April 10, 1951 C. S. METSGER 2,548,268

ENGINE STARTER MESHING MEANS

Filed Nov. 13, 1947 2 Sheets-Sheet 1

Fig. 1

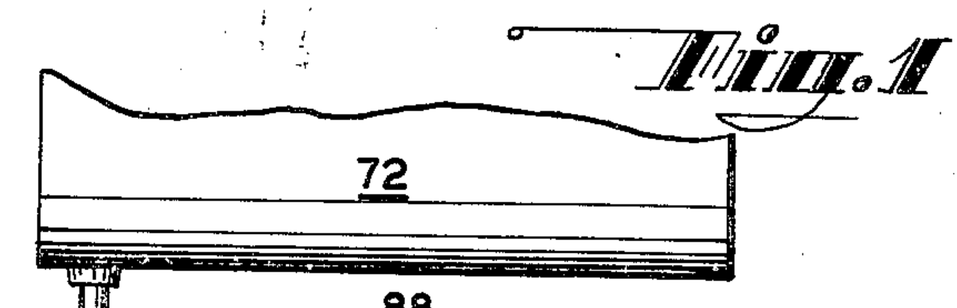


Fig. 2

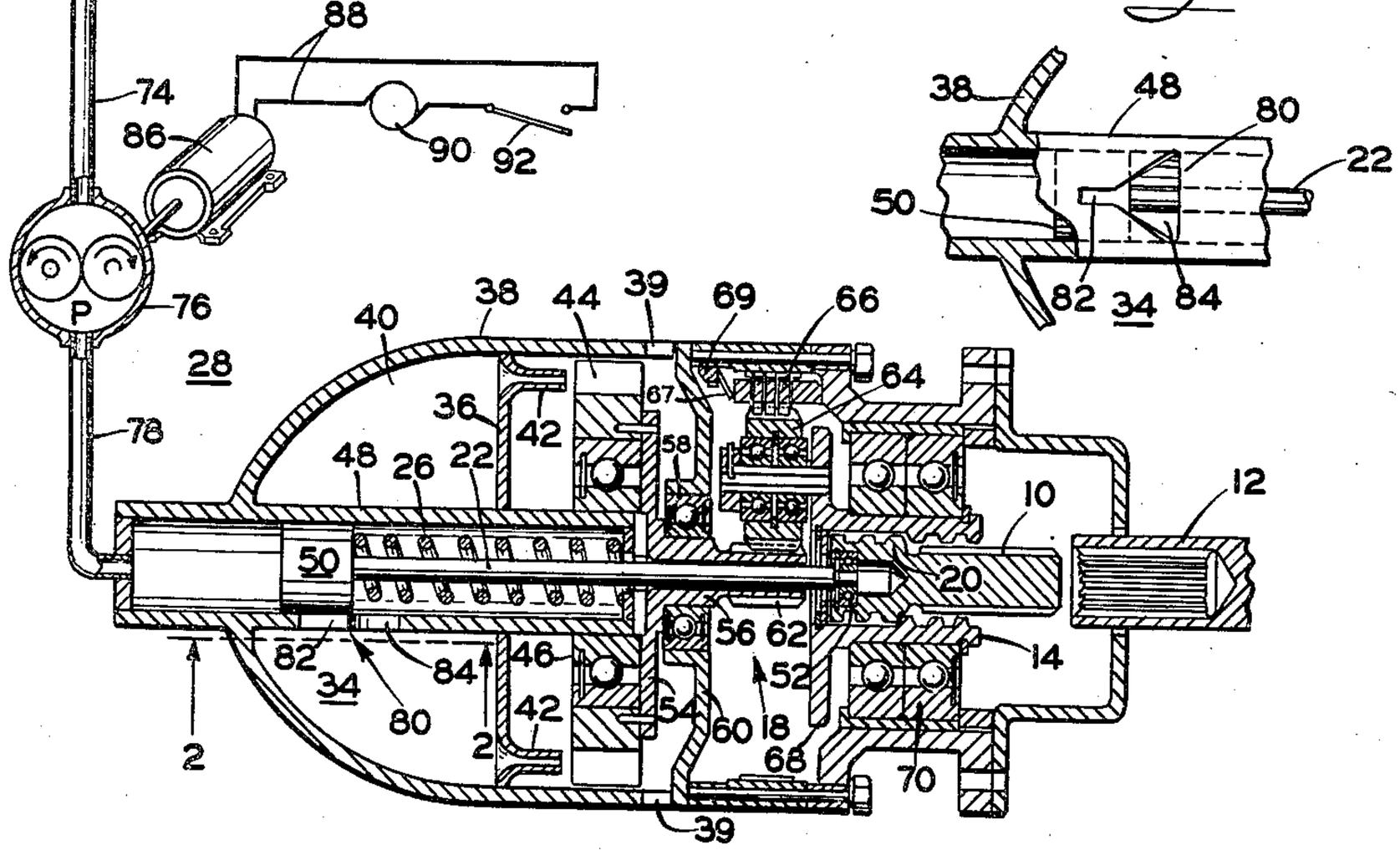
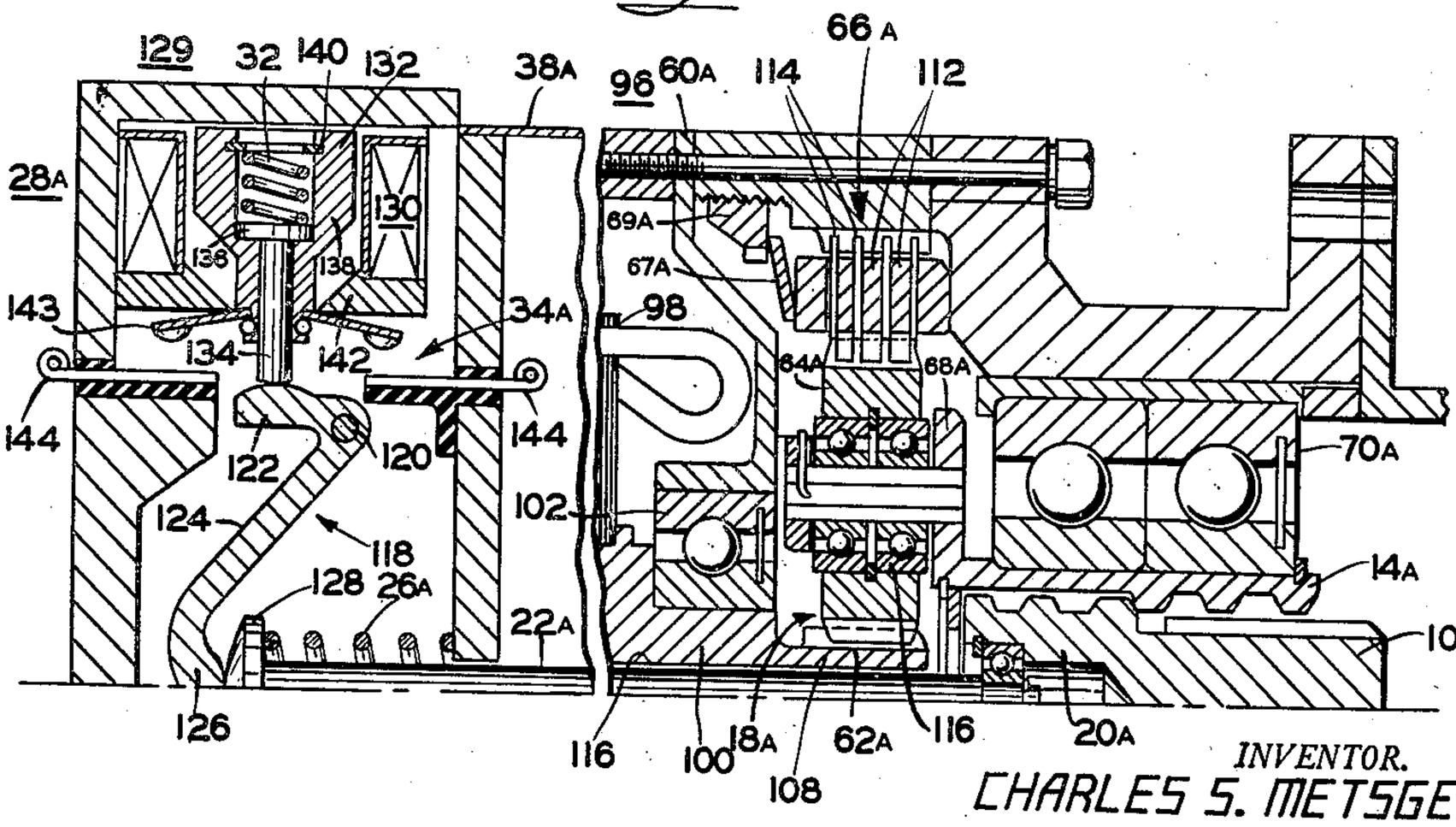


Fig. 3



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Filed Nov. 13, 1947 2 Sheets-Sheet 2

Fig. 4

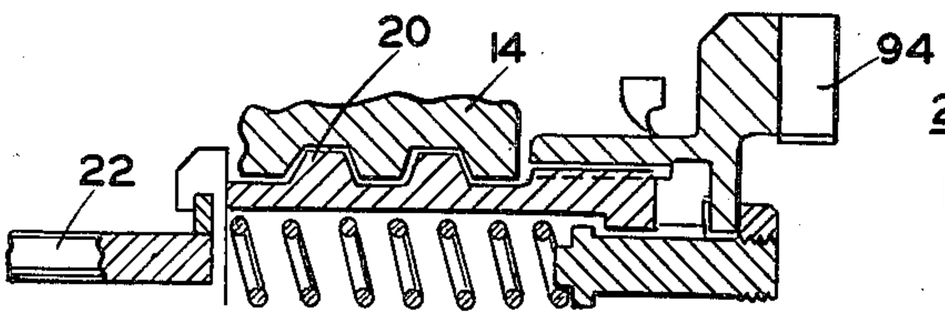
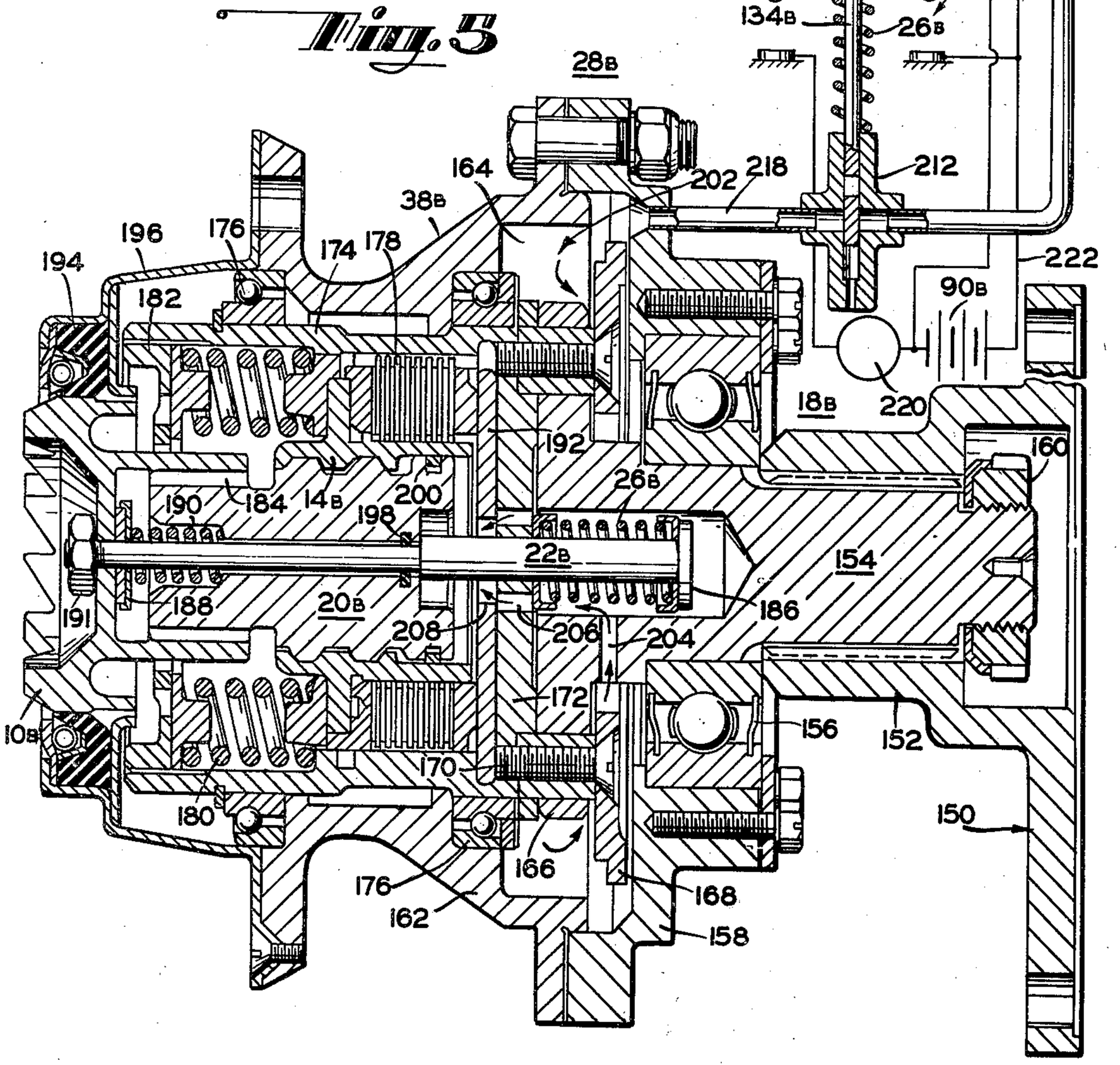


Fig. 5



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ENGINE STARTER MESHING MEANS

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Application November 13, 1947, Serial No. 785,723

5 Claims. (Cl. 123—179)

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The present invention relates to engine starters, and particularly to a starter of the self-contained high-speed type, in which the turning motion is transmitted through a rotatable output member or jaw having its axis of rotation in line with the axis of rotation of an engine member.

Among the objects of the invention are to provide a starter structure or system of greatly increased power and reduced weight as for aircraft service and which shall avoid the disadvantages of overrunning clutches, such as destruction of parts by centrifugal force upon failure of operation, completely separate the high speed meshing starter and engine members, reduce critical tolerances, mesh the starter and engine members prior to a given rate of operation of the starter, and have other advantages.

Another object is to provide a device of the above-indicated character which shall be simple and durable in construction, economical to manufacture, and effective in its operation.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the accompanying drawings wherein three embodiments of the invention are illustrated by way of example.

In the drawings:

Figure 1 is a diagram of a system including a view in section of a starter of the invention;

Figure 2 is a bottom detail view of a portion of the structure of Figure 1;

Figure 3 is a view in side section, parts broken away, of the invention in modified form;

Figure 4 is a fragmentary detail of a modified portion of Figure 1; and

Figure 5 is a side view generally in section, but having parts in elevation, of another form of the invention, and including a diagram of parts associated therewith.

The structure of Figure 1 comprises a rotatable engine-engaging member 10 adapted for axial extension and retraction movements, respectively, between a position released from, and a position meshed with, an engine member 12 for starting the engine, the member 10 being shown in the released position. The device further comprises an axially stationary rotative nut 14, means including driving means 18 adapted to rotate the nut 14, a screw shaft element 20 axially movable relative to, and rotatively movable by, the nut 14 associated with the engine-engaging member 10 for rotating the latter. A meshing rod element 22 is adapted to move the engine-engaging member 10 in its axial extension move-

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ment engaging it to the engine member 12, the members 10 and 12 being of the male and female spline type, respectively having interfitting splines or teeth.

Means including spring means 26 cooperate with the meshing rod 22 to oppose the movement of the engine-engaging member 10 by the rod. Means 28 is adapted, in this instance, to effect the movement of the element 22 through the intermediary of a yieldable or fluid medium such as steam, for example. Throttle means 34 provides for first initiating movement of the rod element 22, and following with rotative action of the engine engaging member 10 by the driving means 18.

The driving means 18 comprises a partition 36 in a housing 38 and, with the latter defining a pressure chamber 40 adapted to contain a catalyst for hydrogen peroxide, such as manganese dioxide, copper, and silver. The partition 36 is provided with nozzles 42 for operating a turbine rotor 44 mounted on a sealed bearing 46 supported by a cylinder 48 carried by the housing 38 therein, the latter of which is provided with exhaust parts 39.

The spring means 26 is disposed around the rod 22 in the cylinder 48, and acts between one end of the cylinder, and a head or piston 50 at one end of the rod for biasing the latter to the position shown, corresponding to the retracted position of the member 10. The other end of the rod 22 is connected to the inner race of a ball-bearing 52 having its outer race connected to the screw shaft 20 therein, so that the latter may be moved axially by, but rotate relative to, the plunger.

The rotor 44 carries a plate 54 including a stub shaft portion 56 journaled in a bearing 58 in a partition 60 of the housing 38 and having a pinion or sun gear 62 meshing with planet gears 64 which mesh with rotatably yieldable axially adjustable toothed discs of a torque limiting disc pack 66, the alternate discs of which are axially adjustably, but non-rotatively, held to the housing 38. The discs of the pack 66 are adjusted relative to each other, as by a belleville spring 67 and a ring nut 69. The rod 22 extends loosely through a bore in the portion 56 and the gear 62.

The planets 64 are journaled on a carrier 68 constituting part of the nut 14, which is journaled in bearings 70 mounted in the housing 38.

The means 28 comprises a source 72 of propellant, such as hydrogen peroxide, communi-

cating through a pipe 74, a gear pump 76 and a pipe 78, with the cylinder 48.

The throttle means 34 comprises the piston 50 and an aperture 80 in the cylinder 48 having a narrow slit portion 82 and a portion 84 diverging from the slit 82. In the inactive condition of the system illustrated, the plunger 50 completely closes the aperture 80, including the slit 82, to prevent communication between the interior of the cylinder 48 and the chamber 40. A motor 86 for driving the pump 76, is fed by conductors 88 from a source of energy 90 and controlled by a switch 92, which, in this instance constitutes the starting switch.

In operation, with the parts of Figures 1 and 2 in the positions shown, closing of the switch 92 energizes the motor 86 to operate the pump 76, which causes propellant from the source 72 to flow through the pipe 74 to the pump and from the latter under pressure through the pipe 78 to the cylinder 48.

The pressure of the propellant initiates movement of the piston 50 to the right from its retracted position, as shown to initiate movement of the rod 22, after which the piston opens the slit 82 to, at first, admit reduced flow of propellant to the chamber 40. This action generates enough steam pressure by the hydrogen peroxide breaking up into oxygen and water in the form of steam upon contact with the catalyst to rotate the turbine slowly until the piston passes the right-hand end of the slit 82 and starts to effect gradually increased flow of the propellant to the chamber 40 by reasons of the enlarged or diverging portion 84 of the aperture 80. Continuation of the action, from the right end of the slit 82, causes the member 10 to engage the member 12 before the rotation of the member 10 attains a predetermined rate such that, if the member 10 butts, instead of immediately meshing with the member 12, it will be turned to meshing position, and meshed under the continued thrust by the piston 50.

Compressed air or other gas may be substituted for the propellant and catalyst arrangement of Figure 1, each form having advantages over the other, for certain applications.

As indicated in Figure 4, the engine-engaging spline member 10 of Figure 1 may be replaced by a usual jaw 94 for meshing engagement with a jaw corresponding to the engine member 12.

The structure of Figure 3, in which certain corresponding parts are designated by corresponding reference characters having the suffix *a*, is adapted to obtain results similar to those of the structure of Figure 1 in general principle, if not in scope, by electrical means.

As in Figure 1, the device of Figure 3, comprises a rotatable engine-engaging member 10*a* adapted for axial extension and retraction movements respectively between a position released from and a position meshed with an engine member (not shown), corresponding to the member 12, for starting the engine. The device further comprises an axially stationary rotative nut 14*a*, means including driving means 18*a* adapted to rotate the nut 14*a*, a screw shaft element 20*a* axially movable relative to, and rotatively movable by, the nut 14*a* associated with the engine-engaging member 10*a* for rotating the latter. A meshing rod element 22*a* is adapted to move the engine-engaging member 10*a* in its axial extension movement engaging it to the engine member.

Means including spring means 26*a* cooperates with the meshing rod 22*a* to oppose the movement of the member 10*a* by the rod. Means 28*a* is also adapted to effect the movement of the element 22*a* through the intermediary of a yieldable medium which, in this case, is a spring 32 which is very much stiffer than spring means 26*a*.

Means 34*a* corresponds to the throttle means 34 of Figures 1 and 2 in that it provides for first initiating movement of the rod element 22*a*, and following with rotative action of the engine-engaging member 10*a* by the driving means 18*a*.

The driving means 18*a*, of Figure 3, comprises a motor 96 including an armature 98, corresponding to the rotor 44 of Figure 1, a shaft 100 journaled by a bearing 102 in a partition 60*a* of a housing 38*a* and having a sun gear 62*a* meshing with planet gears 64*a*. The latter mesh with rotatably yieldable axially adjustable toothed discs 112 of a torque-limiting disc pack 66*a*, the alternate discs 114 of which are axially adjustable but non-rotatively held to the housing 38*a*, the discs of the pack 66*a* also being adjusted relative to each other, as by a belleville spring 67*a* and a ring nut 69*a*. The rod 22*a* extends loosely through a bore 116 in the shaft 100 and the sun gear 62*a*.

The planet gears 64*a* are journaled, as by bearings 116, on a carrier 68*a* constituting part of the nut 14*a*, which is journaled in bearings 70*a* mounted in the housing 38*a*.

The means 28*a* comprises a lever 118 pivotally mounted relative to the housing 38*a*, as by a pin 120, and having a short arm 122 and a long arm 124, the latter of which has an end 126 adapted to cooperate with a head 128 of the meshing rod 22*a* to push the latter to the right against the action of the spring 26*a*.

The means 28*a* further comprises an electrical unit 129 including a solenoid coil 130 surrounding a hollow armature core 132 carrying a plunger 134 axially movable relative thereto, which plunger has a head 136 normally held against a seat 138 of the core by the yieldable medium or spring 32, and which spring is backed and held in place, as by a locking ring 140 in a groove of the armature core 132. Downward movement of the core 132, as shown, is limited by stop means 142. A belleville spring 143, movably carried by the plunger 134, in this instance constitutes a bridging contact member for stationary contact elements 144 adapted to be connected in the circuit of the motor 96.

In operation, with the parts of Figure 3 in the position shown, when the circuit of the solenoid coil 130 is closed, the core 132 descends, carrying the plunger 134 and the spring 32 with it, while retained in the relative positions shown. If the engine-engaging member 10*a* meshes immediately with the engine member, the action of meshing will be carried straight through with the plunger 134 and the spring 32 retained throughout the action in the abovementioned relative position during which the bridging contact member 142 bridges the stationary contact member 144 to close the circuit of the motor 96. However, when the member 10*a* butts the engine member, the downward motion of the plunger 134 stops, while the downward motion of the solenoid core 132 continues against the action of the spring 32 such that, when the contact member 142 bridges the stationary contact member 144 to energize the motor 96, rotation of the armature 98 will cause nut 14*a* to rotate and thereby by means of the threaded engagement thereof with screw shaft element 20*a* will cause meshing of the member 10*a* with the engine mem-

ber before the rotation of the member 10*a* attains a predetermined rate of speed.

The structure of Figure 5, now the subject matter of divisional application Serial No. 167,778, filed June 13, 1950, in which certain corresponding parts are also designated by corresponding reference characters having the suffix *b*, is also adapted to obtain results similar to those of the structures of Figures 1 and 3, in general principle, if not in scope, by the use of compressed gas and rotative driving means of any desired character, such as the rotor of a turbine or the armature of an electric motor.

As in Figures 1 and 3, the device of Figure 5 comprises a rotatable engine-engaging member 10*b* adapted for axial extension from and a position meshed with an engine member (not shown) corresponding to the member 12, but of the jaw, instead of the spline, type, for starting the engine. The device further comprises an axially stationary rotative nut 14*b*, means including driving means 18*b* adapted to rotate the nut 14*b*, a screw shaft element 20*b* axially movable relative to, and rotatively movable by, the nut 14*b* associated with the engine-engaging member 10*b* for rotating the latter. The screw shaft element 20*b*, instead of the rods 22 and 22*a* of Figures 1 and 3, respectively, or of the rod 22*b* of Figure 5, is adapted to move the engine-engaging member 10*b* in its axial extension movement engaging it to the engine member.

Means including spring means 26*b* cooperates with the meshing rod 22*b* to oppose movement of the member 10*b* by the screw shaft 20*b*. Means 28*b* is also adapted to effect the movement of the screw shaft element 20*b* through the intermediary of a yieldable medium, which in this case is compressed air.

Means 34*b* corresponds to the throttle means 34 of Figures 1 and 2, and the means 34*a* of Figure 3, in that it provides for first initiating movement of the screw shaft element 20*b*, instead of the rod element 22*b*, and following with rotative action of the engine-engaging member 10*b* by the driving means 18*b*.

The driving means 18*b*, of Figure 5, comprises a plate 150 adapted for attachment to the rotor of a turbine or other motor, and provided with a female spline extension 152 adapted to receive a cooperating male spline shaft 154, journaled by a bearing 156 in an end plate 158 of a housing 38*b*. The plate 150 is held axially relative to the shaft 154 between the bearing 156 and a nut structure 160 in a cavity of the extension 152.

A portion 162 of the housing 38*b* has a chamber 164 in which is disposed a flange 166 of the shaft 154 which is secured, as by a ring 168 and screws 170, to a closed end wall 172 of a barrel 174 journaled in the housing portion 162 as by bearings 176.

The spline nut 14*b*, in the barrel 174, is connected to the latter by a torque-limiting friction disc pack 178 having interlayered discs fixed to the nut 14*b* and the barrel 174, respectively, and axially biased together, as by helical springs 180 and a ring nut 182 threaded in the opposite end of the barrel 174.

The screw shaft 20*b*, having long-lead thread relation to the nut 14*b* therein, has an axially slidable spline connection 184 to the starter clutch jaw member 10*b*.

The jaw 10*b* and the screw shaft 20*b* are connected by the meshing rod 22*b* having a head 186 and extending through an aperture in the jaw 10*b*, which aperture is closed by a seal 188 biased

against the jaw by a spring 190 extending into the screw shaft 20*b*. A nut 191 is mounted on the rod 22*b* at the left of the jaw 10*b*.

The screw shaft 20*b* is limited in its axial movement to the right, as viewed in the drawing, by engagement with a disc 192 against the barrel end wall 172 and, in its axial movement to the left by a usual shoulder on the screw shaft 20*b* with a shoulder on the spline nut 14*b*. A ring seal structure 194, not germane to the present invention, cooperates between a baffle portion 196 of the housing 38*b* and the jaw member 10*b*.

The screw shaft 20*b*, instead of being for advancement by rotation of the nut 14*b* as in a usual direct-cranking starter having friction means adjacent to the seal 194, the latter of which is not true in this case, is adapted as by seal rings 198 and 200 in grooves of the screw shaft around the rod 22*b* and the shaft 20*b*, respectively, for action as a piston responsive to fluid pressure introduces into the chamber 164.

An inlet 202 admits fluid to the chamber 164 for passage, indicated by arrows, through passageways 204, 206 and 208, see lower central portion of the figure, to the screw-shaft-piston 20*b*.

The means 28*b* comprises an electrical unit 210 corresponding to the unit 129 of Figure 3, with the exception that a plunger 134*b* corresponding to the plunger 134 of Figure 3, instead of being adapted to push a lever, such as the lever 118, has its lower end constructed as the movable element of a valve 212 for controlling the flow of fluid, such as compressed air, form a source 214 through a pipe 216, the valve 212 and a pipe 218 to the inlet 202.

Means 34*b* corresponds to the throttle means 34 of Figures 1 and 2, and to the means 34*a*, of Figure 3, in that it also provides for first initiating the axial extension movement of the screw shaft element 20*b*, during which, prior to rotation of the shaft 154, the element 20*b* will rotate, but not under the power of the shaft 154.

A device 220 corresponds either to a motor such as the motor 86*a*, the motor 96, or as in this instance, another electrical unit, such as a solenoid, for starting a turbine, and is controlled as by a switch 92*b* relative to a source of electromotive force 90*b*.

In operation, with the parts of Figure 5 in the inactive positions shown, when the switch 92*b* is closed, current flows from one side of the source 90*b* through a conductor 222, the switch 92*b*, the solenoid coil 130*b*, of the unit 210, and a conductor 224 to the opposite side of the source 90*b*. This action, first opens the valve 212 to cause flow of fluid from the source 214 through the pipe 216, the valve 212 and the pipe 218 to the inlet 202, and into the chamber 164. From the latter, the fluid flows, as indicated by arrows, through the passageways 204, 206, and 208 to the rear of the piston screw shaft 20*b*, to advance the latter to the left and to push the member 10*b*, through the intermediary of the spring means 180, into engagement with the engine member, during which the shaft 20*b* will rotate in the stationary unit 14*b* to rotate the member 10*b*. The timing of the opening of the valve 212 and the closing of the circuit of the device 200 is, in this instance such that the shaft piston 20*b* will cause the rotating member 10*b* to engage the engine member before driving operation of the shaft 154. Thus, the member 10*b* has a chance to mesh before the application of rotative power. If, however, butting should occur, meshing will be insured upon the first application of rotative driv-

ing power, prior to the attainment of a certain rate of speed by the member 10*b*.

The timing aforesaid may be varied such that power rotation may be applied upon, or at any time before or after, engagement of the member 10*b* with the engine member as desired or dependent upon conditions of, or circumstances surrounding, a particular case.

Although each form of the invention, as stated above, operates on substantially the same broad general principle as the others, the differences in scope or application allow wide divergencies of application, manufacture, assembly, cost, size, weight, materials, repair and almost every conceivable factor which may be associated therewith.

For instance, the device of Figure 1 may provide substantially greater power for a given weight than the device of Figures 3 and 5, thus making it more effective for certain branches of aircraft practice, while the devices of Figures 3 and 5 may be better suited in other branches from the standpoint of cost, replacement, repair or other considerations. The device of Figure 5 has the advantage over the other forms of immediate utilization of standard parts of former starters not previously operable in the same manner.

The invention therefor provides for a very great range of its application and uses, and is an improvement generally in its field.

Although only three embodiments of the invention have been illustrated and described, various changes in the form and relative arrangements of the parts may be made to suit requirements.

What is claimed is:

1. In an engine starting mechanism, the combination of a rotatable engine-engaging member adapted for axial extension and retraction movements, respectively, between a position released from, and a position meshed with, an engine member for starting the engine, an axially stationary rotative nut, means including fluid-responsive driving means adapted to rotate the nut, a screw shaft element axially movable relative to, and rotatively movable by, the nut and associated with the engine-engaging member for rotating the latter, a meshing rod element, one of said elements being operable by fluid pressure to move said engine-engaging member in its said axial extension movement engaging it to said engine member, means including spring means cooperating with said meshing rod element to oppose said movement of the engine-engaging member by said one element, a pressure chamber containing a catalyst associated with said fluid-responsive driving means, a source of propellant, means adapted to convey the propellant under pressure from said source to said one fluid-pressure operable element for first operating the same to initiate said extension movement, and a throttle device including means controlled by said one fluid-operable element to admit the propellant to said chamber for reaction with the catalyst effecting fluid pressure for causing rotative action of said engaging member by said driving means following the initiation of said extension movement.

2. In an engine starting mechanism, the combination of a rotatable engine-engaging member adapted for axial extension and retraction movements, respectively, between a position released from, and a position meshed with, an engine member for starting the engine, an axially stationary rotative nut, means including fluid-responsive driving means adapted to rotate the nut, a screw shaft element axially movable relative to, and rotatively movable by, the nut and associated with the engine-engaging member for rotating the latter, a meshing rod element, one of said elements being operable by fluid pressure to move said engine-engaging member in its said axial extension movement engaging it to said engine member, means including spring means cooperating with said meshing rod element to oppose said movement of the engine-engaging member by said one element, a steam pressure generation chamber associated with said fluid-responsive driving means, a source of fluid pressure, means adapted to convey fluid from said source to said one fluid-pressure operable element for first operating the same to initiate said extension movement, and a throttle device separate from and including means controlled by said one fluid-operable element to admit said fluid to said chamber for the generation of steam to cause rotative action of said engaging member by said driving means following the initiation of said extension movement.

3. In an engine starting device, the combination of a rotatable engine-engaging member adapted for axial extension and retraction movements, respectively, between a position released from, and a position meshed with, an engine element for starting the engine, a meshing rod element, fluid-actuated means adapted to actuate said meshing rod element to effect said extension movement, fluid-responsive rotatable means adapted to rotate said engine-engaging member, a pressure chamber containing a catalyst associated with said fluid-responsive means, a source of propellant, means adapted to convey propellant from said source under pressure to said fluid-actuated means for operating the same to effect said extension movement, and throttle means controlled by said fluid-actuated means to admit the propellant to said chamber for reaction with the catalyst causing fluid pressure for operating said fluid-responsive means.

4. In an engine starting mechanism, the combination of a rotatable engine-engaging member adapted for axial extension and retraction movements, respectively, between a position released from and position meshed with an engine element for starting the engine, an axially stationary rotative nut, driving means adapted to rotate the nut, a screw shaft element axially movable relative to and rotatively movable by the nut and associated with the engine-engaging member for rotating the latter, a meshing rod element, said meshing rod element being adapted to move said engine engaging member in its said axial extension movement engaging it to said engine element, spring means cooperating with said meshing rod element to oppose said movement of the engine-engaging member by said meshing rod element; a first power means including a fluid pump for supplying a fluid medium under pressure to actuate said meshing rod element in opposition to said spring means, a second independent power means including a steam generator and a turbine driven by the steam from said generator to effect rotation of said nut through said driving means, and control means operated by said first power means for initiating operation of said second power means and rotative action of said engine-engaging member by said driving means following initiation of the axial extension movement of the engine-engaging

member by said first power means so that said first and second power means coact to complete meshing of the engine-engaging member with the engine element.

5. In an engine starting mechanism, the combination of a rotatable engine-engaging member adapted for axial extension and retraction movements, respectively, between a position released from and a position meshed with an engine element for starting the engine, an axially stationary rotative nut, driving means adapted to rotate the nut, a screw shaft element axially movable relative to and rotatively movable by the nut and associated with the engine-engaging member for rotating the latter, a meshing rod element, said meshing rod element being adapted to move said engine-engaging member in its said axial extension movement engaging it to said engine element, spring means cooperating with said meshing rod element to oppose said movement of the engine-engaging member by said meshing rod element; a first power means including a source of hydrogen peroxide, a fluid pump for supplying said hydrogen peroxide under pressure from said source to actuate said meshing rod element, a second power means including a chamber for decomposing the hydrogen peroxide to steam, a turbine driven by the steam from the decomposing

chamber, and control means operated by said first power means for initiating operation of said second power means and rotative action of said engine-engaging member by said driving means following initiation of the axial extension movement of the engine-engaging member by said first power means so that said first and second power means coact to complete meshing of the engine-engaging member with the engine element, said control means including a valve operated by said meshing rod element to control the supply of hydrogen peroxide to said chamber from said pump.

CHARLES S. METSGER.

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