QUESTIONS AND ANSWERS

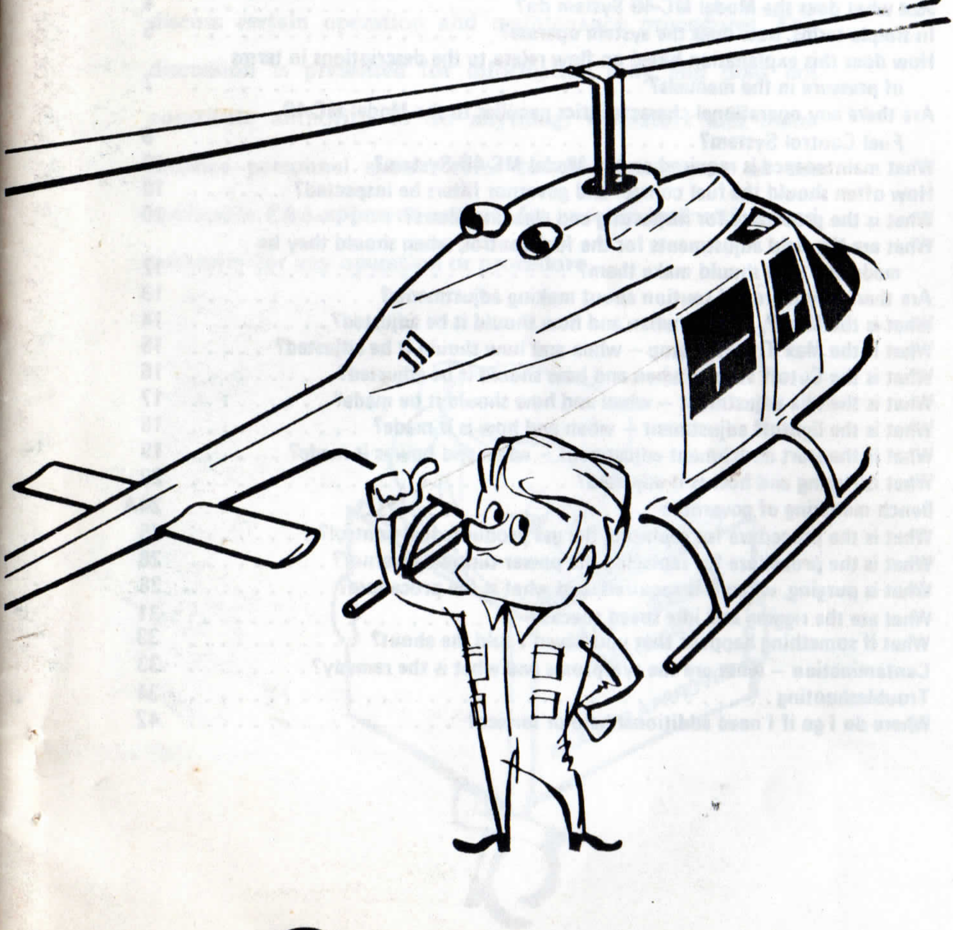
about the

CHANDLER EVANS

MODEL MC-40 FUEL CONTROL SYSTEM

for the

ALLISON 250C20 TURBOSHAFT ENGINE



Colt Industries **Chandler Evans Control Systems Division**

WEST HARTFORD, CONNECTICUT 06101

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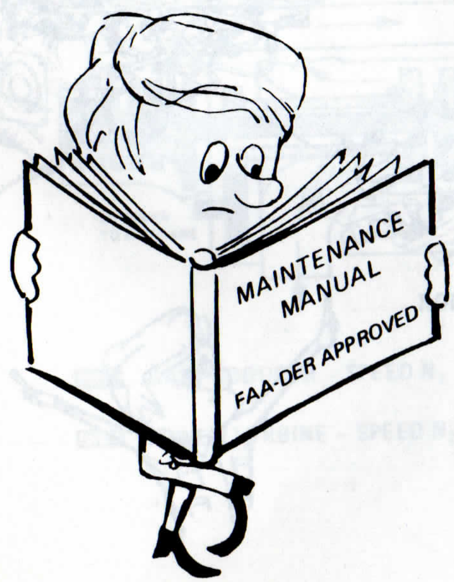
Foreword

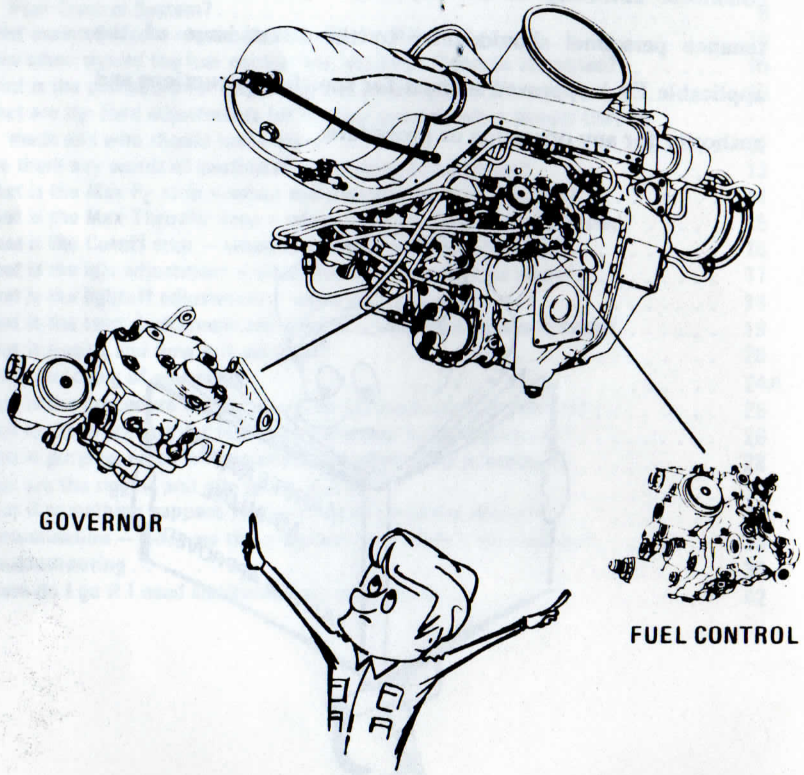
This booklet was prepared by the Chandler Evans Product Support Group to answer the most frequently asked questions about the Model MC-40 Fuel Control System for the Allison 250C20 Turboshaft Engine.

In answering some of the questions it is necessary to discuss certain operation and maintenance procedures. This discussion is presented for information only and does not constitute authority to *do* anything. Operators and maintenance personnel should refer to the latest issue of the applicable FAA-approved manual for specific instructions and authority for any operation or procedure.



"Why two separate units in the MC-40 System?"

Separate units are required since they must be installed at different locations on the engine gearbox. The fuel control has a splined shaft which engages in the accessories gear train, connected to the gas producer turbine. The splined shaft on the governor engages in the output gear train, connected to the power turbine. This arrangement is necessary to pick up and sense the two operating speeds, N_1 and N_2 found in a free turbine engine such as the Allison 250C20.



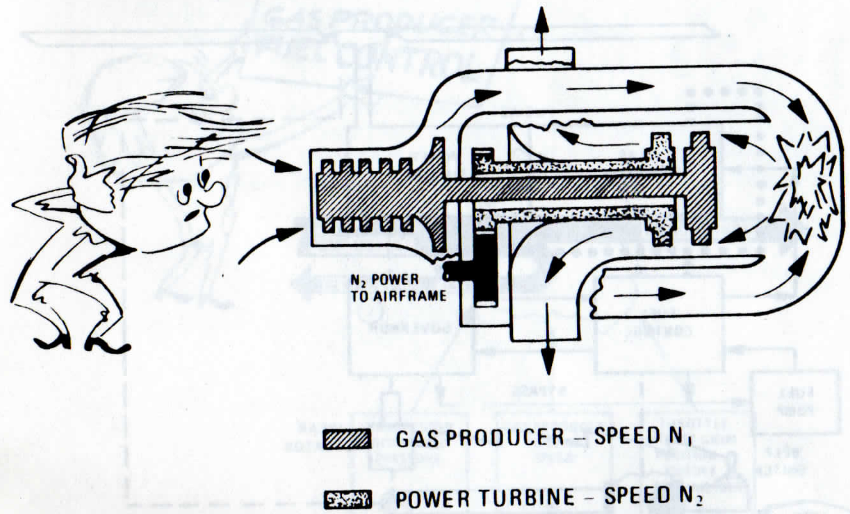
"What is meant by a 'free turbine' engine?"

In the Allison 250C20 engine, there is no direct, mechanical coupling between the two turbines:

1. The gas producer turbine, which drives the compressor.
2. The power turbine, which drives the helicopter rotor through a gear reduction unit.

The two turbines are connected only in terms of gas flow. This "fluid coupling" arrangement permits the turbines to operate at different speeds. To manage fuel flow to the engine for all flight and power requirements, the fuel control system must be sensitive to the speeds of both turbines.

In the Allison 250C20 engine, the gas producer turbine speed is designated as N_1 and the power turbine speed as N_2.



"Just what does the Model MC-40 System do?"

The Model MC-40 System provides for total fuel management to control the operation of the Allison 250C20 engine.

FUEL CONTROL

The fuel control is mechanically connected to the pilot's twist grip and, through the accessories gear train, to the gas producer turbine. It senses compressor discharge pressure through an air line.

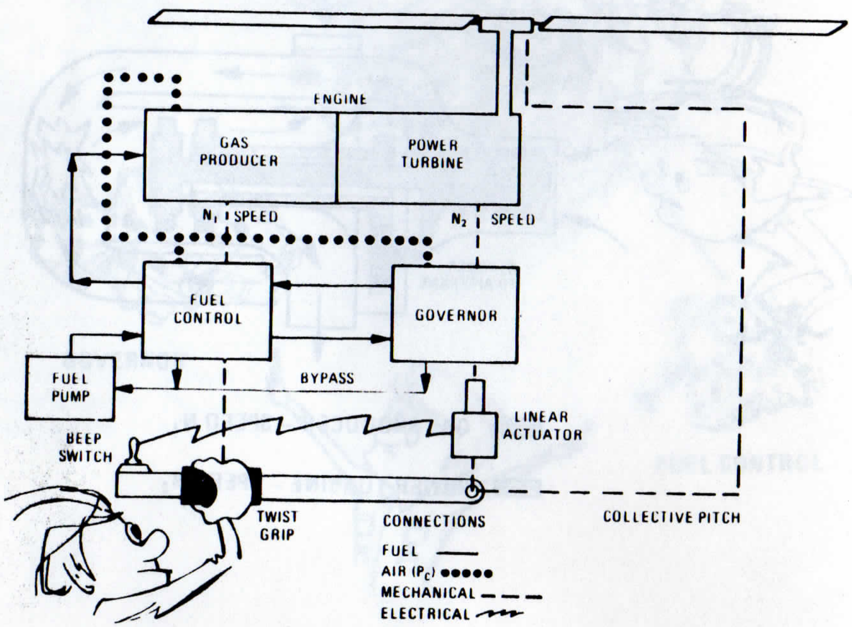
The function of the fuel control is to provide the right amount of fuel to the engine throughout the start cycle, at ground idle and to meet all of the requirements of powered flight. Since the fuel control is sensitive to and controls the speed of the gas producer turbine, it is known as the N_1 control.

GOVERNOR

The governor is mechanically connected to the pilot's collective pitch control through a linear actuator. The actuator is electrically operated by the beep trim switch and allows the pilot to make minor adjustments (approximately 5% total) in N_2 to compensate for aerodynamic and ambient conditions.

The governor is mechanically coupled, through the output gear train, to the power turbine, and also senses compressor discharge pressure through an air line.

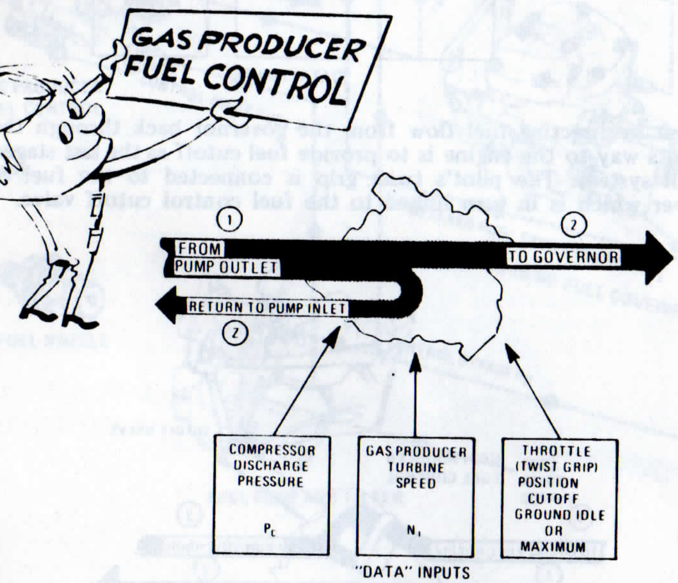
A helicopter is designed to operate with a constant rotor speed in flight. The function of the governor is to maintain the power turbine speed constant (at 100% N_2) under varying load conditions as established by the collective pitch. Because the governor senses and controls power turbine speed, it is known as the N_2 control.



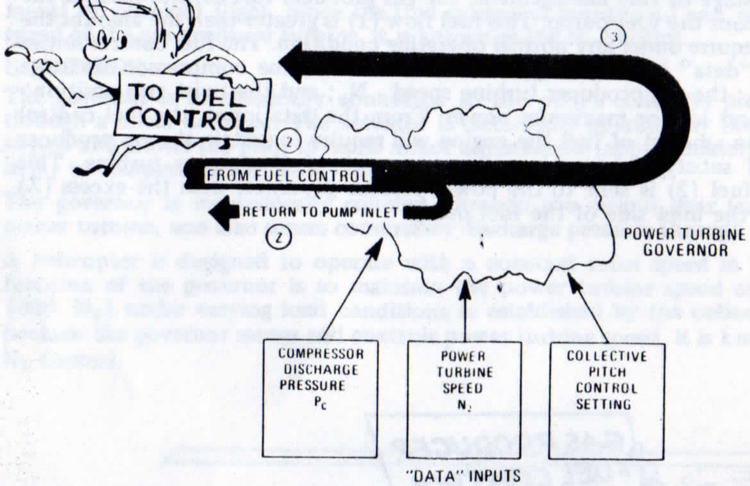
"In simple terms, how does the system operate?"

The easiest way to understand the system operation is in terms of fuel flow, considering both the gas producer fuel control and the power turbine governor as valves with built-in computers. Actually, both the fuel control and governor *do* have built in computers. However, these are hydromechanical computers rather than the electronic type we normally think of.

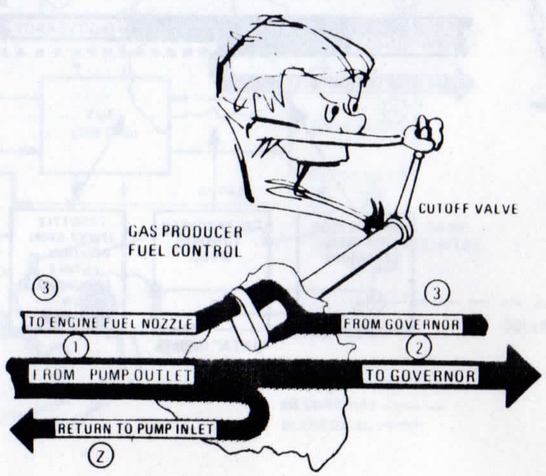
In the first stage of fuel management, the gas producer fuel control receives the total flow from the fuel pump. This fuel flow (1) is greater than the amount the engine will require under any normal operating condition. The fuel control senses or receives "data" input from three sources: the engine compressor discharge pressure - P_c; the gas producer turbine speed - N_1; and the twist grip position - cutoff, ground idle or maximum power. From the data input, the fuel control computes the amount of fuel the engine will require to sustain the gas producer turbine and satisfy the *maximum* requirement of the power turbine. This amount of fuel (2) is sent to the power turbine governor, with the excess (Z) returned to the inlet side of the fuel pump.



The fuel flow from the fuel control to the governor is based on the gas producer turbine needs and *maximum* power turbine requirements. This fuel flow may be greater than the amount required to meet *actual* power requirements at any given moment. The governor senses or receives "data" input from three sources: the engine compressor discharge pressure - P_c; the power turbine speed - N_2; and the collective pitch control setting. From the data input the governor computes the amount of fuel the engine will require to meet actual power requirements and maintain N_2 at 100%, at the same time sustaining gas producer turbine operation. This amount of fuel (3) is sent to the engine, back through the fuel control. Excess fuel (Z) is returned to the inlet side of the pump.



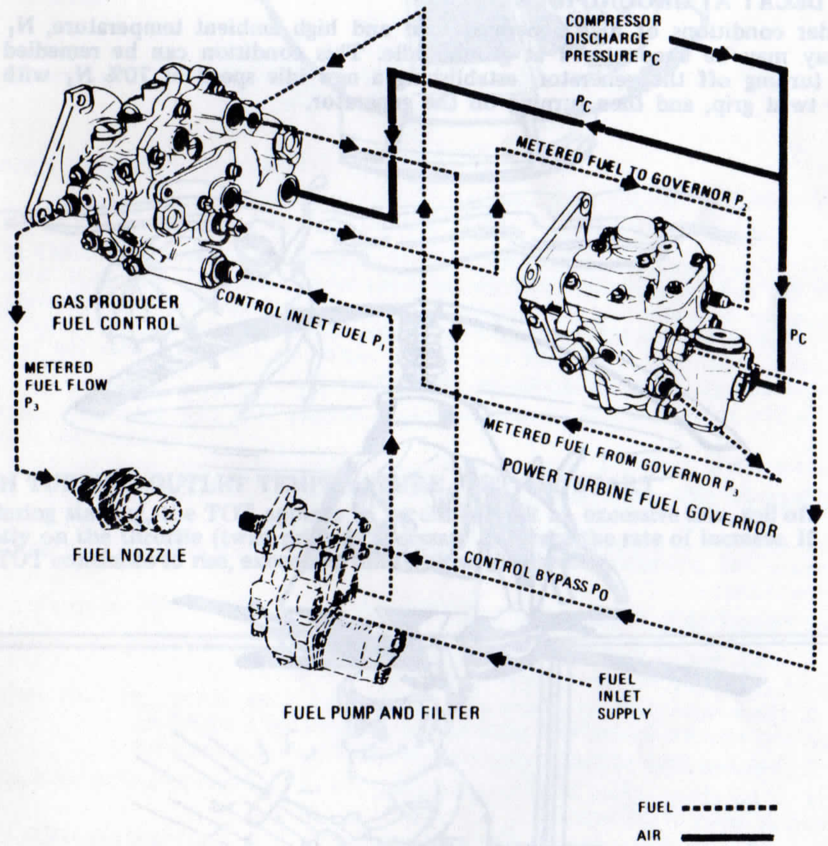
The purpose in directing fuel flow from the governor back through the fuel control on its way to the engine is to provide fuel cutoff as the last stage in the fuel control system. The pilot's twist grip is connected to the fuel control throttle lever which is in turn linked to the fuel control cutoff valve.



"How does this explanation based on flow relate to the descriptions in terms of pressure in the manuals?"

Basically, we're talking about the same thing. Since the engine fuel nozzle is essentially a fixed orifice, flow through it will vary directly with fuel pressure.

This diagram will help to illustrate connections, flow paths and the pressures involved in terms of the actual equipment. P_c, compressor discharge pressure, is supplied to both the fuel control and governor through an air line connected to a pressure tap on the compressor discharge manifold. The fuel pressure subscripts (1, 2 and 3) correspond to the flows we discussed earlier, Z corresponding to zero (0).



"Are there any operational characteristics peculiar to the Model MC-40 Fuel Control System?"

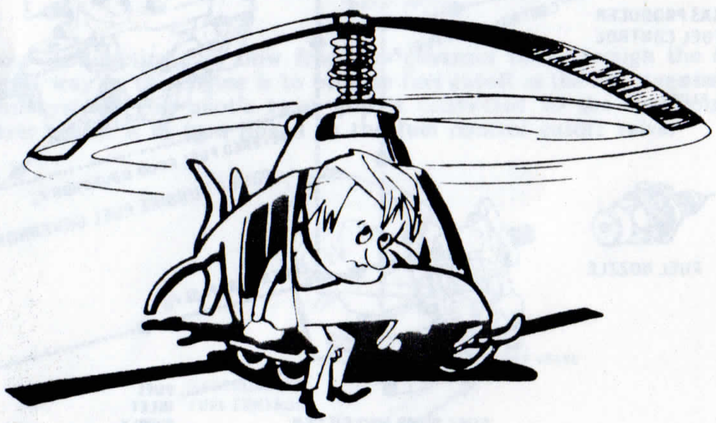
Yes, there are three characteristics that may be experienced under certain conditions. We'll consider these one at a time, describing the characteristic, the conditions under which it may be encountered, and the remedy specified by the aircraft or engine manufacturer.

CAUTION

Be sure to refer to the latest issue of the applicable manual for specific instructions before attempting any of the procedures described.

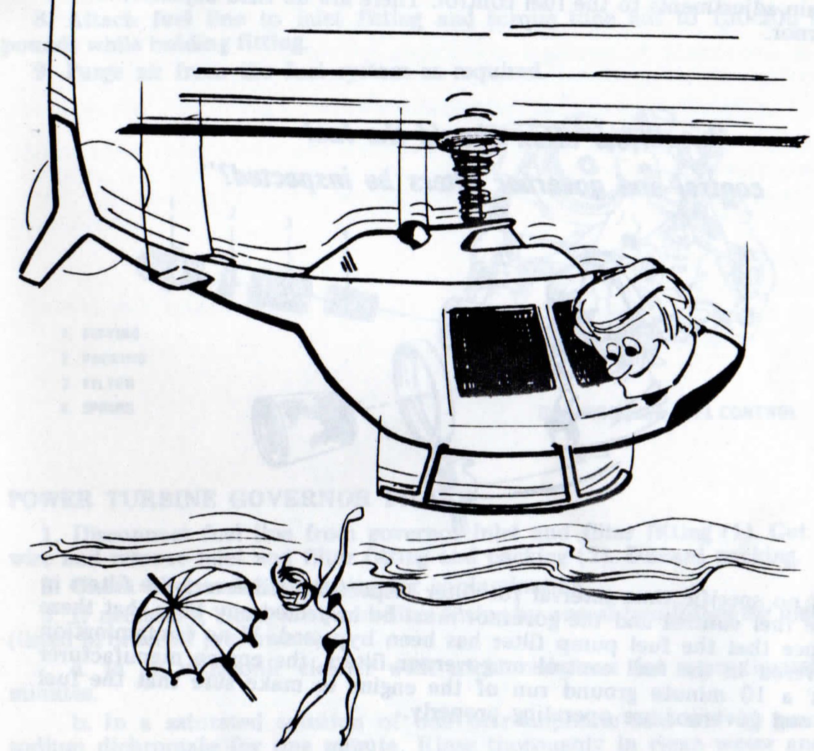
N_1 DECAY AT GROUND IDLE

Under conditions of high generator load and high ambient temperature, N_1 decay may be encountered at ground idle. This condition can be remedied by turning off the generator, establishing a new idle speed of 70% N_1 with the twist grip, and then turning on the generator.



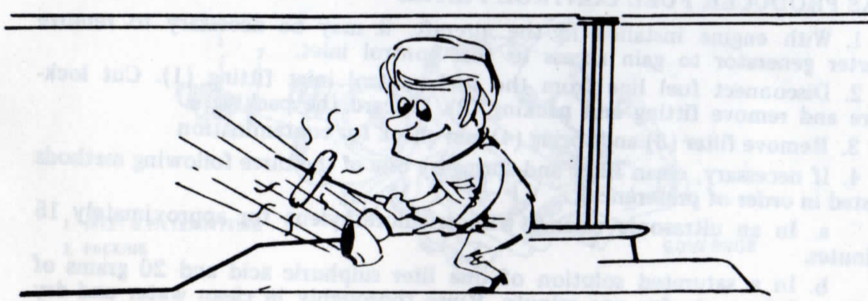
TRANSIENT HIGH N_2

On entering low power conditions, a transient high N_2 condition (105 - 106%) will occur. N_2 will then reset to 102-103%. Thereafter, N_2 must be monitored and re-established at 100% through use of the beeper trim system or through added collective pitch.



HIGH TURBINE OUTLET TEMPERATURE (TOT) AT START

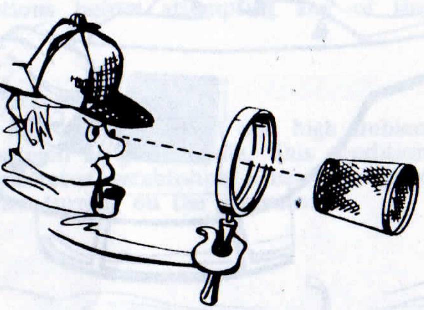
If, during starting, the TOT appears to be climbing at an excessive rate, roll off slightly on the throttle (twist grip) as necessary to retard the rate of increase. If the TOT continues to rise, exceeding limits, close the throttle.



"What maintenance is required on the Model MC-40 System?"

There are no periodic maintenance procedures required. Field maintenance is limited to the inspection and cleaning of the fuel control and governor filters, and certain adjustments to the fuel control. There are no field adjustments for the governor.

"How often should the fuel control and governor filters be inspected?"



There is no specific time interval for filter inspection. However, the filters in both the fuel control and the governor *must* be inspected any time that there is evidence that the fuel pump filter has been bypassed. If no contamination is discovered in the fuel control or governor filters, the engine manufacturer specifies a 10 minute ground run of the engine to make sure that the fuel control and governor are operating properly.

"What is the procedure for inspecting and cleaning the filters?"

Basically the procedures are as follows (refer to the engine manual for specific instructions):

GAS PRODUCER FUEL CONTROL FILTER

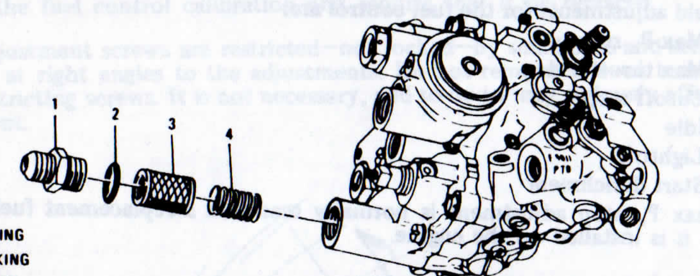
1. With engine installed in the aircraft, it may be necessary to remove starter generator to gain access to fuel control inlet.
2. Disconnect fuel line from the fuel control inlet fitting (1). Cut lockwire and remove fitting and packing (2). Discard the packing.
3. Remove filter (3) and spring (4) and check for contamination
4. If necessary, clean filter and spring by one of the three following methods (listed in order of preference):

   a. In an ultrasonic cleaner with trichlorethylene for approximately 15 minutes.

   b. In a saturated solution of one liter sulphuric acid and 20 grams of sodium dichromate for one minute. Rinse thoroughly in clean water and dry with compressed air.

   c. In mineral spirits, using a clean, stiff brush.

5. Hold filter up to the light and check for contamination between inside and outside screens. Repeat cleaning procedure if necessary.
6. Fit spring (4) into cupped end of filter (3). Keep parts together (use a dab of petrolatum if necessary) and install in fuel control. Press in on filter, compressing spring, to check bypass action.
7. Install fitting (1) with new packing (2). Torque to 60-80 inch-pounds and lockwire.
8. Attach fuel line to inlet fitting and torque tube nut to 150-200 inch-pounds while holding fitting.
9. Purge air from the fuel system as required.



1. FITTING
2. PACKING
3. FILTER
4. SPRING

GAS PRODUCER FUEL CONTROL

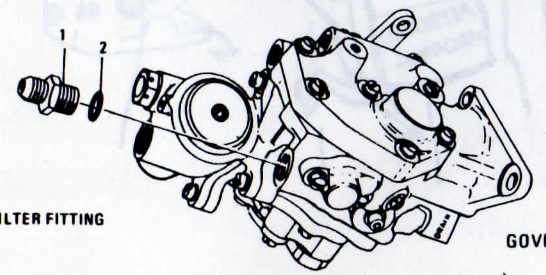
POWER TURBINE GOVERNOR FILTER

1. Disconnect fuel line from governor inlet and filter fitting (1). Cut lockwire and remove inlet and filter fitting and packing (2). Discard packing.
2. Check inlet and filter fitting for contamination.
3. If necessary, clean inlet and filter fitting by one of two following methods (listed in order of preference):

   a. In an ultrasonic cleaner with trichlorethylene for approximately 15 minutes.

   b. In a saturated solution of one liter sulphuric acid and 20 grams of sodium dichromate for one minute. Rinse thoroughly in clean water and dry with compressed air.

4. Check filter for contamination and repeat cleaning procedure if necessary.
5. Install the inlet and filter fitting (1) with new packing (2). Torque to 40-65 inch-pounds and lockwire.
6. Attach fuel line to inlet and filter fitting and torque tube nut to 150-200 inch-pounds.
7. Purge air from the fuel system as required.



1. INLET & FILTER FITTING
2. PACKING

GOVERNOR

"What are the field adjustments for the fuel control, when should they be made, and who should make them?"

To answer the last part of the question first, adjustments to the fuel control should be made only by a qualified aircraft mechanic and then only at installation or to correct an operating deficiency. If the engine is performing up to specifications, tinkering with the adjustments is neither necessary nor desirable.

The field adjustments for the fuel control are:

1. Max P_c stop
2. Max throttle stop
3. Cutoff stop
4. Idle
5. Lightoff
6. Start derichment

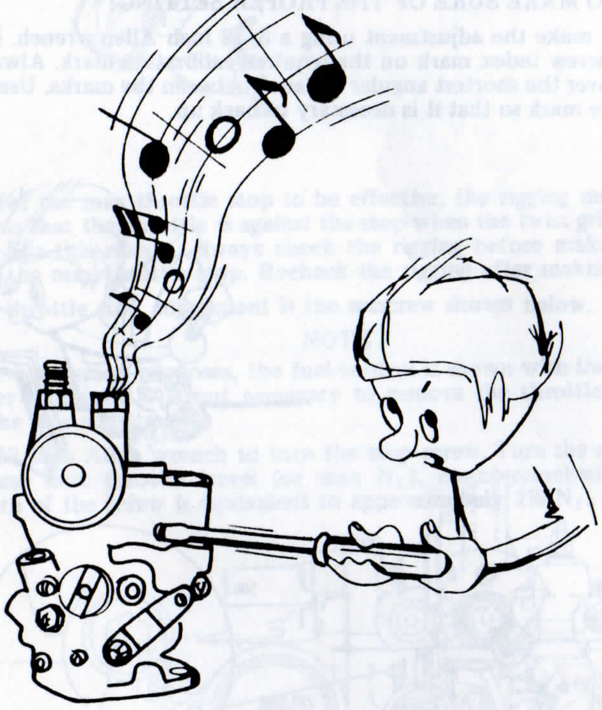
The max P_c stop adjustment is normally made on a replacement fuel control *before* it is installed on the engine.

"Are there any words of caution about making adjustments?"

Yes, there are a couple.

There are many adjustment points on the fuel control in addition to the six mentioned. Some of these are quite similar in appearance but must be performed with the fuel control installed on a test bench. Always consult the engine manual for specific adjustment procedures and *make sure* that the proper screw is being adjusted. Adjustment of the wrong screw may cause a shift in the fuel control calibration and require that it be replaced.

Some adjustment screws are restricted—not locked—by small balls and setscrews installed at right angles to the adjustments. Do not remove or even loosen the small restricting screws. It is not necessary, and to do so may seriously affect the adjustment.

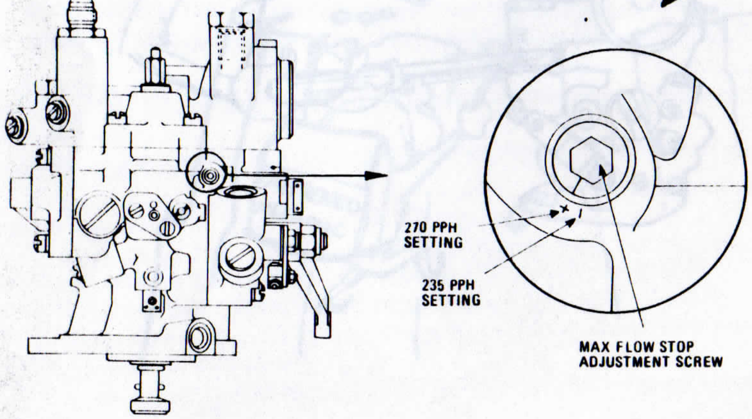


"What is the max Pc stop - when and how should it be adjusted?"

The max P_c stop could be (and sometimes is) called the max flow stop since the effect of increasing compressor discharge pressure (P_c) is to increase fuel flow for engine acceleration. If required, this adjustment is made on a replacement fuel control (or the fuel control on a replacement engine) before installation.

The Max P_c stop adjustment is located as shown in this illustration, near the FUEL IN FROM POWER TURBINE GOVERNOR port. Note that there is an index mark on the adjustment screw and "+" and "–" marks on the housing. The "+" mark corresponds to 270 pph max fuel flow and the "–" mark corresponds to 235 pph max fuel flow. ALWAYS REFER TO THE AIRCRAFT MANUAL TO MAKE SURE OF THE PROPER SETTING!

If necessary, make the adjustment using a 5/32 inch Allen wrench. Position the adjustment screw index mark on the required calibration mark. Always turn the adjustment over the shortest angular distance between the marks. Use care not to overshoot the mark so that it is necessary to back up.



"What is the max throttle stop - when and how should it be adjusted?"

The max throttle stop is a setscrew that limits the travel of the throttle pointer in the max (90°) direction. Its effect is to provide a throttle opening that meets, but does not exceed the engine max power rating of 104% N_1 max.

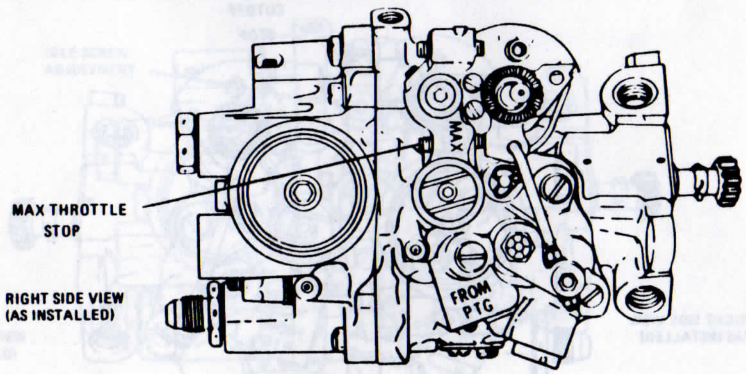
In order for the max throttle stop to be effective, the rigging must be properly adjusted so that the throttle is against the stop when the twist grip is in the max position. For this reason, always check the rigging before making any adjustments to the max throttle stop. Recheck the rigging after making adjustments.

The max throttle stop adjustment is the setscrew shown below.

NOTE

For illustration purposes, the fuel control is shown with the throttle lever removed. It is not necessary to remove the throttle lever to make this adjustment.

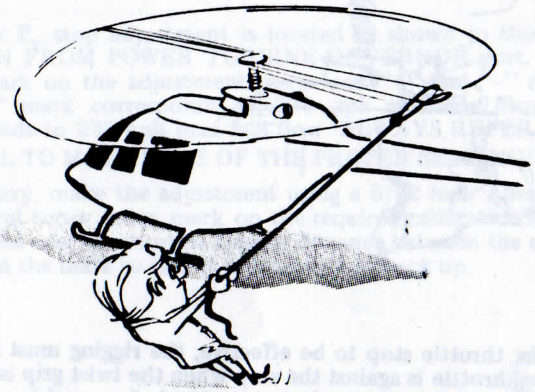
Use a 3/32 inch Allen wrench to turn the stop screw. Turn the screw clockwise to decrease max throttle travel (or max N_1), counterclockwise to increase. A 1/8 turn of the screw is equivalent to approximately 1% N_1.



"What is the cutoff stop - when and how should it be adjusted?"

The cutoff stop is a setscrew that limits the travel of the throttle lever in the min (0°) direction. Its effect is to establish the cutoff position for the throttle. Field adjustment of this stop is normally made to correct an operating difficulty related to cutoff.

For the min throttle stop to be effective, the rigging must be properly adjusted so that the pointer is against the stop when the twist grip is in the cutoff position. For this reason, always check the rigging before making any adjustments to the cutoff stop. Recheck the rigging after making adjustments.

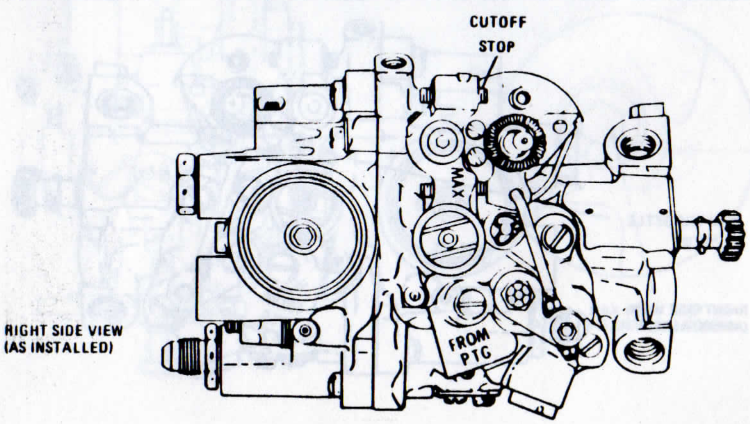


The cutoff stop adjustment is the setscrew shown below.

NOTE

For illustration purposes, the fuel control is shown with the throttle lever removed. It is not necessary to remove the throttle lever to make this adjustment.

On aircraft configurations that permit travel below 0°, the stop screw may be adjusted to a minus 2°. Using a 3/32 inch Allen wrench, turn the stop screw counterclockwise to decrease stop setting. A 1/4 turn of the screw is equivalent to approximately 1° on the quadrant.



"What is the idle adjustment - when and how should it be made?"

The idle adjustment should more properly be called the idle trim adjustment since it is used to trim the idle (N_1) speed when the fuel control throttle pointer is at 30°.

The adjustment is necessary only when the N_1 idle speed is outside the specified limits with the generator turned off. Since idle speed is also based on a 30° fuel control quadrant setting, always check the rigging and readjust, if necessary, before making the idle adjustment.

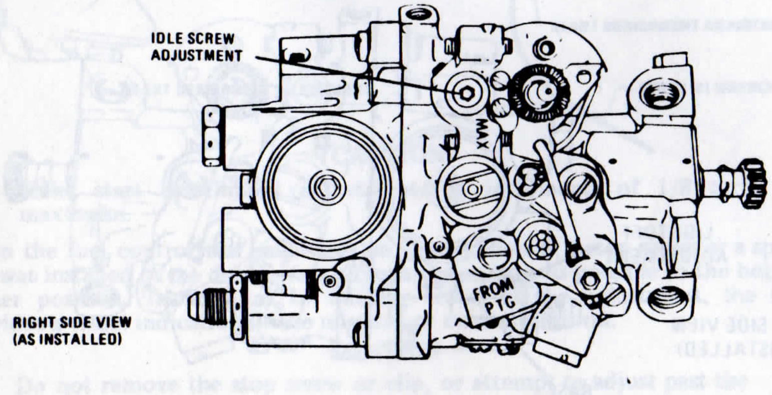
The idle adjustment is the screw shown below.

NOTE

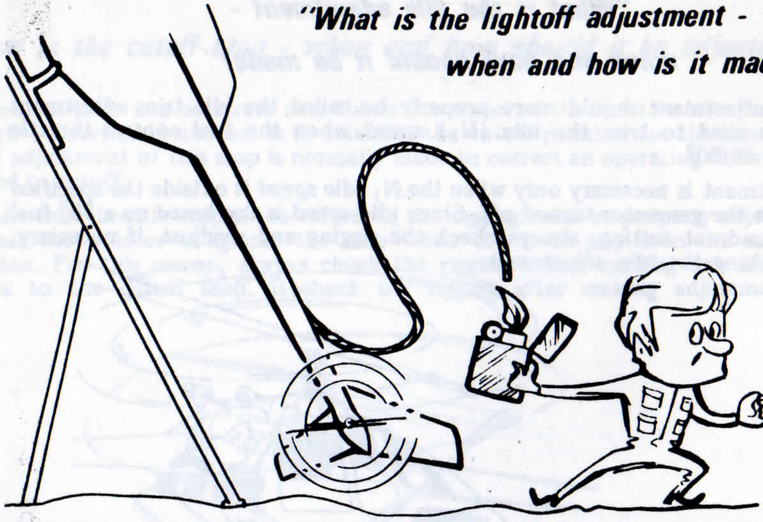
For illustration purposes, the fuel control is shown with the throttle lever removed. It is not necessary to remove the throttle lever to make this adjustment.

Make sure that the fuel control is set at 30° on the quadrant with the twist grip in idle before making any adjustments.

Use a 5/32 inch Allen wrench to adjust the idle screw. Turn the screw clockwise to increase N_1 idle speed, counterclockwise to decrease. A 1/8 turn of the idle screw is equivalent to approximately 1% N_1.



"What is the lightoff adjustment - when and how is it made?"



The lightoff adjustment regulates a stop that controls the fuel flow at lightoff (15% N_1). Adjustment is necessary only when lightoff problems are encountered during starting.

If the lightoff adjustment is too low the engine may fail to light off or the lightoff temperature may be too low. If the adjustment is too high, the lightoff temperature may be too high.

The lightoff adjustment is made at the screw shown below.

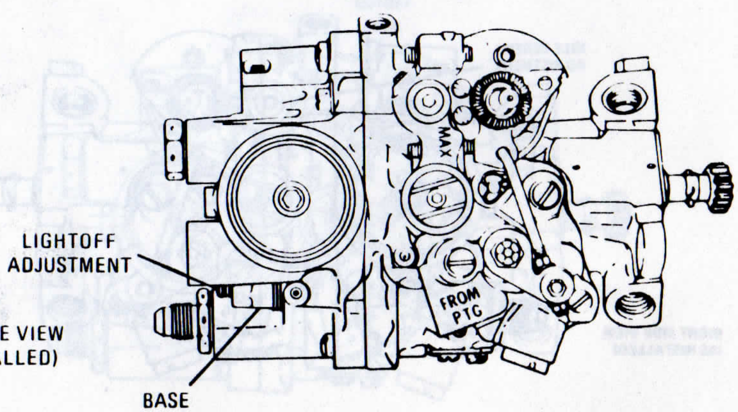
CAUTION

> Do not disturb the setting of the base into which the lightoff adjustment is threaded. The base is a precise test bench adjustment.

Using a 5/64 inch Allen wrench, turn the adjustment screw clockwise to decrease lightoff fuel flow, counterclockwise to increase.

CAUTION

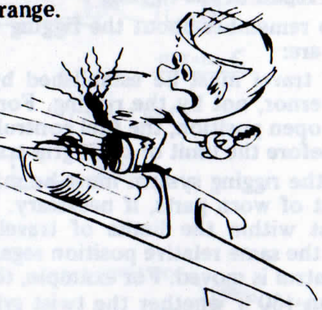
> Make lightoff adjustments in increments of 1/16 turn maximum. Limit total adjustment to ±1/4 turn from the original setting.



"What is the start derichment adjustment - when and how is it made?"

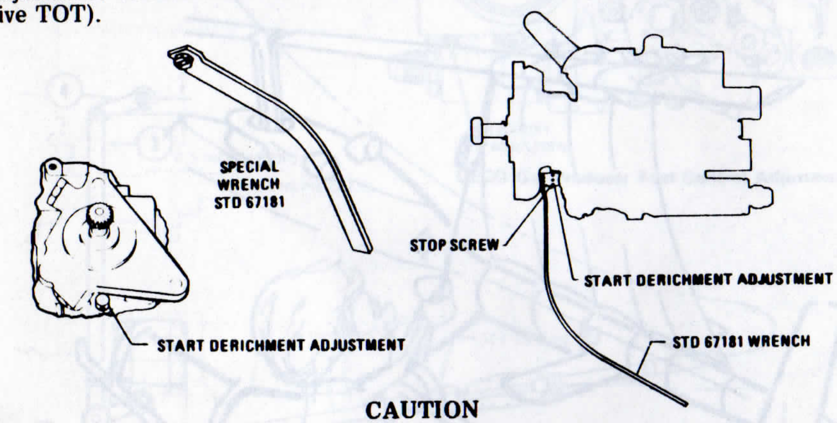
During start, from approximately 25% N_1 to approximately 40% N_1 temporary fuel derichment, or a dip in the fuel flow is required to provide the starting performance. When fuel flow is plotted against N_1 this dip in fuel flow takes the appearances of a notch, so that is what it is commonly called.

The duration or width of the notch is controlled by the start derichment adjustment. Decreasing the width of the notch generally results in faster, hotter starts. However, if the notch is too narrow, excessively high TOT may be encountered in the 25% to 40% N_1 acceleration range.



As shown here, the start derich adjustment is located near the bottom of the fuel control, close to the mounting pad. Clearances are such that the use of the special wrench (Chandler Evans Part No. STD67181) is recommended, although a 1/4 inch Allen wrench with a 1/2 inch offset may be used.

Turn the derichment adjustment clockwise (viewed from end of adjustment screw) to decrease notch width (move toward hotter, faster starts). Turn the adjustment counterclockwise to increase notch width (move away from excessive TOT).



CAUTION

> Make start derichment adjustments in increments of 1/8 turn maximum.

When the fuel control was calibrated on the test bench, a stop screw or a spring clip was installed in the derichment adjustment as close as possible to the bottom center position. In addition to limiting travel of the adjustment, the stop provides a visual indication of the nominal or normal position.

CAUTION

> Do not remove the stop screw or clip, or attempt to adjust past the stop.

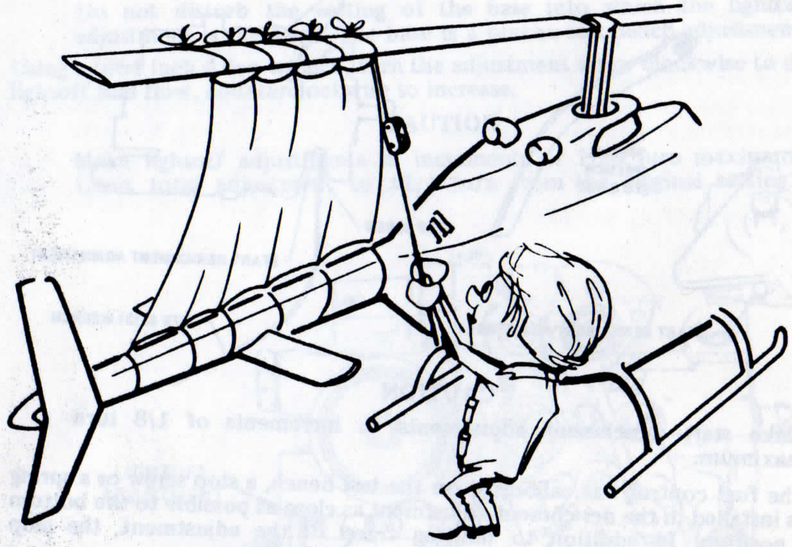
"What is the rigging and how is it adjusted?"

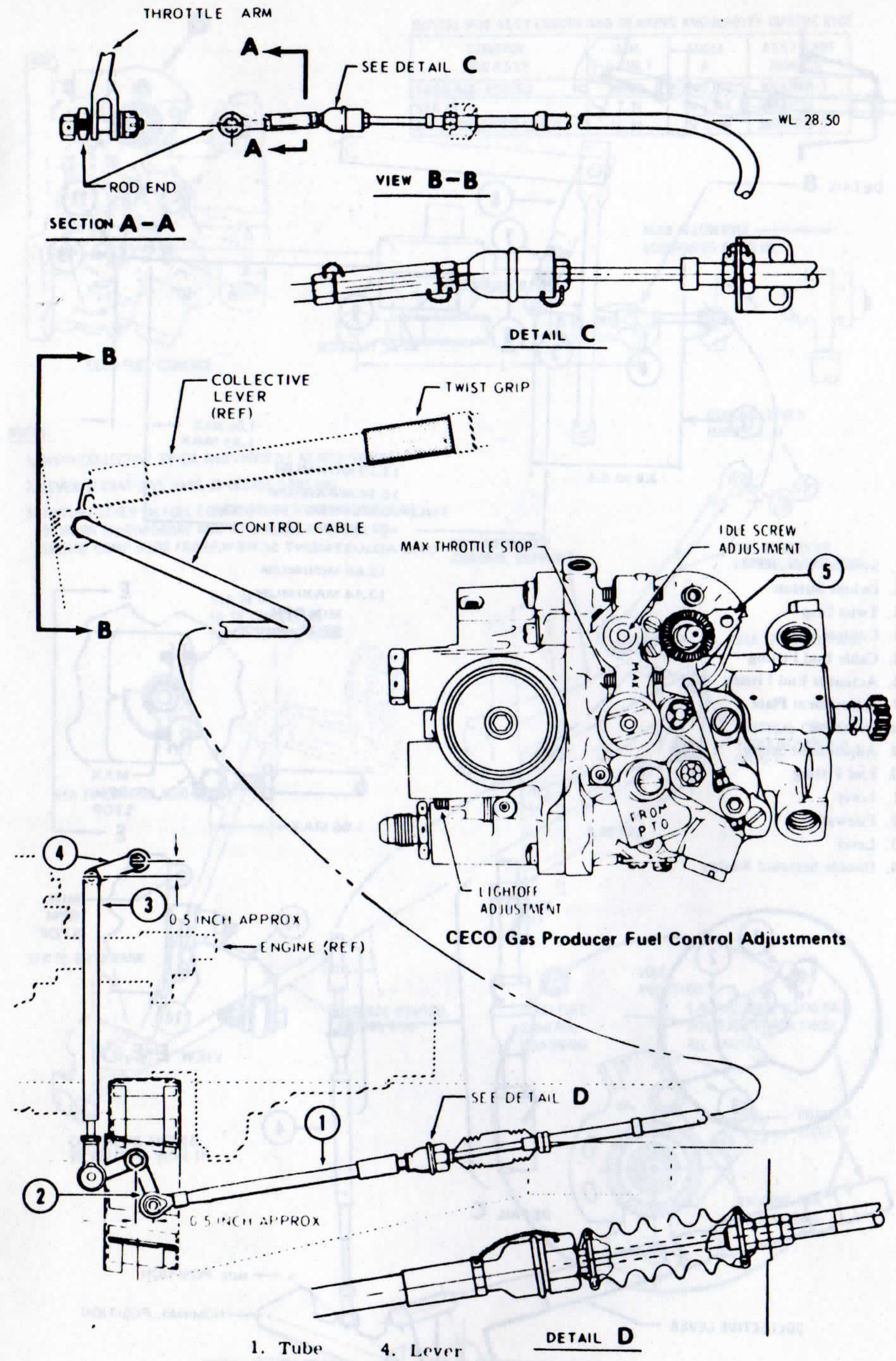
The rigging is the assembly of bellcranks, cables, fittings, levers, tubes and other mechanical devices used to transit motion from the aircraft controls to the fuel control system. Typical rigging systems are shown on the following pages for both the gas producer fuel control and the power turbine governor. Always refer to the aircraft manual for exact procedures and requirements for the adjustment and repair of the rigging.

Important things to remember about the rigging with relationship to the MC-40 fuel control system are:

1. The limits of travel must be established by the mechanical stops on the fuel control or governor, not by the rigging. For example, when the twist grip is moved to the full open position, the fuel control pointer must contact the max throttle stop at or before the limit of twist grip travel.

2. Looseness in the rigging system must be minimized by proper adjustment and the replacement of worn parts, if necessary. It is extremely important that, for any given point within the limits of travel, the aircraft control and the operating unit be in the same relative position regardless of the direction or speed that the aircraft control is moved. For example, the fuel control pointer must be in the same position (30°) whether the twist grip is moved to IDLE from the full open or cutoff position. The fuel control pointer must be in the same position whether the twist grip is slowly rolled into IDLE or snapped into position. (Refer to the rigging check on page 31.)

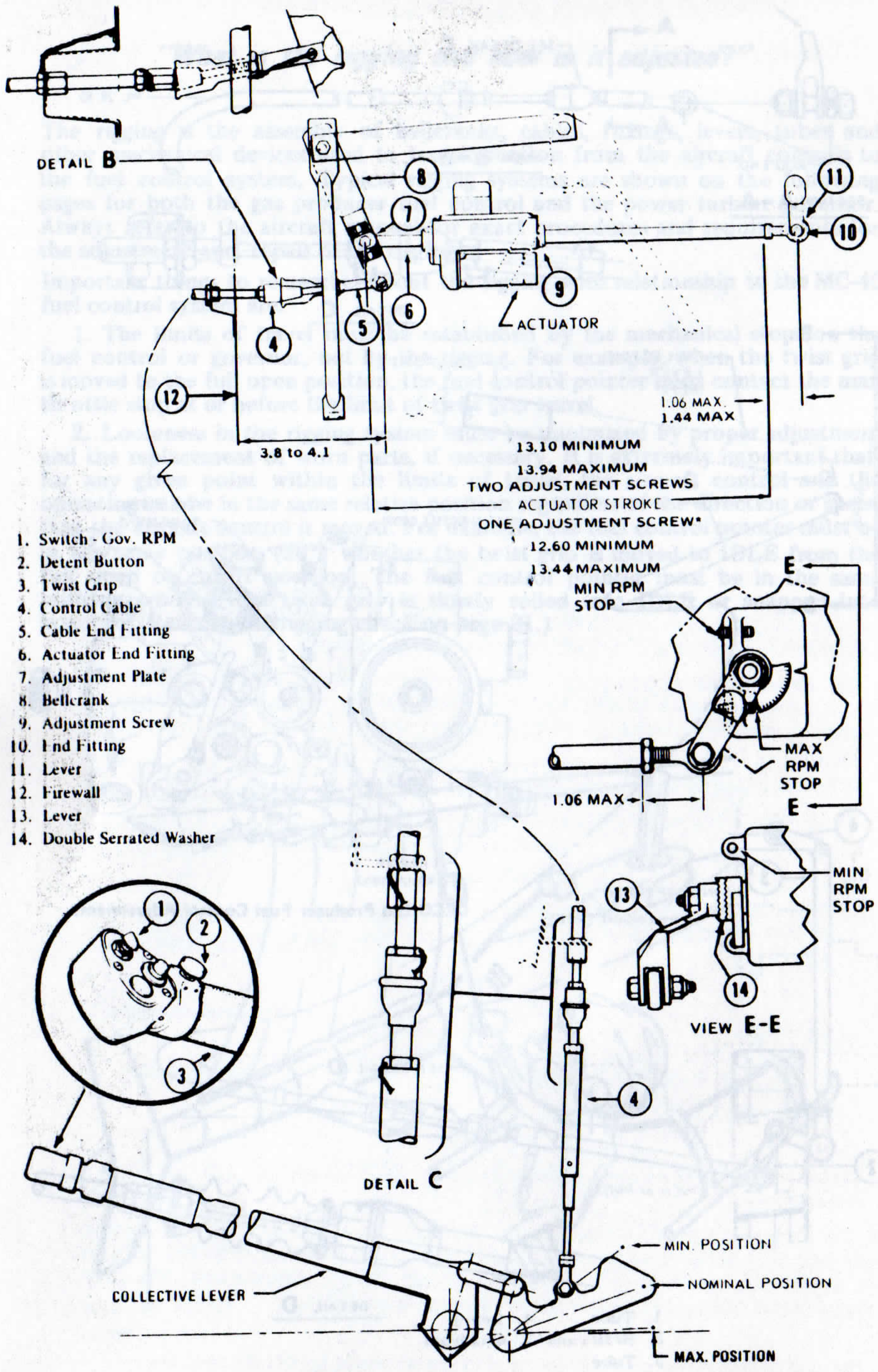




CECO Gas Producer Fuel Control Adjustments

1. Tube
2. Bellcrank
3. Tube
4. Lever
5. Quadrant

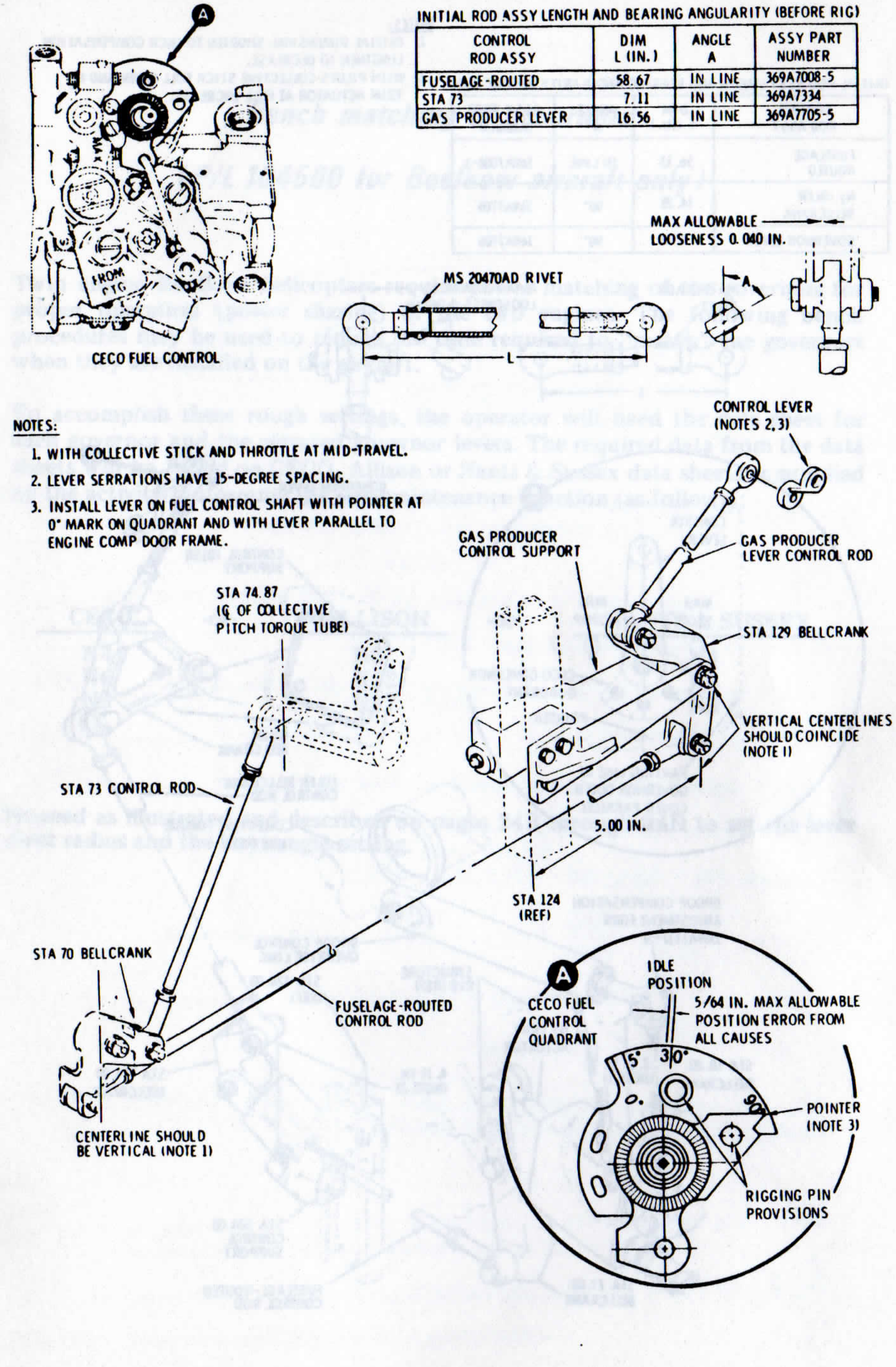
Bell Jetranger Gas Producer Fuel Control (N_1) Rigging



Bell Jetranger Governor (N_2) Rigging

INITIAL ROD ASSY LENGTH AND BEARING ANGULARITY (BEFORE RIG)

CONTROL ROD ASSY	DIM L (IN.)	ANGLE A	ASSY PART NUMBER
FUSELAGE-ROUTED	58.67	IN LINE	369A7008-5
STA 73	7.11	IN LINE	369A7334
GAS PRODUCER LEVER	16.56	IN LINE	369A7705-5



NOTES:

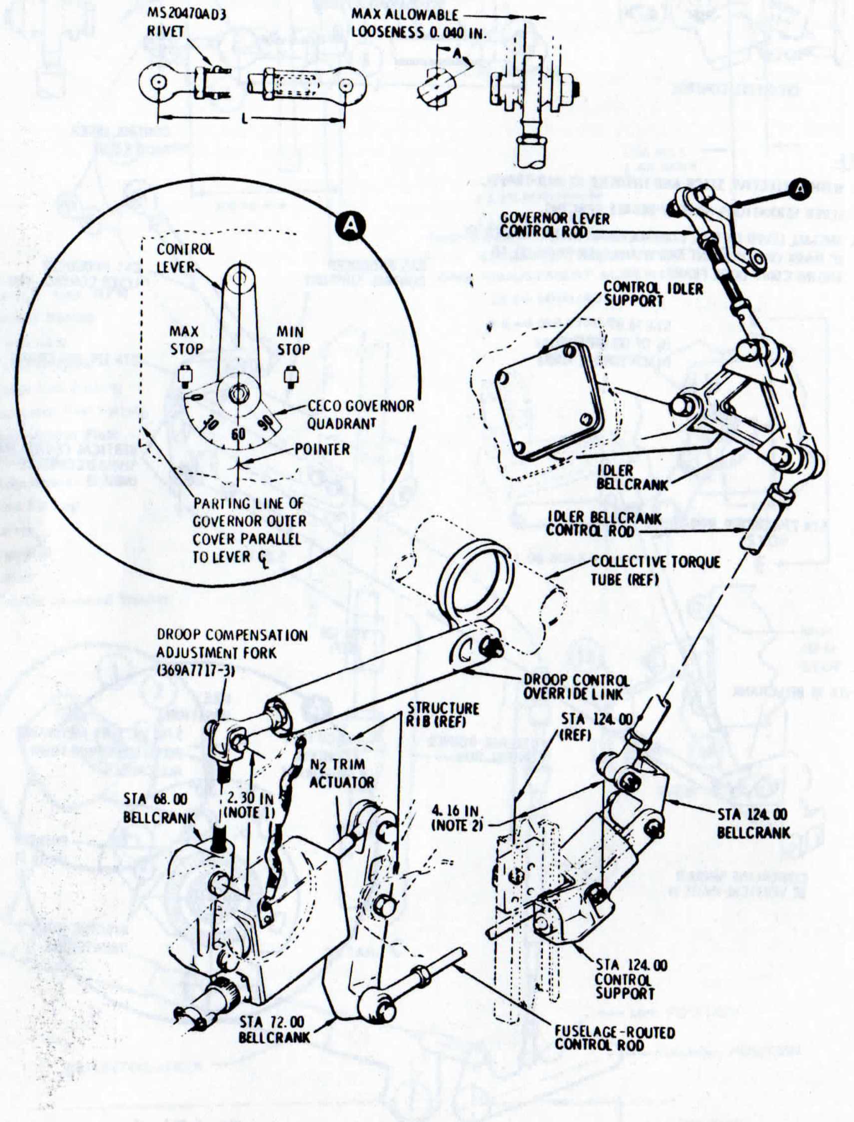
1. WITH COLLECTIVE STICK AND THROTTLE AT MID-TRAVEL.
2. LEVER SERRATIONS HAVE 15-DEGREE SPACING.
3. INSTALL LEVER ON FUEL CONTROL SHAFT WITH POINTER AT 0° MARK ON QUADRANT AND WITH LEVER PARALLEL TO ENGINE COMP DOOR FRAME.

Hughes 500C Series Gas Producer Fuel Control (N_1) Rigging

NOTES:
1. INITIAL DIMENSION: SHORTEN TO INCR COMPENSATION, LENGTHEN TO DECREASE.
2. WITH PILOTS COLLECTIVE STICK FULL DOWN AND N_2 TRIM ACTUATOR AT FULL INCREASE.

INITIAL ROD ASSY LENGTH AND BEARING ANGULARITY (BEFORE RIG)

CONTROL ROD ASSY	DIM L (IN.)	ANGLE A	ASSY PART NUMBER
FUSELAGE ROUTED	56.13	IN LINE	369A7008-3
N_2 IDLER BELLCRANK	14.28	90°	369A7705
GOVERNOR LEVER	4.15	90°	369A7706



Hughes 500C Series Governor (N_2) Rigging

Bench matching of governors

(P/L 104500 for Boelkow aircraft only)

Twin engine Boelkow helicopters require power matching of the governors for proper operation (power sharing) of the two engines. The following bench procedures may be used to reduce the time required to "match" the governors when they are installed on the aircraft.

To accomplish these rough settings, the operator will need the data sheet for each governor and the serrated governor levers. The required data from the data sheets will be found on CECO, Allison or Hants & Sussex data sheets as supplied by the activity performing the last maintenance function (as follows):

CECO		ALLISON		HANTS & SUSSEX
N4	-or-	N5	-or-	N4
N6		N12		N6
N9		N17		N9

Proceed as illustrated and described on pages 24B through 24D to set the lever pivot radius and the lever angle setting.

Setting the lever pivot radius

Use the following formula to determine the lever pivot radius:

$$R = \left(\frac{4200 - N9}{N6 - N4} + 126\right) \times \frac{1000}{30}$$

Where:

R = mathematical setting of attachment bolt on the splined bar in millimeters. This determines control rate response.

NOTE

Divide answer in millimeters by 25.40 to convert to inches.

4200 = reference speed setting = 100% RPM

N4 = governor fuel flow at specified speed setting No. 4 ________ (RPM)

N6 = governor fuel flow at specified speed setting No. 6 ________ (RPM)

N9 = governor fuel flow at specified speed setting No. 9 ________ (RPM)

126 = known positive 3% advance in RPM

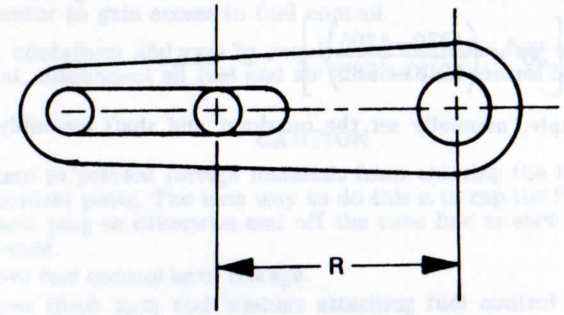
Example (N4 = 4205; N6 = 4370; N9 = 3685):

$$R = \left(\frac{4200 - 3685}{4370 - 4205} + 126\right) \times \frac{1000}{30} = 58.66 \text{ millimeters}$$

or

$$R = \frac{58.66}{25.40} = 2.30 \text{ inches}$$

For this example, set the pivot lever radius (center to center distance) at 58.66 millimeters or 2.30 inches at installation.



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Lever Pivot Radius

Setting the lever angle

Use the following formula to determine the lever angle setting:

$$\angle_G = \angle_2 - \left[30 \times \left(\frac{N6 - N4}{4200 - N9}\right)\right] + 2^\circ$$

Where:

$\angle_G$ = angular setting of power lever shaft on the governor scale. This is used to achieve power turbine speed requirements.

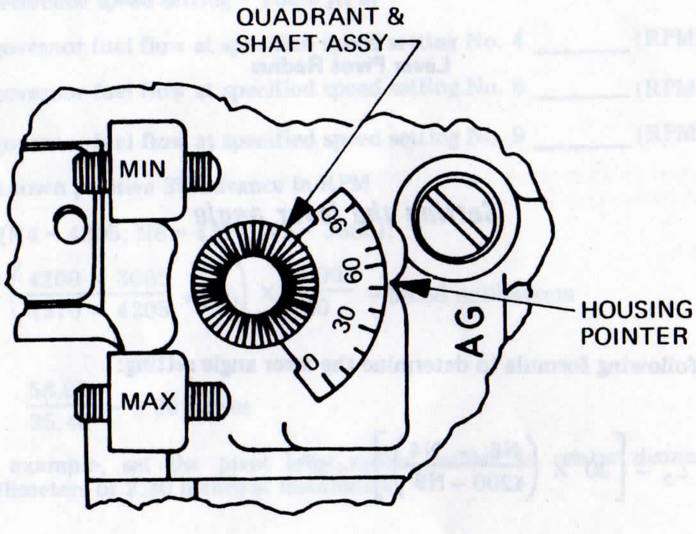
$\angle_2$ = power lever angular setting at reference point No. 2 on Data Sheet.

N4, N6, N9 = same as for setting the lever pivot radius.

Example: ($\angle_G$ = 64°; N4, N6, N9 same as pivot radius example):

$$\angle_G = 64^\circ - \left[30 \times \left(\frac{4370-4205}{4200-3685} \right) \right] + 2^\circ = 56.4^\circ$$

For this example, manually set the quadrant and shaft assembly at 56.4° at installation.



Lever Angle Setting

"What is the procedure for replacing the gas producer fuel control?"

Here is a summary of the procedure specified by the engine manufacturer (refer to the engine manual for specific steps and requirements):

1. With the engine installed in the aircraft, it may be necessary to remove starter generator to gain access to fuel control.

2. Using containers and rags as required to minimize fuel spillage in engine compartment, disconnect all fuel and air lines to fuel control by loosening tube nuts.

CAUTION

Use care to prevent foreign materials from entering the lines or the fuel control ports. The best way to do this is to cap the fuel control port and plug or otherwise seal off the tube line as each line is disconnected.

3. Remove fuel control lever linkage.

4. Remove three nuts and washers attaching fuel control to gearbox, and remove fuel control.

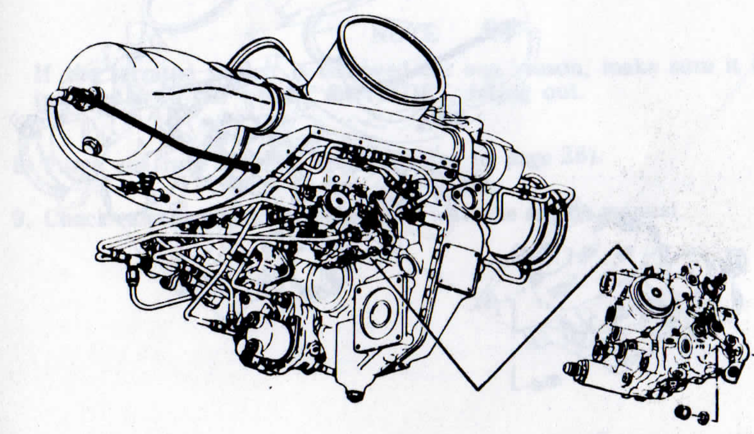
5. Remove all fittings required for the installation and transfer them to replacement fuel control.

CAUTION

Use care not to apply any load to the fuel control splined shaft when removing or installing fittings.

6. Check max P_c stop setting on the replacement fuel control against the aircraft requirement. Adjust the max P_c stop, if necessary (refer to page 14).

7. Lubricate spline on replacement fuel control with Lubriplate 130A, (Fiske Bros. Refining Co., Newark, N.J.) or equivalent. Install fuel control on the gearbox and retain with three washers and three nuts. Tighten nuts to 70-85 inch-pounds.



8. Removing protective caps and plugs, reconnect tube lines to fuel control. Tighten all fuel line tube nuts to 150-200 inch-pounds. Tighten air (P_c) line tube nut to 80-120 inch-pounds.

9. Check the cutoff stop setting. If aircraft configuration permits, adjust to minus 2° (refer to page 16).

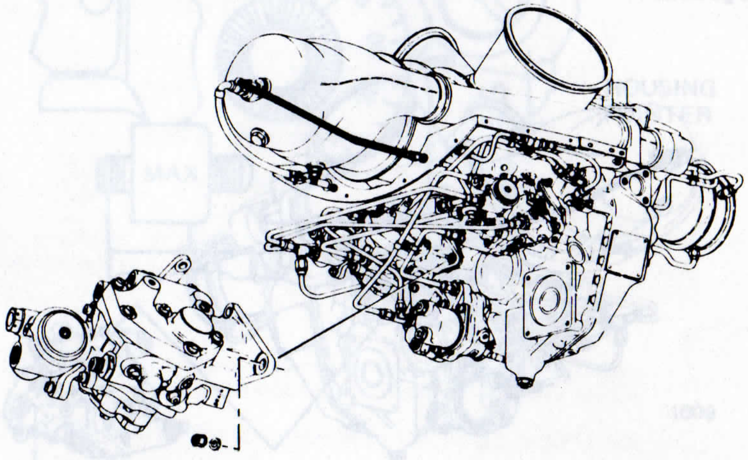
10. Set the fuel control throttle to 30° and install rigging pin, through hole in the fuel control pointer, into the hole in the housing. Chandler Evans Part No. STD67182 is recommended, but a piece of 5/32 inch drill stock may be used.

11. Check that the pointer is exactly on 30° with rigging pin installed. If not, realign quadrant.

12. Attach linkage to the fuel control lever.
13. Remove the rigging pin.
14. Purge all air from the system by purging (refer to page 28).
15. Perform operational checks (refer to page 30).
16. Check run the engine in accordance with the engine manual.

"What is the procedure for replacing the power turbine governor?"

Here is a summary of the procedure specified by the engine manufacturer (refer to the engine manual for specific steps and requirements):



GOVERNOR

1. Using containers and rags as required to minimize fuel spillage in engine compartment, disconnect all fuel and air lines to fuel control by loosening tube nuts.

CAUTION

Use care to prevent foreign material from entering the tube lines or the governor ports. The best way to do this is to cap the governor port and plug or otherwise seal off the tube line as each line is disconnected.

2. Remove governor lever linkage.

3. Remove three nuts and washers attaching governor to gearbox, and remove governor.

4. Remove all fittings required for installation and transfer them to replacement governor.

CAUTION

Use care not to apply any load to the splined shaft on the fuel control when removing or installing fittings.

5. Lubricate spline on replacement governor with Lubriplate 130A (Fiske Bros. Refining Co., Newark, N.J.), or equivalent. Install governor on gearbox and retain with three washers and nuts. Tighten nuts to 70-85 inch-pounds.

6. Removing protective caps and plugs, connect tube lines to governor. Tighten all fuel line tube nuts to 150-200 inch-pounds. Tighten air (P_c) line tube nuts to 80-120 inch-pounds.

7. Set governor lever to read 80° on the quadrant. Attach the lever linkage, maintaining the 80° setting. If necessary, adjust lever position by loosening nut and repositioning lever and serrated washer as required. Tighten nut to 65-80 inch-pounds.

NOTE

If the serrated washer is removed for any reason, make sure it is installed with the word, "OUTSIDE", facing out.

8. Purge air from the fuel system (refer to page 28).

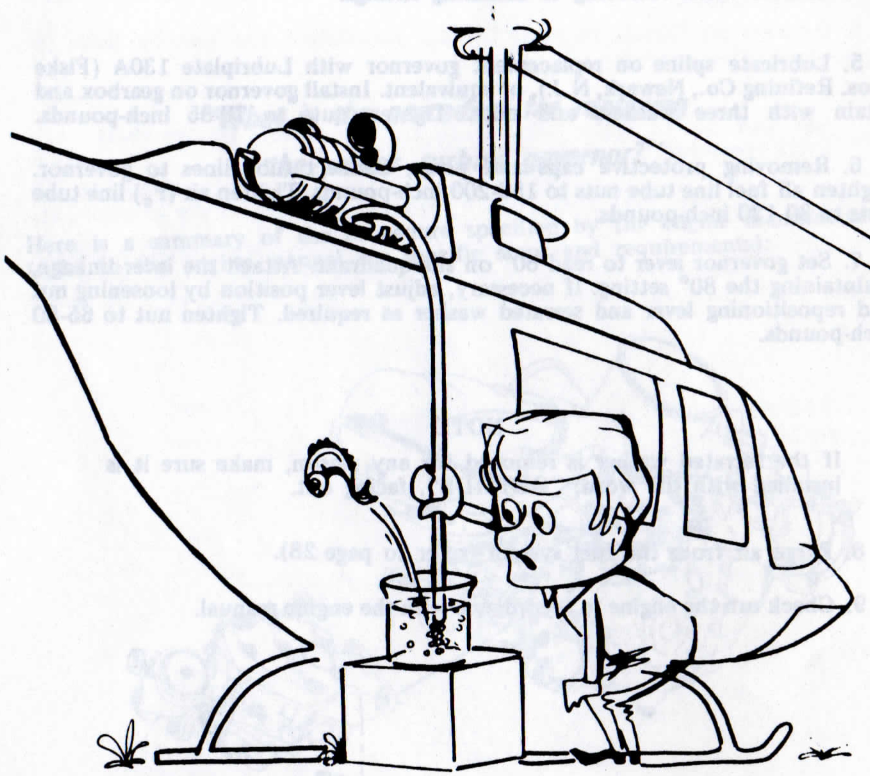
9. Check run the engine in accordance with the engine manual.

"What is purging, when is it required, and what is the procedure?"

Purging—not to be confused with engine purging—is the process for removing air from the fuel system. It is similar to bleeding except that the flow rates are such that air is literally forced out of the system, rather than depending on the action of gravity alone.

Purging is always required whenever the fuel system is opened up for maintenance. This includes filter maintenance, component replacement, or any time that a fuel line connection is broken for any reason.

In spite of all precautions, air may get into the fuel system without the system being opened up. Whenever air in the system is suspected as the cause for false starts or erratic operation, the fuel system must be purged.



The steps required for purging the total fuel system are as follows (refer to the engine manual for specific procedures):

NOTE

If required because of maintenance, purging of the total system may or may not be necessary. For example, if maintenance involved only the replacement of the fuel nozzle, purging at that point may be all that is required.

1. Consider the use of an auxiliary power supply, if possible. Total system purging may result in a substantial drain on the batteries.

2. With fuel boost pump on, loosen coupling nut at the fuel pump inlet until all air has escaped and fuel flows in a solid stream. Retighten coupling nut and turn off boost pump

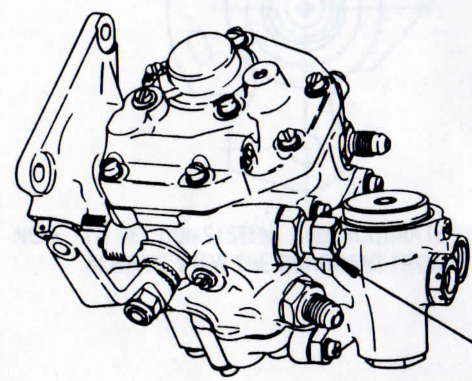
3. Break the tube "B" nut at the governor bypass (PO) port and cover with a rag.

4. Disconnect the fuel line at the fuel nozzle.

5. Place a container or containers under the aircraft to collect fuel drainage.

6. Plug in the battery cart or the APU power source and pull the ignition circuit breaker.

7. Open the fuel fire wall valve, turn on the boost pumps and open the throttle to full open.



8. Allow fuel to flow from the bypass line for 30 seconds. Then, loosely install the "B" nut at the governor bypass (PO) port with boost pressure on. Do this by moving the wrench under cover of the rag previously placed. The rag will keep fuel from spraying.

9. With the fuel nozzle line still open and the boost pressure still on, motor the starter to purge air from the nozzle line. After 30 seconds, observe the fuel flow for the absence of air. Repeat the starter motoring if necessary to clear all air from the system.

10. When all air is expelled from the system, close the throttle, connect the fuel line to the nozzle and tighten the "B" nut at the governor bypass (PO) port.

11. Turn off the boost pumps and clean up the area. As soon as possible, start the engine in accordance with the engine manual and perform a ground run.

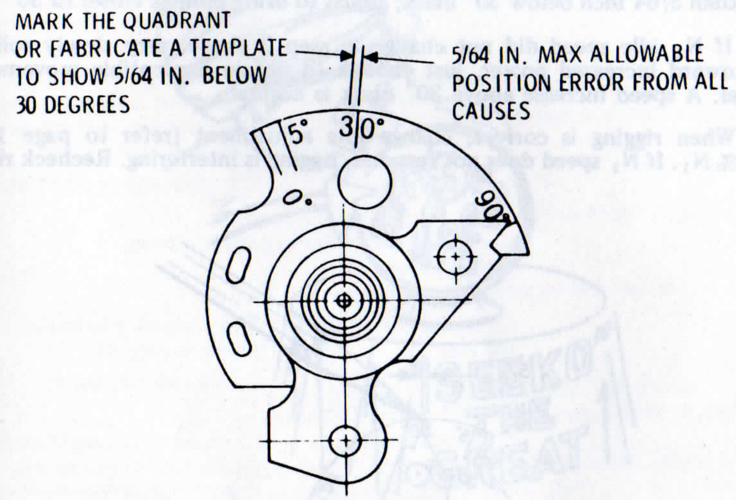
NOTE

Use the boost pump or pumps to fill the fuel lines and components after engine or fuel component installation and also after long idle periods. If the aircraft is equipped with boost pumps, ALWAYS start and operate the engine with the boost pumps ON.

"What are the rigging and idle speed checks?"

Rigging check

The engine manual specifies that the rigging check be made whenever the fuel control or some element of the rigging system is replaced. This check is made with the engine shut down. Here is a summary of the procedure (refer to the engine manual for specific steps and requirements):



NOTE: TO GET CONSISTENT AND ACCURATE READINGS ALWAYS VIEW THE QUADRANT FROM SQUARE AWAY.

1. Rotate twist grip back and forth and check that fuel control pointer makes physical contact with cutoff and max throttle stops at or before extreme limits of twist grip travel. Adjust rigging if necessary (refer to aircraft manual).

2. Lock fuel control pointer in 30° position with rigging pin and check rigging for looseness. Minimize looseness by parts replacement and/or adjustment (refer to aircraft manual).

3. Check that any remaining looseness is within the limits shown above by moving twist grip from full open to IDLE position. (If the helicopter has dual controls, refer to NOTE on page 32.)

Idle speed setting check

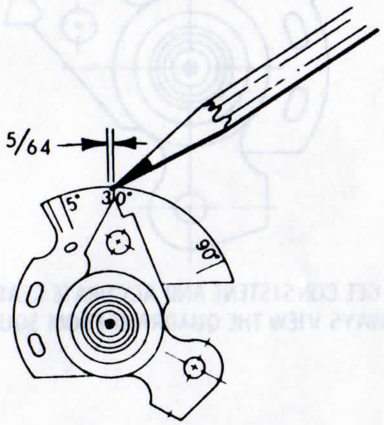
With the engine running, stabilized idle speed should repeat every time, whether the twist grip is slowly rolled or snapped into the IDLE position. If not, the engine manual specifies that the idle adjustment rigging be checked. Here is a summary of the procedure (refer to the engine manual for specific steps and requirements):

1. Roll twist grip to IDLE, let N_1 stabilize and mark (pencil) precise position of pointer on fuel control quadrant.

2. Depress the twist grip idle detent and very slowly rotate twist grip toward cutoff just enough to obtain perceptible (width of pencil mark) movement of pointer. If N_1 idle speed changes, adjust aircraft rigging. If pencil mark is at or above 30° mark, adjust to bring pointer to just below 30° mark. If pencil mark is more than 5/64 inch below 30° mark, adjust to bring pointer closer to 30° mark.

3. If N_1 idle speed did not change in step 2 above, very slowly roll twist grip toward increased power, just enough to obtain perceptible movement of pointer. A speed increase above 30° mark is normal.

4. When rigging is correct, change idle adjustment (refer to page 17) to 60-62% N_1. If N_1 speed does not respond, rigging is interfering. Recheck rigging.



NOTE

On some helicopters, when dual controls are installed, the higher idle speed setting (at the 30° mark rather than 5/64 in. below the mark) may be required to prevent inadvertent overcontrol and shutdown. (Refer to the applicable aircraft manual.)

"What if something happens that you haven't told me about?"

On the following pages, you'll find a summary Troubleshooting chart covering the MC-40 system and related fuel system components. Some of these situations have been covered in this booklet, (remedies noted*) and some have not. Refer to the engine and aircraft manuals for additional troubleshooting information and specific instructions for *all* remedial procedures.

Contamination–what are the symptoms and what is the remedy?

Almost any of the operating problems listed in the Troubleshooting chart may be caused by contamination, in addition to the "probable causes" listed. If the MC-40 system fails to respond to adjustments or other remedial procedures, then contamination must be suspected. Before repair or overhaul of the system components is considered, the fuel control or the governor or both units should be flushed to remove any possible contamination, and their performance rechecked. The units must be removed from the engine and flushed as specified in 250-C20-CSL-1034 (fuel control) and/or 250-C20-CSL-1035 (governor). Proceed in accordance with these directives or contact your MC-40 distributor.

Trouble Shooting

Item	Trouble	Probable Cause	Remedy
1	Engine fails to reach 15% cranking speed.	Inadequate torque at starter pad.	Check output of starter and battery.
2	Engine fails to light off.	Air in the gas producer fuel control and lines.	Purge air from the system. (Refer to page 28)*
		Preservation oil fouling the spark igniter.	Try a second start.
		Faulty circuit to ignition unit.	Listen for ignition operation. Observe for fuel vapor coming out of the exhaust. Check input power to ignition unit. Isolate and replace defective part.
		Faulty ignition exciter.	Listen for igniter operation. Observe for fuel vapor coming out of exhaust. Replace with known satisfactory unit.
		Faulty spark igniter.	Listen for igniter operation. Observe for fuel vapor coming out of exhaust. Replace with known satisfactory unit.
		Insufficient fuel in tanks.	Fill tanks with correct fuel.
		Gas producer fuel control remains in cutoff.	Check linkage.
		Lightoff adjustment too low.	Make lightoff adjustment (Refer to page 18)*
		Insufficient fuel pressure to fuel pump.	Turn on aircraft boost.
		Spark igniter firing intermittently.	Check input voltage to exciter. Check ignition exciter by replacing temporarily with a known satisfactory unit.
		Fuel nozzle valve stuck.	Replace fuel nozzle.
		Fuel pump inoperative. (Fuel vapor will not be observed leaving the exhaust.)	Check pump for sheared drives or internal damage; check for air leaks at inlet or fluid leaks at outlet.
		Water or other contaminant in fuel.	Check a sample of fuel from the bottom of the tank. If contaminated, disconnect the fuel line at the fuel nozzle, drain all fuel then flush the system with clean fuel.
		Fuel nozzle orifice clogged.	Check fuel filter, replace nozzle.

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
3	Engine lights off but will not accelerate to idle speed in 45 seconds.	Air in the gas producer fuel control lines.	Purge air from the system (Refer to page 28)*
		Inadequate torque at starter pad.	Check condition of battery and starter to determine if sufficient N_1 cranking speed is attainable.
		Dirty compressor.	Clean compressor and bleed valve.
		Insufficient fuel supply to gas producer fuel control.	Check fuel system to ensure all valves are open and pumps are operative.
		Insufficient fuel pressure to fuel pump.	Turn on aircraft boost pump.
		Gas producer fuel control and/or power turbine governor bypass valve or relief valve stuck open.	Disconnect the fuel line at the fuel nozzle, flush system with clean fuel then replace control.
		Fuel nozzle partially clogged with carbon.	Clean fuel nozzle.
		Fuel nozzle check valve stuck partially open.	Replace fuel nozzle.
		Start derichment adjustment to low.	Make start derichment adjustment. (Refer to page 19)*
		Gas producer fuel control calibration has shifted.	Replace control. (Refer to page 25)*
		Anti-icing valve open and cabin heat on.	Close anti-icing valve and turn off cabin heat.
		Foreign object damage or erosion to compressor.	Inspect compressor.

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
4	Acceleration temperature too high during start.	Operating ambient temperature higher than gas producer fuel control calibration for standard day.	Depress detent, slightly retard throttle and monitor TOT rate of increase. If TOT rate does not decrease, close throttle. (Refer to page 9)*
		Insufficient time allowed for draining after an unsuccessful starting attempt.	Purge the engine by motoring with the gas producer lever and ignition switch in OFF for approximately 10 sec before attempting a second start.
		Reduced battery capacity. This can produce low cranking speed.	Recharge or replace battery.
		High residual TOT (turbine outlet temperature) in excess of 200°C.	Motor engine with starter leaving gas producer lever and ignition OFF.
		Starter which is not capable of dry motoring gas producer (N_1) above 15 percent.	Replace starter.
		Gas producer lever (twist grip) in ground idle position prior to and during starter engagement.	Review starting procedure.
		Dirty compressor.	Clean compressor and bleed valve.
		Fuel nozzle valve stuck full open.	Replace fuel nozzle.
		Excessive compressor air leaking.	Check for leaks. Be sure that anti-ice valve is fully closed.
		Bleed control valve stuck closed.	Replace bleed control valve.
		Lightoff adjustment too high. (At 15% N_1.)	Make lightoff adjustment. (Refer to page 18)*
		Gas producer fuel control start derichment too rich. (At 25% to 40% N_1)	Adjust start derichment. (Refer to page 19)*
		Gas producer fuel control calibration has shifted.	Replace faulty control if start temperature exceeds 927°C (1700°F).

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
5	Acceleration or lightoff temperature too low during starting.	Fuel control system air sensing lines leaking.	Check air lines and fittings for leaks.
		Lightoff adjustment too low. (At 15% N_1.)	Make lightoff adjustment. (Refer to page 18)*
		Gas producer fuel control start derichment too lean. (At 25% to 40% N_1.)	a. Check quadrant position to be 30°. b. Adjust start derichment. (Refer to page 19)*
		Gas producer fuel control calibration has shifted.	Replace control. (Refer to page 25)*
6	Engine Speed cycles at idle.	Gas producer fuel control bypass valve not operating freely.	Disconnect the fuel line at the fuel nozzle, flush system with clean fuel. Purge system. If condition still exists, replace control. (Refer to pages 25 and 28)*
7	Idle speed too low.	Incorrect gas producer lever setting.	Check that quadrant is at 30°.
		Malfunctioning tachometer.	Replace tachometer.
		Excessive generator load.	Reduce electrical load requirement.
		Dirty compressor.	Clean compressor and bleed valve.
		Gas producer fuel control idle adjustment incorrectly set.	Correct the setting. (Refer to page 17)* Adjust cw to increase N_1 speed – 1/8 turn equals approx 1%.
		Air sensing lines leaking.	Check for leaks. Tighten coupling nuts as required.
8	Idle speed too high.	Incorrect gas producer lever setting.	Check that quadrant is at 30°.
		Malfunctioning tachometer.	Replace tachometer.
		Gas producer fuel control idle adjustment incorrectly set.	Correct the setting. (Refer to page 17)* Adjust ccw to decrease N_1 speed – 1/8 turn equals approx 1%.

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
9	Low power with high TOT.	Compressor foreign object damage.	Replace compressor if damage exceeds limits.
		Dirty compressor.	Clean compressor and bleed valve.
		Bleed control valve has failed to close.	Check compressor discharge pressure sensing line for leaks and for security.
			Replace bleed control valve.
		Excessive compressor air leaks.	Repair leaks.
		Faulty TOT indicator.	Replace indicator.
		Anti-icing valve leaking.	Check linkage or replace valve.

NOTE

The effect of anti-icing air flow on engine performance is as follows:

Type of Operation	Approximate Effect on Performance Available At Power Levels Above 40,000 N_1 Speed*
Constant TOT, 737°C (1358°F) Max continuous	a 49 hp decrease and a 2.3% (1140 rpm) decrease in N_1 (gas producer) speed
Constant N_1 speed, 100% (50,200 rpm)	An 11 hp decrease and a 36°C (65°F) increase in TOT
Constant hp (346) and constant collective pitch (load) operation	A 0.73% (370 rpm) increase in N_1 speed and a 48°C (87°F) increase in TOT

* These values are for standard day, sea level conditions and will vary with changes in ambient temperature and altitude. The effects at lower powers and speeds will be only slightly different but still immediate and definite.

Item	Trouble	Probable Cause	Remedy
		Heat control valve.	Cap off engine bleed manifold to isolate trouble.
		Faulty torquemeter indicating system.	Replace gage or transmitter.
10	Low power with TOT below max limit.	Gas producer control lever does not reach maximum speed adjustment stop.	Adjust linkage to the gas producer fuel control (lever against max stop).
		Gas producer control lever maximum speed adjustment stop not properly set.	Correct the maximum speed adjustment setting. Adjust cw to increase N_1 speed – one turn equals approx 1%. (Refer to page 15)*
		Max Pc stop improperly set.	Reset gas producer fuel control max Pc stop. (Refer to page 14)*

*Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
11	Low measured TOT at normal or high power.	Faulty TOT indicator.	Replace indicator.
		Faulty TOT thermocouple assembly.	Replace thermocouple assembly.
12	Engine N_1 or N_2 overspeeds.	Gas producer fuel control linkage not properly set.	Check linkage for proper operation and adjustment.
		Defective gas producer fuel control or power turbine fuel governor.	Replace defective control or governor. (Refer to page 25 or 26)*
		Faulty N_1 or N_2 tachometer.	Replace generator or indicator.
13	Excessive exhaust torching during transients.	Fuel nozzle malfunction.	Replace fuel nozzle.
		Excessively rich gas producer fuel control.	Replace control. (Refer to page 25)*
		Leaking accessory bleed lines.	Repair or replace lines.
14	Slow to accelerate from idle to power on the ground.	Dirty compressor.	Clean compressor and bleed valve.
		Loose Pc pneumatic fittings.	Tighten or replace as required.
		Excessive generator load.	Reduce electrical load.
		Excessive compressor air leakage.	Check for leaks and repair.
		Gas producer control acceleration schedule too lean.	Replace control. (Refer to page 25)*
		Excessive bypass flow from power turbine governor.	Replace governor. (Refer to page 26)*
15	Slow to accelerate to power while in flight.	Same as in preceding Trouble.	Correct as in preceding Trouble.
		Governor linkage incorrectly rigged.	Check rigging. Correct linkage as required.
16	TOT approx 30°C lower than normal at idle.	Bleed control valve stuck closed.	Replace bleed control valve.
17	Compressor surge during starting or near the idle speed.	Dirty compressor.	Clean compressor and bleed valve.
		Excessively rich gas producer fuel control.	Replace gas producer fuel control. (Refer to page 25)*

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
18	Compressor surge during starting.	Bleed control valve stuck closed.	Replace bleed control valve.
		Excessively rich gas producer fuel control.	Replace gas producer fuel control. (Refer to page 25)*
19	Compressor surge during acceleration.	Bleed control valve has failed to open.	Replace bleed control valve.
		Excessively rich gas producer fuel control.	Replace gas producer fuel control. (Refer to page 25)*
		Compressor erosion.	Inspect compressor. Correct as required.
20	Compressor surge during low power operation.	Bleed control valve has failed to open.	Replace bleed control valve.
21	Excessive fuel leaking from the fuel pump overboard drain ports.	Fuel pump drive shaft seal diaphragm ruptured or leaking.	Replace fuel pump.
22	More than 5 drops per min fuel leakage from either the fuel control or the governor overboard drain line.	Gas producer fuel control failure.	Replace fuel control. (Refer to page 25)*
		Power turbine governor failure.	Replace governor. (Refer to page 26)*
23	Faulty torquemeter indication.	Clogged torquemeter bleed orifice.	Replace power and accessories gearbox.
		Clogged torquemeter pressure sensing oil line.	Replace power and accessories gearbox.
		Torquemeter supporting bearing failure.	Replace power and accessories gearbox.
24	Continuous exhaust smoking.	Oil leakage from forward compressor bearing oil seal or power turbine carbon face seal.	If oil consumption exceeds limits, replace faulty component.
25	Unable to stop engine.	Gas producer fuel control fuel cutoff valve not closed.	Close the aircraft fuel shutoff valve to stop the engine. Then check control linkage rigging (cutoff stop) and gas producer control quadrant at cutoff to be minus 2°. If trouble cannot be corrected by adjustment, replace gas producer fuel control. (Refer to page 25)*

* Refer to applicable aircraft or engine manual for specific procedures and requirements.

Item	Trouble	Probable Cause	Remedy
26	Afterfire.	Fuel control not in cutoff.	Check that gas producer quadrant is against cutoff stop. If not, adjust rigging. If OK, adjust stop to setting of minus 2° (1/2 turn counterclockwise on aircraft configurations that permit travel below 0°). Refer to page 16)*
		Oil leak.	See trouble condition Oil Leakage During Shutdown Periods.
		Burner drain valve line obstruction.	Check the drain lines. Clean or replace as necessary.
		Sticking burner drain valve.	Replace valve.
		Fuel nozzle valve stuck open.	Replace fuel nozzle.
27	Oil leakage during shutdown periods. (Smoking on shutdown)	Oil leakage from compressor forward bearing seal.	Replace compressor.
		Oil leakage from turbine or combustion section.	Remove and inspect the external check valve.
			Inspect for leakage from power turbine carbon face seal.
28	Oil leaking from weep holes at gas producer fuel control and/or power turbine fuel governor.	Check engine oil seal.	Replace leaking seal.
29	Unstable or erratic operation.	Air in fuel system causing loss of governor action.	Purge thoroughly. (Refer to page 28)*
		Dirt in fuel system causing moveable fuel control or governor component to stick.	Check condition of fuel filters in aircraft, fuel pump and fuel control. Replace any components which have become contaminated.
30	Excessive NR droop at take off, hover or cruise (occurring overnight or after maintenance).	Air in governor.	Purge thoroughly. (Refer to page 28)*
		Governor failure.	Check beep motor adjustment and rigging before replacing governor.
31	Adjustment fails to correct problem or produces unanticipated change.	Wrong screw or plug being adjusted.	Check applicable FAA approved manual to make sure of precise location before making adjustments.

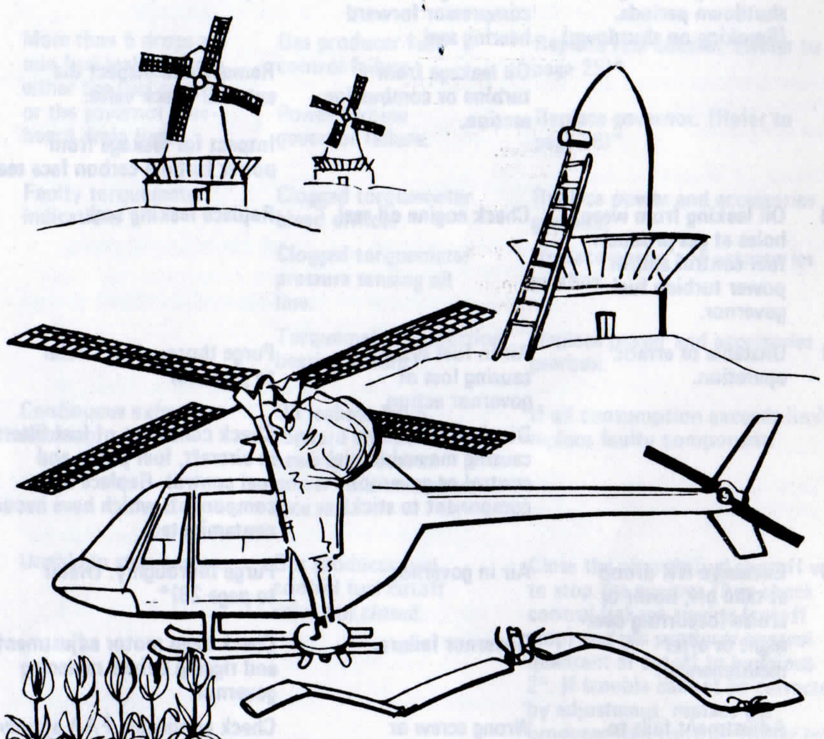
* Refer to applicable aircraft or engine manual for specific procedures and requirements.

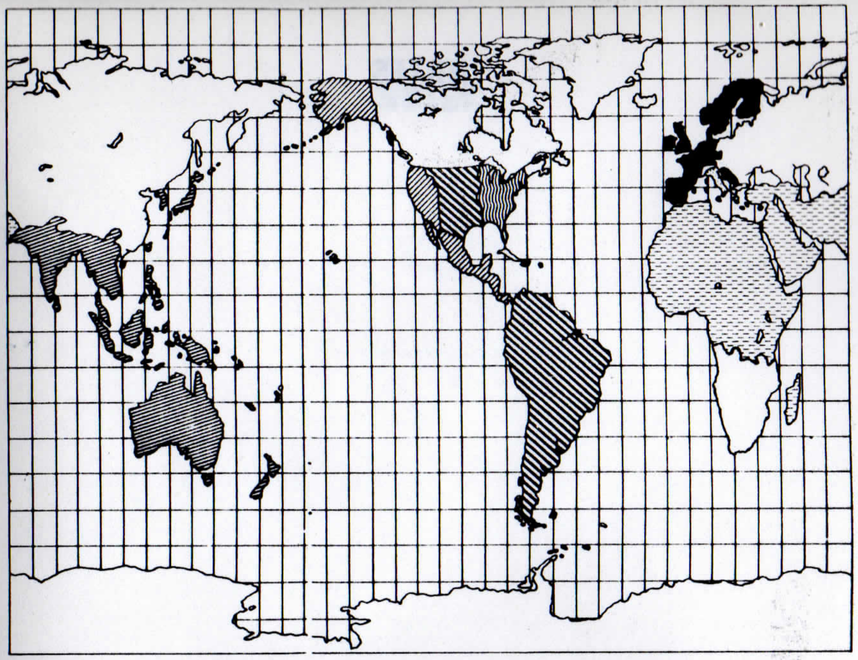
"Where do I go if I need additional help or service?"

The Chandler Evans distributor network provides full local support throughout the world. Experienced gas turbine specialists have been selected to meet Model MC-40 service requirements for owner-operators of aircraft equipped with the Allison 250C20 engine.

Distributor products and services include:

- Warranty service
- Exchange fuel controls and governors
- Complete overhaul and repair capabilities
- Field service representatives
- Training





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