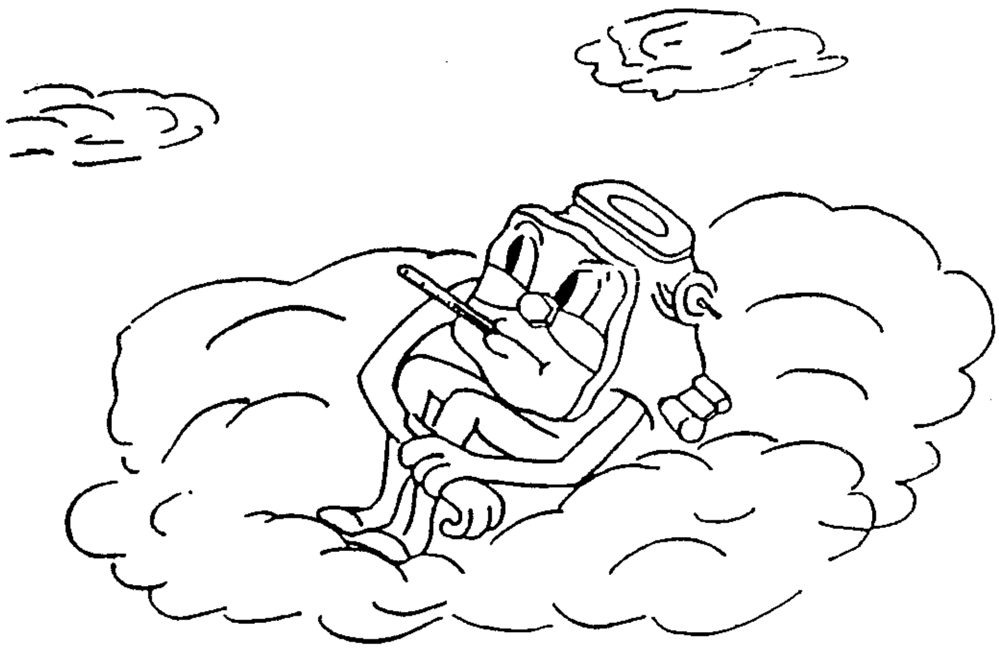
TROUBLESHOOTING TECHNIQUES

FOR THE PRECISION AIRMOTIVE RSA FUEL METERING SYSTEM



PRECISION

PRECISION AIRMOTIVE CORPORATION
3220 100th Street S.W. # E • Everett, WA 98204 • USA

Form 15-810B

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This troubleshooting techniques manual has been prepared and distributed by Precision Airmotive Corporation, and is intended as a TROUBLESHOOTING GUIDE ONLY. The information is presented as an aid to problem isolation and DOES NOT supersede any published airframe/engine manufacturer publications nor does it supersede information contained in Precision Airmotive published overhaul manuals, bulletins, letters, or operation and service manuals. Diagrams are presented as an aid to understanding the troubleshooting technique and may bear little resemblance to the actual operating hardware. Any questions or comments regarding information contained in this manual should be directed to:

Precision Airmotive Corporation
3220 100th ST. S.W. #E
Everett, WA. 98204

ATTN. Product Support Dept.

This Manual, form 15-810B, contains information which is in addition to information contained in the previous version, form 15-810, of this manual. Added information is the result of much appreciated feedback from mechanics, owners, and operators concerning the resolution of problems experienced since original publication of this manual.

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THE ART
OF
TROUBLESHOOTING

Troubleshooting effectively is an art that separates the professionals from the amateurs. To be able to pinpoint the problem or problems causing the malfunction is effective troubleshooting. Removing and replacing components on a trial and error basis is shotgun troubleshooting in it's worst form. Shotgunning is extremely costly for the owner and it teaches the technician nothing. To be effective, trouble shooting must be an analysis of the problem, it's probable causes, and the necessary actions to correct the problem, and if possible, prevent it from happening in the future.

We must keep several points in mind in developing an effective troubleshooting procedure for engines, their systems , and components. A suggested method which, with minor changes, can be adapted to almost any engine consists of five basic steps. these are:

1. Studying the symptoms
2. Isolating the system affected
3. Determining the probable causes.
4. Checking and repairing
5. Testing and documenting your actions

This brochure has been prepared to aid the mechanic in effectively troubleshooting the RSA fuel injection system. An inspection run-up sheet, figure 1, is included (and may be copied) for use in studying and isolating systems affected. Possible causes are listed on the following sheets, along with methods for determining correct operation of the individual components without resorting to "changing the part to see if that fixes the problem.

Read all bulletins carefully before removing a unit for compliance . Pay particular attention to the section which identifies the units affected by the bulletin by the part number and serial number , if listed. It is embarrassing to spend an hour removing a unit, then not be able to find the part you are supposed to inspect because it does not match the description given in the bulletin. It is also expensive to send a unit to a repair facility for bulletin compliance; make sure the bulletin does apply. If in doubt, call ask someone for help.

Precision Airmotive Corporation
3220 100th Street S.W. #E
Everett, WA 98204

Attn. Product Support (206) 353-8181
FAX: (206) 348-3545

INSPECTION RUN-UP SHEET

AIRCRAFT N______________ O.A.T.________ F
SERIAL NO. ______________ HOURS ______
DATE INSPECTION COMPLETED ______________
MECHANIC NUMBER ______________________

PRE-INSPECTION	RT.	LT.	POST INSPECTION	RT.	LT.
1. Oil Press/Temp	/	/		/	/
2. Fuel Press.					
3. Mag Drop (RT)			(RT)		
(LT)			(LT)		
4. Static RPM					
a. Fuel Flow					
b. M.A.P.					
5. CHT and/or EGT					
6. Idle Speed					
7. Fuel Selector (all positions)					
8. Suction Gage					
9. Carb Heat					
10. Cabin Heat					
11. Cowl Flaps					
12. Ammeter					
13. Engine Response					
14. Prop Response					
15. Idle Cutoff RPM Rise					

Full rich operation/pressure sensitivity check:

	Fuel Press	RPM	M.A.P.
Boost Pump OFF:		1000	
		2000	

	Fuel Press	RPM	M.A.P.
Boost Pump ON:		1000	
		2000	

COMMENTS:

Figure 1. Inspection Run-Up Sheet

AIR IN FUEL SYSTEM

Refer to Figure 2.

1. Connect a length of clear Teflon tube between servo out fuel line and flow divider. A 2- to 3-inch piece of tube is all that is generally required to be clamped between two AN style fittings.

2. Run engine and watch for air bubbles. Do not run the engine without the cowling for sustained periods as engine damage may occur.

3. If air bubbles are noted, locate source and correct. Primary sources are:

    A. Deteriorated fuel hoses.
    B. Deteriorated main fuel pump inlet fitting seals. (See Lycoming S.B. 374.)
    C. Airframe boost pump shaft seal leakage.
    D. Damaged cones and flares on fuel line fittings.
    E. Fuel lines routed too close to the exhaust system.

NOTE

Fuel fittings and lines can leak air and not fuel. If having the boost pump on improves operation, then a leaky fitting or hose is possible between the boost pump and the main fuel pump. A large air leak or boost pump shaft seal leak may not give improved operation with the boost pump on.

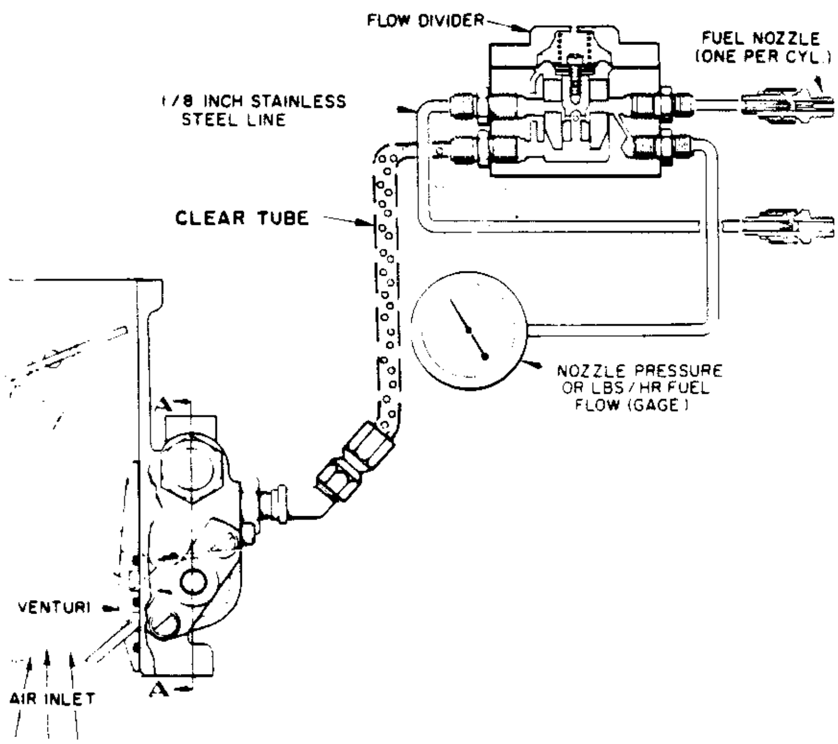


Figure 2. Checking for Air in Fuel System

CHECKING FUEL NOZZLES

CAUTION

THE FOLLOWING TEST IS INTENDED AS A TROUBLESHOOTING AID ONLY AND SHOULD NOT BE CONSTRUED AS A CALIBRATION CHECK OF THE NOZZLE ASSEMBLIES. SHOULD A QUESTION EXIST REGARDING SERVICEABILITY OF A GIVEN NOZZLE ASSEMBLY, THE UNIT MUST BE SENT TO A CERTIFIED OVERHAUL/REPAIR FACILITY.

PRIOR TO INSTALLING A NOZZLE ASSEMBLY, ALWAYS REFER TO THE ENGINE MANUFACTURER'S INSTRUCTION MANUALS FOR THE PROPER TORQUE VALUE OF NOZZLES AND LINES.

<u>NOTE</u>: Baby bottles work best for this check since they are calibrated in cc's and milliliters.

1. Remove nozzles from cylinder and reconnect to nozzle lines.
2. Insert nozzles into container to capture fuel.
3. With Throttle OPEN, Mixture CLOSED, turn boost pump on.
4. Open mixture control to the FULL RICH position; time for 15 or 30 seconds (depending upon container size), then close mixture and turn off boost pump.
5. Set containers on a level surface and check for approximate equal volume from each nozzle. See Figure 3.

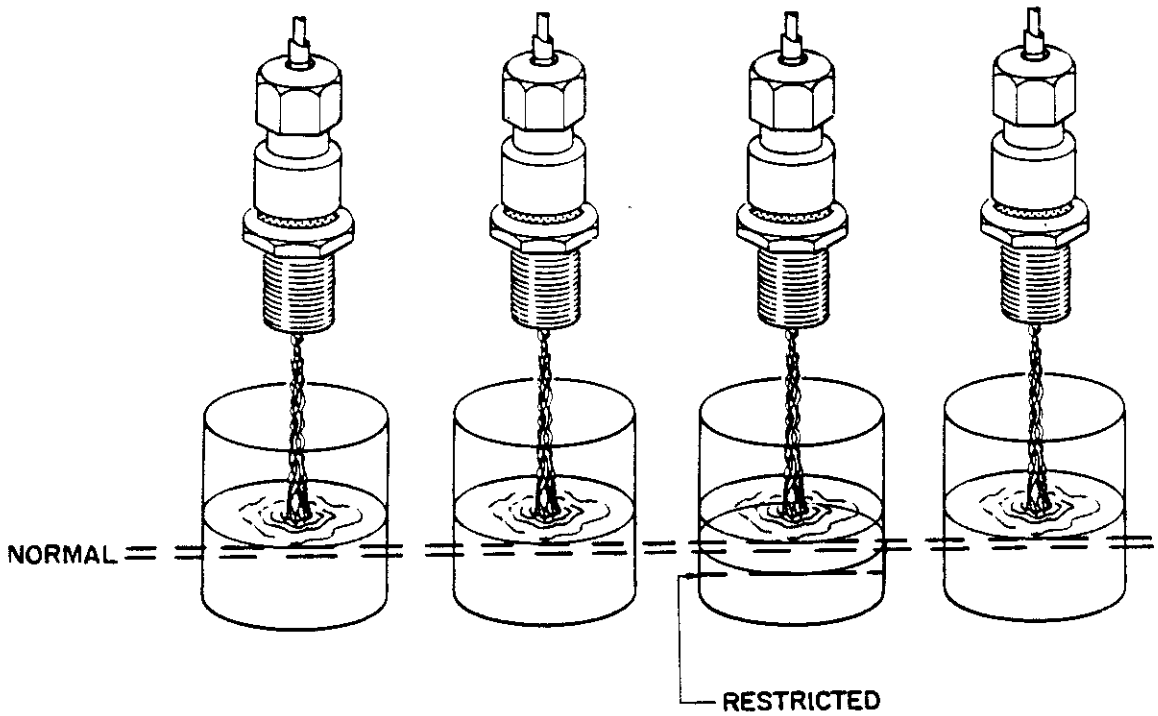


Figure 3. Contamination Check of the Nozzle Circuit

6. Some variation is normal; a large variation indicates a restricted system. Check for contamination in nozzles, nozzle lines, and flow divider. On two-piece style nozzles (see Bendix Bulletin RS-77, Lycoming S.I. 1414 and 1231), ensure that all inserts have been installed in nozzle bodies.

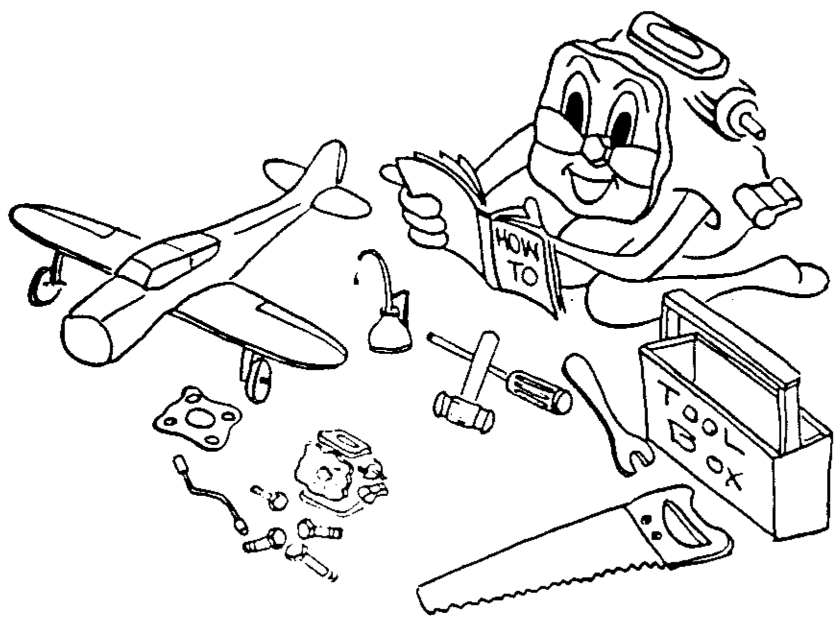
7. Locate and correct the source of contamination before returning the aircraft to service.

Possible causes of problems:

a. Improperly cleaned, damaged, and/or inspected nozzles.

b. Contaminated flow divider (may require partial disassembly).

c. Deteriorated flexible fuel lines/improper line between flow divider and servo (see Lycoming S.I. 1274).



CENTER BODY SEAL CHECK

NOTE

This procedure was published in Bendix Bulletin RS-20, Revision 2, dated 8-17-71, and Lycoming Service Instruction S.I. 1166A, dated 10-01-71, for servo units incorporating older style center body seal assemblies. It is presented here as a step in the troubleshooting elimination process when a rich idle is indicated, and only applies to servo units listed in the above bulletins.

1. Cap outlet from servo unit to flow divider.

2. Remove screws holding air inlet duct to injector.

3. Open throttle wide open and move mixture control to the full rich position.

4. Turn on boost pump for approximately 3 minutes while checking for leakage in the injector venturi or out the impact tubes.

5. Turn off boost pump and reconnect fuel line. If excess leakage was noted, remove servo unit for repair, see Figure 4. Excess leakage is identified as fuel running out the impact tubes or venturi (on units using the bullet type venturi).

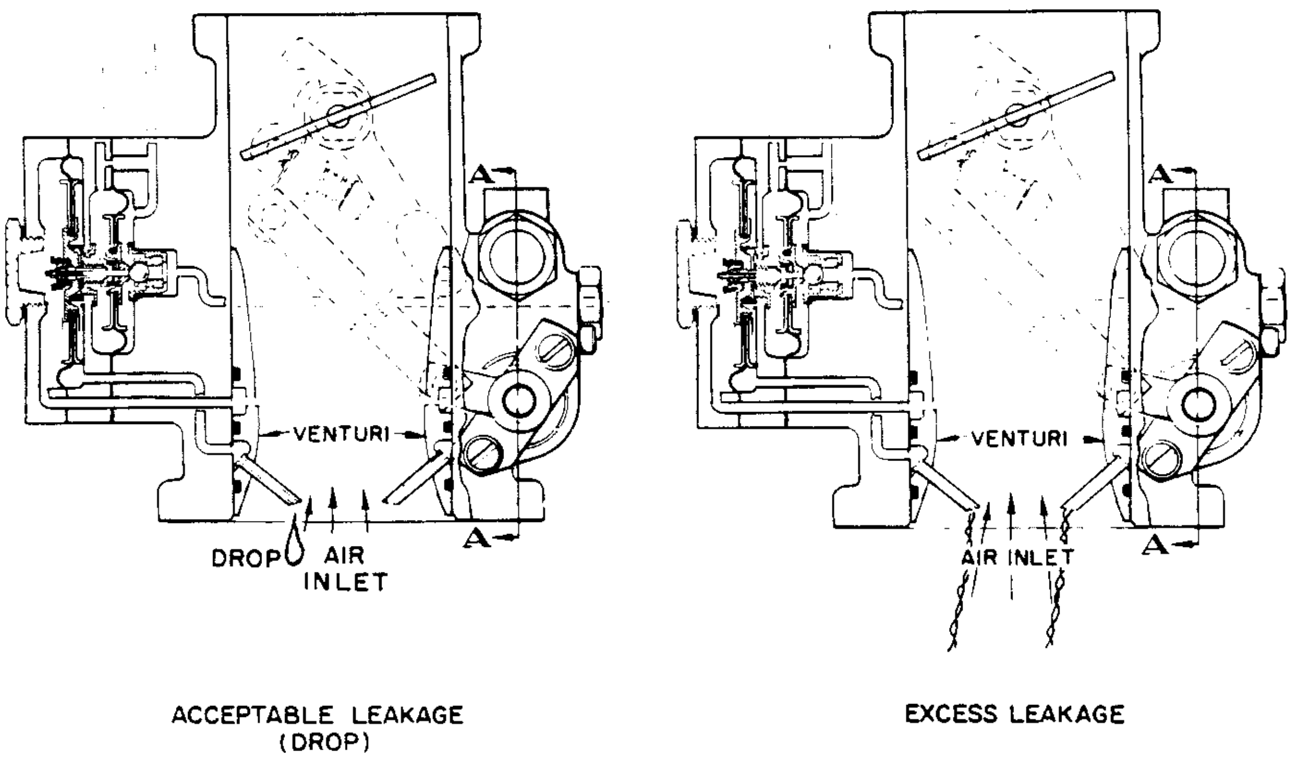


Figure 4. Leakage Limits

RS- & RSA FUEL INJECTORS

MANUAL MIXTURE CONTROL LEAKAGE

The Manual Mixture Control on the RS-RSA fuel injectors, in the idle cutoff position, will only reduce fuel flow sufficiently to stop the engine. It is not intended as a fuel shutoff valve. When an engine has a tendency to run on with the mixture in idle cutoff, the following check should be made to determine the integrity of the servo unit.

1. Disconnect the fuel outlet line from the servo. A flexible hose or clear tube may be attached to direct fuel into a container, preferably a baby bottle because it is calibrated in cc's. We really do not care what you use; a beer bottle works well too, but then you need something to measure the fuel that has been captured. (Do not drink the contents of the bottle.)

2. Open the throttle approximately half way, and place the mixture control lever in the idle cutoff position.

3. Turn on the boost pump and observe for leakage from the outlet. Allow 2 minutes for this test.

4. If no leakage appears, then great - you have a super-tight system. Otherwise, measure the amount of captured fuel and divide by 2 (minutes) or however many minutes you let the boost pump run. This value is the cutoff valve leakage.

   Now do not be upset if it leaks. Even new units delivered from the factory are allowed to leak up to 5 cc's per minute. If leakage exceeds 7-8 cc's per minute, servo repair should be accomplished according to Bendix S.I.L. 16, Revision 2, or later revision.

OFF-IDLE STUMBLE

Off-idle stumble is normally the result of having the following items misadjusted, attempting to "SMOOTH" out the idle speed.

1. Idle mixture link misadjusted too long or too short.

2. Idle speed adjustment backed out too far compensating for a possible induction leak.

3. Magneto to engine timing advanced from 3 to 5 degrees past manufacturers recommendations to smooth out idle after adjustments 1 and 2.

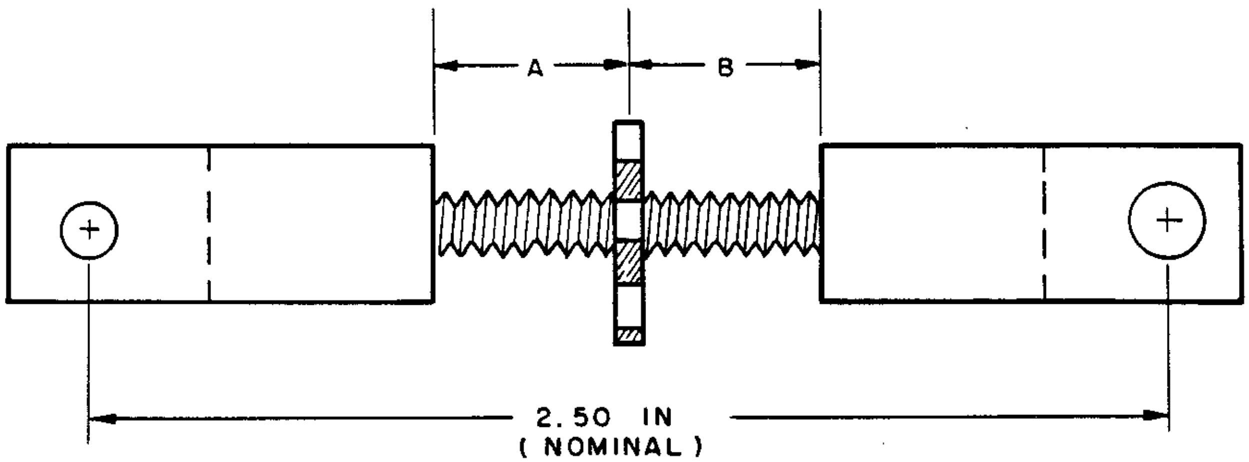


Figure 5. Idle Mixture Leakage

TO CORRECT

1. Remove idle mixture link and reset to the nominal 2.50 inch dimension as shown in Figure 5. The "A" and "B" distances should be equal at the 2.50 dimension. Reinstall idle mixture link. Refer to the master clevis settings list at the end of this manual for exact clevis settings for a particular parts list control.

2. Time magnetos to the engine per the engine manufacturer's instructions.

3. Start engine and allow to warm up.

   A. Set idle speed to obtain recommended speed.

   B. Set idle mixture to obtain 25 to 50 RPM rise. (CLEAR ENGINE AFTER EACH ADJUSTMENT.)

   C. Reset idle speed as necessary.

4. If off-idle stumble still persists, locate the cause and correct.

NOTE

IDLE SPEED AND MIXTURE ADJUSTMENTS MAY BE MADE WITH THE BOOST PUMP ON OR OFF. A NOTICEABLE SHIFT IN ENGINE OPERATION AT IDLE (NORMALLY EXCESS RICHNESS) WITH BOOST PUMP ON VERSUS BOOST PUMP OFF MAY INDICATE THAT THE SERVO UNIT REQUIRES RETURN FOR CORRECTION OF PRESSURE SENSITIVITY.

POSSIBLE CAUSES:

A. Intake manifold air leak.

   1) Manifold drains sticking open

   2) Loose pipes or damaged couplings or "0" rings

B. Damaged nozzle or plugged air bleed.

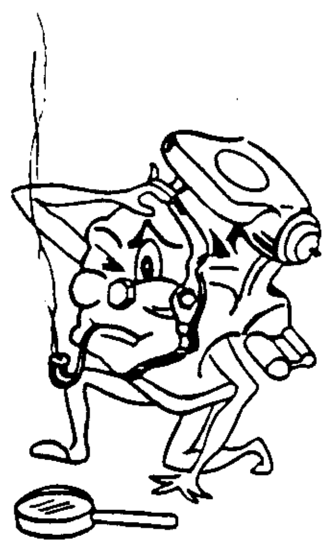
C. Magneto internal timing wrong or shifted.

D. Flow divider sticking open.

E. Air in the fuel system.

F. Servo unit regulator contaminated; send in for repair.

Servo unit regulator contamination can be the result of several items. Poor induction air seals between the filter and servo are the major source of contamination.



TESTING THE SERVO UNIT

ON THE AIRCRAFT

During the troubleshooting process it is possible to check the servo unit as installed on the aircraft for an excess rich or lean condition. This is only an approximate check for troubleshooting. Should a question exist regarding serviceability of the servo, the unit must be sent to a certified overhaul/repair facility.

The servo may be checked for proper IDLE flow as follows:

1. Reset the idle mixture link as indicated under "OFF-IDLE STUMBLE," using master clevis setting as specified for the given parts list control in Tables 1, 2, 3, and 4.

2. Set idle stop screw to give throttle plate to bore clearance as specified in the chart in Tables 1, 2, 3, and 4. Servo units will require partial removal to set this clearance.

3. With the servo outlet line placed in a graduated container capable of holding at least 300 cc's, turn on boost pump with the throttle held solid in the idle position. Open the mixture control for 3 minutes and close. Turn off boost pump.

4. Take the measured fuel and divide the quantity by 3 (minutes). The resulting number (cc's of fuel) should approximate the value shown in Tables 1, 2, 3, and 4. These are only approximate values as some variation may occur due to the condition of the idle valve. Large variations should be considered unacceptable. If the clevis cannot be adjusted to obtain flow within limits specified, the servo unit should be sent in for further evaluation on a test bench.

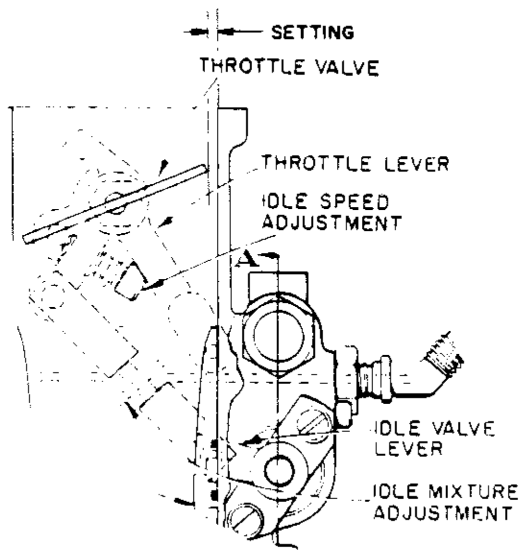


Figure 6. Setting Throttle Valve

TABLE 1. MASTER CLEVIS SETTINGS
FOR <u>BASIC</u> PARTS LISTS OF RSA-5'S

SETTING NO.	CLEVIS SETTING IN INCHES	THROTTLE SETTING	FUEL FLOW CC'S
A	2.664	0.006	40-70
B	2.423	0.006	40-70
C	2.640	0.006	40-70
D	2.620	0.006	40-70
E	2.626	0.006	40-70
F	2.870	0.006	40-70
G	2.506	0.006	40-70
H	2.5	0.020	70-120
I	2.5	0.008	40-90
J	2.5	0.006	40-70

PARTS LIST	SETTING NO.	REF NO.	PARTS LIST	SETTING NO.	REF NO.
RSA-5AB1					
2524199	D	(30/35)	2524348	E	(25/30)
2524216	D	(37/40)	2524359	D	(30/37)
2524254	D	(30/35)	2524450	C	(22/28)
2524262	D	(37/40)	2524459	A	(22/28)
2524378	D	(28/34)	2524475	D	(22/28)
2524712	F	(42/47)	2524550	A	(22/28)
2524858	H	(46/54)	2524575	A	(22/28)
			2524590	A	(22/28)
RSA-5AD1			2524592	A	(22/28)
2524054	A	(22/28)	2524623	A	(22/28)
2524119	A	(22/28)	2524634	A	(22/28)
2524145	B	(22/28)	2524640	E	(22/28)
2524171	A	(22/28)	2524673	A	(22/28)
2524189	A	(22/28)	2524682	E	(25/30)
2524213	A	(22/28)	2524688	E	(22/28)
2524242	B	(22/28)	2524723	G	(22/28)
2524243	A	(22/28)	2524742	G	(26/32)
2524263	A	(22/28)	2524752	G	(26/32)
2524291	A	(22/28)	2524840	A	(22/28)
2524297	A	(22/28)	2524905	B	(22/28)
2524307	B	(22/28)	2524937	A	(22/28)
2524328	B	(22/28)	2524939		(65/71)
2524335	B	(22/28)	2524948	A	(22/28)
2524341	A	(22/28)	2524979		(55/61)

TABLE 2. MASTER CLEVIS SETTINGS
FOR PARTS LISTS OF RSA-7'S

P/L NO.	CLEVIS SETTING IN INCHES	THROTTLE SETTING	FUEL FLOW CC'S
2524347	2.592	0.006	40-60
2524624	2.592	0.006	70-110

TABLE 3. MASTER CLEVIS SETTINGS
FOR PARTS LISTS OF RS-10'S

BASIC NO.	CLEVIS SETTING IN INCHES	THROTTLE SETTING	FUEL FLOW CC'S
391821	2.375	0.006	10 CC'S/CYL
2524696	2.375	0.006	20 CC'S/CYL
2524470	2.375	0.006	10 CC'S/CYL
2524665	2.375	0.006	20 CC'S/CYL
2524367	2.398	0.006	20 CC'S/CYL
2524014	2.398	0.006	20 CC'S/CYL
391825	2.431	0.006	10 CC'S/CYL
391787	2.375	0.006	10 CC'S/CYL

TABLE 4. MASTER CLEVIS SETTINGS
FOR PARTS LISTS OF RSA-10'S

P/L NO.	CLEVIS SETTING IN INCHES	REF NO.	THROTTLE SETTING	FUEL FLOW CC'S
RSA-10AD1				
2524030	2.435	(50/56)	0.006	70-110
2524152	2.435	(50/56)	0.006	70-110
2524163	2.484	(60/66)	0.006	70 110
2524175	2.418	(55/65)	0.006	70-110
2524255	2.575	(50/56)	0.006	70-110
2524256	2.575	(57/63)	0.006	70-110
2524311	2.435	(50/56)	0.006	70-110
2524318	2.435	(50/56)	0.006	70-110
2524757	2.435	(50/56)	0.006	70-110
RSA-10DB1				
2524267	2.5	(56/62)	0.006	70-110
2524275	2.530	(54/60)	0.006	70-110
2524276	2.5	(56/62)	0.006	70-110
2524423	2.550	(54/60)	0.006	70-110
2524593	2.481	(46/52)	0.006	70-110
2524649	2.500	(62/69)	0.006	70-110
2524799	2.5	(54/60)	0.006	70-110
2524855	2.481	(40/45)	0.006	70-110
RSA-10DB2				
2524501	2.484	(52/65)	0.006	70-110
2524708	2.500	(52/65)	0.006	70-110
2524896	2.5	(55/60)	0.006	70-110
RSA-10ED1				
2524273	2.481	(35/43)	0.006	70-110
2524298	2.481	(35/43)	0.006	70-110
2524366	2.5	(55/65)	0.006	70-110
2524420	2.5	(35/43)	0.006	70-110
2524422	2.512	(35/43)	0.006	70-110
2524477	2.5	(52/58)	0.006	70-110
2524491	2.481	(35/43)	0.006	70-110
2524492	2.5	(52/58)	0.006	70-110
2524500	2.445	(54/60)	0.006	70-110
2524534	2.481	(35/43)	0.006	70-110
2524556	2.481	(35/43)	0.006	70-110
2524582	2.481	(35/43)	0.006	70-110
2524693	2.5	(48/54)	0.006	70-110
2524709	2.500	(44/50)	0.006	70-110
2524811	2.5	(35/43)	0.006	70-110
2524846	2.5	(54/60)	0.006	70-110
2524859	2.512	(35/43)	0.006	70-110
2524880	2.5	(65/71)	0.006	70-110
RSA-10ED2				
2524791	2.520	(55/61)	0.006	70-110

INTERMITTENT POWER LOSS

The most aggravating problem for a mechanic is trying to find the reason(s) for an intermittent power loss. Generally, this is not caused by the fuel servo unit. Many times it is the interuption of either the air or fuel supply to the fuel injection servo unit by such things as air in the fuel or a restricted induction air duct.

NOTE

> The words power loss used here refer to the complete stopping of the engine and subsequent ability to restart and obtain full power.

The servo unit will not cause an intermittent/inconsistent power loss even momentarily. If a servo unit would happen to be responsible for an engine stoppage, i.e., an internal servo failure, the cause of the stoppage would remain and be readily apparent during flow test and tear-down inspection.

If a power loss is accompanied by high fuel flow, check nozzles, nozzle lines, and flow divider for indications of a contamination problem. Check for water or moisture in the fuel. Given the right situation, this can form ice crystals in the fuel, temporarily blocking the fuel nozzles. Once the engine has stopped, the ice will melt and the fuel supply will be restored. High fuel flow (normally a pegged gage) will accompany this situation. Ice could also block other fuel lines and not melt until after the aircraft has landed.

Check intake system, especially double walled ducting, for integrity.

Check air filter for condition, particularly after flying in wet conditions, and alternate air door for proper operation.

Check aircraft main fuel filter for contamination such as water, salt, sand, etc. Also ensure filter housing is properly installed as this could be a source of air in the fuel.

Check fuel hoses for deterioration or a flap of rubber near fitting ends.

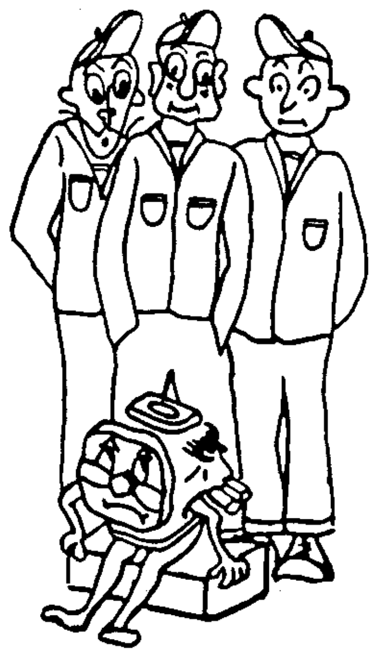
Check for compliance with A.D. 75-09-15; this is an old A.D. that deals with changing the flow divider gasket.

Check ignition and ignition components. Many times failure of these components will symptomize a fuel system problem to the extent that leaning the mixture improves engine operation and ability to achieve full power.

Check valve guides for looseness.

Check exhaust system--especially muffler baffles--for deterioration.

Check for air in the fuel system, see page 3, Air in Fuel System, especially if the power loss is associated with a particular aircraft attitude.



ENGINE HANGS DURING ACCELERATION

Though the causes of engine hang-ups during acceleration are many and varied, it has been noticed that the speed at which the engine hangs and the actual problem are related.

SPEED	PROBLEM	CAUSE
1700-1800	Engine hangs on first start of the day and operates normally until next days start.	Oil or fuel contamination of servo regulator. Normally this is the first sign of a turbocharger seal leak.
	Engine hangs or is slow to transition this range.	Ignition problem.
1900	Propeller	Wrong pitch setting.
2100-2200	Engine is slow to transition this range and may run rich.	Turbo system component.
	Engine runs rich and hangs--will not accelerate past 2200 RPM.	Internal timing.
2200-2400	Engine rus rich and will accelerate through this if leaned with mixture.	Propeller low pitch stop setting or internal propeller problem.
		Differential controller or bypass valve (waste gate).

LEAN ENGINE

Engine runs lean at settings above idle. Bench test of servo indicates that the servo unit is at or above the nominal new limit setting.

1. Check the flow divider for sticking. If sticking is the result of contamination, then locate and correct source of contamination.

2. On RSA-7AA1 controls, check "Rose bud" (fitting) for incomplete machining, burrs, or contamination.

3. Check nozzle lines for breaks at braze joints. For brazed joints and proper ID of fuel lines, see Lycoming S.I. 1301.

4. Induction air leaks. Pressure check induction system. (Disconnect M.A.P. gage before performing pressure check.)

5. Check fuel system for air leaks especially if idle is erratic.

FUEL FLOW INDICATION

1. Reads too high accompanied by rich running engine.

   a. Partially restricted nozzle, nozzle line, and/or flowdivider. See Checking Nozzles.

   b. Fuel pump by-pass valve sticking (positive displacement pumps only), identified by high fuel pump outlet pressure.

2. Reads too low and engine operation is normal.

   a. Damping restrictor in flowdivider/fuel servo unit plugged. Gage channel in flowdivider plugged.

   b. Reading at idle is zero and increases when boost pump is turned on and returns to zero: faulty gage.

   c. Wrong gage installed. Fuel pressure at idle is less than 1/2 psi. A different gage is required for four, six, and eight cylinder engines.

d. Plugged air bleed on one or more nozzles.

FUEL FLOW FLUCTUATION

1. Check pressure from main pump to servo unit for fluctuation. pressure fluctuations indicate possible fuel pump problems.

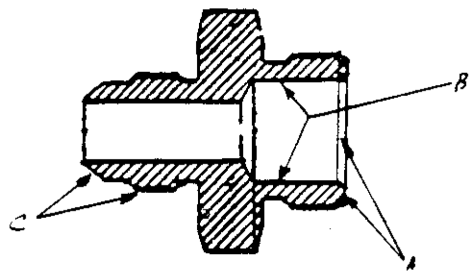
2. Check for plugged main aircraft fuel filter.

3. Check for air in the fuel in accordance with procedure outlined on page 3, air in fuel system.

4. Check servo unit for water contamination.

5. Ensure fuel flow gauge line has been purged of air.

6. Check servo fuel inlet fitting (filter side) for corrosion,see figure 7.



Areas A and B, No corrosion permitted

Figure 7. Typical Inlet Fitting

ENGINE RUNS RICH AND ROUGH UNTIL OIL TEMP REACHES 130-140 DEGREES

The Precision Airmotive system is not affected by oil temperature. This problem has been found to be a spalled lifter(s) on some engines. Contact the engine manufacturer.