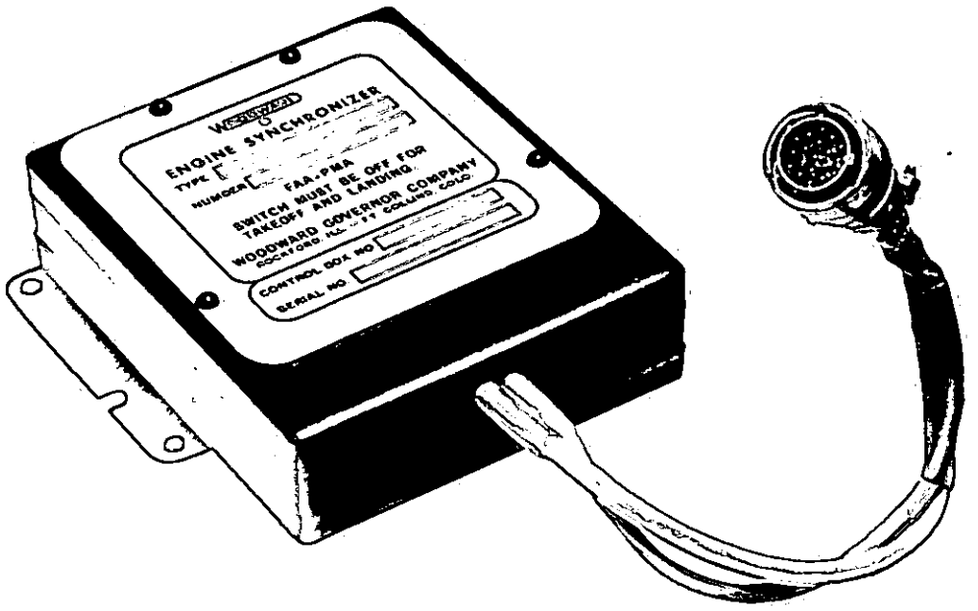
WOODWARD

BULLETIN 33113A

WOODWARD ELECTRONIC SYNCHRONIZER FOR THE CESSNA CITATION 500 SERIES JET AIRCRAFT



WOODWARD GOVERNOR COMPANY

AIRCRAFT CONTROLS DIVISION

ROCKFORD, ILLINOIS, U.S.A.

SEPTEMBER 1973

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33113A

WOODWARD

CONTENTS

WARNING

FAILURE TO FOLLOW INSTRUCTIONS HEREIN CAN CAUSE PERSONAL INJURY AND/OR PROPERTY DAMAGE.

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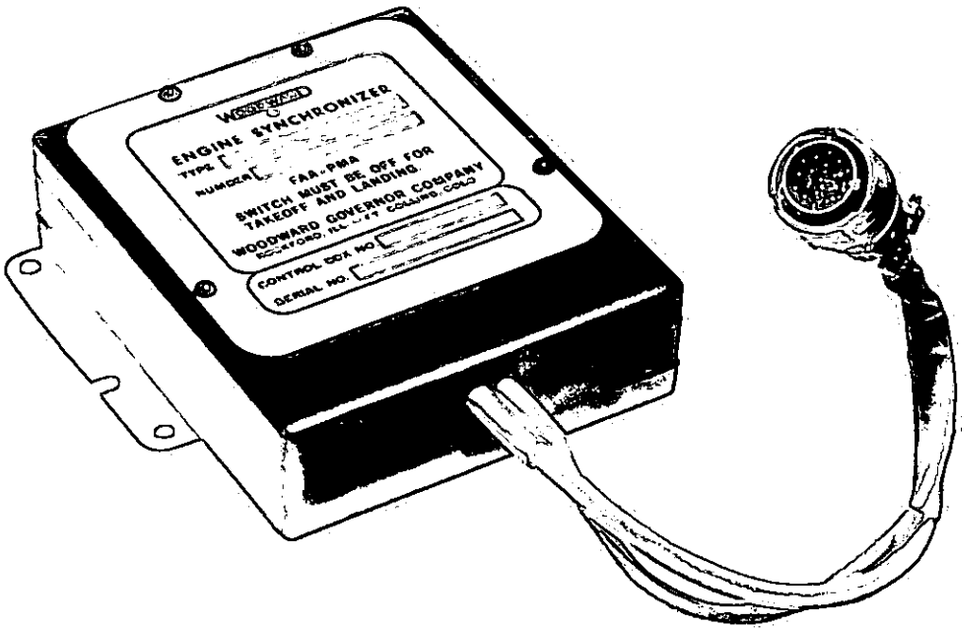


Figure 1. Synchronizer Control Box

GENERAL INFORMATION: The Woodward Electronic Synchronizer automatically matches the speeds of the fans or turbines on the Cessna Citation. The speed of the "slave" engine will follow changes in the speed of the "master" engine over a predetermined limited range. This limited-range feature prevents the slave engine losing more than a fixed amount of rpm in case the master engine is shut down with the synchronizer in the "FAN" or "TURBINE" position. Normal rpm settings and procedures are unchanged.

EQUIPMENT: The synchronizing system consists of a synchronizer control box, a speed setting actuator, an adjustable rod end trimming assembly, a flexible rotary shaft assembly and electrical connectors and cables. The control box (figure 1), which is mounted conveniently in the cabin area, contains all the transistorized circuits, and operates on 28-volt d-c power, drawing less than 1 amp. The box has a remote "OFF/ON" switch that will select fan or turbine synchronization. This is the only control required.

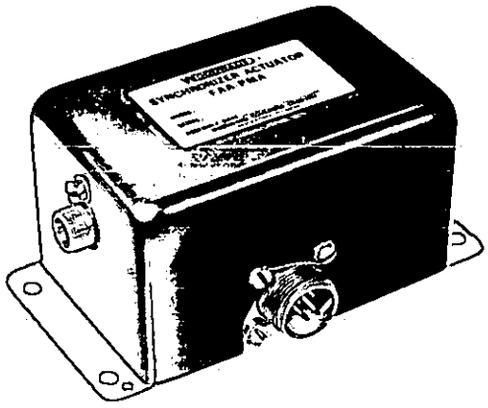


Figure 2. Actuator

The actuator (figure 2) is a stepping motor which operates on command from the control box. In the 213522 System, the actuator is mounted in the tail cone compartment and the rod end assembly in the power lever linkage. In the 213541 System, the actuator is mounted in the nacelle and the rod end assembly on the fuel control lever. The P/N of the system is stamped on the control box nameplate. The rod end trimmer assembly is shown in figure 3. The actuator trims the slave engine fuel control speed setting through the flexible shaft and rod end trimmer assembly.

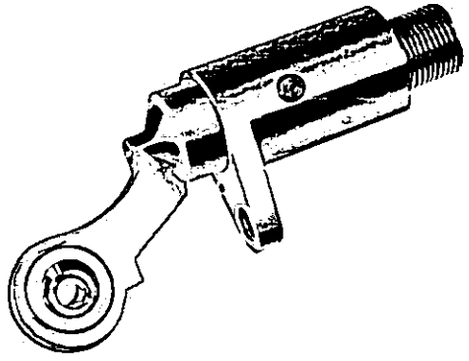


Figure 3. Typical Rod End Trimmer Assembly

The synchronizer utilizes a speed signal from the engine fan or turbine tachometer generators. (figure 4). A frequency doubler is added to each speed sensing circuit to provide the control box with a more usable input.

OPERATION: Three Phase alternating current from the tachometer generators is fed into the control box (figure 5). When any difference in the frequency is detected, a signal is sent from the control box to the actuator, which trims the speed of the slave engine to match that of the master engine exactly. Normal fuel control operation is unaffected. The synchronizer will continuously monitor the engine speeds and reset the slave engine speed setting as required. Operating range of the actuator is approximately $\pm$ 1.5% of fan or turbine rpm.

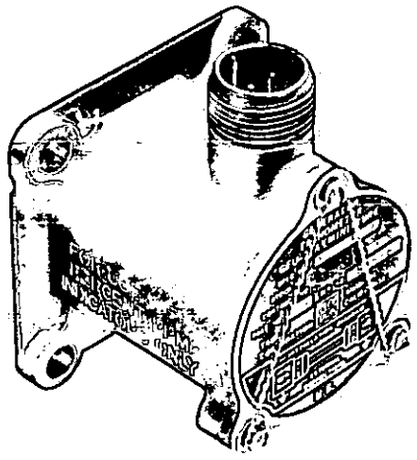


Figure 4. Tachometer Generator (not furnished)

FLIGHT PROCEDURES: Turn the synchronizer control switch to the "OFF" position during take-off and landing. During take-off, the engine rpm is determined by the maximum speed setting of each fuel control or the engine pressure ratio; therefore, the synchronizer is not used under this condition. When the switch is turned to the "OFF" position, the actuator runs to the center of its range before stopping. This insures correct rigging between the quadrant power lever and fuel control at maximum and minimum position.

After making the first power reduction after take-off, roughly synchronize the engines manually and turn on the synchronizer to fan or turbine as desired. The slave engine speed will be automatically matched to the speed of the master engine. In making subsequent rpm adjustments (as from climb to cruise), adjust the master and slave engines to the desired rpm moving both power levers together as usual. This will keep both fuel control speed settings close enough to remain within the limited adjustment range of the slave engine. If the synchronizer is unable to adjust the slave engine rpm to match the master engine, the actuator has reached the end of its travel. Turn the synchronizer switch "OFF" (which will allow the actuator to return to the centered position), synchronize manually, and turn the synchronizer to "FAN" or "TURBINE" again. When the indicator light is on, it shows that the synchronizer is turned on.

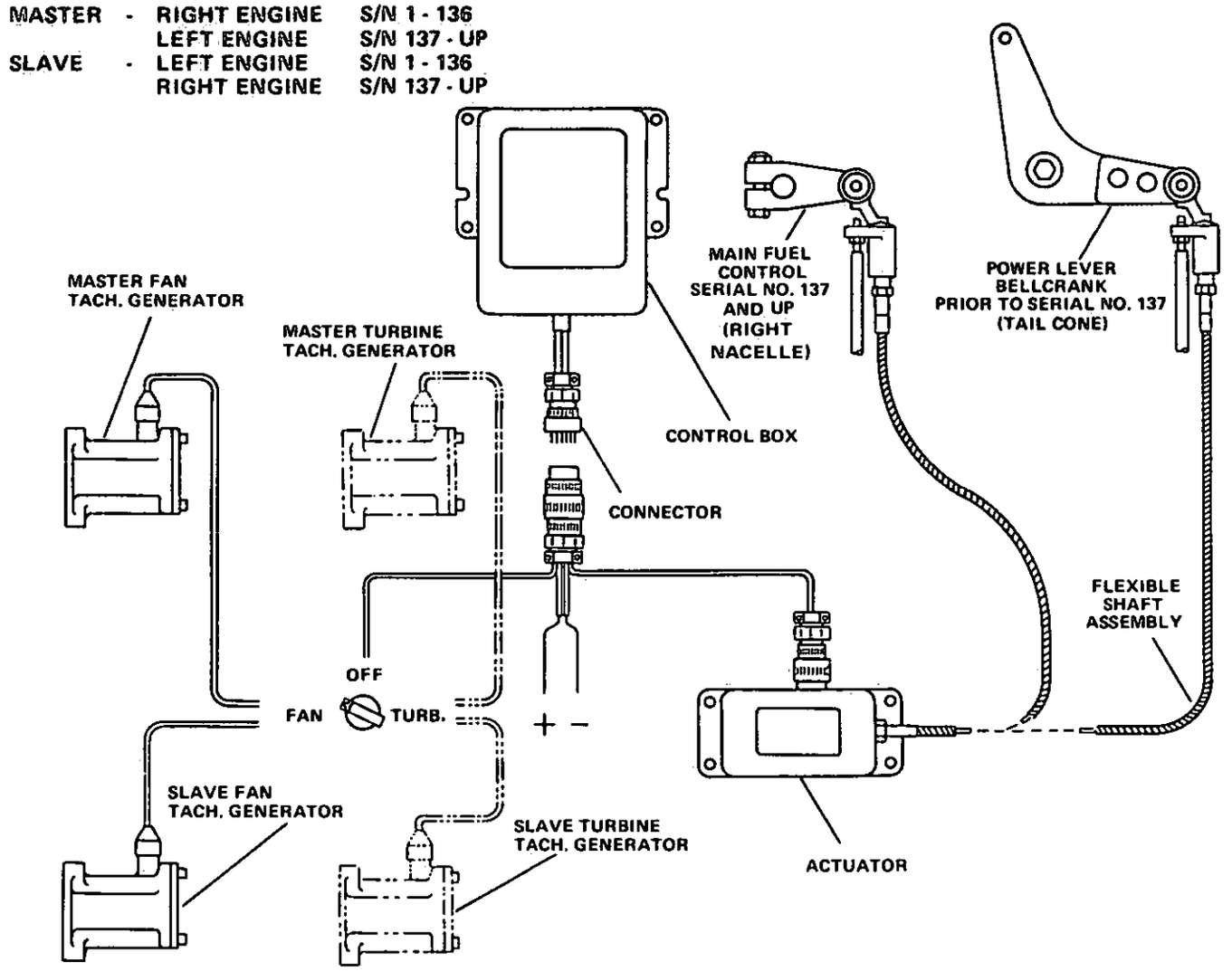


Figure 5. Schematic Diagram of Synchronizer Operation - Tachometer Generators

FUNCTIONAL TEST: To test the operation of the synchronizer in flight, first synchronize manually and turn the synchronizer switch to "FAN" or "TURBINE" position. Then slowly adjust the master engine power lever, in small increments, to increase and decrease rpm.

In determining rpm range limits, turn the synchronizer to "FAN" or "TURBINE" position. With the synchronizer in the "FAN" or "TURBINE" position, move the master engine power lever to a point which is close to the end of this limited travel. Turn the synchronizer "OFF". An unsynchronized condition will develop as the actuator moves to its mid-position. When the synchronizer is turned to "FAN" or "TURBINE" position again, synchronization will result. If the units do not become synchronized, the actuator has reached the end of its travel and must be recentered in this manner:

1. Turn the switch "OFF".
2. Synchronize the engines manually.
3. Turn the switch to "FAN" or "TURBINE" position.

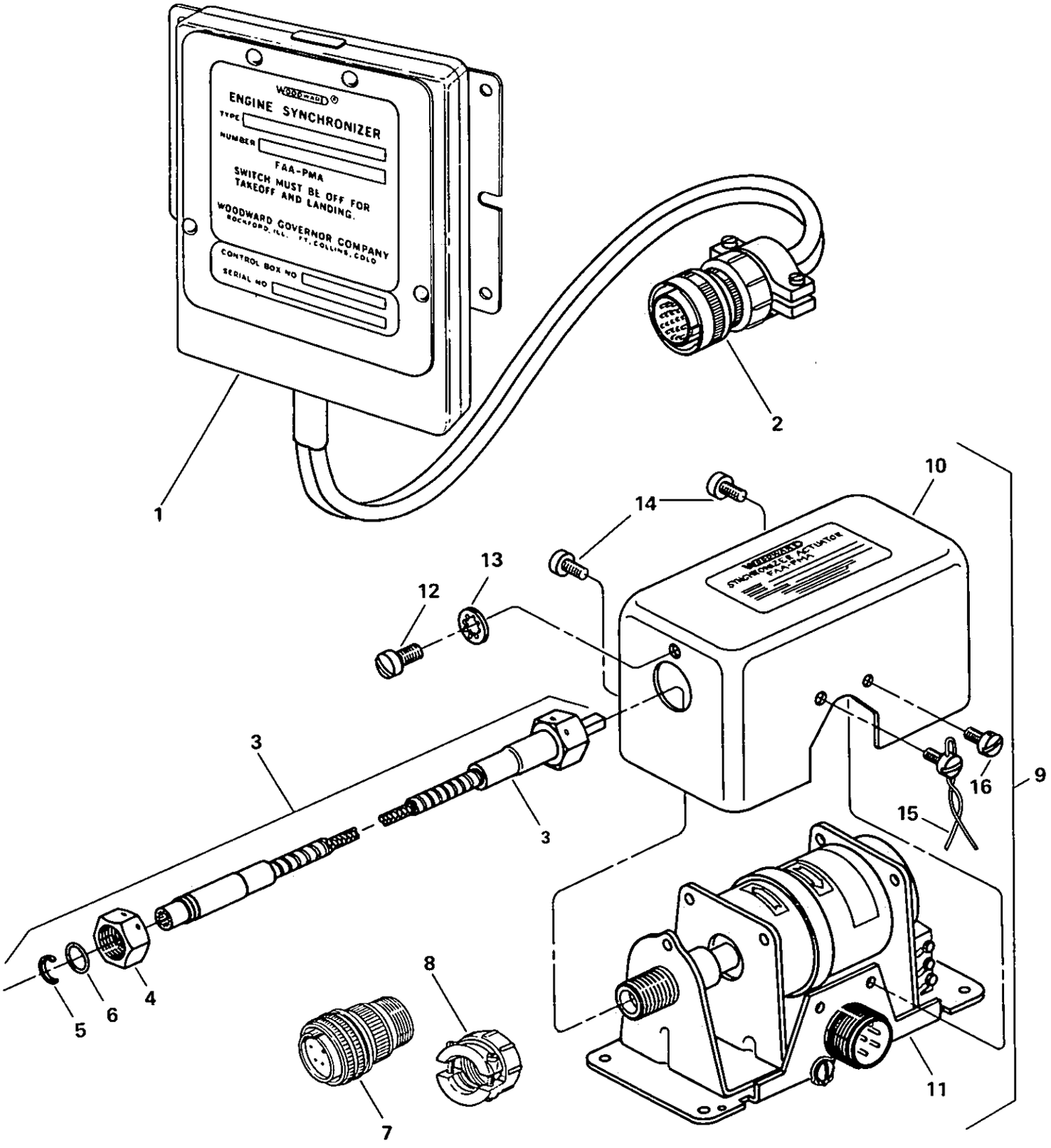


Figure 6. Control Box and Assessories

CESSNA CITATION KIT 213522 and KIT 213541

PARTS LIST FOR CONTROL BOX AND ACCESSORIES

Figure & Index No.	Part Number	Name	Quantity
6-1	213723	Assembly—Control Box.....	1
-2	1630-956	Connector – 19 Pin (Male)	1
(-2)	(No Number)	(Connector – 19 Pin) (Female).....	(1)
-3	1551-036	Shaft Assembly – Flexible ..... (Kit 213522 only)	1
-3	213031	Shaft Assembly – Flexible ..... (Kit 213541 only)	1
-4	1551-050	.Nut Hex	1
-5	011661	.Retaining "C" Ring	1
-6	1355-041	.Packing – 500 O.D. Preformed "O" Ring.	1
-7	233062	Socket – Connector	1
-8	203233	Clamp – Cable	1
-9	213100	Actuator Assembly –Synchronizer.....	1
-10	213009	.Cover –Actuator	1
-11	No Number	.Motor – Base	1
		(ATTACHING PARTS)	
-12	188736	.Screw	1
-13	218345	.Washer – No. 8 – Shakeproof	1
-14	1028-872	.Screw – No. 8 – 32X.28 – (Self-tapping) ..	2
-15	057761	.Wire – Lock	1
-16	189906	.Screw – No. 8 – 32X.250 DR – Fillister ..	2
		– – – * – – –	

MAINTENANCE:

GENERAL: When requesting additional information concerning operation and maintenance, or when ordering replacement parts, it is essential that the following information be included:

1. Part number of the synchronizer system and control box (shown on nameplate).
2. Bulletin number (this is bulletin 33113).
3. Part number and name or description of part.

PREVENTIVE MAINTENANCE: No maintenance is required on the control box, actuator, flexible shaft assembly, or rod end trimming assembly, apart from visual inspection at the time of regular aircraft inspections and the procedure detailed below. Make sure that the electrical connections, flexible shaft, etc. are securely attached. Every 100 hours inspect the rod end trimming assembly, paying particular attention to the bearing.

REPAIR: At the time of main fuel control overhaul, remove the flexible shaft assembly. Clean and lubricate shaft with Molykote lubricant. Also at this time remove the cover from the actuator. Apply Alpha-Molykote "G" to spiral grooves of the switch actuating disc at one end of the actuator motor.

SPEED PICKUP: Follow Normal Servicing and Overhaul Procedures recommended by the manufacturer of the tachometer generators.

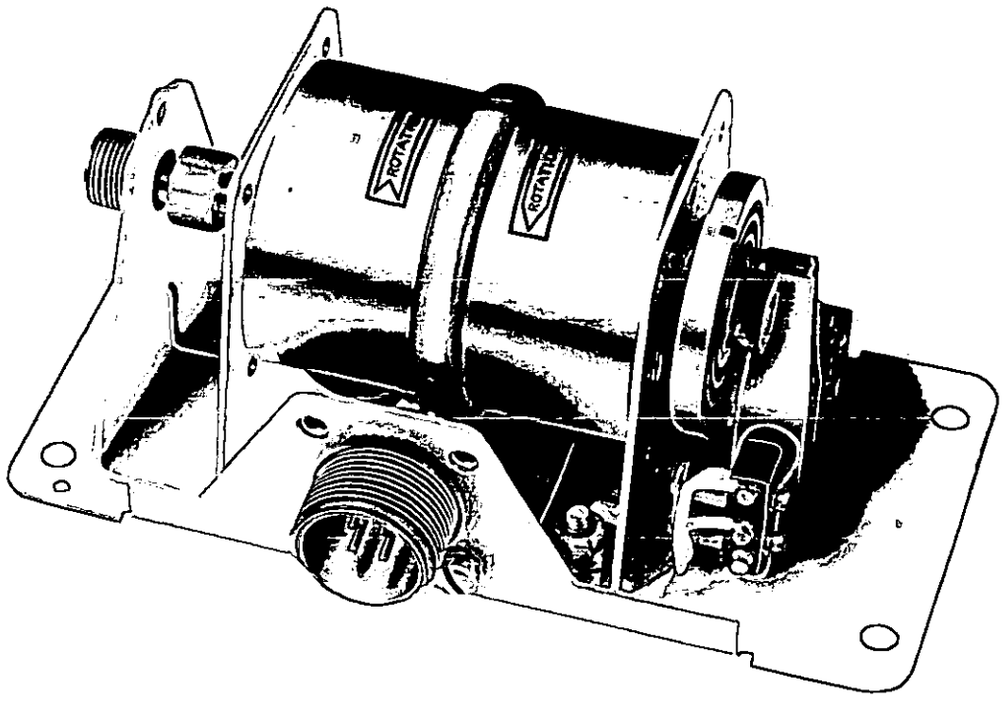


Figure 7. Actuator with Cover Removed

ADJUSTABLE ROD END – TRIMMER ASSEMBLY: Two different main fuel control lever rod-end trimming assemblies are in use. A typical configuration is shown in figure 9. At the time of fuel control overhaul, the rod end assembly should be replaced with an exchange unit:

REMOVAL:

1. Disconnect the flexible rotary shaft assembly (figure 8) from the speed setting actuator.
2. Disconnect the flexible rotary shaft assembly and the main fuel control linkage or power lever linkage from the adjustable rod end trimmer assembly.
3. These rod end trimmer assemblies are lubricated with a baked-on dry lubricant which should not require any routine maintenance. If new lubricant is needed at any time, the rod end trimmer should be exchanged.

REINSTALLATION:

1. Rotate the splined shaft in the rod end trimmer assembly by hand and count the total number of turns available (attach the flexible shaft and turn the free end). RETURN IT TO THE CENTER OF ITS RANGE.
2. With the adjustable rod end trimmer assembly centered, reinstall on the power lever bellcrank linkage or on the lever linkage of the fuel control just as you would with a standard rod end.
3. Again manually rotate the rod end trimmer to one end of its travel. Move the power lever through its entire range and observe the fuel control speed adjusting lever to be certain it hits both maximum and minimum rpm stops. Manually rotate the rod end trimmer to the opposite end of its travel and again move the power lever through its entire range. This assures that the aircraft rigging allows "stop-to-stop" travel with any possible rod end trimmer setting.
4. Count the total turns available in the speed setting actuator motor and TURN TO THE CENTER OF ITS RANGE (turn clockwise or counterclockwise by inserting a screwdriver in the actuator drive and turning by hand). Recenter the rod end trimmer and connect the flexible shaft assembly to the actuator and rod end trimmer.

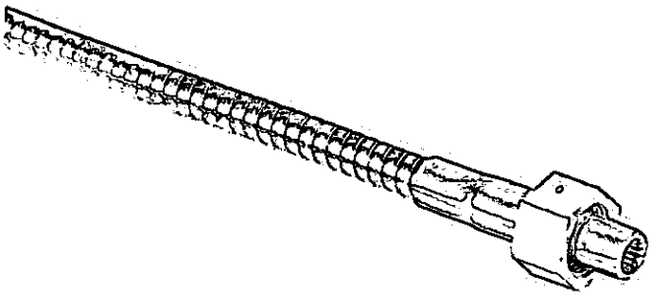


Figure 8. Typical Flexible Shaft Assembly

AFTER INSTALLATION IS COMPLETED, FUNCTIONALLY CHECK POWER LEVER RIGGING AS FOLLOWS:

A. Maximum Power Check and Flight Idle Check.

1. Synchronizer "OFF."
2. Operate both engines on the ground at 65%.
3. Turn synchronizer to "FAN" or "TURBINE" position.
4. Slowly (15-20 seconds) advance the slave power lever to 70% allowing the adjustable rod and trimmer to adust to its longest length. (Engines will be out of synchronization as you have exceeded the trimming range).
5. Leave the master engine at 65% and the synchronizer in the "FAN" or "TURBINE" position. Advance the slave power lever to 100% and determine that you can get 100%. Pull synchronizer circuit breaker.
6. Retard power lever to idle and determine that the engine does not shut down. Reset synchronizer C/B.

7. Turn synchronizer "OFF", reset slave engine to 65% and manually synchronize.

8. IF YOU DID NOT REACH 100% AT MAXIMUM POWER, OR IF THE ENGINE SHUT DOWN AT IDLE, YOU WILL HAVE TO RERIG.

   Adjust the rod end trimmer back on the threaded power lever rod to decrease length. If it is necessary to rerig, you must again accomplish the cutoff check, item 8B., after rerigging.

   NOTE: This check insures that the slave engine will not shut down with the power lever in the flight idle position and the adjustable rod end trimmer at its maximum length.

B. Cutoff Check.

1. Operate both engines on the ground at 65% and turn synchronizer to "FAN" or "TURBINE" position.

2. Slowly (15-20 seconds) retard the slave engine to 60% allowing adjustable rod end trimmer to adjust to its shortest length. Engines will be out of synchronization as you have exceeded the trimming range.

3. Leave the master engine at 65% and the synchronizer in the "FAN" or "TURBINE" position.

4. Go to idle cutoff on the slave engine and be sure it will shut down.

5. Restart slave engine and turn synchronizer "OFF" allowing adjustable rod end trimmer to center.

6. IF THE SLAVE ENGINE DID NOT SHUT DOWN, YOU WILL PROBABLY HAVE TO RIG THE QUADRANT STOP IN THE COCKPIT TO GIVE MORE OVERTRAVEL ON THE SLAVE POWER LEVER.

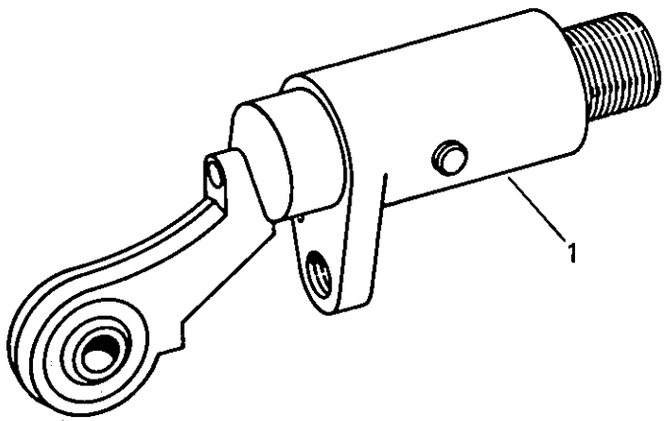


Figure 9. Typical Adjustable Rod End Trimmer Assembly

CESSNA CITATION KIT 213522 and KIT 213541

PARTS LIST FOR ADJUSTABLE ROD END TRIMMER ASSEMBLIES

FIGURE & INDEX NO.	PART NUMBER	NAME	QUANTITY
9-1	213447	Rod End Assy. – Speed Trimming (Kit 213522 only)	1
9-1	5333-032	Rod End Assy. – Speed Trimming (Kit 213541 only)	1

ELECTRICAL TESTING:

SYNCHRONIZER WIRING TEST: Before starting this test, be sure the control box is disconnected, the master switch is off, and the synchronizer circuit breaker is pulled. Disconnect the rpm indicators to remove their resistance from the system during the electrical check. Make the following tests, using an ohmmeter on the pin receptacles of the 19 pin MS 3116 connector. Zero the ohmmeter and read on the X1 or X10 scale.

CAUTION: Do not use a probe that overstresses the receptacle. Insert and remove probe carefully. Failure to do so will result in loose pin connections and faulty synchronizer operation.

DO NOT PLUG IN CONTROL BOX UNTIL THIS TEST HAS BEEN SATISFACTORILY COMPLETED. EVEN WITH THE SWITCH "OFF" THE CONTROL BOX COULD BE PERMANENTLY DAMAGED.

1. When the system meets all of the test values below, turn the master switch on and reset the synchronizer circuit breaker (CONTROL BOX must still be unplugged) and make the voltage check in Table 3.
2. Check tachometer generator output with the engines running at any cruise rpm. In the "FAN" and "TURBINE" position, check potential between pin receptacles J and G, J and A, and G and A. Also check potential between pin receptacles K and F, K and A, and F and A. Voltage must be a minimum of 10 volts at minimum cruise rpm, and a maximum of 21 volts at maximum cruise rpm. Voltages are RMS voltages as read on a 5000 ohm/volt a-c voltmeter. (Woodward Test Instruments 213606 and 213614 may also be used for this test.) If you do not obtain this voltage, replace the tachometer generator.
3. When the system complies with the specifications above, the control box may be connected.
4. If the synchronizer malfunctions now, the cause of the malfunction can probably be traced to the control box, or the mechanical function of the flexible shaft or speed trimmer. Check for a high friction level in the rod end trimming mechanism. Be sure to center the actuator and rod end trimming device before mating the flexible shaft. Malfunctions in the tach generating system that affect fan or turbine rpm indication will affect the synchronizer. If rpm indication is normal but values checked here are not, check leads between the indicator and 19 Pin MS Connector.
5. In troubleshooting the system, check all pins to ground. A and H should show continuity, all others open.

TABLE 1

STEP NO'S 1-6 Test for Defective Actuator

STEP NO.	TEST BETWEEN RECEPTACLE LETTERS	With Actuator Centered	OBTAIN With Actuator Uncentered 180°		ACTION (If Out of Limits)
			Turn Clockwise (Facing Drive End) To Uncenter	Turn Counterclockwise (Facing Drive End) To Uncenter	
1	E & A	Open circuit (high resistance)	6.5 to 8.5 ohms	6.5 to 8.5 ohms	Bench Check the Actuator as shown on page 10.
2	E & C	Open circuit (high resistance)	13 to 17 ohms	Closed circuit (0 to 1.0 ohms)	
3	E & D	Open circuit (high resistance)	Closed circuit (0 to 1.0 ohms)	13 to 17 ohms	
4	D & A	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms	
5	D & C	13 to 17 ohms	13 to 17 ohms	13 to 17 ohms	
6	C & A	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms	

TABLE 2

STEP NO'S. 7-12 Test for Defective Tachometer Generator STEP NO'S. 13-15 Test Aircraft Wiring

STEP NO.	TEST BETWEEN RECEPTACLE LETTERS	OBTAIN	ACTION (If out of limits)
7	J & G Master Tachometer Generator System	*	Repair wiring if at fault. Replace tachometer generator if at fault.
8	J & A Master Tachometer Generator System	*	
9	G & A Master Tachometer Generator System	*	
10	K & F Slave Tachometer Generator System	*	
11	K & A Slave Tachometer Generator System	*	
12	F & A Slave Tachometer Generator System	*	
13	H Aircraft Ground	Closed circuit (zero ohms)	Trace wiring to determine poor ground. Locate and correct the short circuit.
14	A Aircraft Ground	Closed circuit (zero ohms)	
15	B Aircraft Ground**	Open circuit (very high resistance)	

* Some equal resistance value in each of the circuits. Should not be shorted or open. Test both "FAN" and "TURBINE" positions.

** B & aircraft ground will read some low resistance value if you cannot open the circuit breaker. If the synchronizer shares a circuit breaker with another circuit, you may read a resistance value of the other circuit.

NOTE: If you are using the 213614 test instrument you will see 20-60 ohms on this check. To determine that this is not a power lead fault see that this resistance value is the same with the test instrument connected or disconnected.

TABLE 3

STEP NO. 16 Test for Supply Voltage and Polarity

STEP NO.	TEST BETWEEN RECEPTACLE LETTERS	METER READING	ACTION (If out of limits)
16	B & A	Same as supply voltage and polarity of pin B must be positive and pin A must be negative.	Trace wiring to determine fault or reversed polarity.

BENCH TESTING OF THE ACTUATOR:

1. Make the tests in Table 4 using an ohmmeter on the pins of the disconnect. Zero the ohmmeter and read on the XI scale.
2. Exchange the actuator if it does not meet these resistance values. If it does meet these values on the bench check, but did not meet values on page 9, the aircraft wiring must be at fault. Check for continuity of the four actuator leads. See Table 6, page 12.

TABLE 4
Bench Test for Actuator

TEST BETWEEN RECEPTABLE LETTERS	OBTAIN		
	With Actuator Centered	With Actuator Uncentered 180°	
		Turn Clockwise (Facing Drive End) To Uncenter	Turn Counterclockwise (Facing Drive End) To Uncenter
D & C	Open Circuit (high resistance)	6.5 to 8.5 ohms	6.5 to 8.5 ohms
D & B	Open circuit (high resistance)	Closed circuit (zero ohms)	13 to 17 ohms
D & A	Open circuit (high resistance)	13 to 17 ohms	Closed circuit (zero ohms)
A & C	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms
A & B	13 to 17 ohms	13 to 17 ohms	13 to 17 ohms
B & C	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms

TEST EQUIPMENT

The following test equipment may be used to test the synchronizer system:

1. 213606 (figure 10) is a simple test instrument that mates to the MS 3116 Connector. It has pulse indicating lights and jacks for checking voltages and resistance values only. (These readings are given on the wiring test above.) It can be built in the field from the diagram and parts list in figure 11.

2. 213614 (not shown) is a more versatile piece of test equipment. It has pulse indicating lights, jacks for checking voltages and resistance values, and an oscillator system with which tachometer generator output may by simulated. This allows partially checking the control box without running the engines. 213614 can be purchased from the Woodward Governor Company.

If either test instrument is plugged into the system during flight (or ground) testing, the pulsing and direction of pulsing of the actuator will be indicated by the flashing lights of the instrument. Normal synchronizing action is such that the lights will flash alternately. A pulse in one direction may be followed by no action, one, or possibly two, pulses in the opposite direction. In most installations, the synchronizer will respond to a relative rotation of 240° between fans. For this reason it is seldom inactive for very long periods of time, and then only under ideal flight conditions with basically well-matched power plants. See V-42 (page 32) for a description of control box malfunction or system defects that can be detected by observing actuator pulse light activity.

By observing actuator pulse light activity on 213606 or 213614 the control box or system defects listed in Table 5 can be detected.

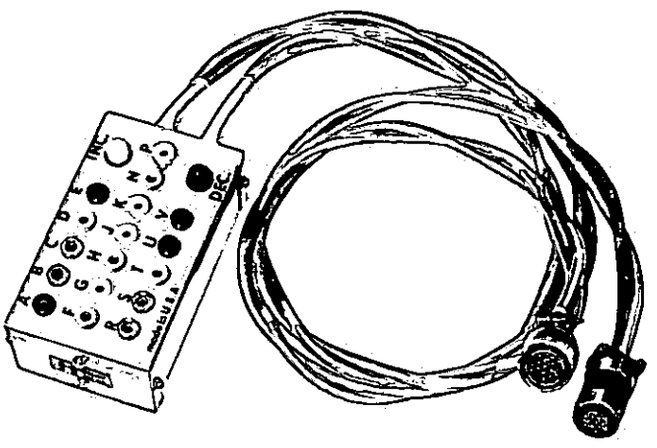


Figure 10. Woodward Test Instrument 213606

TABLE 5
STEP NO'S. 1-5 Pulse Testing for Control Box or System Defects

MALFUNCTION	CAUSE	CORRECTION
1. Double pulsing (both lights flashing simultaneously).	1. a. Excessive voltage spikes on bus caused by generator or other electrical accessory. b. Malfunctioning control box.	1. a. Repair the offending accessory. b. Return to Woodward Governor Company for repair.
2. Either or both lights on continuously.	2. Malfunctioning control box, actuator, or wiring.	2. Determine the malfunction with wiring check sheet.
3. No pulsing activity.	3. Malfunctioning control box.	3. Determine the malfunction with the wiring check sheet or 213614 test instrument.
4. Excessive pulsing in one direction.	4. Excessive torque required to trim the fuel control in one direction (this assumes the fuel control is equally responsive in each direction).	4. Check for high friction level or misalignment in the flex shaft or rod end trimmer.
5. Excessive pulsing in both directions.	5. a. Excessive torque required to trim the fuel control in both directions. b. Excessive lost motion in the actuating cable from the power level to fuel control. The rod end trimmer is moving the cable instead of the fuel control. c. Excessive fuel control hysteresis requiring different arm positions depending on the direction or arm movement to reach the same rpm.	5. a. Check for high friction level or misalignment in the flex shaft or rod end trimmer. b. Remove all possible lost motion in actuating cable and attaching bolts. c. Exchange fuel control.

TABLE 6

	TO CHECK AIRCRAFT WIRING WITH ACTUATOR REMOVED	
MS 3116 F	Pin A to aircraft ground	zero ohms
MS 3116 F	Pin C to aircraft ground	Open circuit (very high resistance)
MS 3116 F	Pin D to aircraft ground	Open circuit (very high resistance)
MS 3116 F	Pin E to aircraft ground	Open circuit (very high resistance)

PARTS LIST FOR 213606 SYNCHRONIZER TEST INSTRUMENT

BOX:	(1) Bud "MINIBOX" P/N CU-2106-HG
BANANA JACK:	(19) E. F. Johnson, type (black), Current Rating 10 amps, 9000 volt d-c P/N 108-900
LAMP:	(2) Drake Mfg. Company, Indicating Lamp, P/N 5131-038-304, 28 volt Maximum Lens - White, Mounting Hole .468"
CABLE:	Two 10 conductor, Belden 8456-100 (No. 22 AWG stranded wire)
GROMMET:	(1) HeyCo 8P-1
PLUG:	(1) MS 3116 F 14-19P
SOCKET:	(1) MS 3116 F 14-19S
BULB:	(2) Miniature Flange - Base Lamp, 28 volt .04 amp., Mfg. by G.E. P/N 327,334 - or 387
DIODE:	(1) I/N 456

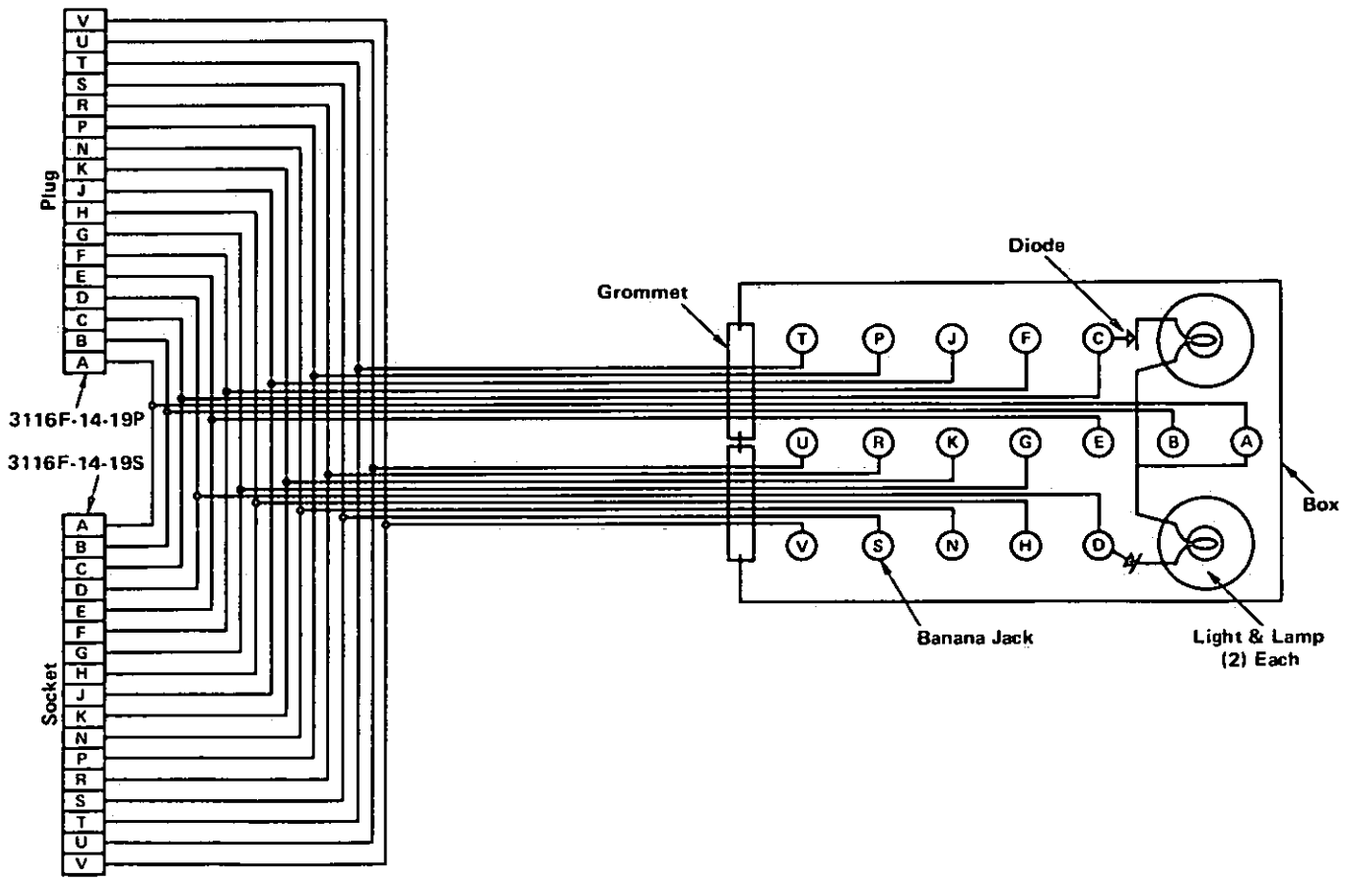


Figure 11. Diagram of Woodward Test Instrument 213606

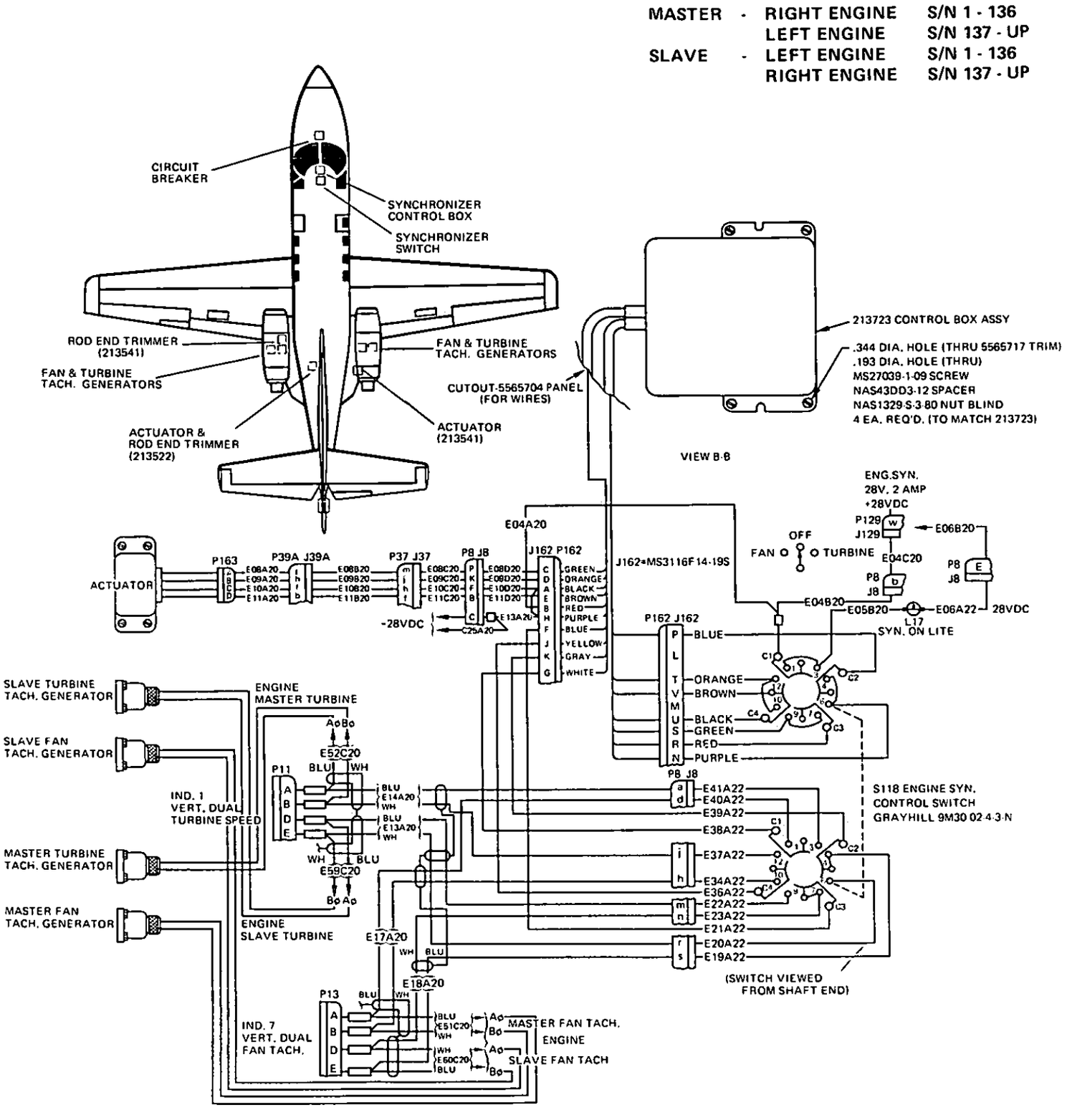


Figure 12. Wiring Diagram Cessna Citation 500 Series of Synchronizer Installation

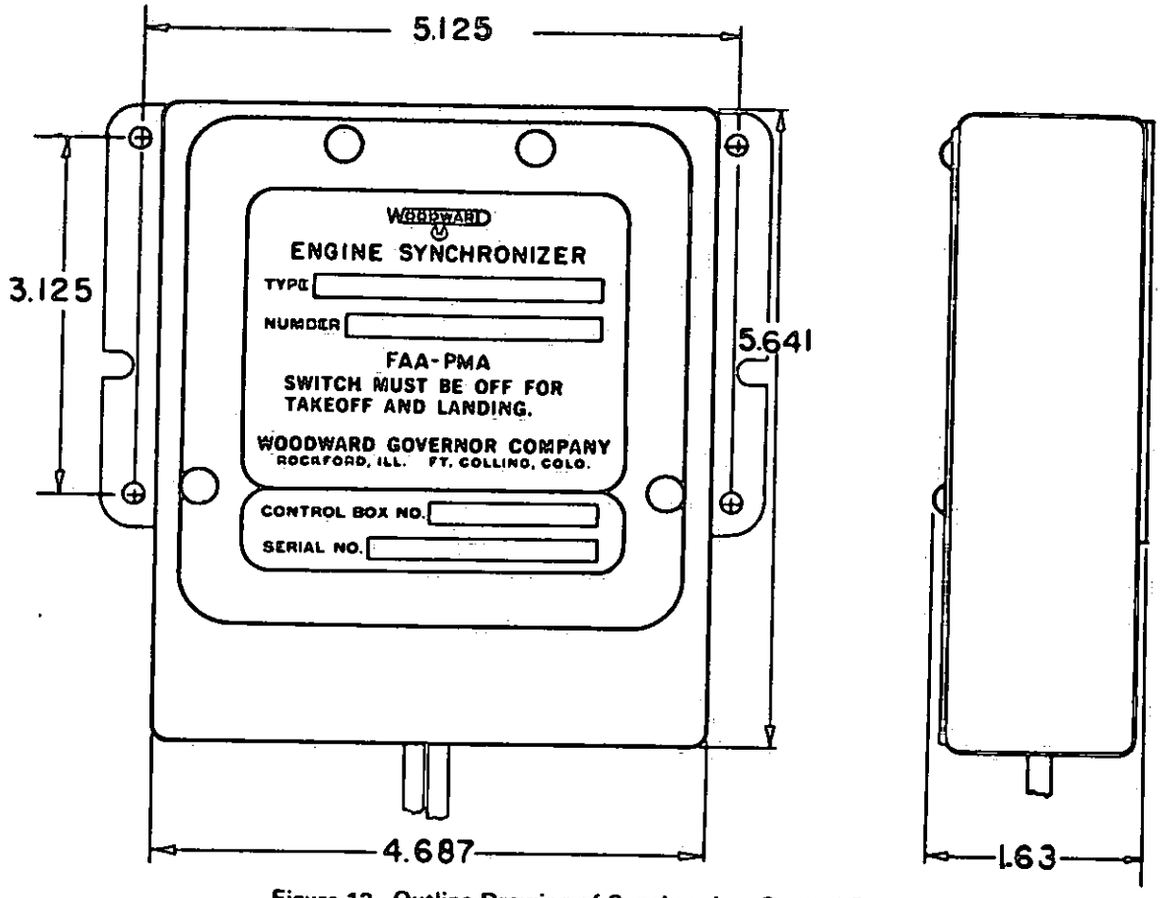


Figure 13. Outline Drawing of Synchronizer Control Box

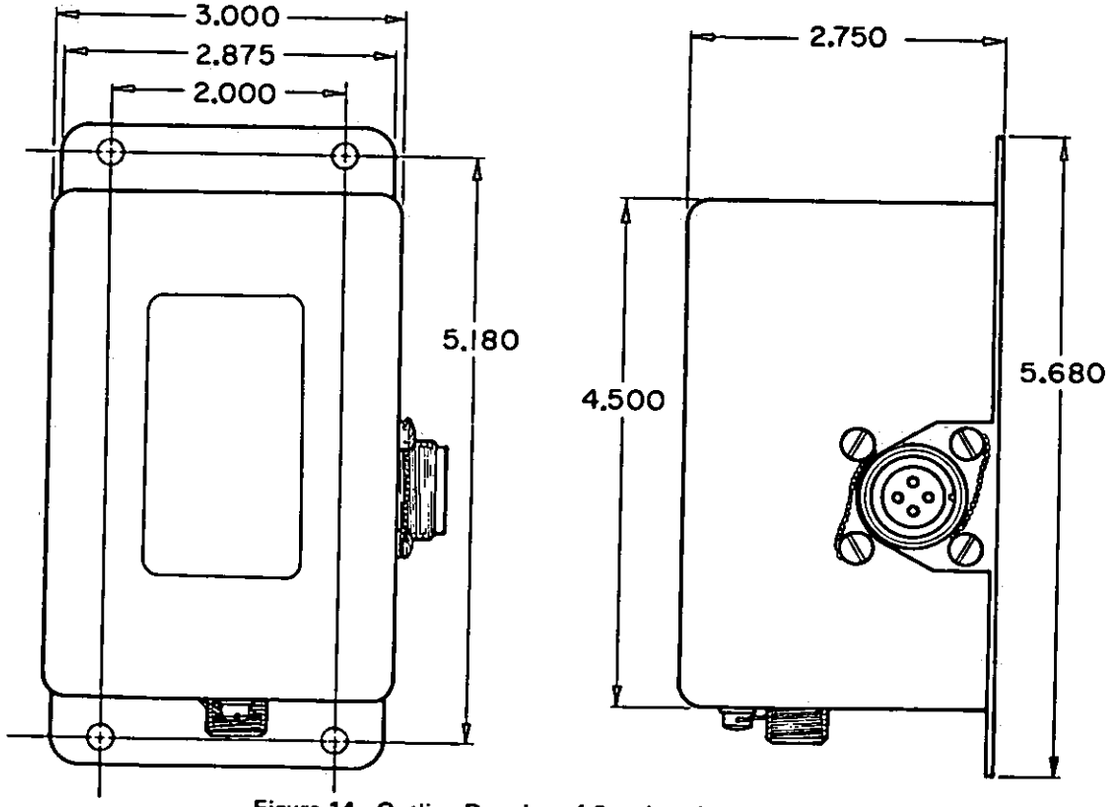


Figure 14. Outline Drawing of Synchronizer .

SYNCHRONIZER TROUBLESHOOTING

FIELD TROUBLESHOOTING WITH MINIMUM EQUIPMENT: In the event of a synchronizer malfunction the following guides will help locate the trouble. We are assuming that only the usual mechanics' tools and an ohmmeter and voltmeter are available. Because of the difficulty in troubleshooting the transistorized control box in the field, it is easier to determine if the other units are satisfactory and determine that the box is at fault by elimination.

GROUND CHECKS:

1. Check to see that the master switch is on, the circuit breaker is not tripped or the fuse is not blown. Also make sure that the MS 3116 Connector is properly mated with the connector in the aircraft wiring system. This eliminates the more obvious causes of malfunction.

2. Separate the MS 3116 Connector (figure 5) and complete the tests listed on the synchronizer wiring test (pages 9 & 10). Complete each step regardless of how recently the installation was made. Pin numbers are detailed on the installation drawing.

   CAUTION: Do not overstress the pin receptacles. Large probes will damage the receptacle and cause intermittent operation.

3. Remove the flexible rotary shaft assembly at the actuator. Insert a driver in the actuator and rotate it through its range. It should rotate freely except for the ratcheting effect of the detents. Normal output torque is 2.0 lb. in. The 3 turn actuator should have a range of 53-54 steps and stop positively at each end. Leave the actuator in the center of its range. (Do not exceed 24 oz. in. torque against the stops.)

4. Adjust the rod end trimmer assembly by rotating the flexible shaft assembly to check the amount of torque required. A 25 oz. in. input to the flexible shaft should produce a minimum of 9 pounds force at the rod end trimmer. Recenter the rod end trimmer and attach it to the actuator. This has verified an acceptable friction level of the rotating parts.

5. With the MS 3116 connector separated and the engines running near cruise rpm, probe pins K and F, K and A, and F and A for the slave engine tachometer generator voltage in the "FAN" or "TURBINE" position. Also probe pins J and G, J and A, and G and A for the master engine tachometer generator voltage. These values should be between 10 volt minimum and 21 volt maximum. These are RMS voltages as read on a 5000 ohm/volt a-c voltmeter. Be sure to check all 3 phases.

If all of the above tests are OK, the aircraft can be flown. In flight, turn the synchronizer to "FAN" or "TURBINE" position and complete the functional test. (See page 3.)

NOTES:

1. A steady voltage applied to the actuator will cause it to fail, usually through shorted wiring.

2. Be thorough. Complete each test as listed.

3. Wiring technique should be of the highest caliber to eliminate any intermittent conditions that are time consuming to troubleshoot and which can damage the electrical units despite circuit breaker protection.

4. If an actuator is replaced because of shorted or open windings, in most cases the control box must also be replaced. (See V-42 on page 32.)

HINTS FOR SYNCHRONIZER TROUBLESHOOTING: Think of the synchronizer as an electronic speed trimmer able to recognize and correct speed errors before they produce an audible beat.

1. Think of the tachometer generator as a small alternator that is sending an alternating current to the control box in the cabin. The control box is going to compare the frequency of the a-c generated by each side. The voltage peaks must be within certain values to be "seen" by the control box.

2. Think of the control box as an electronic device that will accomplish two functions. First, it will "see" and "compare" the phase of the a-c being generated by each tachometer generator. If the phase (because of frequency) does not change identically, a speed error is indicated. Second, it will generate a 24-volt d-c pulse to step the actuator in such a direction as to reduce the speed error.

3. Think of the actuator as two back-to-back solenoids with a means of changing their pulsing motion to a rotary motion in small steps. It will receive its direction of rotation depending on which side of the control box generates the direct current pulse.

4. Think of the rod end speed trimmer as a vernier device to lengthen or shorten the main fuel control speed setting rod without your moving the power lever. It will complete the "knuckle-rolling" function of synchronization for you. It will lengthen or shorten depending on the rotation of the actuator and flex shaft.

CONTENTS

SYNCHRONIZER TROUBLESHOOTING

WOODWARD

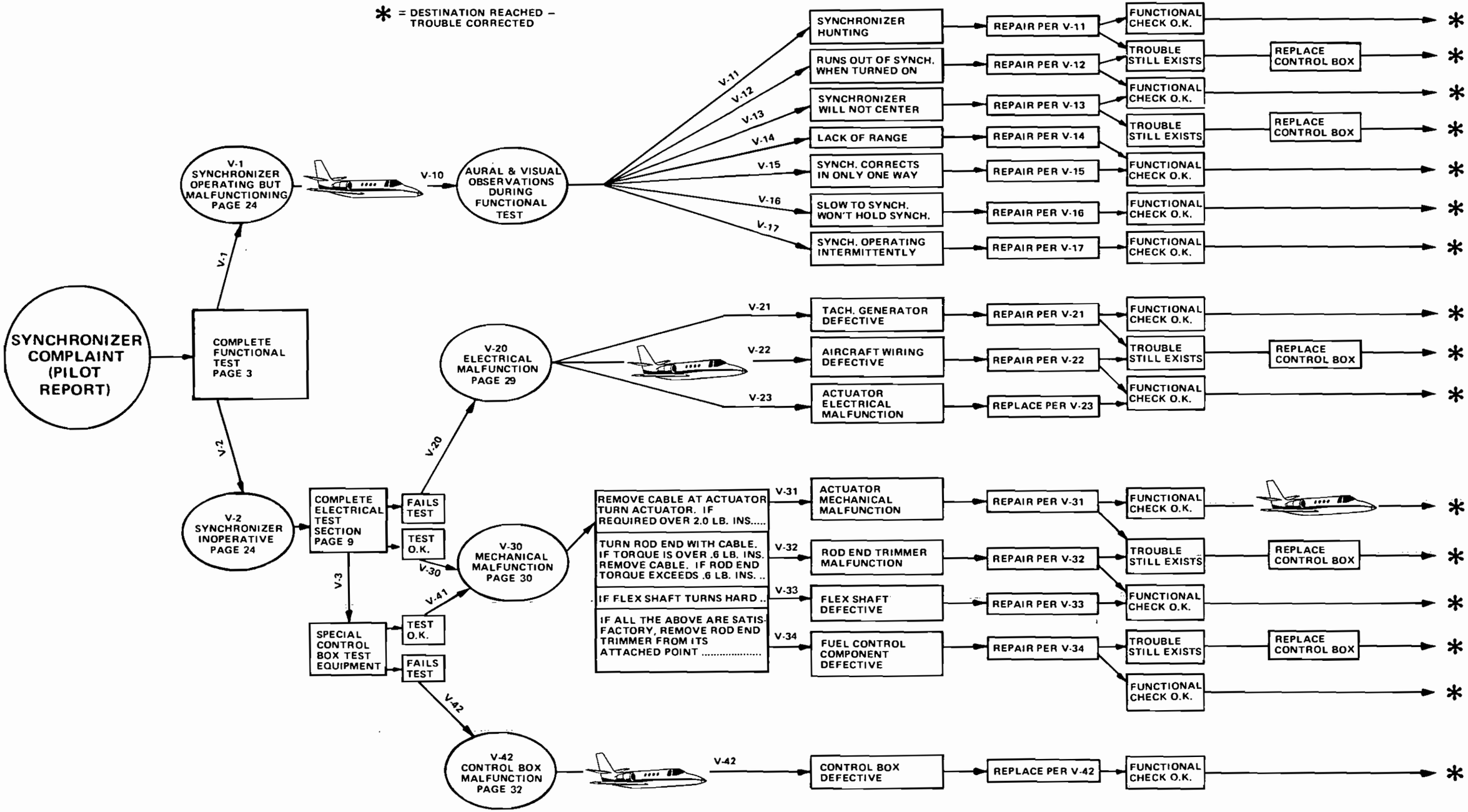
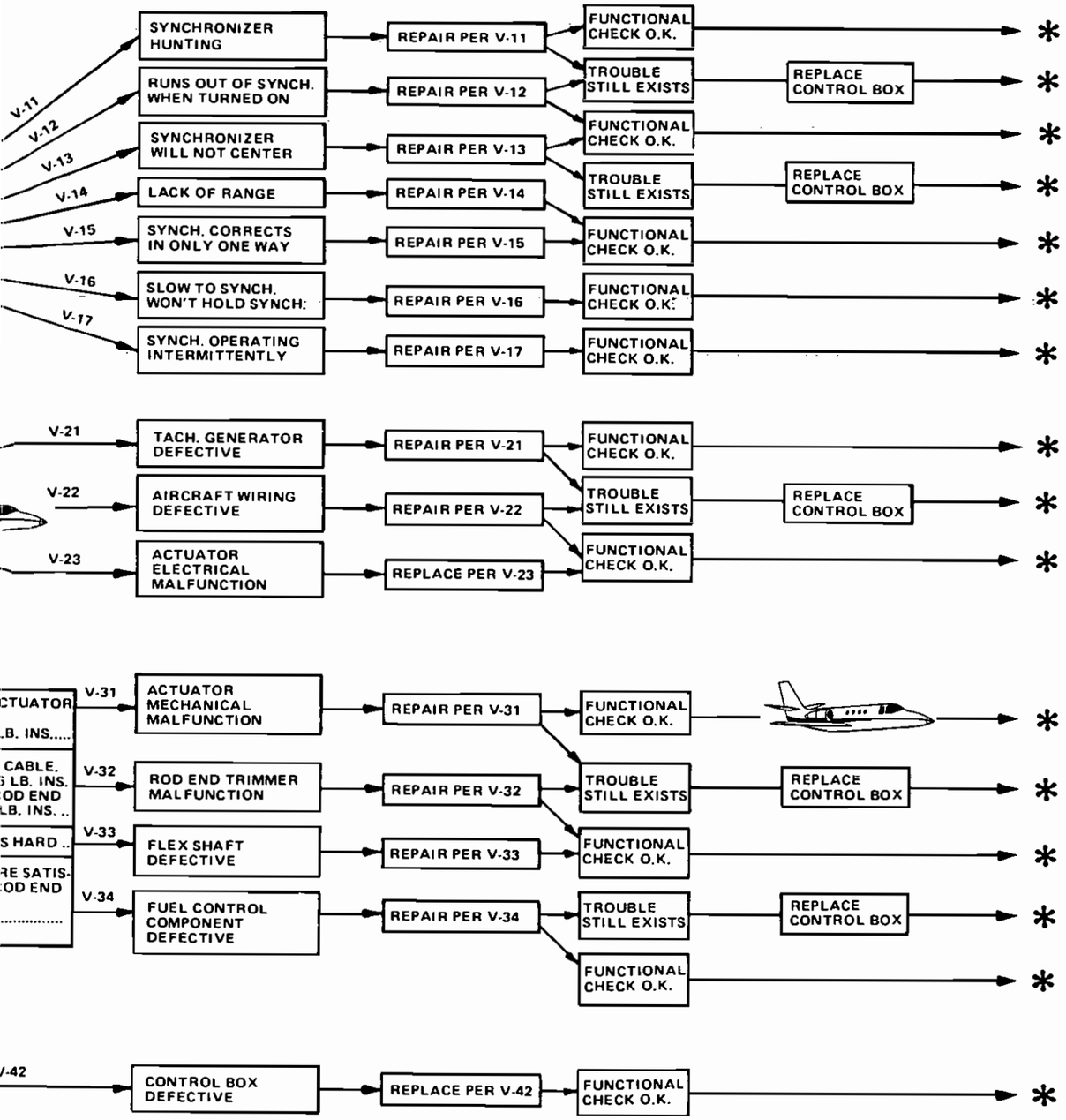


Figure 15. Troubleshooting "Airways" Chart - Cessna Citation 500 Series



rways" Chart - Cessna Citation 500 Series

SYNCHRONIZER TROUBLESHOOTING GUIDE

SYNCHRONIZER COMPLAINT (Pilot Report): Determine all you can from the pilot's report or from your own observation by means of the functional check. Does a report of "inoperative" mean that the system is completely non-responsive to a speed error, or is it working but not synchronizing properly? Refer to figure 15: Troubleshooting "Airways" Chart. A thorough discussion may lend clues to start you off on the right airway. If possible, operate the system yourself to determine the characteristics of the malfunction.

For a functional check, set power levers within a few rpm and allow the synchronizer to trim the rest. A functional check of the total range available is called for later.

Check the system circuit breaker and see that it is not tripped. In some cases it has been combined with another system. The synchronizer control box is "on the line" any time the master switch is "ON" – only its output is off if the synchronizer switch is "OFF" – therefore, if there is any malfunction involved, the control box should be unplugged. For best actuator protection, the system circuit breaker should have a 2 amp. rating. If your system has one in excess of that, it would be well to reduce it to 2 amp. A discussion of the reason why appears under "Actuator Electrical Malfunction" (V-23, page 30).

After completion of the functional check and consideration of the above instructions, you now know which airway you should follow for the system is either "completely inoperative" or it is "operating, but malfunctioning". Go back to the Airway map (figure 15), start at one of the above two check points and call the page number shown for further "clearance". Follow the instructions listed after each malfunction until arriving at "trouble corrected" point.

V-I (SYNCHRONIZER OPERATING BUT MALFUNCTIONING): You are now "holding" over the checkpoint "operating but malfunctioning". The aural and visual indications received while completing the functional check on page 3 should "clear" you directly down one of the 7 airways that best describes your trouble. The only equipment used to arrive down one of these 7 airways is your ears, a tachometer, and a tach-mounted synchroscope (if the aircraft is so equipped). Use of the Woodward test equipment provides you with actuator pulse indicating lights which will help you in your decisions. The simple actuator pulse indicator 213606 can be built from the drawing shown on figure 13.

V-2 (SYNCHRONIZER INOPERATIVE): If the functional check determined that the synchronizer was inoperative, you have two main routes to follow. The electrical check list shown on page 9 and an ohmmeter will help you chart your course. If you have special Woodward test equipment, you have an alternate course through to the control box check. However, if you do not have this special equipment, you will follow the two main routes of electrical or mechanical malfunction. If no malfunction is found, you will arrive at the control box by elimination.

Complete the electrical check list on page 9. If your system fails the check list follow "V-20". If your system passes the electrical check list follow route "V-30".

If you have control box test equipment, follow "V-3" after you have completed the electrical check list. Completing the electrical check list at this point is important. It will establish whether the tachometer generator, actuator, or bus leads are contributing to the problem.

V-3 (TEST CONTROL BOX): If you have special Woodward test unit 213614, you can explore the control box via the fair weather airway "V-3". As you may have guessed by now, exploring control box troubles without the special test equipment is a "finger on the map" all the way and entails trouble-shooting by "elimination". This is why most all other routes have the control box as an alternate in the event correcting all known troubles still leaves the system inoperative.

Test unit 213614 replaces the aircraft speed signal with the output of two oscillators, one of which is variable. Insert the test instrument connectors in the system, select "oscillator output" on the test instrument, and turn the synchronizer to "FAN" or "TURBINE" position. By varying the output of the one oscillator you can underspeed or overspeed the "simulated" slave engine, fan or turbine. The pulse lights will reflect the output of the control box, and the movement of the rod end trimmer can be observed as it acts to match speed. As this speed control "loop" is not closed, the rod end trimming will have no effect on stopping the "simulated" speed error. You will do this manually by means of the variable oscillator. Expect the light actions shown on page 12.

If the control box checks OK (the system has already passed the electrical check sheet) then you are cleared along "V-41" back to a mechanical malfunction as being your trouble. If the control box fails the test you have an electronic malfunction

which places you on "V-42" to a malfunctioning control box. Proceed to "V-42" "Control Box Defective".

V-11 (SYNCHRONIZER HUNTING): If the speed of the slave engine is hunting, check the following possibilities:

1. Mechanical binding in the main fuel control speed setting lever. The high breakaway torque causes an overcorrection for the speed error in alternate directions.

2. If the master engine speed is varying, the slave engine will follow. This would indicate a problem in the basic speed of the master engine; item 1 above would be a likely cause.

3. Mechanical binding of the rod end trimmer where it is attached to the speed control linkage. The Uniball must be free to swivel throughout its range of operation.

Test equipment will show excessive pulsing, alternating in direction as the synchronizer chases the speed error. Remember: the synchronizer has no anticipating capability, it corrects for an *existing* speed error.

It is unlikely that the synchronizer is causing the hunting as the rpm change per actuator step is small and reduced to approximately 1/2 its normal gain during the step that reverses direction. The normally high friction level of the rod end trimmer thread is not conducive to overrunning the speed setting being sought. Abnormally poor fuel control response could contribute to speed hunting. Also check to see if you are trying to synchronize in a speed regime in which the synchronizer is not expected to operate.

REMEDY:

1. & 3. Correct any mechanical binding in areas listed above.

2. Overhaul fuel controls.

If the trouble still exists, refer back to Airways Chart.

V-12 (SYNCHRONIZER RUNS OUT OF SYNCHRONIZATION WHEN TURNED ON): If the synchronizer runs the slave engine, fan or turbine, out of synchronization when it is turned to "FAN" or "TURBINE" position, one of the following may be involved:

1. The leads from the fan or turbine rpm indicators may be reversed. In this condition the control box "sees" the wrong engine as being slow or fast. C Phase of all tachometer generators is grounded. A Phase and B Phase of the master engine tachometer generator (fan or turbine) must go to pins J and G. A Phase and B Phase of the slave engine, (the engine with speed-changing capability) tachometer generator (fan or turbine) must go to pins K and F. If these leads are reversed, the pulse generated is in a direction such as to increase the speed error.

2. The actuator leads may be connected to the wrong pin of the MS 3116 Connector. Leads C and D deliver the 40 millisecond pulse determining the direction of actuator rotation. If these leads are reversed the actuator will step in a direction such as to increase the speed error.

The above problems would be most likely to occur on initial installation or following wiring repairs or modifications.

3. Intermittent shorts or opens in the speed signal or its wiring can cause the synchronizer to run out of synchronization when turned to "FAN" or "TURBINE" position. In this case the frequency generated by the defective tachometer generator is not representative of its true speed and in most all cases will be less. The control box "sees" this engine as being slow and makes the seemingly appropriate correction which steps the slave engine out of synchronization. In most cases, if the slave tachometer generator is involved, the slave engine will increase its speed out of synchronization. If the master tachometer generator is involved, the slave engine will decrease its speed out of synchronization. If the intermittent is in the fan tachometer generator, it will affect only the "FAN" position of the switch. The same applies to the turbine tachometer generator and switch position.

This is more likely the case if this trouble occurs in a system that has been working in the past. In all three cases, the synchronizer will step in the opposite direction back to center when turned off if there is any master tachometer generator signal.

REMEDY:

1. Connect a voltmeter to leads K and F, K and A, and F and A to see that a voltage is generated when the slave engine (fan or turbine) is started and at J and A, J and G, and G and A when the master engine (fan or turbine) is started.

2. Check motor leads against the installation drawing.

3. Monitor the tachometer generator voltage produced in flight. If it is wavering, an intermittent fan or turbine tachometer generator short or open should be suspected. 213606 or 213614 test instruments will make this easier.

If trouble still exists, refer back to Airways Chart.

V-13 (SYNCHRONIZER WILL NOT CENTER): Whenever the control box is turned off, the actuator should return to the center of its range before shutting off. This insures an equal synchronizing range the next time it is turned on. With the synchronizer switch in the "OFF" position, a centering mode is established which will step the actuator back to center if it is not already at center. The actuator determines the proper direction by means of the centering switches operated by the spiral groove on the end of the actuator shaft.

Failure to return to center could be caused by any of the following:

1. Malfunctioning master tachometer generator.
   a. Shorted to ground.
   b. Leads shorted together.
   c. Open circuited.
2. Defective centering circuit in the control box.
3. Mechanically misrigged. The actuator depends on proper rigging to insure that it can travel the required distance to center. If the rod end trimmer thread bottoms before the actuator reaches center it will prevent the centering switches from opening. In this case the synchronizer would have less than 1/2 of its normal range.
4. Centering mechanism defective, switch arm bent.
5. Centering switches defective.
6. Rod end trimmer, flexible shaft assembly, or actuator bound up mechanically preventing rotation to the center position.

An aural indication of the centering function will be provided if you make the practice of manually adjusting slightly out of synchronization before turning the synchronizer to "FAN" or "TURBINE" position. When you turn the synchronizer off on final approach, you will hear the unsynchronized condition develop as the actuator returns to center. After the synchronizer is turned off, it should go to center in a maximum of 5 seconds. If it cannot center, the pulse lights of the test instrument will flash continuously in one direction.

REMEDY:

1. Replace or repair tachometer generator or repair leads.
2. Exchange the control box.
3. Rerig by turning the actuator and the rod end trimmer to the center of their range before mating the flex shaft assembly.
4. Exchange the actuator.
5. Exchange the actuator.
6. Reduce friction to an acceptable level.

If trouble still exists, refer back to Airways Chart.

V-14 (LACK OF RANGE):

1. The first requirement for a full synchronizing range is proper rigging. All systems are rigged by turning both the actuator and the rod end trimmer to the center of their ranges before mating the flexible shaft assembly. You will find that the actuator has 3 turns or 53 steps. Rod end trimmers will have 6 to 8 turns. With proper rigging the actuator always provides the stops to limit the travel. The range varies with the installation, but is usually a minimum of plus or minus 1.5% of the cruise rpm.

The synchronizing range can be checked by completing the functional check on page 3.

2. Be sure you are not trying to synchronize too close to a mechanical stop on the fuel control. The rod end trimmer must be free to move through its entire range without hitting a mechanical stop.
3. Lost motion in the actuating cable from the power lever to the fuel control can be critical. If the lost motion trims easier than the fuel control, the rod end trimmer is required to remove the lost motion before effective fuel control lever movement can result.

   (NOTE: The linear movement required to take up the lost motion results in a subtraction from the .230" range of the rod end trimmer, and reduces the synchronizing range.)
4. Mechanical binding of the rod end trimmer or actuator at one or both ends of their ranges would also reduce the total range. Test instruments 213606 or 213614 will show continuous pulsing without speed change as you reach the end of the range.

REMEDY:

1. Rerig properly.
2. Adjust cabin power lever to move fuel control lever farther away from stop.
3. Remove all possible lost motion in actuating cable and attaching bolts.

4. See that rod end trimmer and actuator work smoothly from stop to stop.

If trouble still exists, refer back to Airways Chart.

V-15 (SYNCHRONIZER CORRECTS IN ONLY ONE DIRECTION – INCREASE OR DECREASE RPM): A condition where the synchronizer will correct in only one direction could be caused by one of the following:

1. One side of the actuator motor is malfunctioning with either a shorted or open winding or a mechanical malfunction. In this case, the synchronizer could operate in one direction only, either in the synchronizing or centering mode; therefore the rod end trimmer could be in almost any position. If it was turned on very long, it would probably work its way to one end and stay there. The electrical check list (page 9) would detect this condition.

2. One side of the control box is inoperative. If the side used for centering was inoperative, the system could synchronize only toward the "decrease rpm" direction. It would not return to center when turned off, so the rod end trimmer would probably work to one end of its travel and stay there. If the side used for centering was alright and the other side was inoperative, the system would only synchronize toward the "increase rpm" direction. Each time the synchronizer was turned off, it would return to center. In the centering mode, only one side of the control box is used; the direction of actuator rotation is determined by the centering switches.

3. Mechanical binding in one direction. The force required is usually higher in one direction than the other, due to the control lever return spring or speeder spring forces in the main fuel control. This may mean that the synchronizer can trim in one direction but not in the other. There is also a slight difference in the force available to extend or withdraw the rod end trimmer depending on the manner in which the rod end trimmer is loaded.

4. Improper rigging could cause this condition, but in a special way. If the system were rigged with the rod end trimmer at one end of its travel when the actuator was centered, it would always start from a position (when turned on) in which it could only trim in one direction; however, once led away a few steps by a speed error in the proper direction, it could then synchronize around that position. Each time the system was turned off, it would again return to a position from which it could trim only one way.

Test instruments 213606 or 213614 incorporating actuator pulse lights would help determine the above conditions.

1. In condition 1 above, pulse lights are activated in one direction only during the functional check (page 3) in either the synchronizing or centering (switch off) mode.

2. Same as (1) above if the centering side is inoperative. If the opposite side is inoperative, pulse lights in the other direction would be seen when the control box was turned off.

3. Condition 3 would show normal pulse activity in one direction, excessive pulsing in the opposite direction. Possibility of continuous pulsing when the control box is turned off if it is trying to center in the high force direction.

4. Move the master lever slightly in a direction from which it will correct. From then on, the light action and synchronization should be normal.

REMEDY:

1. Exchange the actuator.
2. Exchange the control box.
3. Correct binding.
4. Rerig.

If trouble still exists, refer back to Airways Chart.

V-16 (SLOW TO SYNCHRONIZE: WON'T HOLD SYNCHRONIZATION): This condition could be caused by any of the following:

1. Excessive double pulsing of the control box. During double pulsing, both sides of the actuator motor are energized at the same time, the actuator is prevented from rotating either way, and proper corrective pulses are lost. Excessive double pulsing makes the system slow to synchronize and the synchroscope (if installed) will exhibit a nervousness that reflects the difficulty with which corrective pulses reach the actuator. Double pulsing will be hard to determine without a test instrument. It often can be improved with a change in power or rpm setting. With a test instrument the actuator pulse lights will flash simultaneously.

2. Excessive double pulsing caused by voltage spikes from some electrical accessory.

3. Excessive mechanical friction in the actuator will retard synchronization. Torque required to manually rotate the actuator through the detent steps should not exceed a torque of 2.0

lb. in. The cover can be removed to determine the cause of excessive rotational drag. The centering switch and cam can be lubricated with Alpha-Molykote "G". The centering switch arm pin should not bottom in the groove.

NOTE: Keep Alpha-Molykote "G" away from switch terminals.

4. Excessive lost motion in the actuating cable from the power lever to the fuel control could cause slow speed response to fuel control lever movement. This lost motion creates a "dead band" that the synchronizer has to cross each time the speed error reverses direction. A speed error must exist longer to produce the necessary steps to complete synchronization. This occurs every time the speed error reverses actuator direction.

The flexible shaft assembly should not need lubrication. If it does it will be necessary to use a Molykote lubricant such as Alpha-Molykote "G", thinned with mineral oil based lubricant, that will flow along the flexible shaft as the inner shaft cannot be removed without a swedging tool for reinstallation of the end washer. If the inner shaft is frayed, or the outer housing broken, the flexible shaft assembly must be replaced.

The rod end trimmer should be turned with a mild load (2-3 lb.) applied to the end to see if the threads are ragged, parts galled, or in need of lubricant. A 1.5 lb. in. applied torque should produce a rod end force of 9 pounds minimum. The fuel control speed setting shaft or control arm must be free to prevent slow operation in one or both directions.

The above problems can be observed with the test instruments. The double pulsing is explained above. The other conditions would be indicated by the following light action:

If the speed setting mechanism is mechanically bound in both directions, there would be an abnormal amount of light activity for the observed speed correction. In general, the actuator should cross its 53 step range in 9 to 10 seconds.

If the speed setting mechanism is mechanically bound in one direction, it is easily seen by the light activity. Establish a given out of synchronizer condition. Turn the synchronizer to "FAN" or "TURBINE" position and count the pulses until synchronized. Turn off the synchronizer and count the pulses to center. Do this 2 or 3 times; the pulses necessary in each direction should be approximately equal. While synchronizing, count the total pulses toward decrease and increase over a 3 minute period. The totals should be equal within 2 or 3 pulses.

REMEDY:

1. Exchange the control box if there is excessive double pulsing (double pulsing in excess of 5% of total pulses).
2. Repair the offending electrical accessory.
3. Correct the mechanical binding that is causing the slow synchronization in either or both directions.
4. Remove all possible lost motion in actuating cable and attaching bolts.

If trouble still exists, refer back to Airways Chart.

V-17 (SYNCHRONIZER OPERATES INTERMITTENTLY): This usually indicates an electrical malfunction. The best route to finding the trouble would be to complete the electrical test section (page 9), while the system is inoperative. The trouble area would be more clearly indicated if you have a test instrument which incorporates actuator pulse lights. Check for the following:

1. A marginally high mechanical friction level that is permitting the synchronizer to work one time and not another. With a test instrument you would notice a high pulse rate without effective speed change. When the system was working it would probably be slow to synchronize.
2. An intermittent short in the tachometer generator or wiring. The control box essentially turns off when a short exists in the tachometer generator lead. When the short is removed the system is again operative. The result would be intermittent synchronizer operation. An "open" could have the same result.
3. An intermittent fault in the control box. This would probably be indicated by an absence of any pulse light activity or by periods of complete double pulsing which prevents effective speed correction.
4. An intermittent open in the actuator or motor leads. The electrical check sheet should locate this. If it was an intermittent *short* the control box would be permanently damaged or the circuit breaker would be tripped, and the synchronizer action would no longer be intermittent.
5. A damaged MS 3116 control box connector. The connector can be damaged by probing the pin receptacle with objects that are too large. Check *each* of the 19 receptacles.
6. Abnormally large voltage spikes on the bus from some other malfunctioning electrical accessory. This can cause continuous double pulsing.

REMEDY:

1. Decrease torque required to drive the rod end trimmer.

2. Repair or replace tachometer generator.
3. Exchange the control box.
4. Exchange the actuator or repair lead.
5. Replace MS 3116 control box connector.
6. Repair offending electrical accessory.

If trouble still exists, refer back to Airways Chart.

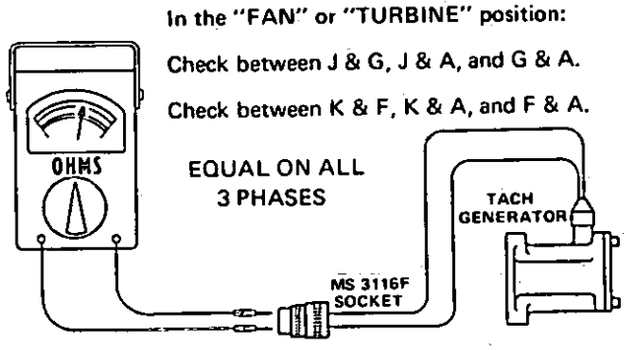
V-20 (ELECTRICAL MALFUNCTION): If the electrical check list shown on page 9 indicated an electrical problem you have 3 main courses. V-21, V-22, or V-23. If the system failed steps Nos. 1-6 (page 9) of the check list, follow V-23 to an actuator electrical malfunction.

If the system fails steps Nos. 7 thru 12 (page 10), the tachometer generators are malfunctioning and you should follow route V-21 to "Tachometer Generator Defective".

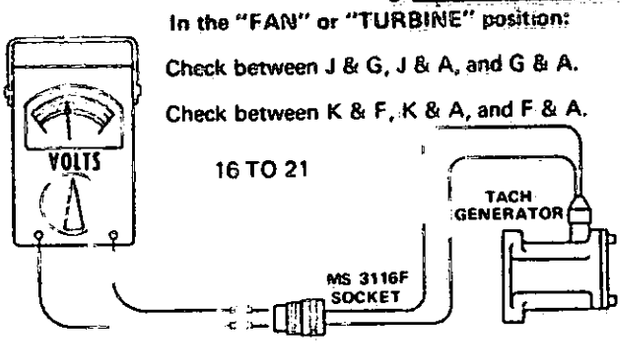
If the system fails the remainder of the checklist (tachometer generator proves to be all right or the actuator bench checks all right), then proceed to check point "Aircraft Wiring Defective" (V-22).

If trouble still exists, refer back to Airways Chart.

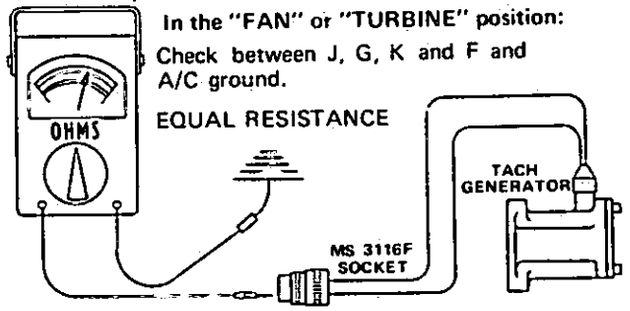
V-21 (TACHOMETER GENERATOR – MALFUNCTIONING): The resistance value of each phase should be equal. (If trouble is suspected, check the resistance value when the tachometer generators are *hot*. The resistance may be found to be varying. Disconnect the rpm indicators to prevent a resistance reading through the indicator.):



With the engines operating at cruise rpm, the tachometer generator should produce about 18 to 21 volts (a-c). This is the RMS value as read on a 5000 ohm/volt voltmeter. The voltage at minimum cruise rpm must be at least 16 and the maximum voltage at maximum cruise must not exceed 21 volts:



Be sure that leads J and G go to the master engine and that leads K and F go to the slave engine. A resistance check of all leads to ground (on the X10 scale) will determine if either lead or the coil is grounded. This check must show equal resistance from each pin:



An intermittently (fan or turbine) open or grounded tachometer generator may or may not show up on a voltmeter depending on the frequency of the intermittent. However, either condition will have the effect of running the synchronizer out of synchronization. A wavering voltmeter reading would indicate trouble.

Be sure that wiring techniques are of the highest quality.

REMEDY:

Repair or replace the malfunction tachometer generator.

If trouble still exists, refer back to Airways Chart.

V-22 (AIRCRAFT WIRING DEFECTIVE):

1. If the tachometer generators check out OK after being separated from the aircraft wiring, and the actuator successfully completes a bench check, the aircraft wiring should be checked in accordance with standard practice for continuity of the wires. The wires should also be checked for possible short circuits to ground. With the actuator and the tachometer generators disconnected and the circuit breaker pulled, only pins A and H should show continuity to ground.

2. Check the pin receptacles of the MS 3116 control box connector for loose pins. Loose pin receptacles are usually caused by test probes having overstressed the clips. One loose pin will not be noticed when mating the two halves but can cause annoying intermittent conditions.

3. Power lead polarity must be observed. With the master switch on and the circuit breaker closed, pin B must be positive with respect to pin A.

REMEDY:

1. Repair short or open in wiring.

2. Replace MS 3116 control box connector if pin receptacles are loose.

3. Correct reverse polarity if found.

If trouble still exists, refer back to Airways Chart.

V-23 (ACTUATOR ELECTRICAL MALFUNCTION): The actuator must meet the resistance values specified on page 9 of the electrical check sheet. This checks each 7.5 ohm motor winding and the centering switches. If the resistance values are not met, remove and bench check the actuator to determine if the actuator or aircraft wiring is at fault. If the motor windings are open or shorted, the actuator should be replaced. A winding shorted to aircraft ground will permanently damage the control box. WHEN THE ACTUATOR IS REPLACED FOR A SHORTED OR OPEN WINDING, THE CONTROL BOX MUST BE REPLACED ALSO UNLESS YOU HAVE WOODWARD TEST EQUIPMENT NO. 213614 TO INSURE THAT THE CONTROL BOX IS FUNCTIONAL.

If both the actuator and the control box are damaged, replacing only one unit may result in subsequent damage to that unit. The control box can fail in a "turned on" condition. This will fail the actuator as it is designed to use a pulsing voltage. A 2-amp. circuit breaker will provide protection for the actuator. The 2 amp. circuit breaker will trip if the control box turns on steady as the actuator ampere draw will be 3.5. It will not trip in normal operation because the voltage applied is of only 40 millisecond duration with a maximum of 5 pulses per second. We recommend any system protected by higher rating circuit breakers be changed to 2 amperes for this reason. For the purpose of a bench check, 24 volts may be applied across actuator pins A and C, and B and C to check the actuator pulsing but this must be of only *momentary* duration.

The centering switches establish a centering mode when the control box is turned off. This centering mode drives the actuator to the center of its range (unless it was already there). There is a 4 to 8 step deadband when both centering switches are open. This electrical center is 2 to 4 steps away from true mechanical center. If the switches are loose, and the deadband lost, the actuator would not meet the check sheet values. When the system was shut off, it would double pulse or oscillate depending on the overlap of the centering switches.

With 213614 you can safely pulse the actuator either in the aircraft or on the bench with a suitable harness. First determine that the actuator winding is not shorted by completing steps Nos. 1-6 Table 1, page 9. If the winding is open, there will be no pulse light indication. The test instrument will have to be in the manual pulse position for this check.

You can test for a "turned on" control box with 213614 in the following manner:

1. Connect the test instrument to the aircraft wiring; leave the control box disconnected.

2. Turn the aircraft master switch "on".

3. Have the 213614 test instrument selector switch in the "internal oscillator" position.

4. Turn the control box on (still disconnected).

5. As you connect the control box, observe the light action. If one or both lights turn on steady, disconnect and replace the control box. This test will prevent damage to the actuator by a control box which failed in a "turned-on condition".

   (NOTE: The actuator should be disconnected for this test.)

6. For additional pulse light action, see page 12.

REMEDY: Exchange the actuator. CAUTION: Be sure to check control box (per above instructions) to avoid damage to new actuator.

If trouble still exists, refer back to Airways chart.

V-30 (MECHANICAL MALFUNCTION): If the electrical check list did not indicate any electrical malfunction, it may be that the synchronizer is recognizing the speed error, generating the corrective pulse, but the system cannot mechanically correct. Use of test equipment that includes pulse lights would clearly indicate this as you would see constant pulsing in one direction with no change in speed error or a hesitant change in speed error. This mechanical malfunction would fall in the categories shown by the routes away from the "mechanical malfunction" check point.

Remove the flexible shaft assembly at the actuator.

Turn the actuator by means of a square drive in the drive end. The torque required should not exceed 2.0 lb. in. This includes the rotational torque and the torque required to overcome the detents. If there is undue drag, or the torque required is in excess of 2.0 lb. in., follow course marked V-31.

If the actuator torque required is within limits, turn the rod end trimmer by means of the flexible shaft at the squared end. Check the squared end for engagement in the actuator. The torque required should not exceed .6 lb. in. If you can't, disconnect the flexible shaft assembly at the rod end trimmer and follow course V-32. If the rod end trimmer is free, check the flexible shaft assembly. Follow course V-33.

If the flexible shaft is free, remove the rod end trimmer from the fuel control and exercise the speed setting lever. Follow course V-34.

If trouble still exists, refer back to Airways Chart.

V-31 (ACTUATOR MECHANICAL MALFUNCTION): The force required to manually turn the actuator should not exceed 2.0 lb. in. The detents that provide the 18 steps per revolution give a ratcheting effect as you turn the shaft. An abnormally high friction level in the actuator would be caused by:

Bent actuator motor shaft.

Excessively worn motor bushings or shaft.

Dry or corroded internal detents.

Centering switch follower arm dragging in the spiral disc groove.

Centering switch follower arm frozen at the pivoting end.

Bent centering switch follower arm.

Flexible shaft driver rubbing against the flexible shaft attaching frame.

NOTE: Part No. 213100 actuator operates through 3 turns and develops 1.5 lb. in. torque.

REMEDY: Lubricate affected area. If actuator is damaged, exchange it.

If trouble still exists, refer back to Airways Chart.

V-32 (ROD END TRIMMER MALFUNCTION): The 1.5 lb. in. actuator torque will develop 9 pounds force at the rod end; depending on the friction level of the rod end trimmer. A high friction level can be caused by lack of lubrication, contamination, misalignment, and binding at the attaching point.

Rod end trimmers are now lubricated with a baked-on dry lubricant that will not require any maintenance unless it becomes contaminated. Rod end trimmers should be protected from engine cleaning solvents. The rod end trimmer should trim freely with any suitable turning device. If the rod end trimmer lacks lubrication or has become sticky due to heat, it should be exchanged. Also refer to page 7 and to figure 9, page 8.

If the rod end trimmer is side loaded due to flexible shaft assembly misalignment, re-route the flexible shaft assembly to relieve this condition. The flexible shaft assembly should be parallel to and in line with the fuel control actuating rod. The rod end trimmer Uniball should be spaced such that the Uniball is free to swivel. The rod end trimmer should trim with a maximum torque of .6 lb. in. applied to the actuator end of the flexible shaft assembly.

REMEDY: Lubricate or replace as necessary.

If trouble still exists, refer back to Airways Chart.

V-33 (FLEXIBLE SHAFT MALFUNCTION): The square end of the flexible shaft should slip freely into the squared drive of the actuator.

There should be no frayed strands on the rotary flexible shaft. Check that the squared edges have not rounded.

Check that the snap ring seats squarely on the rod end trimmer. Check that the driving end of the inner shaft does not rub on the rod end trimmer housing and that the tightening action of the flexible shaft housing nut doesn't bind the inner drive. Snap rings should not be loose in the groove. Outer flexible shaft housings pulled apart must be replaced.

V-34 (FUEL CONTROL COMPONENT MALFUNCTION): Operate the fuel control lever to see that it adjusts smoothly and without any high breakaway torque. High friction level can exceed the synchronizer trimming force. A high breakaway torque can cause speed hunting.

High lever forces would have to be corrected by lubrication or disassembly of the fuel control.

REMEDY: Service Fuel Control

If trouble still exists, refer back to Airways Chart.

V-42 (CONTROL BOX INOPERATIVE): Partially or totally inoperative control boxes are repaired only by replacement exchange. The control box is not field repairable. The plastic cases are sealed for protection to the components. Prompt notification is important in the case of control box malfunctions to give you maximum protection under warranty.

The control box and actuator have the capability of damaging each other as follows: If the control box "turns on" steady by failing shorted, it can subsequently fail the actuator by burning out one or both actuator motor windings unless it is powered through a 2-amp. circuit breaker. Conversely, if the actuator leads short to ground, the power transistors of the control box will be permanently damaged. Following this double failure, if you replace only one of the units it will be damaged by the same process. Therefore, if you replace a damaged control box, complete the electrical check list on page 10 to insure that the actuator is undamaged. If you replace a shorted or open actuator, replace the control box also as a shorted actuator would have permanently damaged the control box. (An actuator with an open winding probably shorted sometime during the failure process.) Test equipment could keep the control box replacement from being mandatory if the pulse lights are monitored continuously when the control box is plugged in. See "Actuator Electrical Malfunction" (V-23) for instructions on this.

CAUTION: The control box can be damaged by moisture. If water enters the box via the wire bundle, or condensation takes place in the box, internal corrosion will cause an electrical failure. See page 12 for actuator pulse light activity to be expected.

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