

# WNG01: Actuator Modification Instructions

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*For MICHAEL MALCOLM*

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## **CONFIDENTIALITY**

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## Approvals for Rev 1.0



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## Revision History

Revision	Date	Description	By
1.0	2018-03-13	Initial Release for Client Review	Nuvation

## Table of Contents

Approvals for Rev 1.0 .....	2
Revision History .....	3
List of Figures.....	5
List of Tables .....	6
1 Introduction .....	7
1.1 Purpose.....	7
1.2 Reference Documentation .....	7
1.3 Related Documentation .....	7
2 Functional Overview .....	8
2.1 Actuator Interface and Replacement of Existing Thermostat.....	8
3 Modification Instructions – Background .....	9
3.1 Existing Actuator Connectors (Coolant and Oil) .....	9
3.2 Actuator Connector, Oil.....	10
3.3 Actuator Connector, Coolant.....	11
4 Modification Instructions – Details.....	12
5 Modification Instructions – Results .....	18

List of Figures

Figure 1: P51 Actuator and Thermostat Schematic..... 8

Figure 2: Unmodified Actuator (Coolant Shown, Oil is Similar) ..... 12

Figure 3: Actuator Bottom View – Coolant ..... 13

Figure 3: Actuator Bottom View - Oil ..... 14

Figure 4: Switch View A – Coolant..... 15

Figure 4: Switch View A – Oil ..... 15

Figure 5: Switch View B – Coolant..... 16

Figure 5: Switch View B – Oil ..... 16

Figure 6: Interrupter Switch View ..... 17

Figure 7: Modified Actuator ..... 18

Figure 8: Modified Actuator, Bottom View ..... 19

Figure 9: Modified Actuator, Completed ..... 20

List of Tables

Table 1: Pinout for Existing Actuators (Coolant and Oil) ..... 9

Table 2: Pinout for Actuator Connector, Oil ..... 10

Table 3: Pinout for Actuator Connector, Coolant..... 11

## 1 Introduction

The North American P-51 Mustang has two thermostatic actuators that open and close the air outlet flaps (also called, “doors”) of the coolant and oil radiators. These electrically-driven devices control the operating temperature of the engine. The thermostatic controllers for these actuators are no longer produced, and old stock of these controllers are dwindling and have aged to a point where they require extensive overhaul and are of poor reliability.

### 1.1 Purpose

The digital controller described below will solve the worst of these problems by replacing the actuator’s electro-mechanical control system with a digital control system that uses a RTD (resistance temperature device) temperature sensor and modern computer control. It will give the pilot greater visibility into the operation of the actuator, the position of the outlet flap, and the temperature of the coolant/oil. It will provide a cockpit warning in the event that the temperature becomes unsafe, and it will maintain a complete record of operating temperatures and outlet flap movements.

### 1.2 Reference Documentation

AN 03-5CH-17, Handbook of Instructions with Parts Catalog, Models R-4250 and R4310  
Thermostatic Actuators, 10 January 1945

### 1.3 Related Documentation

WNG01 Hardware Design Document (HDD)

WNG01 Firmware Software Design Document (SDD)

WNG01 Mobile Software Design Document (SDD)

WNG01 Acceptance Test Plan (ATP)

## 2 Functional Overview

### 2.1 Actuator Interface and Replacement of Existing Thermostat

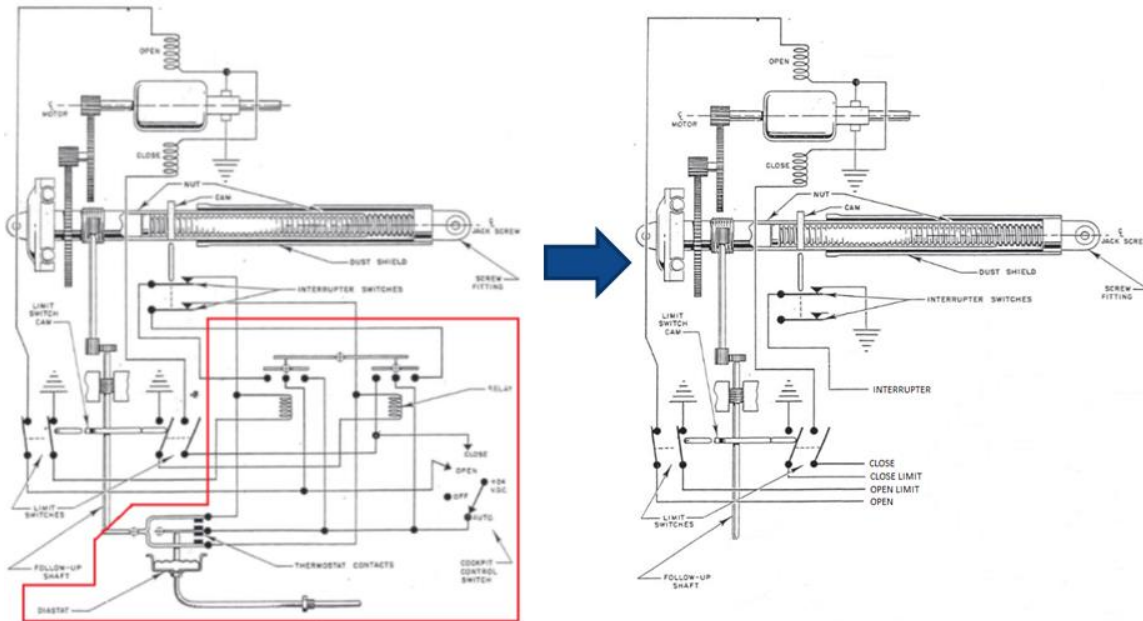


Figure 1: P51 Actuator and Thermostat Schematic

Figure 1 shows a schematic of the existing radiator door actuators (the schematic is identical for the oil and the coolant control systems) on the P51. The area highlighted in red is the OEM thermostat that will be replaced by the new digitally-controlled unit. The actuator itself has proven reliable over the years and will not be replaced. The image on the right shows the connections that will be made between the existing actuator/switches and the new control unit. The actuator itself runs off of nominally 24V supplied by a lead acid battery and DC generator that can exceed 28V when the aircraft is at operating RPM. All switches/contacts will maintain nominally 24V switch levels, and the motor will be driven directly from the new control unit as well. This will necessitate some protection on the controller PCB against automotive-type load dump, voltage spike, and reverse battery connection scenarios on the nominal 24V rail.



### 3 Modification Instructions – Background

The actuators require modification from a 5-pin MS connector shown in Section 3.1, to an 8pin MS connector shown in Sections 3.2 and 3.3. The 8 pin connector brings out additional interfaces not available in the unmodified version, and also removes a significant portion of unused functionality (the old mechanical automatic controller) from the actuator.

#### 3.1 Existing Actuator Connectors (Coolant and Oil)



**Connector Part Number:** MS3102R16S-8P

**Manufacturer:** ITT Cannon

**Description:** CONN RCPT 5 POS BOX MNT W/PINS, Normal Keying

PIN #	TYPE	Connection	Description	Connected to DEVICE
A	GND	GND	Ground Reference	
B	I, PWR	AUTO	Enables Automatic Control Mode, Battery +24V Power Input. Current can be drawn from this pin to drive actuators.	
C	I	MAN_OPEN	Manually opens the cooling door	
D	I	MAN_CLOSE	Manually closes the cooling door	
E	NC	NC	Not connected	

Table 1: Pinout for Existing Actuators (Coolant and Oil)

### 3.2 Actuator Connector, Oil



**Connector Part Number:** MS3102R16S-1P

**Manufacturer:** ITT Cannon

**Description:** CONN RCPT 7 POS BOX MNT W/PINS, Normal Keying

PIN #	TYPE	Connection	Description	Connected to DEVICE
A	O	CLOSE_ACT_OIL	High current drive to close door	
B	O	OPEN_ACT_OIL	High current drive to open door	
C	I	CLOSE_LIM_OIL	Logic input to indicate end of travel of actuator, closed door	
D	I	OPEN_LIM_OIL	Logic input to indicate end of travel of actuator, open door	
E	I	INT_OIL	A logic input activated once per screw revolution of the actuator	
F	O	ID/Presence Detect	4.7kOhm resistor to GND for presence detect/ID	
G	GND	GND	Ground Reference	

Table 2: Pinout for Actuator Connector, Oil

### 3.3 Actuator Connector, Coolant



**Connector Part Number:** MS3102R16S-1PW

**Manufacturer:** ITT Cannon

**Description:** CONN RCPT 7 POS BOX MNT W/PINS, W Keying

PIN #	TYPE	Connection	Description	Connected to DEVICE
A	O	CLOSE_ACT_COOL	High current drive to close door	
B	O	OPEN_ACT_COOL	High current drive to open door	
C	I	CLOSE_LIM_COOL	Logic input to indicate end of travel of actuator, closed door	
D	I	OPEN_LIM_COOL	Logic input to indicate end of travel of actuator, open door	
E	I	INT_COOL	A logic input activated once per screw revolution of the actuator	
F	O	ID/Presence Detect	10kOhm resistor to GND for presence detect/ID	
G	GND	GND	Ground Reference	

**Table 3: Pinout for Actuator Connector, Coolant**

## 4 Modification Instructions – Details

The opened, unmodified actuator looks as shown below. The first step is to unscrew and de-solder all wiring from the components labelled “Thermostat Contacts” and “Relays”.

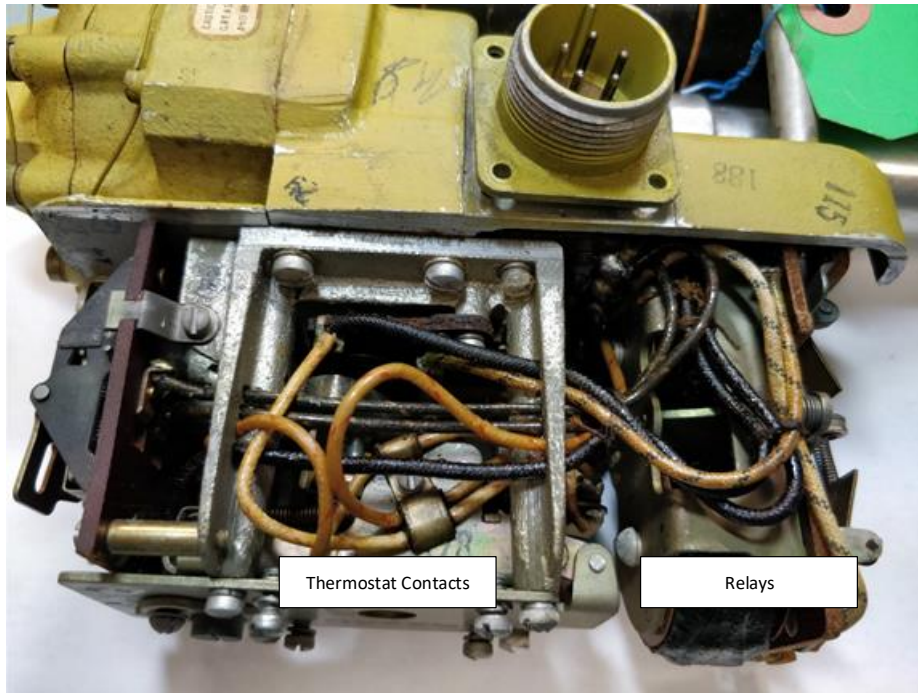


Figure 2: Unmodified Actuator (Coolant Shown, Oil is Identical)

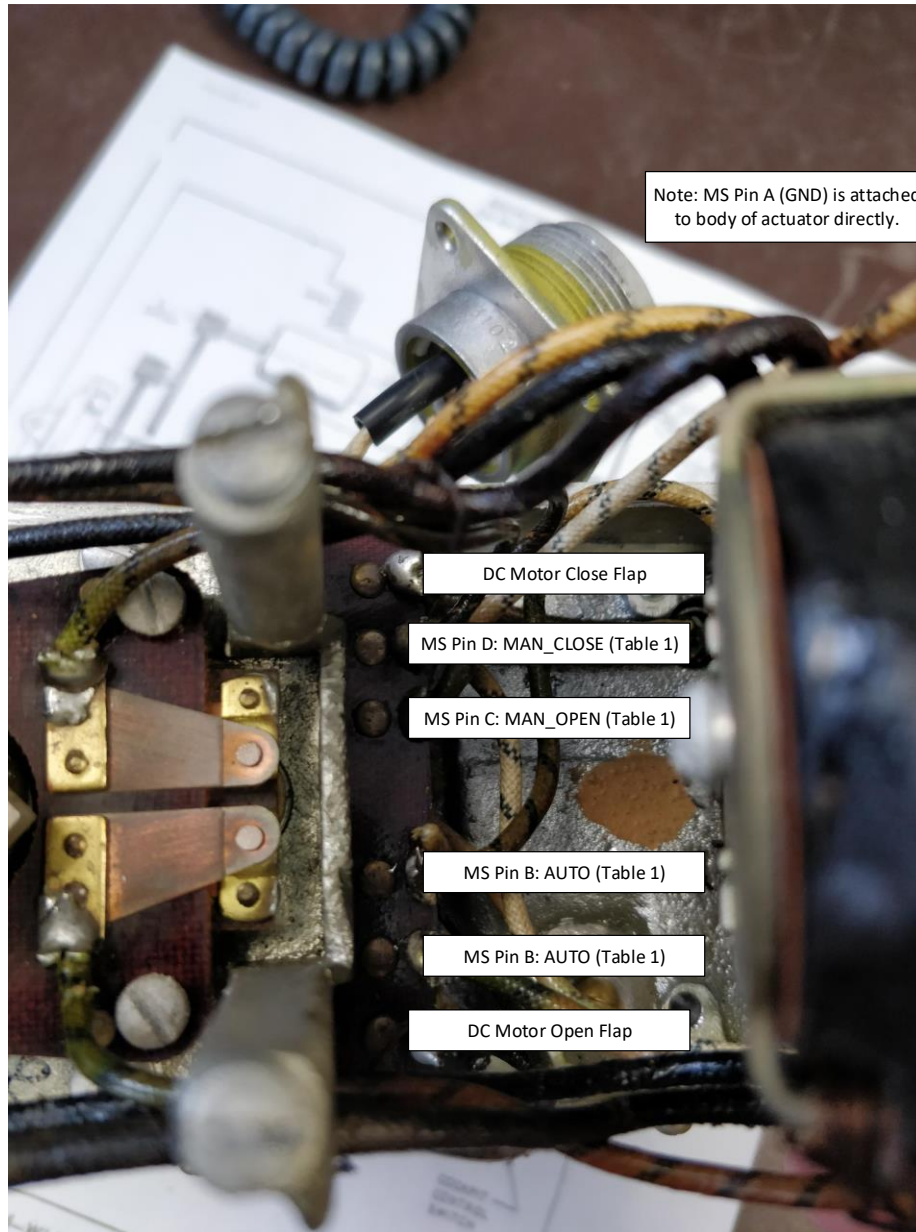
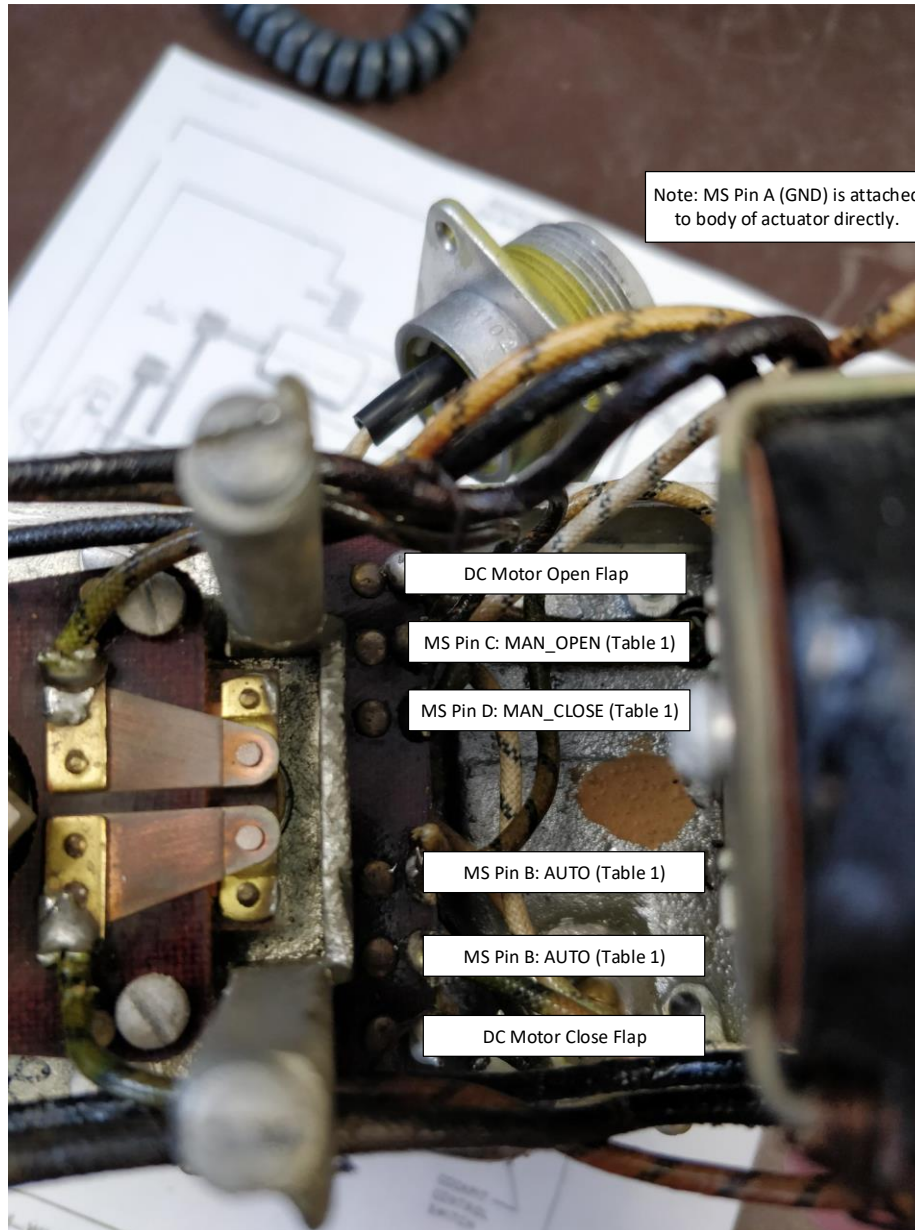


Figure 3: Actuator Bottom View – Coolant



**Figure 4: Actuator Bottom View - Oil**

With the Thermostat Contactor removed 6 solder joints are visible as shown in Actuator Bottom View figures. The wires connecting to the old “AUTO” circuit can be removed, and the solder joints for MAN\_CLOSE and MAN\_OPEN should be unwired from the old 5-pin MS connector and re-attached to the new MS 8-pin connector. The ground connection is also visible from the bottom side (a ring terminal screwed to the body of the actuator housing). The ground connection must also be transferred to the new 8-pin connector.



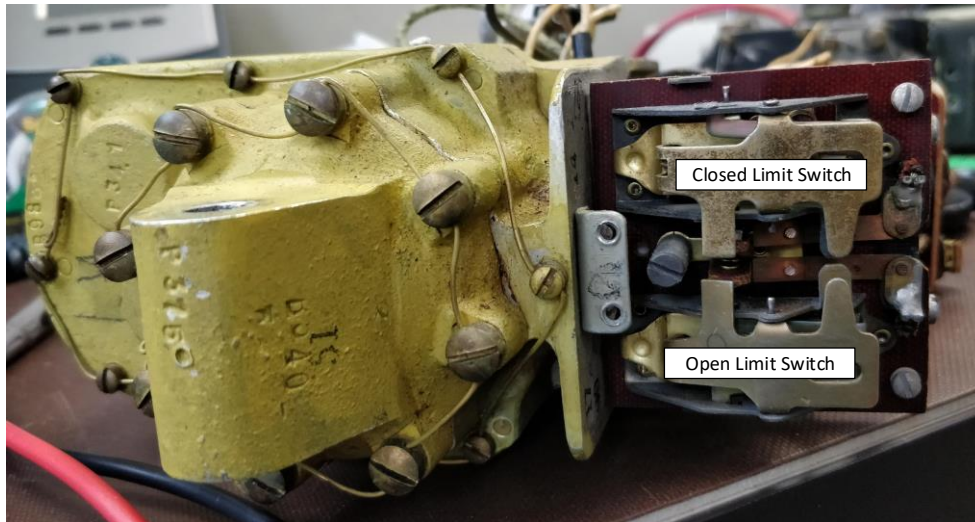


Figure 5: Switch View A – Coolant

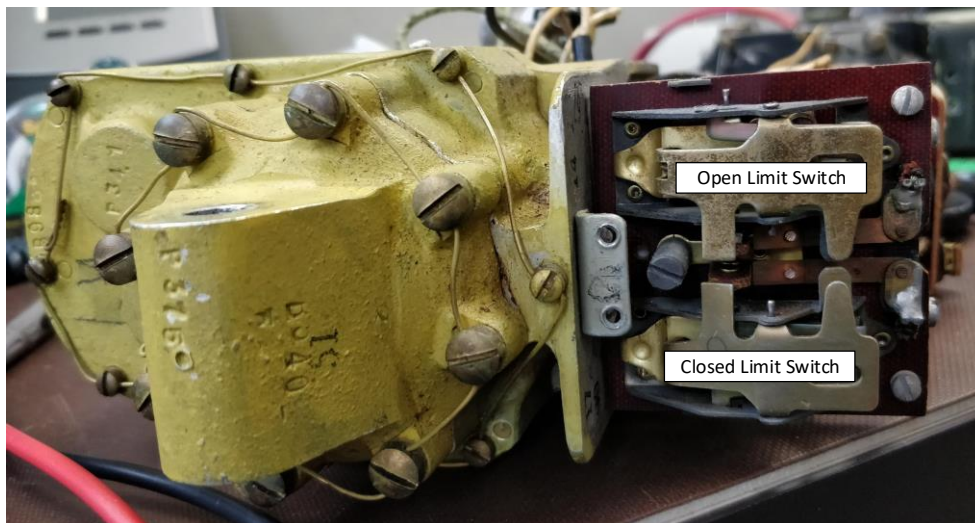


Figure 6: Switch View A – Oil

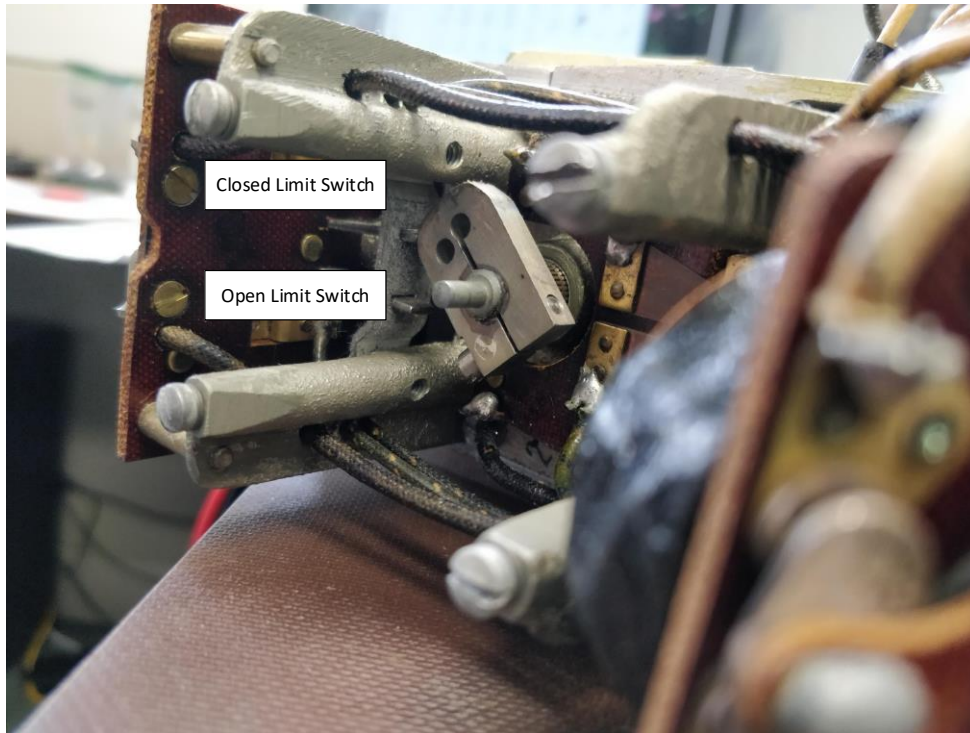


Figure 7: Switch View B – Coolant

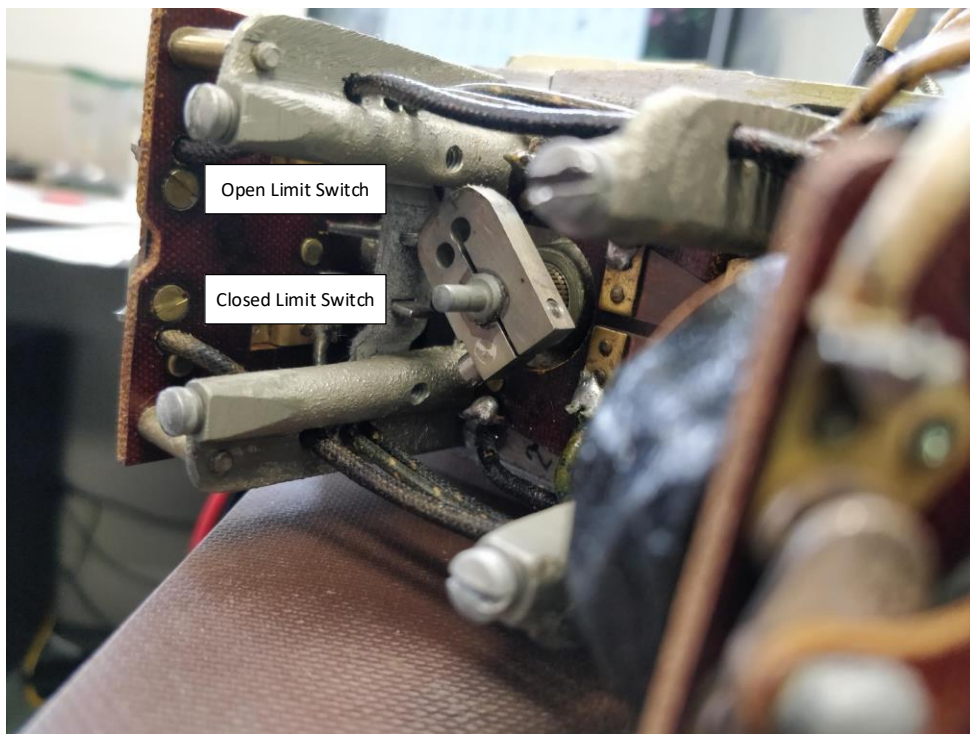
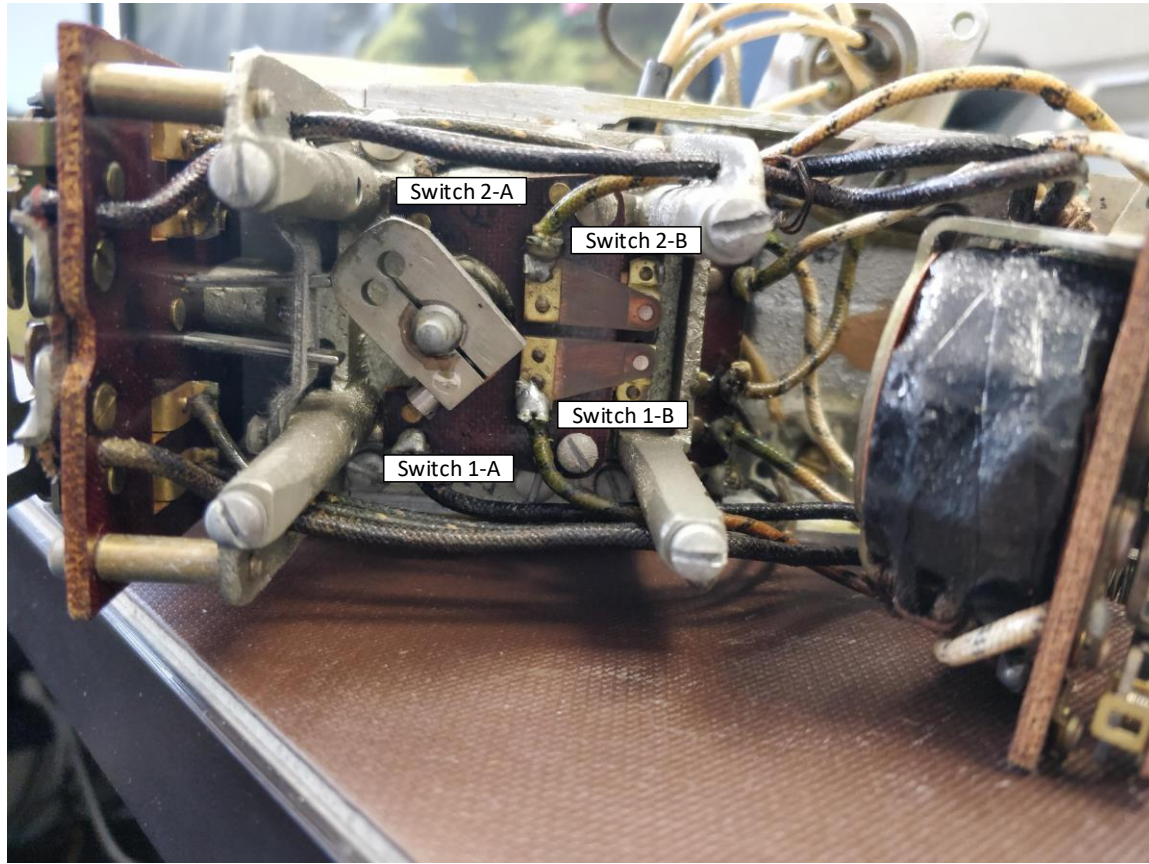


Figure 8: Switch View B – Oil

The switches are labelled in the Switch View figures. Remove the existing wiring and attach new wires from here directly to the new 8-pin MS connector.





**Figure 9: Interrupter Switch View (Coolant and Oil are Identical)**

The interrupter switch is shown in Figure 9: Interrupter Switch View. There are two interrupter switches with identical circuitry, since there were two relays (one for open and one for close) in the old automatic controller. Only one switch is required as an indicator in the new design. Completely un-wire Switch 2 (contacts A&B), and re-wire Switch 1. Switch 1-A goes to ground (attach a wire with a ring terminal and screw it to the actuator body). Switch 2-A goes to the new 8-pin MS connector.

## 5 Modification Instructions – Results

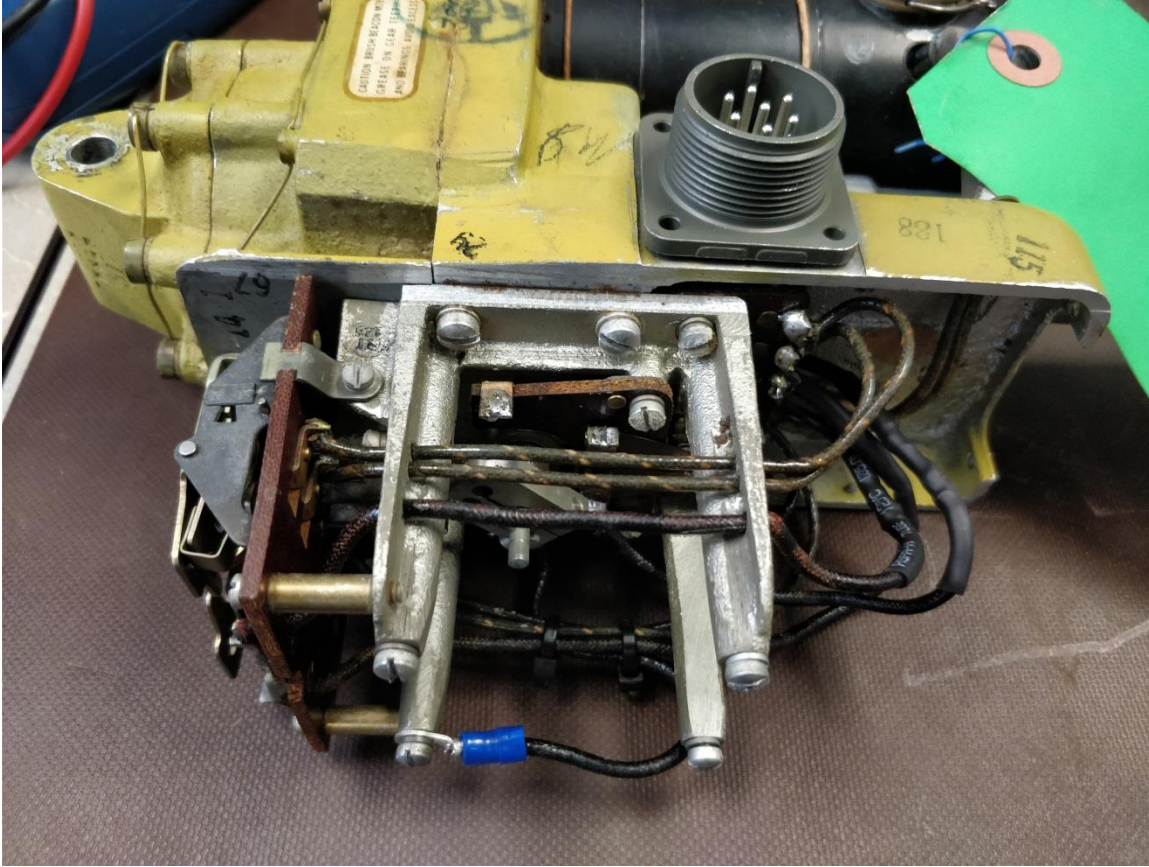


Figure 10: Modified Actuator

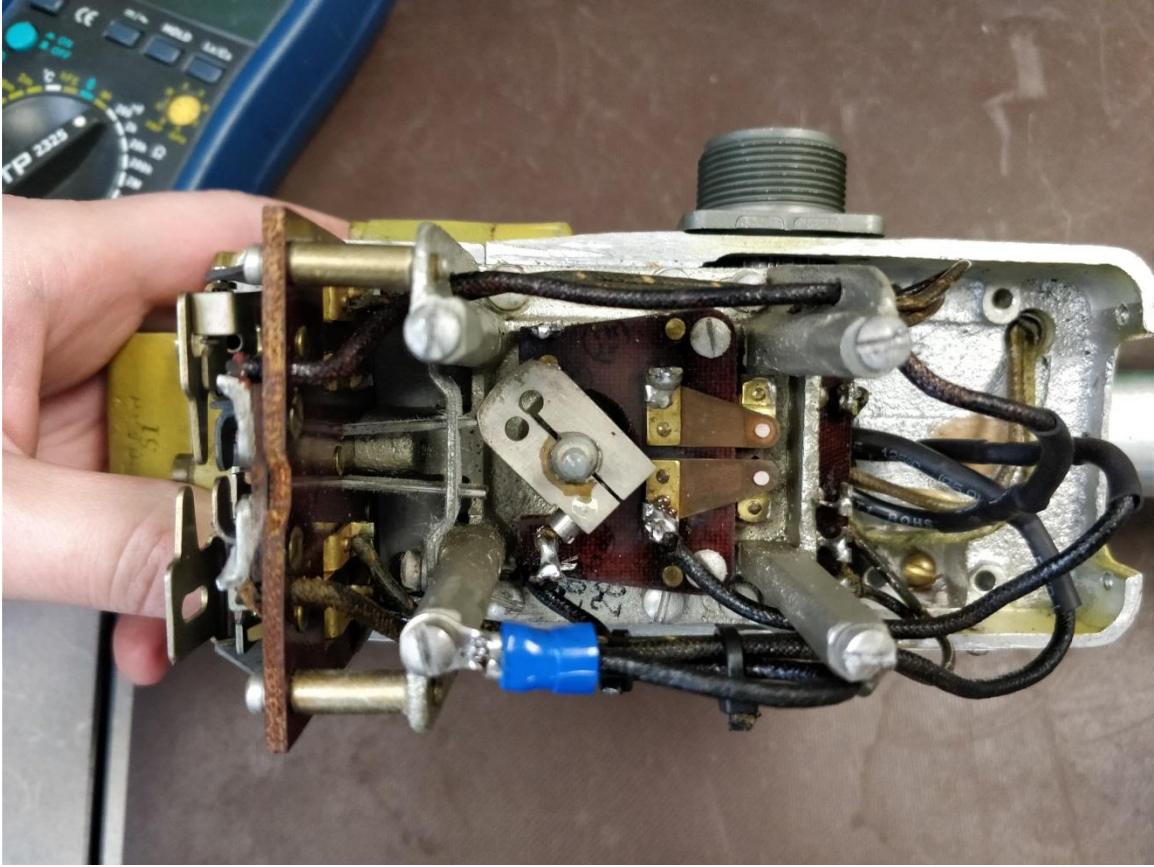


Figure 11: Modified Actuator, Bottom View



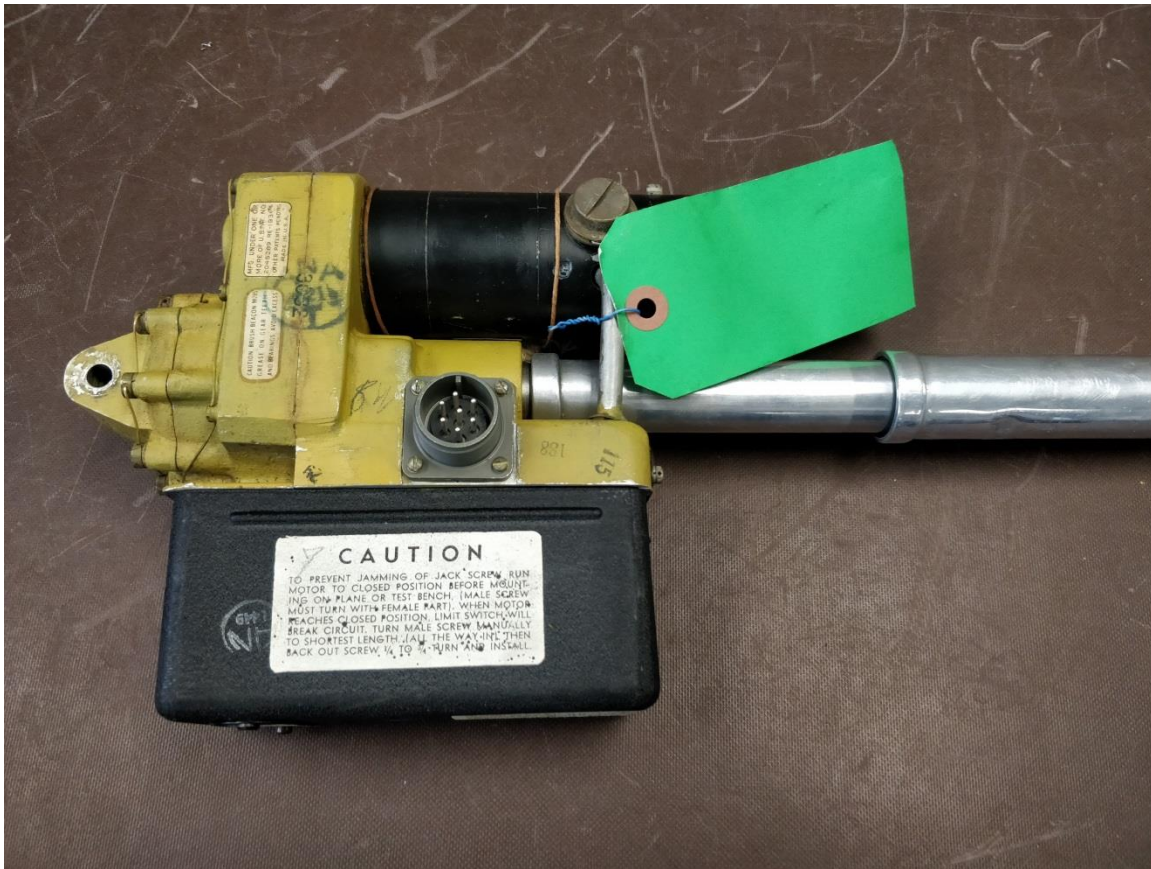


Figure 12: Modified Actuator, Completed