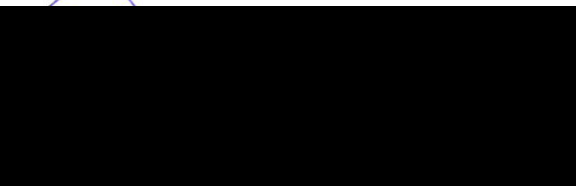


**FLUID SYSTEMS DIVISION
PARKER HANNIFIN CORPORATION
711 TAYLOR STREET
ELYRIA, OHIO 44035**

5 DECEMBER 2017

**2C27-1 CENTRIFUGAL FUEL PUMP CARTRIDGE
EXAMINATION**

Prepared By



Daniel E. Scholz P.E.
Air Safety Investigator

Parker was contacted by Joshua Cawthra, Senior Aviation Accident Investigator, National Transportation Safety Board, requesting assistance in the investigation of a Parker 2C27-1 centrifugal fuel pump cartridge. Joshua reported this pump cartridge was removed from a Bell 206B (N211CS) that sustained substantial damage during a forced landing following a loss of engine power.

On 31 August 2017 the 2C27-1 centrifugal fuel pump cartridge was hand carried to Parker by Steven Heard and Sandor Janosy, both Aviation Safety Inspectors Federal Aviation Administration. The Unit was examined this day by Daniel Scholz, Air Safety Investigator Parker.

Upon completion of this examination the 2C27-1 centrifugal fuel pump cartridge was taken by Steven Heard (FAA) for return to the NTSB.

FUEL PUMP INFORMATION

Model No.	2C27-1
Serial No.	4H234 on Nameplate
Manufacture Date	April 1981, (if parts from Parker unit of same S/N)
Overhauled by:	Fleet Support Services, Inc.

TESTING AS RECEIVED

28 VDC was applied and no flow was observed. Using a multi-meter across the positive and negative terminals, no continuity was observed. From the exterior of the cartridge the impeller would rotate by hand. Acceptance Test Procedure Hydro Test (Leakage test) was performed and the unit leaked through the O-rings at both 60 and 10 psig.

FUEL PUMP EXTERNAL EXAMINATION

Photos 2C27-1 4H234 31 Aug17_010 through 2C27-1 4H234 31 Aug17_022 show the unit as received. Rusty Upper Brush Card fasteners were observed along with the rusty negative terminal screw. Refer to photos 2C27-1 4H234 31 Aug17_013 and 2C27-1 4H234 31 Aug17_014. The unit's field tube appeared different in color and surface finish than Parker's unit. Parker's field tubes have a smooth uniform finish around the circumference of the tube and are Cadmium plated with a Yellow Dichromate Dip. The field tube of this unit was more silver in color and had an unusual surface finish shown in photo 2C27-1 4H234 31 Aug17_015.

FUEL PUMP INTERNAL EXAMINATION

Prior to disassembly the unit's interfaces were marked for examination reassembly if needed. Refer to Photos 2C27-1 4H234 31 Aug17_023 and 2C27-1 4H234 31 Aug17_024. Removal of the Motor cover exposed the Brush Card Phenolic Insulator and Upper Brush Card itself. Both of these items were covered with debris (FOD). Refer to Photos 2C27-1 4H234 31 Aug17_029 and 2C27-1 4H234 31 Aug17_032. The Motor Brush marked "K194" in Photo 2C27-1 4H234 31 Aug17_035 is not of Parker design. The Upper Motor Brushes in 2C27-1 4H234 31 Aug17_036 through 2C27-1 4H234 31 Aug17_039 show arcing on one of the Brushes. Arcing of this degree will shorten pump motor service life. Debris was found throughout the inside of the motor cavity with the heaviest as corrosion on the inside of the field tube or on adjacent components such as the Lower Brush Card. Refer to 2C27-1 4H234 31 Aug17_042 through 2C27-1 4H234 31 Aug17_050. The Motor Armature potting between the laminations had swelled past the lamination diameter indicating that the pump had been run dry. This design pump circulates fuel through the motor to cool the motor and lubricate the bearings. When run dry, fuel will not be available to cool the motor, thus the motor temperature will increase. As the motor temperature increases the copper windings within the armature will expand pushing the potting between the laminations beyond the lamination diameter. Continued increase in pump temperature will open the Thermal Fuse, shutting off power to the pump's motor. Refer to Photos 2C27-1 4H234 31 Aug17_052 and 2C27-1 4H234 31 Aug17_066. The Thermal Fuse continuity was checked and the fuse was found to be open. Aside from the motor overheating as a possible cause for the open Thermal Fuse, the Thermal Fuse was contacting the Armature during operation of the pump. As the Armature rotated the friction of the contact added to the temperature of the Thermal Fuse. Refer to Photos 2C27-1 4H234 31 Aug17_058, 2C27-1 4H234 31 Aug17_059, and Photos 2C27-1 4H234 31 Aug17_075 through 2C27-1 4H234 31 Aug17_077. The Pump's Impeller consists of 3 initial blades that pull fuel into the Impeller Eye, 2 of the 3 were blocked by a black substance. Refer to 2C27-1 4H234 31 Aug17_071 through 2C27-1 4H234 31 Aug17_074.

DISCUSSION

This design Cartridge and corresponding Canister make up a complete Boost Pump Assembly. The basic design is to allow the replacement of the Cartridge in the field without the necessity of draining the fuel from the fuel tank. The Pump Canister has an internal ball check valve for "Idle Bypass", where if this Boost Pump is inoperative the Engine Driven Pump can still draw fuel through the Boost Pump Canister with minimal pressure drop. During Boost Pump operation the ball check closes due to Boost Pump Discharge Pressure.

This unit identified as 2C27-1 serial number 4H234 was received in an inoperable condition for the following reason:

Thermal Fuse was found open from over-heating. Either from Dry Run or Dry Run in combination with the Armature rubbing the Thermal Fuse. The Thermal Fuse performed as designed to shut off the power to the pump before the pump casing could reach the auto-ignition temperature of fuel (approximately 390⁰ F).

When the Thermal Fuse is open no power could reach to the Pump Motor. Thus, the motor would not run.

The Impeller blockage on the leading edge of 2 of the 3 leading Impeller Vanes happened prior to the Pump Motor becoming inoperative. When this unit went into idle bypass most if not all the fuel flow would travel through the bypass porting within the Pump Canister.

It should be noted that Parker does not provide instructions, parts or support for the overhaul of this product outside of Parker.

APPENDIX A

PHOTO LOG

Photograph Numbering Format:

<u>Pump Model</u>	<u>Serial Number</u>	<u>Photo Date</u>	<u>Photo Number</u>
2C27-1	4H234	31 Aug 2017	001

Photograph Number	Description
2C27-1 4H234 31Aug17_001	Unit as received
2C27-1 4H234 31Aug17_002	Unit as received
2C27-1 4H234 31Aug17_003	Unit as received
2C27-1 4H234 31Aug17_004	Unit as received
2C27-1 4H234 31Aug17_005	Unit as received
2C27-1 4H234 31Aug17_006	Unit as received
2C27-1 4H234 31Aug17_007	Unit as received
2C27-1 4H234 31Aug17_008	Unit as received
2C27-1 4H234 31Aug17_009	Unit as received
2C27-1 4H234 31Aug17_010	Unit as received
2C27-1 4H234 31Aug17_011	Unit as received
2C27-1 4H234 31Aug17_012	Unit as received
2C27-1 4H234 31Aug17_013	Rusty Screw Heads
2C27-1 4H234 31Aug17_014	Rusty Screw Head
2C27-1 4H234 31Aug17_015	Name Plate attached as received
2C27-1 4H234 31Aug17_016	Name Plate attached as received
2C27-1 4H234 31Aug17_017	Name Plate
2C27-1 4H234 31Aug17_018	Name Plate
2C27-1 4H234 31Aug17_019	Name Plate
2C27-1 4H234 31Aug17_020	Name Plate
2C27-1 4H234 31Aug17_021	Cartridge Clocking Mark
2C27-1 4H234 31Aug17_022	Name Plate removed
2C27-1 4H234 31Aug17_023	Marking for Reassembly if needed
2C27-1 4H234 31Aug17_024	Marking for Reassembly if needed
2C27-1 4H234 31Aug17_025	Removal of Brush Card Screws
2C27-1 4H234 31Aug17_026	Removal of Motor Stud Nuts
2C27-1 4H234 31Aug17_027	Brush Card Phenolic Insulator
2C27-1 4H234 31Aug17_028	Inside of Motor Cover
2C27-1 4H234 31Aug17_029	Brush Card Assembly
2C27-1 4H234 31Aug17_030	Brush Card Assembly
2C27-1 4H234 31Aug17_031	Brush Card Phenolic Insulator
2C27-1 4H234 31Aug17_032	Brush Card Phenolic Insulator
2C27-1 4H234 31Aug17_033	Brush Spring
2C27-1 4H234 31Aug17_034	Brush Spring
2C27-1 4H234 31Aug17_035	Non-Parker Motor Brush
2C27-1 4H234 31Aug17_036	Motor Brush Wear Pattern - OK

Photograph Number	Description
2C27-1 4H234 31Aug17_037	Motor Brush Wear Pattern - OK
2C27-1 4H234 31Aug17_038	Motor Brush Signs of Arcing
2C27-1 4H234 31Aug17_039	Motor Brush Signs of Arcing
2C27-1 4H234 31Aug17_040	Brush Card Debris
2C27-1 4H234 31Aug17_041	Brush Card Debris
2C27-1 4H234 31Aug17_042	Field Tube Heavy Corrosion
2C27-1 4H234 31Aug17_043	Field Tube Heavy Corrosion
2C27-1 4H234 31Aug17_044	Field Tube Heavy Corrosion
2C27-1 4H234 31Aug17_045	Field Tube
2C27-1 4H234 31Aug17_046	Field Tube
2C27-1 4H234 31Aug17_047	Field Tube Heavy Corrosion
2C27-1 4H234 31Aug17_048	Heavy Debris on Lower Brush Card
2C27-1 4H234 31Aug17_049	Heavy Debris on Lower Brush Card
2C27-1 4H234 31Aug17_050	Heavy Debris on Lower Brush Card
2C27-1 4H234 31Aug17_051	Motor Armature
2C27-1 4H234 31Aug17_052	Motor Armature Potting Swelled
2C27-1 4H234 31Aug17_053	Armature Commutator – Signs of Arcing
2C27-1 4H234 31Aug17_054	Armature Contacting Thermal Fuse
2C27-1 4H234 31Aug17_055	Armature Contacting Thermal Fuse
2C27-1 4H234 31Aug17_056	Armature Contacting Thermal Fuse
2C27-1 4H234 31Aug17_057	Armature Contacting Thermal Fuse
2C27-1 4H234 31Aug17_058	Armature Contacting Thermal Fuse
2C27-1 4H234 31Aug17_059	Non-Parker Marking on Armature
2C27-1 4H234 31Aug17_060	Commutator Wear Pattern OK
2C27-1 4H234 31Aug17_061	Commutator Signs of Arcing
2C27-1 4H234 31Aug17_062	Commutator Wear Pattern OK
2C27-1 4H234 31Aug17_063	Commutator Wear Pattern OK
2C27-1 4H234 31Aug17_064	Non-Parker Marking
2C27-1 4H234 31Aug17_065	Non-Parker Marking
2C27-1 4H234 31Aug17_066	Swelled Potting Indication DRY RUN
2C27-1 4H234 31Aug17_067	Lower Brush Card
2C27-1 4H234 31Aug17_068	Lower Brush Card
2C27-1 4H234 31Aug17_069	Lower Brush Card
2C27-1 4H234 31Aug17_070	Impeller Eye
2C27-1 4H234 31Aug17_071	Debris across 1 st Impeller Blade Inlet
2C27-1 4H234 31Aug17_072	Debris across 1 st Impeller Blade Inlet
2C27-1 4H234 31Aug17_073	Debris across 2 nd Impeller Blade Inlet
2C27-1 4H234 31Aug17_074	No Debris on 3 rd Impeller Blade Inlet
2C27-1 4H234 31Aug17_075	Contact Mark from Armature Rubbing Thermal Fuse
2C27-1 4H234 31Aug17_076	Contact Mark from Armature Rubbing Thermal Fuse
2C27-1 4H234 31Aug17_077	Contact Mark from Armature Rubbing Thermal Fuse
2C27-1 4H234 31Aug17_078	Debris on Pump Housing
2C27-1 4H234 31Aug17_079	Debris on Pump Housing
2C27-1 4H234 31Aug17_080	Packing for Return to NTSB

Photograph Number	Description
2C27-1 4H234 31Aug17_081	Packing for Return to NTSB
2C27-1 4H234 31Aug17_082	Packing for Return to NTSB



2C27-1 4H234 31Aug17_001 – Unit as received



2C27-1 4H234 31Aug17_002 – Unit as received



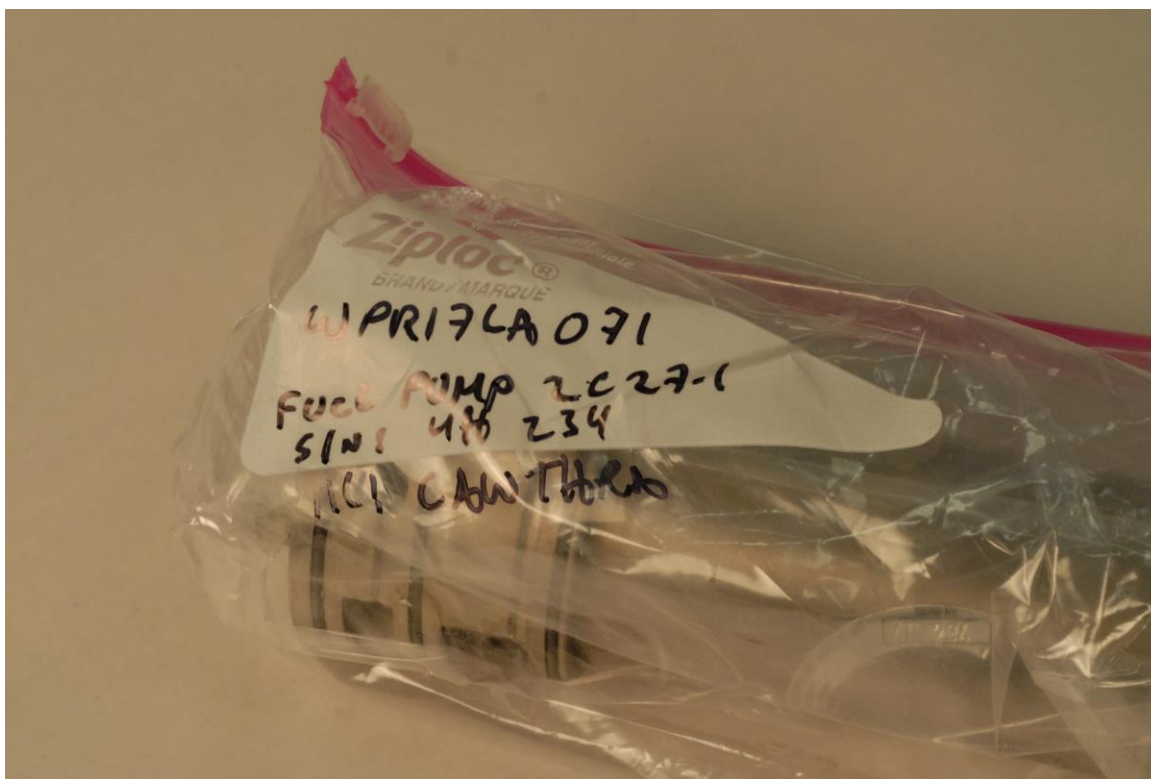
2C27-1 4H234 31Aug17_003 – Unit as received



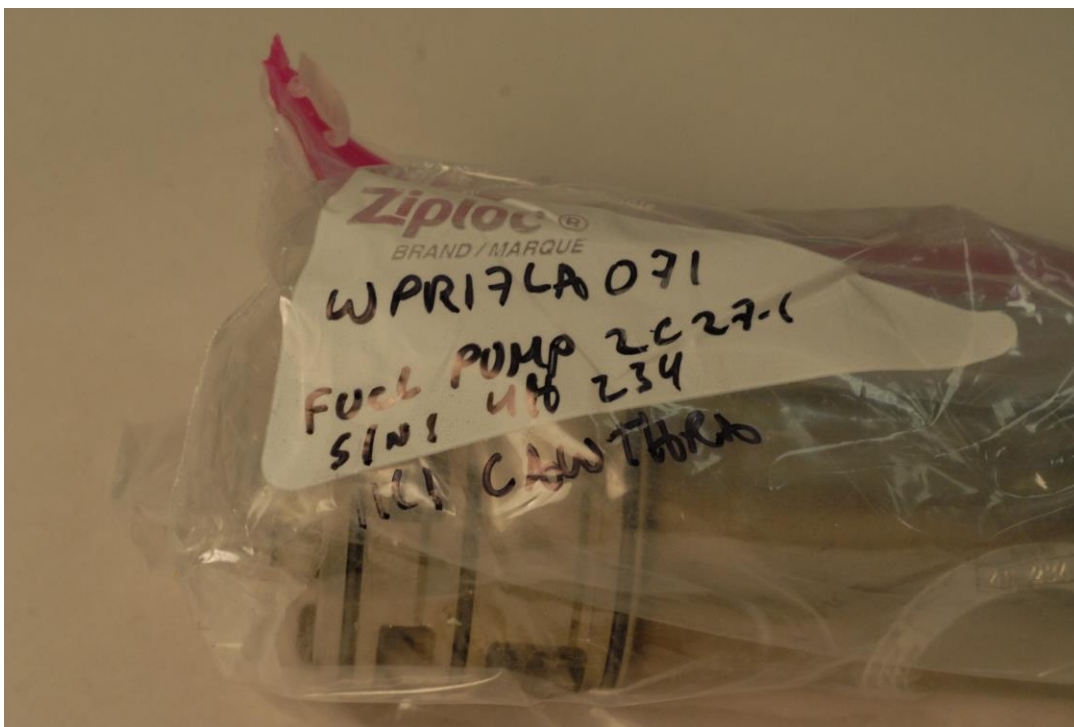
2C27-1 4H234 31Aug17_004 – Unit as received



2C27-1 4H234 31Aug17_007 – Unit as received



2C27-1 4H234 31Aug17_008 – Unit as received



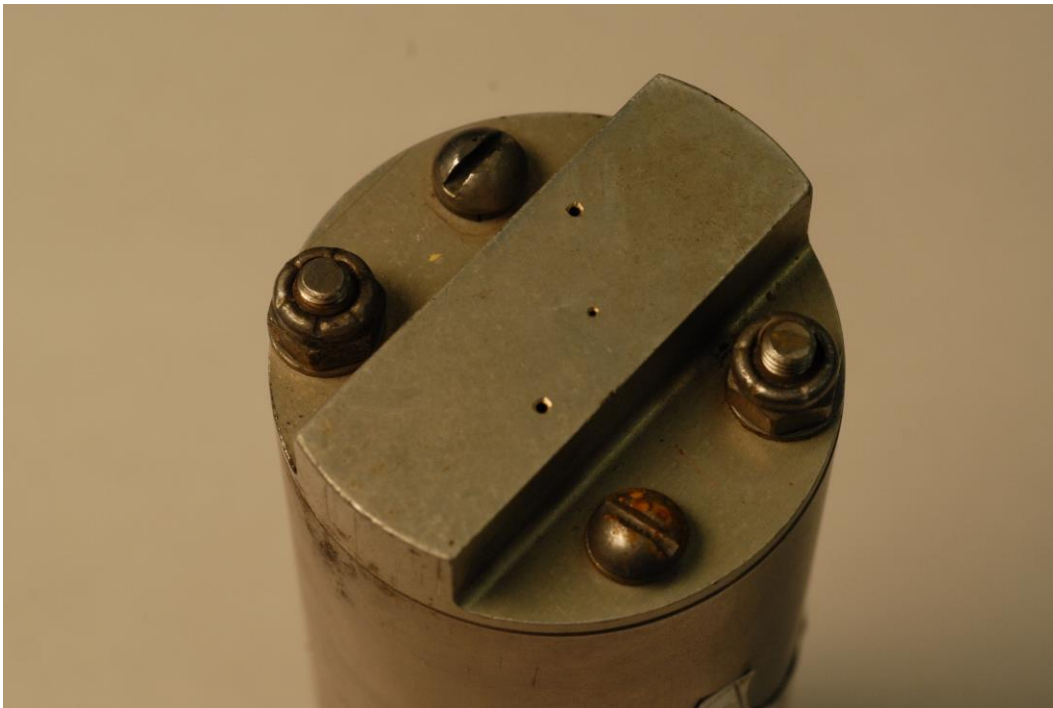
2C27-1 4H234 31Aug17_009 – Unit as received



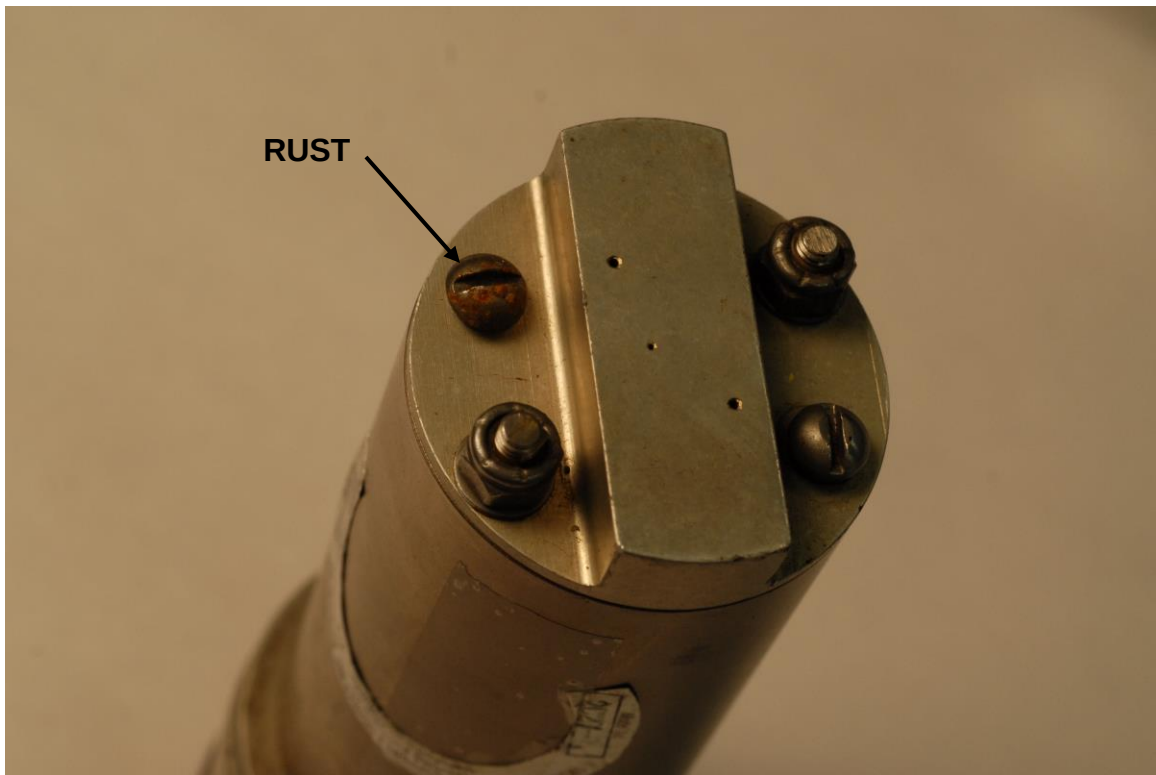
2C27-1 4H234 31Aug17_010 – Unit as received



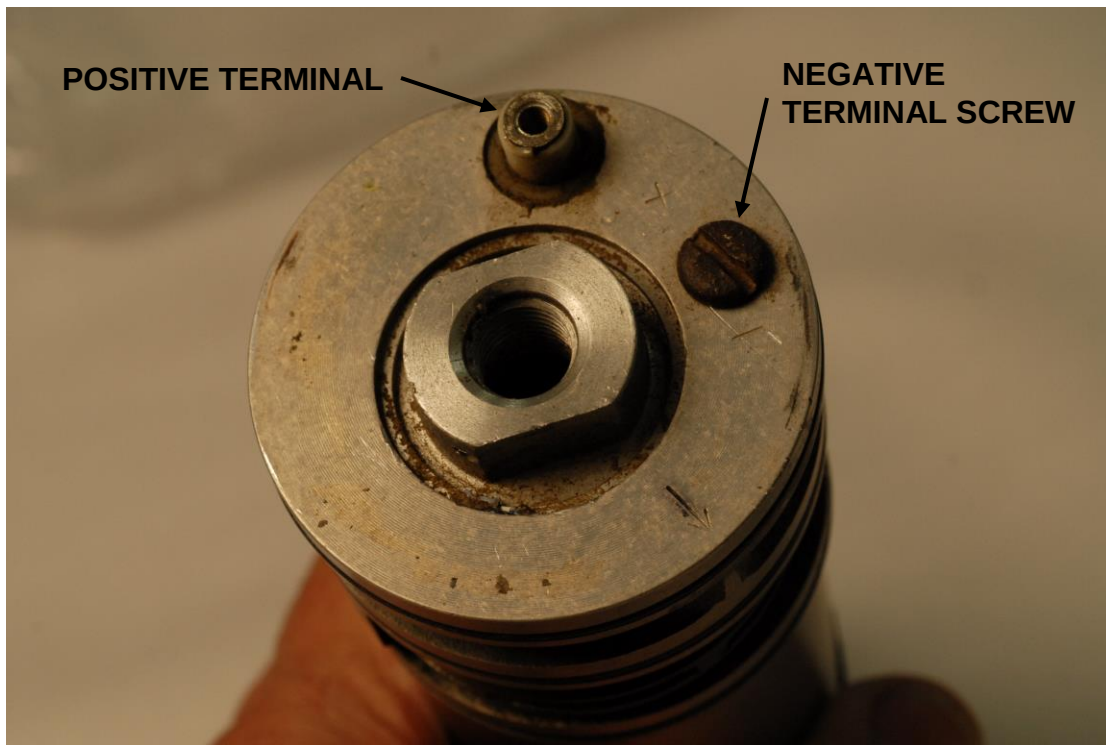
2C27-1 4H234 31Aug17_011 – Unit as received



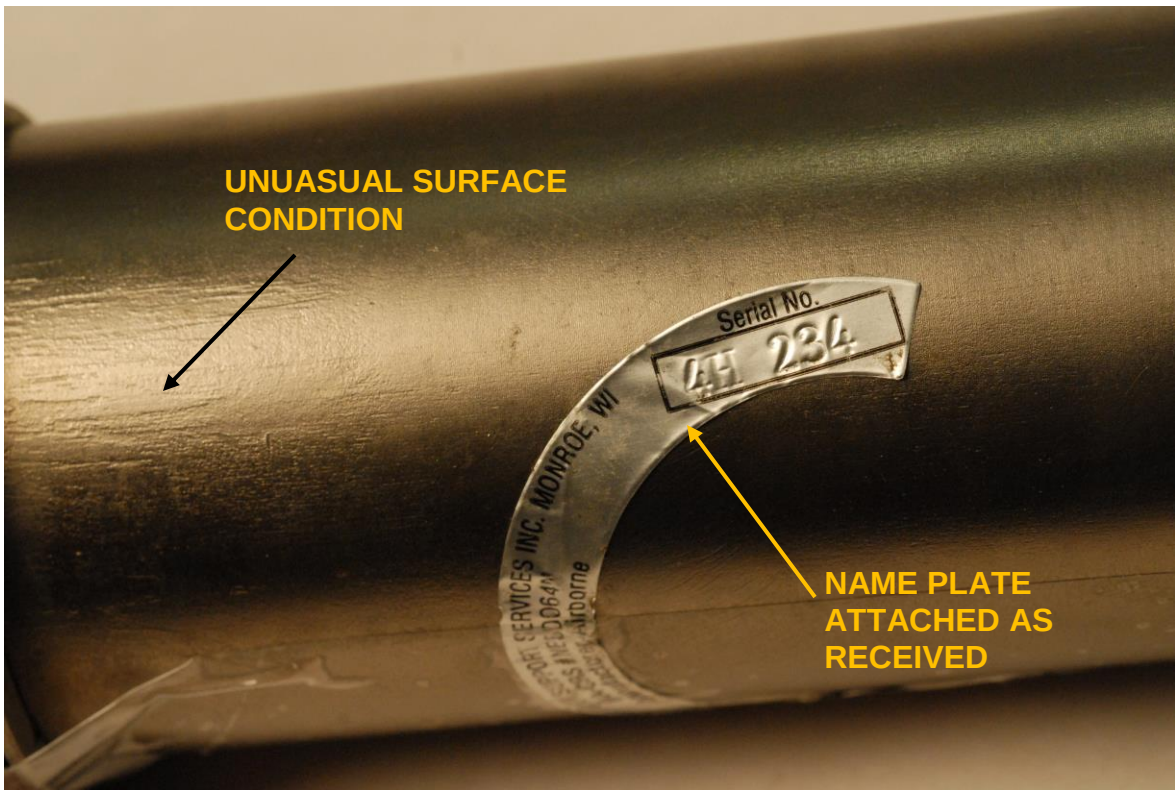
2C27-1 4H234 31Aug17_012 – Unit as received



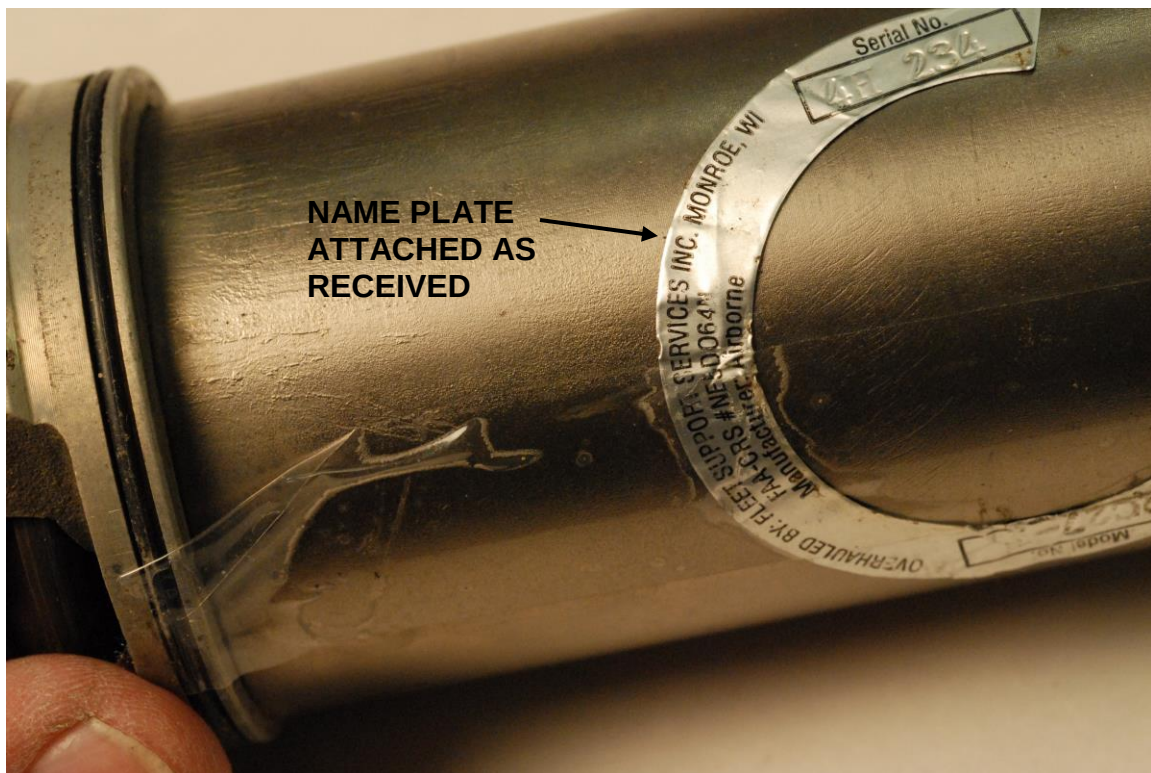
2C27-1 4H234 31Aug17_013 – Rusty Screw Heads



2C27-1 4H234 31Aug17_014 - Rusty Screw Head



2C27-1 4H234 31Aug17_015 - Name Plate attached as received



2C27-1 4H234 31Aug17_016 - Name Plate attached as received



2C27-1 4H234 31Aug17_017 – Name Plate



2C27-1 4H234 31Aug17_018 – Name Plate



2C27-1 4H234 31Aug17_019 – Name Plate



2C27-1 4H234 31Aug17_020 – Name Plate



2C27-1 4H234 31Aug17_021 - Cartridge Clocking Mark



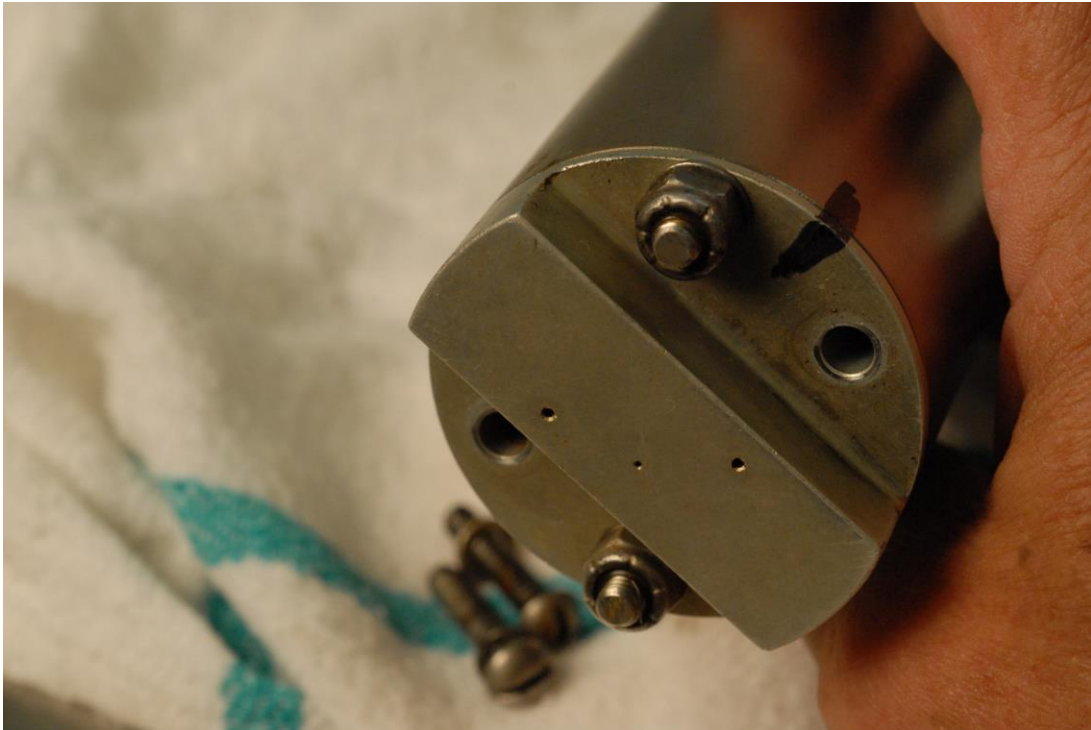
2C27-1 4H234 31Aug17_022 – Name Plate removed



2C27-1 4H234 31Aug17_023 – Marking for Reassembly if needed



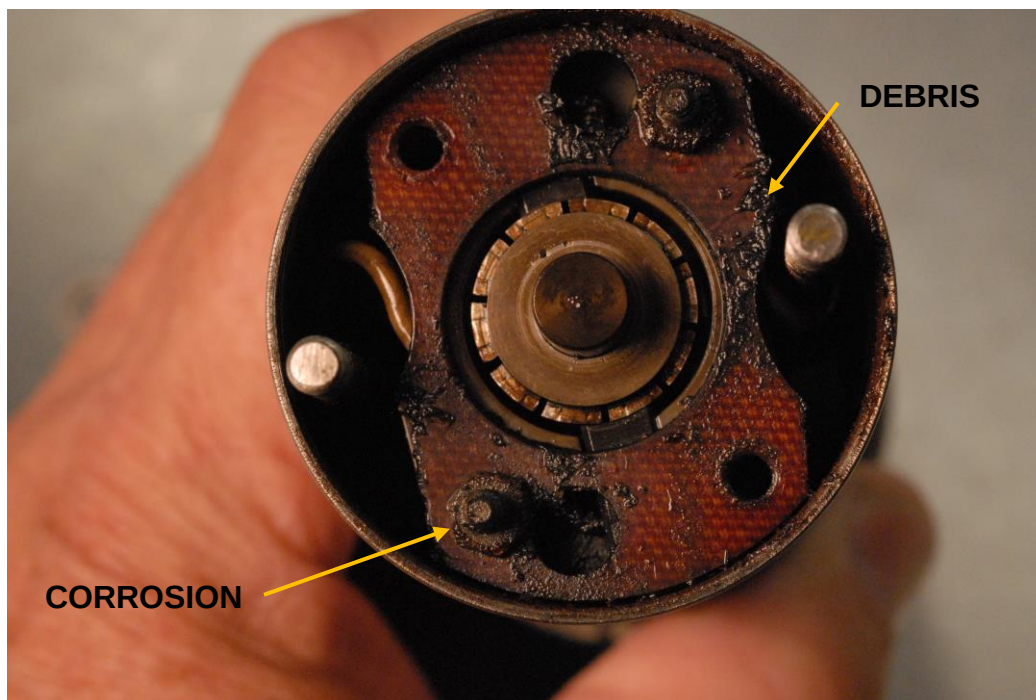
2C27-1 4H234 31Aug17_024 – Marking for Reassembly if needed



2C27-1 4H234 31Aug17_025 - Removal of Brush Card Screws



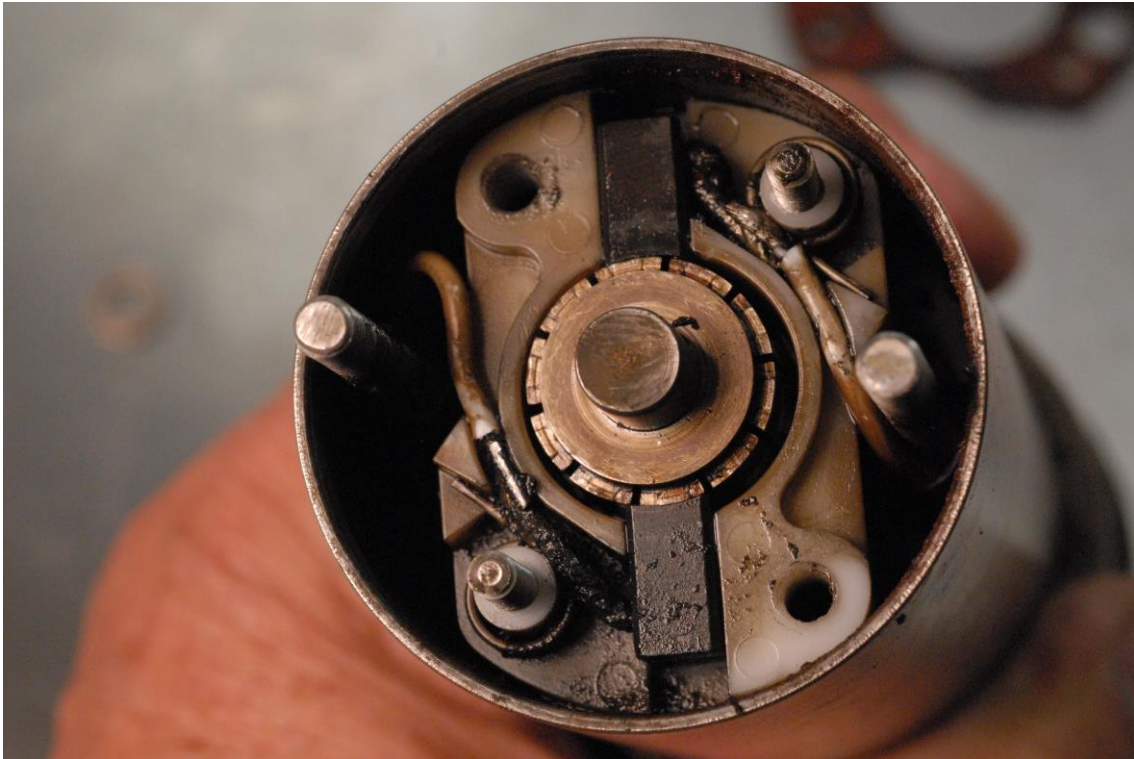
2C27-1 4H234 31Aug17_026 | Removal of Motor Stud Nuts



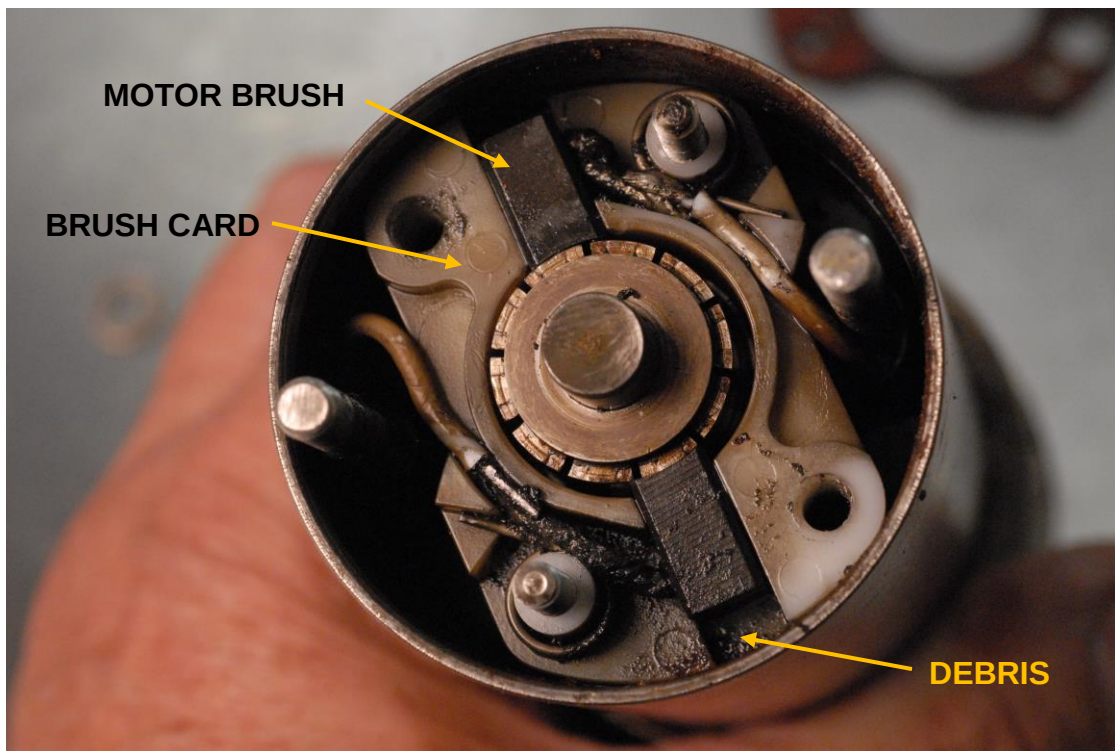
2C27-1 4H234 31Aug17_027 - Brush Card Phenolic Insulator



2C27-1 4H234 31Aug17_028 – Inside of Motor Cover



2C27-1 4H234 31 Aug17_029 - Brush Card Assembly



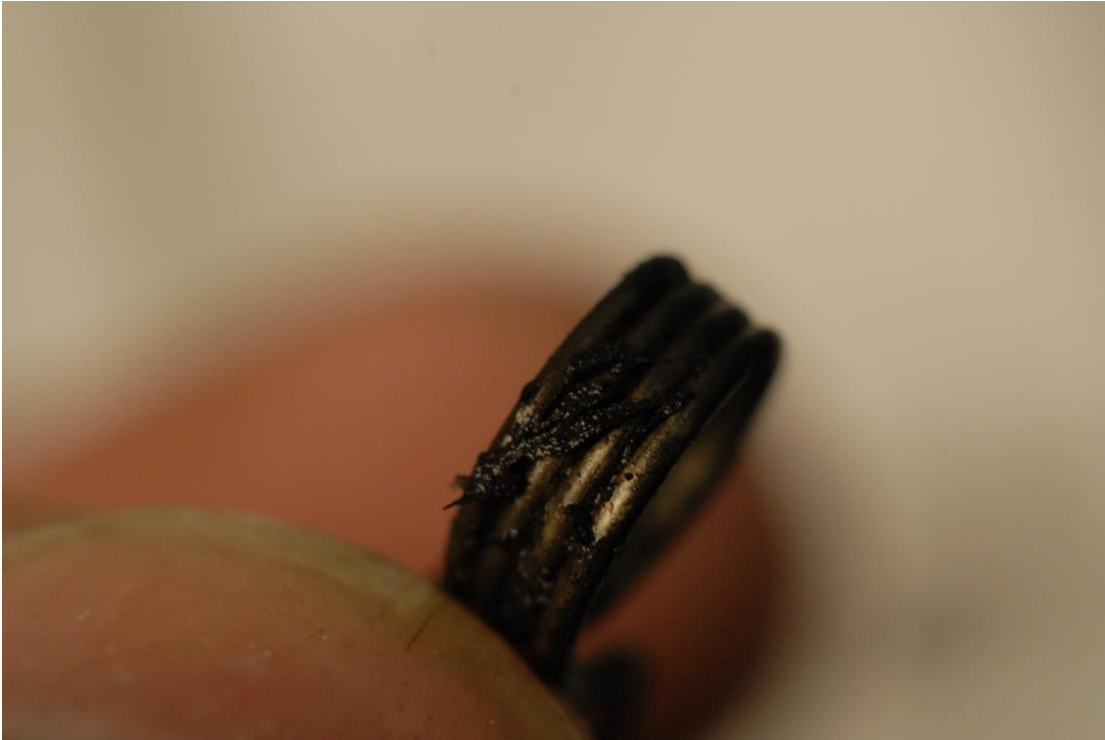
2C27-1 4H234 31Aug17_030 – Brush Card Assembly



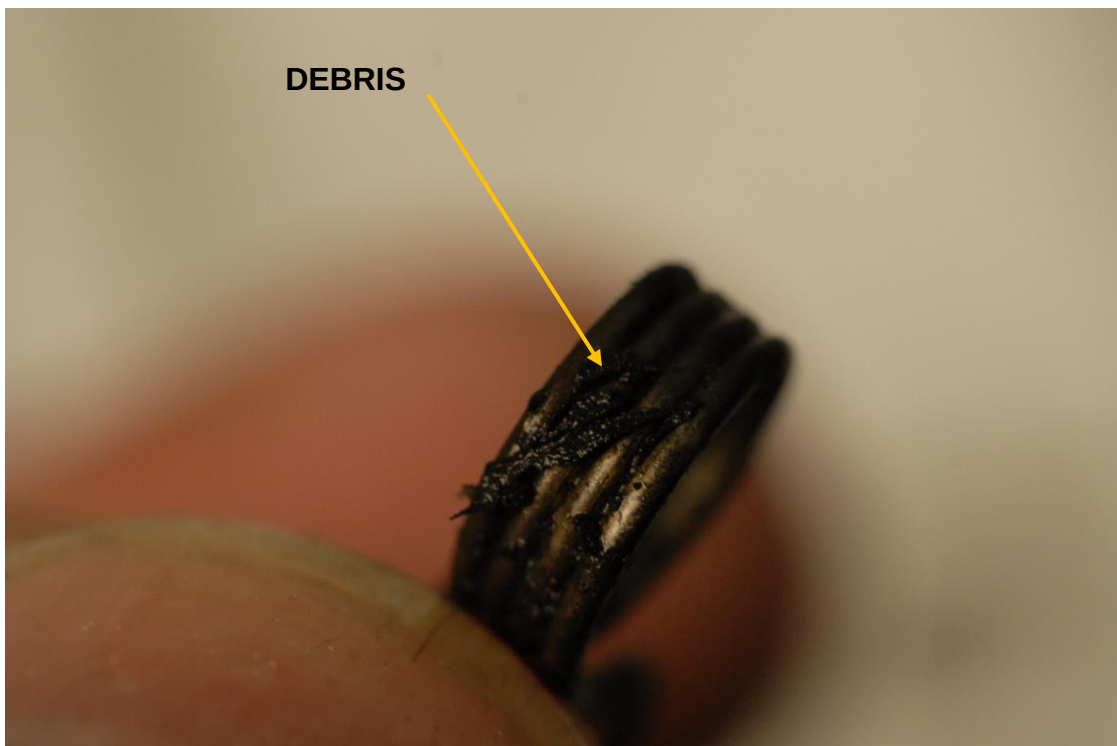
2C27-1 4H234 31Aug17_031 – Brush Card Phenolic Insulator



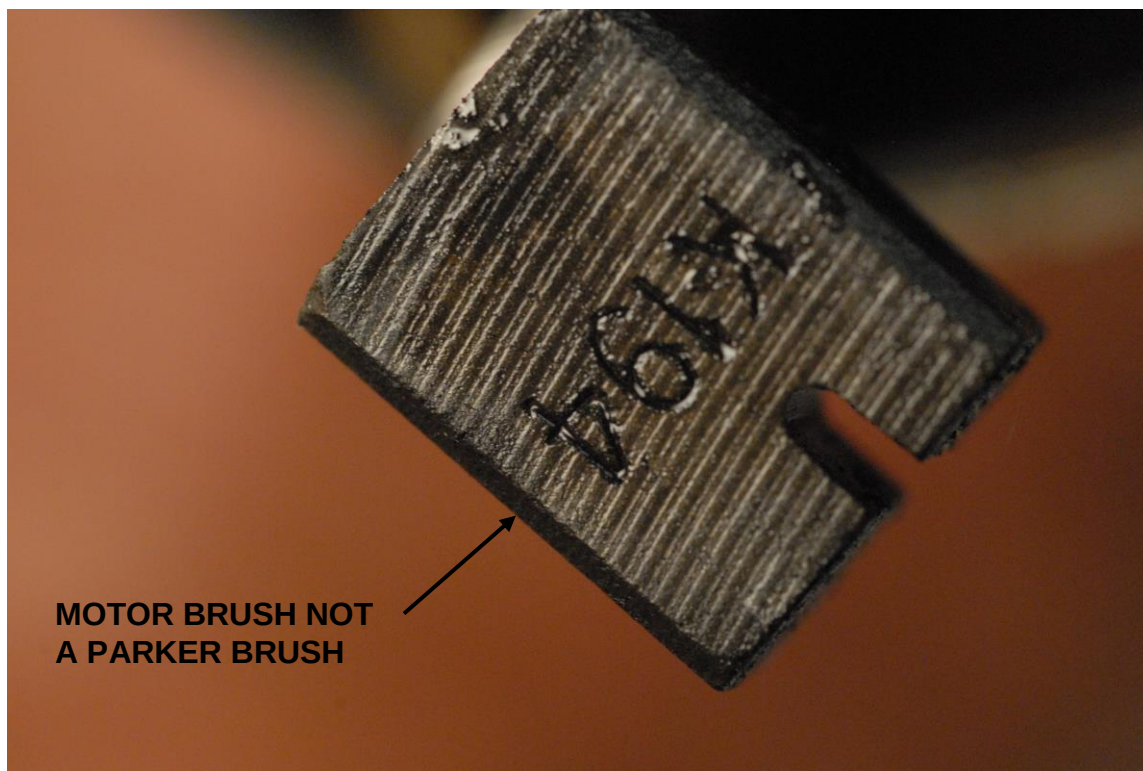
2C27-1 4H234 31Aug17_032 - Brush Card Phenolic Insulator



2C27-1 4H234 31Aug17_033 – Brush Spring

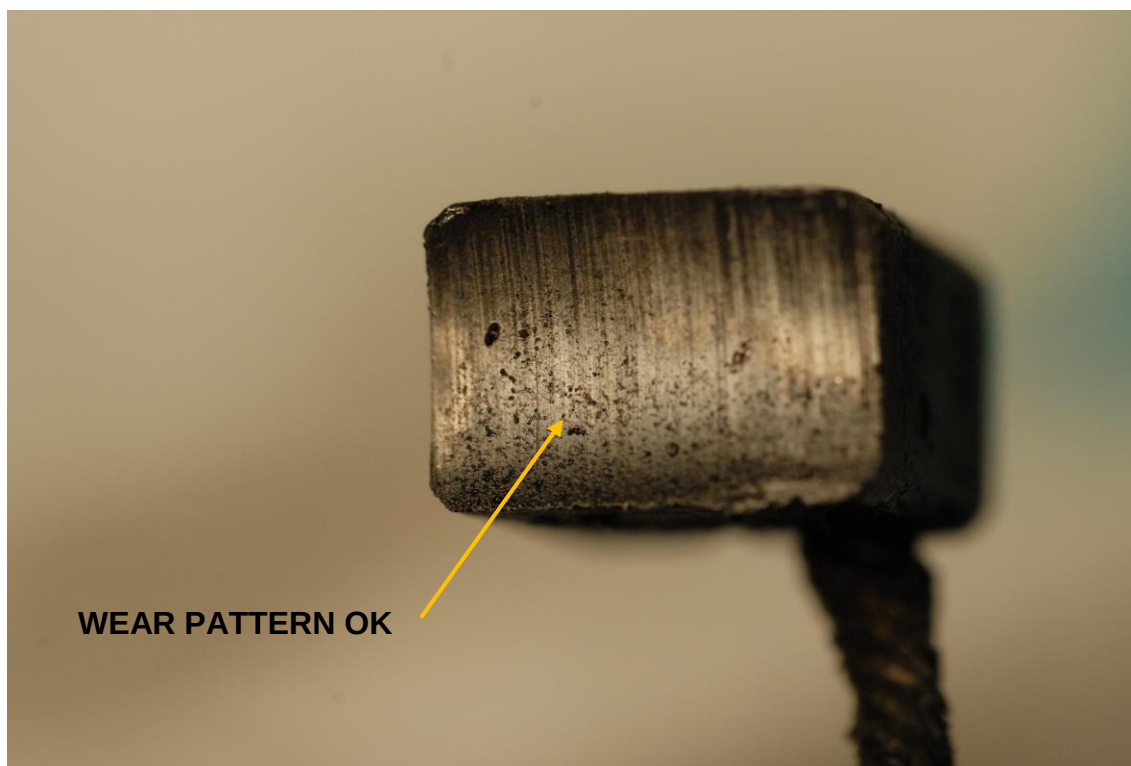


2C27-1 4H234 31Aug17_034 - Brush Spring



**MOTOR BRUSH NOT
A PARKER BRUSH**

2C27-1 4H234 31Aug17_035 – Non-Parker Motor Brush

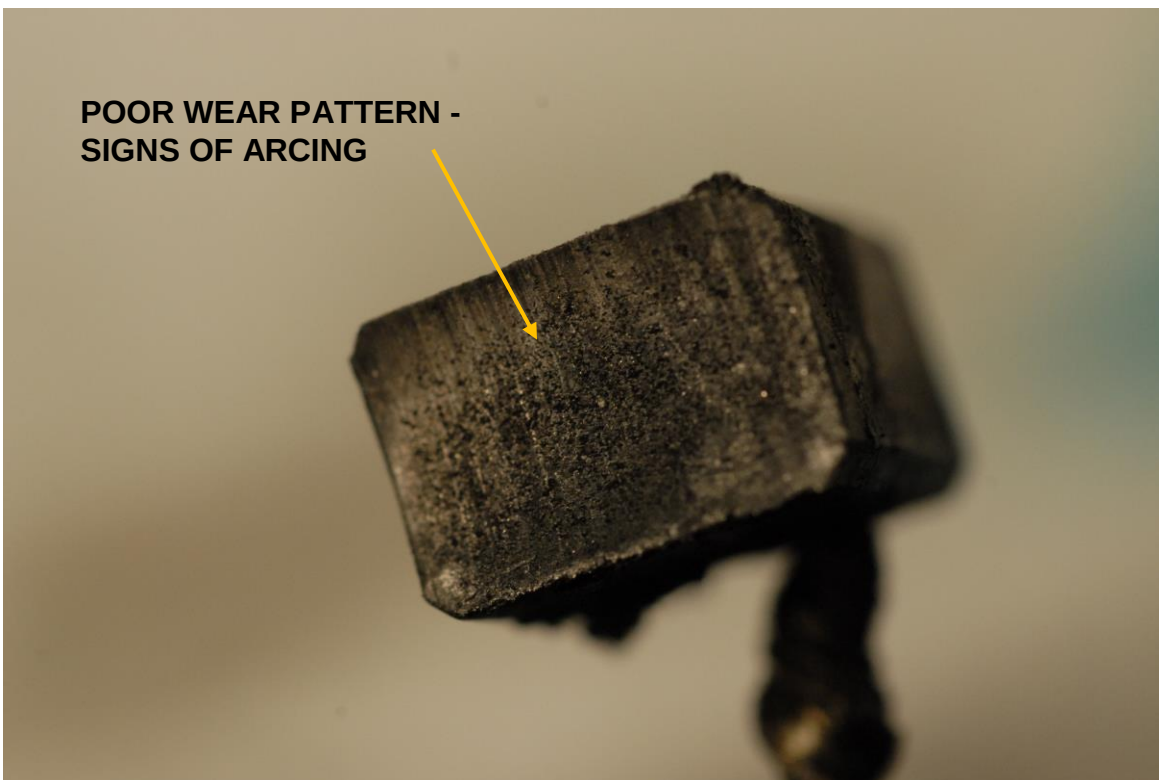


WEAR PATTERN OK

2C27-1 4H234 31Aug17_036 - Motor Brush Wear Pattern - OK



2C27-1 4H234 31Aug17_037 - Motor Brush Wear Pattern - OK

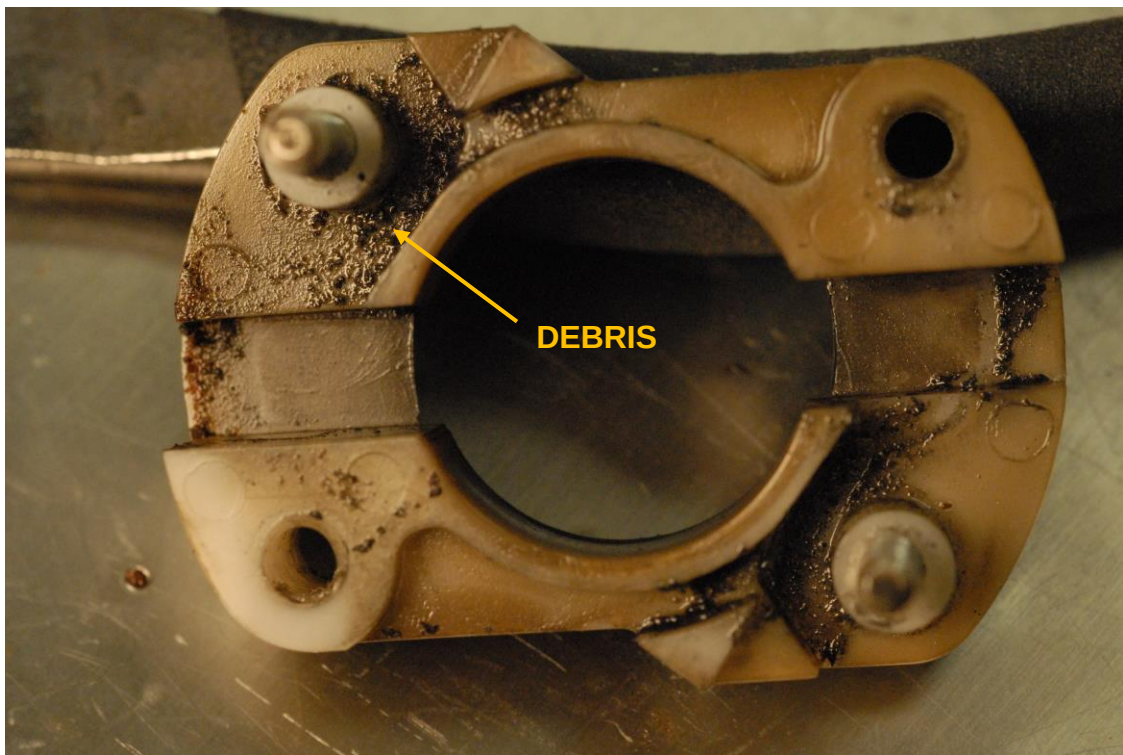


**POOR WEAR PATTERN -
SIGNS OF ARCING**

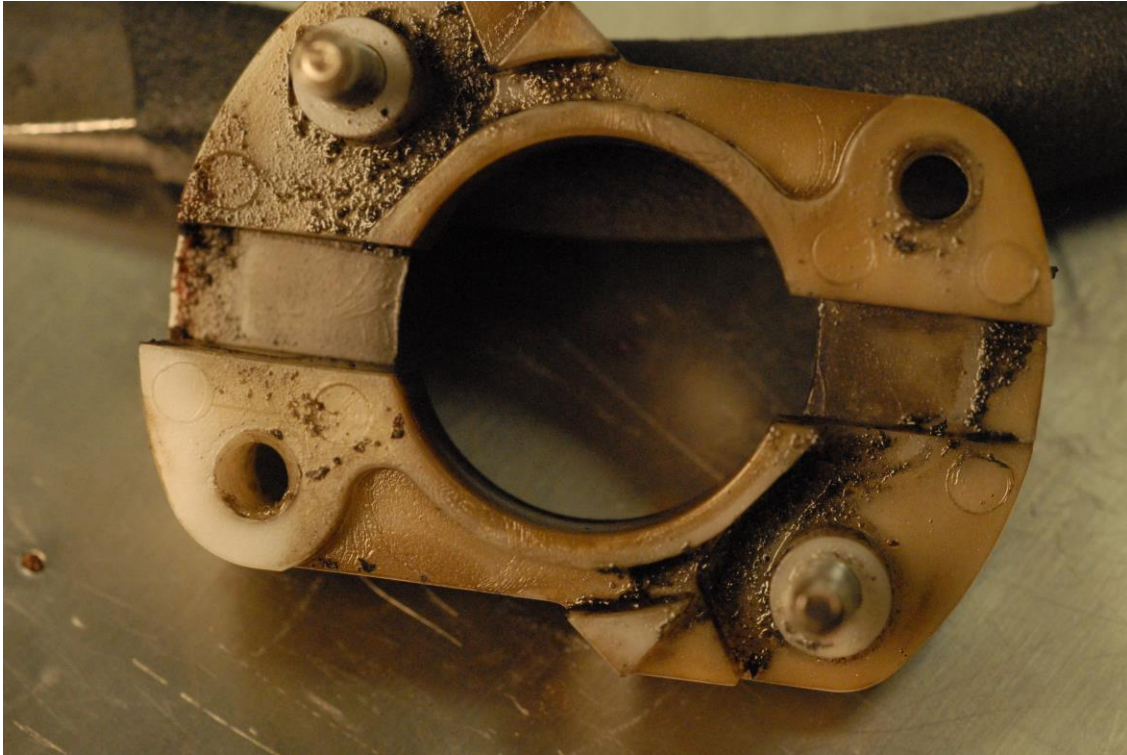
2C27-1 4H234 31Aug17_038 – Motor Brush Signs of Arcing



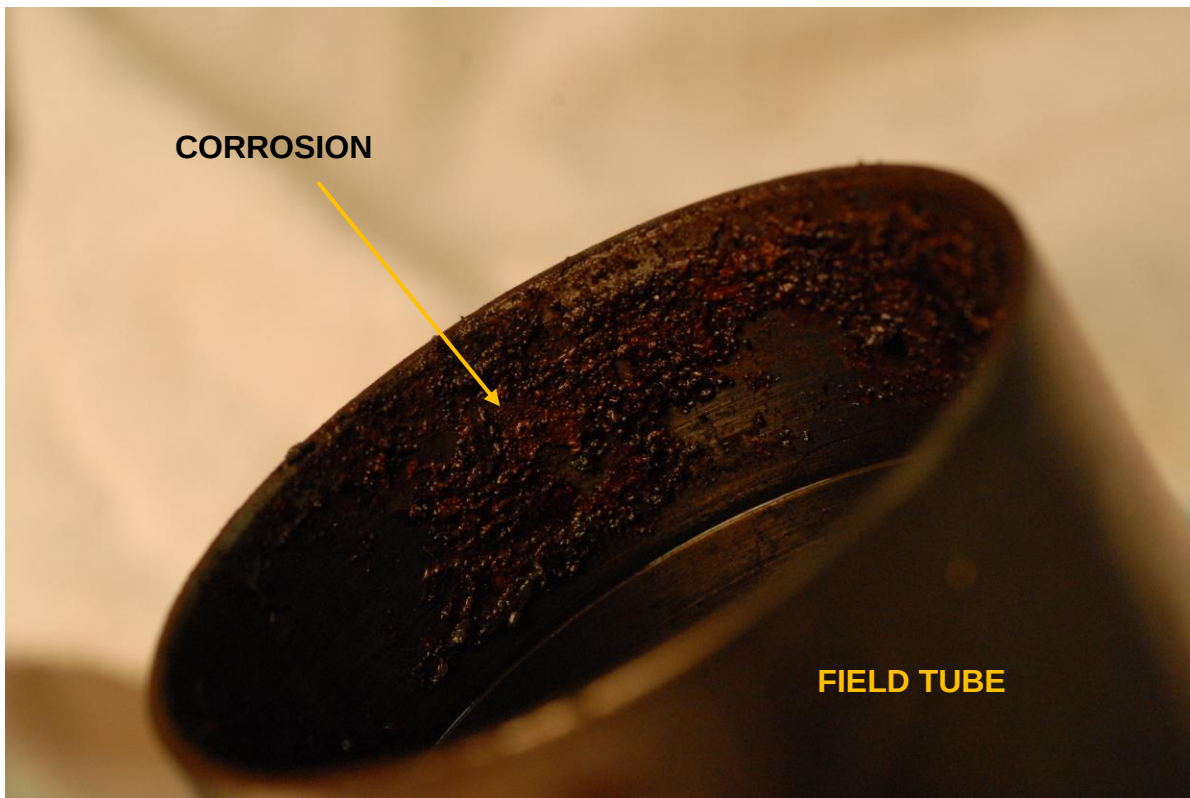
2C27-1 4H234 31Aug17_039 - Motor Brush Signs of Arcing



2C27-1 4H234 31Aug17_040 - Brush Card Debris



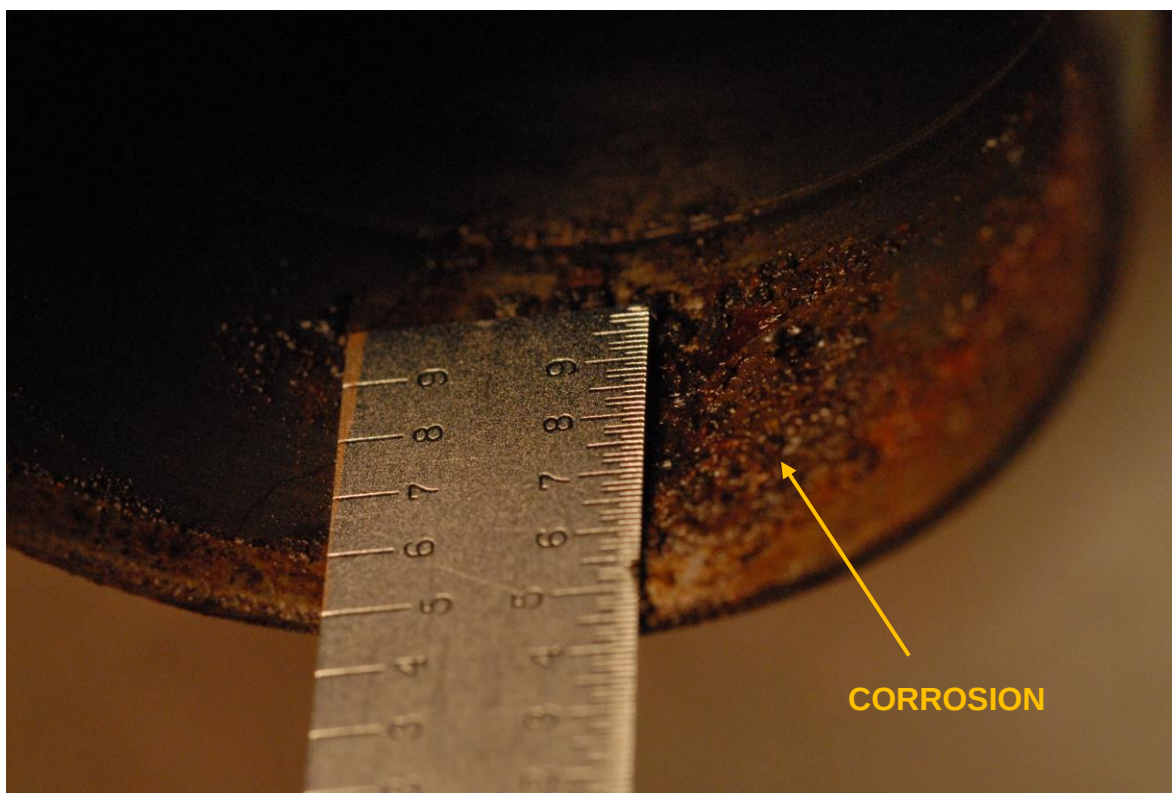
2C27-1 4H234 31Aug17_041 - Brush Card Debris



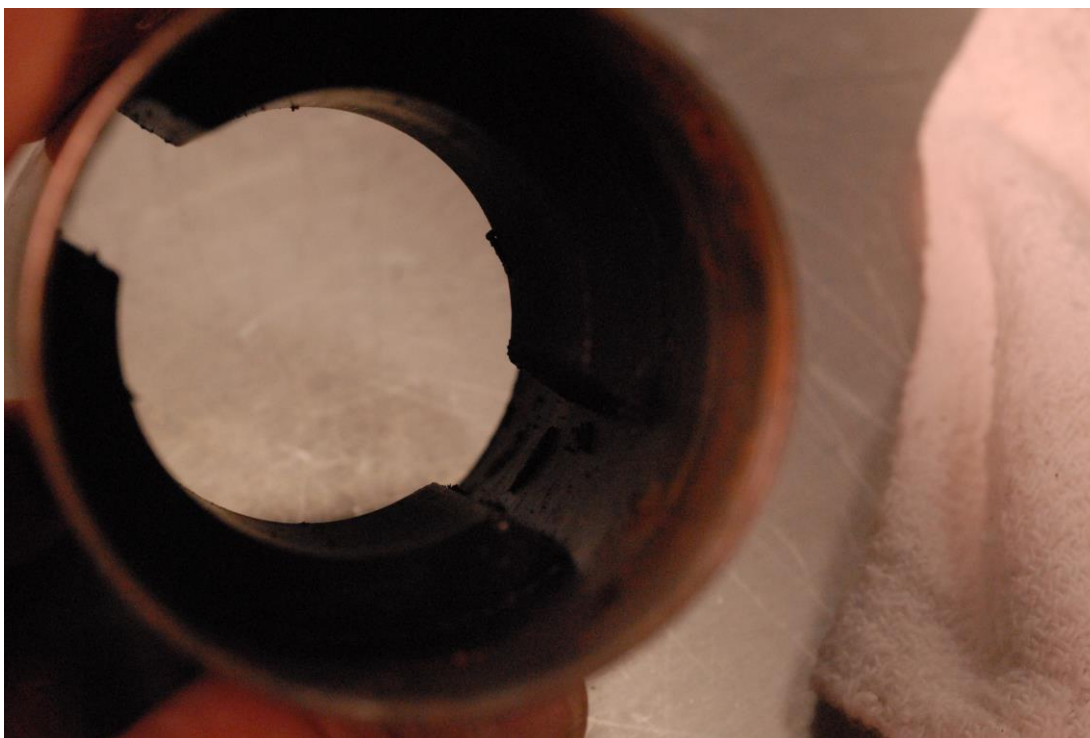
2C27-1 4H234 31Aug17_042 – Field Tube Heavy Corrosion



2C27-1 4H234 31Aug17_043 – Field Tube Heavy Corrosion



2C27-1 4H234 31Aug17_044 – Field Tube Heavy Corrosion



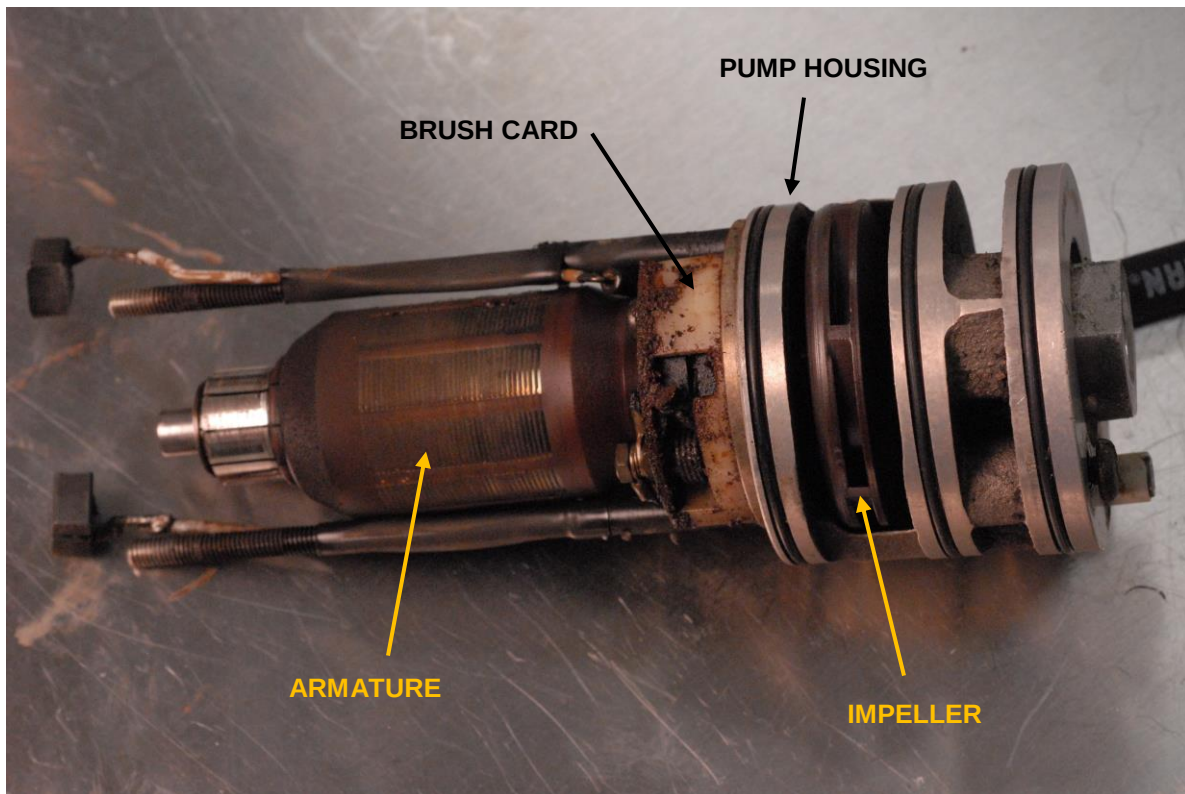
2C27-1 4H234 31Aug17_045 – Field Tube



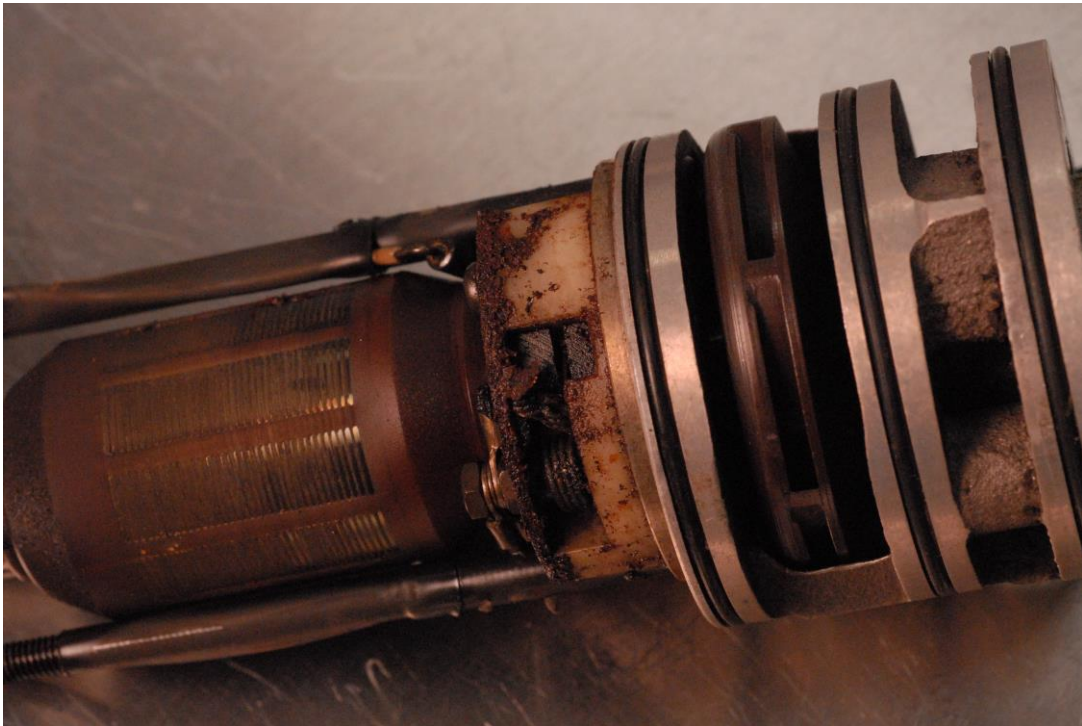
2C27-1 4H234 31Aug17_046 – Field Tube



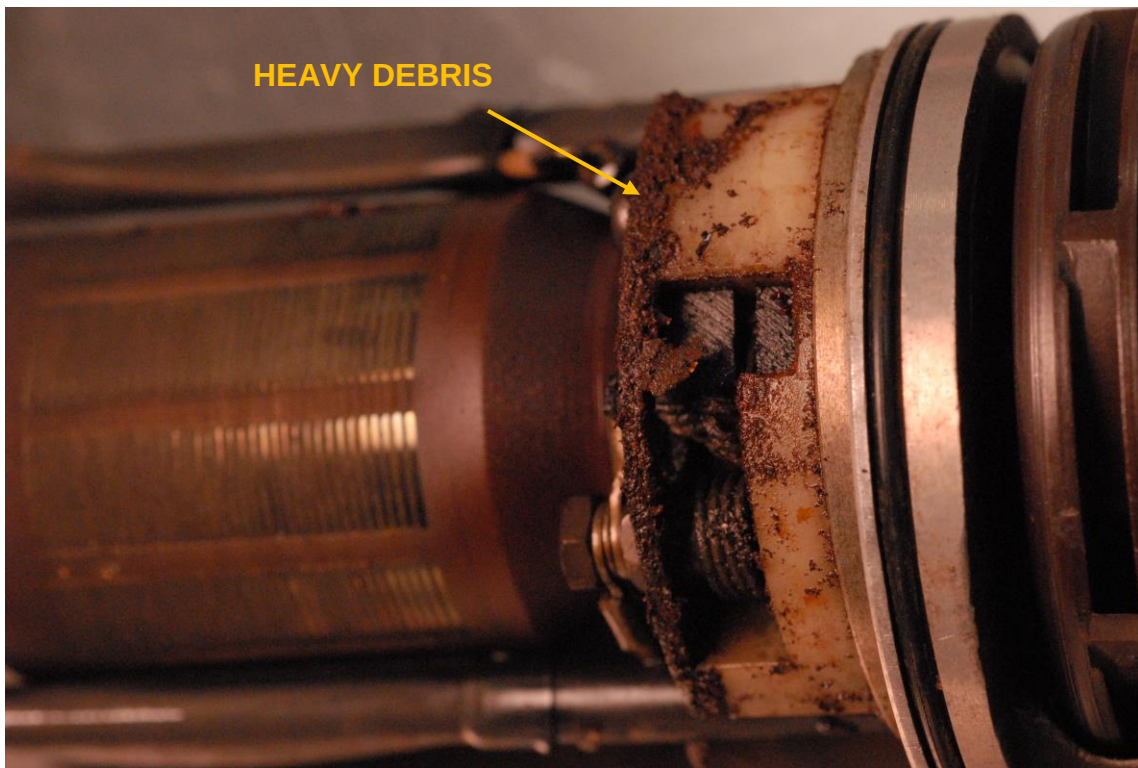
2C27-1 4H234 31Aug17_047 – Field Tube Heavy Corrosion



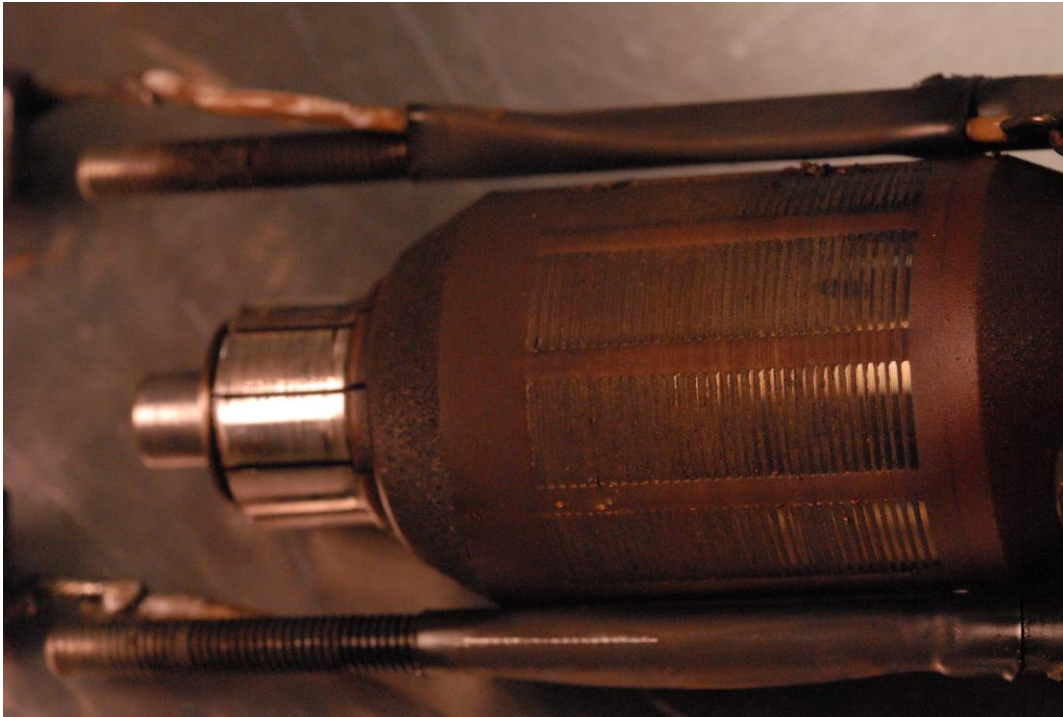
2C27-1 4H234 31Aug17_048 - Heavy Debris on Lower Brush Card



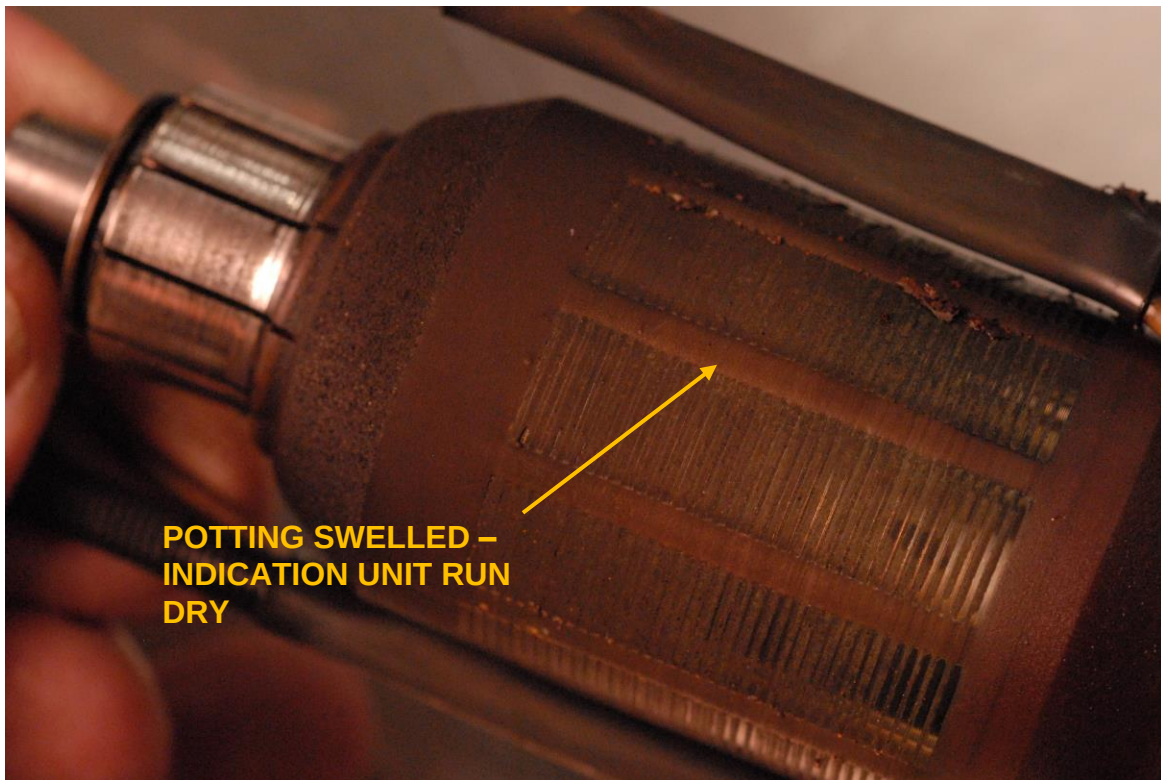
2C27-1 4H234 31Aug17_049 - Heavy Debris on Lower Brush Card



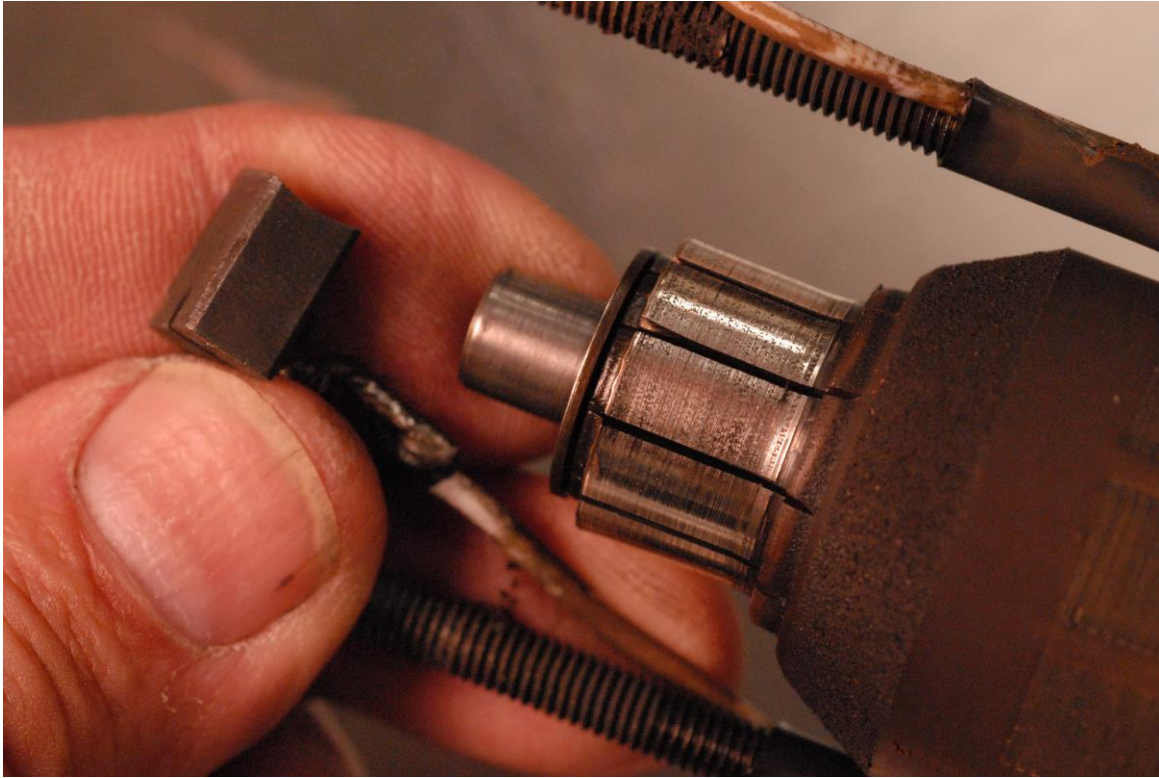
2C27-1 4H234 31Aug17_050 - Heavy Debris on Lower Brush Card



2C27-1 4H234 31Aug17_051 – Motor Armature



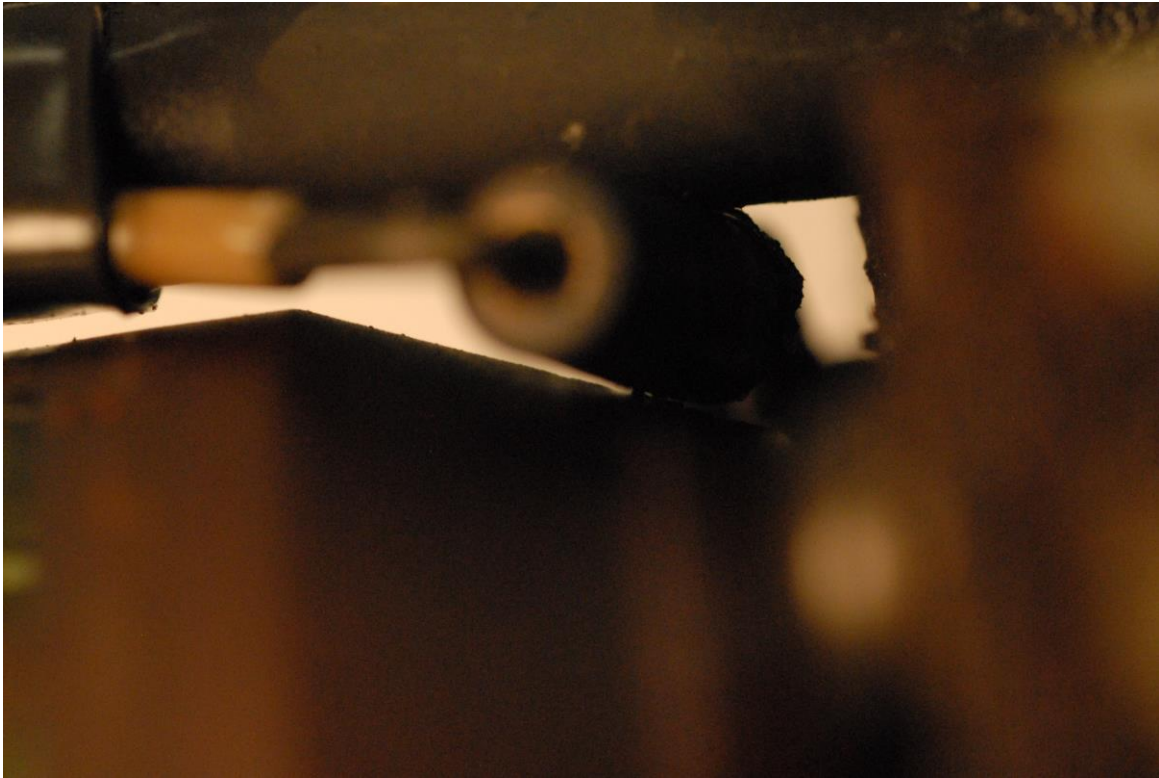
2C27-1 4H234 31Aug17_052 – Motor Armature Potting Swelled



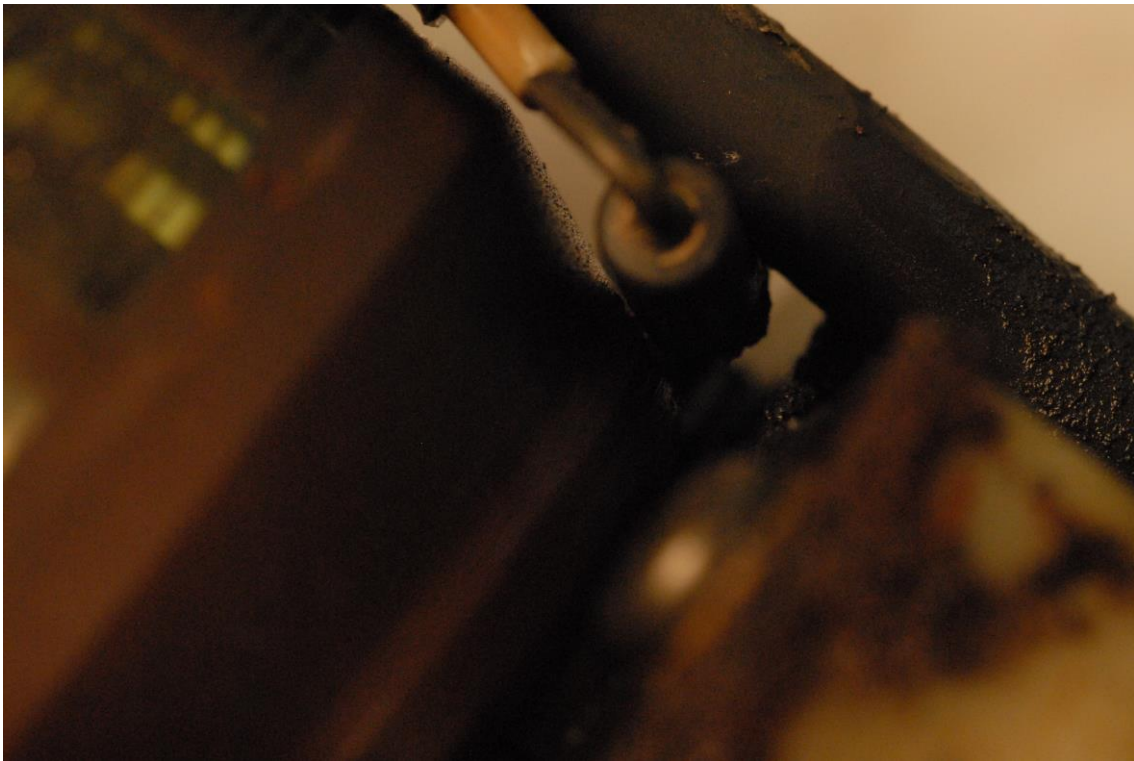
2C27-1 4H234 31Aug17_053 - Armature Commutator – Signs of Arcing



2C27-1 4H234 31Aug17_054 – Armature Contacting Thermal Fuse



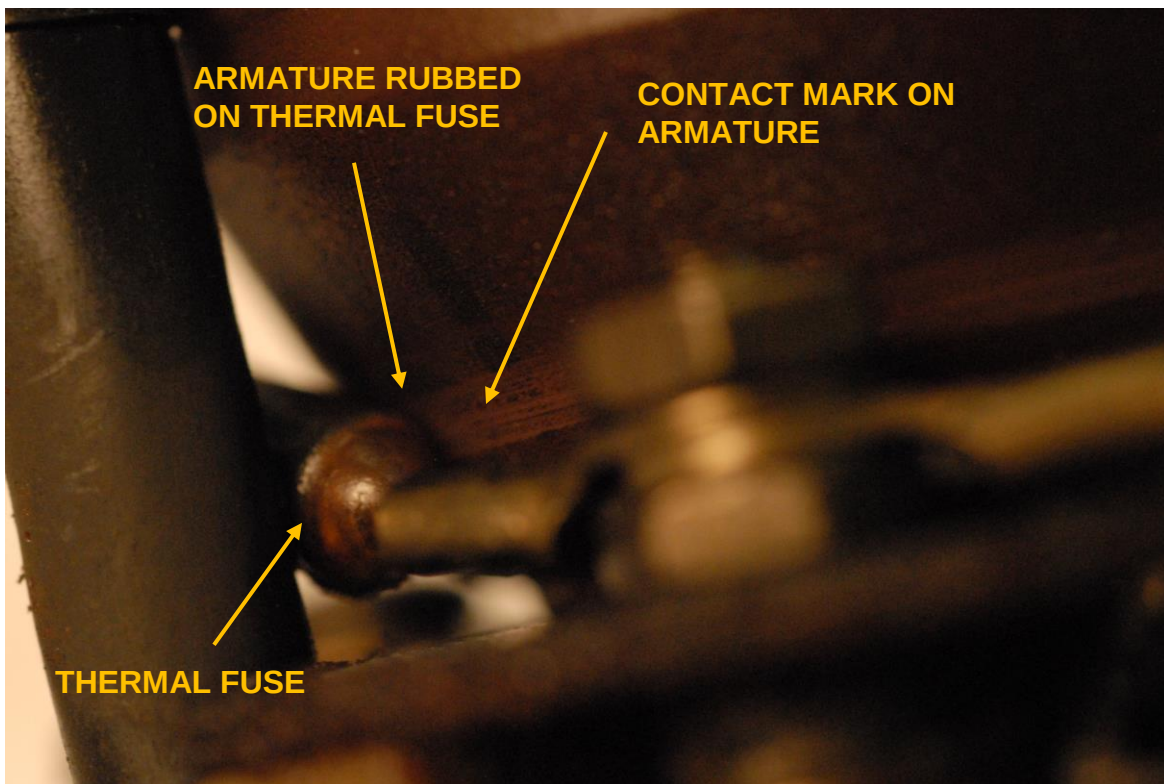
2C27-1 4H234 31Aug17_055 – Armature Contacting Thermal Fuse



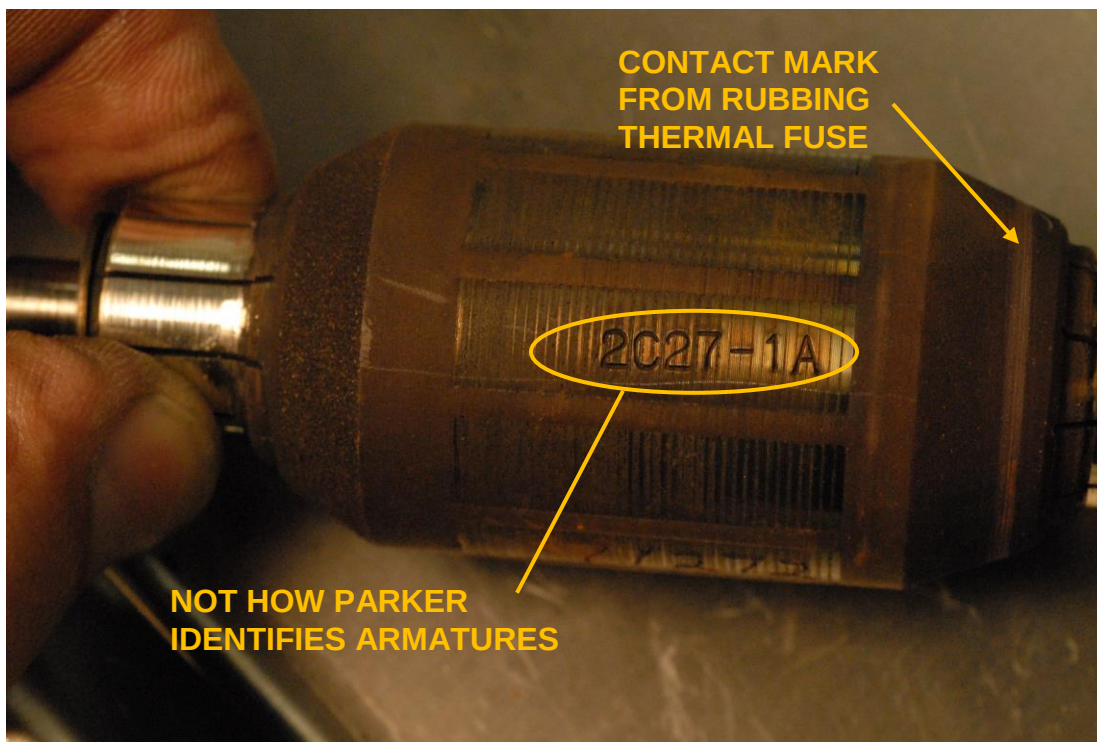
2C27-1 4H234 31Aug17_056 – Armature Contacting Thermal Fuse



2C27-1 4H234 31Aug17_057 – Armature Contacting Thermal Fuse



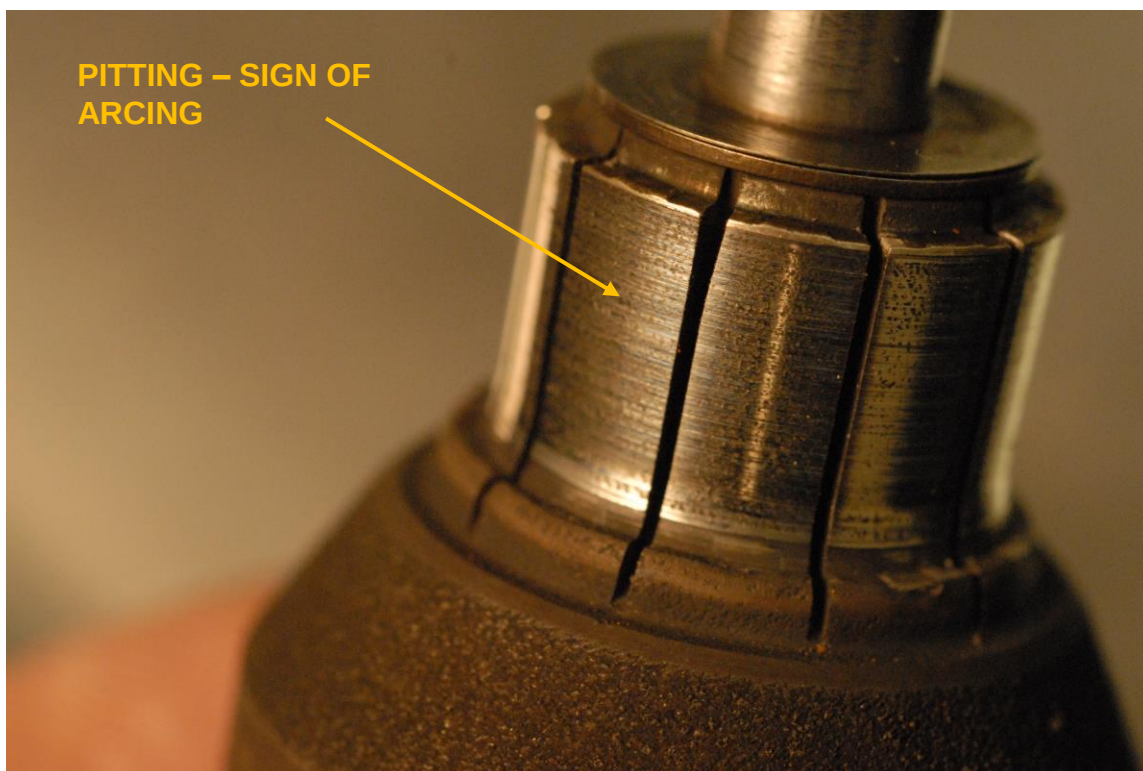
2C27-1 4H234 31Aug17_058 – Armature Contacting Thermal Fuse



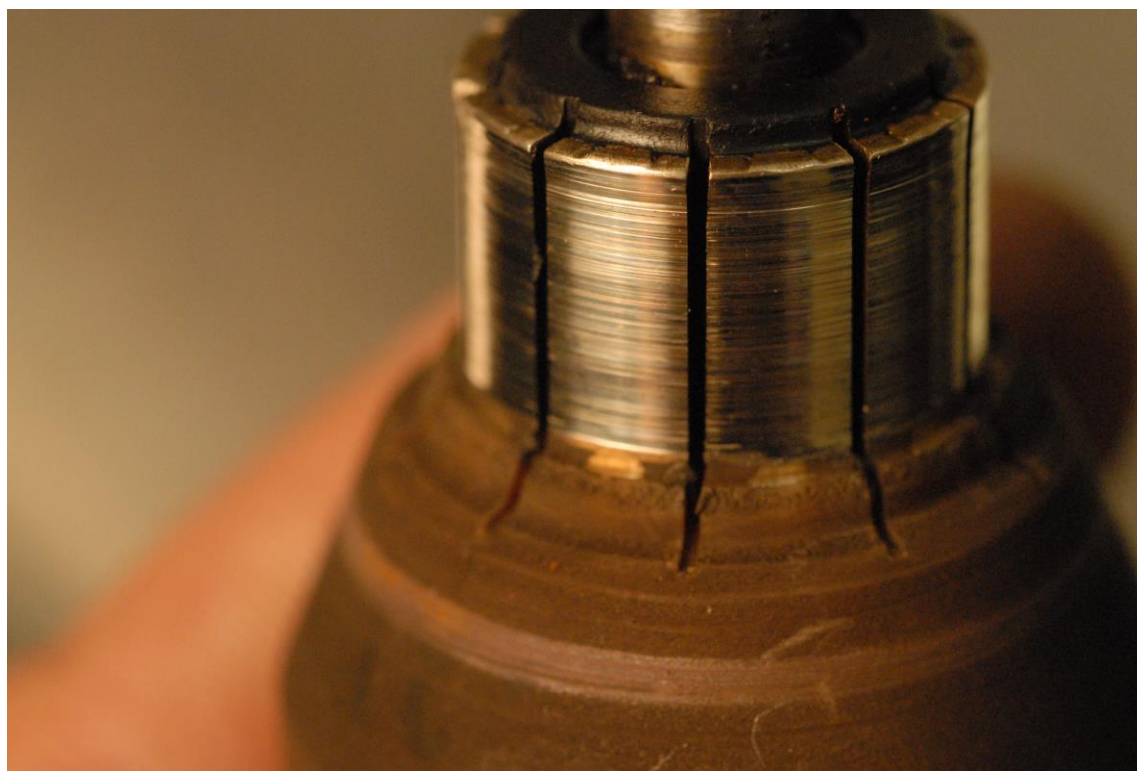
2C27-1 4H234 31Aug17_059 - Non-Parker Marking on Armature



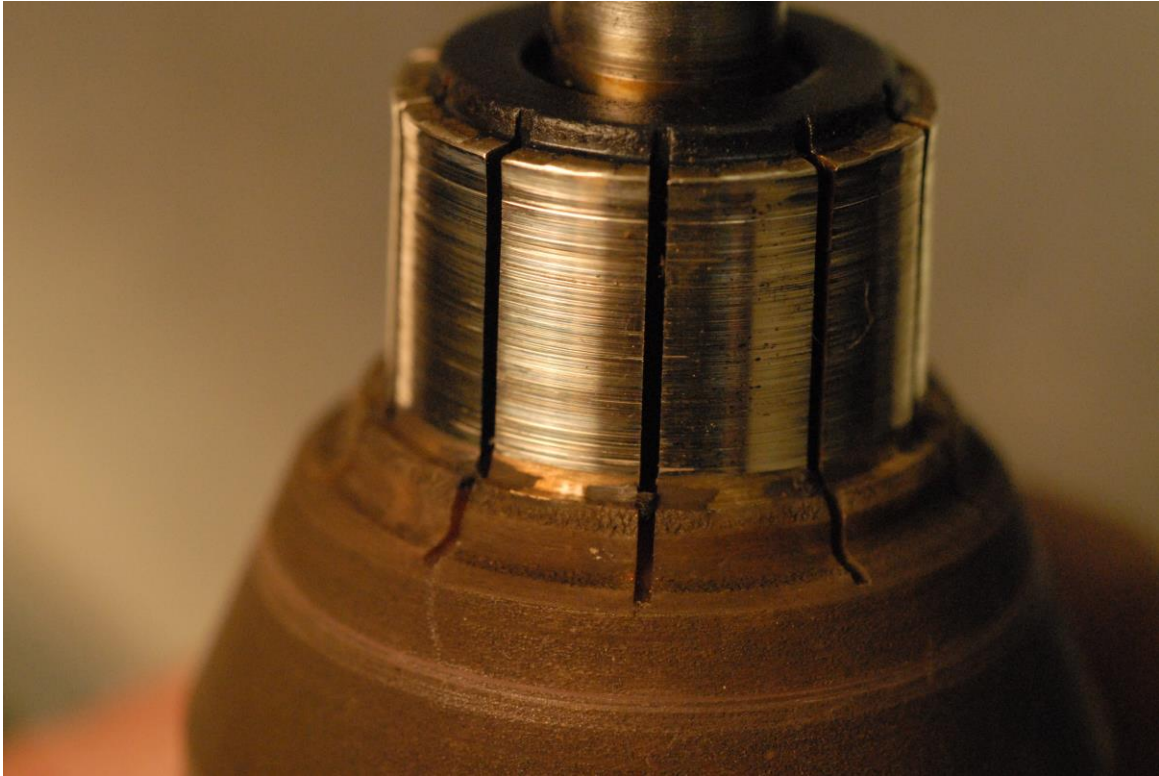
2C27-1 4H234 31Aug17_060



2C27-1 4H234 31Aug17_061 – Signs of Arcing



2C27-1 4H234 31Aug17_062 – Wear Pattern OK



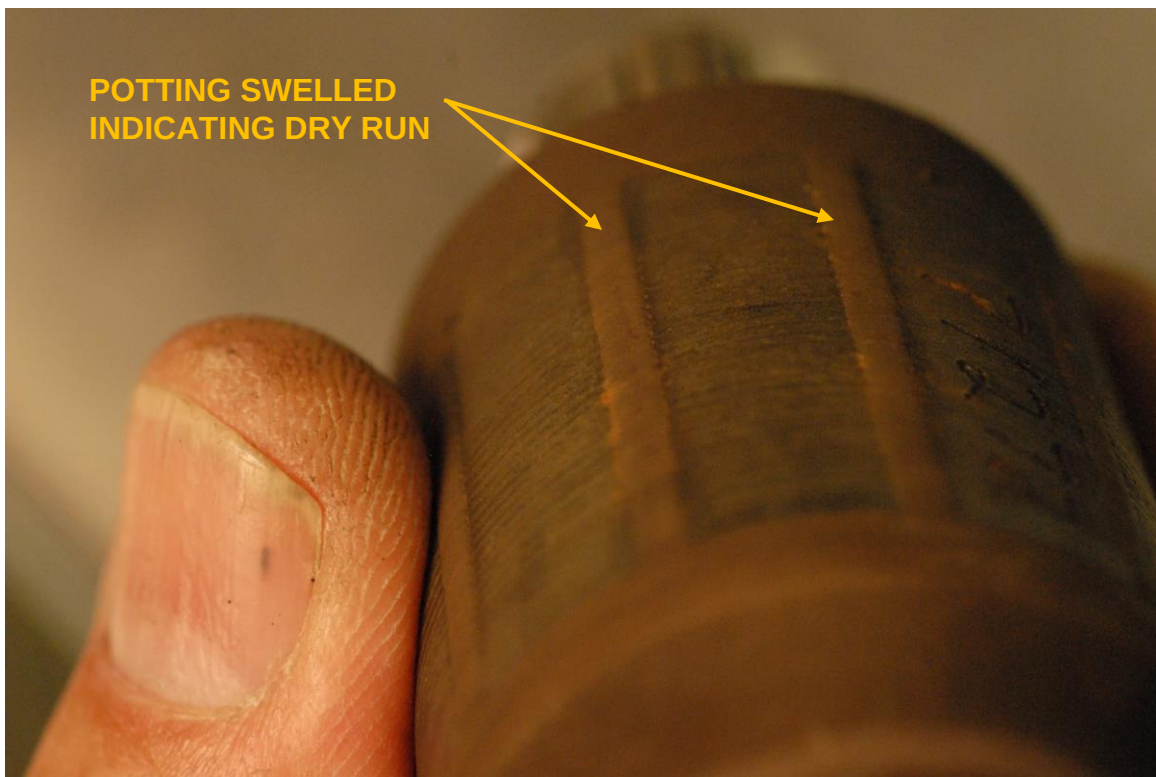
2C27-1 4H234 31Aug17_063 – Wear Pattern OK



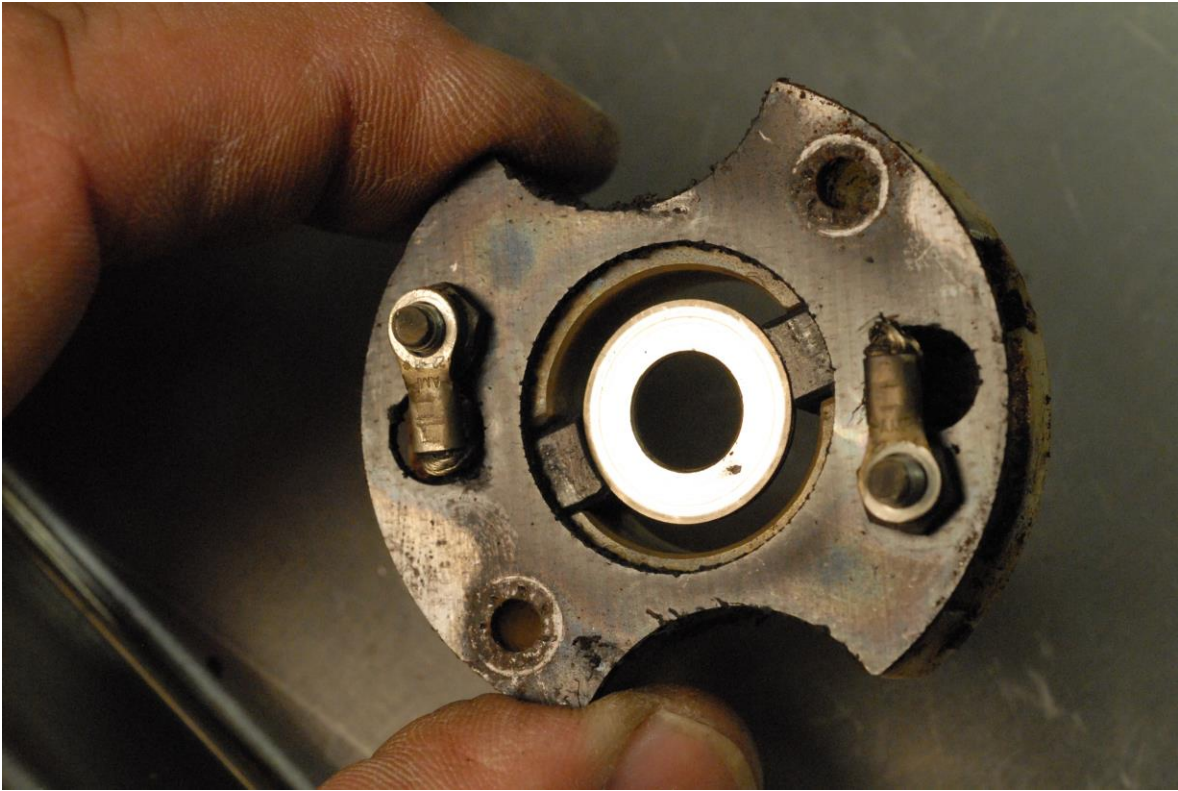
2C27-1 4H234 31Aug17_064 – Non-Parker Marking



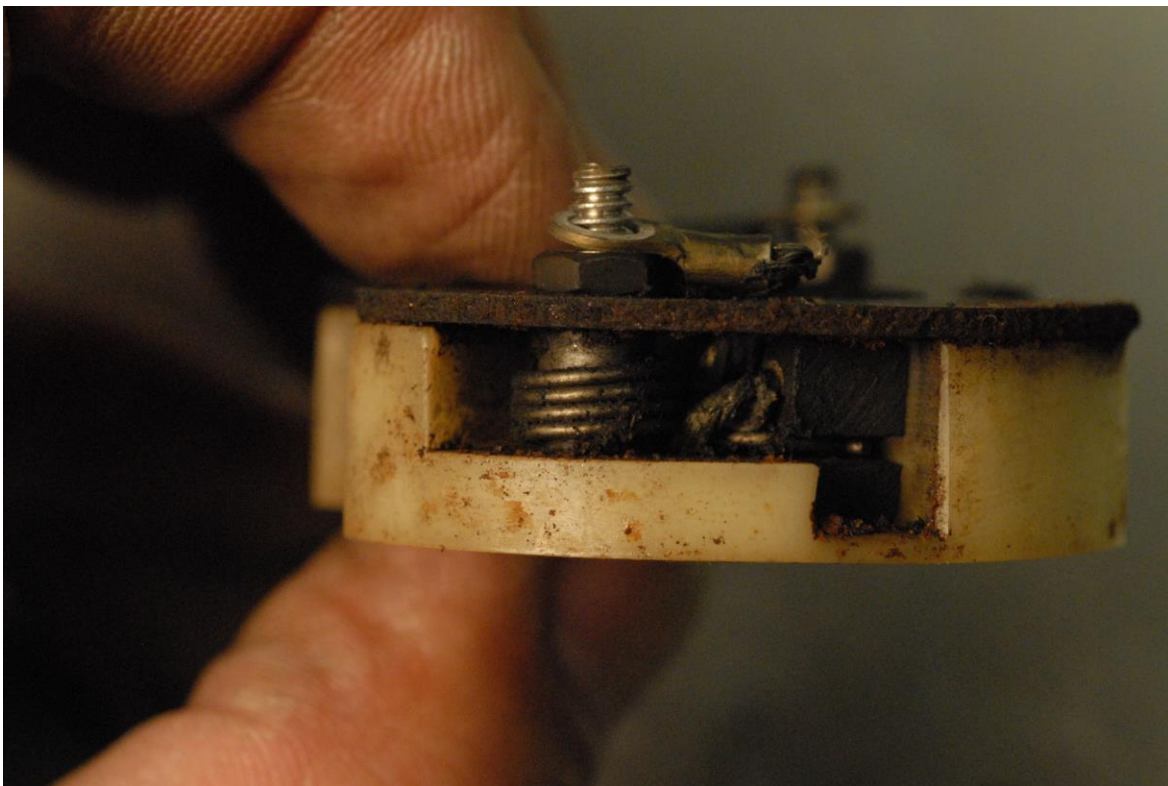
2C27-1 4H234 31Aug17_065 - Non-Parker Marking



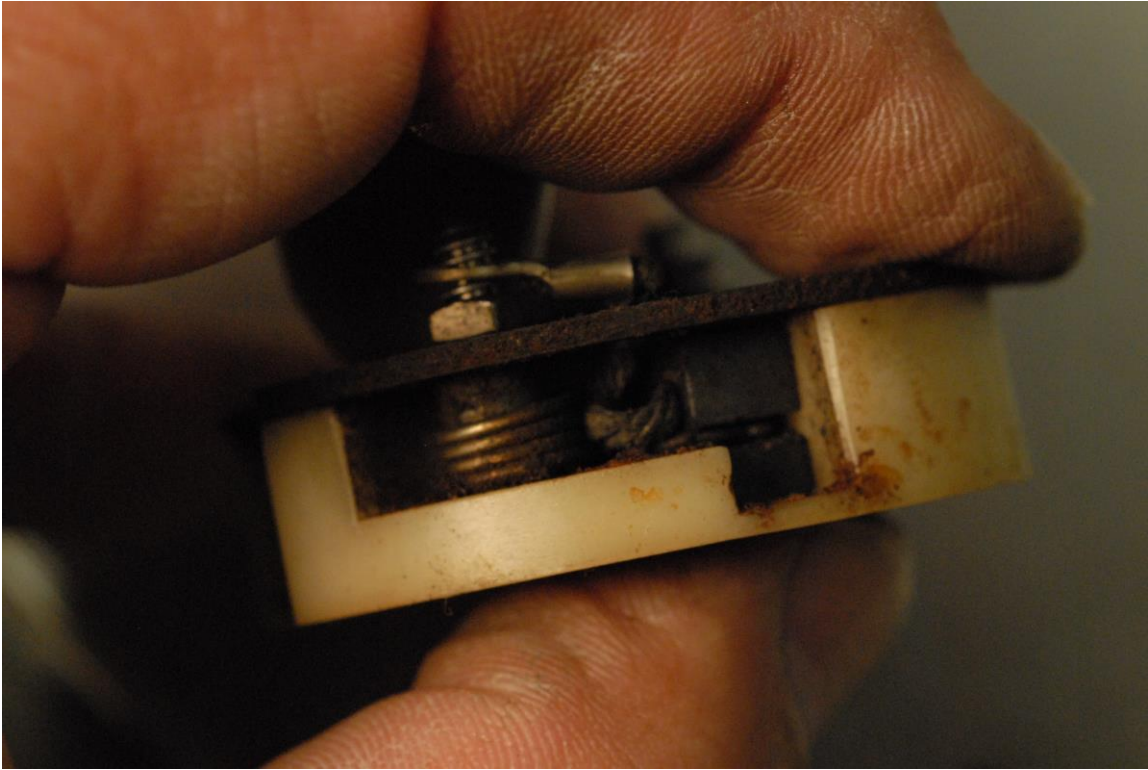
2C27-1 4H234 31Aug17_066 -Swelled Potting Indication DRY RUN



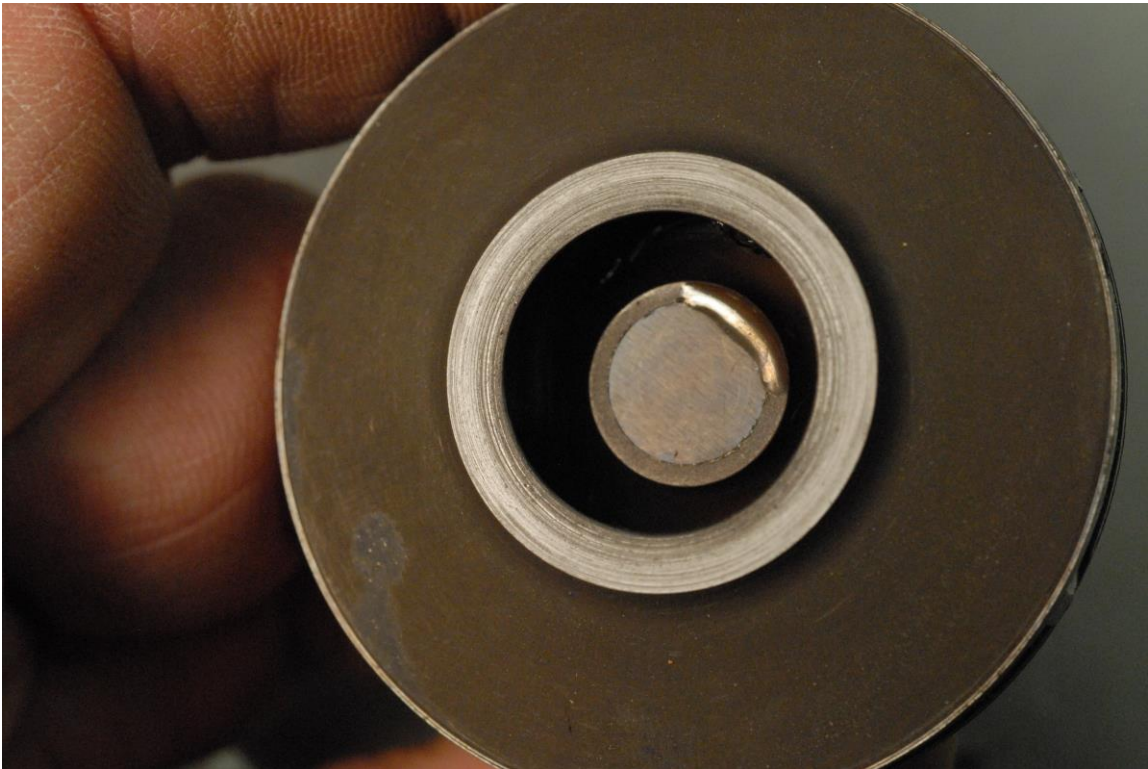
2C27-1 4H234 31Aug17_067 – Lower Brush Card



2C27-1 4H234 31Aug17_068 – Lower Brush Card



2C27-1 4H234 31Aug17_069 – Lower Brush Card



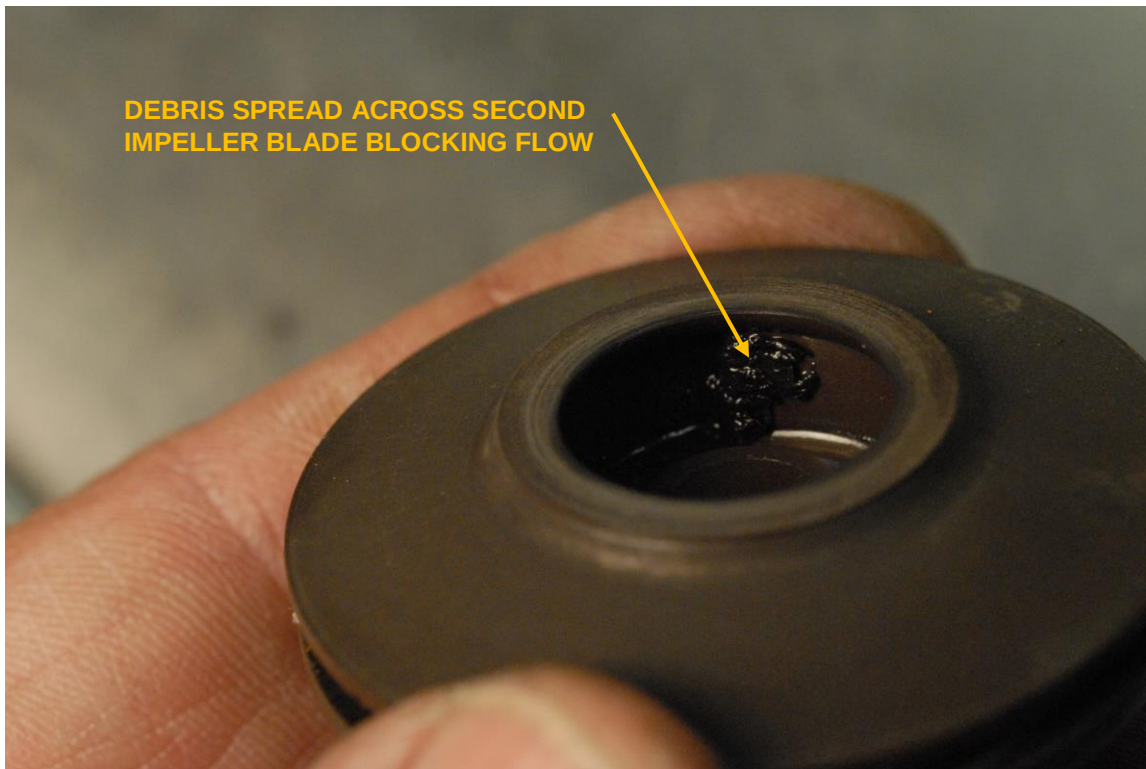
2C27-1 4H234 31Aug17_070 - Impeller Eye



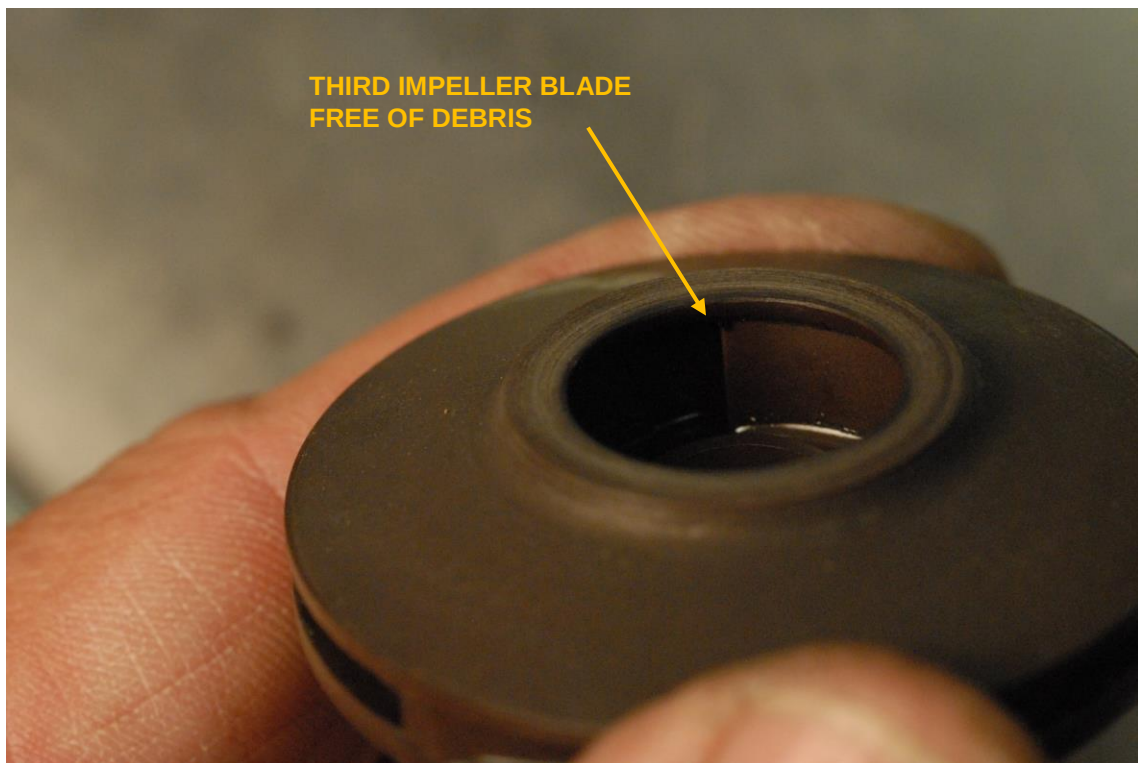
2C27-1 4H234 31Aug17_071 – Debris across 1st Impeller Blade Inlet



2C27-1 4H234 31Aug17_072 – Debris across 1st Impeller Blade Inlet



2C27-1 4H234 31Aug17_073 - Debris across 2nd Impeller Blade Inlet



2C27-1 4H234 31Aug17_074 - No Debris on 3rd Impeller Blade Inlet



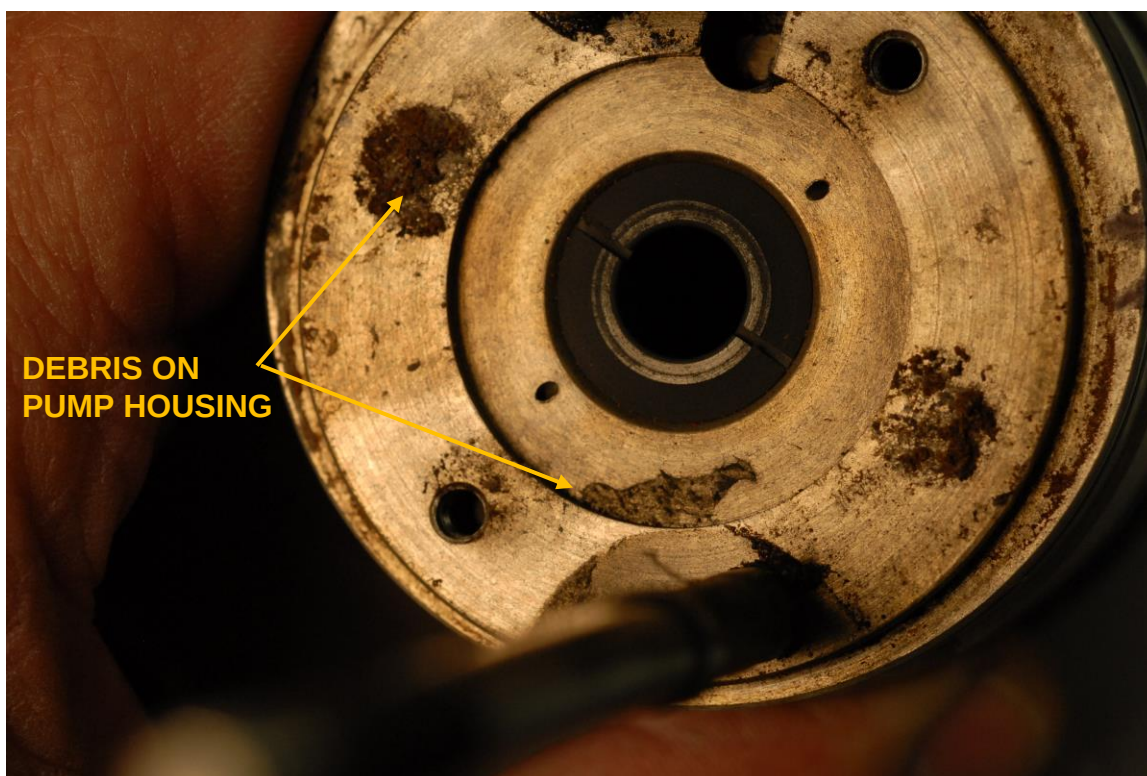
2C27-1 4H234 31Aug17_075 - Contact Mark from Armature Rubbing Thermal Fuse



2C27-1 4H234 31Aug17_076 - Contact Mark from Armature Rubbing Thermal Fuse



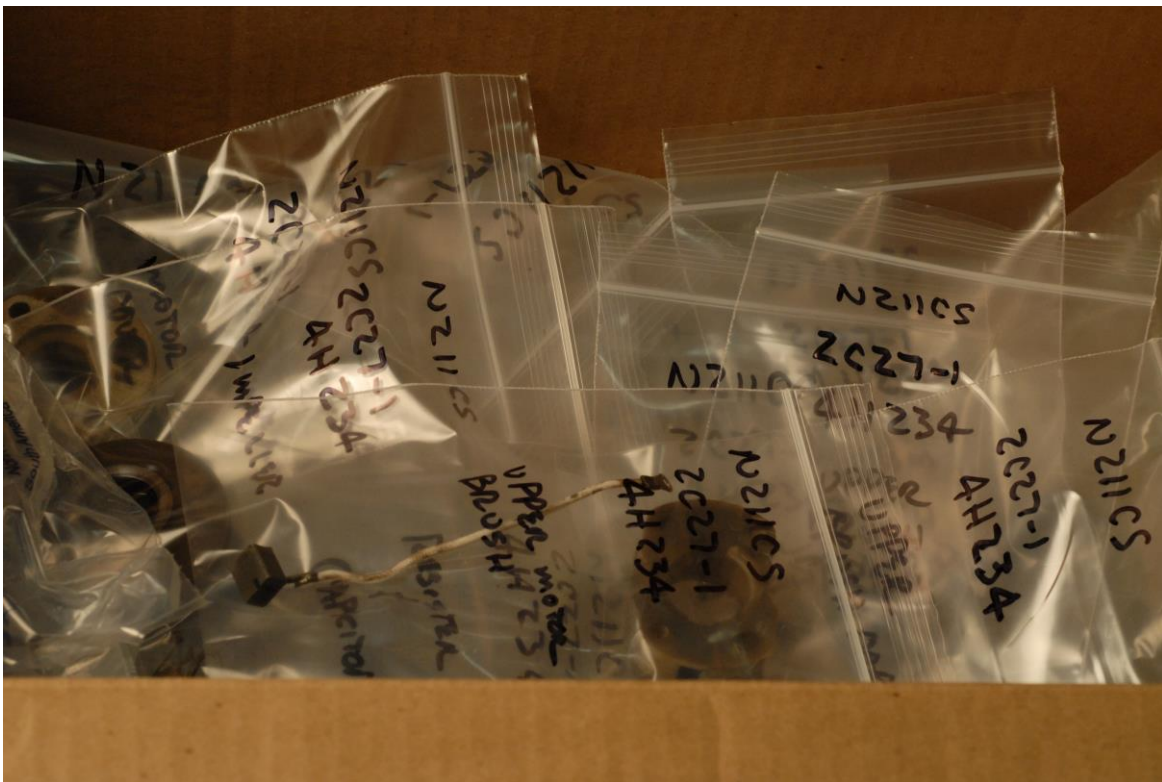
2C27-1 4H234 31Aug17_077 - Contact Mark from Armature Rubbing Thermal Fuse



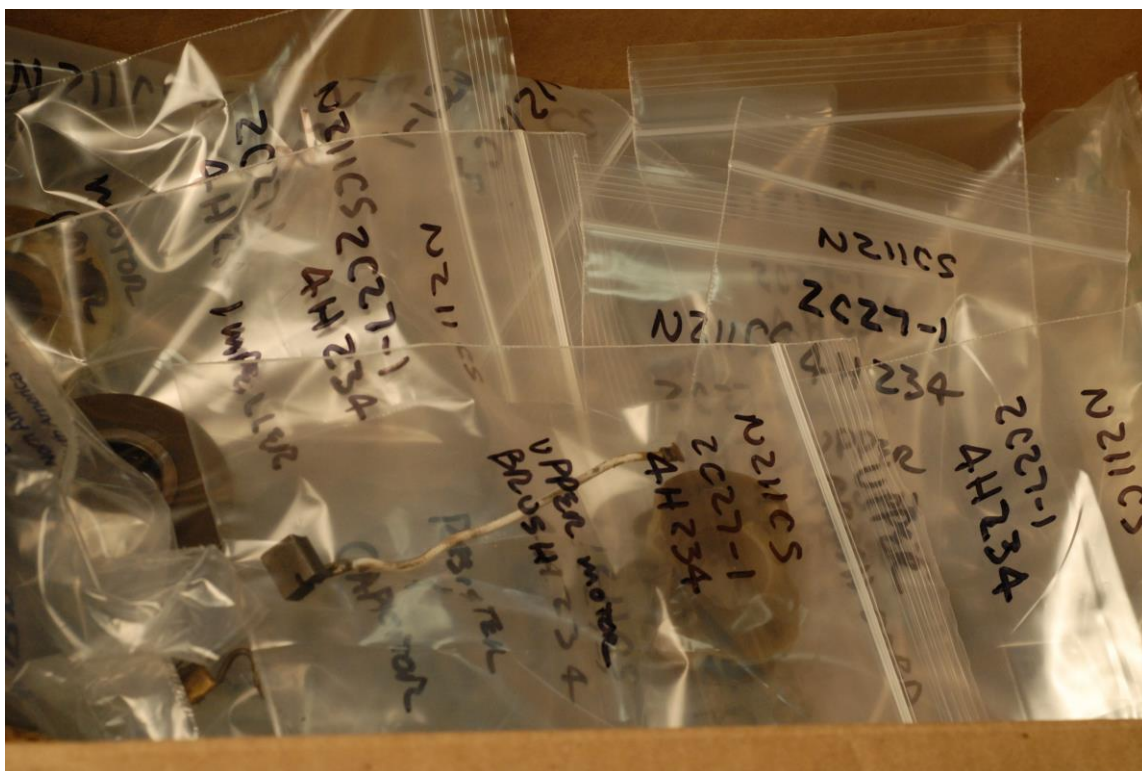
2C27-1 4H234 31Aug17_78 – Debris on Pump Housing.



2C27-1 4H234 31Aug17_079 - Debris on Pump Housing



2C27-1 4H234 31Aug17_080 - Packing for Return to NTSB



2C27-1 4H234 31Aug17_081 - Packing for Return to NTSB



2C27-1 4H234 31Aug17_082 - Packing for Return to NTSB