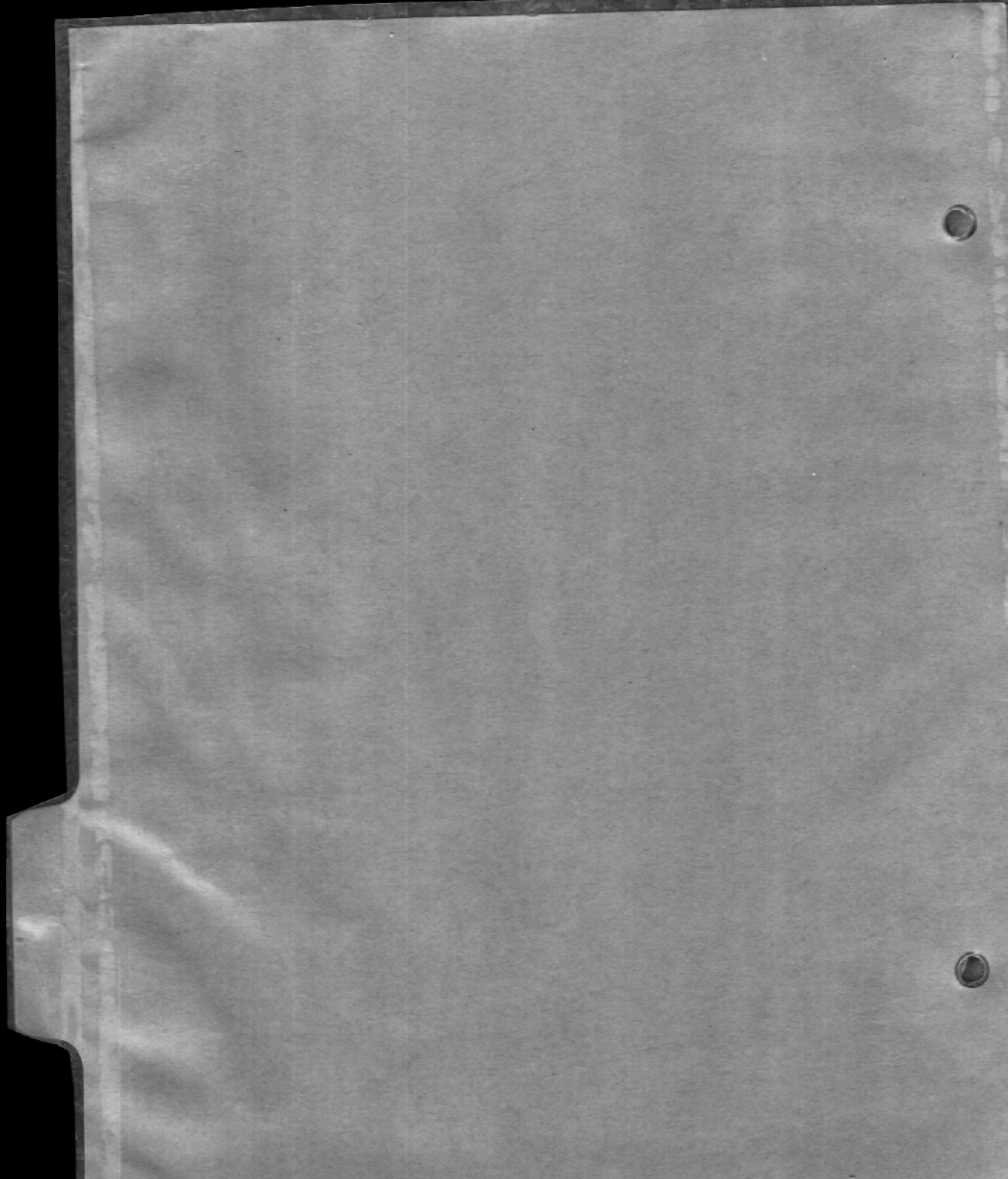


CHAPTER 5

ENGINE STARTING

(July, '58)

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ENGINE STARTING**



Chapter 5

ENGINE STARTING AND GROUND TESTING

Preparation for starting

1. (1) If the aircraft is picketed remove all picketing equipment.
- (2) Remove the weatherproof covers.

Note...

The pressure head and wheel covers should not be removed until the aircraft is prepared for flight.

- (3) Ensure that the aircraft is headed into wind and that the ground in the vicinity of the air-intakes is free from loose stones and other objects which might be drawn into the air-intakes.

Notes...

- (a) The aircraft must be positioned on grass or concrete; jet aircraft must not be run-up on tarmac.
- (b) If the engine has not been run for some time, fuel vapour may have accumulated in the combustion chambers. To avoid combustion of any such vapour, remove the air intake and propelling nozzle covers, to ventilate the engine, 15 minutes before attempting to start or making any functional check of the ignition system.

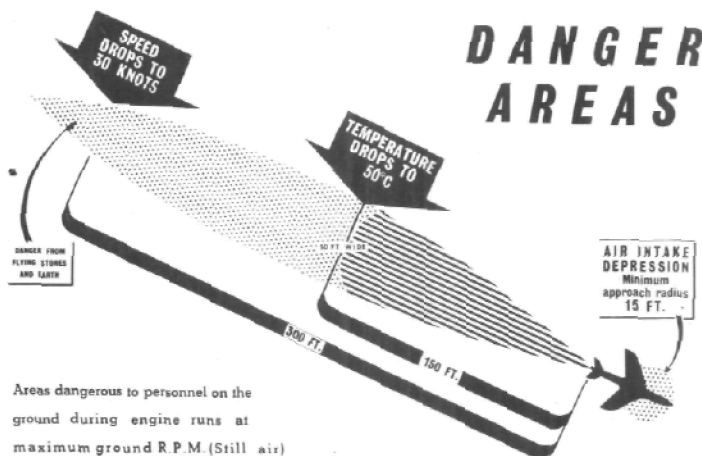


Fig.1 Engine running danger areas

- (c) The aircraft must be so positioned that the jet pipe is not directed towards any building or aircraft within a distance of 100 yards. For further details of safety precautions refer to AP 3158, Vol.2, Leaflet No. H.11 and to fig.1.
- (4) Correctly chock the main wheels and ensure that CO2 fire extinguishers are at hand (not foam or carbon tetrachloride extinguishers).
 - (5) Check that the air-intakes are clean and free of loose articles, then fit the air-intakes safety guards if aircraft is not to be flown immediately after ground testing.
 - (6) Ensure that the oil content of the engine sump and accessories gearbox is correct.
 - (7) Verify that the main and nose wheel shock-absorber struts appear normal.
 - (8) Remove the control locks, if fitted, and examine the flying controls for full and free movement.
 - (9) Ensure that all hydraulic accumulators are correctly charged.
 - (10) Ensure that the flaps are up and that there is a minimum hydraulic pressure of 1000 lb/in² in the brake system. The hydraulic hand pump (Chap.4, fig.1) may be used to achieve these conditions; the hand pump handle is stowed in clips inside the engine access panel.
 - (11) Ensure that the tanks contain sufficient fuel.
 - (12) Ensure that all access panels are securely fastened.
 - (13) Ensure that the starting team is not wearing head-dress or loose clothing, that they fully understand their responsibilities and signals to be used, and that the look-out man is positioned.
 - (14) Ensure that all personnel keep clear of the air-intakes, starter exhaust and jet pipe (fig.1).
 - (15) Switch ON the battery master switch and engine master switch. Press the re-light switch and listen for the pronounced crack of the two high-energy igniters firing. Switch OFF the electrical supply.

- (16) Check the anti-icing system gate valve by switching it ON and OFF and ensuring that it opens and closes in 10 seconds (approx) in each direction and that the indicator on the starboard shelf adjacent to the switch is functioning.
- (17) Load the triple-breech starter (Chap.4). After the first cartridge has been fired, the two succeeding cartridges are selected automatically when the starter push-switch is operated.

Starting procedure and checks

CAUTION . . .

- (1) If icing conditions prevail, i.e. when fog, mist, sleet or rain reduce visibility below 500 yards and ambient air temperature is below +2 deg.C, ground running must be avoided as there is a serious risk of ice formation in the aircraft air intakes with consequent risk of damage to the engine by ingested ice.
 - (2) If visibility is between 500 and 1000 yards and ambient air temperature is between +2 deg.C and +5 deg.C, the engine may be run with anti-icing switched on immediately after starting but acceleration and I.G.V. ram checks must not be made and all throttle movements must be made smoothly. The use of engine anti-icing results in an increase in JPT of approximately 20 deg.C but the JPT must be kept below the specified upper limit (by restricting the throttle opening). During running, a constant watch must be kept for the formation of ice on the aircraft air intakes; should icing occur, the engine must be stopped immediately.
 - (3) If the ambient temperature is below -40 deg.C, the engine must be externally heated before attempting a start.
2. (1) If necessary, connect an external power supply to the aircraft (Chap.4, fig.1, item 17).
 - (2) The H.P. fuel cock control lever locks into place in the ON and OFF positions in its quadrant. The handle must be pressed downwards before the lever can be moved from either position. Ensure that the controls are set as follows:-

(a)	Throttle	CLOSED
(b)	H.P. fuel cock	OFF
(c)	L.P. fuel cock	ON
(d)	Ground electrical supply (if connected)	ON
(e)	Battery master switch	ON
(f)	JPT controller	ON
(g)	Anti-icing switch	SHUT
(h)	Cabin pressure switch	OFF
(j)	Ignition switch	ON
(k)	Starter circuit breaker	IN
(l)	Engine switch	ON
(m)	Fuel tank pump switches (L.P. warning light extinguished)	ON

- (3) Move the H.P. fuel cock control to ON and press the starter button without delay; the engine should accelerate rapidly to 1500 rev/min on the starter. The rev/min will usually decrease by about 200 as the engine lights up and then increase to ground idling speed at 3000 ± 100 rev/min. This sequence should take about 30 seconds. Check that the generator warning lights are extinguished before the rev/min reach 2500, also check that the fire warning light remains extinguished during the start. When stabilised ground idling rev/min are established, check that:-

- (a) Engine oil pressure is registered.
- (b) The hydraulic triple pressure gauge indicates 2800 to 3000 lb/in² system pressure and 1500 lb/in² in each brake.
- (c) The JPT does not exceed 525 deg.C.

Note . . .

The JPT may rise above this figure momentarily during the start.

CAUTION . . .

If, during acceleration, the engine shows any sign of compressor surge (a rumbling noise, possibly accompanied by rising JPT), close the throttle immediately; if the engine then runs normally, open the throttle slowly to the desired rev/min. If the surge persists, the cause must be ascertained and eliminated in accordance with AP 102C-1512 to 1517-1.

◀ Failure to start

3. (1) If the starter cartridge fails to fire, close the H.P. cock immediately and check that the switches have been correctly selected. Wait 30 seconds then repeat the starting procedure. If the second and third cartridges fail to fire (with 30 seconds wait between each attempt) proceed as follows:-
- (i) Switch OFF all electrical supply and wait at least one minute.
 - (ii) Disconnect the electrical lead to the starter.
 - (iii) Remove all cartridges.
 - (iv) Check the cartridge firing electrical supply. If necessary, the full electrical starting circuits must be checked in accordance with AP 101B-1302-1.
- (2) If the cartridge fires and the engine rotates but fails to light up, close the H.P. cock as soon as the failure is apparent. Wait at least 10 minutes to ensure that accumulated fuel drains from the engine, then check for any residual fuel in the jet pipe. If there is, carry out a dry run, i.e. a starting cycle with the H.P. cock OFF and the ignition switch OFF; the engine master switch must remain ON. Check that both igniter units are functioning by pressing the relight button (with both the engine master and ignition switches ON) and listening for the pronounced 'cracking' sound caused by the electrical discharge across the igniter plug points. It is extremely unlikely that the 'cracking' from both igniter plugs will coincide so that the sounds will be irregular if both igniter units are functioning.

WARNING . . .

THE ELECTRICAL ENERGY STORED IN THE IGNITION UNIT CAPACITORS IS POTENTIALLY LETHAL. BEFORE HANDLING AN IGNITION UNIT, H.T. CABLE OR IGNITER PLUG, DISCONNECT THE L.T. SUPPLY AND WAIT FOR AT LEAST ONE MINUTE TO PERMIT THE STORED ENERGY TO DISSIPATE.

- (3) If the engine persistently fails to light up, although it rotates normally (up to 1500 rev/min) on the starter, the defect must be investigated in accordance with AP 102C-1512 to 1517-1. ▶

Note ...

- (1) Faulty cartridges are to be disposed of in accordance with current regulations for the disposal of high explosives.
 - (2) If three cartridges have been fired in quick succession, allow 10 minutes to elapse before reloading. If a further three cartridges are fired in quick succession, allow a further 20 minutes to elapse before reloading.
- (4) If the engine fails to rotate after a normal starter combustion cycle:-
- (a) Do not attempt another start under any circumstances.
 - (b) Investigate the cause of engine non-rotation in accordance with AP 102C-1512 to 1517-1.

Engine running checks and stopping

4. The life of a gas turbine is adversely affected by high jet pipe temperatures and by rapid changes of temperature, any unnecessary starts, sudden accelerations or running at high power must be avoided. Routine ground running is mainly confined to checking the aircraft systems (engine starting system, electrical generation, hydraulic pressure etc.). Checks in excess of those given in the next paragraph should be unnecessary unless an engine fault has been reported by the pilot. All fault diagnosis and rectification (and any adjustments) on the e.c.u. are to be made in accordance with AP 102C-1512 to 1517-1. Even apparently minor engine fuel system adjustments, e.g. ground idling speed, require reference to the engine log book to determine what further adjustment may be made without exceeding specified limits. Engine log book entries of all adjustments are also required.

5. Routine checks subsequent to carrying out the 'Starting procedure and checks' comprise:-

(1) Increase the rev/min to 3500 (using a smooth and progressive throttle lever movement) and check that the oil pressure is a minimum of 10 lb/in².

(2) Close the cabin hood with the hood actuator (described in Chap.2) and check that the hood seal inflates.

(3) Close the throttle to the ground idling position and allow the rev/min and JPT to stabilize. Check that these figures are within the limits given in 'Starting procedure and checks'.

(4) Select H.P. fuel cock OFF.

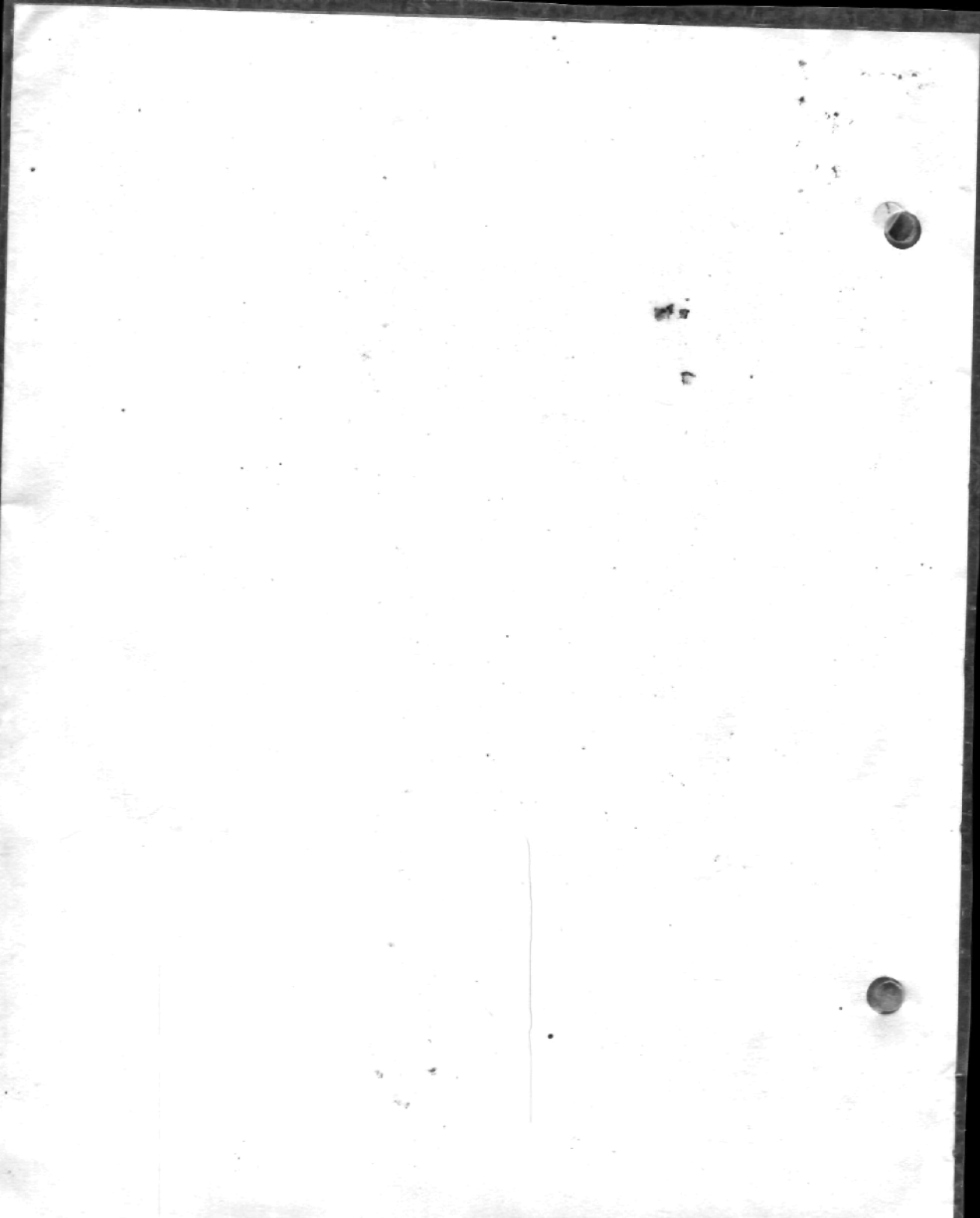
(5) Check that the engine runs down freely and that the run-down time is not less than 35 seconds.

(6) Check that the generator warning lights illuminate as the rev/min fall to between 1700 and 1500.

(7) Check that fuel runs from the engine drains during the run-down period.

(8) After the engine stops, select or check:-

(a)	Fuel tank pump switches	...	...	...	...	...	...	OFF
(b)	Engine master switch	...	...	...	...	...	...	OFF
(c)	Ignition switch	...	...	...	...	...	...	OFF
(d)	Cabin pressure	...	...	...	...	...	...	OFF
(e)	Anti-icing switch	...	...	...	...	...	...	SHUT
(f)	Battery master switch	OFF
(g)	Ground electrical supply	OFF
(h)	L.P. fuel cock	OFF



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