ATTACHMENT 3

MAINTENANCE GROUP CHAIRMAN'S FACTUAL REPORT

DCA-07-MA-310

DC-9/MD-80 Maintenance Manual (Boeing) recommended maintenance practices, section 80-10-00 Cranking – Description and Operation (Boeing Procedure)

CRANKING - DESCRIPTION AND OPERATION

1. General

A. The cranking portion of the engine starting system converts energy of high temperature compressed air into starting torque sufficient to accelerate the engine to starting and self-sustaining speed within the required time. Components utilized during cranking operations include the engine start switch, starter air shutoff valve, and pneumatic starter (Figure 1).

B. Pneumatic power for cranking operations is provided by the onboard APU, cross-bleeding from an operating engine, or an external power source.

C. The control and indicating system comprises the cranking portion of the engine starting system.

2. Control and Indicating

A. Description

(1) The control and indicating system provides means to actuate the starter air shutoff valve, control pneumatic supply to the starter, indicate position of starter shutoff valve, and terminate the starting cycle. The system consists of the engine start switch, starter air shutoff valve, pneumatic starter, and indicating light.

(2) Engine Start Switch - The engine start switch, located on the forward overhead panel in the flight compartment, controls the operation of the starter air shutoff valve. The switch is a toggle-type switch, and is actuated when placed and held in the ON position. The switch operates in conjunction with the ignition system controls. Power to the switch is provided by the DC TRANSFER BUS. For a complete description and operation of the ignition system (PAGEBLOCK 74-00-00/001 Config 2).

(3) Starter Air Shutoff Valve - The valve is a diaphragm-actuated, butterfly-type, pneumatic valve and is electrically controlled and pneumatically operated. The valve functions to control the flow of pneumatic energy to the starter. The valve consists of a valve body housing with an integral, butterfly-type closure element and appropriate inline end flanges for direct mounting; a diaphragm-type pneumatic actuator, mechanically coupled through a lever arm to the butterfly shaft; a solenoid-operated, single-ball selector valve with manual override button for control of valve position in the event of inoperative solenoid valve; a rate-control orifice which provides a controlled opening time; a stainless steel wire mesh filter; and a mechanical pointer for visual indication of valve position. The upper end of the butterfly shaft is provided with wrenching flats to allow manual opening of the valve in the event of loss of actuator supply pressure. (Figure 2)

(a) An electrical switch on the lower end of the butterfly shaft energizes the indicating light on the annunciator panel in the flight compartment when the butterfly valve is open.

(b) The solenoid-operated switcher valve controls the opening rate of the butterfly to limit maximum starter impact torque experienced during running engagements, such as restarts of an engine, windmilling in flight, or coast-down after shutdown on the ground.

(c) Access to the manual override button is through starter valve and manual override access door (7707C) for left engine or (7808C) for right engine, located on the forward lower cowl door or by opening forward lower cowl door.

(4) Pneumatic Starter - The starter is a single-stage turbine consisting of the following major components: scroll, turbine wheel, reduction gear train, overrunning clutch, splined output shaft, and starter housing.

AAL **AAL 101-108, 110-190, 197, 201-207, 209-326, 401-599**

AAL NOTE: (Figure 4)and (Figure 3).

AAL **AAL ALL**

(a) The starter gears and bearings are lubricated by a self-contained oil system. Fill and drain ports are provided in the housing for servicing the oil system. The housing also incorporates a mounting flange to match the pad on the engine accessory drive case.

(b) The starter output shaft, which is splined to the engine gearbox, is lubricated by the engine oil system. The shaft incorporates a shear section to protect the engine in the event of starter malfunction or failure.

B. Operation

(1) When the engine start switch is placed and held in the ON position, 28 vdc power is supplied to the starter air shutoff valve solenoid. (Figure 1)

(2) Actuation of the shutoff valve solenoid allows inlet air pressure to be ported to the open chamber of the valve actuator. Since the effective area of the open chamber is larger, relative to the close chamber, the actuator forces open the butterfly and keeps it open. As the butterfly moves away from the closed position, the valve position indicating switch closes and completes the indicating light circuit. This action causes the valve position indicating light on the annunciator panel to come on. Opening of the valve butterfly allows air to flow to the inlet of the starter.

(3) Air entering the starter inlet flows through the stator and is directed radially inward to propel the turbine wheel to high-speed rotation. Expended air is exhausted overboard through the exhaust duct.

(4) Initial reduction of the high rotational speed is accomplished as the pinion gear on the turbine wheel shaft drives the planetary gears in the reduction gear system. The planetary gears transmit the rotary motion to the spur gearshafts on which the gears are installed. The integral spur gears on the gearshafts in turn transmit motion to the ring gear, causing a further gear reduction and increase of torque.

(5) When rotating at low speeds, the pawl springs in the clutch system drive shaft force the drive shaft to engage with the ratchet jaw-teeth on the gear and hub-jaw. This action allows the gear and hub-jaw to transmit the rotational force to the engine gearbox through the drive and output shafts. The torque-speed relationship at the output shaft, when driving the engine through the gearbox, provides power to accelerate the engine to light-off speed and to assist the engine to self-sustaining speed. When engine lightoff and acceleration occur, the drive and output shafts rotate with the engine. The overspeed rotation causes the pawl to ratchet on the teeth of the slower rotating gear and hub-jaw. As the speed of the engine increases, the pawls function as flyweights and overcome the force of the pawl springs. This allows the pawls to be completely withdrawn from engagement with the ratchet jaw-teeth of the gear and hub-jaw and to disengage the starter from the engine.

(6) Releasing the engine start switch deenergizes the starter air shutoff valve solenoid. This action causes the shutoff valve to close and terminate the starting cycle. When the butterfly reaches the closed position, the valve position indicating switch opens and deenergizes the indicating light circuit. The indicating light goes off and remains off as long as the shutoff valve is in the closed position. The starting cycle can be terminated at any time by releasing the engine start switch.

CAUTION: DO NOT OPERATE THE STARTER SHUTOFF-VALVE MANUALLY WHEN THE SYSTEM IS NOT PRESSURIZED UNLESS SPECIFIED DIFFERENTLY. THIS WILL HELP PREVENT DAMAGE TO THE STARTER SHUTOFF-VALVE DIAPHRAGMS.

(CAUTION PRECEDES)

CAUTION: USE ONLY HAND PRESSURE TO DEPRESS OVERRIDE BUTTON. USE OF SCREWDRIVER OR OTHER TYPE OF PRYING DEVICE TO DEPRESS OVERRIDE BUTTON CAN DEFORM SLENDER PIN MECHANISM INSIDE VALVE. A DEFORMED OVERRIDE BOTTOM PIN CAN HOLD SOLENOID SWITCHER BALL OFF ITS SEAT WHICH ALLOWS VALVE TO OPEN UNCOMMANDED WHEN AIR PRESSURE IS AVAILABLE TO ENGINE START VALVE. IF UNDETECTED OR UNCORRECTED, THIS CONDITION WILL RESULT IN SIGNIFICANT DAMAGE TO ENGINE STARTER.

(7) In the event starter air shutoff valve solenoid valve is inoperative, the solenoid manual override button is depressed to actuate the starter air shutoff valve. Depressing the button accomplishes the same function as normal electrical actuation of the valve.

CAUTION: IF STARTER SHUTOFF VALVE HAS BEEN WRENCHED OPEN, VISUALLY CHECK VALVE POSITION INDICATOR TO ENSURE IT CLOSES WHEN WRENCH IS REMOVED. STARTER CAN FAIL DUE TO AN OVER-SPEED CONDITION IF SHUTOFF VALVE IS NOT CLOSED. WRENCH VALVE CLOSED IF NECESSARY.

AAL (8)

AAL **AAL 101-108, 110-190, 197, 201-207, 209-326, 401-599**

AAL In the event of loss of actuator supply pressure, the valve can be opened manually by engaging
AAL a wrench (WRE 9550 or equivalent) on the hexagon flats at the upper end of the butterfly shaft. A
AAL notch across the hexagon flats points to the words OPEN or CLOSED on the switch cover to
AAL indicate the valve butterfly position.

AAL **AAL ALL**

(4) Check that START VALVE OPEN light located on annunciator panel comes on.

NOTE: Communications with flight compartment is essential during this test.

(5) Check for N_2 tachometer indication.

(6) Release engine start switch.

(7) Check that START VALVE OPEN light located on annunciator panel goes off.

(8) De-energize electrical buses.

B. Test Manual Override Button

(1) Place fuel shutoff lever in OFF position.

(2) Make certain ignition selector switch is OFF.

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(3) With electrical buses energized and regulated pneumatic supply of 36 ±5 psig (248.2 ±34.5 kPa)supplied to starter system, push manual override button and hold for approximately 30 seconds, or until engine stabilizes.

NOTE: The normal stroke of the override button is approximately 1/16 in. (1.6 mm). If the button stroke appears greater than 1/16 in. (1.6 mm) or if the return action appears sticky, then a deformed override button pin should be suspected.

(4) Release manual override button.

NOTE: If the starter air shutoff valve butterfly should stick during test, free butterfly as follows.

AAL (5) Open or close valve as necessary using a wrench (WRE 9550 or equivalent) on wrenching flats
AAL located on position indicator shaft end. (Figure 201)

CAUTION: DO NOT EXCEED TORQUE OF 230 INCH-POUNDS (25.99N·M) WHEN MANUALLY OPENING OR CLOSING VALVE WITH WRENCH.

CAUTION: IF STARTER SHUTOFF VALVE HAS BEEN WRENCHED OPEN, VISUALLY CHECK VALVE POSITION INDICATOR TO ENSURE IT CLOSES WHEN WRENCH IS REMOVED. STARTER CAN FAIL DUE TO AN OVER-SPEED CONDITION IF SHUTOFF VALVE IS NOT CLOSED. WRENCH VALVE CLOSED IF NECESSARY.

CAUTION: BEFORE CLOSING VALVE WITH WRENCH, CLOSE ENGINE PNEUMATIC CROSS-FEED VALVE OTHERWISE DAMAGE TO STARTER MAY OCCUR AS RESULT OF OVERSPEED CONDITION.

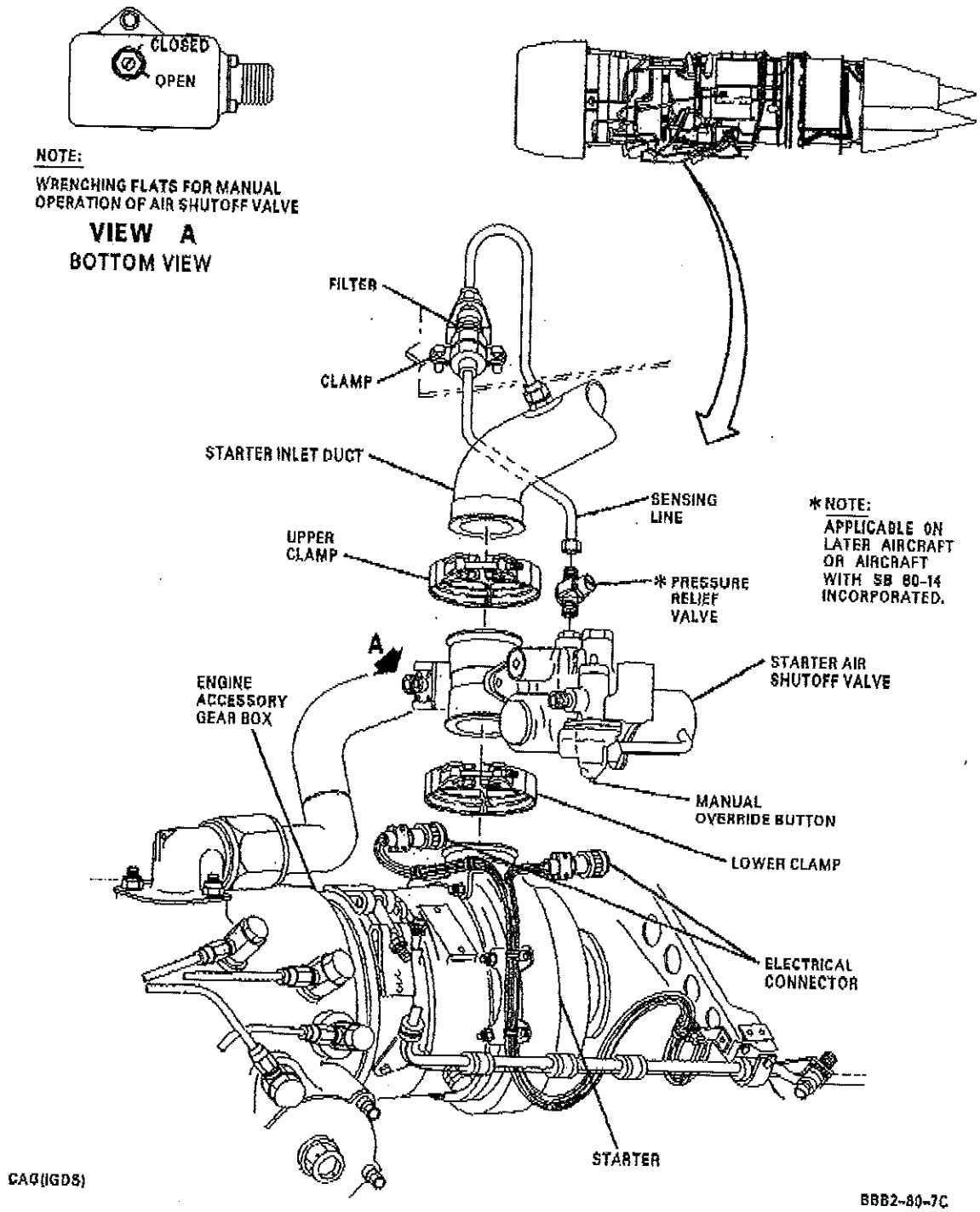
(6) De-energize electrical buses.

6. **Removal/Installation Pressure Relief Valve**

NOTE: The following procedures only apply to later aircraft or aircraft with SB 80-14 incorporated.

A. Remove Relief Valve (Figure 202)

(1) Tag throttle/thrust reverser lever.



Starter Air Shutoff Valve -- Installation
Figure 201/80-10-02-990-810