Chapter 8

STARTER MOTOR, ECLIPSE PIONEER, TYPE 915-3F

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Starter motor, Eclipse Pioneer, Type 915–3–F	*Ref. No. 137F/915–3F*
Voltage	24*V d.c.*
Rating	30 *sec.*
Rotation (viewed from jaw end)	*Clockwise*
Motor and flywheel speed	15000 *rev/min.*
Normal clutch setting	600 + 50 — 0 *lb. ft.*
Brushes:	
Grade	*Ref. No. 137AA/839317*
New length	0·5 *in.*
Min. length	$\frac{5}{16}$ *in.*
Spring pressure	24–28 *oz.*
Commutator:	
Min. diameter	1·375 *in.*
Undercut depth	0·31–0·46 *in.*

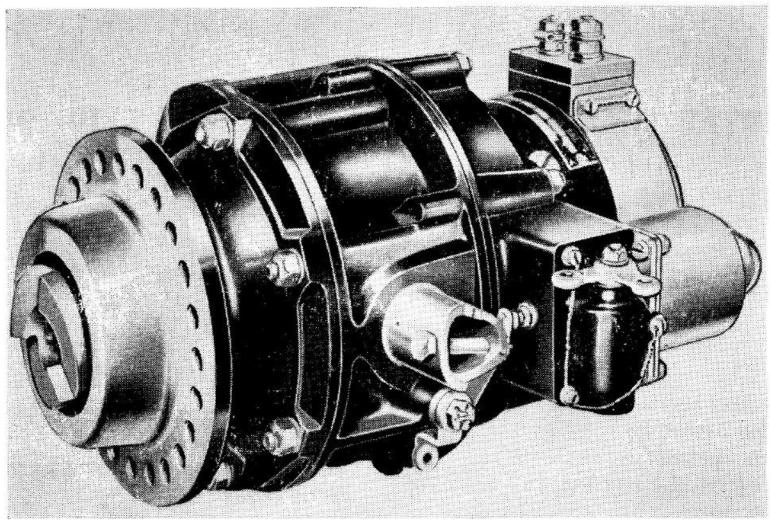


Fig. 1 Starter motor, Eclipse Pioneer, Type 915–3–F

Introduction

1. The starter motor Type 915–3F is designed for use with aircraft engines with piston displacements not exceeding 1830 cubic inches. It functions normally as an electric inertia starter, but under emergency conditions is can be operated as a hand inertia starter.

DESCRIPTION

General

2. The starter consists of three basic components; the motor and flywheel section, gear section, and the solenoid assembly. The gear section is bolted to the inner end of the motor assembly and the solenoid is mounted on a raised boss on the side of the motor housing. An exploded view of the machine is shown in fig. 2.

Motor and flywheel section

3. This section is composed of the motor housing assembly, armature and flywheel assembly, and the meshing device assembly. The motor is a four-pole, series-wound unit having four brushes, two of which are earthed to the motor housing. A removable window strap, assembled around the outer periphery of the motor housing, covers the four windows provided to facilitate inspection and replacement of the motor brushes. The positive terminal posts of the motor and meshing solenoid assembly are mounted on an insulating terminal board which is attached to the side of the motor housing. The terminal posts extend through the terminal insulating block which is fitted into the inner face of the motor housing. The brush spring release handle, which protrudes from the outer end of the motor housing, operates the brush spring release mechanism for manual operation of the starter.

Motor housing assembly

4. The brush board assembly, brush spring release mechanism, motor housing, and yoke and field coil assembly comprise the motor housing assembly.

5. *Brush board assembly.*—The brush board assembly is attached to the inner face of the closed end of the motor housing. A boss is provided at the perimeter of the moulded bakelite brush board for connecting the leads from the external solenoid terminal post and the meshing solenoid. The four brush boxes are attached to the board by rivets. The brush springs are assembled on adjusting sleeves which are mounted on the spring posts. The spring posts extend through the brush board and mount the lever and pin assemblies at their inner ends.

6. *Brush spring release mechanism.*—The pins of the lever and pin assemblies extend

into slots cut into the inner diameter of the lever operating ring. The lever operating ring is fitted into a channel in the motor housing, concentric with and behind the brush board. The spring-loaded brush spring release handle mounts a plate at its inner end, which is fitted into a groove in the face of the lever operating ring. Movement of the handle imparts rotary motion to the operating ring and causes the motor brushes to lift.

7. *Motor housing.*—The motor housing encloses the starter motor, and the flywheel, and incorporates a raised boss which provides two mounting pads for attachment of the meshing solenoid assembly and the meshing device assembly. A single-sealed ball-bearing is pressed into the liner in the end face of the motor housing. The ball-bearing supports the commutator end of the motor armature and is assembled in the housing so that the sealed face is adjacent to the commutator. A bearing cap, attached to the housing by four screws, clamps the bearing and the liner in place.

8. *Yoke and field coil assembly.*—The yoke and field coil assembly is assembled into the motor housing and consists of the yoke, the field coil assembly, meshing solenoid lead, and four pole shoes. The pole shoes are assembled into the field coils and are drawn up tight against the yoke by the pole shoe screws, thus clamping the coils in place. The pole shoe screws extend from the outer periphery of the motor housing, through the yoke and into the pole shoes. The meshing solenoid lead passes through a tubular-type insulator to connect the solenoid terminal post to the brush board. The end of the paper insulator are clamped between the field coils and the yoke.

Armature and flywheel assembly

9. The armature and flywheel assembly, which is supported at both ends by ball-bearings, and rotates within the motor housing assembly, consists of the armature assembly, flywheel, ball-bearing, bearing retainer nut, and the Woodruff key. A drive pinion, formed on the flywheel end of the armature shaft, engages the bell gear. The flywheel is pressed on to the armature shaft and held in place by the Woodruff key. The double-sealed ball-bearing is pressed on to the armature shaft against the flywheel hub and is held in place by the bearing retainer nut threaded on the end of the shaft.

Meshing device assembly

10. The meshing device assembly is attached to the outer mounting pad of the motor housing boss and consists of the cover, bell crank, bell crank lever, and the operating shaft. The operating shaft extends through the cover and is supported at each end by bronze bushings. The bell crank is assembled on the threaded end of the shaft and provides for attachment of a pull cable, to mesh the starter jaw. The bell crank lever is mounted on the operating shaft between the two bronze bushings. Two fingers extend from the hub of the bell crank lever and contact the collar which is pinned to the meshing solenoid plunger shaft. The fingers impart longitudinal motion to the plunger shaft when the bell crank is operated.

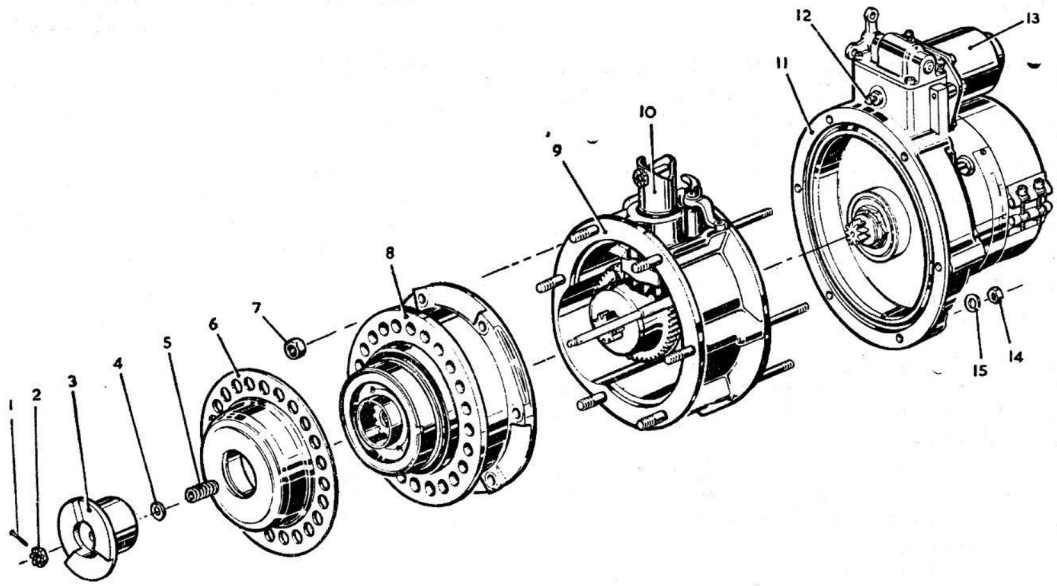
Gear section

11. The gear section is composed of a front and a rear unit and includes the reduction gearing, hand crank mechanism, engaging mechanism and linkage, multiple disc clutch, and starter jaw. The front and rear units are bolted together by studs assembled in the end of the rear housing. The crankshaft collar protrudes from the rear housing and forms the coupling for the hand crank and extension. The collar is provided with a bayonet slot for use with a detachable crank extension; the crank collar bolt is provided for use with permanently mounted crank extensions. The operating lever, located adjacent to the crank collar, actuates the jaw engaging mechanism through internal linkage. A hole, at the outer end of one of the arms of the lever, permits attachment of a pull cable. The end of the other lever arm is curved and extends to the solenoid poppet. The front unit is enclosed in the front housing which forms the mounting flange for attachment of the starter to the engine. The baffle plate contains an oil seal which excludes engine oil from the starter mechanism.

Rear unit

12. The rear unit forms the middle section of the assembled starter and includes the rear housing and studs assembly, crankshaft, bell gear, and engaging linkage.

13. *Rear housing and studs assembly*—Twelve studs, six of which extend from each opposite face of the rear housing and studs assembly, mount the motor assembly and the front unit. A bearing bore, in the outer periphery of the



Key to Fig. 2

1	COTTER PIN
2	NUT (OPERATING ROD)
3	STARTER JAW
4	WASHER
5	SPRING (MESHING ROD)
6	BAFFLE PLATE ASSEMBLY
7	LOCKNUT
8	FRONT HOUSING ASSEMBLY
9	REAR HOUSING ASSEMBLY
10	CRANKSHAFT
11	MOTOR AND FLYWHEEL ASSEMBLY
12	PLUNGER SHAFT POPPET
13	SOLENOID
14	LOCKNUT
15	WASHER

Fig. 2 Exploded view

housing, supports the crankshaft ball bearing. The roller bearing, which supports the inner end of the crankshaft, is supported in a partition formed in the housing. Two bearing bores are located in the outer face of the closed end of the housing. The centre bore supports the driven end armature bearing; the other bore mounts the bearing at the end of the bell gear shaft. A boss, extending from the inner face of the housing, supports the other bell gear ball-bearing.

14. *Crankshaft.*—The crankshaft is assembled into the rear housing and provides the means for manual acceleration of the flywheel. The shaft is supported by ball-bearing and roller-bearing. The outer end of the crankshaft forms the crank collar. The inner end is threaded and has four flats for mounting the driving bevel gear. The bevel gear is held on the shaft by a castellated nut and engages the driven bevel gear mounted on the barrel shaft.

15. *Bell gear.*—The bell gear is a bell-shaped forging with an integral supporting shaft. A large spur gear, formed on the lip of the bell, engages the armature pinion. A spur pinion, formed on the hub of the bell, drives the sun gear. The bell gear shaft is supported in two ball-bearings assembled into the rear housing.

16. *Engaging linkage.*—The engaging linkage consists of the operating lever, clevis shaft, clevis spring, clevis assembly, and the spring-loaded meshing rod. The operating lever is attached to the outer end of the clevis shaft which extends into the rear housing. The clevis assembly, which is attached to the inner end of the clevis shaft, is spring-loaded

by the clevis spring assembled on the shaft. The meshing rod is pinned to the clevis assembly and extends through the barrel shaft, screw shaft, and starter jaw.

Front unit

17. The front unit consists of the front housing, sun gear, barrel and clutch assembly, baffle plate, and starter jaw.

18. *Front housing.*—The front housing forms the starter mounting flange in addition to housing the front unit. The two barrel ball-bearings are assembled into the housing to support the barrel and clutch assembly. The annulus gear is formed on the inner periphery of the housing.

19. *Barrel and clutch assembly.*—The barrel and clutch assembly consists of the planetary pinion assemblies, driving barrel, multiple disc clutch, and jaw engaging mechanism. The clutch and the engaging mechanism are enclosed in the barrel. The planetary pinions are mounted on studs assembled into the back face of the driving barrel. A shaft, which is an integral part of the barrel, protrudes from the centre of its back face and supports the sun gear and the driven bevel gear of the hand crank mechanism. The clutch and engaging mechanism consists of the clutch spacer, clutch discs, spline nut bushing, spline nut, screw shaft, spring spacer, clutch springs, spring ring and stud assembly, and the clutch adjusting nut. The clutch spacer is assembled in the bottom of the barrel to ensure proper location of the clutch discs with respect to the spline nut and barrel splines. The discs of the clutch pack are alternately splined to the barrel and the spline nut. The outer discs mate with the barrel splines; the inner discs engage the splines of the spline nut. The screw shaft moves longitudinally within the spline nut; its external threads mate with threads formed in the inner face of the spline nut. The spline nut bushing is located at the top of the clutch pack and fits around the flange of the spline nut. The spring spacer fits over the top of the spline nut flange and engages the barrel splines. The clutch springs, assembled on the spring ring and stud assembly, and the clutch adjusting nut located at the open end of the barrel, are the means of regulating the clutch setting. Engine oil is prevented from entering the clutch pack by an oil seal and retainer assembly. The seal is pressed into the inner end of the spline nut and fits around the meshing rod.

20. *Sun gear.* The sun gear is a disc-shaped forging with an internal gear formed on the inner periphery of the rim of the disc and a spur pinion cut on the extension of the hub. The large internal gear is driven by the bell gear; the spur pinion drives the planetary pinions which are assembled on the barrel studs.

21. *Baffle plate assembly.*—The baffle plate assembly is mounted on the front housing pilot between the strater jaw and the mounting flange. The oil-sealing portion fits snugly around the outside periphery of the spline nut.

22. *Starter jaw.*—The starter jaw is splined to and rotates with the screw shaft. The longitudinal motion is controlled by the spring-loaded meshing rod.

Solenoid assembly

23. The solenoid assembly is attached to the mounting pad on the motor housing boss. Electrical connections are made from the positive coil terminal to the solenoid terminal post of the main terminal board. The negative side of the coil is earthed to the starter housing. An adjustable poppet and a locknut, assembled on the outer end of the plunger shaft, permit adjustment of the retracted position of the starter jaw and the jaw travel. The solenoid assembly consists of the coil housing, dust cover, coil assembly, end plate assembly, and plunger assembly. The plunger assembly moves longitudinally within the coil core and actuates the operating lever and the engaging linkage. An anti-rattle spring is inserted in the coil core to prevent vibration of the plunger when the engine is running. The shaft of the plunger assembly incorporates a collar which is pinned in place and provides engagement for the bell crank lever. The coil assembly is rigidly mounted in the housing. A groove cut into the outer face of the plunger prevents rotary motion of the plunger.

INSTALLATION

24. The starter mounting flange has 24 holes which permit rotation of the starter in increments of 15 degrees. After the starter has been set in place, the paint should be scraped from the back of the mounting flange around three of the mounting holes which are to be used, thus ensuring a good earth connection between the starter and the engine. Since the

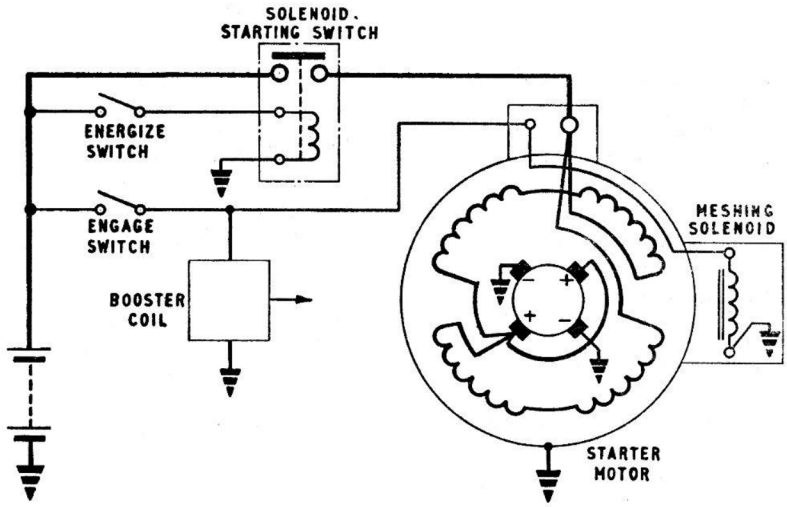


Fig. 3 Typical installation wiring diagram

starter is designed for use with an earth-return system, it is necessary that a good earth return be maintained between the starter, the engine, and the aircraft structure.

OPERATION

Motor

25. Operation of the aircraft starter "Energise" switch closes the starter relay solenoid which supplies 24V d.c. to the motor circuit. The armature rotates and accelerates the flywheel to its normal operating speed of 15,000 rev/min.

Reduction gearing

26. The starter gear train converts the high-speed, low-torque energy of the motor and flywheel to the low-speed, high-torque energy required at the starter jaw to crank the engine. The motor and flywheel torque is transmitted from the armature pinion through the bell gear and sun gear to the planetary pinions which are attached to and drive the driving barrel as they revolve within the fixed annulus gear.

Multiple disc clutch

27. The multiple disc clutch is a torque limiting device designed to protect the starter and engine mechanisms from overload. It is a friction clutch set to a specific torque limit which is determined by the maximum allowable output of the starter and engine-cranking torque requirements. The friction between adjacent discs, alternately splined to the barrel and spline nut, can be regulated by varying the spring pressure of clutch pack. This is accomplished by means of the clutch adjusting nut. When the torque load on the starter exceeds the clutch setting, the clutch will slip and the starter will not assume the added load.

Meshing solenoid and engaging linkage

28. When the flywheel has reached its normal operating speed (15000 rev/min.), the starter "ENGAGE" switch should be closed. Current will then flow through the solenoid coil and cause the starter jaw to be engaged with the engine jaw. The plunger shaft actuates the operating lever attached to the clevis shaft which, in turn, operates the clevis thus advancing the meshing rod. The meshing rod has a shoulder located just behind the screw shaft. As the meshing rod moves forward, this shoulder pushes the screw shaft forward. The starter jaw advances with the screw shaft and engages the engine jaw. Whereupon the mechanical energy of the rotating flywheel and motor armature is transmitted to the engine jaw through the starter reduction gearing, multiple disc clutch, and starter jaw. In the event that the solenoid is not operating, engagement of the starter and engine jaws may be accomplished through the engaging linkage alone. A pull cable attached to either the meshing bell crank, located on top of the solenoid mounting boss, or to the operating lever will actuate the engaging linkage.

Hand crank

29. The starter flywheel may be manually accelerated by means of a hand crank and

extension assembly which may be attached to the starter crankshaft. When the starter is operated manually, the brush spring release handle must be placed in the "OFF" position to release the brush springs allowing the armature to turn freely. Shifting the handle from the "ON" position to the "OFF" position moves the lever operating ring in an arc, and rotates the spring levers which are attached to the spring posts. The brush springs are attached to the spring posts by means of the adjusting sleeves and cotter pins; thus, when the levers rotate, the springs are lifted off the brushes. Torque applied at the hand crank is transmitted to the armature and flywheel assembly through the crankshaft, driving bevel gear, driven bevel gear, and back through the starter gearing. When the flywheel is accelerated to its operating speed, engagement of the starter and engine jaws is accomplished either electrically or manually as described in para. 28.

Starter jaw retraction

30. When the engine starts, both the "ENERGISE" and "ENGAGE" switches are immediately returned to the "OFF" position. When the meshing solenoid circuit is opened, the clevis spring returns the engaging linkage and starter jaw to the retracted position. An additional disengaging action is obtained by the engine jaw overriding the starter jaw as the engine starts.

SERVICING

Housings and mounting flange

31. Examine the unit for housing failures or cracks, especially at the mounting flange. If any cracks or other failures of the housing or flange are observed, the unit must be replaced.

Motor

32. Remove the window strap from the motor and perform the operations outlined in the following paragraphs. Reassemble the window strap upon completion of the inspection.

Brush springs

33. Check the brush spring tension by using a standard spring balance of suitable range. Measure the tension when the end of the spring, which normally rests on top of the brush, is raised $\frac{1}{8}$ in. above the top of the brush box. The tension should be between 24 and 28 oz.

Note . . .

When the spring tension is being checked, ensure that the brush spring release handle is in the "ON" position.

Brushes

34. Brushes should be a free fit in the brush boxes. Binding brushes and brush boxes should be wiped clean with a cloth moistened in lead-free gasoline. New brushes should be fitted if the rate of wear indicates that the minimum length may be reached before the next inspection period. The maximum permissible wear of the brushes is $\frac{3}{16}$ in. from a new length of $\frac{1}{2}$ in. The minimum length of brush permitted is $\frac{5}{16}$ in. Inspect brush lead sleeving and replace if it it is burned or frayed. When new brushes are being installed, make sure that the brush leads are properly covered with sleeving.

Commutator

35. Inspect the contact surface of the commutator for roughness and colour. An even, highly burnished, copper colour indicates satisfactory operation. If the commutator has a dirty appearance, it may be cleaned with a cloth moistened in unleaded gasoline. If the commutator is badly scored or pitted, it must be resurfaced.

Electrical connections

36. Make a visual inspection of all wiring for possible earthed, shorted, or broken leads and for burned, cracked, or unserviceable insulation. Examine all terminal connections for corrosion and security of attachment.

TESTING

Free running test

37. Remove the bearing cap and clamp the bearing by mounting steel washers under two opposite bearing cap screws. Apply a tachometer to the centre of the armature shaft at the commutator end. Run the motor at a speed of 16000 rev/min., disconnect the power supply and shift the brush spring release handle to the "OFF" position. Starting from 15000rev/min. check the time for the armature and flywheel assembly to come to rest. The free run-down time should be not less than three minutes. Return the brush spring release handle to the "ON" position.

Acceleration test

38. Check the time required for the motor to accelerate to a speed of 15000 rev/min.