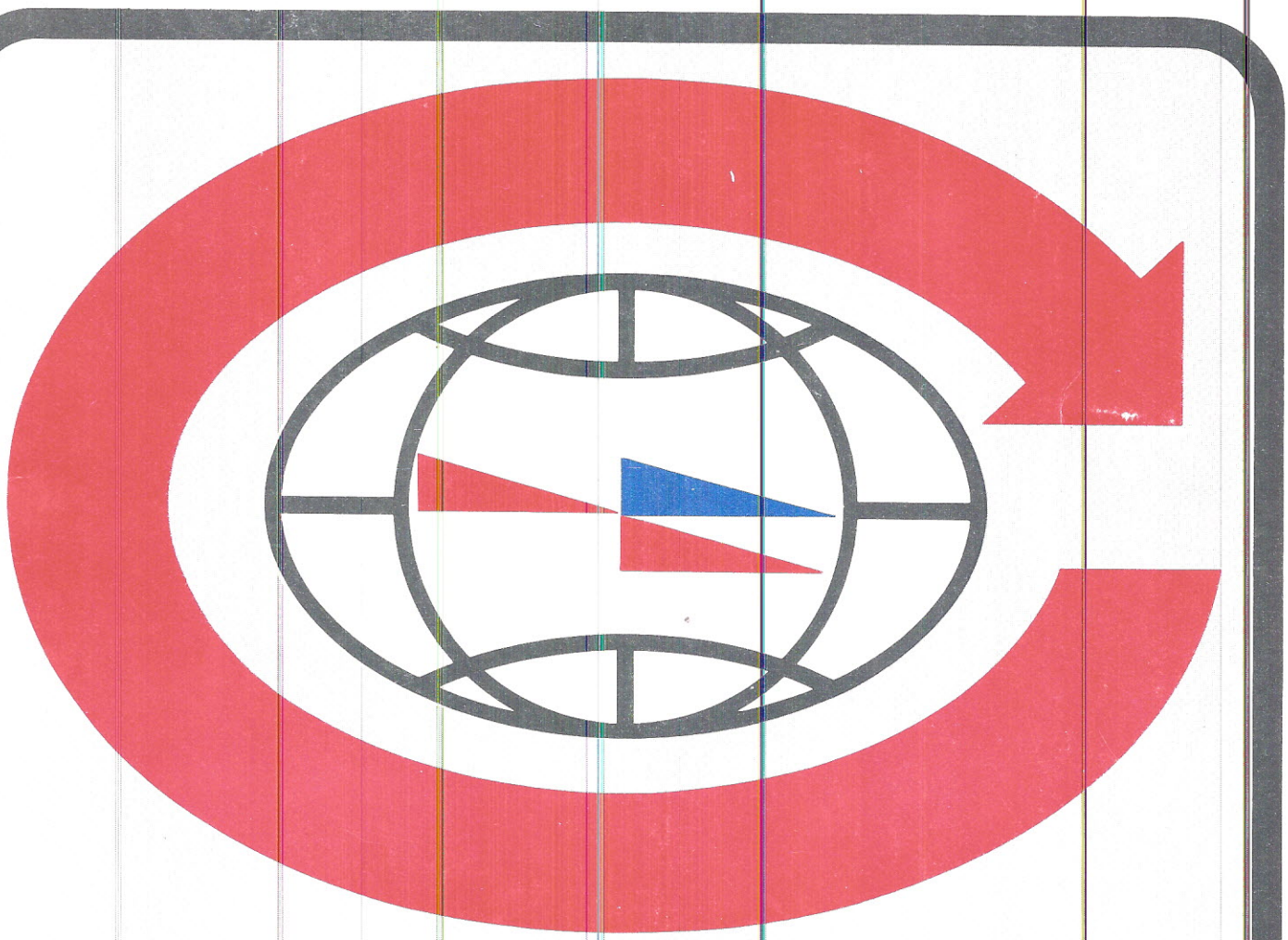
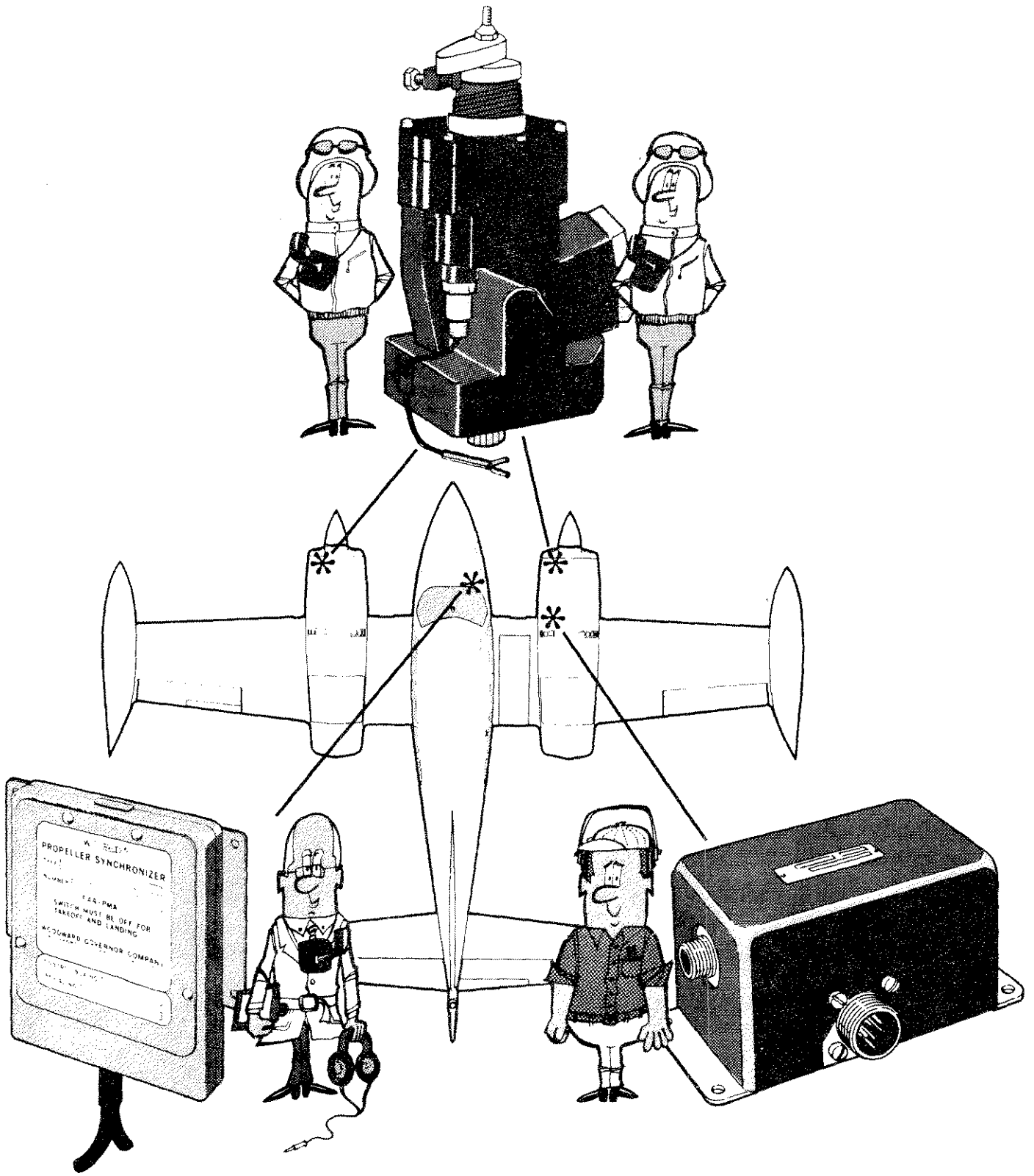
AUTOMATIC PROPELLER SYNCHRONIZATION



cessna training

AUTOMATIC PROPELLER SYNCHRONIZATION



CONTENTS

INTRODUCTION

The propeller synchronizer system, while not a required piece of equipment, is a nice accessory and gives the pilot one less item to monitor.

The synchronizer matches the propeller RPM of both engines and eliminates the unpleasant beat accompanying unsynchronized operation.

Here's how it operates. First, the equipment measures the exact RPM of both propellers. Then it compares this and changes the RPM of the right, or slave, engine to match the left, or master, engine.

The propeller governors are special because of the magnetic pickups and the special flyweight base that create the a-c signal that is recognized by the control box.

The control box in the cabin is a transistorized, solid state, sealed piece of equipment. It's function is to compare the RPM count from each governor and to generate an activating pulse, as required, to the actuator.

The actuator consists of two intermittent duty rotary action solenoids mounted back to back and operating on the same shaft. Pulsing one solenoid transmits a clockwise rotation to the shaft; the other gives a counterclockwise rotation. Each pulse from the control box rotates the shaft 1/18 of one revolution. This distance is controlled by the shaft detent wheel. Attached to the shaft is the square drive receptacle for the flexible drive cable.

At the other end of the flex drive cable is the rod end trimming unit. The actuator regulates the slave, or right governor control arm, using the vernier action of this assembly. This action does not disturb the cockpit propeller control settings.

Being able to use the vernier action of the rod end trimming assembly, attached to the right governor control arm, the automatic propeller synchronizer system has a ±50 RPM range to match the RPM of the right, or slave, engine with the RPM of the left, or master, engine.

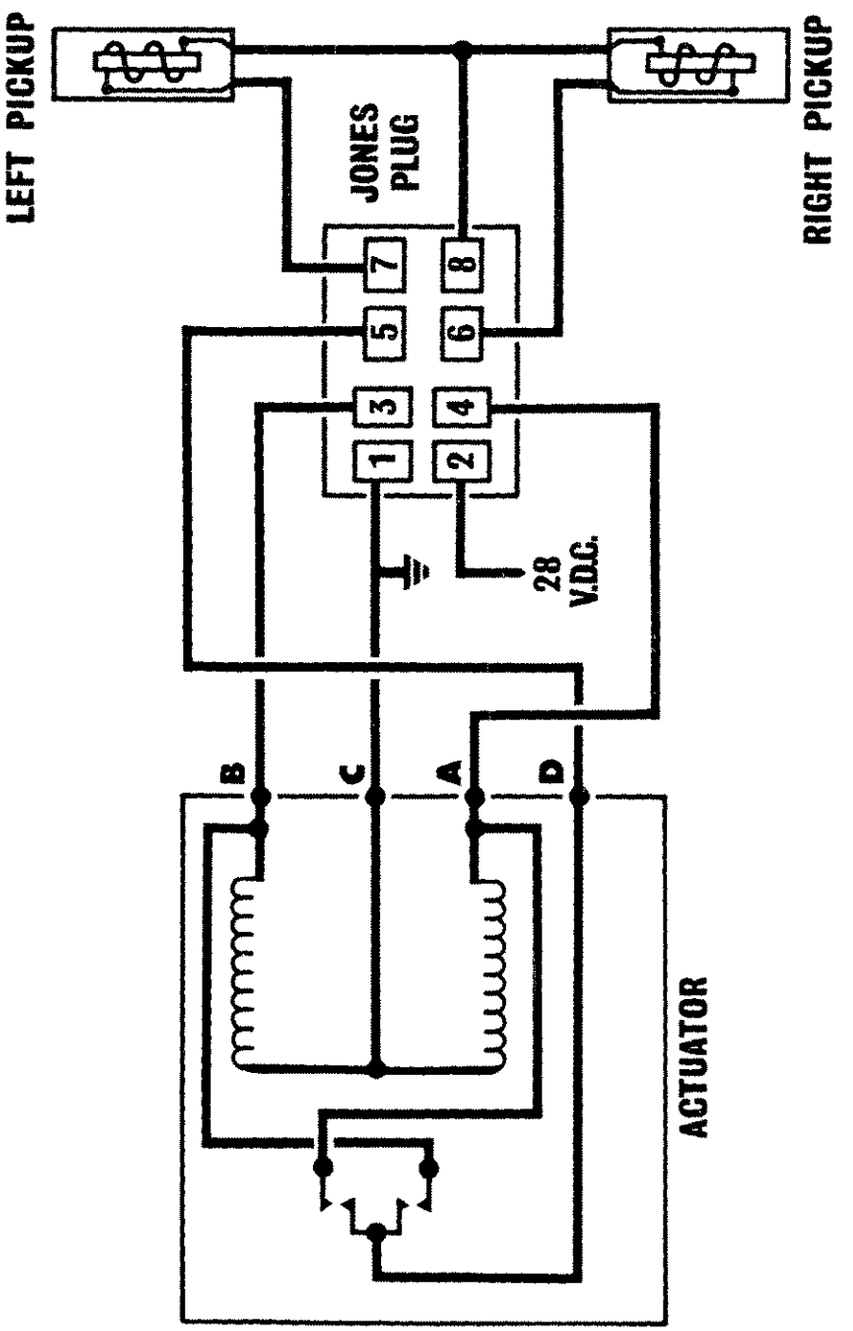
PROPELLER SYNCHRONIZER OPERATION AS STATED IN THE 1968 EXECUTIVE SKYKNIGHT OWNER'S MANUAL.

The Propeller Synchronizer matches propeller RPM of the two engines on the aircraft. The propeller RPM of the slave (right) engine will follow changes in RPM of the master (left) engine over a limited range. This limited range feature prevents the slave engine losing more than a fixed amount of propeller RPM in case the master engine is feathered with the synchronizer on. The synchronizer switch, in the OFF position, will automatically actuate the synchronizer to the center of its range before stopping, to insure that the control will function normally when next turned on. The system indicator light should light when the synchronizer switch is in the ON position.

In addition to maintaining propeller synchronization and elimination of the unpleasant audio beat accompanying unsynchronized operation, the propeller synchronizer can also provide a significant reduction in cabin vibration by maintaining an optimum angular or phase relationship between the two propellers.

With the propellers slightly out of synchronization so that an audio beat is obtained approximately once each 5 seconds, it should be noted that the vibration level of the cabin and instrument panel will increase and decrease at a rate of approximately once each 20 seconds. Optimum operation will be obtained by manually synchronizing the propellers and engaging the synchronizer during the period of minimum vibration. The angular relationship of the propellers should be maintained for extended periods of time unless disturbed by moderate atmospheric turbulence.

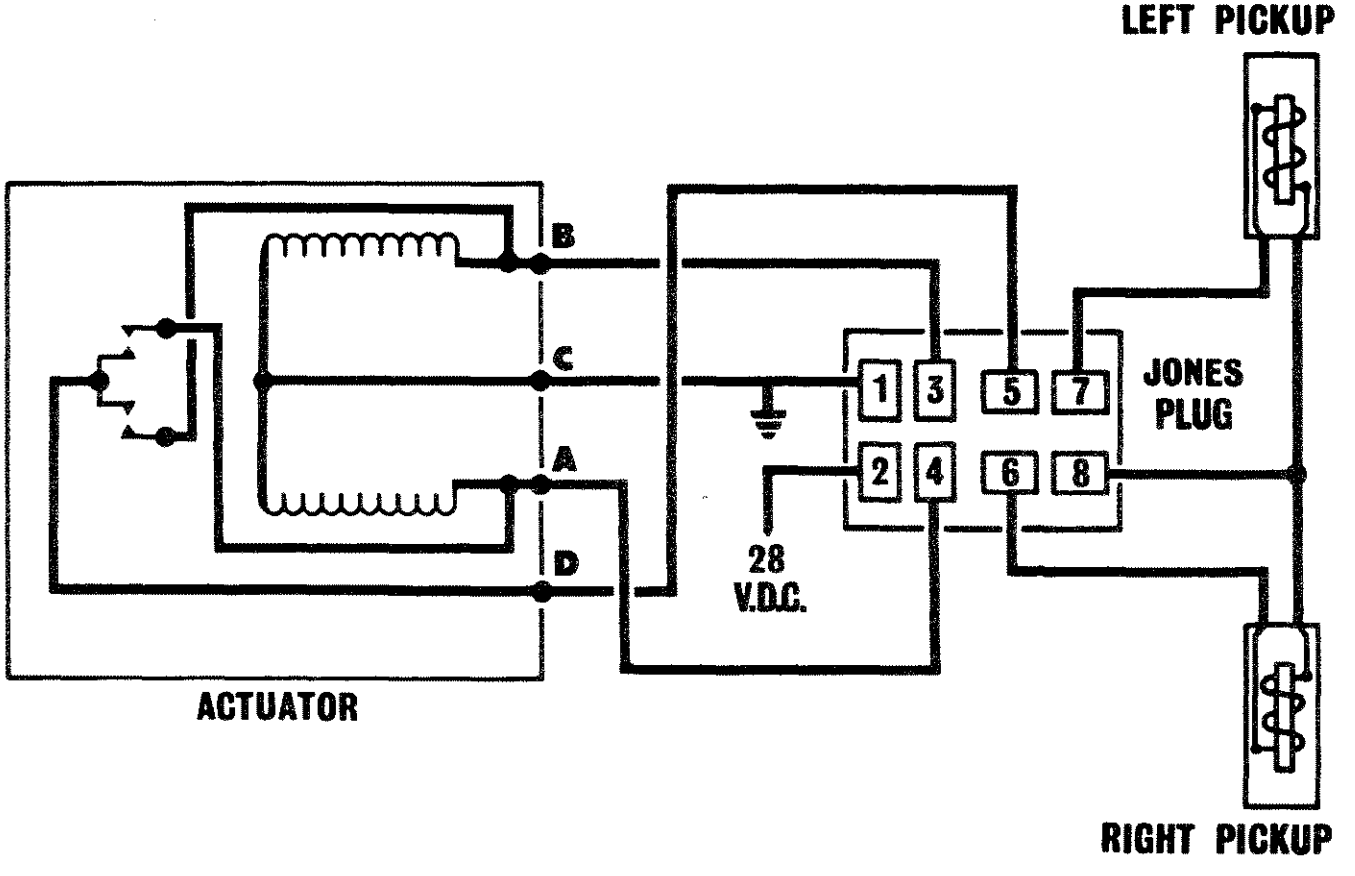
WIRE SCHEMATIC ANSWER SHEET

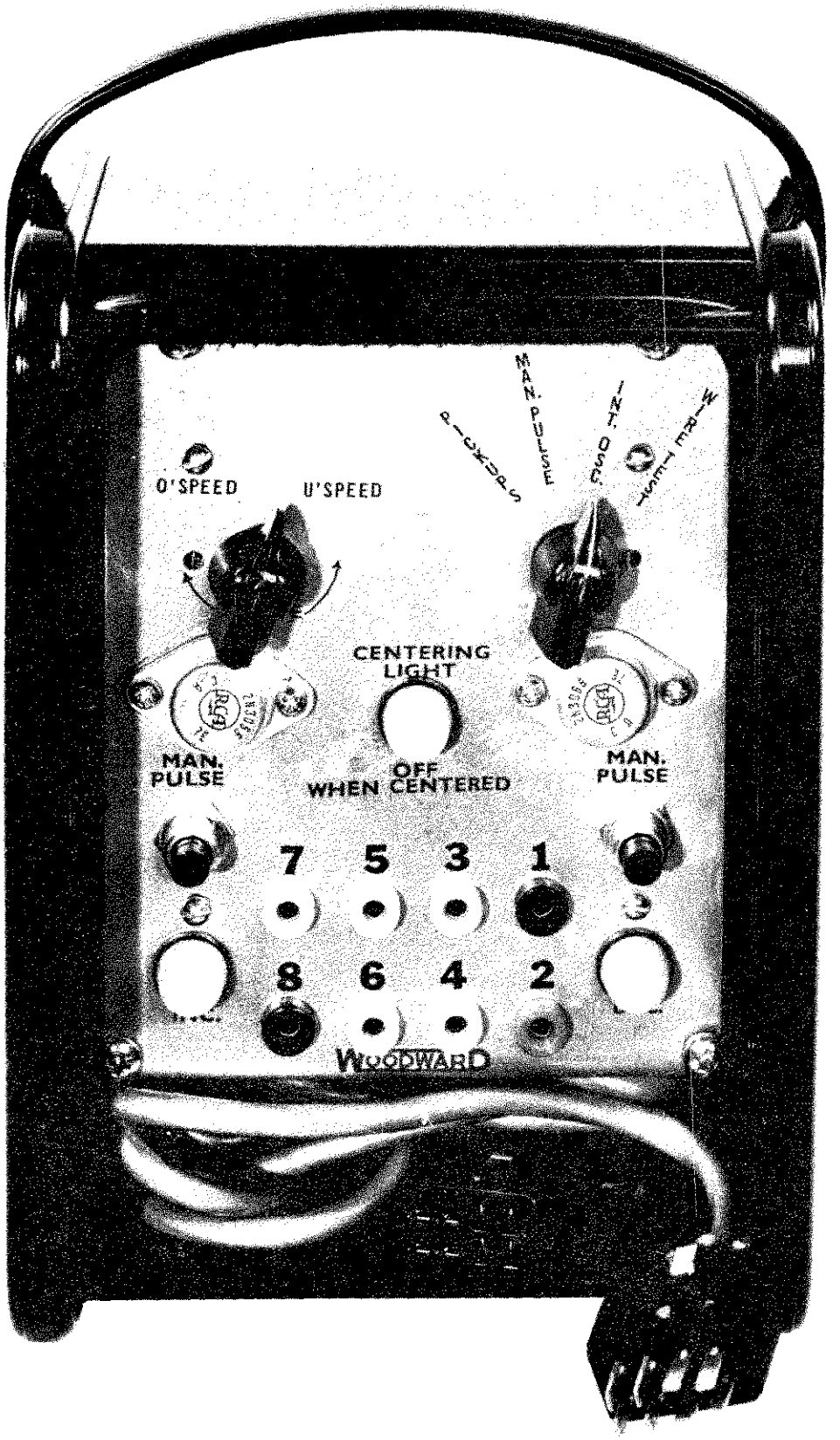


WIRE CHECK ANSWER SHEET

Making the following checks, on a normal system, with the volt-ohm meter, what readings should you obtain?

PIN NOS.	CIRCUITS READ	READING SHOULD BE
JONES PLUG		
#1 to A/C Ground	System Ground	(Direct Short)
#1 to #2	System Ground to Aircraft Bus	Bus Voltage
#3 to #4	Actuator Solenoid Winding	15 ± 2 ohms
#1 to #5	Centering Switches (Act. Centered)	Open Circuit
#6 to #8	Right Pickup Static	100 ± 10 ohms (+10 If HOT)
#7 to #8	Left Pickup Static	100 ± 10 ohms (+10 If HOT)
#6 to #8	Right Pickup at 2000 RPM	3/4 to 2 3/4 V.A.C.
#7 to #8	Left Pickup at 2000 RPM	3/4 to 2 3/4 V.A.C.
#8 to #1	Pickups to System Ground	Open Circuit
ACTUATOR		
A & B	Solenoid Windings	15 ± 2 ohms
C & D	Actuator Centering Switches (Actuator Centered)	Open Circuit
C & D	Actuator Centering Switches (Actuator Not Centered)	7.5 ohms




O'SPEED
U'SPEED
CENTERING LIGHT
MAN. PULSE
OFF WHEN CENTERED
MAN. PULSE
7
5
3
1
8
6
4
2
WOODWARD

WOODWARD

BULLETIN 33049E

(FAA APPROVED PER DESIGNATED ENGINEERING REPRESENTATIVE)

PROPELLER SYNCHRONIZER FOR LIGHT TWIN ENGINE AIRCRAFT

WOODWARD GOVERNOR COMPANY

AIRCRAFT CONTROLS DIVISION

ROCKFORD, ILLINOIS, U.S.A.

DECEMBER 1973

33049E

CONTENTS

WARNING

Failure to follow instructions herein can cause personal injury and/or property damage.

WOODWARD ELECTRONIC SYNCRONIZER
for
SMALL AIRCRAFT PROPELLER GOVERNORS

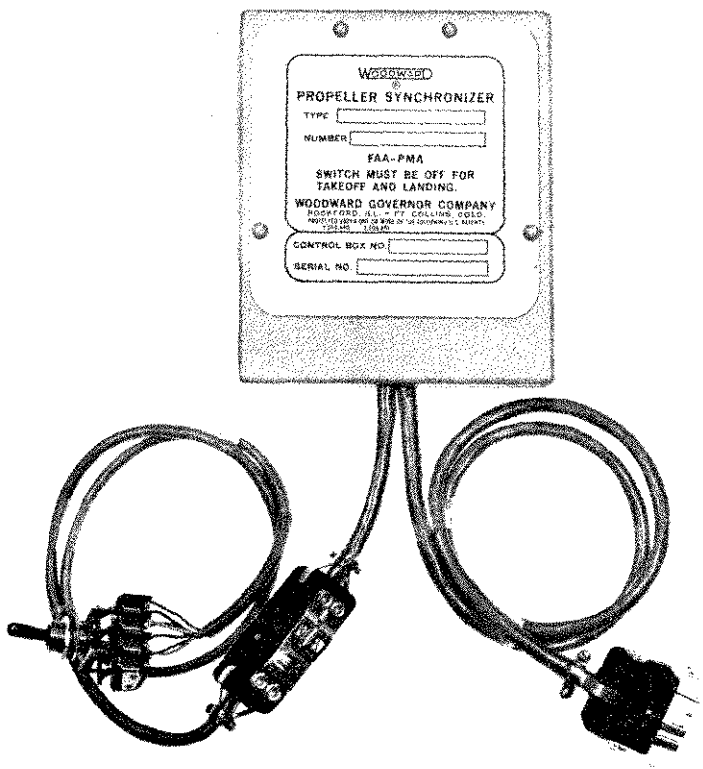


Figure 1. Control Box

GENERAL INFORMATION:

The Woodward Electronic Synchronizer automatically matches the speeds of the engines on light twin engine aircraft. The speed of the "slave" engine will follow changes in the speed of the "master" engine over a predetermined limited range. The limited range feature prevents the slave engine losing more than a fixed amount of rpm in case the master engine is feathered with the synchronizer on. Normal governor speed setting controls and procedures are unchanged.

EQUIPMENT:

The synchronizing system consists of a synchronizer control box, a speed setting actuator, a pulley trimmer assembly or adjustable rod end trimmer assembly, a flexible rotary shaft, two synchronizer type Woodward propeller governors, 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 an "OFF-ON" switch; this is the only control required.

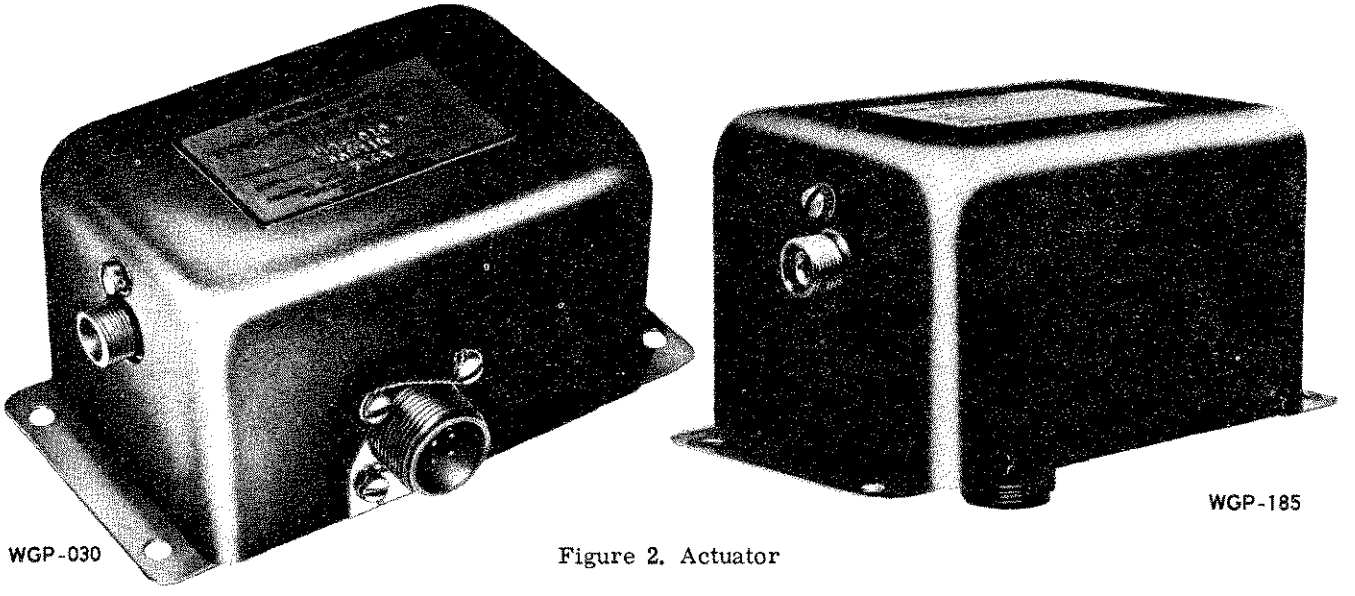


Figure 2. Actuator

The actuator (figure 2) is a step-type motor which operates on command from the control box. It is mounted in the slave engine nacelle. The speed trimmer assembly mounts on the slave engine governor and is linked to the actuator by a flexible shaft. An older type rod end trimmer assembly is shown in figure 3; a newer type is shown in figure 4. Pulley head governors use a pulley trimmer assembly (figure 5). The actuator trims the slave engine governor setting through the flexible shaft.

Each governor is a standard Woodward propeller governor which has a magnetic speed pickup incorporated in the body. Refer to the applicable governor bulletins for parts lists and overhaul details. The total additional weight of the synchronizing system is approximately 6 pounds.

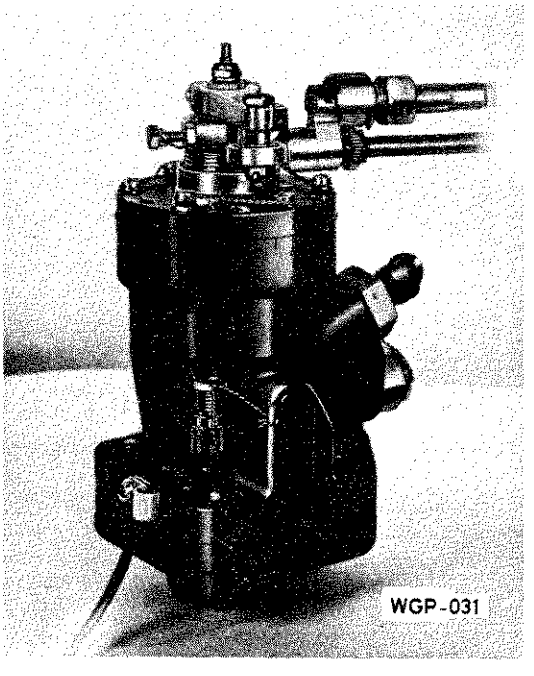


Figure 3. Lever Type Governor with Old Style Trimmer

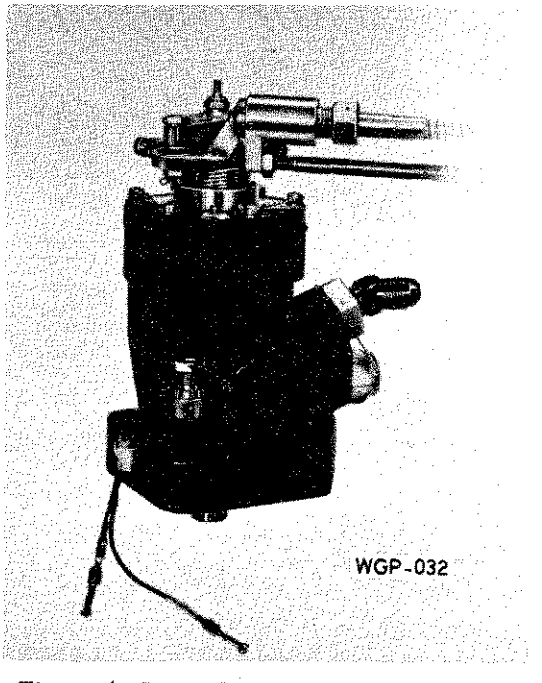


Figure 4. Lever Type Governor with New Style Trimmer

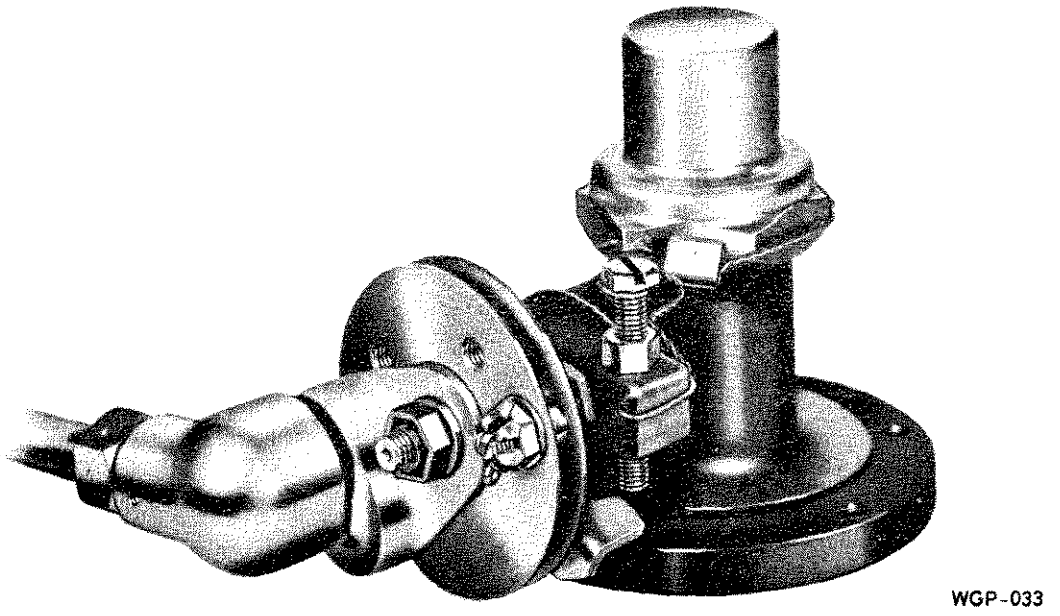


Figure 5. Pulley Trimmer Assembly

OPERATION:

Alternating current generated by the magnetic pickup in each governor is fed into the control box (figure 6). If any difference in the frequency is detected, a signal is sent from the control box to the actuator, which trims the slave governor speed to match that of the master engine exactly. Normal governor 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 plus or minus 50 rpm.

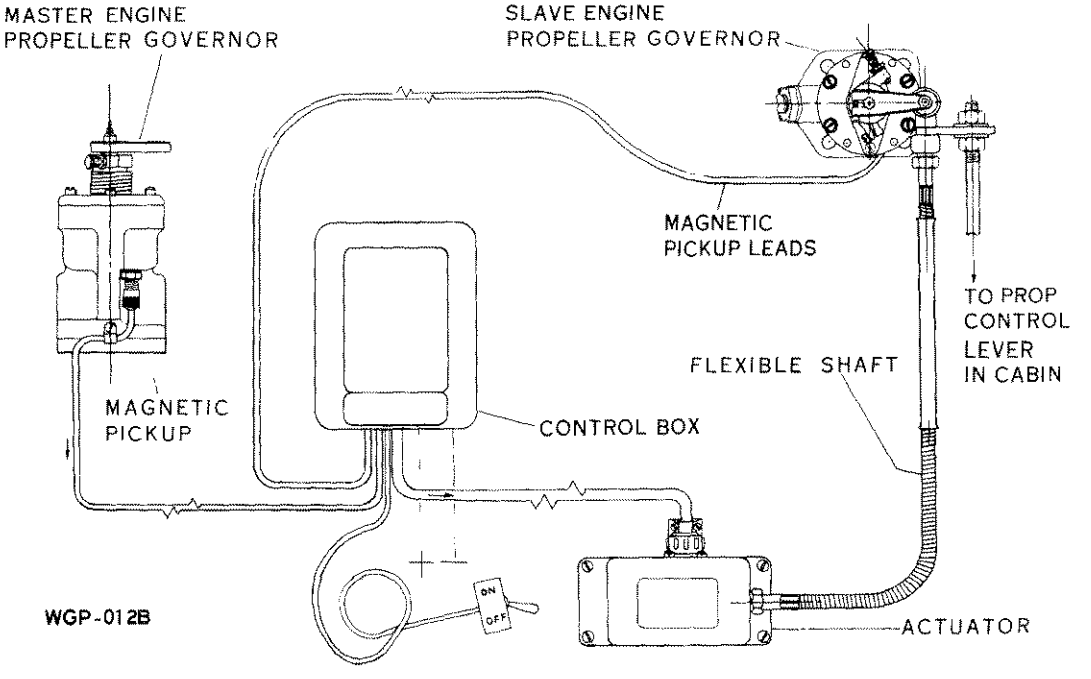


Figure 6. Schematic Diagram of Synchronizer Operation

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 governor; 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.

After making the first power reduction after take-off, roughly synchronize the engines manually and turn on the synchronizer. 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 governor control levers together as usual. This will keep both governor speed settings close enough to remain within the limited adjustment range of the slave engine. If 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 the propellers manually, and turn the synchronizer "ON" again.

FUNCTIONAL TEST:

To test the operation of the synchronizer in flight, first synchronize propellers manually and turn the synchronizer switch "ON." Then slowly adjust the master engine propeller governor control lever, in small increments, to increase and decrease rpm. The rpm range over which the slave engine will remain synchronized with the master engine is the limited range mentioned above. With the synchronizer "ON," move the master engine propeller governor control 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 "ON" 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 "ON."

INSTALLATION:

Installation of the control box, actuator, etc. is to be made according to the instructions in the synchronizer installation manual which is available for the particular aircraft model. The control box is designed to operate at cabin temperatures.

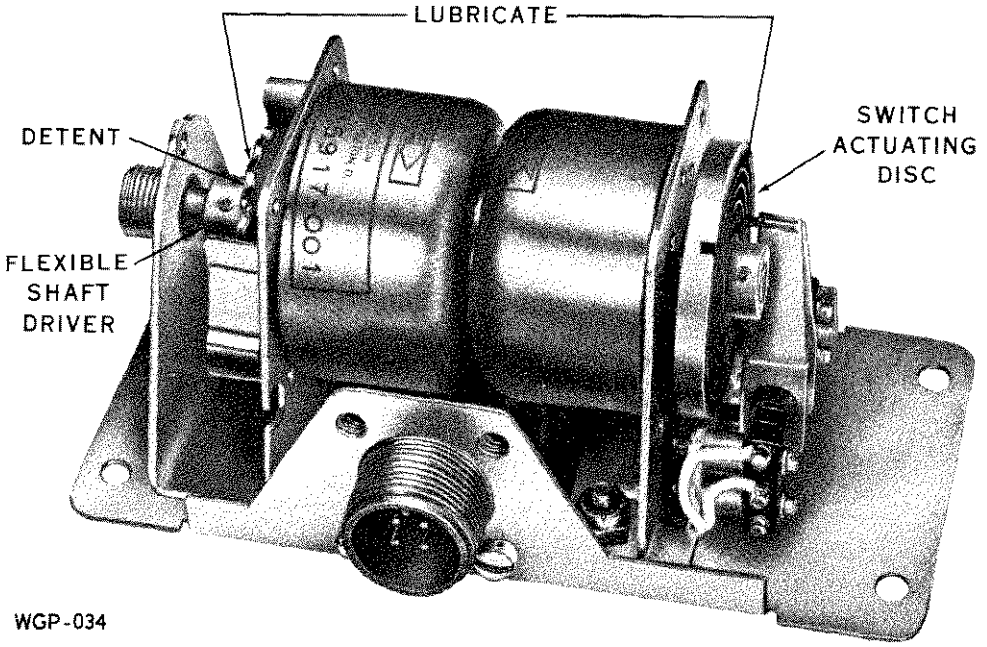


Figure 7. Actuator with Cover Removed (Exposed Detent Type)

MAINTENANCE

GENERAL:

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

1. Serial numbers and part numbers of the governor, control box, and actuator (shown on nameplates).
2. Bulletin number (this is bulletin 33049).
3. Part reference number and name or description of part.

PREVENTATIVE MAINTENANCE:

No maintenance is required on the control box, actuator, flexible shaft, or rod end trimming assembly, apart from visual inspection at the time of regular aircraft inspections. Make sure that the electrical connections, flexible shaft, etc. are securely attached. Every 100 hours inspect the rod end trimmer assembly, paying particular attention to the bearing (No. 31, figure 11).

REPAIR:

Overhaul of the governor should be performed in accordance with the applicable governor bulletin or the governor should be exchanged with the Woodward Governor Company. At the time of governor overhaul, remove the flexible shaft. Clean and lubricate shaft. Also at this time remove the cover from the actuator. Clean internal parts (Micro-switches and electrical connections, etc.).

Apply Alpha-Molykote "G" to spiral groove of the switch actuating disc at one end of the actuator (figures 7 and 8). If the actuator has exposed detents at the other end (as indicated in figure 7) lubricate the detents.

REPLACING MAGNETIC PICKUP IN GOVERNOR: (FAA APPROVED GOVERNOR OVERHAUL STATION OR WOODWARD GOVERNOR COMPANY ONLY):

(Also see applicable governor bulletin and Woodward Propeller Governor Specification Manual.)

1. Remove governor from engine and unscrew pickup.
2. With the governor control arm set at maximum rpm, slowly rotate the governor drive shaft. Screw a new pickup in using your fingers (not a wrench or pliers) until it makes contact internally with the rotating flyweight head. A new packing under the locknut is recommended.
3. Turn the pickup counterclockwise 1/8 turn. Lightly tighten the locknut.
4. Connect a 5000 ohm/volt meter across the pickup leads.
5. Drive governor at minimum cruise rpm and adjust pickup output to obtain 1.0 plus or minus 0.2 volt. Screw pickup in to increase voltage, out to decrease.
6. Tighten the lockwire pickup locknut. CAUTION: Do not exceed 25 lb.-ins. torque.

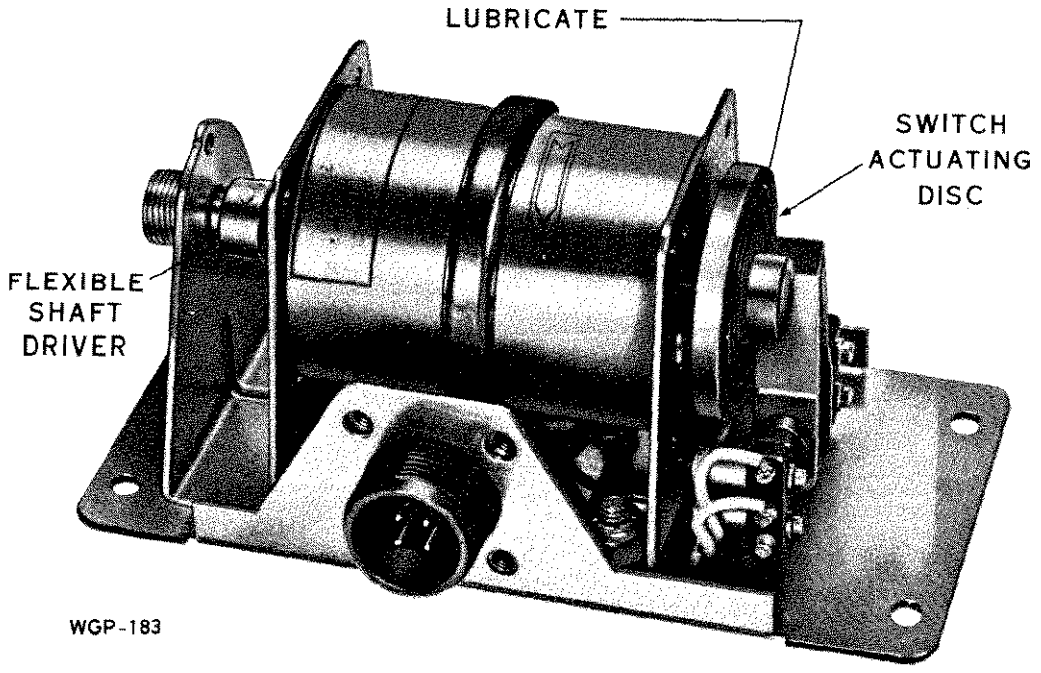


Figure 8. Actuator with Cover Removed (Internal Detent Type)

HOW TO USE THE ILLUSTRATED PARTS BREAKDOWN

GENERAL:

Exploded views of the synchronizer assembly (figures 9 and 10) and associated parts lists consist of a breakdown of the complete assembly.

FIGURE AND INDEX NUMBER COLUMN:

In this column, the digits preceding the hyphen refer to the figure. The digits following the hyphen are the index numbers of the component parts.

PART NUMBER COLUMN:

In this column are listed the Woodward Governor Company part numbers. Woodward Governor Company part numbers may have six or seven digits.

DESCRIPTION COLUMN:

In this column are listed each assembly, and components of the assembly.

UNITS PER ASSEMBLY COLUMN:

Quantities specified in the UNITS PER ASSEMBLY column are the total number or each part required per assembly or subassembly and are not necessarily the total number used in the complete equipment.

USABLE ON CODE COLUMN:

Parts variations within the groups of equipment are indicated by a letter symbol immediately following the units per assembly in the "USABLE ON CODE" column. In cases where the "USABLE ON CODE" column has been left blank, parts listed apply to all equipment covered by this book.

List of Assemblies and Code Call Out

Model No.	Description	Usable as Code
213555	Synchronizer Assembly	A
213188	Synchronizer Assembly	B
213390	Synchronizer Assembly	C
213411	Synchronizer Assembly	D
213421	Synchronizer Assembly	E
213465	Synchronizer Assembly	F
213468	Synchronizer Assembly	G
213485	Synchronizer Assembly	H
213495	Synchronizer Assembly	I
213501	Synchronizer Assembly	J
213510	Synchronizer Assembly	K
213518	Synchronizer Assembly	L
213527	Synchronizer Assembly	M
213528	Synchronizer Assembly	N
213529	Synchronizer Assembly	O
213532	Synchronizer Assembly	P
213533	Synchronizer Assembly	Q
213536	Synchronizer Assembly	R
213537	Synchronizer Assembly	S
213538	Synchronizer Assembly	T
213550	Synchronizer Assembly	U
213556	Synchronizer Assembly	V
213560	Synchronizer Assembly	W
213580	Synchronizer Assembly	X
213590	Synchronizer Assembly	Y
213610	Synchronizer Assembly	Z
213620	Synchronizer Assembly	AA
213637	Synchronizer Assembly	AB
213656	Synchronizer Assembly	AC
213666	Synchronizer Assembly	AD
213667	Synchronizer Assembly	AE
213690	Synchronizer Assembly	AF
213800	Synchronizer Assembly	AG

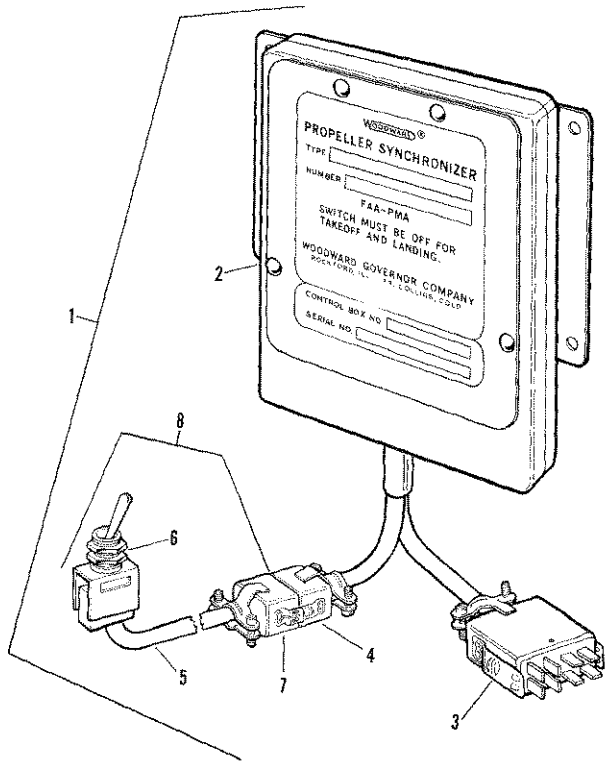


Figure 9. Control Box and Accessories

Parts List for Control Box and Accessories

Figure & Index No.	Part Number	Description	Qty.	Usable On Code
9-1	213350	Box Assembly - Control	1	ABCFGHIJLMN OPQUWXY,AC, AF,AG
	213433	Box Assembly - Control	1	DEKRSZ,AA, AB,AD,AE
	213460	Box Assembly - Control	1	V
	213750	Box Assembly - Control	1	T
-2	8900-070	Box Assembly - Control	1	ABCFGHIJLMN OPQTUVWXY, AC,AF,AG
	8900-082	Box Assembly - Control	1	BEKRSZ,AA, AB,AD,AE
-3	5458-007	Plug Assembly	1	
-4	233032	Socket Assembly - 8 Pin	1	
-5	213144	Cable - 8 Wire Control	1	
-6	233159	Switch - Micro	1	ABCFGHIJLMN OPQUWXY,AC, AF,AG
	233182	Switch - Control Box	1	DEKRSTZ,AA, AB,AD,AE
	1711-518	Switch - 3 P.D.T. Min Toggle	1	V
-7	5458-007	Plug Assembly	1	
-8	5440-028	Switch Assembly - Synchronizer	1	ABCFGHIJLMN OPQUWXY,AC, AF,AG
	5440-030	Switch Assembly - Synchronizer	1	DEKRSTZ,AA, AB,AD,AE
	5440-032	Switch Assembly - Synchronizer	1	V

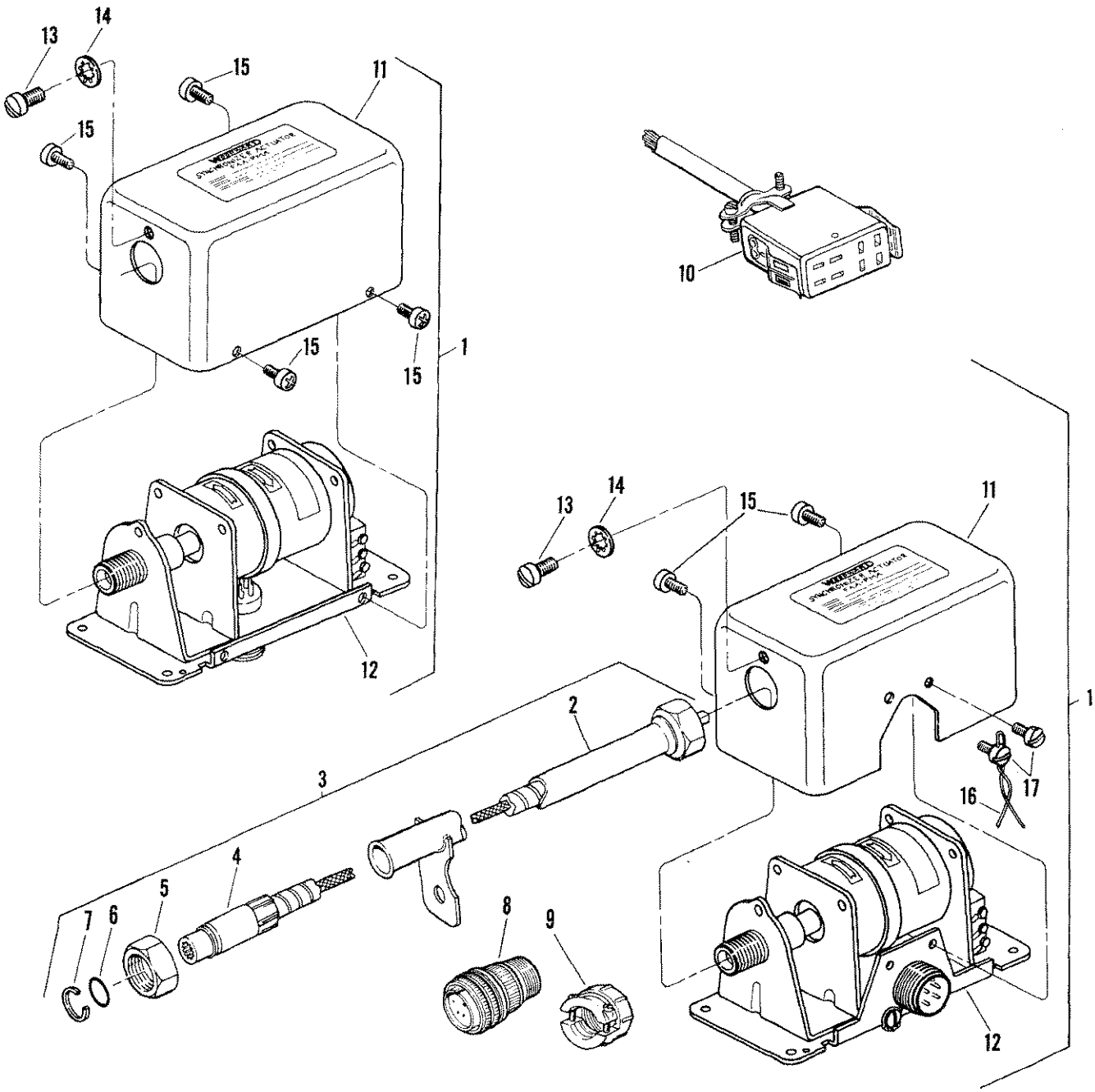


Figure 10. Actuator and Accessories

Parts List for Actuator and Accessories

Figure & Index No.	Part Number	Description	Qty.	Usable On Code
10-1	213100	Actuator Assembly - Synchronizer	1	ABCDEFGHIJKLMNORST UVWXZ,AA,AC,AD,AE,AG
	5485-016	Actuator Assembly - Synchronizer	1	PQ
	5485-020	Actuator Assembly - Synchronizer	1	Y,AF
	5485-040	Actuator Assembly - Synchronizer	1	AB
-2	213376	Tube Assembly - Flex Shaft Guide	1	A
	213281	Tube Assembly - Flex Shaft Guide	1	B
	213348	Tube Assembly - Flex Shaft Guide	1	CY
	213177	Tube Assembly	1	F
	3916-030	Tube - Flex Shaft Guide	1	H
	213394	Tube Assembly	1	I
	213064	Tube - Flex Shaft Guide	1	J
	213178	Tube - Guide	1	K
	213355	Tube Assembly - Flex Shaft	1	RS
	213062	Tube Assembly	1	U
	4354-050	Tube Assembly - Flex Shaft Guide	1	V,AC
	213361	Tube Assembly	1	W
	213316	Tube Assembly	1	X
	4354-046	Tube Assembly - Flex Shaft Guide	1	AD
	4354-054	Tube Assembly - Flex Shaft Guide	1	AE
	213299	Tube - Guide	1	G
-3	213156	Shaft - Flex	1	AGJ,AG
	213158	Shaft - Flex	1	BFKWXZ,AA
	213192	Shaft Assembly	1	CP
	213450	Shaft - Flex	1	DET
	1551-001	Shaft - Gov. to Actuator Flex	1	H
	213359	Shaft - Flex	1	IMNORS
	213150	Shaft - Flex	1	L
	213031	Shaft - Flex	1	U
	1551-005	Shaft - Gov. to Actuator - Flex	1	QVY,AC,AF
	1551-008	Shaft Assembly - Flex	1	AD
	1551-006	Shaft Assembly - Flex	1	AB
-4	1551-028	Shaft - Flex	1	AGJ,AG
	1551-024	Shaft - Flex	1	BFKWXZ,AA
	1551-022	Shaft - Flex	1	IMNORS
	1551-020	Shaft - Flex	1	H
	1551-018	Shaft - Flex	1	QVY,AC,AF
	213191	Shaft - Flex	1	CP
	1551-030	Shaft - Flex	1	L
	1551-026	Shaft - Flex	1	U
	1551-016	Shaft - Flex	1	AB
-5	1551-050	Nut	1	ABCFGIJKLMNOPQRSUV WXYZ,AA,AB,AC,AD,AF, AG
-6	1355-041	Packing - Preformed	1	ABCFGIJKLMNOPQRSUV WXYZ,AA,AB,AC,AD,AF, AG
-7	011661	Ring - Retaining	1	ABCFGIJKLMNOPQRSUV WYZ,AA,AB,AC,AD,AF, AG
-8	233062	Socket - Four Pin Electrical	1	ABCDEFGHIJKLMNORSTU VWXYZ,AA,AC,AD,AE,AF, AG
-9	203233	Clamp	1	ABCDEFGHIJKLRSUVWXY AC,AD,AE,AG
-10	233032	Socket - 8 Contact Jones	1	ABCDEFGHIJKLMNOPRST UVWXYZ,AA,AB,AC,AD, AE,AF,AG
-11	213009	Cover - Actuator	1	ABCDEFGHIJKLMNORSTU VWXZ,AA,AB,AC,AD,AE, AG
	4232-050	Cover - Actuator	1	PQ
	4232-032	Cover - Actuator	1	Y,AF
-12	213298	Motor Base	1	ABCDEFGHIJKLMNORSTU VWXZ,AA,AB,AC,AD,AE, AG
	4019-008	Motor Base	1	PQ
	4019-006	Motor Base	1	Y,AF
-13	188736	Screw	1	
-14	218345	Washer - #8 Shakeproof	1	
-15	1028-872	Screw - 8-32 x .25 Self Tapping	2	ABCDEFGHIJKLMNORSTU VWXZ,AA,AB,AC,AD,AE, AG
	1028-872	Screw - 8-32 x .25 Self Tapping	4	PQY,AF
-16	057761	Wire - Lock	1	
-17	189906	Screw - 8-32 .250 Dr. Fillister	2	ABCDEFGHIJKLMNORSTU VWXZ,AA,AB,AC,AD,AE, AG

ADJUSTABLE ROD END AND PULLEY TRIMMER:

Two different types of rod end trimming assemblies are in use. Their exploded views are shown in figure 11. The pulley head trimmer shown in figure 12 is overhauled and serviced with governor. At the time of governor overhaul, remove, clean, service and reinstall the trimmer as follows:

1. Disconnect the flexible rotary shaft and the governor push-pull control (or pulley cable) from the adjustable rod end trimmer assembly (or pulley trimmer).

2. Rod end trimmers are either lubricated with Molykote "G" or a baked-on dry lubricant. If lubricated with Molykote "G" the rod end trimmer should be exchanged to update the assembly. If the rod end trimmer is lubricated with the baked-on dry lubricant, and is in need of servicing, it should be exchanged. Lubricating this rod end trimmer assembly with liquid lubricant may be harmful when exposed to heat.

3. Refer to Woodward Bulletin 33002 (revision A or later) for details regarding overhaul of pulley head trimmer (figure 12).

4. Rotate the splined shaft in the rod end trimming assembly (or pulley trimmer) 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.

NOTE

Trimming assemblies are designed to have more travel than the actuator with which they are used. If both the trimmer assembly and the actuator are centered before attaching the flexible shaft, the actuator will provide the stops. (3-1/4 and 5-3/4 turn rod end trimming assemblies may be used with the actuator having 3 turns. 5-3/4 turn rod end trimming assemblies must be used with the 5-1/4 turn actuator. The 5-1/3 turn pulley trimmer is used only with 3 turn actuator.)

5. With the rod end trimming assembly (or pulley trimmer) centered, rig the governor push-pull control (or pulley cable) just as you would with standard rigging.

6. Again manually rotate the trimmer to one end of its travel. Move the cockpit prop control through its entire range and observe the governor speed adjusting lever (or pulley) to be certain it hits both maximum and minimum rpm stops. Manually rotate the trimmer to the opposite end of its travel and again move the cockpit control through its entire range. This assures that the aircraft rigging allows stop to stop travel with any possible trimmer setting.

7. 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 trimmer and connect the flexible shaft to the actuator and trimmer.

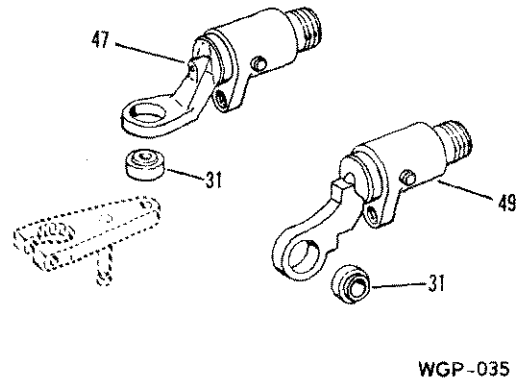


Figure 11. Rod End Trimmer Assembly

Parts List for Rod End Trimmer Assembly

Figure & Index No.	Part Number	Description	Qty.	Usable On Code
11-31	180265	Bearing - Self Aligning	1	ACDEFGHIKL MNOPQRSTUV XYZ,AA,AB, AC,AF,AG
	1417-508	Bearing - Self Aligning	1	AD,AE
-47	213446	Rod End Assembly - Speed Trimming	1	CFHQUVXY, AC,AF,AG
	213448	Rod End Assembly - Speed Trimming	1	PRS
-49	213447	Rod End Assembly - Speed Trimming	1	ADEGIKLNZ, AA
	5333-006	Rod End Assembly - Speed Trimming	1	AD,AE
	5333-008	Rod End Assembly - Speed Trimming	1	MOT
	5333-014	Rod End Assembly - Speed Trimming	1	AB

ELECTRICAL TESTING:

A functional check of the synchronizer system may be made by using Woodward test instrument WT-45960 (figure 15), which allows manual pulsing of the actuator to test the synchronizer. (NOTE: Pickup voltage output cannot be read on WT-45960 until the control box is plugged in). Woodward test instrument 213600 (figure 16) checks the main circuitry of the synchronizer control box. This test equipment must be used as outlined in instructions available from the Woodward Governor Company. WT-45960 will not test newer control boxes. See Service Bulletin No. 33547 for applicable engineering change letters.

SYNCHRONIZER WIRING TEST:

Before starting this test, be sure the control box is unplugged, the master switch is off, and the synchronizer circuit breaker is pulled. Then connect the actuator assembly and the magnetic pickups to the cables. Either pickup wire may be connected to pin receptacle No. 8 of the Jones cinch socket. Connect the other wire to pin receptacle No. 6 for slave engine, and No. 7 for the master engine. Before tying down pickup wires, complete tests 7 and 8 in the following test chart.

CAUTION

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

1. Make the following tests, using an ohm meter to the pin receptacles in the Jones plug socket. Zero the ohm meter and read on the X1 or X10 scale.

CAUTION

Do not use a probe that exceeds .045 in thickness. Insert and remove probe carefully. Failure to do so will result in loose pin connections and faulty synchronizer operation.

TABLE 1
Step Numbers 1-6 - Test for Defective Actuator

Step No.	Test Between Receptacle Numbers	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	5 & 1	open circuit (high resistance)	6.5 to 8.5 ohms	6.5 to 8.5 ohms	Bench Check the Actuator as shown on Page 15.
2	5 & 3	open circuit (high resistance)	closed circuit* (0 to 1.0 ohms)	13 to 17 ohms**	
3	5 & 4	open circuit (high resistance)	** 13 to 17 ohms	* closed circuit (0 to 1.0 ohms)	
4	4 & 1	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms	
5	4 & 3	13 to 17 ohms	13 to 17 ohms	13 to 17 ohms	
6	3 & 1	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms	

* 13 to 17 ohms on Aero Commander systems.
** 0 to 1.0 ohms on Aero Commander systems.

TABLE 2
Step Numbers 7-9 - Test for Defective Pickup
Step Numbers 10-11 - Test Aircraft Wiring
(New Type Magnetic Pickup)

Step No.	Test Between Receptacle Numbers	Obtain	Action (If Out of Limits)
7	8 & 7 (with 6 disconnected at pickup)	52-68 ohms	Repair wiring if at fault. Replace governor if pickup is at fault; replace pickup (Approved Governor Shop)
8	8 & 6 (with 7 disconnected at pickup)	52-68 ohms	
9	8 & aircraft ground	open circuit (very high resistance)	
10	1 & aircraft ground	short circuit zero ohms	Trace wiring to determine poor ground. Trace wiring to remove fault.
11	2 & aircraft ground *	open circuit (very high resistance)	

* "2 & 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.

TABLE 3
Step Numbers 7-9 - Test for Defective Pickup
Step Numbers 10-11 - Test Aircraft Wiring
(Old Type Magnetic Pickup)

Step No.	Test Between Receptacle Numbers	Obtain	Action (If Out of Limits)
7	8 & 7 (with 6 disconnected at pickup)	90-110 ohms	Repair wiring if at fault. Replace governor if pickup is at fault; replace pickup (Approved Governor Shop)
8	8 & 6 (with 7 disconnected at pickup)	90-110 ohms	
9	8 & aircraft ground	open circuit (very high resistance)	
10	1 & aircraft ground	short circuit zero ohms	Trace wiring to determine poor ground. Trace wiring to remove fault.
11	2 & aircraft ground *	open circuit (very high resistance)	

* "2 & 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.

2. When the system meets all of the above test values, turn the master switch on and reset the synchronizer circuit breaker (CONTROL BOX must still be unplugged) and make the following voltage check:

TABLE 4

Step No.	Test Between Receptacle Numbers	Meter Reading	Action (If Out of Limits)
12	2 & 1	Same as supply voltage. Polarity of pin No. 2 must be positive and pin No. 1 must be negative.	Trace wiring to determine fault or reversed polarity.

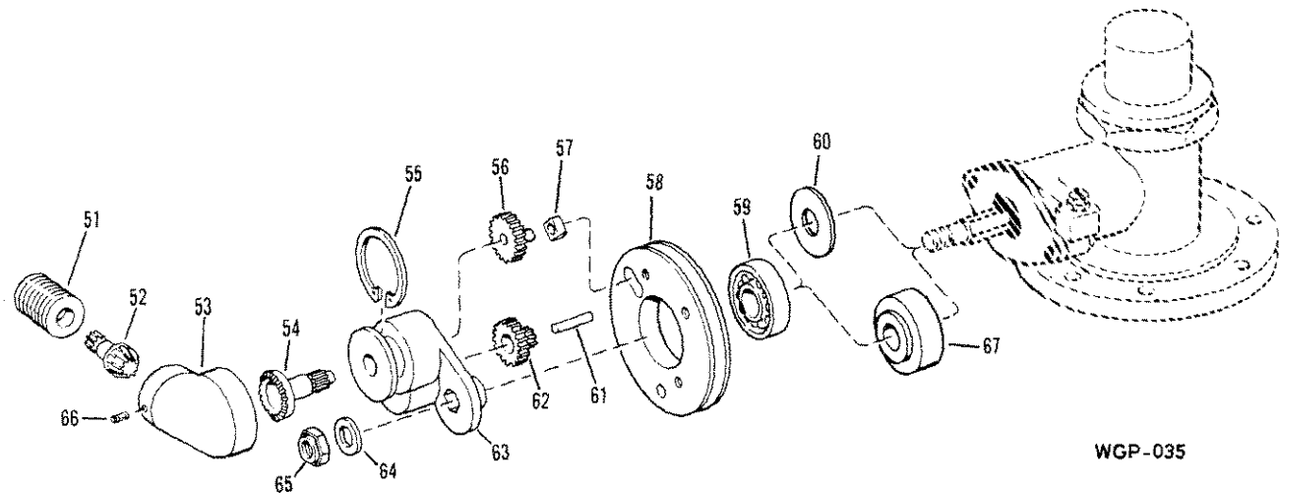


Figure 12. Exploded View of Pulley Head Trimmer

Parts List for Pulley Head Trimmer

Figure & Index No.	Part Number	Description	Qty.	Usable On Code
12-51	213132	Bushing - Threaded	1	
-52	213131	Gear - Pulley Adapter Pinion	1	
-53	213135	Elbow - Pulley Trimming	1	
-54	213130	Gear	1	
-55	190967	Ring - .971 O.D. Retaining	1	
-56	213126	Gear	1	
-57	213128	Block	1	
-58	213351	Pulley - Control	1	
-59	180233	Bearing - Ball	1	
-60	213137	Washer - Bearing Spacing	1	
-61	184888	Pin	1	
-62	213123	Gear Assembly - Reducing	1	
-63	4030-901	Housing Assembly - Pulley Trimmer	1	
-64	186008	Washer - .500 O.D.	1	
-65	218463	Nut - Self Locking	1	
-66	219368	Screw - Set	1	
-67	213285	Spacer - Trimming Head	1	

3. Check magnetic pickup output with the engines running at any cruise rpm. Check potential between pin receptacles 6 and 8. Also check potential between pin receptacles 7 and 8. Voltage must be a minimum of .85 volt at minimum cruise rpm, and a maximum of 4 volts at maximum cruise rpm. Voltages are RMS voltages as read on a 5000/volt a-c voltmeter. (Woodward Test Instrument WT-45960 or 213600 may also be used for this test. For procedure, see Test Instrument operating instructions.) If you do not obtain this voltage, replace governor or have an approved governor repair shop adjust or replace the pickup.

4. When the system complies with the specifications above, the control box may be connected.

5. 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 governor speed trimmer. Check for a high friction level in the trimming mechanism. Be sure to center the actuator and trimming device before mating the flexible shaft. Check rounded edges on the squared end of the flexible shaft.

Governors shipped in March 1969 and later are equipped with an improved type of magnetic synchronizer pickup assembly as illustrated in figure 13.

The new type pickup assembly is readily identifiable from the old type. Note that the new type assembly has a solid steel pickup end while the older type has the ceramic core visible. Also, the new assembly carries the identifying part number "XXXXXXWG 213181" on its outer diameter immediately below the knurled diameter. To aid identification of the new assembly when installed in the governor, the first length of sheathing out from the pickup has been colored white.

NOTE

To check magnetic pickup resistance at the governor, disconnect both connections and measure resistance with an ohm meter. Use the X1 or X10 scale. Replace pickup if reading is other than 90-110 ohms. Refer to page 5. If new type pickup, replace if reading is other than 52-68 ohms.

TROUBLESHOOTING:

When troubleshooting the synchronizer system, determine which type of pickup is installed. The new pickup assembly has a lower resistance value when measured with an ohm meter. Therefore, when troubleshooting a system equipped with the new type pickup, use Table 2. If it is an old type magnetic pickup use Table 3.

NOTE

Any combination of magnetic pickups (old and new hi-temp or hi-temp and low-temp) between engines is acceptable.

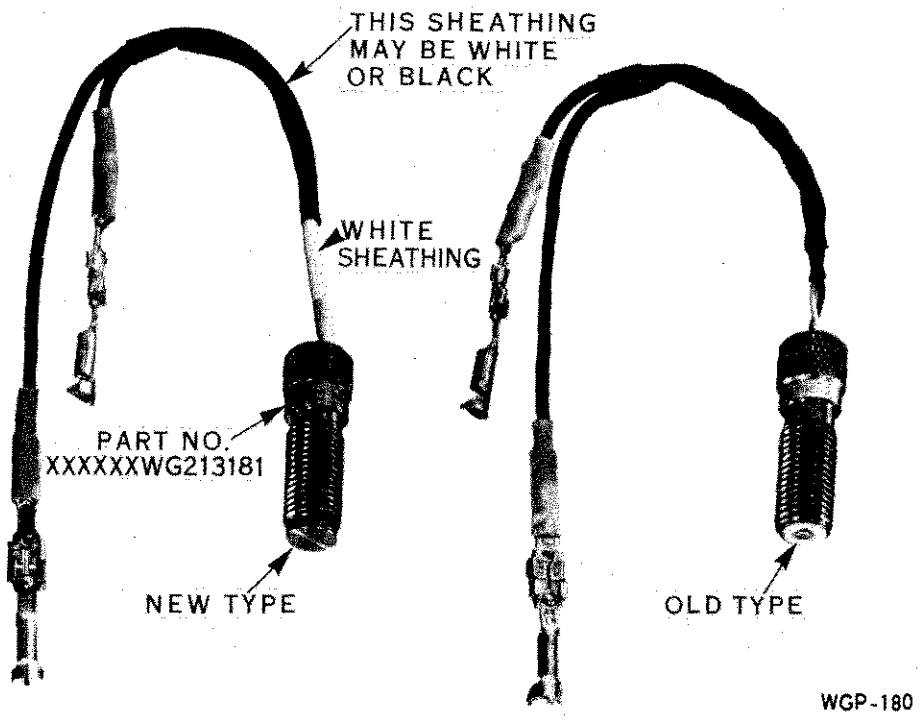


Figure 13. Magnetic Synchronizer Pickup Assemblies

BENCH TESTING OF THE ACTUATOR:

1. Make the tests in Table 5 using an ohmmeter on the pins of the disconnect. Zero the ohmmeter and read on the X1 scale.

2. Replace the actuator if it does not meet these values. If it does meet these values on the bench check but did not meet values of Page 14, the aircraft wiring must be at fault. Check for continuity of the four actuator leads. See page 19.

TABLE 5

Test Between Receptacle Numbers	Obtain		
		With Actuator Uncentered 180°	
	With Actuator Centered	Turn Clockwise (Facing Drive End) To Uncenter	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 (0 ohms)	13 - 17 ohms
D & A	open circuit (high resistance)	13 - 17 ohms	closed circuit (0 ohms)
A & C	6.5 to 8.5 ohms	6.5 to 8.5 ohms	6.5 to 8.5 ohms
A & B	13 - 17 ohms	13 - 17 ohms	13 - 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 Woodward test equipment may be used to test the synchronizer system:

1. WT-46192 (figures 14 and 17) is the least elaborate test instrument available. 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 shown in figure 17.

2. WT-45960 (figure 15) has pulse indicating lights, a built-in meter for voltage readings and manual actuator pulsing buttons.

3. 213600 (figure 16) is the most versatile piece of test equipment available. It has pulse indicating lights, jacks for checking voltages and resistance values, and an oscillator system with which magnetic pickup output may be simulated. This allows partially checking the control box without running the engines. This unit does not have a built-in voltmeter. 213600 may be purchased from the Woodward Governor Company.

If any of the test boxes are 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.

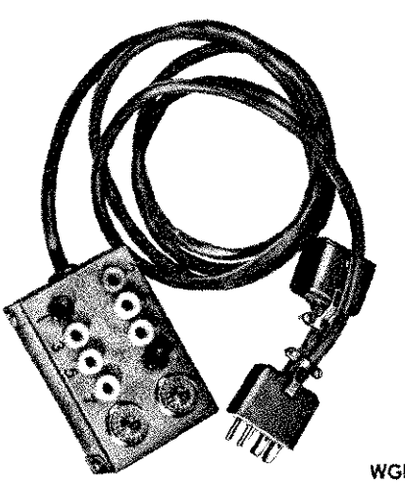


Figure 14. Woodward Test Instrument WT-46192

Figure 15. Woodward Test Instrument WT-45960

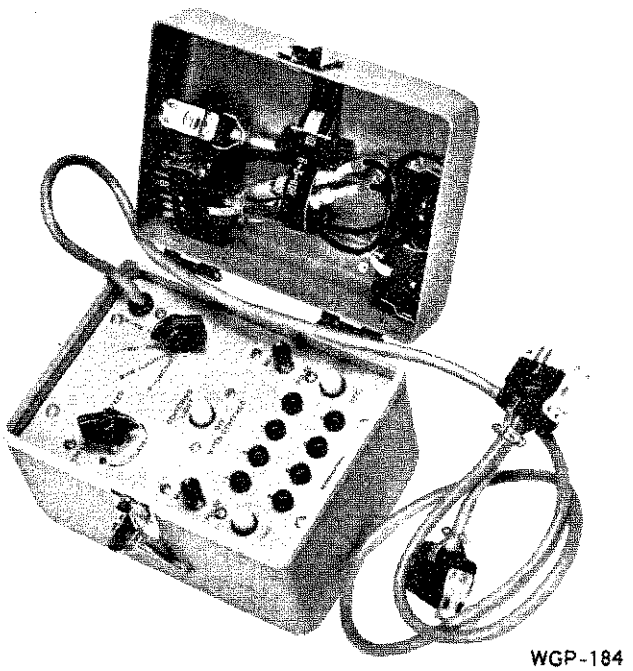


Figure 16. Woodward Test Instrument 213600

In most installations, the synchronizer will respond to an angular phase shift of approximately 12° between propellers. For this reason it is seldom inactive for very long periods of time, and then only under ideal flight conditions with basically well governed power plants. See V-42 (page 34) 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 WT-46192, WT-45960, or 213600 the control box or system defects listed in Table 6 can be detected.

TABLE 6

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. c. Magnetic pickup voltage incorrect.	1. a. Repair the offending accessory. b. Return to Woodward Governor Company for repair. c. Reset to specified voltage. (See page 5.)
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 213600 test instrument.
4. Excessive pulsing in one direction.	4. Excessive torque required to trim the governor in one direction (this assumes the governor and propeller are equally responsive in each direction.	4. Check for high friction level or misalignment in the flex shaft or trimmer.

TO CHECK AIRCRAFT WIRING WITH ACTUATOR REMOVED	
Jones Pin #1 to aircraft ground	0 Ohms
Jones Pin #3 to aircraft ground	Open Circuit (Very High Resistance)
Jones Pin #4 to aircraft ground	Open Circuit (Very High Resistance)
Jones Pin #5 to aircraft ground	Open Circuit (Very High Resistance)

PARTS LIST FOR WT-46192 SYNCHRONIZER TEST INSTRUMENT

BOX: (1) Hammertone gray aluminum 3-1/4" x 2-1/8" x 1-5/8" Bud Box Co. P/N CU-2101-A

BANANA JACK: (8) H.H. Smith Co., type 1509 (black)

LAMP: (2) Dialco midget flange type white lens pilot lamp series no. 177-8430, type no. 0975-503
or
Drake midget flange type white lens pilot lamp no. 5131-038-303

CABLE: (6 ft.) Vinyl covered plastic insulated cable, Belden type 8448 (8 #22 stranded wires)

GROMMET: (1) 5/8" O.D. x 3/8" I.D. black rubber grommet

PLUG: (1) Cinch Jones 8 connector plug P/N P-308 CCT

SOCKET: (1) Cinch Jones 8 connector socket P/N S-308 CCT

BULB: (2) Bayonet type bulb Chicago Miniature P/N 327

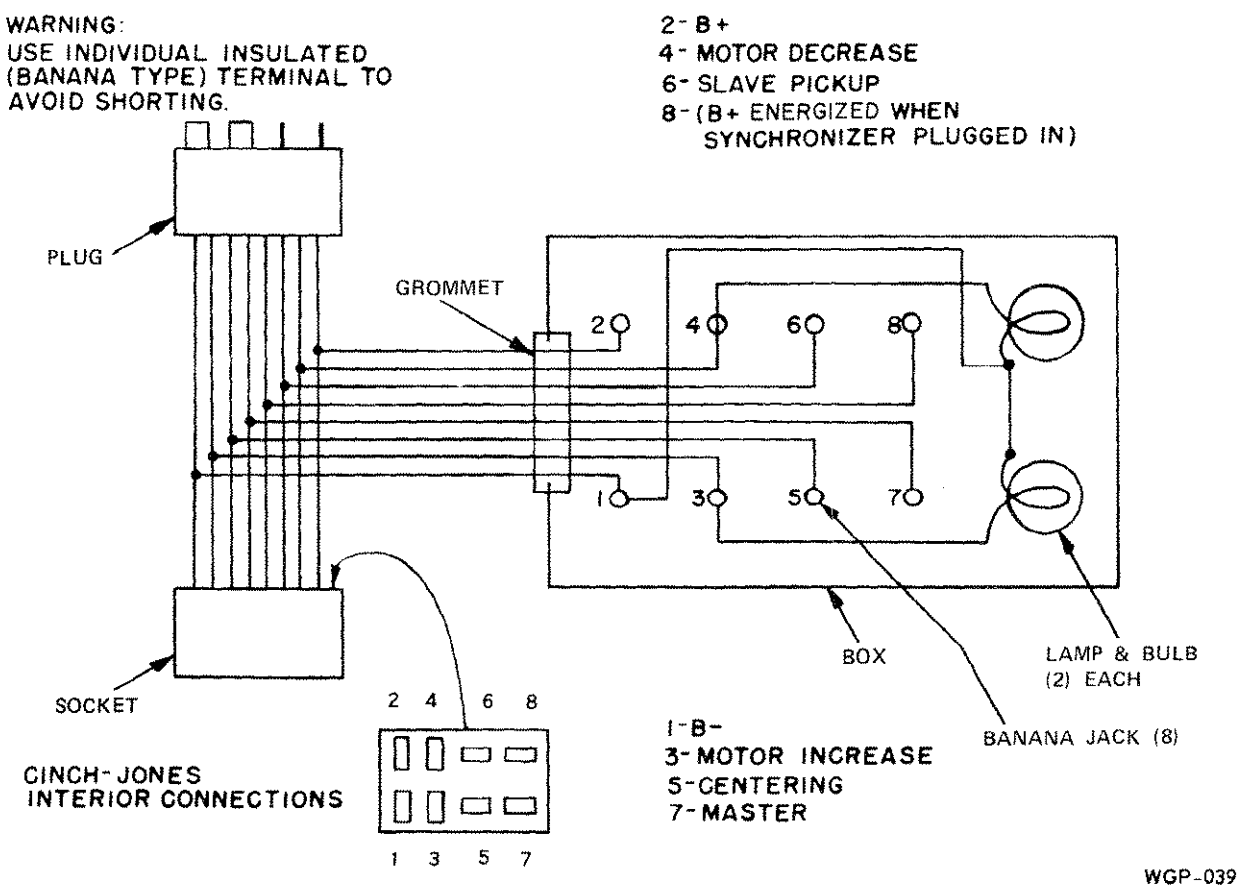


Figure 17. Diagram of Woodward Test Instrument WT-46192

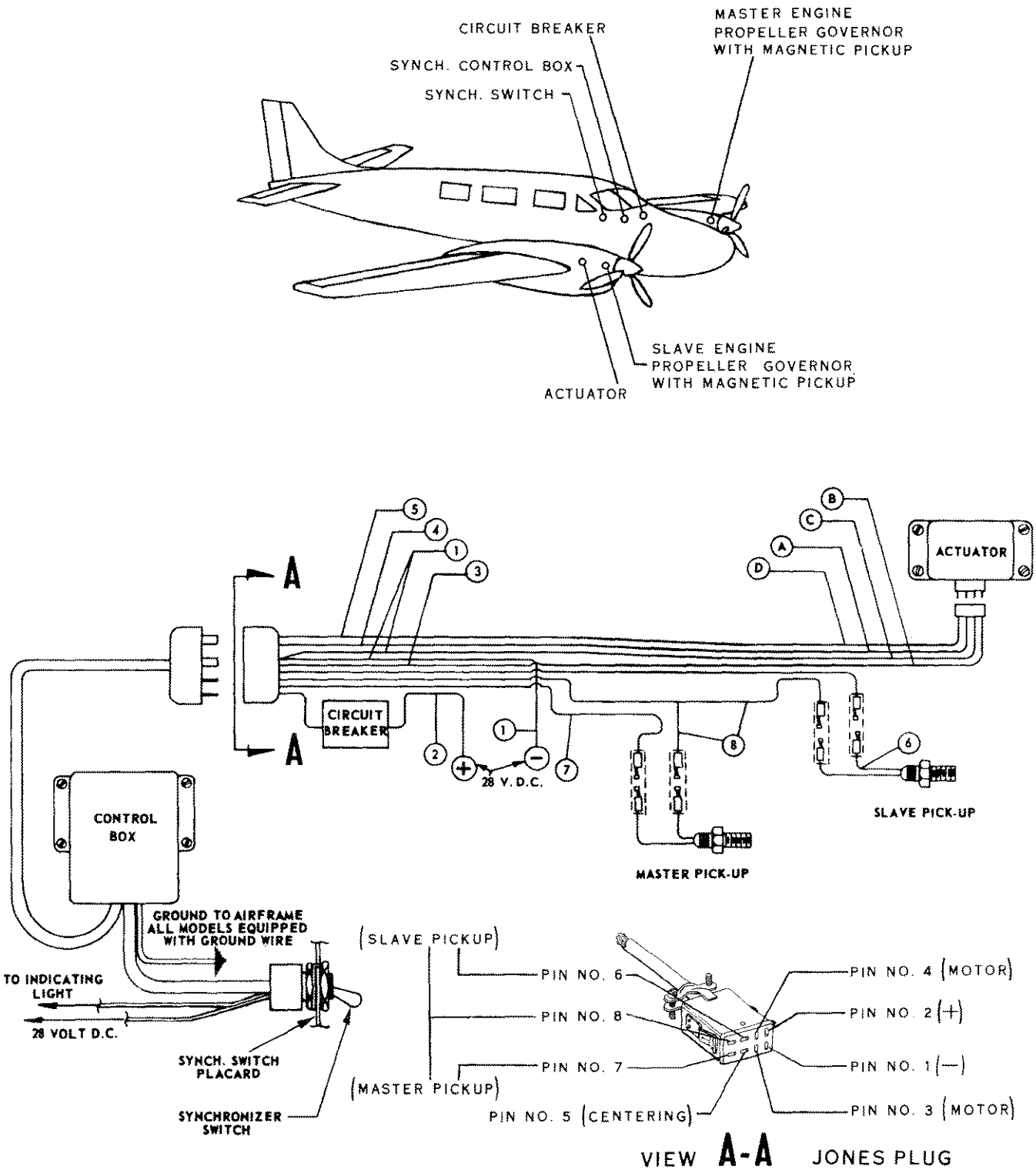


Figure 18. Typical Wiring Diagram of All Synchronizer Installations (Except Aero Commander)

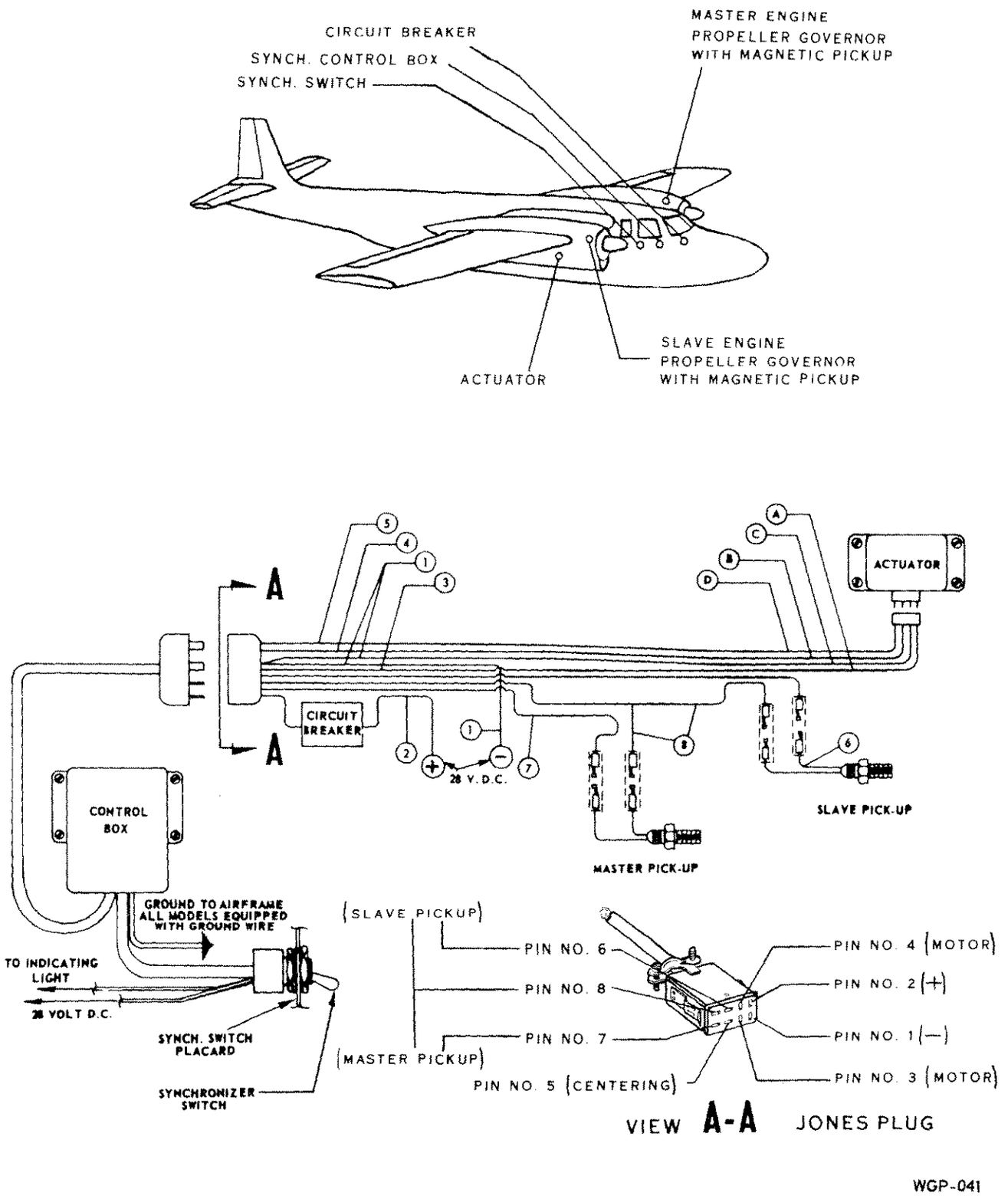


Figure 19. Typical Wiring Diagram of Synchronizer Installation (Aero Commander Only)

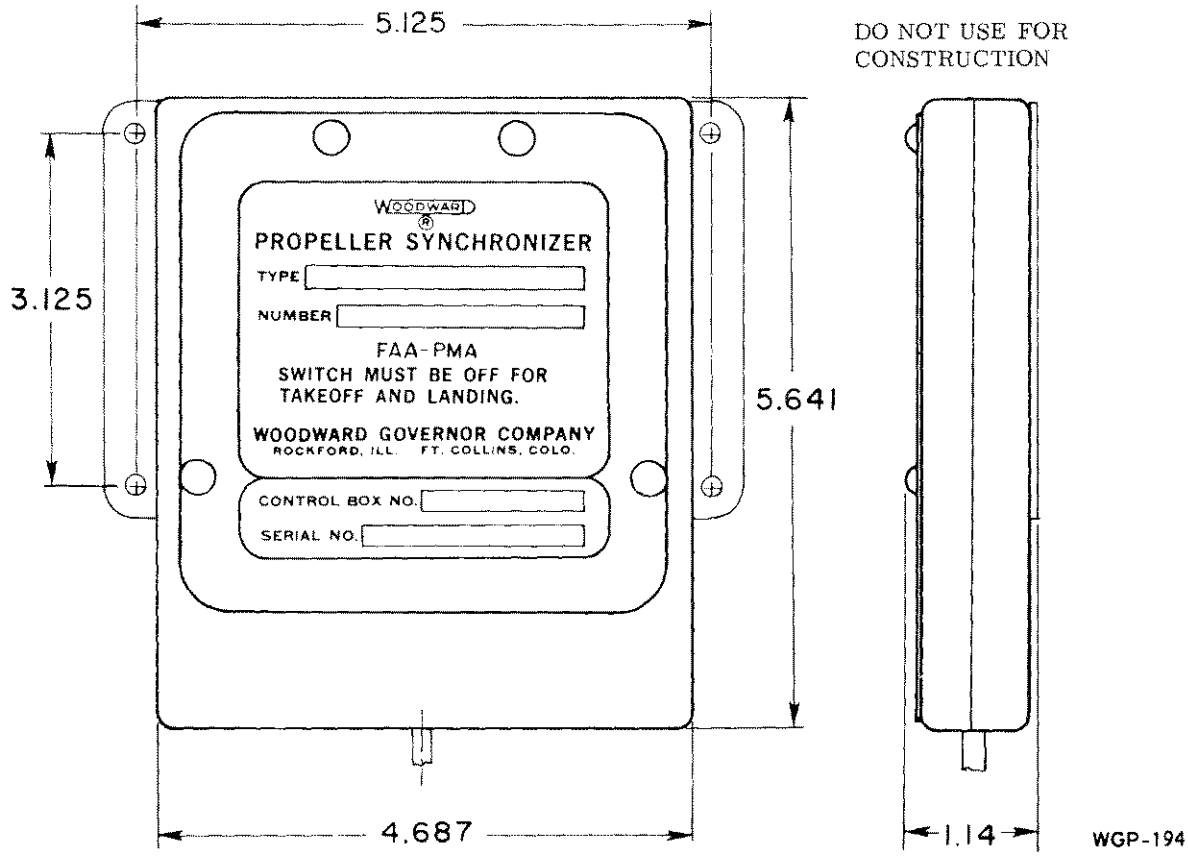


Figure 20. Outline Drawing of Control Box

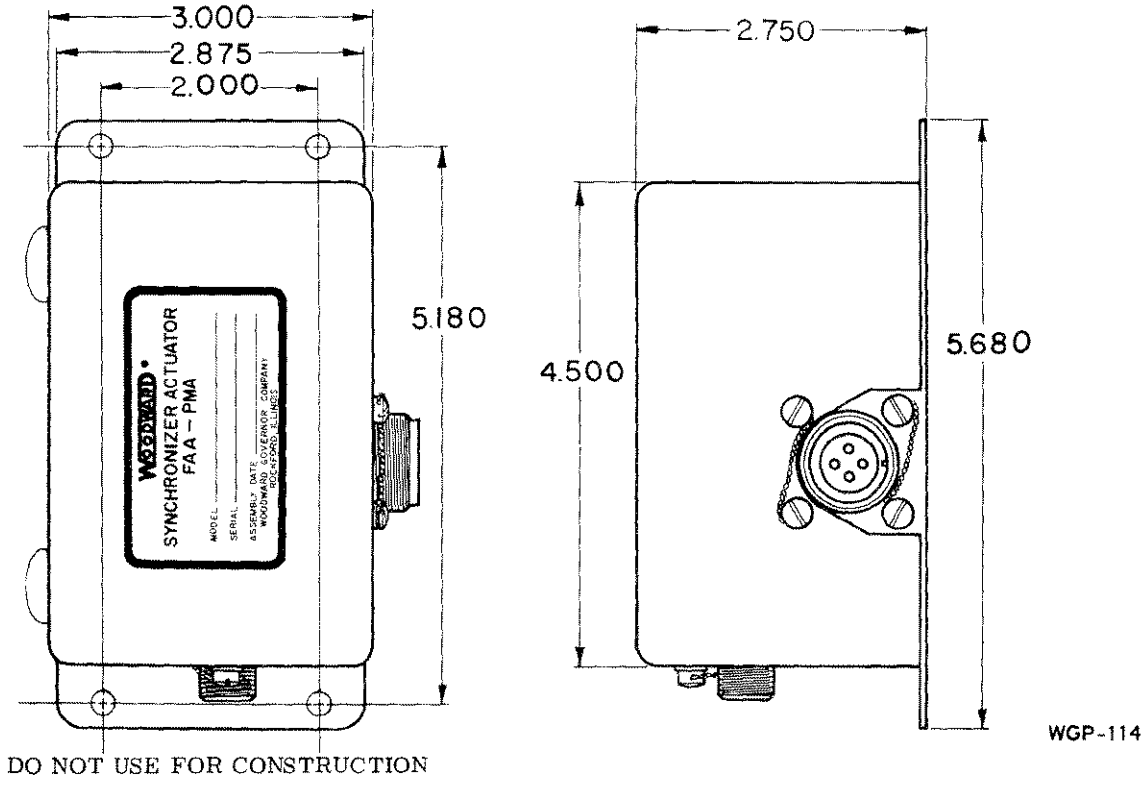


Figure 21. Outline Drawing of Actuator

Page

TEST GUIDE

TEST GUIDE

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 ohm meter and volt meter are available. Because of the difficulty in trouble shooting 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 Jones plug receptacle is properly mated with the Jones plug in the aircraft wiring system. The two halves of the Jones plug should be safety wired or locked together. This eliminates the more obvious causes of malfunction.

2. Separate the Jones plug (3, figure 9 and 10, figure 10) and complete the tests listed on the synchronizer wiring test (page 12). Complete each step regardless of how recently the installation was made. Pin numbers are detailed on the installation drawing. (Note: the drawing shows the female receptacle.)

CAUTION

Do not probe Jones plugs with anything thicker than .045" diameter. Larger probes will damage the receptacle and cause intermittent operation.

3. Visually observe the governor-mounted speed pickups for oil leaks or evidence of loosening. This could indicate a change in pickup clearance.

4. Remove the flexible rotary shaft at the actuator. Insert a screwdriver in the actuator and rotate it through its range. It should rotate freely except for the ratcheting effect of the detent wheel. Normal output torque is 1.5 lb.-ins. The actuator should have a range of 52-54 pulses (3.0 turns), and stop positively at each end. The 5-1/4 turn actuator should have a range of 93-94 pulses. Leave the actuator in the center of its range.

5. Adjust the trimmer by rotating the flexible shaft to check the amount of torque required. An excellent torque level is one that allows you to adjust the trimmer by turning the squared end of the flexible cable with your fingers. It is more difficult to turn the shaft in the decrease rpm direction. But in no case should you need a turning fixture of over 1/4" diameter on the end of the cable to rotate the trimmer freely throughout its full range. Check for rounded edges on the squared end of the flexible shaft. Recenter the trimmer and attach it to the actuator. This has verified an acceptable friction level of the rotating parts.

6. With the Jones plug separated and the engines running, voltage must be a minimum of .85 volt at minimum cruise rpm, and a maximum of 4 volts at maximum cruise rpm. Probe pins 6 and 8 for the slave engine pickup voltage. Probe pins 7 and 8 for the master engine pickup voltage. These are RMS voltages as read on a 5000 ohm/volt a-c voltmeter.

If all of the above tests are O.K., the aircraft can be flown. In flight turn the synchronizer "on" and complete the functional test (see page 4). If it will not pass this test, try the following:

1. With the synchronizer on, see if the synchronizer action is affected by rpm and/or power setting, particularly at lower cruise rpm and power settings. This will indicate a possibly unacceptably rough governor drive. If operation at lower rpm results in improved synchronization, the drives to the governors should be investigated.

2. Reduce the electrical load. Turn off all electrical units including the generators. Leave only the master switch, magnetos, and synchronizer on. If synchronizing is improved, there is a possibility that abnormal voltage spikes on the bus from some other electrical accessory have been upsetting the synchronizer. Isolate the offending electrical accessory and repair it. If the trouble has been traced to the control box, exchange it for another unit.

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. Most wiring problems have involved the small wires leading to the governor pickups.

4. Wiring technique should be of the highest calibre to eliminate any intermittent conditions that are time consuming to trouble shoot and which can damage the electrical units despite circuit breaker protection.

5. If an actuator is replaced because of shorted or open windings, the control box must also be replaced, unless you determine that the control box has not failed in a turned-on condition (see "V42"). If it has failed in a turned-on condition, the new actuator will be damaged.

6. If a Jones plug will not hold a .045" feeler in each pin receptacle, it should be replaced.

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 governor speed pickup as a small a-c 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 governor mounted speed pickup. If the phase (because of the 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 trimmer as a vernier device to lengthen or shorten the governor control linkage without your moving the governor control. 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.

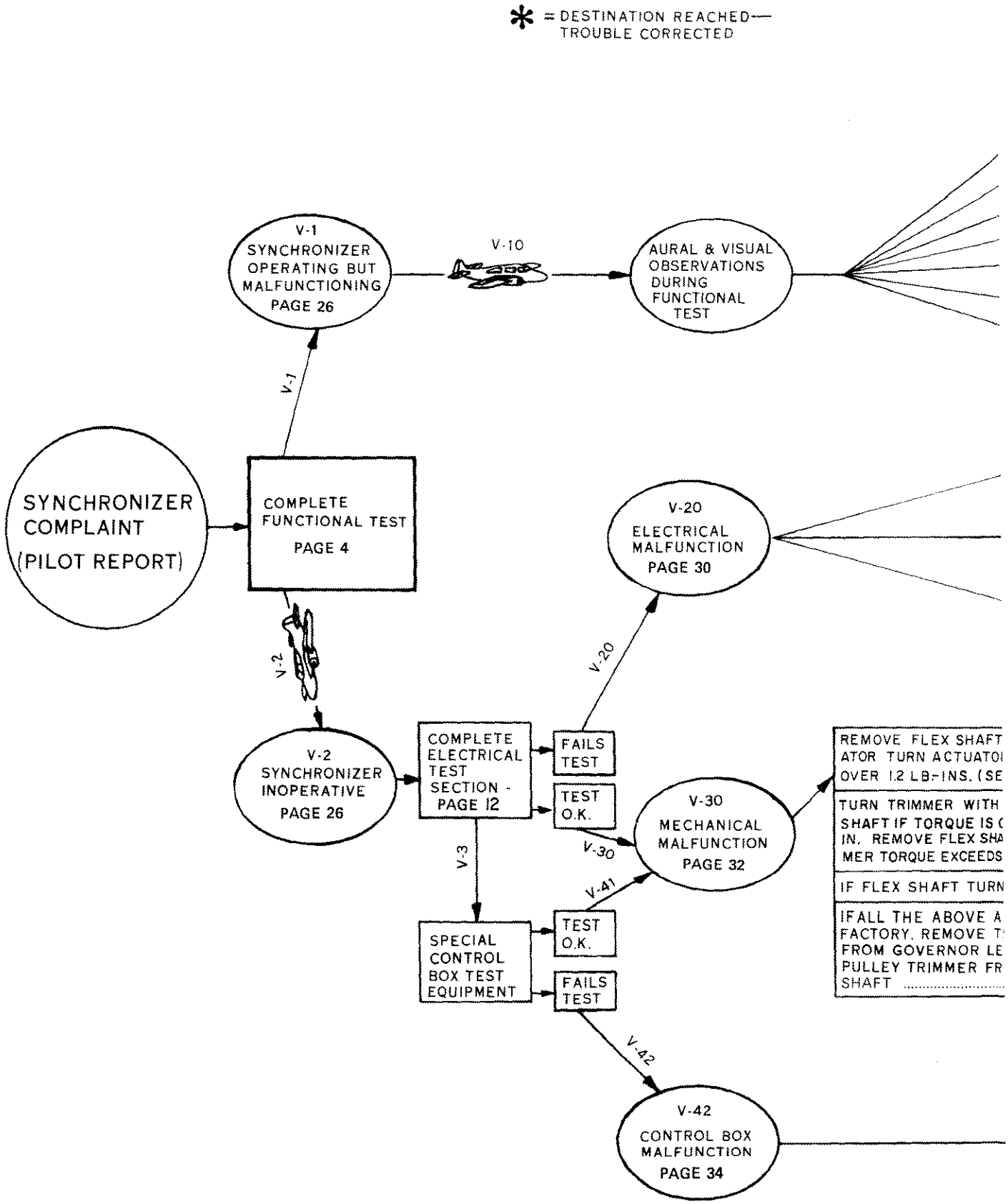
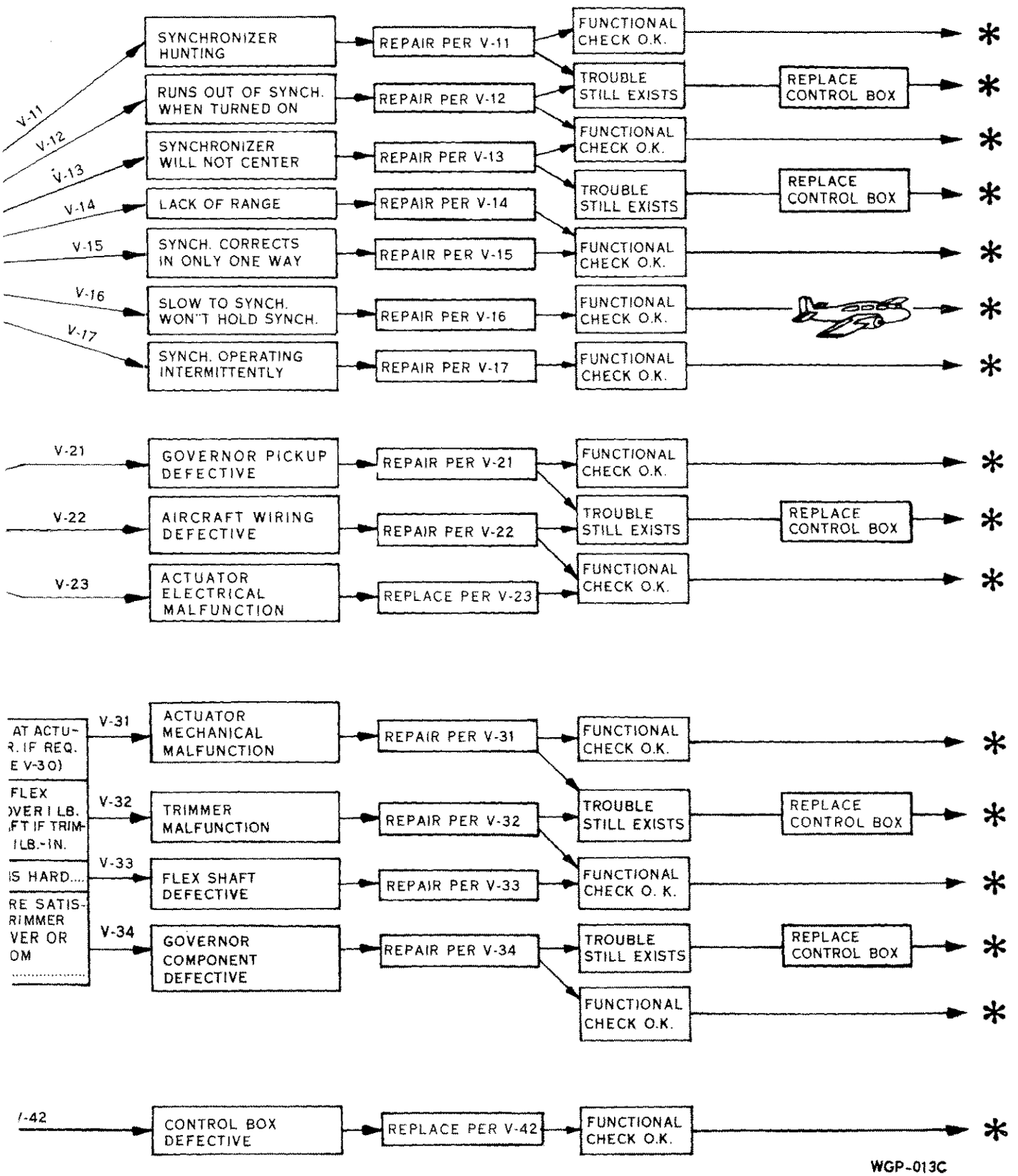


Figure 22. Troubleshooting "Airways" Chart


V-11
V-12
V-13
V-14
V-15
V-16
V-17
SYNCHRONIZER HUNTING
RUNS OUT OF SYNCH. WHEN TURNED ON
SYNCHRONIZER WILL NOT CENTER
LACK OF RANGE
SYNCH. CORRECTS IN ONLY ONE WAY
SLOW TO SYNCH. WON'T HOLD SYNCH.
SYNCH. OPERATING INTERMITTENTLY
REPAIR PER V-11
REPAIR PER V-12
REPAIR PER V-13
REPAIR PER V-14
REPAIR PER V-15
REPAIR PER V-16
REPAIR PER V-17
FUNCTIONAL CHECK O.K.
TROUBLE STILL EXISTS
FUNCTIONAL CHECK O.K.
TROUBLE STILL EXISTS
FUNCTIONAL CHECK O.K.
FUNCTIONAL CHECK O.K.
FUNCTIONAL CHECK O.K.
REPLACE CONTROL BOX
REPLACE CONTROL BOX
*
*
*
*
*
*
*
V-21
V-22
V-23
GOVERNOR PICKUP DEFECTIVE
AIRCRAFT WIRING DEFECTIVE
ACTUATOR ELECTRICAL MALFUNCTION
REPAIR PER V-21
REPAIR PER V-22
REPLACE PER V-23
FUNCTIONAL CHECK O.K.
TROUBLE STILL EXISTS
FUNCTIONAL CHECK O.K.
REPLACE CONTROL BOX
*
*
*
AT ACTU-
R. IF REQ.
E V-30)
FLEX
VER I LB.
FT IF TRIM-
I LB.-IN.
IS HARD....
RE SATIS-
RIMMER
VER OR
OM
V-31
V-32
V-33
V-34
ACTUATOR MECHANICAL MALFUNCTION
TRIMMER MALFUNCTION
FLEX SHAFT DEFECTIVE
GOVERNOR COMPONENT DEFECTIVE
REPAIR PER V-31
REPAIR PER V-32
REPAIR PER V-33
REPAIR PER V-34
FUNCTIONAL CHECK O.K.
TROUBLE STILL EXISTS
FUNCTIONAL CHECK O. K.
TROUBLE STILL EXISTS
FUNCTIONAL CHECK O.K.
REPLACE CONTROL BOX
REPLACE CONTROL BOX
*
*
*
*
*
I-42
CONTROL BOX DEFECTIVE
REPLACE PER V-42
FUNCTIONAL CHECK O.K.
*

WGP-013C

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 22: 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.

The engines must be under governor control for the synchronizer to act as a synchronizer. This often means rather high power settings for ground operation on reciprocating engines; however, it can be accomplished by placing the governor controls just above the feather setting with enough power to bring r.p.m. under governor control. When you increase power without increasing r.p.m. you are under governor control. An in-flight check is best. On the ground, actual synchronization may not be too good because of power variations, gust effect, etc.

For a functional check manually synchronize within a few r.p.m. 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" anytime 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 ampere 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 32).

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 22), start at one of the two above check points and call the page number shown for further "clearance." Follow instructions listed following each malfunction until arriving at "trouble corrected" point.

V-1 (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 4 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 any of the Woodward test equipment provides you with actuator pulse indicating lights which will help you in your decisions. The simple actuator pulse indicator WT-46192 can be built from the drawing shown on figure 17.

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 12 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 and, arrive at the control box by elimination, if it is at fault.

Complete the electrical check list on pages 12 and 13. 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 pickups, actuator, and bus leads are contributing to the problem.

V-3 (TEST CONTROL BOX):

If you have special Woodward test unit no. 213600, 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 no. 213600 replaces the aircraft speed signal with the output of two oscillators, one of which is variable. Insert the Jones plug connectors in the system, select "oscillator output" on the test instrument, and turn the synchronizer on. By varying the output of the one oscillator you can underspeed or overspeed the "simulated" slave engine. The pulse lights will reflect the output of the control box, and the movement of the 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 resistor. Except the light actions shown on page 16.

If the control box checks o.k. (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 governor control arm, pulley trimmer or speed setting shaft. The high breakway torque required causes an overcorrection for the speed error in alternate directions.

2. If the master speed is varying the slave will follow. This would indicate a problem in the basic governing 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 governor control arm. The Uniball must be free to swivel throughout the governing range. In some cases two Uniballs are involved, one at either end of the governor actuating rod. Only one need be free to swivel in this case.

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. On basically poor governed systems it can prevent an audible beat, but cannot prevent the nervousness observed in a synchroscope under these conditions.

It is unlikely that the synchronizer is causing the hunting as the rpm change per actuator pulse is small and reduced to approximately 1/2 its normal gain during the pulse that reverses direction. The normally high friction level of the rod end trimmer thread is not conductive to overrunning the speed setting being sought. Abnormally poor governor 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 governors.

If 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 out of synchronization when it is turned on, one of the following may be involved:

1. The leads from the speed pickups may be reversed. In this condition the control box "sees" the wrong engine as being slow or fast. Pin 8 of the Jones plug is common to both speed pickups. Pin 7 must go to the master engine. Pin 6 must lead to the slave engine, the engine with speed changing capability. If leads 6 and 7 are reversed, the pulse generated is in a direction such as to increase the speed error.

2. The motor leads to the actuator may be connected to the wrong pin of the Jones plug. Leads 3 and 4 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. Leads 3 and 4 are reversed between pulley head or lever head governors because of the nature and direction of the speed changing mechanism. All actuators are wired the same, the necessary change takes place in the aircraft wiring.

3. Intermittent shorts or opens in the speed pickup or its wiring can cause the synchronizer to run out of synchronization when turned on. In this case the frequency generated by the defective pickup 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 pulses the slave out of synchronization. In most cases, if the slave pickup is involved, the slave will increase its speed out of synchronization. If the master pickup is involved, the slave will decrease its speed out of synchronization.

4. Low voltage from one pickup along with runout on the toothed wheel could also cause running out of sync as the amplitude of part of the a.c. generated would not be recognized by the control box.

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 pulse in the opposite direction back to center when turned off.

REMEDY:

1. Connect a voltmeter to leads 6 and 8 to see that a voltage is generated when the slave engine is started and at 7 and 8 when the master is started.

2. Check motor leads against the installation drawing.

3. Monitor the pickup voltage produced in flight. If it is wavering, an intermittent short or open should be suspected. Nos. 213600, WT-45960 or WT-46192 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 pulse 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.

2. One side of the control box in 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 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 transistor is used, the direction of actuator rotation being 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 spring or speeder spring forces. In general, the force required is greater in the "decrease rpm" direction on propeller governors. 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 trimmer is loaded.

4. Improper rigging could cause this condition, but in a special way. If the system were rigged with the 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 pulses 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.

Any of the test instruments incorporating 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 4) in either the synchronizing or centering (switch off) mode.

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

3. Condition no. 3 would show normal pulse activity in one direction. Possibility of continuous pulsing when the control box is turned off 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. Replace actuator.

2. Replace 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 caused by a control box malfunction. 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 and/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 will retard synchronization.

   Torque required to manually rotate the actuator through the detent steps should not exceed a torque of 2.0 lb.-ins. The cover can be removed to determine the cause of excessive rotational drag. The detent wheel and balls of exposed detent type can be lubricated with Molykote G or equivalent. The centering switch arm pin should not bottom in the groove. (NOTE: keep Molykote G away from switch terminals.)

The flexible shaft should not need lubrication. If it does it will be necessary to use a lubricant that will flow along the cable, as the inner cable cannot be removed on later assemblies without a swedging tool for reinstallation of the end washer. If the inner cable is frayed, or the outer housing broken, the cable 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.-ins. applied torque should produce a rod end force of 9 lb. minimum. Rod end trimmers can be serviced as described on page 10. The governor speed setting shaft or governor control arm must be free to prevent slow operation one or both directions.

The above problems can be observed with any of 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 10 to 12 seconds.

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

1. Malfunctioning slave governor pickup.
   a. Shorted to ground.
   b. Leads shorted together.
   c. Open circuited.
   d. Pickup to gear (wheel) clearance too great.
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 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, 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 on the synchronizer. When you turn the synchronizer off on final approach, you will hear the non-synchronized 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 instruments will flash continuously in one direction until the engine speed decreases, during taxiing, to a point at which pickup output is insufficient to activate the control box.

REMEDY:

1. Replace pickup, adjust clearance, or repair leads.
2. Replace control box.
3. Rerig by turning the actuator and the trimmer each to the center of its range before mating the flex shaft.
4. Replace actuator.
5. Replace 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 trimmer to the center of their ranges before mating the flexible shaft. You will find 3 turn (54 step) and 5-1/4 turn (93 step) actuators. Rod end trimmers will have 3-1/4 or 5-3/4 turns. Pulley trimmers have 5-1/3 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 1-1/2% of the cruise rpm.

The synchronizing range can be checked by completing the functional check on page 4.

2. Be sure you are not trying to synchronize too close to a mechanical stop on the governor. The trimmer must be free to move through its entire range without hitting a mechanical governor stop.
3. The control box may be malfunctioning and will not recognize speed errors of any appreciable magnitude. With this condition you will find you can lead the slave through the entire range if you move the master slowly, but it will not "pull in" if you set up a 1% off-speed before turning the synchronizer on. This condition might not interfere with normal synchronizing as the off speeds are usually small; however, it does indicate a partial malfunction of the control box.
4. Mechanical binding of the trimmer or actuator at one or both ends of their ranges would also reduce the total range. Test instruments nos. 213600, WT-45960, or WT-46192 will show continuous pulsing without speed change as you reach the end of the range. If the control box is malfunctioning as noted above, it will probably be associated with double pulsing of the actuator.

REMEDY:

1. Rerig properly.
2. Adjust cockpit prop control lever to move speed control lever farther away from stop.
3. Replace control box.
4. See that 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. In this case, the synchronizer could operate in one direction only, either in the synchronizing or centering mode; therefore the 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 12) would detect this condition.

If the speed setting mechanism is mechanically bound in one direction, it is easily seen by the light activity. Establish a given out of synch. condition (10 to 15 rpm). Turn on the synchronizer 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. Replace the control box if there is excessive double pulsing (double pulsing in excess of 10% 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.

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 12), 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 speed pickup or wiring. The control box incorporates a protective feature that essentially turns off when a short exists in the pickup lead. (This feature is incorporated in all except for earlier control box assemblies.) Change letters shown in Service Bulletin 33547 can be used to determine old and new type boxes.
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 Jones plug or actuator Amphenol connector. The Jones plug can be damaged by probing the pin receptacle with objects that are too large. The probe should not be thicker than .045" dia. Check each of the 8 receptacles with a .045" dia. feeler. Each should grip the feeler well enough to hold the weight of the Jones plug.
6. The synchronizer switch could cause this; however, it has only occurred on the older switches on the 213433 control box "C" series and earlier.
7. 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 trimmer.
2. Repair pickup lead or replace pickup.
3. Replace control box.
4. Replace actuator or repair lead.
5. Replace Jones plug.
6. Replace control box.
7. Repair offending electrical accessory.

If trouble still exists, refer back to Airways Chart.

V-20 (ELECTRICAL MALFUNCTION):

If the electrical check list shown on pages 12 and 13 indicates an electrical problem you have 3 main courses: V-21, V-22, V-23. If the system failed steps nos. 1-6 (page 12) of the check list follow V-23 to an actuator electrical malfunction.

If the system fails step nos. 7, 8, or 9 (page 13), the governor speed pickup or pickups are malfunctioning and you should disconnect the wires at the pickup. Follow route V-21 to "Governor Pickup Defective."

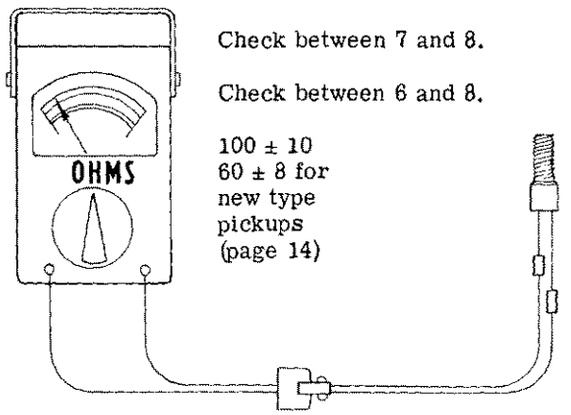
If the system fails the remainder of the check list, if the pickup proves to be alright, and if the actuator bench-checks alright, then proceed to check point "Aircraft Wiring Defective" V-22.

If trouble still exists, refer back to Airways Chart.

V-21 (GOVERNOR PICKUP - OR PICKUPS - MALFUNCTIONING):

The governor speed pickup incorporates a coil of fine wire. The resistance value of this coil should be 100 plus or minus 10. *(If trouble is suspected, check the resistance value when the pickups are hot. The resistance may be found to be varying and increasing out of tolerance with temperature. An additional 10 ohms increase is allowed at temperatures of 150° F.):

*NOTE: The ohm value of this coil should be 52-68 with new type magnetic pickup.

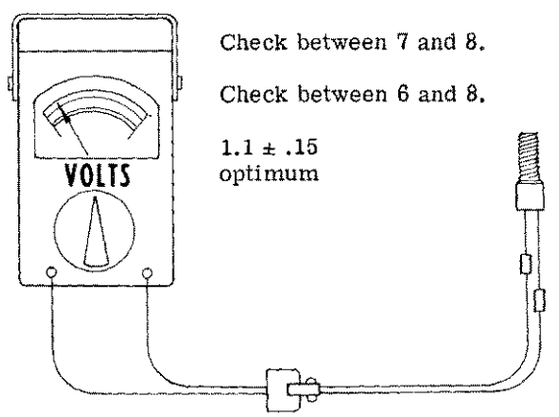


Check between 7 and 8.

Check between 6 and 8.

100 ± 10
60 ± 8 for new type pickups (page 14)

With engines operating at cruise rpm, the pickup should produce about 1.1 volts (a-c). This is the R.M.S. value as read on a 5000 ohm/volt voltmeter. The voltage at minimum cruise rpm must be at least .85 and the maximum voltage at maximum cruise must not exceed 4 volts:

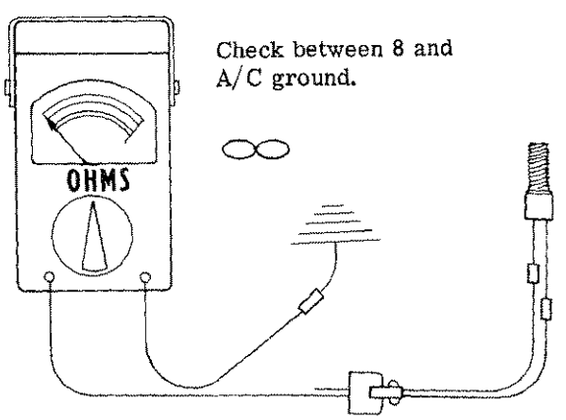


Check between 7 and 8.

Check between 6 and 8.

1.1 ± .15 optimum

Be sure that leads 7 and 8 go to the master engine and that leads 6 and 8 go to the slave engine. A resistance check of lead 8 to ground (on the X10 scale) will determine if either lead or the coil is grounded. This check must show "open circuit:"



Check between 8 and A/C ground.

Threaded pickups can be replaced (only by an FAA approved governor overhaul station or the Woodward Governor Company) in accordance with the instructions of page 5. Extreme care must be taken not to screw the pickup into the toothed wheel. Normal clearance between the pickup and the wheel is only .005" - .010". This pickup has 24 threads per inch so the pickup will be backed up 1/8 to 1/4 turn after contacting the toothed wheel. Do not attempt this without removing the governor. Exercise extreme care. Locknuts on the pickup should not be tightened in excess of 25 lb.-ins. Unthreaded type pickups can be replaced in the field. The correct gap is preset and assured by parts tolerances.

An intermittently open or grounded pickup 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. If viewed on an oscilloscope, the optimum peak-to-peak voltage would be 4 volts. In all but the latest systems lead 8 shorted to ground will trip the circuit breaker anytime that the master switch is turned on, even though the synchronizer is turned off. Lead 6 or 7 shorted to ground will damage older type control boxes. Later control boxes essentially turn themselves off until the short is removed. Change letters shown in Service Bulletin 33547 can be used to determine old and new type boxes.

Maximum support should be provided for the pickup wires as the leads, of necessity, are fine wire. There are two pickups in use, a ceramic cored "high temperature" type and a phenolic cored "low temperature" type. Be sure that wiring techniques are of the highest quality.

Leaks around the pickup would indicate a loose locknut, defective "O" ring, or cracked pickup barrel. Replace any malfunctioning pickup or exchange the governor.

REMEDY:

Replace the malfunctioning pickup. Use high temperature pickup only.

If trouble still exists, refer back to Airways Chart.

V-22 (AIRCRAFT WIRING DEFECTIVE):

1. If the speed pickups 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 (Jones plug to component connections and bus). The wires should also be checked for possible short circuits to ground. With the actuator and the speed pickups disconnected and the circuit breaker pulled, only pin 1 should show continuity to ground.

2. Check the pin receptacles of the Jones plug for loose pins. Loose Jones pin receptacles are usually caused by test probes having overstressed the clips. All receptacles should hold well on a .045"

feeler. One loose pin will not be noticed when mating the two halves but can cause annoying intermittent conditions. The two halves of the Jones plug should be safety wired together.

3. Power lead polarity must be observed. With the master switch on and the circuit breaker closed, pin 2 must be positive with respect to pin 1.

REMEDY:

1. Repair short or open in wiring.

2. Replace Jones plug if pin receptacles are loose.

3. Correct reverse polarity if found.

If trouble still exists, refer back to Airways Chart.

V-23 (ACUTATOR ELECTRICAL MALFUNCTION):

The actuator must meet the resistance value specified on page 15 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, NOS. WT-45960 or 213600 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 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 that older systems 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 pins A & C and B & 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 WT-45960 or 213600 you can safely pulse the actuator either in the aircraft or on the bench with a suitable harness. If the motor winding is grounded due to defective wiring, the pulse light in the test instrument will come on and stay on. If it is being supplied by a 2 amp. breaker, the circuit breaker will trip. 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 WT-45960 or 213600 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 test instrument selector switch in the automatic synchronize 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 is for the purpose of determining that the control box will not damage the actuator.

6. For additional pulse light action, see page 17.

REMEDY:

Replace 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 at the actuator. Turn the actuator by means of a square drive in the drive end. The torque required should not exceed 1.2 lb.ins. for the type shown in figure 7 or 2 lb.-ins. for the type shown in figure 8. This includes the rotational torque and the torque required to raise the detent balls against their springs. If there is undue drag, or the torque received is in excess of that specified, follow course marked V-31.

If the actuator torque required is within limits, turn the 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.-ins. In most cases you should be able to turn it with your fingers on the squared end. If you can't disconnect the cable at the trimmer and follow course V-32.

If the trimmer is free, check the flexible shaft. Follow course V-33.

If the flexible shaft is free, remove the trimmer from the governor and exercise the governor control lever or the pulley. 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 1.2 lb.-ins. for the type shown in figure 7 or 2 lb.-ins. for the type shown in figure 8. 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 motor actuator shaft.

Excessively worn motor bushings or shaft.

Dry or corroded detent balls on the drive end.

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.

Flexible shaft driver slipping on the drive shaft (early series actuators using set screws to lock driver on shaft). While this would not result in a high torque required, it would result in pulsing of the actuator making no effective speed correction.

NOTE

Actuators develop 1.5 lb.-ins. torque minimum.

REMEDY:

Lubricate affected area. If actuator is damaged, replace the actuator.

If trouble still exists, refer back to Airways Chart.

V-32 (TRIMMER MALFUNCTION):

The 1.5 lb.-ins. torque will develop 6 to 11 pounds force at the rod end, depending on the length of the flexible shaft and 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 with the governor arm.

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 rod end trimmer was lubricated with Molykote "G," the rod end trimmer should be exchanged to update the assembly. If the rod end trimmer was lubricated with the baked-on dry lubricant, and is in need of servicing, it should be exchanged. Lubricating this rod end trimmer assembly with liquid lubricant may be harmful when exposed to heat.

If the rod end trimmer is side loaded due to governor flexible shaft misalignment, re-route the flexible shaft to relieve this condition. Older type rod end trimmers with the exposed gearing are particularly sensitive to any side loading caused by improper routing of the flexible shaft. The flexible shaft should be parallel to and in line with the governor actuating rod. The rod end Uniball should be spaced such that the Uniball is free to swivel. The rod end trimmer should trim with a maximum torque of 1 lb.-in. applied to the actuator end of the flexible shaft.

Pulley trimmers must rotate freely. The trimmer should be able to be rotated with the fingers on the squared end of the flexible shaft. It will normally be harder to trim a governor toward decrease r.p.m. than toward increase. Pulley trimmers can be disassembled for lubrication or can be exchanged for another trimmer.

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. Older flexible shafts without the swedged washer on the actuator end must be checked to be sure they are not shrinking out of engagement with the actuator. The inner shaft should extend 1/2" to 5/8" beyond the outer housing with a 5 lb. pull applied to the outer housing. Check that the squared edges have not rounded.

Check that the snap ring seats squarely on the trimmer. Check that the driving end of the cable does not rub on the 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 housings pulled apart must be replaced.

V-34 (GOVERNOR COMPONENT MALFUNCTION):

Operate the governor control lever or the pulley (in the case of pulley head governors) to see that it adjusts the speeder spring smoothly and without any high breakaway torque. High friction level can exceed the synchronizer trimming force. A high breakaway torque can cause speed hunting. On pulley head governors, operate the pulley shaft by turning the pulley. It should be smooth with progressively increasing force required as the speeder spring is compressed.

High lever or pulley forces would have to be corrected by lubrication or disassembly of the governor (by an FAA approved governor overhaul station or Woodward Governor Company).

REMEDY:

Service governor.

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. Proper testing of the control box in the field after repairs is difficult. 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 the 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 will subsequently fail the actuator by burning out one or both actuator motor windings. 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 12 to insure 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" (V23) for instructions of this.

CAUTION

The control box can be damaged by moisture. If rain water enters the box via the wire bundle, or condensation takes place in the box, internal corrosion will cause an electrical failure. See page 16 for actuator pulse light activity to be expected.

WOODWARD

SERVICE LETTER

FAA APPROVED BY DESIGNATED ENGINEERING REPRESENTATIVE

February, 1975

SUBJECT

Connecting the Woodward 213600 Synchronizer Test Instrument to the aircraft electrical system when troubleshooting or checking the synchronizer system.

Several 213600 test instruments recently returned for repair prompts us to emphasize that it is possible to plug in the tester incorrectly, thereby damaging its circuitry, and to explain the proper use of the test equipment.

Correct test methods are shown in Figures 1 and 2 on the reverse of this letter. Figure 1 shows the "Wire" and "Manual Pulse" test configuration. Figure 2 shows the "Internal Oscillator" and "Pickup" test configuration.

CAUTION

Make certain that the synchronizer OFF/ON switch IS NOT connected to the 213600 test instrument.

Figure 3 shows the 213600 tester incorrectly plugged into the synchronizer OFF/ON switch. A test unit connected in this manner receives a "dead short" to aircraft ground, resulting in damage to the tester with no evaluation of any phase of the synchronizer system.

WOODWARD GOVERNOR COMPANY
AIRCRAFT CONTROLS DIVISION
ROCKFORD, ILLINOIS, U.S.A.

System and test instrument connections for –

WIRE and MANUAL PULSE TESTS

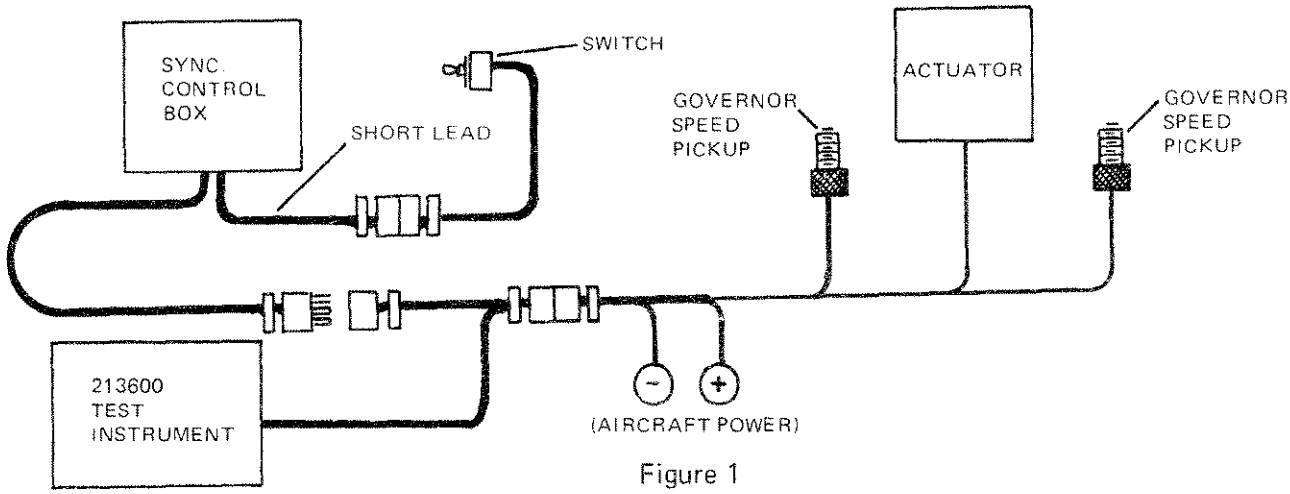


Figure 1

INTERNAL OSCILLATOR and PICKUP TESTS

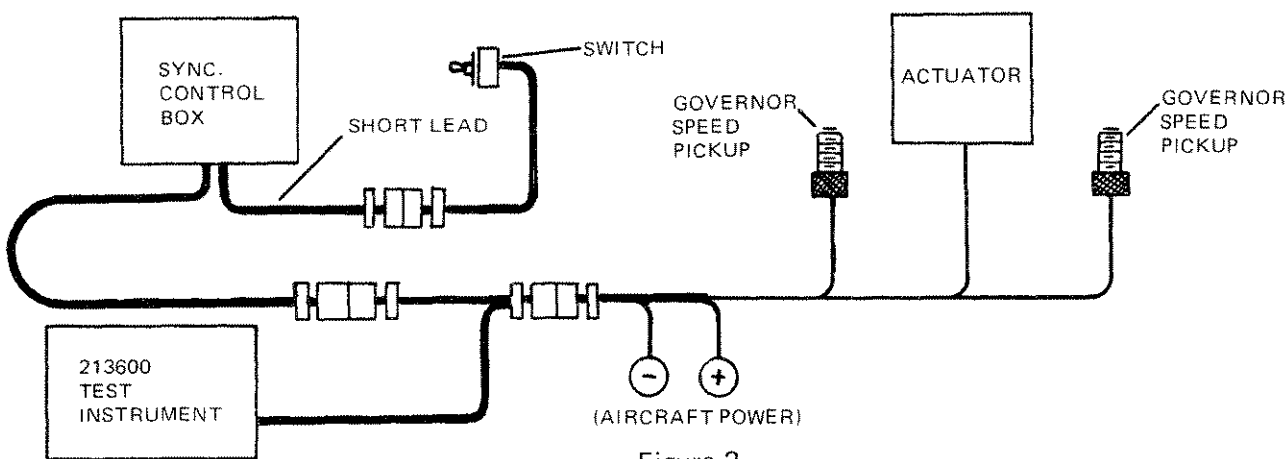


Figure 2

WRONG CONNECTION

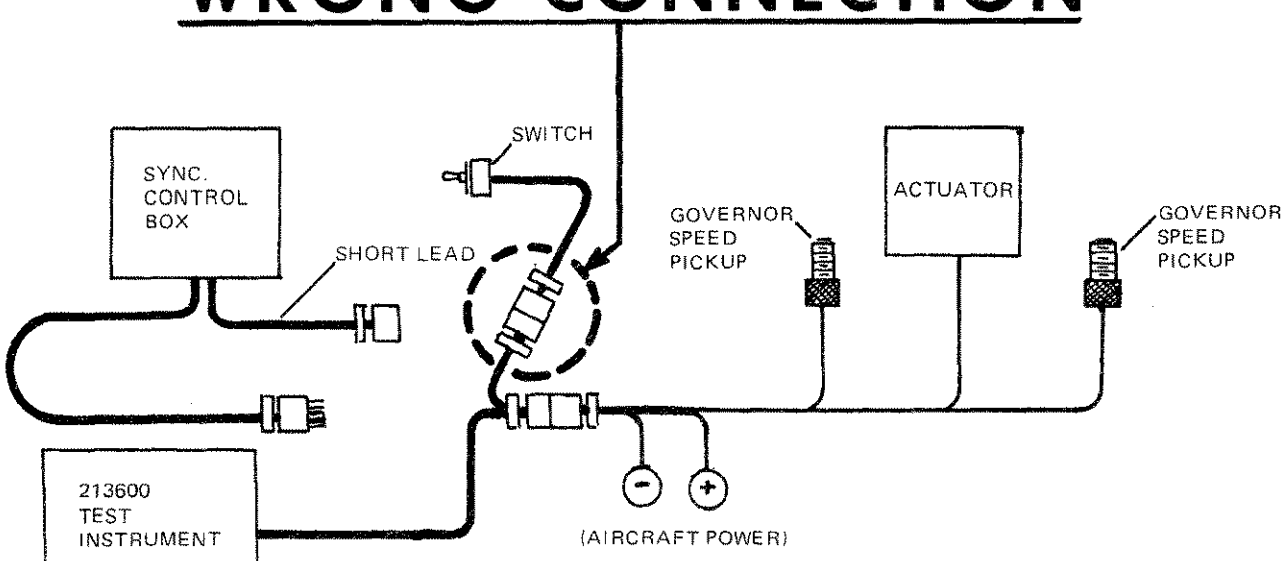


Figure 3

WOODWARD SERVICE BULLETIN

FAA APPROVED BY DESIGNATED ENGINEERING REPRESENTATIVE

April, 1975

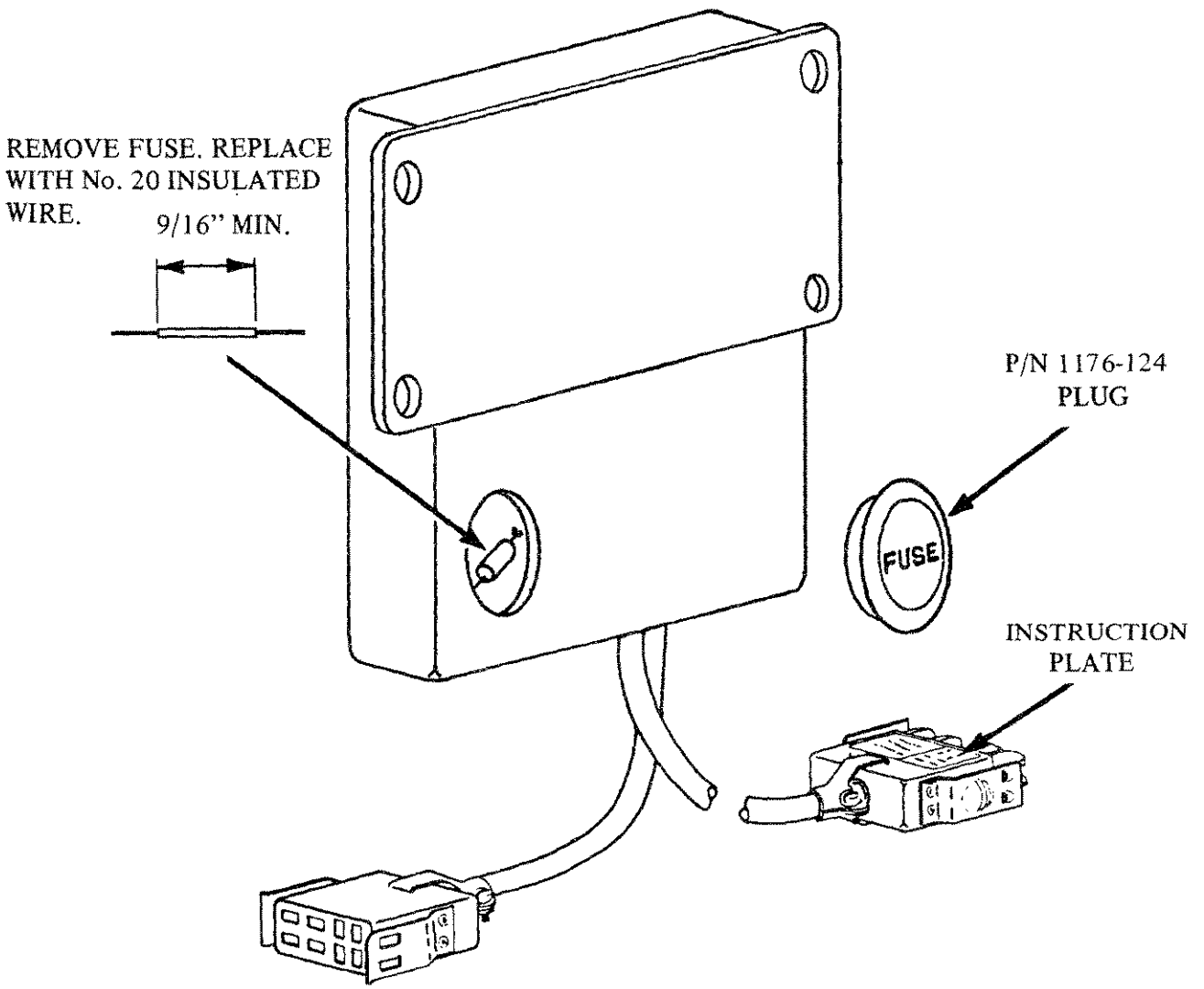
TO

1. Manufacturers and operators of Twin Engine Airplanes that use the Woodward Electronic Synchronizer or Synchrophaser.

2. Aircraft service facilities and certificated governor repair stations.

SUBJECT

Replacement of a blown fuse (shown below) with a 20 gauge insulated wire jumper.



WOODWARD GOVERNOR COMPANY
AIRCRAFT CONTROLS DIVISION
ROCKFORD, ILLINOIS, U.S.A.

PURPOSE

To prevent further nuisance fuse failures that sometimes occur.

EQUIPMENT AFFECTED

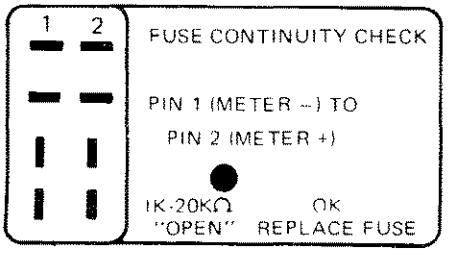
All Synchronizer & Synchrophaser Control Box assemblies manufactured or repaired after March 10, 1975.

COMPLIANCE

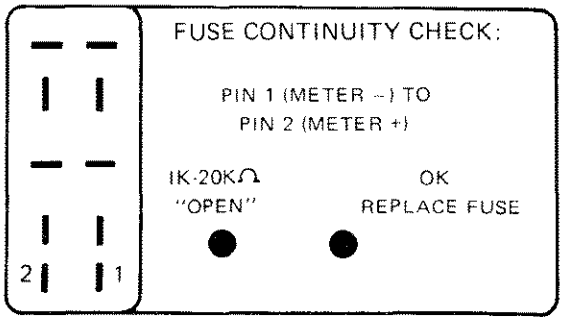
No field compliance required until a fuse failure occurs.

DETAILS

During an interim period, all control boxes are being manufactured and repaired without a fuse until a new fuse configuration becomes available. The synchronizer system will again be dependent upon the airplane circuit breaker for overload protection. Units that have not been reworked should still have the instruction plate on the male connector.



Instruction plate for 8 pin Jones Plug



Instruction plate for 10 pin Jones Plug

CORRECTIVE ACTION

If a synchronizer or synchrophaser malfunction occurs, check first for an open fuse as indicated on the instruction plate using the following information.

1. The ohmmeter polarity must match the polarity of pins 1(-) and 2(+). If the meter polarity is unknown, simply test one way then reverse the test leads.
2. Fuse continuity will be indicated by a reading of 1,000 to 20,000 ohms. The X1 scale of most meters is unsuitable for this check.
3. If the continuity check is made at the fuse rather than the pins, the polarity or meter scale is not critical.

If the fuse is open, simply replace it with an appropriate length of 20 gauge insulated wire. Use caution during the replacement to insure that no excess solder runs through and beneath the circuit board where damage may result.

Regardless of the fuse condition, continue with a complete wiring check to insure the integrity of the aircraft wiring and components. (See list following for aircraft and bulletin number containing appropriate wiring check.)

Remove the instruction plate on the male connector to show compliance with this bulletin. Warranty will not be affected.

AIRCRAFT	WOODWARD BULLETIN
Beech Baron	33049
Duke/56TC	33049
Queen Air/Twin Bonanza	33049
King Air (Synchronizer)	33049
King Air (Synchrophaser)	33083
Cessna 310, 320, 337, 340, 401, 402, 414, 421	33049
Cessna 500	33113
Dassault Falcon C, D, E, F	33128
DeHavilland DHC-6	33049
Embraer EMB-110 (Synchronizer)	33049
Embraer EMB-110 (Synchrophaser)	33083
Gates "Learjet" 23, 24, 25	33062 & 33125
IAI Westwind	33125
Mitsubishi MU2 (Synchronizer)	33049
MU2 (Synchrophaser)	33083
Piper PA31P	33049
PA31T	33049
Rockwell 500, 560, 680, 685	33049
680T, V, W 681	33063
690	33115
40, 60, 70 Sabre	33125
75A Sabre	33128
Swearingen Merlin/Metro	33049

PUBLICATIONS AFFECTED

Operation and service manuals will be updated at next issue.

WOODWARD SERVICE BULLETIN

FAA APPROVED BY DESIGNATED ENGINEERING REPRESENTATIVE

MAY 1975

TO

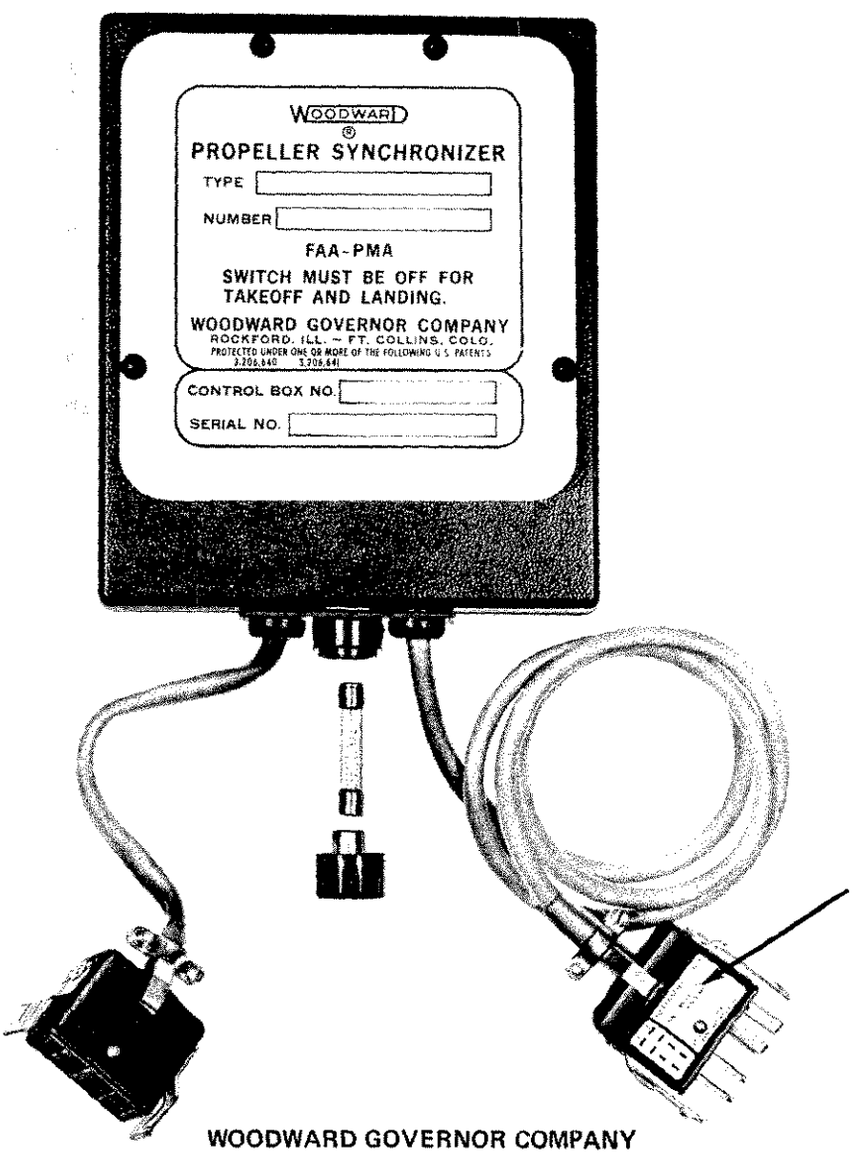
1. Manufacturers and operators of Twin Engine Airplanes that use the Woodward Electronic Synchronizer or Synchrophaser.

2. Aircraft service facilities and certificated governor repair stations.

SUBJECT

1. Introduction of a "Slo-Blo" type fuse configuration to all new and overhauled synchronizer and synchrophaser control boxes.

2. Identifying and checking the fuse.



INSTRUCTION PLATE

WOODWARD GOVERNOR COMPANY
AIRCRAFT CONTROLS DIVISION
ROCKFORD, ILLINOIS, U.S.A.

33557

PURPOSE

To supersede the earlier resistor type fuse configuration.

EQUIPMENT AFFECTED

All Synchronizer & Synchrophaser Control Box assemblies manufactured or repaired after June 1, 1975.

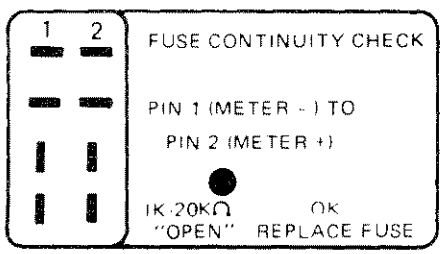
COMPLIANCE

None required. Conversion will be made at overhaul by the Woodward Governor Company.

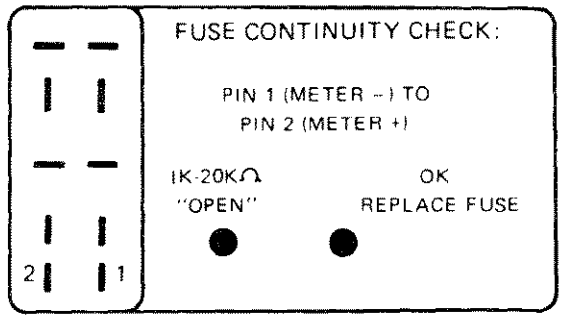
DETAILS

The earlier resistor type fuse proved marginal in certain aircraft whose actuator current draw was higher than normal because of high system activity or high ambient and operating temperatures.

NOTE



Instruction plate for 8 pin Jones Plug



Instruction plate for 10 pin Jones Plug

If a synchronizer or synchrophaser malfunction occurs, check first for an open fuse as indicated on the instruction plate using the following information.

1. The ohmmeter polarity must match the polarity of pins 1(-) and 2(+). If the meter polarity is unknown, simply test one way then reverse the test leads.
2. Fuse continuity will be indicated by a reading of 1,000 to 20,000 ohms. The X1 scale of most meters is unsuitable for this check.
3. If the continuity check is made at the fuse rather than the pins, the polarity or meter scale is not critical.

If the fuse is open, simply replace it with another 1.5 ampere "Slo-Blo" fuse.
Woodward P/N 1641-270
Little Fuse P/N 31301.5

Regardless of the fuse condition, continue with a complete wiring check to insure the integrity of the aircraft wiring and components. (See list following for aircraft and bulletin number containing appropriate wiring check.)

AIRCRAFT		WOODWARD BULLETIN
Beech:	Baron	33049
	Duke/56TC	33049
	Queen Air/Twin Bonanza	33049
	King Air (Synchronizer)	33049
	King Air (Synchrophaser)	33083
Cessna 310, 320, 337, 340, 401, 402, 414, 421		33049
Cessna 500		33113
Dassault Falcon C, D, E, F		33128
DeHavilland DHC-6		33049
Embraer EMB-110 (Synchronizer)		33049
Embraer EMB-110 (Synchrophaser)		33083
Gates "Learjet" 23, 24, 25		33062 & 33125
IAI Westwind		33125
Mitsubishi	MU2 (Synchronizer)	33049
	MU2 (Synchrophaser)	33083
Piper	PA31P	33049
	PA31T	33049
Rockwell	500, 560, 680, 685	33049
	680T, V, W, 681	33063
	690	33115
	40, 60, 70 Sabre	33125
	75A Sabre	33128
Swearingen Merlin/Metro		33049

PUBLICATIONS AFFECTED

Operation and service manuals will be updated at next issue.

USING WOODWARD BULLETIN #33049E AS A GUIDE, ANSWER THE FOLLOWING QUESTIONS

1. During takeoff and landing, turn the synchronizer control switch to the

   A. Standby position
   B. "ON" position
   C. "OFF" position
   D. Makes no difference

2. To functional test the synchronizer in flight, first

   A. Synchronize the propellers manually
   B. Turn synchronizer switch "ON"
   C. Turn synchronizer switch "OFF"
   D. Open system circuit breaker

3. A high percentage of governor troubles may be traced to

   A. Poor workmanship
   B. Dirty engine oil
   C. Bad propeller cables
   D. Too much propeller wash

4. Rod end trimming assemblies being used may have a travel of

   A. 3 & 5 1/2 turns
   B. 2 & 5 turns
   C. 3 1/4 & 5 3/4 turns
   D. 4 & 5 turns

5. The part number for the rod end bearing is

   A. 33049-21
   B. 33049-28
   C. 33049-29
   D. 33049-31

6. When probing the female Jones plug, the largest diameter probe you should use is

   A. .032 inches
   B. .040 inches
   C. .045 inches
   D. .052 inches

7. When reading pickup output, the minimum resistance per volt ac voltmeter you should use is

   A. 5000/volt ac voltmeter
   B. 2500/volt ac voltmeter
   C. 10,000/volt ac voltmeter
   D. Makes no difference

8. When bench testing a centered actuator, after zeroing ohmmeter, a test on pins D & B should give

   A. 6.5 to 8.5 ohms
   B. Open circuit
   C. 13 to 17 ohms
   D. Shorted circuit

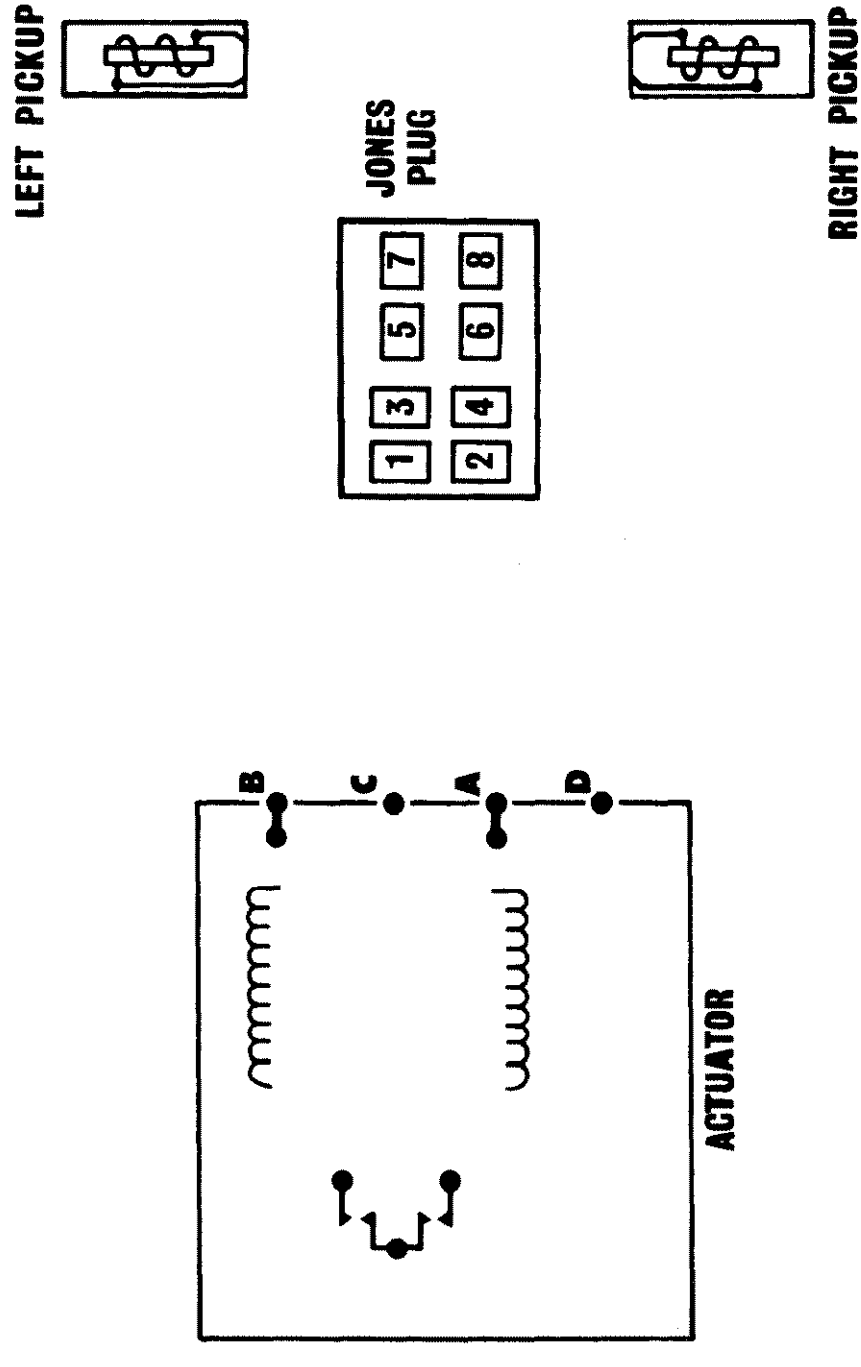
9. In most installations the synchronizer will respond to an angular phase shift between propellers of approximately

   A. 5 degrees
   B. 360 degrees
   C. 18 degrees
   D. 12 degrees

10. Normal torque output of the actuator is

   A. 15 lb. - inches
   B. 1.5 lb. - inches
   C. 52 lb. - inches
   D. 54 lb. - inches

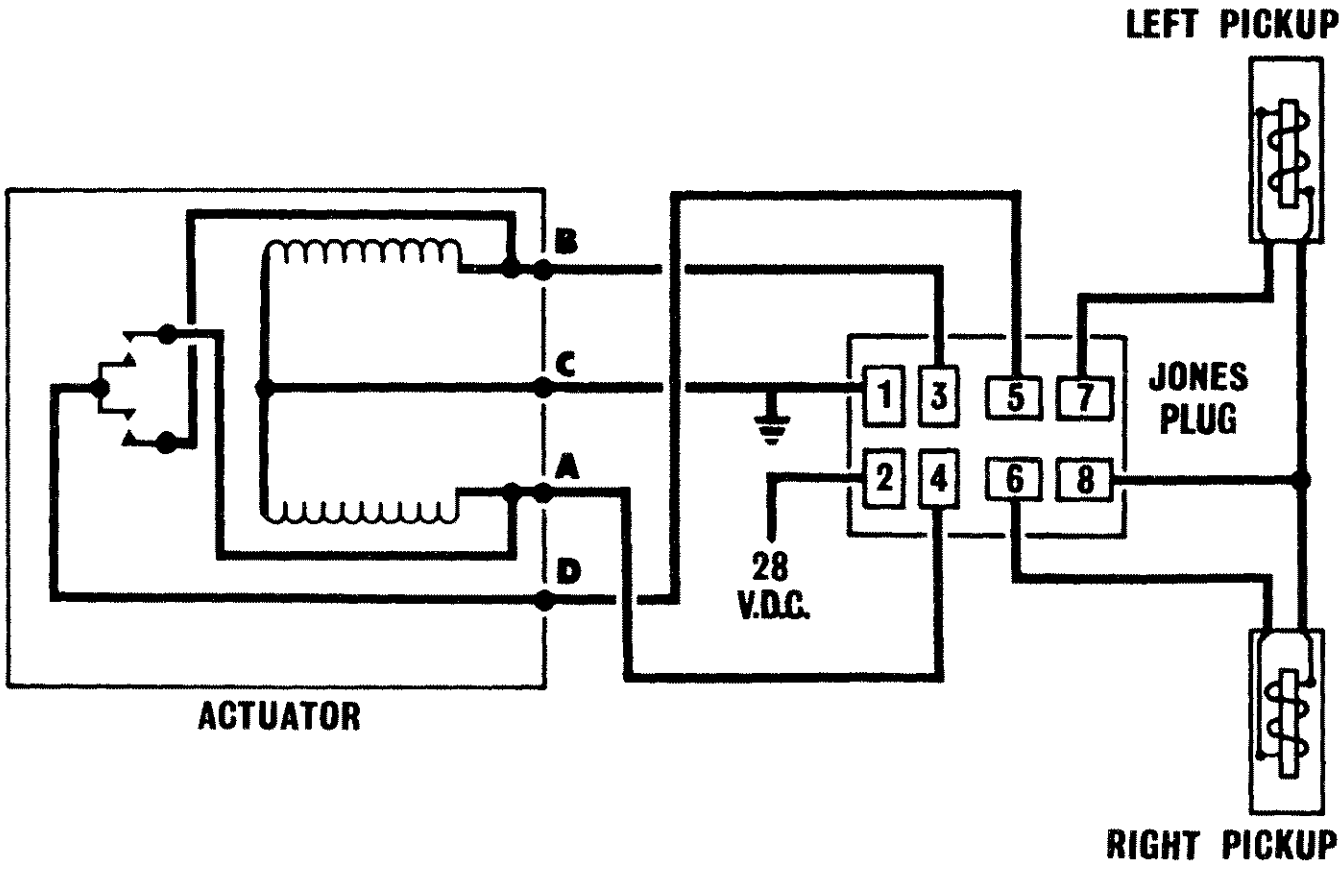
WIRE SCHEMATIC FROM JONES PLUG TO COMPONENTS



WIRING CHECK

Making the following checks, on a normal system, with the volt-ohm meter, what readings should you obtain?

PIN NOS.	CIRCUITS READ	READING SHOULD BE
JONES PLUG		
#1 to A/C Ground	System Ground	_____
#1 to #2	System Ground to Aircraft Bus	_____
#3 to #4	Actuator Solenoid Winding	_____
#1 to #5	Centering Switches (Act. Centered)	_____
#6 to #8	Right Pickup Static	_____
#7 to #8	Left Pickup Static	_____
#6 to #8	Right Pickup at 2000 RPM	_____
#7 to #8	Left Pickup at 2000 RPM	_____
#8 to #1	Pickups to System Ground	_____
ACTUATOR		
A & B	Solenoid Windings	_____
C & D	Actuator Centering Switches (Actuator Centered)	_____
C & D	Actuator Centering Switches (Actuator Not Centered)	_____



TROUBLESHOOTING TIPS

Field problems experienced with the synchronizer system have emphasized the following service recommendations.

1. When probing the Jones plug do not - I repeat DO NOT - partially separate the Jones plug halfs and use your meter probes on the exposed male pins. This can damage the control box.

2. Be Thorough. Complete each test as listed. No Short Cuts.

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

320

1. Check to see that the guide tube has not shifted in the Adel clamps that position it. The Adel clamps get brittle and allow the tube to shift ahead or back introducing misalignment between the flexible cable and rod end. The same condition will allow the tube to rotate, causing misalignment.

2. Keep the inner and outer flexible shaft lubricated.

3. Keep the control box free from moisture, either condensation or "run in" along the wires. Orient the control box so water will not run in. While this is equally important on all models, service experience shows that the 320 installations is susceptible to this type of damage. Cessna Multiengine Service Letter covers this subject.

400 SERIES

1. Restrain the rear uniball with spacer washers and allow the uniball at the governor to correct for misalignment of governor control rod.

2. Tighten the locknut on the governor control rod so that the rod end does not strike the exhaust heat baffle or the engine mount.

ALL MODELS

1. Most wiring problems have involved the small wires leading to the governor pickups.

2. Protect the pickup wires with fiberglass tubing. Protect the wires from damage, chafing and heat.

3. Be certain that the pickup wire wristlock connectors are snapped together securely.

4. Check the pickup and actuator wires for chafing where they pass through grommets particularly if the synchronizer was installed in the field. When installed in the field, the wires are often not tied into the existing bundle and are the most susceptible to chafing.

5. Be sure all replacement pickups are the 213181 high temperature pickups.

6. Do not probe the Jones plug connector with anything thicker than .045 inches. If the female connector, held in an inverted position, will not hold a .045 inch probe in each location, it should be replaced.

7. Do not connect a newly installed control box until you have checked the actuator for proper ohm value in accordance with the wiring test sheet. A low resistance or shorted actuator will permanently damage the control box.

8. If you are replacing a shorted actuator you must be certain that the control box has not failed in a "turned on" condition. If it has, it will destroy the new actuator winding in several minutes. If you have test equipment, insert it in the system, turn on the master switch and the synchronizer switch. If the actuator pulse light turns on steady the control box is damaged. If you have no test equipment, remove the cover of the actuator, turn on the master switch and the synchronizer switch. The actuator will probably pulse once. If the actuator windings heat up, the control box has failed and is energizing the actuator continuously. If it pulses once but there is no heat rise, the control box may not be operational but it has not failed in a manner that will damage the actuator.

9. Keep actuator detents and switch arm lubricated to prevent galling.

10. Keep liquid lubricants and washing solvents off the Fel-Pro'd rod end assemblies. The baked-on dry moly is designed to operate dry. Liquid lubricants may cook out and have gummy residue.

11. When tightening the governor control rod locknut on older style rod ends, be sure you use a thin wrench to hold the rod end bushing. The wrench should not be over 3/32 inches to be sure that the locknut is not tightening on the jaws of the inner wrench instead of the hex headed bushing.

12. Keep the rod end trimming assembly free. You should be able to trim the governor by turning the squared end (actuator end) of the cable with your fingers.

13. Be sure the flexible shaft snap ring seats well on the rod end. If there is interference, open up the I.D. of the rod end threaded adapter with a letter "V" drill. If you do not, the cable will be misaligned and the snap ring pulled off as you tighten the nut.

14. When work has been completed on the system, safety or tie the two halfs on the Jones plug together.

15. Control boxes bearing a "D" or later suffix (such as 213433D) will not be damaged by an actuator motor lead short to ground. These control boxes will electronically shut themselves off until the short is corrected.

Woodward Governor Company
Main Office: Rockford, Illinois, U.S.A.
Fort Collins, Colorado, U.S.A. - Tokyo, Japan
Sydney, N.S.W., Australia

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Slough, Berks, England

Woodward Governor GmbH
Lucerne, Switzerland

Woodward Governor (Quebec) Ltd.
Montreal, Quebec, Canada