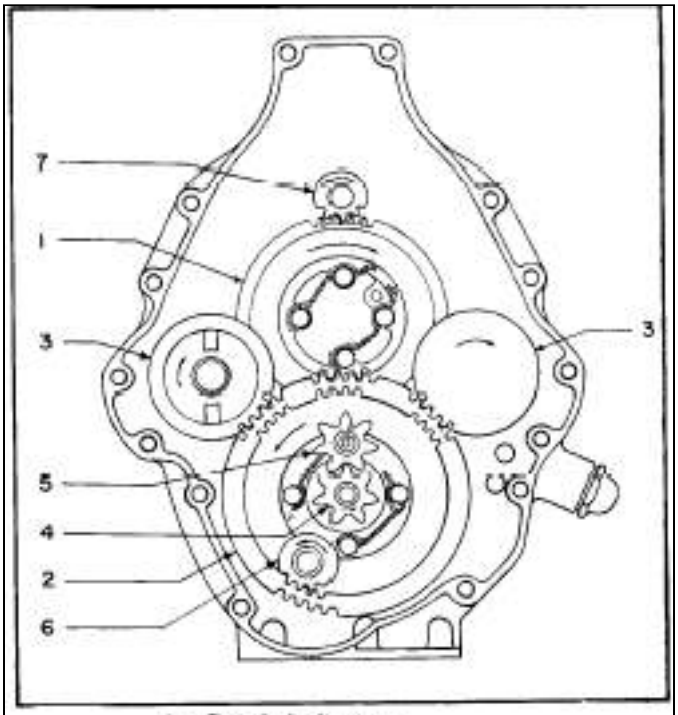
STARTER --Pull to Electric FEATURES
Starter pilot shaft.

Changing from Pull-Type to Electric Control;

To change from the Pull-Type to the electric control starter, the pinion gear pilot shaft must be removed. The starter pinion gear which protrudes from the clutch assembly of the starter has a coaxial hole of about 5/8ths diameter. If original, it is lined with a thin shell of Oilite material which has been pattern indented (to hold more oil). When at rest, the pinion gear is pulled back (by spring pressure inside the starter plunger, the item that always drools oil) but when the starter handle is pulled, the arm at the starter pushes the plunger toward the engine such that, if the two gears' teeth are aligned, the starter pinion gear meshes with the crankshaft gear.

To offset the sideways thrust which bears on the pinion gear, it is center supported by the pilot shaft; it goes over the pinion pilot shaft which is mounted in the case. The length of the pilot shaft is such as to permit the pinion gear to slide inwards and stay supported when meshed.

In this first figure from pp 19 of the engine overhaul manual for the C-XX -12, -14, and -16 engines and the O-200 engines, the relative position of all the gears is shown with the view from the back of the engine.

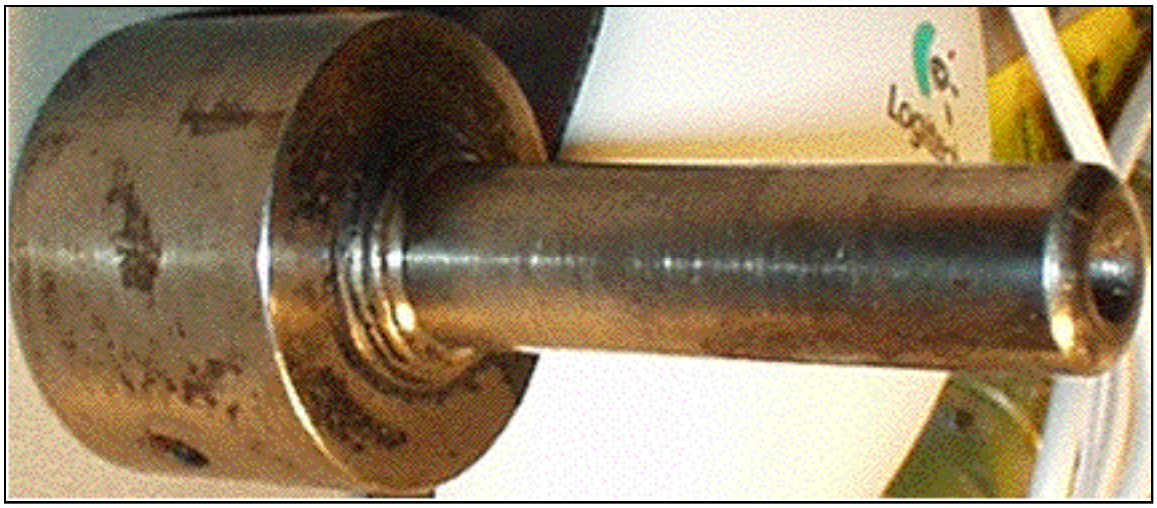


1. Crankshaft gear
2. Camshaft gear
3. Magneto drive gears
4. Oil pump driving impeller
5. Oil pump driven impeller
6. Generator drive gear
7. Starter pinion

Figure 10. Gear Train of -12, -14, -16 and O-200 Models.

This following picture of the pilot shaft illustrates the features which make it work; the pilot shaft, the "bell" portion which fits in a nest in the engine case, and the hole in the bell into which fits a dowel embedded in the case so the pilot shaft part cannot rotate as the pinion gear rotates on the pilot shaft. The radial scratches are indicative of the contact between the pinion gear internal Oilite bearing, but those you see here were accentuated because the pinion gear fractured on my engine, and the internal bearing then was scratching the shaft instead of riding on a layer of oil.

The stains show where the bell portion met with the case seams, at 90 degrees to the hole into which the retaining dowel fits. The bell portion is hollow, and at first glance it appears that there is a hole running entirely through the shaft , but it does not. The hole and threads in the shaft end and the indents here and within the center of the hollow bell are for mounting and retaining on a lathe while the part is cut and finished to size. The overall length is 3-1/2 inches and the bell diameter is 1-1/2 inches. I took the picture with the mouse in the background and with the part upright. To make it fit the paper, I rotated the image, so the mouse may look a bit "odd".

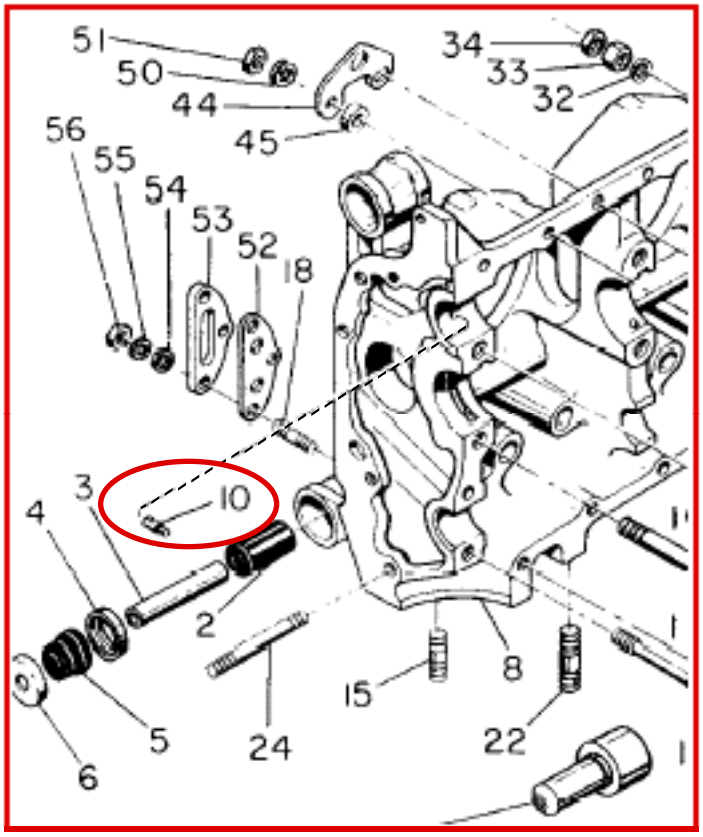


From pp 66 of the overhaul manual, this figure shows how the pilot shaft is installed. Not visible in this view is the dowel which protrudes from the case to mesh with the hole in the pilot shaft "bell" portion to keep the item from rotating or shifting from position as the pinion gear rotates on the pilot shaft.

Figure 27. Installing Starter Pinion Pivot

The dowel is a bit tricky to find in the engine case blowup, so I have accentuated it with the dotted line and the red circle around the dowel and its identifying "item 10" on the next page. This figure shows the callout for the dowel.

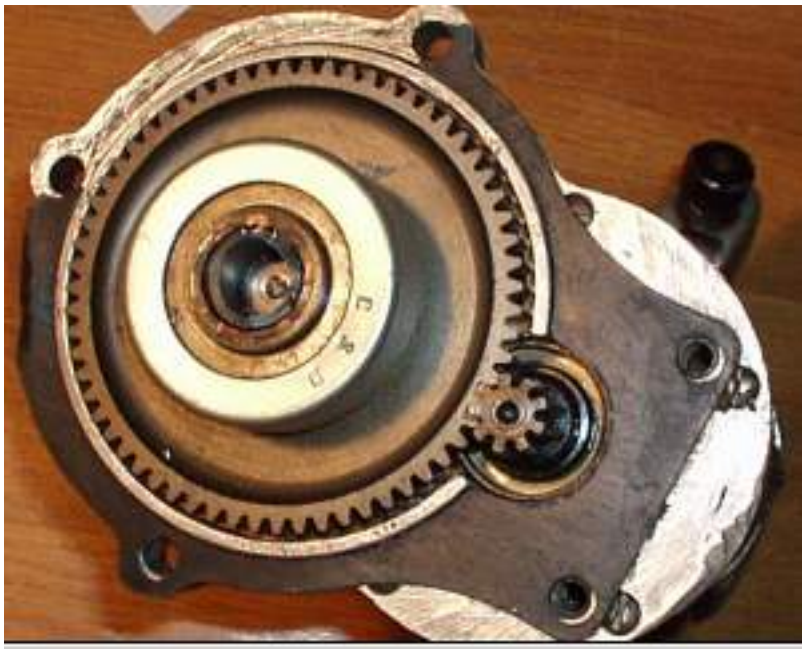
Figure & Index No.	Part Number	1 2 3 4	Description
2-8	No Number	.	Crankcase - Left . . . .
-9	21080	.	Dowel - 1/4 in. dia. x 9/1
-10	22811	.	Dowel - Starter pinion pi



Item 10 is the dowel which is embedded in the case to hold the pilot shaft in place and to prevent it from rotating when the starter pinion gear is engaged.

Another picture of the shaft part to illustrate the anti-rotation retaining hole, relative sizes, parting line impressions, and corrosion.

The business end of the starter...it is from my plane and the missing pinion gear parts are shown later. The pinion gear fractured. The overrunning clutch is the round silver item with the imprinted letters.



A closeup of the center illustrates the remainder of the pinion gear. In the center is the end of the plunger; behind it is a spring which provides the rebound source when you push the starter cable handle back to the rest position after engine start. There are two springs in the plunger, one to force the pinion gear into mesh with the main gear of the engine, and the rebound spring.

The parts left over after the pinion gear fractured due to improper materials and improper heat treatment, as acknowledged by the maker, Niagara. The copper/brass item is the "bearing" which resides inside the pinion bearing and which provides the surface which contacts the pilot shaft. The missing piece of the gear? Inside the engine, causing the damage shown to the right rear piston. Although the owner of Niagara (still in business and bigger than ever) confirmed that the parts were flawed, he felt no responsibility for the damage and need to disassemble the engine for the missing parts. He commented; "....oh, those blasted little Continentals....we found the alloy of the pinion gears was wrong and they had not been heat treated properly...'. Thanks.

The damaged piston found at engine teardown.

A note for those who do not understand “overrunning clutch”. It means that the clutch couples the movement of the starter motor and its big gear to the pinion gear so that the engine main gear can be rotated to start the engine. Once the engine is started, it is not desirable to keep the pinion gear in mesh with the main gear of the engine because the string of parts cannot stand the tremendous increase in rotation

rates. Consequently, as the engine drives the pinion at a speed greater than the starter-induced speed, the clutch "lets go" so there is no torque between the pinion gear and the main gear and that allows a fast retraction of the pinion gear out of mesh.

Oilite is the name of material, usually bronze, which has been sintered and then impregnated with a lubricant, usually oil. Sintered means that the bronze has been re-shaped from the solid to be tiny, tiny little balls. Those balls are put in a die which has the reverse shape of the desired part, and then heated and the balls forced together under considerable pressure. The heat and pressure welds the balls to each other, deforming them as it does so, but they are not so compacted as to completely become a solid again. The Oilite shapes appear as and react as a solid of good strength, but there a millions of little holes between the balls. When the shape is done, the Oilite material is immersed in hot, very hot, oil under pressure and then removed and allowed to cool. The combination draws the oil into the voids. Oilite, because the oil keeps wicking to the surface, provides its own lubrication for years.

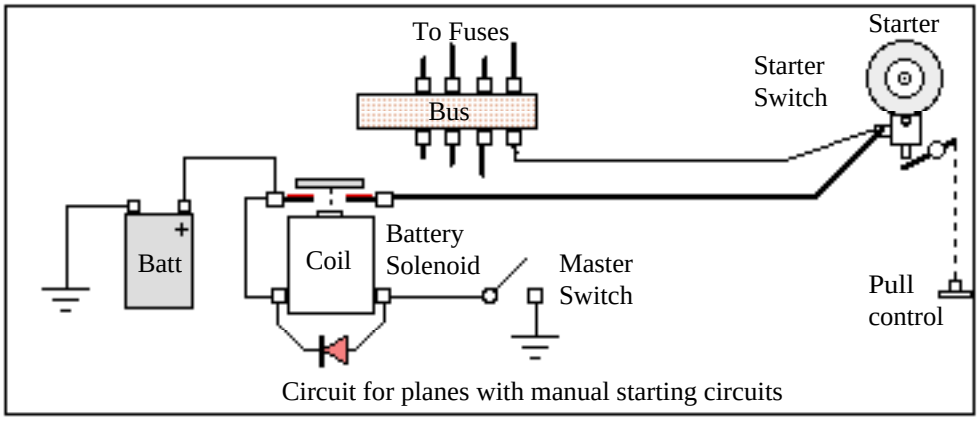
Changing From The Manual Starter To An Electric Start Type:

The "kick" which induced putting this article together was the comment by another owner of a 140 that they were having the starter replaced with an electric start while they were on vacation and he wondered why the mechanic had made it very clear to him that a manual start could not be used in place of the old manual start unless the case was taken apart to allow replacement of the "stub" which he had to cut off for the electric start unit to work. The "stub" that must be cut off to allow the electric start unit to work is the pilot shaft shown and explained earlier.

None of us know how they get into the engine to make the cut nor how they keep the chips or swarf from getting in the engine. None of the advertisement for the electric starter make any mention of this step and the consequences.

The Electrical Changes:

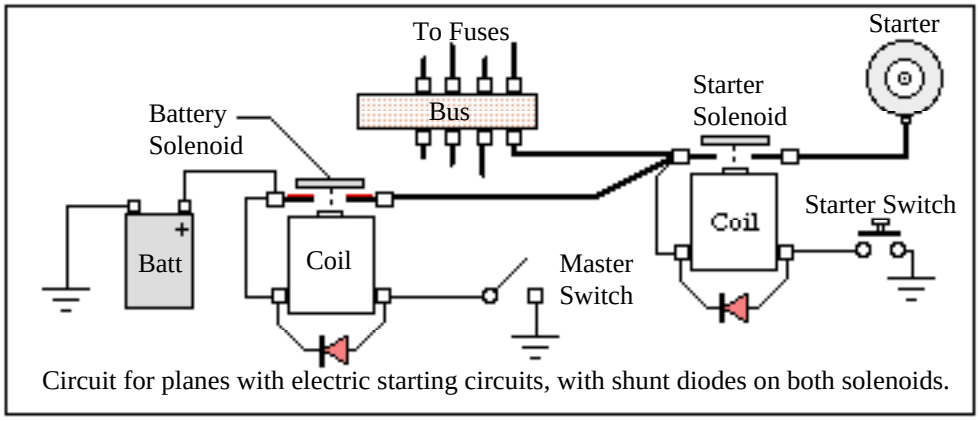
This next figure is a simplified version of the power circuit when using a manually activated starter system, leaving out such items as the alternator/generator and ammeter.



Circuit for planes with manual starting circuits

The pull control forces the lever on the starter to push the plunger which in turn forces the gear to either go into mesh with the main gear or, with the spring pressure behind it, go into mesh just as soon as the starter makes a tiny movement. The second action of the lever, once it has moved the gears into mesh or spring loaded it to mesh, is to make the switch which applies the current to turn the starter.

The circuit shown next, also simplified, does include the additions for the starter..the starter switch on the instrument panel, the starter solenoid and the changes in the wiring. The common connection of the wire from the battery solenoid is to the input terminal of the starter solenoid rather than the main stud of the manual starter and so the wire to the bus is now also connected to the input terminal of the starter solenoid.



Circuit for planes with electric starting circuits, with shunt diodes on both solenoids.

The pink items are diodes, installed on both the coils (there is a Cessna letter to install the one on the battery solenoid), are magic items which pass no current until the switch for each is released, at which time they do pass the reverse current surge, preventing a high voltage pulse from appearing on the airplane bus. Because putting the one on the battery solenoid means you stand on your head for a short period, and because the addition is not "mandatory", many FBO's never mention it or install it. It is worth while having the diode (s).

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