve 10, the pin 21 also moves to the right in the slot 22 and in so doing the weight of the pinion carrying end of the yoke 5 causes the yoke to swing about its supporting sleeve 10. The swinging movement in the yoke cooperating with longitudinal movement thereof causes the pinion 6 to move into engagement with the engine gear 19.

Fig. 6[a] shows a guide for the yoke whereby the projection on the motor frame shown in Figs. 1 to 6 may be eliminated.

An inwardly extending pin 24 on the inside of the bore in the yoke 5 rides in a slot 25 provided in the periphery of the sleeve 10. This guide performs the same function as the guide 22 of Figs. 4 to 6.

While the unbalanced weight of the yoke should be such as to cause the engagement of the driving pinion and the engine gear, still this weight, which can be determined when designing the starter, is small enough to produce but a small impact between the pinion and engine gear when engaging. Thus the breakage of teeth is reduced.

The tendency to wedge is reduced or eliminated for the same reason as in the starter shown in Figs. 1 to 3.

Figures 7 to 9 show an engine starter in which the yoke 5 is merely rotated about its supporting sleeve 10 to move the driving pinion into engagement with the engine gear 19.

The sleeve 10 is supported by the motor shaft 1 which is free to rotate therein. The inner end of the sleeve rests against a shoulder 26 on the motor shaft 1.

The outer end of the motor shaft 1 carries a square nut 27 fastened thereto to rotate therewith.

The square nut 27 fits in the square opening of a sleeve 28 having at its inner end an opening of reduced diameter threaded to engage the threaded outer end of the sleeve 10.

Thus as the motor shaft 1 and the square nut rotate, the sleeve 28 is rotated on the sleeve 10, and is moved to the left due to the threaded engagement of the two sleeves.

The circumferential groove 29 near the inner end of the sleeve 28 carries a collar 30 supporting a ring 31 having a projection 32 in which an opening is provided.

This ring 31 and its apertured projection are moved to the left with the sleeve 28 when the motor shaft 1 is operated, and cooperates with mechanism about to be described to cause the yoke 5 to swing about its pivot and move the pinion 6 into engagement with the engine gear 19.

For this purpose, the relatively stationary projection 17 of the motor frame 13 has a horizontal track 33 along which the horizontal flat face of the wedge 34 is adapted to travel.

The inclined face 35 of the wedge 34 engages the curved face 36 at the lower edge of the yoke 5, and moves the yoke 5 about its pivot.

In order that the wedge 34 may be moved along the track 33, the projection 32 of the ring 31 is connected therewith through a rod 37. The reduced end of the rod passes through the opening in the projection 32. The projection 32 and the rod 37 are yieldingly connected together through a coiled spring 38 encircling the reduced end of the rod and seated against the stop 39 and the projection 32. The spring 38 normally holds the projection 32 against a shoulder on the rod 37.

A collar 40 fastened to the track projection 17 guides the rod and maintains the wedge 34 in operative relation to the track 33 and the yoke 5.

An intermediate pinion 41, mounted upon the sleeve 10 to rotate therewith, meshes with the pinion 6.

When the motor shaft 1 starts to rotate, the inertia of the meshing pinions 6 and 41 maintains the sleeve 10 relatively stationary and limits the rotational velocity thereof with respect to the motor shaft 1 and sleeve 28. Thus the sleeve 28 rotates on the sleeve 10 and moves longitudinally with respect thereto until the inner face or shoulder of the sleeve 28 abuts the face of the square nut 27. The sleeve 10 is thereby locked to and rotates with the sleeve 28. The sleeve 10 and the shaft 1 are thus locked together.

During the longitudinal movement of the sleeve 28, the spring 38 is first compressed and the connecting rod 37 and wedge 34 are moved longitudinally by and with the sleeve 28. Thus the wedge 34 rotates the yoke 5 about its pivot—the sleeve 10—and moves the driving pinion 6 into engagement with the engine gear 19 for starting the engine.

Thus the engine gear 19 is driven positively by the motor shaft 1 through the nut 27, locked sleeves 28 and 10 and the meshed pinions 41 and 6 which form a substantially non-yielding connection.

When the engine has begun to operate on its own power, the speed thereof exceeds that of the motor and causes an increase in speed of the pinion 6. This increased speed is communicated through the pinion 41 to the sleeve 10. Thus the speed of sleeve 10 now exceeds that of the sleeve 28, causing the longitudinal movement of the latter to

the right. Consequently, the wedge 34 is moved away from its position against the yoke 5. The yoke 5 is free to move about its supporting sleeve 10, and is caused to so move by the increased speed of the engine. Thus the pinion 6 is automatically moved out of engagement with the engine gear and, the motor having been stopped, the parts of the engine starter return to their normal position of rest.

The driving pinion of the starter shown in Figs. 7 to 9 and the engine gear are substantially in the same plane. The pinion and engine gear when meshing yieldingly mesh substantially along the entire length of the teeth. Since the spring 38 forms no part of the driving connection between the motor and the engine, it may be made light. Consequently, the possibility of breakage of teeth and wedging of the starter at either limit of its movement is reduced. Furthermore, the tendency of the driving pinion and the engine gear to demesh when passing over a compression point is reduced.

Figures 10 and 11 show an engine starter employing yielding means for causing the longitudinal and vertical movement of the driving pinion into engagement with the engine gear which is then driven positively from the motor shaft through a substantially non-yielding connection.

The yielding means for effecting the movement of the pinion carrying yoke into driving position comprises a nut 42 threaded on the motor shaft 1 and a coiled spring 43 encircling the shaft and secured at one end to the nut 42 and at its other to the sleeve 10 mounted to travel longitudinally on the shaft 1 and to rotate thereon.

A nut 44 secured to the outer end of the motor shaft limits the movement of the traveling nut 42 in one direction.

The sleeve 10 carries a collar 45 which when fastened thereto by a set screw 46 retains the yoke 5 in adjusted position on the sleeve 10.

The pinion 41 meshing with the driving pinion 6 is mounted on the sleeve 10 and rotates therewith.

The inner end of the sleeve 10 carries a driven clutch member 47 which rotates therewith and which is adapted to be moved into engagement with the driving clutch member 48 secured to the motor shaft 1, when the yoke 5 travels longitudinally along the shaft 1.

In order to effect the rotary movement of the yoke 5 while the same is traveling longitudinally along the motor shaft 1, the yoke carries a pointed guide pin 49 which cooperates with an opening 50 in a boss 51 on the motor frame 13.

Normally the point 49′ of the guide pin 49 is positioned just inside the opening 50 and rests against the edge thereof. As the yoke 5 travels longitudinally, it tends to force the guide pin into the opening 50, and since the inclined face of the guide pin 49 is resting on the edge of the opening, this edge travels relative to the inclined face and along the same. Consequently, the guide pin 49 moves into the cooperating opening 50, and the yoke 5 is rotated about the shaft 1 while traveling longitudinally thereon.

When the pin 49 is within the opening 50, the yoke 5 is in driving position, and the driving pinion 6 is in engagement with the engine gear 19 and the clutch members are locked together.

Thus the engine gear is positively driven from the motor shaft through the clutch members 47 and 48, the sleeve 10 and the intermediate and driving pinions 41 and 6 which constitute a substantially non-yielding connection.

When the engine is operating on its own power, its speed exceeds that of the motor. Consequently, the speed of the sleeve 10 and driven clutch member 47 will be increased and will exceed that of the motor shaft 1 and the driving clutch member 48.

The yoke will therefore be forced to travel to the left along the motor shaft 1, whereupon the clutch members will disengage and the guide pin 49 will be moved out of its cooperating opening 50. Thus the driving pinion 6 will be moved out of engagement with the engine gear 19, and, the motor meanwhile having been stopped, the parts of the engine starter will be returned to their normal positions of rest.

Spring 43 merely permits yielding meshing of the driving pinion and the engine gear, and may therefore be light. The force necessary to move the pinion into engagement with the engine gear is small. Since the spring 43 is light, the force exerted in moving the pinion into engagement with the engine gear is small; consequently the possibility of breakage of teeth is reduced.

Single threads of small pitch on the driving shaft 1 may be employed, for the driving connection between the shaft and the engine gear does not include these threads. Thus the tendency of the driving pinion to wedge is reduced.

Due to the low pitch of the threads on the traveling nut and the driving shaft there is no tendency for the pinion to move out of engagement with the engine gear until the tapered end of the guide pin 49 begins to ride along the periphery of the opening 50. Thus the tendency of the pinion and the engine gear to demesh when the engine passes over a compression point is eliminated.

The term "accelerate" as employed in the specification and claims means "to rotate with increasing angular velocity."

The invention contained herein is of course susceptible of other embodiments and adaptations.

I claim—

1. An engine starter having in combination a rotatable feed screw shaft, a pinion to be moved thereby into engagement with a part of the engine to be started, a travelling nut on the feed screw shaft yieldably connected to the pinion, a clutch member fixed to the shaft, and a second clutch member connected to the pinion and engageable with the first clutch member when the pinion meshes with the engine part to establish a driving connection between the shaft and engine part from which the screw of the shaft, the nut and the yieldable connection are excluded.

2. An engine starter having in combination with a motor driven shaft and an engine gear, a normally balanced rotatable driving pinion, and means including a biasing inertia member actuated by the shaft for moving the pinion into engagement with the engine gear, said member continuously engaging the pinion and mounted outside the axis of rotation thereof.

3. In combination with an engine to be started from an electric motor, a rotatable feed screw shaft, a pinion to be moved thereby into engagement with a part of the engine to be started, a traveling nut on the feed screw shaft yieldably connected to the pinion, and clutch members engageable when the pinion meshes with the engine part to establish between the motor and the engine part a driving connection from which the yieldable connection and traveling nut are excluded.

4. In an engine starter, the combination of a rotatable driving pinion to be moved into engagement with a part of the engine to be started, a rotatable member connected to the pinion, a rotatable driving shaft adapted to be accelerated, a nut on the shaft yieldably connected to the pinion, screw threads on the shaft engaging the nut and cooperating with the pinion and member so as to cause simultaneous motion of rotation and translation of the pinion during the period of acceleration of the driving shaft prior to contact of the pinion and engine part, and clutch members engageable when the pinion engages the engine part so as to establish a driving connection between the driving shaft and the engine part independently of the screw threads.

5. In combination with an engine to be started from an electric motor, a screw threaded shaft to be accelerated by the motor, a driving pinion, a traveling nut on the shaft yieldably connected to the pinion so the shaft will move the pinion into engagement with a part of the engine, the pitch of the screw threads and mass of the pinion being so related that the pinion has motion of both rotation and translation during the period of acceleration of the shaft prior to contact of the pinion and engine part so as to increase the duration of the translation period, and clutch members engageable when the pinion engages the engine part, so as to establish between the shaft and pinion a driving connection from which the screw threads of the shaft are excluded.

6. An engine starter having in combination, a rotatable feed screw shaft, a driving pinion to be moved thereby into engagement with a part of the engine to be started, a travelling nut on the feed screw shaft, a resilient connection between the nut and pinion, and a rotatable member bearing directly on the shaft and cooperating therewith and with the nut and pinion to cause the pinion to rotate during the motion of translation thereof, the simultaneous motion of rotation and translation of the pinion being dependent upon the acceleration of the shaft.

7. An engine starter having in combination, a rotatable feed screw shaft, a driving pinion to be moved thereby into engagement with a part of the engine to be started, a travelling nut on the feed screw shaft, a resilient connection between the nut and pinion, a rotatable member supported by the shaft in actual contact therewith and movably connected with the pinion so as to allow relative bodily movement therebetween, said member cooperating with the shaft, nut and pinion so as to cause the rotation of the pinion during the motion of translation thereof, the simultaneous motion of rotation and translation of the pinion being dependent upon the acceleration of the shaft.

8. An engine starter having in combination a rotatable feed screw shaft, a driving pinion to be moved thereby into engagement with a part of the engine to be started, a traveling nut on the feed screw shaft, and a rotatable member intermediate the shaft and pinion and cooperating therewith and with the nut to cause the pinion to rotate during the motion of translation thereof, said member being supported by the shaft independently of the pinion, the simultaneous motion of rotation and translation of the pinion being dependent upon the acceleration of the shaft.

9. Starting means for an engine to be started from a rotatable driving shaft, comprising a driving pinion pivotally supported outside its axis of rotation and mounted to travel in planes parallel and normal to its support into engagement with the engine gear, and means controlled by the driving shaft for causing the pinion to travel into engagement with the engine gear.

10. An engine starter having in combination an engine gear and a screw threaded shaft adapted to be accelerated up to constant speed, a yoke supported by the shaft, a driving pinion carried by the yoke for en-

gagement with the engine gear, a travelling nut on the shaft connected to the pinion, a non-driving meshing cushioning spring between the nut and pinion, the pitch of the screw threads and mass of the pinion being so related that the pinion has motion of both rotation and translation during the period of acceleration of the shaft prior to contact of the pinion and the engine gear so as to increase the duration of the translation period, and means for swinging said pinion into engagement with the engine gear during said period of translation.

11. An engine starter having in combination a screw threaded shaft adapted to be accelerated up to a constant speed, a yoke supported by the shaft, a driving pinion carried by the yoke for engagement with a part of the engine to be started, a traveling nut on the shaft connected to the pinion, a non-driving spring for cushioning the meshing impact between the pinion and engine part, the pitch of the screw threads and mass of the pinion being so related that the pinion has motion of both rotation and translation during the period of acceleration of the shaft prior to contact of the pinion with the engine part so as to increase the duration of the translation period, and means co-operating with said yoke during said period of translation for swinging the pinion about the shaft into engagement with the engine part.

12. An engine starter having in combination a screw threaded shaft adapted to be accelerated up to a constant speed, a driving pinion for engagement with a part of the engine to be started, a support for the pinion carried by the shaft, a traveling nut on the shaft connected to the pinion, the pitch of the screw threads and mass of the pinion being so related that the pinion has motion of both rotation and translation during the period of acceleration of the shaft prior to contact of the pinion with the engine part so as to increase the duration of the translation period, and means carried by the motor frame co-operating with such support to swing the same about the shaft during the period of translation to move the pinion into engagement with the engine part.

13. In combination with an engine to be started from an electric motor an engine gear, a screw threaded shaft to be accelerated by the motor, a driving pinion supported outside the shaft for engagement with the engine gear, a traveling nut on the shaft yieldably connected to the pinion, the pitch of the screw threads and mass of the pinion being so related that the pinion has motion of both rotation and translation during the period of acceleration of the shaft prior to contact of the pinion and engine gear so as to increase the duration of the translation period and means for moving the pinion bodily about the shaft during said period of translation into engagement with the engine gear.

14. A starter for an engine having in combination with a rotatable driving shaft and an engine gear, a yoke pivotally mounted for longitudinal movement on and rotary movement about its pivot, a pinion carried by the yoke and upon movement thereof engaging the engine gear, and connections between the shaft and the yoke for moving the latter into engaging position.

15. An engine starter having in combination with a motor driven shaft and an engine gear, a support, a yoke pivotally supported thereby, a driving pinion rotatively mounted in the yoke and movable longitudinally therewith on the support and about the same into engagement with the engine gear, and a driving connection between the motor driven shaft and the pinion.

16. An engine starter having in combination with a driving shaft and an engine gear, a driving pinion pivotally supported outside its axis of rotation and mounted to move longitudinally along its support and to swing about the same into engagement with the engine gear, and means cooperating with the driving shaft for causing the pinion to move into engagement with the engine gear and for driving the pinion.

17. An engine starter drive having in combination with an engine member, a rotatable shaft and a pinion, means for effecting engagement and disengagement of the pinion with the engine member, said means including the shaft and a member having a screw threaded connection thereto and a yielding connection to the pinion, and a driving connection established between the shaft and engine member when the pinion is in engagement with the engine member, the pinion being included in said driving connection and the screw threaded member being excluded therefrom.

18. A starter for an engine having in combination with a motor driven shaft and an engine gear, a pivoted yoke mounted for longitudinal movement on its pivot, a pinion rotatively mounted in the yoke, a connection between the driving shaft and the yoke whereby the driving shaft causes the longitudinal movement of the yoke on its pivot, and means cooperating with the yoke to cause the same to rotate on its pivot during its longitudinal movement thereon, whereby the pinion is moved into engagement with the engine gear.

19. Starting means for an engine, comprising a rotatably driving shaft, a pivotally supported rotatable driving pinion, and means cooperating with the driving shaft for causing the pinion to travel in a plane oblique to its axis of rotation into engagement with the engine gear.

20. An engine starter having in combination, a motor driven shaft and an engine gear, a support, a yoke pivoted thereon, a driving pinion rotatably mounted in the yoke and movable longitudinally therewith on the support and into engagement with the engine gear, and a driving connection between the motor driven shaft and the pinion.

21. An engine starter having in combination, a motor driven shaft and an engine gear, a support, a bracket pivoted thereon, a driving member rotatably mounted in the bracket and movable longitudinally therewith on the support and into engagement with the engine gear, and a driving connection between the motor driven shaft and the driving member.

22. An engine starter having in combination a rotatable feed screw shaft, a rotatable driving pinion, a resilient connection between the shaft and the pinion through which the shaft moves the pinion from non-driving to driving relation to the engine, and causes it to rotate during such movement, a clutch member fixed to the shaft, a clutch member connected to the driving pinion and moved into engagement with the other clutch member when the pinion reaches driving position so as to establish a direct driving connection from the shaft to the engine from which the resilient connection is excluded.

23. An engine starter through which an engine is to be started from an electric motor, a rotatable feed screw shaft a rotatable driving pinion, a traveling nut on the screw shaft, a yieldable connection between the nut and pinion through which the shaft moves the pinion from non-driving to driving relation to the engine and rotates and accelerates the pinion during such movement, a clutch member connected to the pinion and movable therewith, and a clutch member fixed to the shaft and engaged by the first clutch member upon movement of the pinion into driving position so as to establish a driving connection between the shaft and the pinion from which the yieldable connection is excluded.

In witness whereof, I have hereunto subscribed my name.

EDWARD I. DEUTSCH.