Chapter Nine

GROUND OPERATION

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THIS CHAPTER, which is applicable to the Ghost 48 Mk. 1 and the Ghost 48 Mk. 2, describes the technique of handling the engine on the ground —i.e., starting the engine, making the required ground running checks, and stopping the engine— while the aircraft is in service. Where the information concerns one mark of engine only, this is indicated in the text.

Reference should be made also to the general information contained in chapter 5 unless the operator is well acquainted with these particular engines.

GROUND RUNNING PRECAUTIONS

The general and ground running precautions detailed in chapter 5, pages 2 and 3, should be observed strictly, as also should the instructions regarding the turbo starter which are given on page 4 of that chapter.

FILLING AND REPLENISHING THE OIL SUMP

The correct lubricating oils are specified in the Leading Particulars at the beginning of this handbook, and clean oil to the correct specification only may be used. The oil capacity of the engine is tabulated below :—

OIL CAPACITY (PINTS)
Measured with engine stopped

	48 Mk. 1	*48 Mk. 2*
Maximum oil sump capacity	16·0	18·0
Oil system capacity	4·5	4·0
Total capacity	20·5	22·0
Usable oil	11·0	14·5

Checking the oil level

To check the oil level, press in the oil level plunger which is immediately below the oil level sight glass on the starboard side of the oil sump, see illustrations on facing page. Retain pressure on the plunger for 5 to 10 seconds, thus allowing the oil level in the sump and sight glass to equalise. Release the plunger and then observe the oil level as indicated in the sight glass. To simplify observation of the oil level, a screen painted with black and white diagonal stripes is placed behind the sight glass ; when the sight glass contains oil these stripes tend to appear to be horizontal, as a result of refraction. The sight-glass housing is calibrated and, therefore, it is possible to estimate the quantity of oil which must be added to replenish the sump.

Ghost 48 Mk. 2. Great care must be taken to avoid overfilling the Ghost 48 Mk. 2 sump, on this engine the eighteen-pint-level mark on the sight-glass housing is marked FULL, and no attempt must be made to fill the sump above this eighteen-pint level. Overfilling can cause a column of air to be trapped in the sight glass, if the oil level rises above the upper connecting hole and the oil level plunger is not depressed whilst the sump is being filled. This makes it impossible to check the oil level in the sump as the level in the sight glass, even when the plunger is depressed, suggests that the sump is only partially filled ; when, in fact, it is already overfilled. To obviate this, when filling or replenishing the sump, the oil level should be checked at frequent intervals, by pressing in the plunger.

At minus 5 deg. C. and below, lubricating oil to specification D.Eng.R.D.2479 is very viscous and oil level reading on the sight glass becomes very inaccurate. Therefore, when operating at minus 5 deg. C. or below, the oil level should be checked, and the sump replenished, whilst the engine is still warm.

To fill or replenish the sump

To fill or replenish the sump, having first checked the oil level as described in the preceding paragraphs, remove the spring-loaded bayonet-fastened oil filler cap from the oil filler on the top

wheelcase, and pour in the required quantity of oil. Allow ample time for the oil to drain from the top wheelcase into the sump before accepting the oil level as indicated in the sight glass as being a true indication of the quantity of oil in the engine. Take care to ensure that the sump is never overfilled. Take care to ensure that no dirt or foreign bodies enter the engine through the oil filler whilst the cap is removed ; there is no form of strainer in this filler. When the oil level is correct, ensure that the oil filler cap is replaced securely.

When filling a completely dry engine, e.g., after complete dismantling and reassembly, the full quantity of oil quoted against ' total capacity ' in the table, will be required but the whole of this quantity cannot be put into the sump at one filling, as an intermediate motoring-over period will be necessary in order to circulate oil into the hidden oil ways and pockets in the system. Where an electric starter can be fitted, or where provision has been made for motoring the turbo starter with compressed air, this intermediate motoring-over can be accomplished easily. In the absence of these facilities, the priming operations described in chapter 8 become of paramount importance and must be conscientiously completed before any attempt is made to start the engine by means of the turbo starter.

LOW TEMPERATURE LUBRICATION

The lowest oil temperature for starting or opening-up the engine using the normal oil, D.Eng.R.D.2479, is minus 10 degrees C. ; or using D.Eng.R.D.2487 minus 40 degrees C. Therefore, to ensure a satisfactory initial rate of oil circulation, protection of the engine, or pre-heating of the oil, under severe conditions, is necessary. Oil temperatures in flight will be satisfactory owing to the heat generated by the operation of the engine.

LOADING THE TURBO STARTER

Special attention must be paid to the precautions detailed in chapter 5, page 5; further information regarding the turbo starter is contained in chapter 50.

The electric circuit, through which the cartridges are fired, is not complete until during the last 30 degrees of rotation of the breech cap, when the cap is being screwed into the breech chamber ; just before engagement of the locking ratchets a spring-loaded contact on the breech lines up with an insulated slip-ring on the cap and completes the firing circuit. The switches in the breech are interconnected so that it is impossible to fire either cartridge until both caps are screwed to a safe operating position ; this position is indicated by the engagement of the locking ratchets, if the teeth of the locking ratchets cannot be engaged the starter cannot be fired. It must be clearly understood that the firing circuit is not broken by merely pressing the thumb catch and thus disengaging the locking ratchets ; the breech cap must be unscrewed at least 30 degrees before the circuit is broken.

TO LOAD THE TURBO STARTER, proceed as follows.

(1) Ensure that the engine starter master switch is in the OFF position.

(2) Press the thumb catch on one of the breech caps, to disengage the locking ratchets, and unscrew the breech cap.

(3) Examine the bore of the breech to ensure that it is clean and free from carbon and oil. If necessary, clean the bore and thread, using the cleaning brushes provided—Rotax tools NT4720, 1, 2, 3, and 4. Carbon in the bore can be softened and removed by using a cloth moistened with methylated spirit or trichlorethylene.

(4) Examine the breech cap, ensuring that the spring-loaded centre contact is clean and operates freely. If the contact is sticking, use a hypodermic or similar syringe to inject methylated spirit through the small hole in the centre of the contact ; this will soften the carbon, which will be ejected with the methylated spirit if the contact is pressed in smartly. If a syringe is not available, apply the methylated spirit by means of a spirit-soaked cloth. Trichlorethylene may be used as an alternative to methylated spirit. Ensure that the earth-return spring and the cartridge-retaining spring are free to operate, and that the contact surface of the earth-return spring is clean. Finally, lightly smear the breech cap thread with graphite grease to specification D.T.D. 582, D.T.D.806, or Aeroshell grease 8.

(5) Remove one of the cartridges from the special satchel, or from the stowage on the aircraft, and check that it is a live cartridge ; the magnesium disc will be missing from the end of a fired cartridge and the discharge holes will be visible in the end cap ; dimples in the magnesium disc of a live cartridge are caused when the cartridge is pressure tested during manufacture.

(6) Carefully examine the cartridge to ensure that it is clean and that the duralumin case is free from roughness, dents, or bulges, etc., which might cause difficulty when it was required to remove the cartridge from the breech. If there is any doubt as to the serviceability of a cartridge, do not use it.

(7) Place the flanged base of the cartridge in the breech cap, pressing it sideways against the spring in the cap until the flange slips into position in the offset groove in the breech cap. Turn the cartridge, relative to the breech cap, to ensure that it is right home and that good contact will be made with the centre and earth contacts.

(8) Insert the cartridge into the breech and, holding the locking ratchet on the cap clear of the fixed ratchet on the breech by pressing the thumb catch, screw in the breech cap. Under no circumstances may a tommy bar be used to tighten the breech cap ; if the cap will not go home fully by hand pressure, the cartridge, breech, and breech cap must be thoroughly examined and the cause rectified —the cause will probably be particles of dirt.

(9) When the breech cap is home fully, release the thumb catch and ensure that the locking ratchets engage over their entire length.

(10) Load the second breech in a similar manner.

BEFORE STARTING THE ENGINE

Before starting an engine which is newly installed, or which has been stored, or from which certain components have been removed for servicing operations, the appropriate checks and preparatory operations should be carried out as described in chapter 8.

If the fuel system, or the rear bearing oil supply, has been disconnected since the previous engine run ensure that these are primed as described in chapter 8.

If the engine has been standing idle for more than seven days, or if the turbo starter has been newly fitted, prime the turbo-starter gearbox as described in chapter 8.

Check the oil level in the sump, and replenish if necessary. If the ambient temperature is below the minimum specified for the oil in use, the oil should be warmed to at least this temperature before replenishing the sump, or the engine should be heated by means of a ground heater unit until the oil temperature reaches this value.

Remove the air-intake and propelling nozzle covers, and, if an immediate take-off is not contemplated, replace the former by wire-mesh debris guards. Make a check to ensure that no loose parts, tools, or rags, have been left lying about the engine ; particularly examine the air-intakes and ducts which lead to the impeller. Refer to chapter 5 if snow or ice is encountered.

PRECAUTIONS DURING STARTING

Ensure that the precautions detailed in chapter 5, page 2, are observed, with particular reference to the instruction that the aircraft be headed, as nearly as possible, into wind. Failure to observe this instruction can result in a serious fire hazard. On one occasion, when the engine bay cowling had been removed to check the engine whilst it was running, and the aircraft was standing tail into wind, when an attempt to start was made, the turbo-starter safety disc blew. Flame was emitted from the starter exhaust, and the fairly strong wind, blowing from the rear of the aircraft, directed the flame on to the top of the wing in the vicinity of the main fuel tank filler. This area was wet with fuel, after a splashy fill up, and the fuel was ignited.

During starting, the ground crew must watch the starter exhaust for evidence of safety disc failure or cartridge hang-fire, so that they can indicate to the occupant of the cockpit whether he may proceed with the firing of a second cartridge.

During a normal start, a Ghost 48 Mk. 2 will tend to light-up later than a Ghost 48 Mk. 1 ; this is due to inherent differences between the two fuel systems. The design of the Dowty spill-burner fuel system, fitted to the Ghost 48 Mk. 2, is such that the circulating pump withdraws all fuel from the burners, burner manifolds and inlet and spill pipes, during the stopping cycle ; whereas the Lucas fuel system, fitted to the Ghost 48 Mk. 1, remains full of fuel right up to the fuel flow distributor. Therefore, although the Dowty system is designed so that the fuel tank booster pump can prime the system as far as possible before the main shaft assembly commences to rotate, a time lapse inevitably occurs before the remainder of the fuel system priming can commence to function ; in the design, every effort has been made to reduce this time interval to an absolute minimum, consistent with ensuring that no dribbling occurs from the burners, as this would result in flame from the exhaust upon starting and overheating of the nozzle and turbine blades.

Ghost 48 Mk. 1. During a normal start, the turbo starter brings the engine up to approximately 1500 r.p.m. and self-sustained acceleration then brings the engine speed up to the normal idling speed.

Ghost 48 Mk. 2. During a normal start, the turbo starter brings the engine up to approximately 1500 r.p.m. but light-up occurs during the subsequent deceleration. Light-up should occur before the engine speed has fallen below about 1100-1200 r.p.m. and the engine should then accelerate to the normal idling speed.

In both marks, when using a turbo starter the initial acceleration is extremely rapid. When an electric starter is used, light-up takes place at about 700-900 r.p.m. and the electric starter assists the engine to accelerate up to approximately 1500 r.p.m., self-sustained acceleration then bringing the engine speed up to the normal idling r.p.m.

Light-up can be heard, or can be observed on the jet temperature gauge.

Immediately it is apparent that the engine has not started normally, SHUT the high pressure (H.P.) fuel cock ; move the lever as far aft as it will go.

If light-up occurs late in the deceleration following the discharge of the turbo-starter cartridge, or, where an electric starter is being used, towards the end of the automatic starting cycle or during the deceleration after the electric starter has been switched off, the engine may either accelerate very slowly to its normal idling speed, or may labour at about its light-up speed. This will cause very high temperatures throughout the combustion, turbine, and exhaust systems. In either case, excessive jet temperatures may be indicated on the gauge in the cockpit and visible flame will be emitted from the exhaust ; as there is only one thermocouple to record jet pipe temperature and as this is fitted at the highest point, overheating can occur without an indication on the gauge, due to the ignition of unburnt fuel which has drained to the lower part of the combustion and exhaust systems. The extent of such overheating and the time during which visible flame will be emitted, depends on the engine speed at which light-up occurs.

If light-up is only a little late with flame from the exhaust visible for not more than 5-10 seconds, **and the engine accelerates normally** the throttle should remain SHUT, or, if open, should be SHUT,

immediately idling speed is reached and the engine should be held at this speed for not less than one minute to allow temperatures to stabilize before opening the throttle for ground running checks, to taxy, or for take-off.

In all other instances where the engine does not start normally, the H.P. fuel cock must be SHUT immediately to stop the engine. Do not open the throttle whilst the engine is labouring at an r.p.m. below the normal idling speed in an attempt to obtain that speed. The low r.p.m. may be due to some fault in the fuel system, and if the throttle is opened, overfuelling may be caused; resulting in overheating and serious damage to the turbine.

Late light-up may be caused by defective ignition or by late fuel discharge from the burners due to insufficient priming of the fuel system. *In the case of the Ghost 48 Mk. 2,* to minimise the likelihood of the latter, it is recommended that the fuel tank booster pump should be switched ON, and the H.P. fuel cock lever moved to OPEN as early in the starting drill as possible, and that 5 seconds should elapse after these operations before the starter push-button is pressed to fire the turbo-starter cartridge. This procedure will be found to reduce the amount by which the r.p.m. falls below the peak cranking speed prior to light-up. *In the case of a Ghost 48 Mk. 1* which has been newly installed and is being started for the first time, or on which a fuel system component has been changed, or which has been standing idle for some time, insufficient priming is the more likely cause.

Normally, complete priming of the Ghost 48 Mk. 1 is ensured by the simulated start which is made whilst de-inhibiting the fuel system as described in chapter 8. Where a Ghost 48 Mk. 1 is being run daily, the fuel system will remain fully primed, but where a number of days have elapsed since the engine was last run, the fuel may have drained out of the burners and the burner feed pipes.

Where either mark of engine has failed to start normally for the foregoing reason, the subsequent attempt to start should be successful as the abortive attempt to start the engine will have primed the fuel system fully.

STARTING DRILL

To obviate the waste of turbo-starter cartridges consequent upon abortive attempts to start the engine, it is advisable to check the electrical ignition equipment as described in chapter 8, page 6, prior to starting the engine as detailed below.

(1) Move the low pressure (L.P.) fuel cock lever to the ON position (forward and up). *Ghost 48 Mk. 1 only,* ensure that the fuel pump isolating switch is OFF.

(2) Move the ground/flight switch (early aircraft) to FLIGHT, or the battery isolating switch (later aircraft) to ON.

(3) Switch ON the fuel tank booster pump; check that the warning lamp goes out (early aircraft) or that the indicator shows white (later aircraft). *In the case of the Ghost 48 Mk. 2,* it is essential to switch ON the fuel tank booster pump before attempting to start the engine as the spill-burner fuel system relies upon the booster pump pressure for its self-priming characteristic.

(4) Move the H.P. fuel cock lever to OPEN (fully forward).

(5) Check the oil temperature; no attempt must be made to start with an oil temperature below the minimum specified for the oil in use.

(6) *Ghost 48 Mk. 1*

First start of each day. Position the throttle lever at one-third open; this instruction is not applicable where an electric starter is fitted, in which case all starts should be made with the throttle fully SHUT.

All subsequent starts of that day. Ensure that the throttle lever is in the fully SHUT position.

Ghost 48 Mk. 2. **All starts.** Ensure that the throttle lever is in the fully SHUT position.

WARNING. When starting with the throttle one-third open, it is most important to SHUT the throttle immediately light-up occurs, failure to do this can result in serious damage to the nozzle and turbine blades.

(7) Move the engine starter master switch to ON.

(8) *Early aircraft only.* Advance the cartridge selector in a clockwise direction from OFF to 1 or 2 as appropriate, and rotate the Venner time switch to ON; this gives approximately 20 seconds operation of the high energy ignition equipment, after which period a clockwork mechanism in the switch returns the dial pointer to the OFF position and cuts off the supply of current to the ignition units.

Ghost 48 Mk. 2. Before proceeding ensure that at least 5 seconds has elapsed since the H.P. fuel cock lever was moved to OPEN, to ensure adequate priming of the fuel system.

(9) Press the starter push-button to fire the turbo-starter cartridge. *On later aircraft,* operation of the starter push-button automatically supplies current for a pre-set period to the ignition equipment and selects the appropriate cartridge before firing it. *If an electric starter is fitted,* press the starter push-button for two seconds and then release it.

WARNING. If the engine does not accelerate normally after light-up and labours, with excessive jet pipe temperature and the emission of visible flame from the exhaust, SHUT the

H.P. fuel cock immediately to stop the engine. If the engine main shaft rotates but the engine speed progressively drops below 1100 r.p.m., indicating that the engine has not lit up, the H.P. fuel cock must be SHUT before the engine speed has fallen to 1000 r.p.m. This is of primary importance in the case of the Ghost 48 Mk. 2 as, if the H.P. fuel cock is not shut whilst the engine main shaft is rotating, the self-emptying cycle of the spill-burner fuel system cannot take place and the subsequent attempt to start will involve a 'wet' start and serious overheating of the engine.

WHEN THE ENGINE HAS REACHED IDLING SPEED

When the engine has attained its normal idling speed (early aircraft only) advance the cartridge selector, in a clockwise direction, to OFF.

ENGINE STARTER MASTER SWITCH

Except where Venom mod. 290 has been embodied, the engine starter master switch must remain in the ON position at all times when the engine is running and when the aircraft is in flight, as this switch controls the supply of current to the relighting system. Where Venom mod. 290 has been embodied, the relighting circuit is independent of this switch.

SUBSEQUENT ATTEMPTS TO START

Failure to start may be indicated by: failure to light-up, which can be heard or observed on the jet temperature gauge; or by failure to accelerate after light-up, which may be accompanied by a rapid rise of jet temperature to an excessive figure and 'rumbling'. **Immediately it is apparent that the engine has not started normally, return the H.P. fuel cock lever to the SHUT position** (fully aft.) On early aircraft only, advance the cartridge selector, in a clockwise direction to OFF. If an electric starter is fitted, at the completion of the electric starting cycle, return the engine master switch to the OFF position. Do not attempt to restart until the combustion chambers have drained.

AFTER FAILURE OF THE CARTRIDGE TO FIRE (engine main shaft failing to rotate), wait at least 15 seconds before returning the H.P. fuel cock lever to the OPEN position and selecting and firing a second cartridge; on later aircraft operation of the starter push-button automatically selects and fires the next cartridge.

FAILURE OF THE ENGINE MAIN SHAFT TO ROTATE OR LOW ENGINE SPEED and a heavy discharge of yellow smoke, over a period of approximately eleven seconds, from the turbo-starter exhaust, indicates that the turbo-starter safety disc has blown; possibly due to excessive pressure caused by a faulty cartridge. Should three consecutive failures of the safety disc occur, the cause may be blockage of the nozzles in the turbo-starter nozzle ring, and the starter should be removed, examined, and cleaned in accordance with the instructions contained in chapter 50. If the engine main shaft has been rotated, the drainage period specified in the Operating Limitations must be observed.

In the event of safety disc failure, the cartridges in the starter at the time of this failure must be removed and fresh cartridges inserted before any further attempts are made to start the engine.

If a second cartridge is observed to have fired after the engine has started, or if the engine main shaft fails to rotate although correct burning of the cartridge is witnessed, the starter must be removed for examination and investigation of the electrical circuits as necessary.

Ghost 48, Mk. 2, IF THE ENGINE MAIN SHAFT ROTATES BUT THE R.P.M. PROGRESSIVELY DROPS below 1100 r.p.m., indicating that the engine has failed to light-up, the H.P. fuel cock must be returned to the SHUT position **before the engine speed has fallen to 1000 r.p.m.**

IF THE ENGINE FAILS TO LIGHT-UP, no attempt must be made to re-start until the combustion chambers have drained; the drainage period after a false start specified in the Operating Limitations must be observed strictly. To reduce the drainage period, and to ensure that the maximum amount of fuel is drained out of the exhaust cone, fireguard, and cowling, it is advisable to rock the aircraft tail booms. After any failure to start, particularly after failure to light-up, consideration must be given to the fire hazard incurred by the fuel drained on to the ground beneath the aircraft. To minimize the risk of a fire, when the engine subsequently starts successfully, it is advisable to move the aircraft to a new location before attempting a further start.

Ghost 48 Mk. 1 only. Failure to light-up may be due to the metering plunger, in the fuel flow distributor, sticking, and, as the fuel pressure at the one-third open throttle position may be insufficient to overcome this stiction, it is permissible to attempt a second start with an increased throttle opening; as emphasised in the starting drill, however, it is most important to SHUT the throttle immediately light-up occurs.

FAILURE TO ACCELERATE AFTER LIGHT-UP may be due to light-up occurring too late in the deceleration of the engine main shaft; in any event, if the r.p.m. falls as low as 1000 r.p.m. the H.P. fuel cock must be shut immediately. If the engine fails to start at the second attempt, investigate and rectify the defect as described in chapter eleven.

A THIRD CARTRIDGE IS NOT TO BE FIRED until the breech temperature has dropped to about 45 deg. C. The spent cartridges should be removed and the breeches left open to assist cooling.

IF AN ELECTRIC STARTER IS FITTED, when more than one motoring cycle is necessary, time must be allowed for the starter motor to cool. It is permissible to carry out three cycles with a two-minute interval after each of the first two cycles, followed by a twenty-minute interval after the third cycle but an interval of 3-4 minutes between consecutive cycles is recommended.

FAILURE TO START

A defect is probable if the engine fails to start

Fig. 1 and 2 deleted, refer to Fig. 6 and 7 of chapter 8 for illustrations showing attachment of oil pressure gauge T.79300 to engine.

after two attempts and the cause should be investigated in accordance with the fault diagnosis table given in chapter eleven.

GROUND RUNNING CHECK

Unnecessary ground running should be avoided as this wastes fuel. The frequency and extent of the ground running checks must be at the discretion of the responsible engineer or pilot but as a guide, when the engine is in regular use, and is known to be running satisfactorily, the complete ground running check need only be made once every seven days.

All ground running checks should be conducted with the engine bay cowlings open, or removed, so that any leaks may be detected immediately and rectified.

When ground running during times of low ambient temperature and high air moisture content, e.g. fog at low temperature, ice may form on the wire-mesh debris guards which are fitted over the air-intakes. This can result in air starvation and partial collapsing of the air-intake ducting, particularly when the engine is running at large throttle openings. Such air starvation can cause a rapid rise in jet pipe temperature and serious overheating of the nozzle and turbine. Under such atmospheric conditions, a careful watch should be kept on the wire-mesh debris guards, during ground running, and the engine stopped, and the debris guards removed, if ice is seen to be forming on them. Before proceeding, make a check to ensure that there are no indications of collapsing of the air-intake ducting, and before re-starting the engine and continuing the ground-run with the debris guards removed, ensure that the ground in the vicinity of the air-intakes is swept clear of debris.

The engine must not be run at large throttle openings unless the fuel tank booster pump is switched ON ; serious damage can be caused to the fuel pumps if full duty running is carried out with the tank booster pump switched OFF.

When the ambient air temperature is below the minimum specified for the oil in use, if any oil heater mechanism is provided in the aircraft, it should be turned ON during ground running ; the oil temperature should be observed frequently to ensure that the maximum temperature, appropriate to the specification of oil in use, is not exceeded and the heater adjusted accordingly.

If excessive oil temperatures are attained, even when any heater mechanism is turned OFF, the engine must be stopped and the cause investigated.

At each combustion chamber inspection period; whenever any servicing or minor repair has involved dismantling or disturbing any part of the main oil pressure system ; or when an engine is newly installed, or has been stored : prior to the subsequent ground running check, *or whenever it is required to check the oil pressure,* connect 0-100 lb. per sq. in. pressure gauge T.79300 to the connection on the top wheelcase (Fig. 6 and 7, chapter 8) so that the oil pressure at maximum continuous r.p.m. may be checked during the ground run.

Having started the engine :—

(1) Allow the engine to idle for about two minutes. During this time make a careful inspection to ensure that there are no gas, fuel, or oil leaks ; pay particular attention to all fuel and oil pipes and their connections. Ensure that the oil temperature, and the jet pipe and rear bearing temperatures are within the limits specified in the Operating Limitations. At each combustion chamber inspection period, check the delivery of the rear bearing metering pump at 3000 r.p.m., as described in chapter 13 ; *Ghost 48 Mk. 1, pre-mod. 431,* similarly check the delivery of the front bearing metering pump.

(2) Slowly increase the r.p.m. watching for any signs of gas, fuel, or oil leaks, and listening for any unusual noises, until governed speed is reached. Check the governed speed and the jet pipe temperature at full throttle—ensure that they are within the limits. In the circumstances detailed in the preceding paragraph, check the oil pressure when the engine is running at maximum continuous r.p.m.

Ghost 48 Mk. 1 only. Check the operation of the fuel pump isolating valve—the r.p.m. should increase to the setting of the higher governor when the fuel pump isolating switch is moved to the ON position. Failure of the r.p.m. to increase may be due to an electrical fault in the switch, wiring, or L.T. supply. If these items are satisfactory, the defect is probably in the fuel pump solenoid. Whilst 'isolated', examine the fuel pipes and connections **downstream** of the control valve assembly for leaks. Return the isolating switch to the OFF position. If the r.p.m. does not return to normal when the isolating switch is returned to the OFF position, the cause may be that the isolating valve in the fuel pump is sticking in the closed position.

(3) Throttle back to a convenient r.p.m. and make a general inspection for gas, fuel, and oil leaks.

(4) Throttle back to idling r.p.m. Check the slow-running speed when the throttle lever is in the fully SHUT position. Make a general inspection for gas, fuel, and oil leaks.

Ghost 48 Mk. 1 only. Re-check the operation of the fuel pump isolating valve—there should be a definite increase in r.p.m. when the fuel pump isolating switch is moved to the ON position, as the front engine-driven fuel pump will be controlled by its relief valve setting instead of by the barometric pressure control and the air-fuel ratio control. Whilst 'isolated',

examine the fuel pipes and connections **up-stream** of the control valve assembly for leaks. Return the isolating switch to the OFF position.

(5) Allow the engine to idle for about half a minute, to allow the temperature conditions to stabilize, and then stop the engine.

(6) Make a careful visual examination of the engine, looking particularly for evidence of gas, fuel, or oil leaks, and for blowing joints.

Ghost 48 Mk. 1. The sequence of checks for fuel leaks when 'isolated' (sub-para. 2 and 4) has been selected to ensure that the relevant pipes and their associated components are examined whilst the greatest pressure is developed in the specified part of the fuel system.

If, whilst idling on the ground, the r.p.m. falls below the minimum idling speed, STOP the engine and make a fresh start. If the trouble persists, the cause should be investigated, and remedied, as described in chapter eleven. If, under these conditions, the throttle is opened in an attempt to attain the normal idling speed, overfuelling may be caused ; resulting in overheating and serious damage to the turbine.

Ghost 48 Mk. 2. Appreciable changes in governed r.p.m. may be observed during daily operation. When a cold engine is opened up to full throttle the maximum r.p.m. attainable may be below the normal take-off r.p.m. To avoid needless time being spent attempting to overcome this apparent running defect, it should be noted that these changes are the result of changes in the fuel supply pump operating temperature. It is to overcome this temperature effect that the governor adjustment instructions state that before adjusting the governor it is essential that the engine is run for at least three minutes to allow the fuel system to warm up to its normal operating temperature. This effect can be overcome, to some degree, if the governed speed at full throttle is re-checked at the end of the ground running check before stopping the engine. Provided that the low r.p.m. is not caused by some other defect, the engine may be cleared for flight provided that at the pre-take-off check the governed speed is not less than 10150 r.p.m.

STOPPING THE ENGINE

Before stopping the engine, SHUT the throttle and allow the engine to idle for about half a minute, to allow the temperature conditions to stabilize.

(1) SHUT the H.P. fuel cock, and commence to time the run-down of the main shaft.

(2) Switch OFF the fuel tank booster pump.

(3) When the engine has stopped, move the ground/flight switch to GROUND or the battery isolating switch to OFF. The battery isolating switch must not be moved to BATTERY ISOLATE until the generator warning light has come on and the engine has stopped ; failure to observe this instruction will result in damage to the electrical power system.

(4) Switch OFF the starter master switch. Where Venom mod. 290 has been embodied, this switch may be at OFF already.

(5) Turn OFF the L.P. fuel cock.

Ghost 48 Mk. 1. Even if the engine is to be re-started after only a short time, it is essential to turn OFF the L.P. fuel cock. This is to avoid a hot start due to the pressure head from the main fuel tanks causing a flow through the low pressure pipe between the L.P. fuel filter and the fuel flow distributor, and thence, via the distributor piston, to the combustion chambers. Mod. 1074 introduces a non-return valve to minimise this seepage of fuel into the engine.

FREE RUNNING CHECK

Whilst the engine is running-down, listen carefully for any unusual noises ; if any are heard they should be investigated immediately. Whenever the opportunity arises, note the time taken, after shutting the H.P. fuel cock, for the main shaft assembly to come to rest from idling speed. In still air, the rotor should come to rest in approximately 1 to 2 minutes. As rotation ceases, the rotor should show a tendency to swing back ; this will not occur if there is any undue friction or tightness. With a new engine and full complement of engine-driven accessories, the time to run down may be less, but if it is less than one minute, a further check should be made with the engine-driven aircraft accessories removed.

WHEN THE ENGINE HAS STOPPED

Immediately the engine has stopped, replace the air-intake and propelling nozzle covers. Allow sufficient time for the oil to drain down into the sump, check the oil level, and, if necessary, replenish the sump with the correct oil. Check the engine bay cowling for cleanliness, looking particularly for evidence of fuel or oil leaks.

UNLOADING THE TURBO STARTER

Always treat this type of starter as though it contained live cartridges.

Do not leave cartridges, fired or unfired, in the breech longer than is necessary. Spent cartridges must not be left in the breech for more than eight hours.

Unfired cartridges should not be allowed to remain in the starter breech after flight as live cartridges deteriorate if allowed to 'soak' under these conditions. When the engine has stopped and there is no flow of cooling air, the temperature, after about 30 minutes, may be as high as 60/70 deg. C. Each time this process is allowed to occur, the burning rate of the charge increases until, ultimately, the charge becomes explosive. The cartridge in this condition is dangerous for handling and storage, and, if used in the starter, will blow the safety disc when fired.

If one cartridge has been fired and the second, which is still live, is removed before it has been fired, that cartridge must: either be replaced in the breech in the next barrel to be fired, normally the one from which it was taken and an expended cartridge loaded into the second breech barrel, or it must be returned to the ammunition depot for refilling. Such cartridges must not be returned to store; such cartridges may be identified by the smoke blackening on the smaller end, due to the firing of the first cartridge in the breech. In these circumstances, it is suggested that the cartridge be left in the breech cap (i.e. omit operation 4 of the unloading sequence), and that the breech cap and cartridge be labelled with the aircraft number and breech number from which it was taken; to ensure its replacement in the next breech to be fired.

When operating under freezing conditions, the turbo-starter breeches should be unloaded, cleaned, and re-loaded immediately the engine is shut-down (whilst it is warm). This is particularly important after short ground runs as, if left, the moisture produced by firing the cartridge freezes in the breeches and makes cartridge removal and breech cleaning almost impossible. In flight the continued operation of the engine (heat) dries out this moisture and less trouble is experienced than after short ground runs.

UNLOAD THE TURBO STARTER as follows.

(1) Ensure that the engine starter master switch is OFF.

(2) Press the thumb catch on the breech cap, to release the locking ratchets, and unscrew the breech cap. Removal is easier while the breech is warm and if the breech has been properly cleaned prior to loading. If the cap is difficult to turn, a tommy bar $\frac{5}{16}$ in. diameter by 9 in. long may be used; this is only permissible when removing the cap.

(3) Withdraw the breech cap and cartridge.

(4) Press the cartridge sideways, against the spring in the breech cap, to disengage the flange at the base of the cartridge from the groove in the cap, and separate the cartridge from the breech cap.

(5) Repeat the foregoing to unload the second breech.

(6) Clean both breeches and their caps as described on page 2.

Spent cartridges should be returned to the ammunition store, as they can be recharged. All cartridges must be examined visually immediately after removal from the starter to ensure that the centre bolt at the exit end of the cartridge is attached. If the centre bolt is missing, the starter must be removed from the engine and dismantled sufficiently for the bolt to be removed.