air cadets

the next generation

air cadet publication

ACP 34

aircraft operation

volume 3 - aircraft handling

Amendment List		Amended by	Date Incorporated
No	Date		
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

ACP 34

AIRCRAFT OPERATION

CONTENTS

Volume 3

Aircraft Handling

ISSUED 2000

FOREWORD

For a long time, military aviation was the province of men only. However, year by year, more and more women are joining the men in this demanding area of endeavour. We welcome them, and assure all readers that where male pronouns are used in this manual, it is purely in the interests of brevity.

CHAPTER 1

AIRCRAFT MAINTENANCE

Introduction

Ground Organisation

1. Aircraft cannot operate without the backing of an efficient and effective ground organisation. It is therefore right and proper that before we consider the principles of operating aircraft in the air, we examine the ground organisation upon which the aircrew so vitally depend. The RAF's maintenance organisation concerns itself not only with aircraft, but also with avionics systems, aircraft escape systems, survival equipment, weapons, flight simulators and synthetic trainers, surface-to-air missile systems, raiders, communications and control systems, motor transport, and the training and testing equipment needed to support all these, including operational or support software. However, we shall confine ourselves mostly to aircraft maintenance.

MAINTENANCE

Maintenance Policy and Objectives

How aircraft are maintained in the RAF

2. The RAF's maintenance policy is based on a finely judged balance of preventive and corrective maintenance. The balance is critical - a policy aimed too much at preventing breakdowns (ie, "over-maintenance") would keep the aircraft in the hangar most of the time, but conversely a policy that relied too much on waiting for faults and then correcting them would be hazardous.

3. The objectives of the RAF's maintenance organisation are in 2 main categories, "operational" and "maintenance". The operational objectives are:

a. To generate the aircraft and equipment needed to counter surprise attack.

b. To support intensive flying over a sustained period in NBC or other hostile environments (NBC = nuclear, biological, chemical).

c. To generate aircraft and equipment needed for NATO and our own National commitments.

d. To satisfy such contingency plans as may be ordered by higher authority.

e. The efficient provision of serviceable aircraft and equipment needed for peacetime tasks (eg training, humanitarian, etc).

The maintenance objectives require the best possible balance of preventive and corrective maintenance, so as to:

f. Minimise costs (manpower and resources).

g. Minimise faults that would hazard an aircraft, or affect its operational capability, or need expensive repairs.

h. Find ever-better ways of improving reliability and maintainability.

Preventive Maintenance.

Types of servicing

4. The aims of preventive maintenance are to reduce the probability of failures; to restore the inherent level of aircraft and equipment reliability after a pre-determined amount of time or use; and to ensure that time and use do not effect the performance of aircraft and equipment. Within the RAF this comprises 4 types of maintenance:

a. Servicing. Servicing (or “flight servicing” when applied to aircraft) is the maintenance that is needed after a period of use (eg a flight), plus preparation for the next period of use. It involves checking consumables (eg oil, fuel, oxygen), replenishing them where needed, and examining for any obvious signs of unserviceability (eg fuel leaks, excessive oil consumption, cracks, corrosion).

b. Scheduled Maintenance. Scheduled maintenance is done at regular, pre-determined intervals - and its aims are to:

(1) Keep the aircraft in a sound overall condition.

(2) Minimise random faults and hence the amount of corrective maintenance needed.

(3) Minimise the amount of routine day-to-day attention needed.

c. Condition-based Maintenance. Some aircraft parts are given continuous monitoring, as opposed to the routine checks required in servicing and scheduled maintenance. When a condition that needs attention is found, whether by continuous or routine monitoring, the repair work is called “condition-based maintenance”. Where condition monitoring is done using non-destructive testing (NDT) - eg X-rays to reveal fatigue cracks - or by Spectrum Oil Analyzed Particles (SOAP) techniques, servicing of the item can usually be left until a condition that needs attention is revealed. This is in preference to replacing or repairing the item at fixed intervals, which or safety would necessarily be more frequent ñ and hence more costly ñ than with condition-based maintenance.

d. Out-of-Phase Maintenance. Not all parts of an aircraft or equipment require servicing at the intervals required by the normal maintenance cycle. The term “out-of-phase maintenance” describes scheduled or condition-based maintenance which is needed at intervals that do not fit the maintenance cycle.

Corrective Maintenance.

5. Corrective maintenance is carried out when a fault occurs, so as to make the aircraft serviceable again. As faults are random, corrective maintenance cannot be planned or timetabled. However, condition-monitoring techniques can be used during the corrective work to determine the extent of the fault, and perhaps detect associated faults.

Contingency Maintenance

6. In war operations or in transition-to-war to fulfil the operational task, it may be necessary to relax maintenance standards; this can include the suspension of scheduled and condition-based maintenance. ìContingency maintenanceî, which is a level of preventative maintenance considered essential in the particular circumstances, would then be introduced. The amount of contingency maintenance needed would be identified, and there would be a planned programme for each aircraft type.

Modifications

7. Modifications to aircraft are needed from time to time. They may be made for various reasons ñ for example, to remedy a design fault that has come to light in all aircraft of that type, or to incorporate new technology designed to improve performance or safety. However, whatever the origin, modifications must only be undertaken when authorised, and under strictly controlled procedures. The reason for this is to control costs, minimise downtime (the period when the aircraft is out of use) and ensure that the safety of the aircraft is not endangered by unauthorised or incorrect work.

MOD Form 700 Series

Maintenance Records

8. Each individual aircraft has its own MOD Form 700. This ìAircraft Maintenance Data Formî shows the current condition of the aircraft, ranging from when the next scheduled servicing is due, to when it was last refuelled and how much fuel was put in. The form is actually a whole series of forms, too numerous to describe here, but some examples are:

a. MOD Form 701 - information on the aircraft's permitted fuels and oils, basic weight, tyre pressures, alignment record, aircraft dimensions, etc.

b. MOD Form 703 - Onboard Software Log - where the aircraft has computerised onboard system(s), this form would be used to indicate to the pilot the identity of the software loaded into the system(s).

c. MOD Form 725, Flying Log and Fatigue Data Sheet - details of each flight, including fatigue meter readings where fitted.

d. MOD Form 725A, Air-to-Air Transactions - details of in-flight refuelling.

e. MOD Form 705, Flight Servicing/Fuel Certificate - used for the certifying of flight servicing and fuel states. It contains the previous Captain's After-Flight Declaration, which includes (amongst many other matters) details of any faults that became evident whilst he was responsible for the aircraft, and certification that the ejector seat mechanism has been set to the "safe for parking" condition. This signed declaration returns responsibility for the aircraft to the ground engineers, who then record details of the flight servicing when it is completed. The Flight Services Co-ordinator signs the Flight Services Certificate to confirm the details, and in due course the Captain for the next flight accepts responsibility for the aircraft by signing the Captain's Acceptance Certificate. The Captainís signature certifies (amongst other details) that he is aware of all relevant details in the Form 700 series. These details always include the fuel state and can include other items. Two important examples are operating limitations which might have been imposed by certain modifications; and the acceptance of certain faults which will be fixed at a later date, but do not prejudice the particular flight about to be undertaken.

How maintenance records are used

9. Many details from the Form 700 series of RAF and Fleet Air Arm aircraft are fed into the RAF's maintenance data system (MDS). The MDS can provide, rapidly and accurately, information on defects and servicing work done. This enables engineering managers to obtain better reliability and make the best use of servicing resources. The system comprises 6 major data elements; each element concentrates on a particular aspect of maintenance data, but they all have considerable interdependence. The 6 elements are faults (or defects), modifications, manpower utilization, task achievement, technical costs and logistics. The faults/ defects element provides a wide range of routine and one-off outputs for the support of engineering analysis, survey and review. Aircraft fatigue monitoring is also provided, and units (RAF stations) and their higher formations (Groups and Commands) can be supplied with fatigue index information on floppy disks; this information is extremely useful in fleet management (eg controlling the consumption of fatigue life amongst the aircraft in the fleet, planning ahead for the replacement of aircraft or parts that are approaching the end of their fatigue life).

10. By now, you should have some insight into the careful organising and planning that goes into the maintenance of Royal Air Force aircraft. The next step (Chapter 2) is to see how those aircraft are handled when they reach the users.

Self Assessment Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. What is the RAF's maintenance policy based on?

2. What is an RAF Form 700?

3. What is an MOD Form 703?

4. What is an MOD Form 705 used for?

CHAPTER 2

GROUND HANDLING

Introduction

1. This chapter deals with the general principles used in the RAF for handling aircraft on the ground. Local circumstances and operating conditions may sometimes require minor change to those general principles.

Seeing In and Seeing Off

How a handling team operates

2. Aircraft arrivals and departures are usually attended by a handling team comprising two tradesmen. The handling team will marshal an arriving aircraft into a parking area which has been cleared of foreign objects and non-essential items of ground equipment (a foreign object in this context includes a boost of objects which are at first sight trivial, but could damage an aircraft - eg discarded drink cans, old cleaning rags, small stones and such like can be blown by the jet efflux of one aircraft into another's air intake; or spare rivets, bolts etc lost during servicing can damage the tyres. Hence the term FOD - foreign object damage). When signalled by the aircraft captain, chocks are inserted and ground power and any necessary ground servicing equipment is connected. Fire extinguishers are positioned and manned as required during engine shut-downs, aircraft steps are positioned and the aircrew are assisted with unstrapping. Finally the handling team will fit safety devices (eg safety pins to make the ejection and any other covers, blanks and plugs that are needed - eg cover or sleeve over the pitot head, a plug for the static vent).

3. Similar actions are carried out in reverse order for aircraft departures.

Marshalling

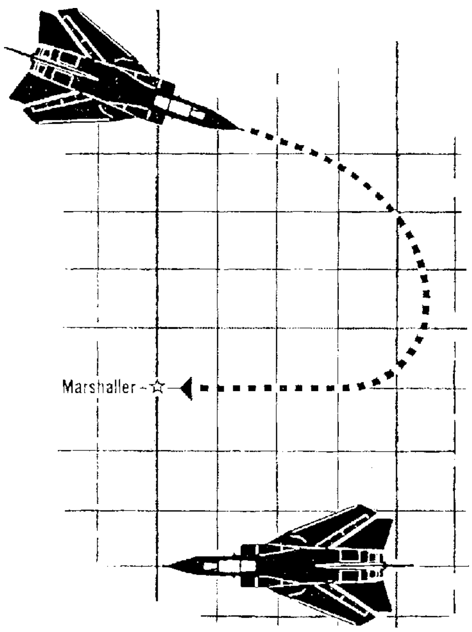
4. The aim of the marshaller is to assist the pilot in the safe manoeuvring of the aircraft on the ground. The marshaller communicates with the pilot by making visual signals with his arms and hands. More than 70 signals are used in the RAF. Some of the most frequently seen signals are illustrated in the Annex at the end of this chapter.

5. The extent of the marshalling assistance given will depend upon the pilot's familiarity with the airfield, the number of obstructions, the size of the aircraft and the field of view from the cockpit. At an unfamiliar airfield taxiing instruction can be passed by radio; also, for a long tortuous route, marshallers may be stationed at intervals, or "follow me" vehicles may be used.

How a Marshall operates

6. Marshalling Procedure - Day. Marshalls identify themselves to pilots by energetic waving of the arms in a circular motion. The marshaller may wear clothing of a distinctive colour as an aid to identification. The type of marshalling will vary with circumstances - to park an aircraft in a particular position when the approaches to it are clear, requires only that the marshaller gives the pilot an indication of where the aircraft must finally be stopped. This is done as early as possible by the marshaller standing on the required spot with arms outstretched, facing towards the final position of the aircraft. The pilot is then free to taxi the aircraft in a path of his own choosing to the spot indicated (Fig 2-1).

Fig 2-1 *Marshalling on an Unobstructed Dispersal*



If obstructions exist, two extra personnel may be required to complete the marshalling team. They would walk on either side of the aircraft, ahead of the wing tips and signal to the pilot if there is sufficient clearance for the aircraft to pass the obstructions. This assistance is most likely to be necessary when marshalling large aircraft with restricted fields of view from the cockpit.

7. Marshalling Procedure - Night. While taxiing at night in congested areas, detailed marshalling directions are necessary, although the need is less if taxiing lights are used (these are lights built into the aircraftís structure, normally the wings, and they are used similarly to headlights on cars). If dispersal areas are floodlit, marshalling assistance can be reduced to that given in daylight. Navigation lights (the coloured lights - red, green, white - on the wing tips and tail) must always be on, and taxi lights used (although care should be taken not to dazzle the marshaller). Marshallers must position themselves where they can be seen by the pilot at all times, and they carry wands or torches for identification. If the pilot loses sight of the marshaller he will stop the aircraft until the marshaller has repositioned and can be seen.

8. Responsibility. The pilot is responsible for the safety of the aircraft and is not required to comply with marshalling instructions he considers to be unsafe. He is at liberty to pursue the course of action he thinks best - this could include consulting the airfield controller by radio, taking rapid action to avoid an obstruction, or stopping the aircraft completely.

Chocks, Safety Devices, Blanks and Covers

After landing - Safety precautions

9. Whenever aircraft are shut down and stationary on the ground, and during engine runs, they should be securely chocked. Safety devices, blanks and covers should be fitted throughout the time that the aircraft is shut down, unless removed temporarily for maintenance.

Danger Zones

Danger of propeller and rotor blades

10. Danger zones are those areas in which there is a high risk of injury to personnel when aircraft components or systems are operated on the ground. Normally they will comprise areas around engine intakes and exhausts, propellers and helicopter rotors. In particular, piston-engined aircraft propellers should always be considered ìliveî: it is not unknown for a faulty switch to leave the ignition live when it was thought to be off - and someone moving the propeller slightly (perhaps by just leaning on it) has caused the engine to fire. You can imagine the injuries caused by a propeller which suddenly rotates when it was thought to be harmless. For this reason, the propellers of piston-engined aircraft should be hand-swung only by

trained ground crew, properly authorised and using approved procedures. Helicopter rotor blades can be especially hazardous when the helicopter is on the ground in gusty wind conditions. The gusts can cause “blade sailing” which can bring the rotating blades closer to the ground than their normal running height.

Wheel and Brake Fires

Danger of wheel brake fires

11. Aircraft wheel brakes operate just like other vehicle brakes - a pad made of heat-resistant and hard-wearing fibre presses against a disc attached to the wheel (or it may be a drum instead of a disc in some simple aircraft). The friction force between the pad and the disc opposes the rolling movement of the wheel, and slows the aircraft down. The friction heats up the disc, which normally dissipates the heat safely into the air around it. However, during prolonged taxiing, or after an abnormal landing (eg too high a landing speed, a very short runway, landing in a tailwind instead of a headwind, landing overweight), the brakes can overhead and a brake or a wheel can catch fire. If this occurs whilst the aircraft is in or entering dispersal, the ground handling team would attempt to put out the fire using their ground fire extinguishers. However, they would take special care, due to the danger of explosion if their actions with the fire extinguishers caused the aircraft wheel or brake assembly to cool down unevenly or too rapidly. The safest course of first aid action against an aircraft wheel or brake fire is:

a. To stand forward or rearward of the wheels depending on the prevailing wind, but never in line with the axle, as this is the most likely path that debris would take if an explosion occurred.

b. To operate the fire extinguisher at the limit of its range, and to spray the extingushant downwards towards the wheels, ensuring that the flow strikes the ground 0.3m away from the wheels and flows onto the wheels.

Manhandling and Towing

Movement of aircraft by ground crew

12. So far, in discussing the movement of aircraft on the ground, we have confined ourselves to those occasions when qualified aircrew have been taxiing the aircraft under engine power. However, there are many occasions when ground crew need to move aircraft.

13. Aircraft may never be taxied into or out of hangars. Whenever aircraft are left in hangars it follows that they must be towed or manhandled on to the ASP or dispersal before flying can commence and vice versa after the flying programme is completed.

14. The normal method of moving an aircraft is to tow it with a suitable vehicle fitted with a towing arm connected to the nose or tail wheel of the aircraft. If a vehicle is not available, the aircraft may be manhandled into the required position. In this case great care must be taken by the handling party to push against only the strong parts of the aircraft. Damage would be caused by pushing on vulnerable parts such as ailerons, elevators or lightly made fairings.

Members of a handling crew

15. Whenever an aircraft is to be moved a handling party, with each member qualified for the duty, is detailed consisting of:

a. An experienced supervisor.

b. One person in the cockpit to operate the brakes when required.

c. One at each wing tip to ensure obstacle clearance.

d. Either a driver for the towing vehicle, or a sufficient number of persons to manhandle the aircraft.

16. Parking. The handling party will act in accordance with the orders for the particular type of aircraft, which will normally include:

a. Park the aircraft facing into wind so that no part of one aircraft overlaps any part of another.

b. Double chock the wheels ñ fore and aft.

c. Release the brakes.

d. Check the electrical services, ignition switches and fuel cocks are turned off.

e. Apply control locks.

f. Fit pitot and static vents covers.

g. If aircraft are to be left for any length of time lock canopies and doors, fit canopy covers, wheel covers and engine covers and set drip trays.

Refuelling

17. Aircraft are refuelled in accordance with local orders and normally this will be after every flight. On completion of the day's flying the aircraft will be refuelled before it is parked or put away in a hangar. This prevents condensation inside the empty tank and so reduces the tendency of water contamination in the fuel. It also means that the aircraft can be ready to fly at an earlier stage the next time it is brought out of the hangar.

How an aircraft is fuelled

18. Aircraft may be refuelled in many ways: by hand by decanting fuel from cans direct into the aircraft tanks; by bowsers built specially for the task; by high pressure direct from specially built ground installations; by portable fuel tanks powered by hand or mechanical pumps (most likely at a temporary base); or, while still in flight, from another "tanker" aircraft.

19. The mobile bowser in its various forms is the normal conveyor of fuel from storage tanks to aircraft. The general layout is basically the same for each type of bowser; fuel is pumped through delivery hoses by the bowser's main engine or a small donkey engine housed at the rear of the vehicle: the pumps are sometimes reversible to provide equally speedy defuelling when necessary. A typical aircraft/ bowser disposition is shown at Fig 2-2.

Earthing an aircraft when refuelling

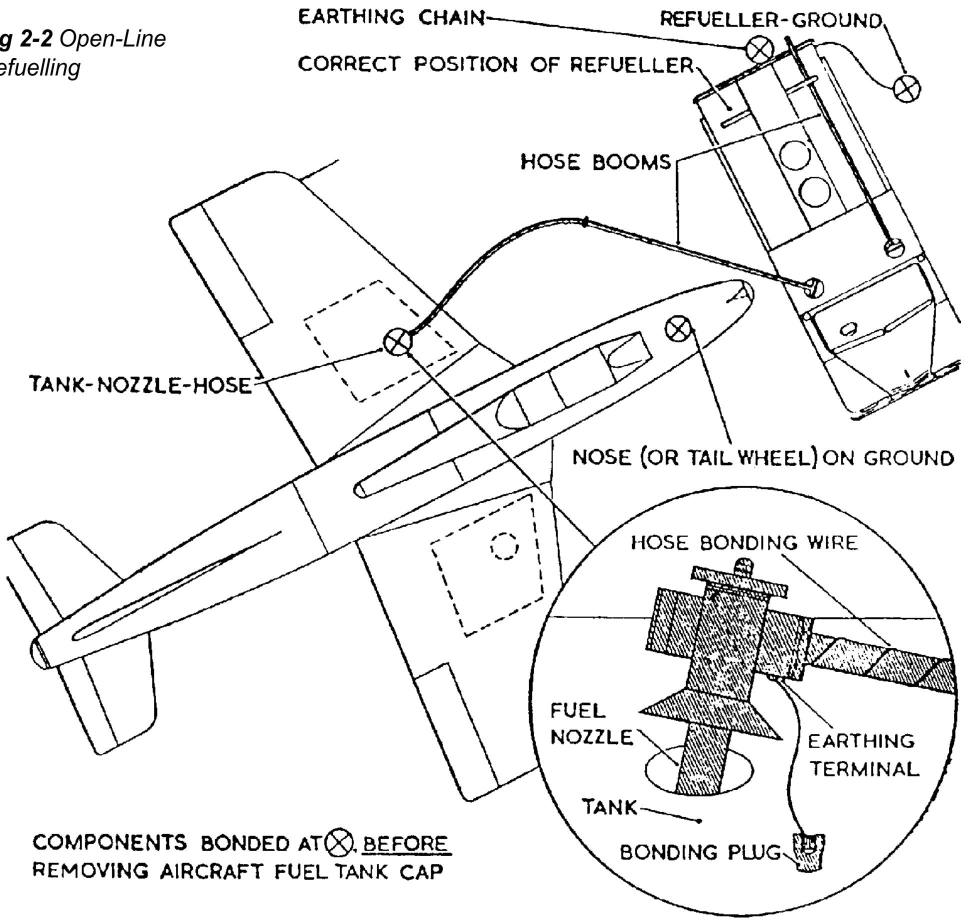
20. The risk of fire is a very real one during re-fuelling and every precaution must be taken to prevent ignition. A primary precaution is to prevent a spark from static electricity and a first action is to provide adequate bonding, ie the linking of metal parts by a conductor to ensure that static electricity can run to earth. This is shown in the diagram at Fig 2-1, where it can be seen that:

a. The aircraft is earthed.

b. A piece of conducting wire connects the aircraft to the delivery hose.

c. The bowser is earthed.

Fig 2-2 *Open-Line Refuelling*



Other precuations when refuelling

21. In addition to the safeguards against static electricity there are many other precautions to be taken and most refuelling orders will include the following:

a. Be absolutely certain that the correct grades of fuel and oil are put into the appropriate tanks.

b. Leave air space in oil tanks for expansion and frothing of oil when heated.

c. Never refuel an aircraft in a hangar; or an aircraft with the engine running, unless specifically authorised in special circumstances.

d. Always ensure that the fuel passes through a filter before it enters the tanks.

e. Refuelling crew must not carry cigarette lighters or non-safety matches and must wear rubber or crepe soled shoes.

f. Avoid fuel spillages, but if one occurs, call a fire tender to wash it away.

g. Work on electrical or radio equipment (including R/T transmission) must not be conducted whilst refuelling is in progress, or within 15m of an aircraft which is being refuelled.

h. Refuelling should not be carried out within 40m of an aircraft with engines running.

i. Refuelling vehicles should be positioned so that they can be quickly moved in the event of a fire.

j. Place suitable fire extinguishers ready for use.

k. Stand only on the approved walkways on the aircraft.

l. Replace filter caps and check they are fitted properly.

m. Enter details of the refuelling/defuelling in MOD Form 705.

Pressure Refuelling

22. With pressure refuelling the fuel delivery nozzle has to make a fuel tight joint with the aircraft, and the fuel is then pumped into the aircraftís tanks under high pressure. The result is that refuelling time is dramatically reduced ñ which is very important whilst air-to-air refuelling when the tanker and receiver are vulnerable to attack. Pressure refuelling is also used on the ground with many modern aircraft.

23. The basic difference between the system for pressure refuelling on the ground and that for use in flight is the position of the filling point. For either system all tanks or tank groups are fitted with shut off valves, mechanically or electrically operated. The valves give positive fuel shut-off when the receiving aircraft has reached the desired fuel level, and there are pressure relief arrangements to protect the aircraft fuel lines. Important precautions to be taken when pressure refuelling are to ensure that the refuelling coupling is correctly connected, that bonding is complete, aircraft switches are set and that the maximum refuelling pressure is not exceeded.

Types of Fuel

24. Fuels used in the RAF and RN fall into one of 4 categories:

a. AVGAS- aviation gasoline.

b. AVTUR - aviation turbine fuel (kerosene).

c. AVTAG - aviation turbine widecut gasoline.

d. AVCAT - aviation turbine fuel, used largely by the Royal Navy.

e. No naked lights or flame (smoking) to be within 30m. Only flame proof torches to be used.

Grades of AVGAS

AVGAS is divided into tow grades, that used for a particular engine being determined by the compression ratio and maximum manifold air pressure rating of the engine, the operational role in which it is employed, and the geographic locality in which it is used. The use of AVTUR or AVTAG in turbine engines is usually determined by the design specification of the engine. The majority of gas turbine engines may be run on either of these subject to certain precautions and limitations and detailed in the Aircrew Manual for the specific aircraft type.

Loading

Dangers of overloading aircraft

25. Large aircraft have an air quartermaster, whose responsibilities include supervising the loading and security of loads. He must satisfy the captain of the aircraft that the load is evenly distributed and securely stowed, and that the centre of gravity (C of G) is within limits.

26. Overloading has the following effects:

a. It increases the stalling speed and landing and take-offs runs.

b. It reduces rate of climb.

c. It reduces range and endurance.

d. In twin or multi-engined aircraft it may make it impossible to maintain flight in the event of an engine failure.

e. It lowers the aircraft's ceiling (ie the height to which it can climb)

27. It is of little use ensuring that the maximum all up weight is not exceeded if the aircraft is not properly balanced owing to the uneven distribution of the load. The load must be distributed so that the C of G falls within the limits for the aircraft concerned. The aircraft is then correctly balanced fore and aft and may be flown safely.

Conclusion

28. The modern military aircraft is a complex and highly developed machine which needs thorough inspection and periodic changing and servicing of components to keep it at a high level of operational efficiency. Over the years, much study has been put into the development of a system that will reduce to a minimum the portion of an aircraft's life during which it is compulsorily grounded for servicing and to ensure the highest standards of mechanical reliability and aerodynamic efficiency.

Aircrew and groundcrew working together

29. The system depends for its success not only on the skill and enthusiasm of the ground staff but also on the co-operation of the aircrew. The pilot and his crew have a direct responsibility for the servicing of the aircraft which they fly and much will depend on their early and accurate reporting of snags. The development of the team spirit which no amount of organisation of regulation can of itself bring about is, in fact, the keystone of the RAF's aircraft maintenance policy.

Self Assessment Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. What is FOD?

2. What is the aim of a marshaller?

3. How do Marshalls identify themselves to pilots?

4. Who is responsible for the safety of an aircraft?

5. What are the responsibilities of an air quartermaster?

CHAPTER 3

PREPARATION FOR FLIGHT

Aircraft Captain

Why we need an aircraft captain

1. Throughout the period of operation of an aircraft, at all times there must be one person in charge who, however well his crew are doing their jobs, is the one to take over supreme charge in an emergency. That person is the aircraft captain. The position is one of great responsibility, and the person filling it must have special qualities. The captain may have to persuade, he may have to drive ñ but at all times he has to lead. Without leadership, no military enterprise of any importance has ever been carried through with success. Although any member of an aircraft crew may be appointed as the captain of the aircraft this appointment is most often held by the pilot.

Personal Preparation

Prior to flying

2. To undertake this responsibility the captain of an aircraft must ensure adequate preparation for flight, and it is his duty to see that he and his crew are prepared for it. Among his preparations he will make certain that:

a. He and all crew members are thoroughly familiar with the aircraft and their own roles, and are trained and practiced to the extent that they have confidence in themselves and each other. To this end, the captain and crew will make full use of all available training aids such as flight simulators, instructional fuselages, and mock-ups of fuel, hydraulic and electrical services.

b. He and his crew understand perfectly the aim of the flight and that he has done everything necessary to achieve that aim.

c. The personal fitness of himself and all crew members is such that he will carry out the flight correctly and safely. The safety of the aircraft and its crew can be jeopardized by an unfit pilot or crew member.

d. The relevant order books have been read and understood. Military Flying Regulations, Air Staff Instructions and the Station Flying Order Books are all relevant and must be read and understood before a captain may take charge of an aircraft.

e. The flying clothing and safety equipment of himself and all crew members is complete and in good repair. It is essential that all aircrew take good care of their flying clothing and safety equipment at all times. Serviceability checks are done by the user before each flight.

f. Appropriate crew members have carried out the correct flight planning, and that all the information necessary to ensure the safe navigation of the aircraft has been obtained. The success of any sortie may depend more upon the thoroughness of this aspect of pre-flight preparation than any other.

Flight Planning

3. Pre-flight planning requires a knowledge of:

a. The weather conditions at the time and a forecast of how the weather is likely to change during the flight.

b. Air traffic control clearance, together with details of available diversion airfields and restricted airspaceís in the region of the flight.

c. Navigation pre-calculations and preparation of maps and charts.

Self Briefing

4. This preparation often takes the form of ìself briefingî in which the pilot/navigator will use the weather and air traffic control information displayed in the operations/flight planning room to complete the flight plan and prepare maps and charts.

5. On many units a mass briefing of all aircrew is held at the start of the day's flying, when the squadron commander and specialist officers of air traffic control, the meteorological section and other departments give the latest information on every aspect affecting the day's programme.

Briefing of Passengers

6. If there are passengers the aircraft captain will ensure that they are fully briefed; normally by a crew member ñ particularly, the air loadmaster if there is one. The items to be covered will vary with the circumstances of the flight, but a typical briefing will ensure that passengers understand:

a. That the captain of the aircraft is in command of the aircraft and all persons in it, irrespective of rank, whilst in flight.

b. The correct use of the safety straps and the crash and ditching positions.

c. The manipulation of the escape hatches, and the dinghy position to take up for a ditching.

d. How to fit oxygen masks and operate the oxygen flow controls if oxygen is to be used.

e. How to fit and operate parachutes if these are carried, and the correct exits to be used.

f. The no smoking or naked lights rule when applicable.

g. How to operate any R/T communication equipment form passenger to pilot that might be installed in the aircraft.

Authorization of the Flight

Responsibilities of an Authorizing Officer

7. No pilot may fly without formal authorization of the flight. This is done in the Flight Authorization Book (form 3562) by a nominated officer, normally the flight commander or squadron commander. Before authorizing the flight the officer will take into account such matters as the weather conditions related to the experience of the crew, the instrument flying rating of the pilot, the equipment available in the aircraft and the facilities available for instrument approaches at the destination.

8. In the event of an aircraft accident or breach of flying discipline the relevant Form 3562 is impounded by the investigating authority and the various signatories are held responsible for all the implications of their respective signatures.

9. The initialling of this book by the captain of the aircraft signifies that he understands his responsibilities as captain and that he understands his orders for the particular flight.

10. The book is also the official record of flying times and exercises carried out. It must be completed by the captain of the aircraft on completion of the flight.

MOD Form 700 Series

Importance of Form 700 Series

11. These important documents, the official aircraft maintenance data records, were described in Chapter 1. Like the Flight Authorization Book, they too are impounded in the event of an aircraft accident or a breach of flying discipline.

12. You will recall from Chapter 1 that the Form 700 series tells the pilot such matters as:

a. Whether or not the aircraft is serviceable for flight.

b. The quantities of fuel and oil in the tanks.

c. The armament and oxygen state.

d. The hours flown or run by the engines.

e. The flying hours remaining to the next periodic servicing.

13. The aircraft captain signs one of the Form 700 series (the Form 705) before each flight. His signature is a certificate that he has verified by his own inspection of the form that:

a. Flight servicing has been certified as having been carried out.

b. The aircraft is now shown unserviceable.

c. The time remaining unexpired before the next scheduled servicing is sufficient for completion of the proposed flight.

d. The quantities of fuel, oil, oxygen and armament carried are sufficient for the flight.

e. He is aware of all the work done on the aircraft since its last flight.

f. It has been signed in the appropriate column by the Flight Services Co-ordinator.

14. The aircraft captain will also fill in and sign the form on completion of the flight to certify whether the aircraft is "satisfactory" or not for the next flight. Intelligent use of this certificate by the captain of the aircraft is a valuable aid to efficient servicing.

Pre-Flight Checks

What a pilot is chgecking for

15. On approaching the aircraft the pilot will note its general position in relation to other aircraft and obstructions; he will check the room he has to taxi the aircraft out to the taxiway; and he will note whether all is clear to start engine and that there are no rags, loose articles or stones that may be picked up by the propellers/jet intakes or blown into the intakes of other aircraft. He will check that the aircraft is standing on firm ground, properly chocked, with aids to starting engines properly positioned, and starting crew in place with fire extinguishers of adequate capacity at hand.

16. Detailed checks for the type of aircraft will be found in the Aircrew Manual for the type, but will normally include:

a. External checks.

b. Cockpit checks before starting engines.

c. Warming up and running up (piston engines).

d. Pre-take off checks.

17. Checks may often be in "card" form and may be "called off" to the pilot by another crew member in the form of a challenge and response, in order to ensure that nothing is overlooked. Checks are a pre-requisite of every flight and are integral to the careful team work that goes into preparing the aircraft and crew for flight. They are the final steps in ensuring that all is ready for take off.

External Checks

18. Although the properly completed Form 700 series is an assurance that the aircraft has been serviced, it is good airmanship and a standard practice for a pilot to inspect the outside of the aircraft to ensure that it is aerodynamically and operationally fit for flight. For example he will:

a. First check inside the cockpit to ensure that brakes are on and switches off and will then walk right round the aircraft, checking the external surfaces of fuselage, wings and tailplane for signs of damage, for freedom from ice, for signs of hydraulic fluid, fuel or oil leaks, and will also note whether inspection panels have been properly fastened.

b. Check that the pitot head and static vent covers have been removed; that external control locks and external undercarriage locks have been removed; and that engine covers and/or blanking plates have been removed.

c. Inspect the undercarriage for serviceability, noting any signs of damage or excessive wear in tyres and wheels.

Checks Before Starting

19. Starting engines is a team procedure between the pilot and the ground handling team. The pilot will first ensure that he, the crew and passengers are correctly seated and strapped in. He will then check the cockpit to ensure that fuel and other services required are switched on; that the undercarriage is selected down and is shown as being locked down; that brakes are locked on and adequate pressure is available; and that engine switches are as required. The pilot will then indicate the engine to be started and ensure that all is clear for starting by interrogation of the ground team either verbally or by hand signal. This is normally done by the shout “All clear for starting?” He must then indicate in the same way that he is starting.

Checks After Start-Up

What to look for on engine checks

20. Engine checks after start-up vary according to type. Briefly, on piston engines it is important to check that the oil pressure is beginning to register on the gauge.

Next, at a recommended rpm (1200 for the Bulldog) the engine must be warmed up to the recommended cylinder head and oil temperatures. It will then be run up to higher rpm, to test the power output, correct functioning of both magnetos and correct operation of the propeller variable pitch control. This may be done at the squadron dispersal or may be done after taxiing to the marshalling point at the runway in use. Jet engines do not require warming up or running up, but there is a brief period during start-up, whilst the engine is winding up to idling rpm and the flame is not fully stabilized in the combustion chamber, when the jet pipe temperature gauge must be monitored closely. If the temperature is rising too rapidly the engine must be closed down before the permitted maximum is exceeded ñ otherwise engine damage can occur and, even worse, fire could break out.

Taxiing

21. Any special points to be watched while taxiing are described in the Aircrew Manual for the type. In all aircraft, the pilot must check the brakes as soon as possible after starting to taxi whilst the speed is still low. Whilst taxiing, the pilot will check the aircraft before the brakes lose their effectiveness. The pilot will always keep the amount of engine power used in taxiing as low as possible, since aircraft brakes can quickly overheat if abused.

22. If the aircraft has nose wheel steering, wheel brakes will be used only to slow or stop the aircraft. However, in aircraft without nose wheel steering, the pilot has to use the brakes to steer the aircraft. to gently turn to the left he will apply the left wheel brake very slightly; the left wheel will slow down but the right (unbraked) wheel will not, so the aircraft turns gently to the left. To turn more sharply the pilot applies more brakes to the inside wheel ñ but he must be careful not to apply too much, as on some aircraft this can cause undue loads on the undercarriage assembly which can weaken and eventually fracture it. In particular, no aircraft should ever be turned with one wheel locked by its brake, as the scrubbing action between the locked wheel and the ground can badly damage the tyre, or even tear it off the wheel. The application of brake to one wheel and not the other, in order to steer the aircraft is called ìdifferential brakingî. A common method of braking on aircraft is to have brake pedals on the rudder bar, positioned just above the rudder pedals so that the pilot can operate the brake pedals with the ball of his foot or his toes. The

left toe brake operates the left wheel brake, and the right toe brake operates the right wheel brake. In addition, there will also be a parking brake, which operates on both wheels.

23. Taxiing speeds depend entirely on he circumstances, but the overall consideration must be to limit the speed to that which gives time to cope with any emergency and to limit the stresses on the undercarriage. When taxiing among, or close to obstructions, or when turning sharply, the speed must be kept low.

24. In tail wheel aircraft, where the centre of gravity is behind the main wheels, there is a tendency for a turn, once started, to tighten up. In nose wheel aircraft, where the centre of gravity is ahead of the main wheels, a natural directional stability results and the turning force has to be maintained to sustain the turn.

25. The wind velocity can be an important consideration when taxiing. The effect of the wind on the keel surfaces (ie the fin and rudder) normally tends to turn an aircraft into wind and this ìweather cockî effect is most noticeable in light aircraft with large keep surfaces. In a strong wind, the effectiveness of the brakes in countering weather cocking may well be the limiting factor in the use of these aircraft. In strong or gusty winds the controls must be held firmly to prevent them being blown against their stops; Aircrew Manuals indicate when control locks may be used when taxiing. In aircraft fitted with irreversible power-operated controls, the wind has no effect on the controls. Manuals indicate when control locks may be used when taxiing. In aircraft fitted with irreversible power-operated control, the wind has no effect on the controls.

26. The pilot must keep a good look-out for obstructions and other aircraft at all times when taxiing. Additionally, in large aircraft it is normal to post crew members in suitable positions in the aircraft to supplement his look out. In some single piston engine aircraft the pilotís forward view is restricted by the nose, in which case he must taxi slowly and yaw the nose from side to side to ensure that the way ahead is clear. In any aircraft, if doubt exists about the clearances or position of obstacles, the aircraft should be stopped.

27. On aircraft with reverse thrust, if taxiing in icy conditions, its use should be kept to a minimum. Excessive reverse thrust can result in ice contamination of the

wing leading edges. For the same reason aircraft should not be taxied too close behind taxiing aircraft.

Pre-Take-off Checks

28. The aircraft has now been taxied away from the ASP (aircraft servicing platform) or a dispersal area to an area where it can take off. However, despite all the checks that have been carried out so far (pre-flight checks, external checks, pre-starting checks, checks after starting), there remains one more set to be done before take-off - and this set of checks is the most important so far. Whereas all the previous checks are necessary for the efficient operation of the aircraft, those we are about to do now, entitled “pre-take-off check”î, are absolutely essential to the safety of the aircraft (and of all those on board). These pre-take-off checks belong to a group of checks that are vital to the safe operation of the aircraft, hence the actions prompted by them are called “vital action”î.

29. The pre-take-off checks ensure that everything hat is needed for a successful take-off and climb away is functioning and, where appropriate, set correctly - for example, the supply of fuel to the engine, the position of the flaps, the operation of the flight instruments, to name only a few. You may think that this is undue repetition of earlier checks - for example, the fuel supply was selected on before the engines were “locked-on” position - in which case the vital actions will reveal this and put it right.

30. In multi-crew aircraft the checks are read out by a crew member and actioned by the pilot on a”ìchallenge and response” basis, whilst in single-seat aircraft the pilot does them from memory. The vital actions follow the same broad pattern for all aircraft, but they vary in detail between aircraft types; they are given in full in the Aircrew Manual for the type.

31. Every flight undertaken is the culmination of a superb team effort, with vital inputs from a host of ground staff, all working towards an aim which is exactly the same as that of the aircrew ñ a safe and successful flight.

MARSHALLING SIGNALS

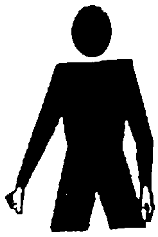
AFFIRMATIVE (I WILL COMPLY OR I UNDERSTAND)

DAY: Hand raised, thumb up.

NIGHT: Same as day signal with wand held as extension of the arm.

AIRCREW: One Flash.

NEGATIVE (NOT CLEAR OR I WILL NOT COMPLY)



DAY: Arm held out, hand below waist level, thumb turned down.

NIGHT: Same as day signal with wand held pointing down.

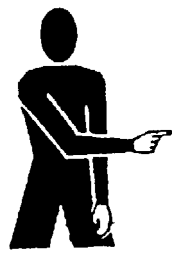
AIRCREW: Steady light.

THIS WAY

DAY: Arms above head in vertical position with palms facing inward.

NIGHT: Same as day signal with wands held vertically and held as extension of the arms.

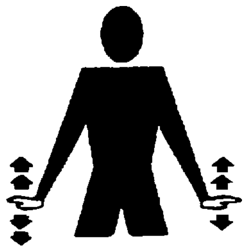
PROCEED TO NEXT MARSHALLER



DAY: Right or left arm down, other arm moved across the body and extend to indicate direction to the next marshaller.

NIGHT: Same as day signal with wands held as an extension of the arm.

SLOW DOWN



DAY: Arms down with palms toward ground, then moved up and down several times.

NIGHT: Same as day signal with wands held horizontally

TURN TO LEFT

DAY: Point right arm downwards, left are repeatedly moved upward and backward.

NIGHT: Same as day signal with wands held as extension of the arms.

***NOTE** Signals para 6 and 7 are used for spot turns for hovering aircraft

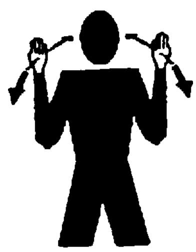
TURN TO RIGHT

DAY: Point left arm downward, right hand repeatedly moved upward and backward. Speed of arm movement indicating rate of turn.

NIGHT: Same as day signal with wands held as extensions of arms.

***NOTE** Signals para 6 and 7 are used for spot turns for hovering aircraft

MOVE AHEAD



DAY: Arms a little apart, palms facing backwards and repeatedly moved upward-backward from shoulder height.

NIGHT: Same as day signal with wands held as extension of arms.

BRAKES

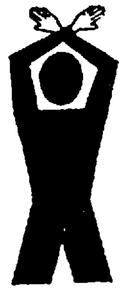
"ON" DAY Arms above head, open palms and fingers raised with palms toward aircraft then first closed.

"ON" NIGHT Arms above head then wands crossed.

"OFF" DAY Reverse of above.

"OFF" NIGHT Cross wands, then uncrossed

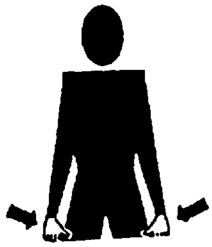
STOP



DAY: Arms crossed above the head palms facing forward.

NIGHT: Same as day signal with wands held as extension of arms.

INSERT CHOCKS



DAY: Arms down, fists closed, thumbs extended inwards, swing arms from extended position inwards.

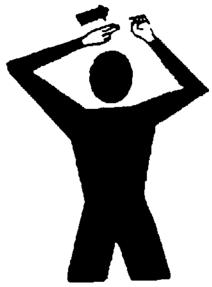
NIGHT: Same as day signal with wands held as extension of arms.

REMOVE CHOCKS

DAY: Arms down, fists closed, thumbs extended outwards, swing arms outwards.

NIGHT: Same as day signal with wands held as extension of arms.

GROUND ELECTRICAL POWER SUPPLY INSERT



DAY: Hands above head, left fist partially clenched, right hand moved in direction of left hand with fist two fingers extended and inserted into circle made by fingers of the left hand.

NIGHT: Same as day signal with left wand held vertical and right wand held horizontal.

GROUND ELECTRICAL POWER SUPPLY DISCONNECT

DAY: Hands above head, left fist partially clenched, right hand moved away from left hand withdrawing first two fingers from circle made by fingers of the left hand.

NIGHT: Same as day signal with left wand held vertical and right wand held horizontal.

START ENGINE(S)

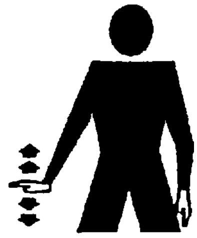
DAY: Left hand overhead with appropriate number of fingers extended to indicate the number of the engine to be started, and circular motion of right hand at head level.

NIGHT: Similar to the day signal except the wand in the left hand will be flashed to indicate the engine to be started.

SLOW DOWN ENGINE(S) ON INDICATED SIDE

DAY: Arms down, with either right or left arm moved up and down, palm facing down, indicating that left or right side engines respectively should be slowed down.

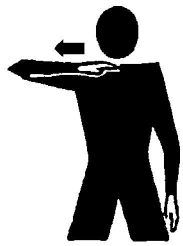
NIGHT: Same as day signal with one wand moved horizontal to ground.



CUT ENGINES

DAY: Either arm and hand, level with shoulder, with hand moving across throat palm down.

NIGHT: Same as the day signal with wands held as extension of arms.



FIRE

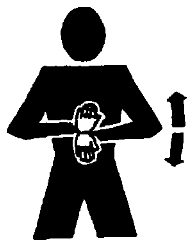
DAY: Make rapid horizontal figure of eight motion at waist level with either arm, pointing as source of fire with the other.

NIGHT: Same as day signal with wands held as extension of arms.

LOWER WING FLAPS

DAY: Hands in front, palms together horizontally then opened from the wrist crocodile-mouth fashion

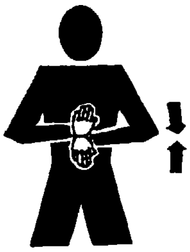
NIGHT: Same as day signal with wands held as extension of hands.



RAISE WING FLAPS

DAY: Hands in front, horizontally, with palms open from the wrists then suddenly closed.

NIGHT: Same as day signal with wands held as extension of hands.



OPEN AIR/SPEED BRAKES

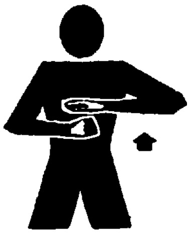
DAY: Hands in front, palms together vertically, then opened from the wrists.

NIGHT: Same as day signal with wands held as extension of hands.

CLOSE AIR/SPEED BRAKES

DAY: Hands in front, vertically with palms open from the wrists then suddenly closed.

NIGHT: Same as day signal with wands held as extension of hands.



ABANDON AIRCRAFT

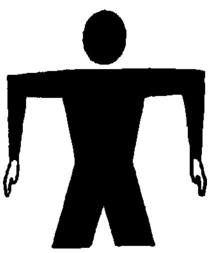
DAY: Simulate unfastening seat belt and shoulder straps and throwing them up and off.

NIGHT: Same as day signal with wands held as extension of arms.

HOT BRAKES

DAY: Arms extended with forearms perpendicular to the ground palms facing inward.

NIGHT: Same as day signal with wands held as extension of arms.



Self Assessment Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. What does pre-flight planning require a knowledge of?

2. What is a Form 3562?

3. Give 4 examples of checks before flying?

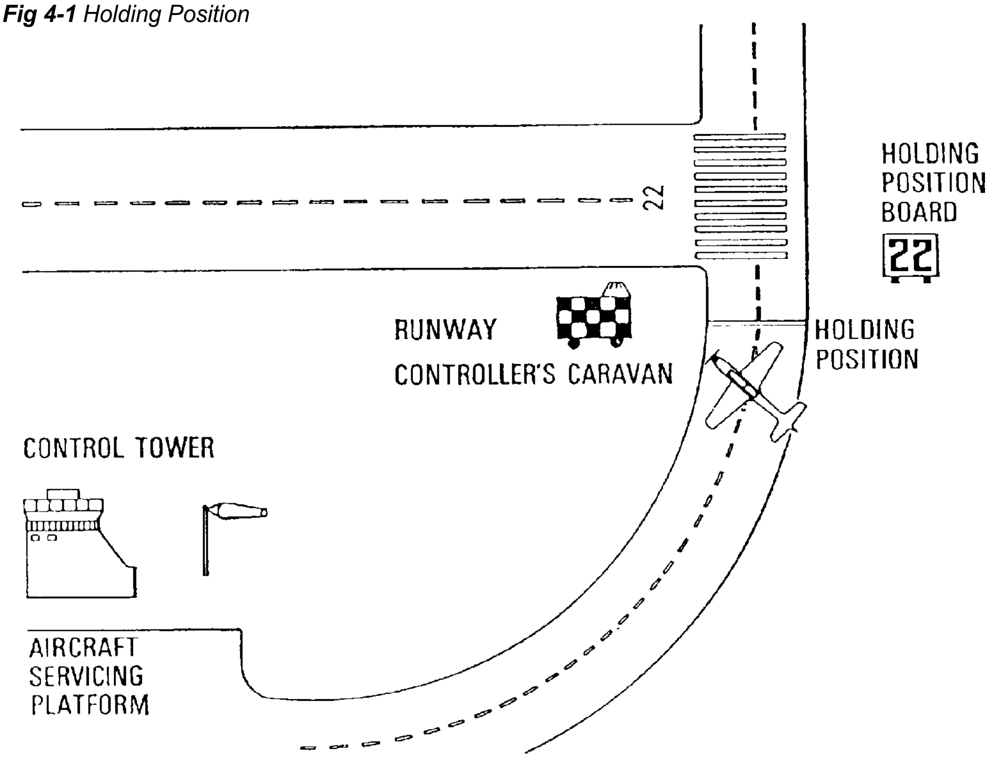
CHAPTER 4

GENERAL FLYING

Take-Off

1. Holding Position. The runway used for taking-off (and for landing) is normally the one into wind. Unless on an operational ìscrambleî the pilot stops the aircraft at the holding position (Fig 4-1). The holding position is a white line across the taxiway, from which the pilot has a good view of the runway, and the finals approach. Light aircraft normally turn about 45° into wind, whilst large aircraft are stopped heading along the taxiway.

Fig 4-1 *Holding Position*



2. Checks. Before taxiing onto the runway in the use a pilot must complete his vital actions, receive permission from the controller and check that the approach is clear. Before starting the take-off run, the flying controls must be tested over their full range of movement for freedom and for operation in the correct sense. Near the holding position is the runway controllerís caravan; one of the runway controllerís duties is to scrutinize aircraft about to take-off, checking for signs of danger such as loose panels, fuel leaks, oil leaks, and hydraulic leaks.

3. Throttle. Full throttle is always used for take-off. The throttle(s) are opened smoothly and firmly to obtain full power as early as possible during the take-off run, careful watch being kept on the engine instruments to ensure that full power is being obtained and that the engine(s) are working within their limits. No special technique is involved when re-heat is used, except that the pilot must be ready for the increased acceleration.

4. Factors Affecting the length of the Take-Off Run. The length of the take-off run depends on:

a. All-up weight.

b. amount of flap used.

c. Engine power.

d. Wind velocity.

e. Runway gradient.

f. Condition of runway surface (snow or slush etc).

g. Air temperature.

h. Airfield elevation (pressure height).

5. All-up Weight. The greater the weight of the aircraft the greater is the lift required for it to become airborne. To gain the extra left needed for an increased weight, the aircraft must be accelerated to a higher speed before it becomes airborne; the greater the weight the slower is the rate of acceleration, both effects lengthening the take-off run. A pilot flying a heavily loaded aircraft must ensure that the runway is long enough for him to become safely airborne.

6. Amount of Flap Used. The use of take-off flap increases the co-efficient of lift and enables the aircraft to become airborne at a lower indicated airspeed (IAS) and, therefore, after a shorter run.

7. Engine Power. The greater the thrust available in a given airframe, the better will be the acceleration and the less the distance required to become airborne.

8. <u>Wind Velocity.</u> The take-off is made into wind, except when the wind is very light and so has little or not effect, in which case the longest runway is usually used. The advantages of taking-off into wind may be seen from Fig 4-2.

a. An aircraft heading into a 20 kt wind has an indicated airspeed (IAS) of 20 kts before it starts moving and so the take-off run is shorter.

b. The angle of climb after becoming airborne is steeper, for although the rate of climb (height gained per minute) is constant, the ground speed (the speed over the ground) is reduced (70 knots as against 90 kts in Fig 4-2)

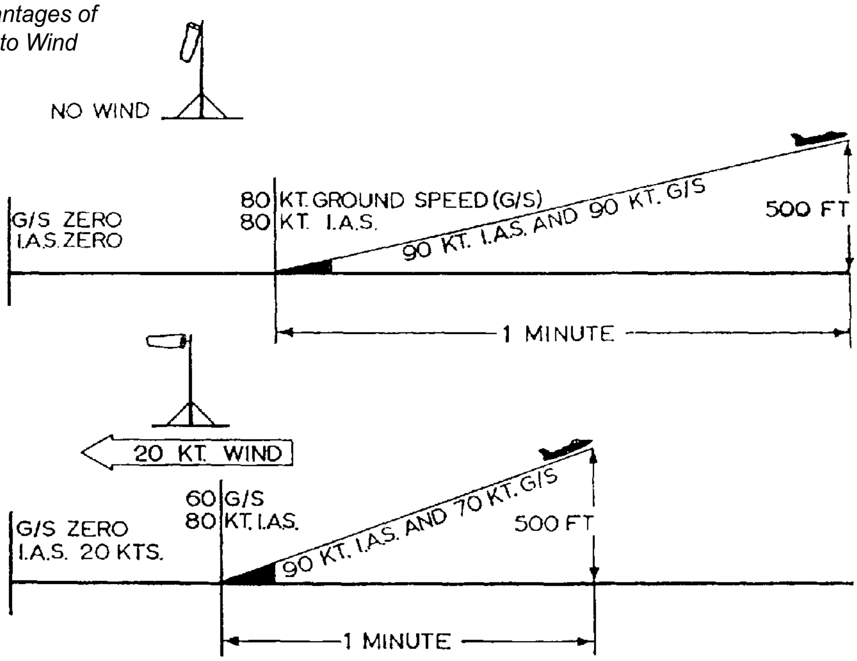
c. The ground speed at the time of becoming airborne is lower and, at the lower ground speed, the stresses on the undercarriage and tyres are reduced.

d. There is no tendency to drift.

e. Directional control is improved in the initial stages of take-off.

f. Following a possible engine failure soon after take-off, or an abandoned take-off, because the ground speed is lower, the touch-down is made more slowly and the distance to run before stopping is shorter.

Fig 4-2 *Advantages of Taking-Off into Wind*



9. Runway Gradient. If the take-off is uphill, then the aircraft will be slower to accelerate and consequently have a longer-take-off run. Similarly, a downhill slope will give a shorter take-off run.

10. Condition of Runway Surface. The retarding effect of snow or slush on the take-off run can be severe, and comparatively small depths of slush are sufficient to prevent an aircraft from accelerating to its “unstick” speed. Before attempting to take-off with slush or snow on the runway the situation should be assessed very carefully.

11. Air Temperature. High air temperature reduces the density of the air. This results in less lift at a given airspeed. The lower air density also reduces the maximum power available from the engines (both jet and unsupercharged piston engines) thus reducing acceleration during the take-off run. Both effects lengthen the take-off run. For example, the thrust of a jet engine is reduced by between 4 and 5% for each 5°C above the standard temperature of 15°C. Thus, during take-off in a temperature of 40°C a loss of power of up to 25% is experienced. The pilot of a heavily-loaded aircraft may have to off-load weight before he can take-off during the heat of the day, or he may schedule his take-off for the cooler hours of the night. The power of supercharged piston engines is not affected until full throttle height is reached.

12. Airfield Elevation. For the same reasons as above, the reduced air density at high altitude airfields increases the length of take-off run. High altitude airfields in the tropics usually have lengthened runways to allow for the reduced lift and decreased engine performance.

13. Take-off Technique - Nose Wheel Aircraft. Having completed the checks (para 2) the pilot taxies onto the runway in use. After lining-up, he taxies forward a few yards to straighten the nose wheel and then opens the throttle smoothly to full power. When take-off power is reached he checks the engine instruments (para 3).

14. During the early part of the take-off run, the aircraft is kept straight by using the wheel brakes (or the steerable nose wheel) but as the speed increases, the rudder becomes effective and is then used for directional control. As the elevators become effective, the control column is moved back to raise the nose wheel a little

off the runway. Care is taken not to raise the nose wheel too high because the increased drag would slow up the rate of acceleration of the aircraft and increase the take-off run, as well as causing the aircraft to become airborne in a semi-stalled condition owing to the very high angle of attack to the wings. When flying speed is reached, the aircraft is flown off the runway by a smooth backward movement of the control column. At a safe speed the flaps are raised and the engine instruments checked again.

15. Take-off Technique - Tail Wheel Aircraft. Having completed the checks (para 2) the pilot taxies on to the runway in use. After lining up, he taxies forward a few yards to straighten the tail wheel and then if applicable, locks it. With the control column held aft of the central position he opens the throttle smoothly to take-off power and checks the engine instruments (para 3).

16. Any tendency to swing is corrected with the rudder, the corrections becoming smaller as the rudder becomes more effective with increasing airspeed. The inherent instability on the ground of the tail wheel type undercarriage requires more care to be taken with the directional control of the aircraft; any slight swing which is not corrected will increase.

17. As the speed increases, the pilot brings the aircraft into the flying attitude by a progressive forward movement of the control column, taking care not to get the nose too low. As flying speed is approached he applies a smooth backward pressure to the control column to unstick at the correct speed.

18. Scrambling. Where, for operational reasons, it is necessary for an aircraft to take-off at a moment's notice, it is previously prepared for flight in every respect, right down to having the engines ground run and checked and the vital actions completed.

Actions When Airborne

Maximum speed with undercarriage down

19. When safely airborne, the brake are applied and the undercarriage retracted whilst a shallow climb is maintained and the IAS allowed to increase to the initial climbing speed. The brakes are applied simply to stop the wheels rotating before the undercarriage is retracted, this being necessary because rotating wheels may damage the aircraft's structure or the flexible brake leads during retraction. There is a maximum speed for flying with the undercarriage down, and the retraction of the undercarriage must be complete before this speed is exceeded.

20. Once the undercarriage is locked up and a safe height is reached the flaps, if used, are raised. When the flaps are fully retracted, the power is reduced to normal climbing power (where this is less than the take-off setting). When the climbing speed has been obtained, the nose is raised to prevent further acceleration and to maintain the climbing speed.

Use of Reheat

21. When reheat is used for take-off, no special technique is necessary other than to check the reheat operations and to raise the undercarriage and flap as soon as possible after becoming airborne. This is necessary because the acceleration can be so rapid that the limiting speeds for the undercarriage and flap can be reached very quickly.

THE CIRCUIT

General Considerations

22. When the pilot has completed his exercise, the normal way of re-entering the circuit in clear visibility is a visual rejoin. Other aircraft may be taking off and completing a circuit in order to practice landings. To reduce congestion and the risk of collision, aircraft should enter the airfield circuit in a planned and systematic manner. To achieve this a standard circuit procedure is taught.

Procedure for Joining the Circuit

23. There are several ways of joining the circuit visually. The one described here is usually employed during the early stages of flying training, or in reduced visibility.

As the airfield is approached, and while maintaining a look-out for other aircraft using, leaving or joining circuit, the pilot carries out various checks in preparation for joining. For the Bulldog these are:

Fuel	sufficient
Instruments	functioning and set
Radio	correct frequency selected
Altimeter	correct setting
Demist and screen heat	as required
Induction air	as required

After being cleared to do so by the airfield controller, he will join overhead the airfield at a minimum of 1000 feet above circuit height (normally 1000 ft - see Fig 4-3). He must reduce to circuit joining speed (100 knots for the Bulldog) before reaching the airfield boundary.

Circuit Pattern

24. The pilot now lets down on the “dead” side in a wide curve (by this means the pilot can continuously check that the airspace just below him, which he is about to enter, is clear of other aircraft). At this stage the aim is to reach the beginning of the downwind leg at circuit height and speed (80 knots, Bulldog) without causing any disturbance to other circuit traffic.

25. Next, the pilot flies the downwind leg parallel to the runway in use and calls “Downwind” when opposite the upwind end of the runway. He completes his pre-landing checks for the vital actions on the downwind leg. For the Bulldog these are:

RPM control	max
Mixture	fully rich
Induction air	cold
Fuel	booster pump on, contents sufficient, selector valve as required
Flap	as required
Harness	tight
Brakes	toes clear

When a suitable position is reached (depending on the wind strength and type of approach being made) the pilot begins a gradual turn onto the final approach, adjusting the turn so that at the end of it the aircraft is lined up with the runway. He makes the "Finals" call to the controller during the turn.

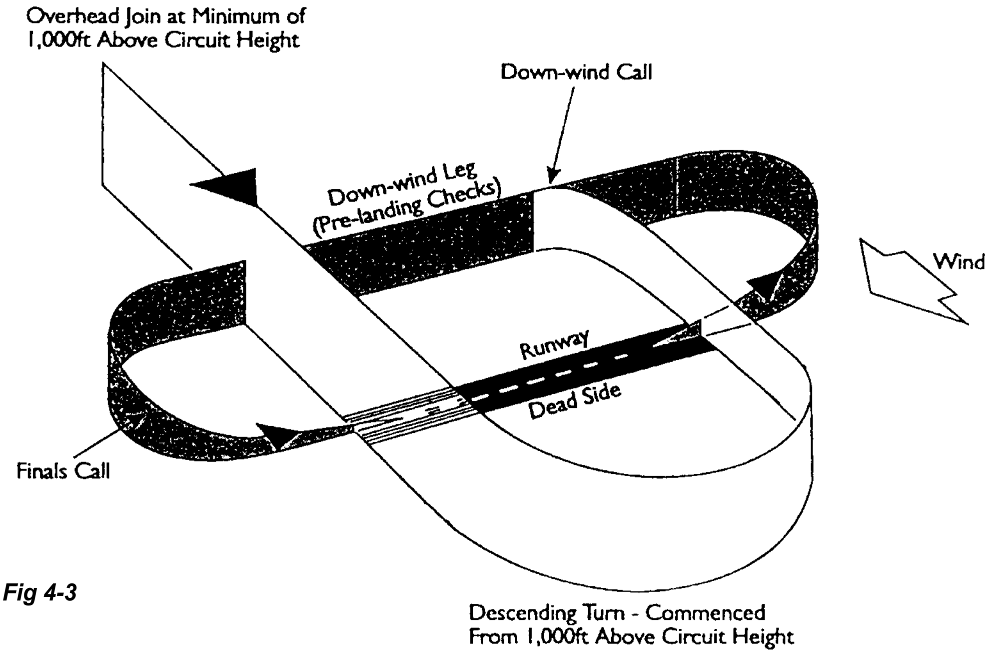


Fig 4-3

THE APPROACH

General Consideration

A good landing

26. The first requirement for a good landing is a good approach ñ which may be made with or without assistance from the engine. An engine-assisted approach is usual but the pilot must be capable of modifying this technique to allow for cross-wind conditions and engine or flap failure. It must be remembered that the jet engine does not respond as quickly as a piston engine when the throttle is opened, so the pilot must be careful not to reduce his rpm below that stipulated in the Aircrew Manual until he is sure he no longer needs power.

Use of Flap

27. The use of flaps on the approach gives the pilot:

a. A steeper path of descent at a given speed.

b. A lower stalling speed, thus permitting an approach at a lower airspeed without reducing the safety margin.

c. A better view over the nose.

28. The amount of flap used depends on the type of aircraft and on the windspeed and direction. It is usual to use partial flap during the early stages of the approach and to select full flap for the final approach and landing.

Effect of Wind

29. The two main advantages of making an approach and landing into wind are:

a. The ground speed is reduced to a minimum for a given airspeed.

b. Drift is eliminated.

Consequently, the landing run will be shortened, the undercarriage will not be subjected to unnecessary side load, and the tendency to swing will be reduced. Also, if it is necessary to go round again, the aircraft will be in the best position to regain height rapidly.

Wing Gradient and Gusts

30. In a strong wind there is a pronounced decrease in windspeed close to the ground, the wind being slowed up by contact with the earthís surface. The effect of a sharp wind gradient on an aircraft approaching to land is to cause a sudden reduction in IAS which can result in a rapid sink and a heavy landing. Gusts are strongest when the wind is strong, and on hot days. The effect of gusts may either be similar to that of a wind gradient or may alternate with a sudden increase in airspeed and lift. A pilot allows for these possibilities by increasing his normal approach speed in strong or gusty winds.

Techniques

31. The classic form of approach is that during which height, speed and power are progressive reduced until the aircraft arrives at the touchdown point with the engine throttled back and the speed at its lowest value above the stall. An alternative method, more commonly used, is to set a constant speed immediately upon starting

the final approach, thereafter controlling the rate of descent by throttle movements. With this method, if the pilot judges the aircraft to be too high on the approach, he throttles back slightly (ie reduces power); at the same time, because of the reduction in thrust, he has to lower the nose slightly to maintain the required airspeed; this increases the rate of descent, which is what the pilot wanted when he sensed that the aircraft was too high. If the aircraft becomes too low on the approach, the pilot uses the reverse technique ñ ie he selects more power, raises the nose to maintain the desired airspeed, thus reducing the rate of descent.

32. Irrespective of the type of approach, the aim should always be to maintain a constant and moderate rate of descent. Although some circumstances may demand a steep approach with a high rate of descent and little or no power or, alternatively, a flat approach with a low rate of descent and a high power setting, such approaches should not be used under normal conditions since the margins of safety are reduced.

LANDING

Considerations

33. As with the take-off, the technique of landing varies with different types of aircraft. Consistently good landings are easier to make on nose wheel aircraft than on one with a tail wheel.

Definitions

34. Terms used to describe the approach to land are:

a. Final Approach. The final approach starts where the aircraft has turned into line with the runway in use.

b. Round-out. In the round-out the pilot changes the descending path of the approach to one level with, and just above, the ground. This action puts the aircraft in a tail down attitude ready for the touch-down and further reduces the speed.

c. Hold-off or Float. This describes the subsequent period in which the aircraft is flown parallel to the ground with increasing angle of attack and falling airspeed until the aircraft touches down.

d. The Touch-down. In a tail wheel aircraft, the touch-down may be made on all three wheels (three-point landing) or on the main wheels only (wheel landing). An aircraft fitted with a nose wheel undercarriage should always be landed on the main wheels only, to prevent damage to the nose undercarriage.

Landing Technique - Nose Wheel Aircraft

35. As the aircraft approaches the threshold of the runway, the rate of descent should be checked by a gentle backward pressure on the control column; at the same time the throttle should be closed gradually. In this attitude the airspeed decreases and the aircraft should be lowered gently onto its main wheels. If, after rounding-out, there is a tendency to float or gain height, the nose has been raised too high during the round-out; the nose should be lowered slightly and the main wheels deliberately run onto the runway, so avoiding any tendency to float.

36. An aircraft with a nose wheel undercarriage should be landed on the main wheels with the nose wheel held off the ground. This attitude of the aircraft is little different from its attitude on a normal approach and, therefore, only a small change of attitude is required when rounding-out. Since the centre of gravity is ahead of the main wheels the aircraft tends to pitch forward onto its nose wheel on touch-down and this reduces the angle of attack so that there is no tendency to balloon off the ground. The nose wheel should be lowered onto the ground before the brakes are used; brakes should then be used to decelerate and maintain a straight landing run.

Landing Technique - Tail Wheel Aircraft

37. Three-point Landing. As he approaches the threshold, the pilot checks the rate of descent by rounding-out and reducing power. He moves the control column progressively back, increasing the attitude (angle of attack) as the speed decreases and holding the aircraft off the ground. Too rapid a movement of the control column causes the aircraft to balloon away from the ground, while too slow a movement allows the aircraft to sink onto its main wheels and bounce. In a well-judged landing the moment is reached when the aircraft will sink into all three wheels together. This is known as the three-point landing and has the following advantages:

a. The touch-down speed is the lowest possible (little more than the stalling speed) and this, combined with maximum aerodynamic braking due to the high angle of attack, gives the shortest landing run.

b. The brakes may be used early on the landing run.

c. There is less danger of the aircraft noting over if the brakes are used too fiercely, or the wheels enter soft ground.

38. Wheel Landing. A wheel landing is one in which the main wheels are placed on the ground before the tail wheel. This type of landing differs from the three-point landing in that, once the aircraft is flying just above the ground, it is not held off but the main wheels are placed gently but deliberately on the ground. The wheel landing may, on occasions, be preferred to the three-point landing because:

a. The change of attitude when landing is less and there is no hold-off, so judgement is easier.

b. It has certain advantages when landing in a cross-wind.

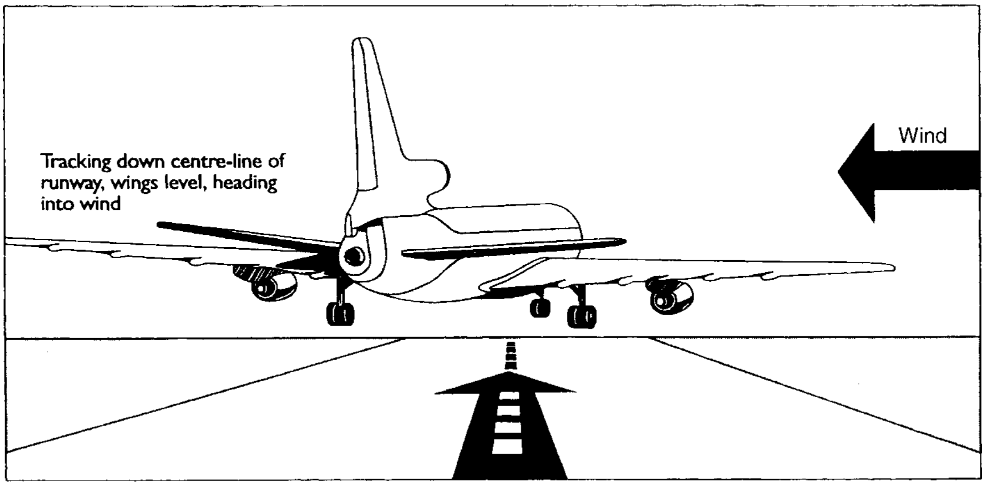
c. It provides a safer means of landing laden aircraft.

The main disadvantage of the wheel landing is that the speed is higher at the moment of touch-down making for a longer landing run.

Cross-wing Approach and Landing

39. If the wind is not directly down the runway ñ that is there is a cross-wind ñ an aircraft on final approach will drift off the runway line if the pilot simply points the nose at the runway. To counter this drift, he must point the nose a few degrees to one side, into the cross-wind. By this means, with the wings level the aircraft will track down the runway centre-line (Fig 4-4).

***Fig 4-4** Cross-Wind Approach*



40. If the aircraft were to be landed with the nose still turned into the cross-wind, the under-carriage could be sheared off. So, just before touchdown the pilot has to yaw the aircraft (using the rudder) to put it in line with the landing path. This requires fine judgement: yaw the aircraft too late, and it touches down with the nose still offset into the cross-wind; yaw it too early and the cross-wind will have time to make the aircraft drift sideways before touchdown. This also raises the possibility of shearing the undercarriage. As in all aspects of flying, the remedy lies in good training, conscientious practice, and the application of the correct technique on every occasion.

Landing Run

41. Brakes. To achieve the shortest landing run, the pilot puts the nose wheel firmly onto the ground (or holds the tail wheel firmly on the ground with the stick back) and applies the brakes. However, to prolong the efficiency and life of the brakes, the pilot uses them wisely according to the landing run available. Great care must be exercised while braking on wet and icy runways to prevent the wheels from skidding. Some high speed aircraft are fitted with special brakes which prevent skidding. A braking effect may also be achieved in other ways, ie by the use of reverse thrust, aerodynamic braking, brake parachute, and flaps.

42. Effect of Flag. In all aircraft the use of flap shortens the landing run because it allows a lower touch-down speed and increases drag.

Procedure After Landing

43. The pilot always aims to clear the runway without delay, and where powered brakes are fitted, checking that there is enough brake pressure for taxiing.

Self Assessment Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. What is the holding position?

2. What is the first requirement for a good landing?

3. What are the two main advantages of making an approach and landing into wind?

4. What are the effects of flap on landing an aircraft?

CHAPTER 5

AEROBATICS AND FORMATION FLYING

Aerobatics and formation flying

1. There is much more to flying than just taking off and landing. RAF training involves a sequence of carefully graded air exercises, which are far beyond the scope of this manual. However, to give you a flavour of what is involved, in this chapter we shall cover the rudiments of two of the more advanced aspects of military flying - aerobatics and formation flying. Also, you will find it useful to have some knowledge of these skills when you see them performed at air displays.

AEROBATICS

2. Introduction. In the early days of air fighting aerobatics were used by pilots to manoeuvre into a favourable firing position, or to avoid the guns of enemy aircraft. Although today aerobatics are little used in aerial combat, they are of great importance in the training of Royal Air Force pilots. They give the pilot confidence in handling his machine in all possible attitudes and accustom him to the high strains he will experience when executing certain manoeuvres during combat fights.

Hasell

3. Before starting any aerobatic exercise, the pilot must always carry out the following checks, which are remembered using the mnemonic "HASELL".

a. Height - sufficient to perform the complete manoeuvre without descending below the prescribed minimum.

b. Airframe - check that flaps and undercarriage are UP, airbrakes tests and IN.

c. Security - all equipment and loose articles should be stowed and the seat harness locked and tight.

d. Engine - all temperatures and pressures normal and fuel sufficient for the exercise.

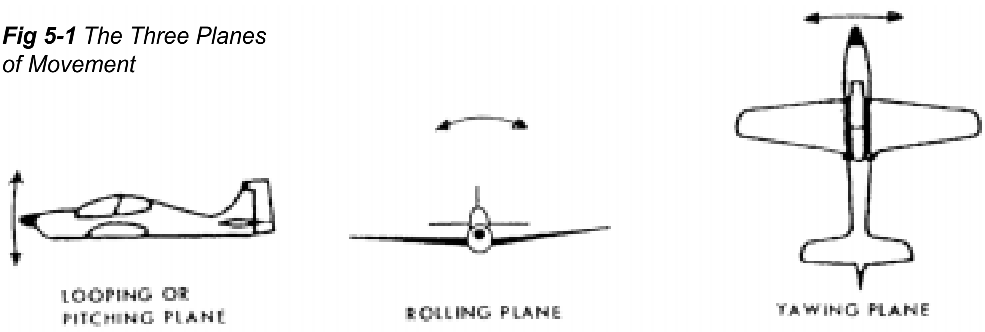
e. Location - make sure that the aerobatics will take place in air space clear of Active airfields, Built-up areas and Controlled airspace. To avoid the possibility of getting lost, select a suitable landmark and keep a position check on it.

f. Look-Out - keep well clear of all other aircraft and cloud, vertically and horizontally, throughout the exercise.

Basic Manoeuvres

4. An aircraft can be manoeuvred in three planes (Fig 5-1). In aerobatics the looping and rolling planes are mainly used, sometimes separately and sometimes in combination. In only a few manoeuvres is the yawing plane used. The best way to understand aerobatics is to see what can be done with an aircraft in each plane in turn, and then to see what is possible when the manoeuvres in different planes are combined.

Fig 5-1 *The Three Planes of Movement*



5. The Loop. The most basic manoeuvre, and the one which is always the first to be taught to pilots during their training, is the loop. In this aerobatic the pilot uses a line feature such as a river or railway line on the ground as a visual reference on which to keep straight. If necessary, he places the aircraft in a shallow dive to gain speed, then taking care to keep the wings level, he raises the nose until the horizon disappears below his field of view. When this happens, he looks as far back over his head as he can and watches for the opposite horizon to come round. As soon as he sees it he checks that his wings are still level. At the top of the loop the airspeed is quite low, and if the loop is pulled too tight the aircraft may stall. So the pilot coaxes it over the top and down the other side, still keeping straight on his line feature. The speed builds up quite quickly on the way down, so that at the end of the aerobatic the pilot has enough airspeed to go into another manoeuvre (Fig 5-2).

6. The Barrel Roll. In the rolling plane, the simplest manoeuvre is the barrel roll, where the aircraft rolls around a point just above the horizon. To do this the aircraft is put into a shallow dive until the correct airspeed is reached then banked

45° in the opposite direction to that in which the roll is to be made. The pilot then flies the aircraft round the outside of an imaginary barrel. The diameter of the barrel may be small or large (but if it is very small it begins to look like the next aerobatic described, the slow roll). Fig 5-2 shows the barrel-shaped path of the aircraft, and a spot above the horizon (usually a small cloud) chosen by the pilot. The small diagram also shows how the cockpit coaming appears to move in a circle around the chosen cloud, as seen by the pilot. A line feature is always useful when practising a barrel roll - the pilot will use it to check that the centre-line of the barrel keeps track with the line feature.

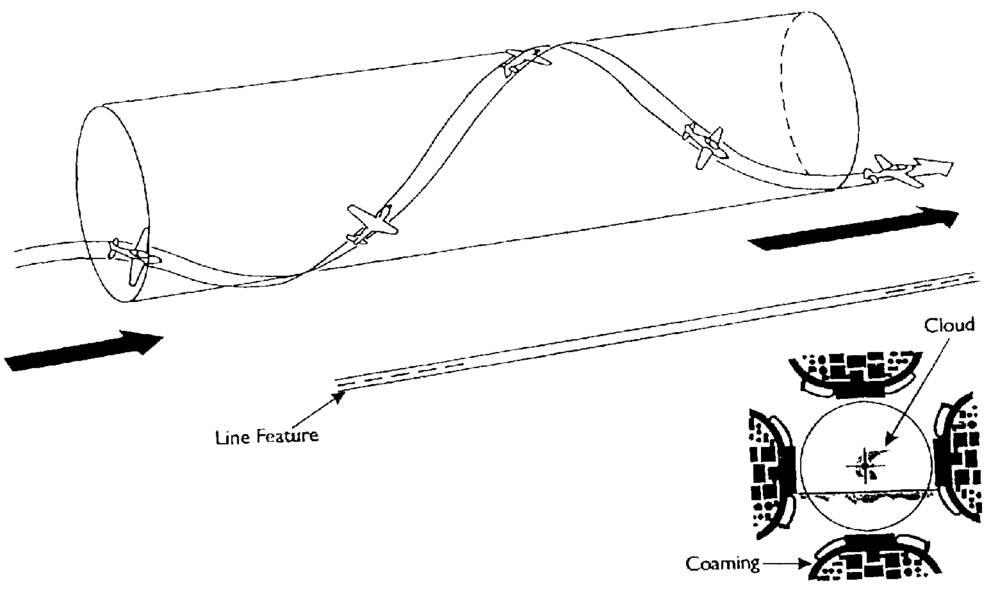


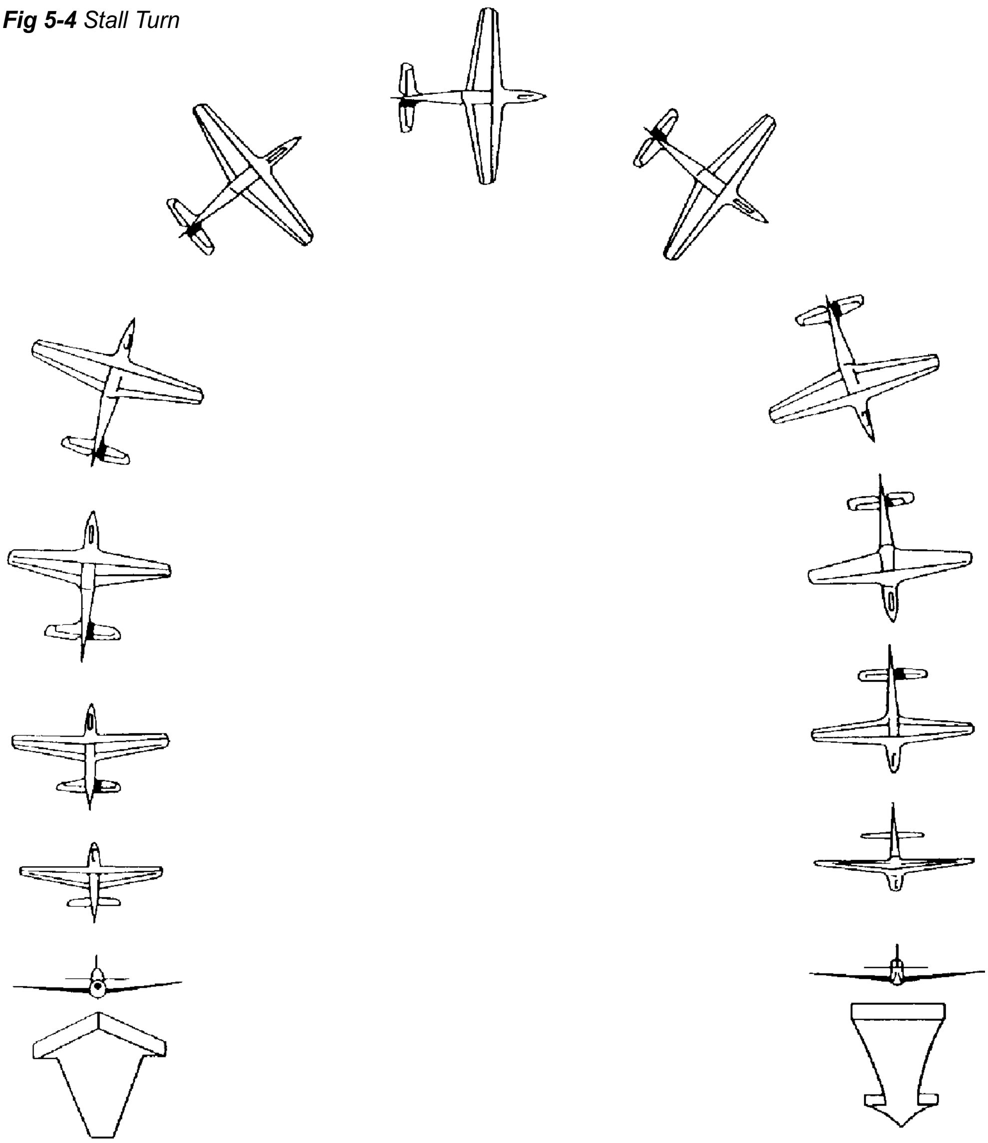
Fig 5-2 *Barrel Roll*

7. The Slow Roll. The slow roll is a rather more difficult manoeuvre. The pilot rolls the aircraft keeping the nose on a point on the horizon instead of round a point just above it. He must co-ordinate his controls very carefully to do the aerobatic smoothly and well. In a good slow roll the aircraft will neither lose nor gain height (Fig 5-3). The rate of roll may vary from one manoeuvre to another, but for each roll, the rate of roll should be constant from beginning to end. A fast roll is easier to fly than a really slow one.

Fig 5-3 *Slow Roll*

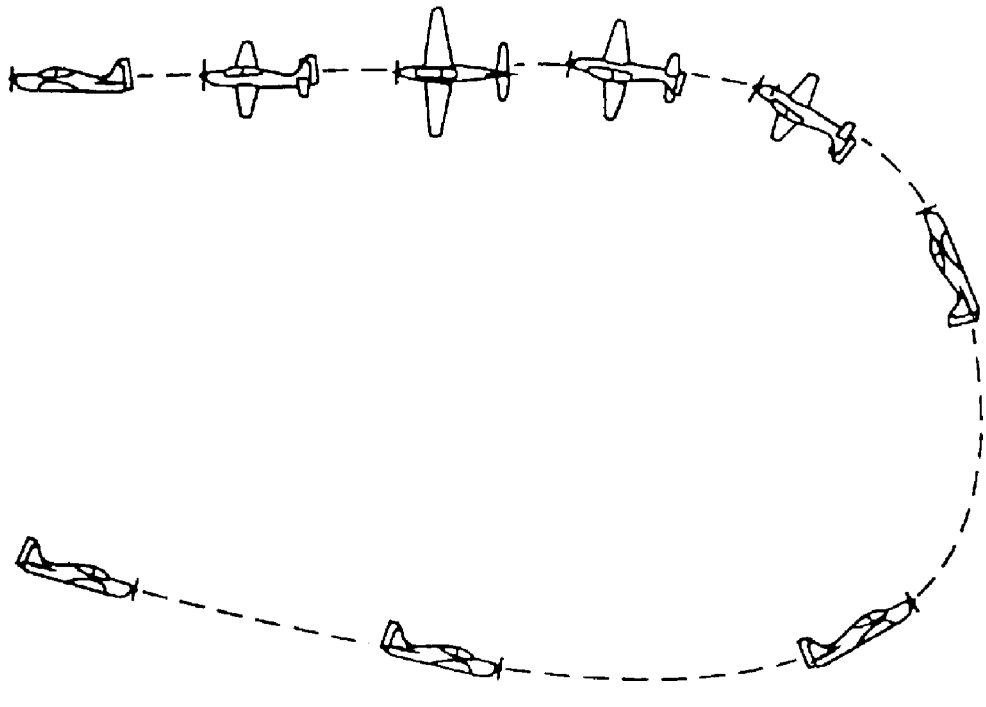
8. <u>The Stall Turn.</u> The stall turn is the only basic manoeuvre in the yawing plane. From level flight, or a shallow dive if extra speed is needed, the pilot eases back the stick to bring the nose up to the vertical position. He holds the aircraft there while the speed falls off. Just before the stall, he applies full rudder to yaw the aircraft round to one side. As the nose comes over, engine power is taken off and the aircraft falls sideways until it is pointed vertically down. The speed rapidly increases, and the pilot then raises the nose with the wings level and the aircraft points back in the direction from which it came; it has turned through 180°(Fig 5-4).

Fig 5-4 *Stall Turn*



9. Roll off the Top. Properly called a “half roll off the top of a loop”, this manoeuvre consists of the first half of a loop followed by half of a slow or barrel roll. It looks better - and is slightly more difficult to perform ñ if a slow roll is chosen (Fig 5-5).

***Fig 5-5** Half Roll off the Top of a Loop*

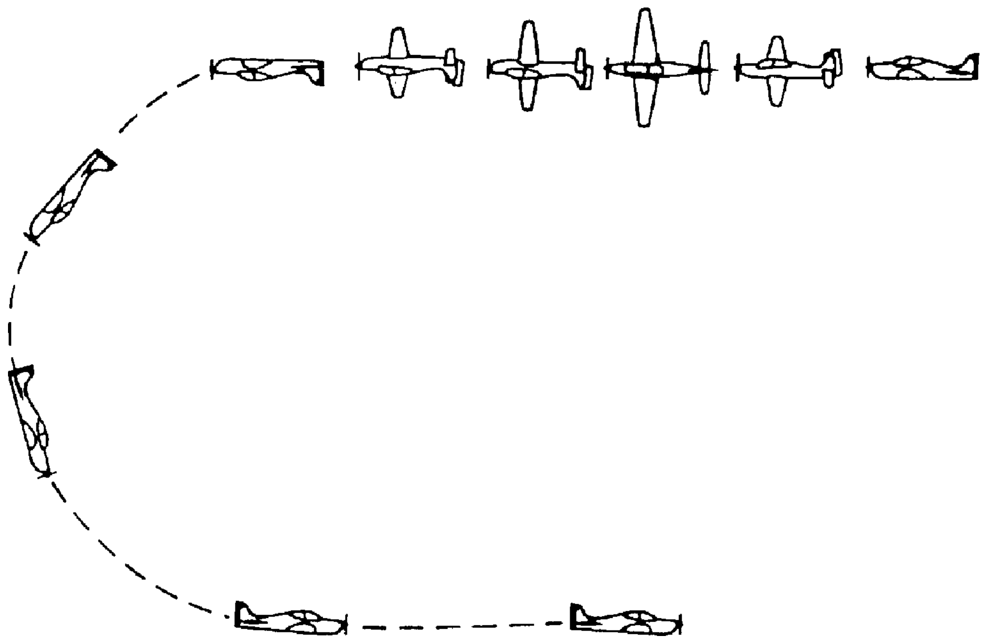


Advanced Manoeuvres

10. All other aerobatics consist of variations or combinations of the basic manoeuvres described above.

11. Half Rolland Pull Through. This is the opposite of a half roll off the top of a loop. It consists of a first half of a slow roll followed by the second half of a loop (Fig 5-6). As the airspeed builds up very rapidly in the second half of the manoeuvre, when the aircraft is going downwards, the speed of entry to the first part (the half roll) must be kept low. Otherwise, in the half loop the maximum permissible speed or the maximum permitted “g” limit (or both) might be exceeded. It helps if the power is reduced on entering the half loop. This manoeuvre always involves a considerable loss of height.

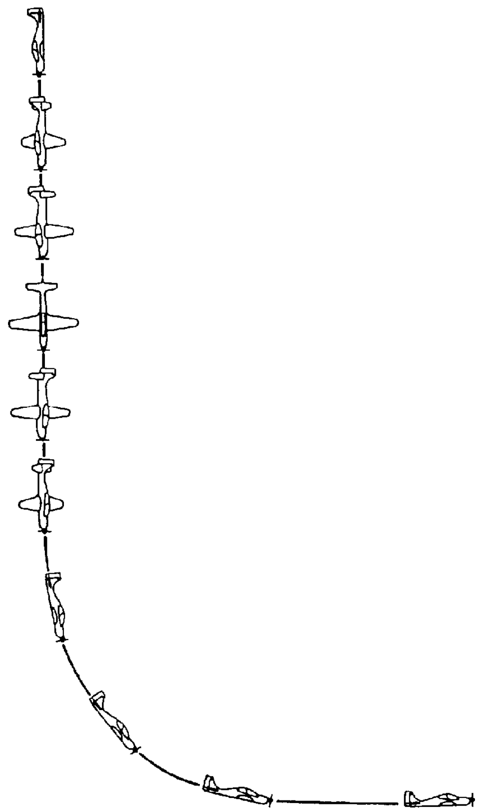
Fig 5-6 *Half Roll and Pull Through*



12. The Upward Roll. The rolling manoeuvres so far mentioned have all been about a horizontal axis. They can also be done about an inclined axis and in the extreme case about a vertical axis. The pilot needs plenty of speed to do an upward roll, so he dives, then raises the nose to the vertical position and rolls round the point directly above him. The roll is kept vertical position and rolls round a point directly above him. The roll is kept vertical by looking out at each wing tip in turn to see that they are both the same distance above the horizon. The airspeed falls off quickly in the upward roll and the pilot must not take too long in getting round. At the end of the roll he should have just enough airspeed to complete a stall turn.

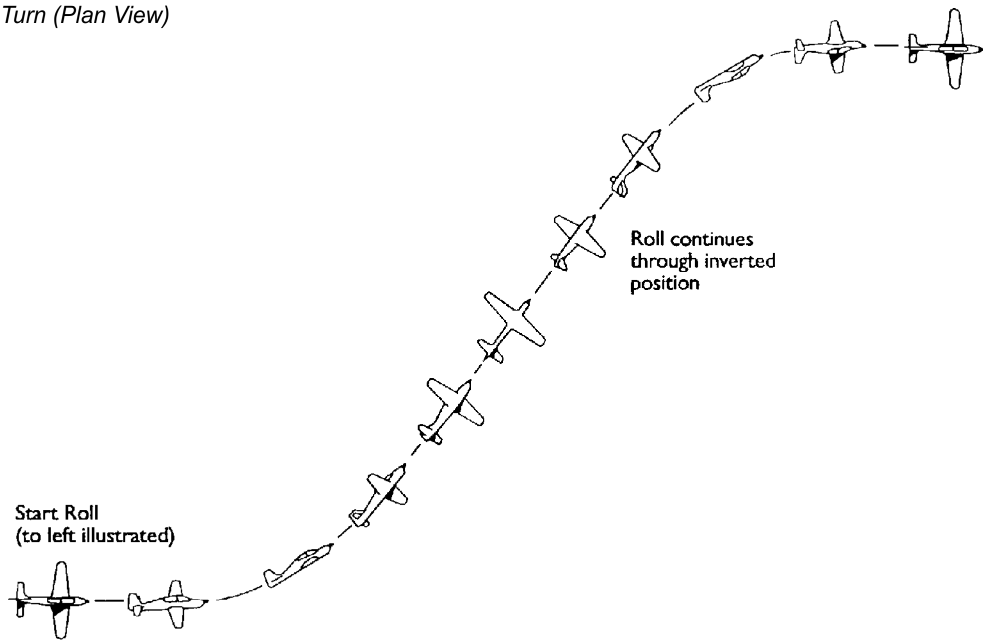
13. Aileron Turn. The aileron turn is a roll flown vertically downwards (Fig 5-7). It may be started from a half roll or from, the second half of a loop; in either case it is started when the aircraft is pointing vertically down. In this manoeuvre speed increases very rapidly and a lot of height is lost. If necessary, power should be reduced and airbrakes opened to control the speed.

Fig 5-7 *Aileron Turn*



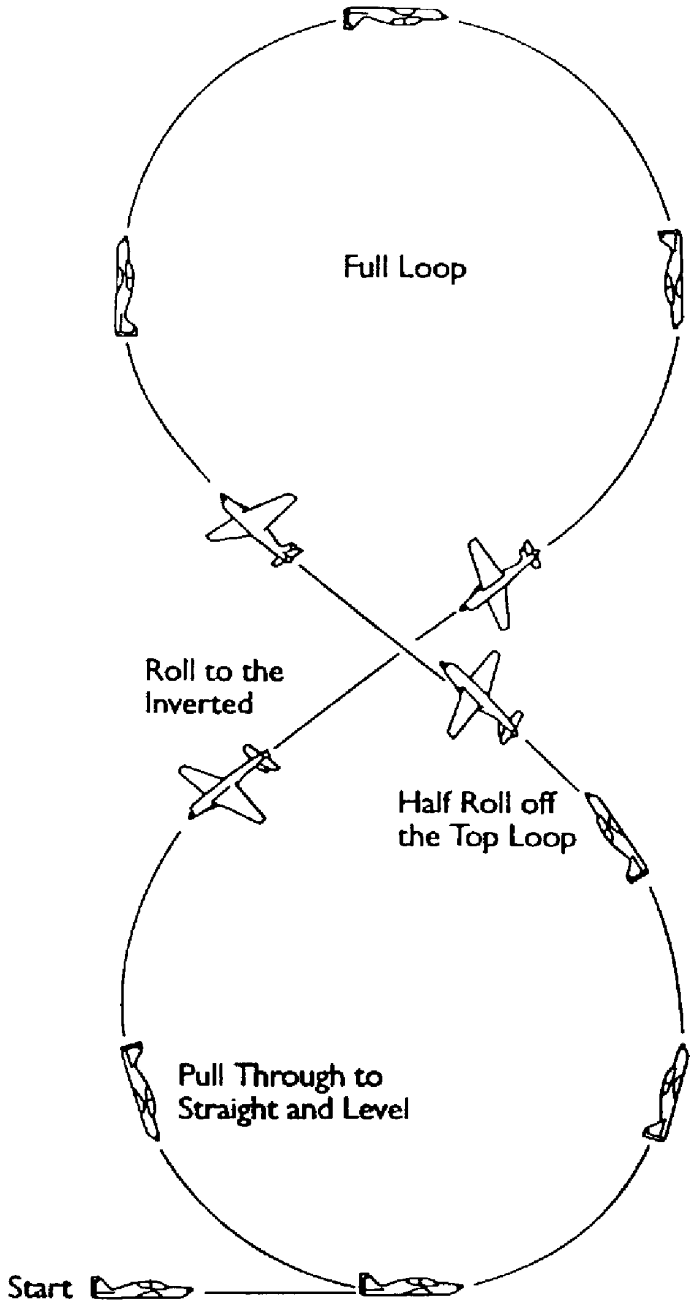
14. <u>The Derry Turn.</u> If an aircraft is in a steep turn in one direction and the pilot wishes to go into a steep turn the other way, he usually rolls through the normal (upright) flying position. In the Derry turn, however, he rolls through the inverted position and may have to raise the nose slightly as he enters the manoeuvres to avoid losing any height (Fig 5-8).

Fig 5-8 *Horizontal Derry Turn (Plan View)*



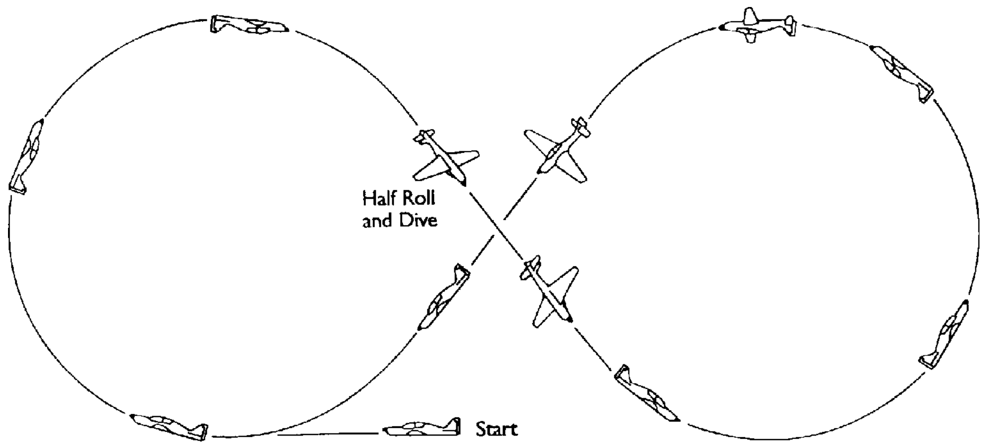
15. Vertical Eight. The vertical figure eight is a combination of a half roll off the top of a loop, a full loop, and a half roll and pull through (Fig 5-9). Speeds at entry and exit are high, and care is essential to avoid exceeding speed and "g" limits.

Fig 5-9 *Vertical Figure Eight*



16. Horizontal Figure Eight. A horizontal figure eight is started as for a loop. The loop is held until the nose is below the horizon on its way down and the aircraft is then half-rolled and dived to gain sufficient speed to enter a further loop as shown in Fig 5-10. A variation on this manoeuvre is the Cuban eight, in which the aircraft is rolled on pulling up into the first loop, completing the loop and half rolling again when pulling up into the second loop.

***Fig 5-10** Horizontal Figure Eight*



17. Hesitation Rolls. Hesitation rolls may be either four-point or eight-point rolls, the difference being that in the four-point roll the roll is temporarily halted after each 90° of roll and in the eight-point roll after each 45° of roll. This manoeuvre can be flown more easily on some aircraft than others, but the higher the speed of entry the greater is the control available and the accuracy of the roll.

18. Inverted Flight. There are few aircraft in which it is permitted to perform prolonged inverted flight or inverted gliding. You are most likely to see some at air shows - and when you do they will most probably be specially built or modified civilian aircraft. The main features of inverted flight are:

a. Aircraft are not designed to take inverted “g” loads as much as they are for normal flight (for example, an aircraft might have a limit of + $6^1/_2$ g, but only -

2g). Therefore, loading during inverted periods must be carefully controlled by the pilot.

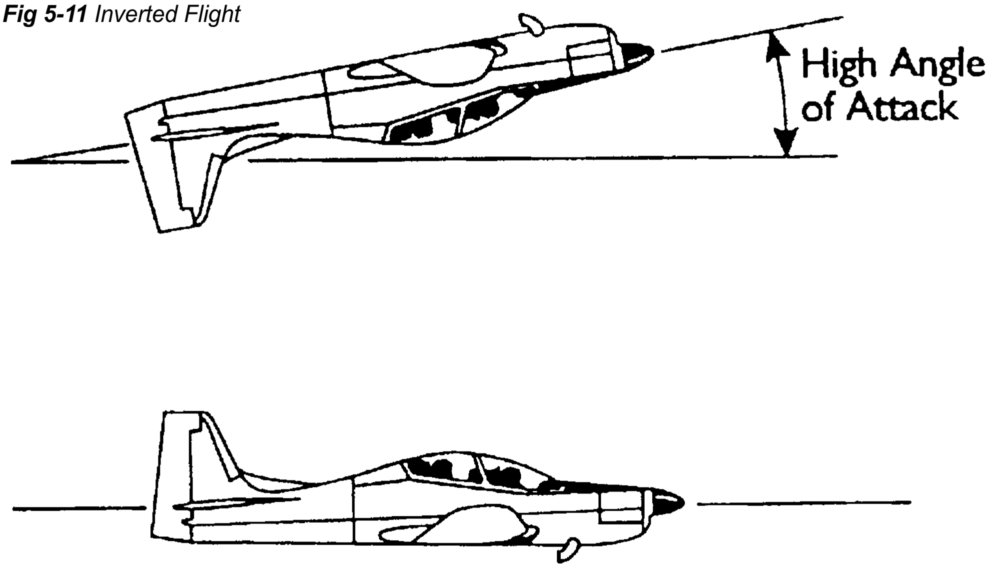
b. The aircraft responds normally when the controls are moved, but the movement of the aircraft relative to the horizon will be the reverse of that for the same control movements in normal flight. For example, to make a descending turn to the left (ie in a clockwise direction), the control column should be eased backwards and to the pilotís right to lower the nose and apply the required degree bank; right rudder should be applied to counteract slip.

c. During inverted flight at a given speed, the lift coefficient is much lower resulting in an increased stalling speed. Because of the lower lift coefficient the wing must be set at a higher angle of attack than for the same speed in normal flight; see Fig 5-11.

d. Due to lower wing efficiency and the high stalling speed, the gliding speed is higher when inverted; about one and a third times the normal gliding speed is generally suitable.

e. The aircraft may be sensitive laterally because any dihedral now has a destabilizing effect.

Fig 5-11 *Inverted Flight*



FORMATION FLYING

Introduction

18. A formation is defined as an ordered arrangement of two or more aircraft proceeding together as an element. Their movement is controlled by an appointed leader termed No 1. The No 1 is responsible for briefing other members of the formation and for ensuring the safe conduct of the formation throughout the sortie. Detailed considerations of the No 1's responsibilities and leadership are given at Paras 21 and 22 below.

19. There are two categories of formation flying:

Close formation

a. Close Formation **-** used for:

(1) Take offs, cloud penetration and landings **-** used mainly by training and fighter aircraft.

(2) Display and show purposes.

Tactical formation

b. Tactical Formation **-** used for all tactical fighter operations. This type of formation is designed to provide all-round search, the best mutual crossover and the best mutual fire support.

20. Only close formation is discussed in this manual. Very briefly, pilots fly in close formation by ignoring their instruments and the horizon to which they normally refer, and concentrate on keeping a fixed position in relation to the leader. They do not take their eyes off him for a second. Aircraft in close formation have been a common sight at air displays for a number of years, and there has always been a very good use for such formations. A group of aircraft staying close together can be taken by their leader or directed by a controller on the ground to the target area. Three or four aircraft can be treated as one unit and thus be used together where they will do most good. They can also be brought back to base (or "recovered" to use the correct expression) as one unit. Instead of one controller trying to give "Controlled Descent through Cloud" to three or four separate aircraft, he gives instructions to the leader, and the others flying in close formation follow his movements. This mans that fewer controllers are needed and time is saved in recovering aircraft in bad weather.

Leadership

Good leadership

21. Successful formation is heavily dependent on good leadership. The No 1 commands the formation and is immediately responsible for its security, the tactics and exercises to be flown and for its safe return to base.

22. The No 1 must fly in a position from which he can communicate with all of his pilots. He must be replaceable by a deputy leader who flies in a pre-arranged position relative to the No 1 and who must at any time be prepared to assume the responsibilities of the No 1. Thorough briefing before any formation flight is vital. Every member of the formation should know precisely the object of the exercise, the general plan of likely formation changes, the emergency procedures and action to be taken in the event of deterioration in weather and airfield state. Whenever possible, the service-wide standard positions and procedures should be used, and the principle of 'minimum change' put into practice. 'Minimum Change' means the smallest number of aircraft movements for any formation change.

The Section

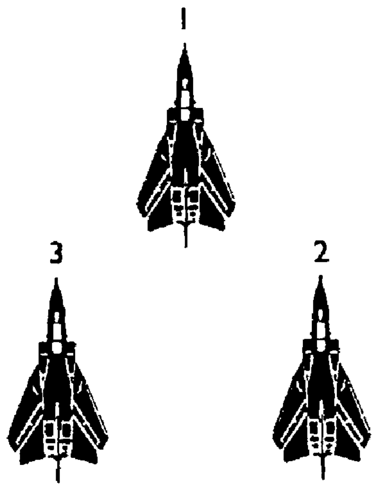
23. The basis of all formations is the section or element, which consists of two or more aircraft all operating under one nominated leader. Larger formations may be formed by the integration of two or more sections. Each section will have its own leader but a leader of the overall formation must also be nominated; he will normally be the No 1 of the lead section.

Section Formations

24. The standard section formations are:

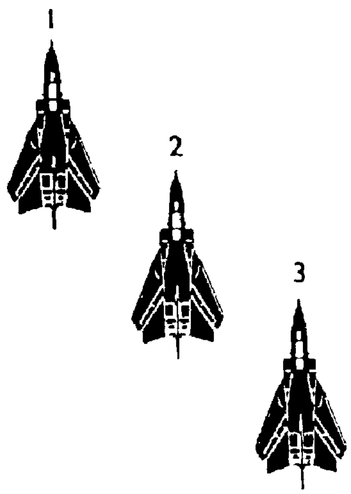
a. Vic-three aircraft as shown in Fig 5-12.

Fig 5-12 *Vic Formation*



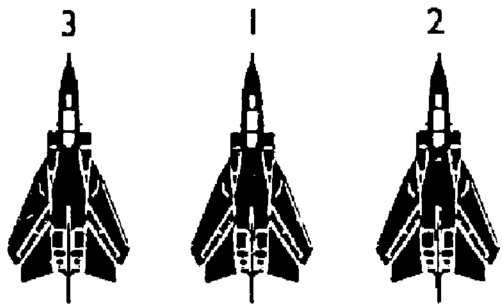
b. Echelon with aircraft disposed as shown in Fig 5-13.

Fig 5-13 *Echelon*



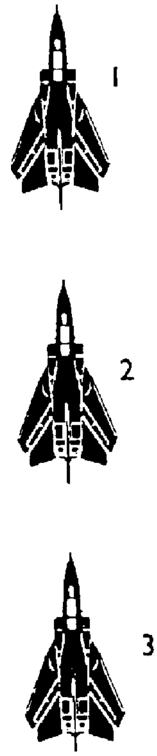
c. Line abreast - with aircraft as shown at Fig 5-14

Fig 5-14 *Line Abreast*



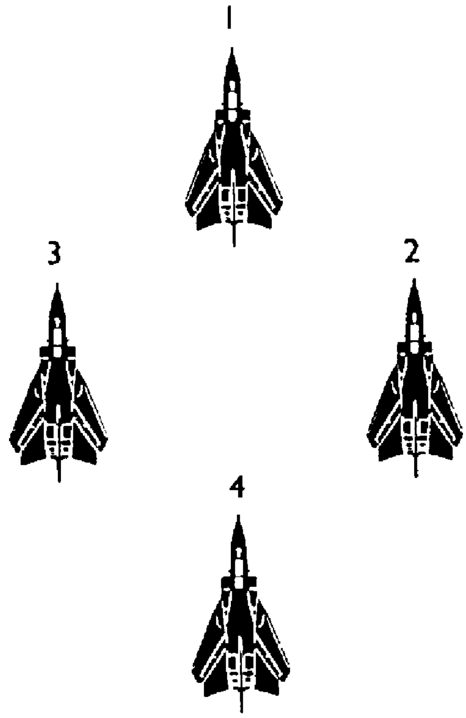
d. Line Astern - with aircraft disposed as shown in Fig 5-15.

Fig 5-15 *Line Astern*



e. Box - with 4 aircraft as shown in Fig 5-16. (NB the only number of aircraft possible for Box is 4).

Fig 5-16 *Box*



25. For cloud penetration the maximum size of a formation should normally be three. A three will invariably fly in Vic, and a pair as an Echelon, as it is essential for the formating pilots to see any hand signals made by the leader.

Close Formation Flying Technique

26. Relative Speeds. The driver of a car subconsciously judges the speed of his vehicle in relation to others against a background of fixed objects - trees, hoses, telegraph poles, etc - which border the road. Such a background does not exist in the air and the only way in which a pilot can be sure of his speed is to look at the airspeed indicator (ASI).

27. Apparent Size. The difference in size of an aircraft viewed from six miles range and from three miles range is very small, but the difference in size of the same aircraft viewed from one mile and 800 yards is quite noticeable. The effect of this is that when one aircraft is overtaking another, even at a high closing speed, the rate of approach appears very low at long ranges (five to ten miles) and seems

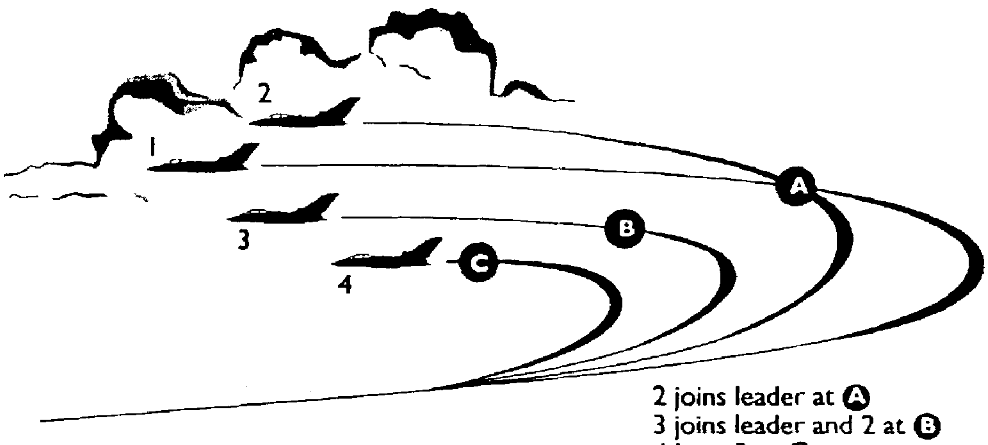
to increase almost imperceptibly until critical range is reached, when the overtaken aircraft appears to grow rapidly in size, and the true speed of approach can be judged.

28. Distance. Judgement of distance in the air is a matter of experience and practice but pilots can attain proficiency in the art more quickly if they realise that the tendency is to underestimate the rate of approach until the final stages. It is helpful, for the initial join-up if the No 1 flies at a constant, known airspeed; a pilot joining the formation can then set his own airspeed to give a reasonable but controllable overtake speed, eg 50 knots is a suitable speed advantage when the range to be closed is neither excessively long nor very short, but this will vary for different aircraft types.

Joining Formation

29. The time spent in joining formation serves no useful purpose and the longer the time taken to assemble a formation, the shorter will be the time that the formation can spend on the air exercise. Thus, pilots should join formation with the least possible delay.

Fig 5-17 *Joining Up After Take-Off*



30. Fig 5-17 illustrates the procedure for joining formation after a stream take-off. The leading aircraft should take-off, and fly straight ahead for a distance varying from 800 yards to one mile, according to the type of aircraft, and thereafter commence a gentle turn. The second aircraft - No 2 of the formation, should then turn inside the leading aircraft, so as to intercept it as soon as possible, and the third and fourth aircraft should carryout a similar procedure, ensuring that they always keep lower numbered aircraft visual while joining; the final join-up should normally be in numerical sequence.

31. It is important that the leading aircraft should settle down to the agreed cruising speed as soon as possible. The following aircraft may then fly with a small overtake speed (approximately 10-20 knots) gaining position by the use of shorter radius turns. In this manner leeway is rapidly made up and individual aircraft are able to take up their positions without excessive changes in airspeed. If the following aircraft either fly the same flight path as the leading aircraft or make a turn of larger radius outside the leaders flight path, they will have to increase their airspeed in order to overtake and will consequently be obliged to make a large alteration in airspeed before they can take their stations. Moreover, a great deal of time and fuel will be wasted.

32. It can be seen that once the joining aircraft is established in the shorter radius turn, all the pilot needs to do is maintain the interception course until he reaches the point at which he can decelerate and move to the correct formation position. To maintain the interception course the lead aircraft must remain in a constant position in the joining pilots field of view. If it moves forward the joining pilot must increase his rate of turn and if it moves backwards the rate of turn must be decreased. It must be remembered that, when the lead aircraft is stationary in the windscreen or canopy a collision course is set-up, so positive clearance in the vertical plane must be established in the later closing stages.

Positions in Basic Formation

33. The distance between aircraft in formation are laid down in relevant instructions and pilots must observe them strictly. No attempt should be made to practise formation flying in manoeuvres until the correct positions for each basic formation position has been learned.

34. When flying in vic or echelon a formation pilot will maintain station by reference to agreed features on the adjacent aircraft (eg, lining up the wing tip and the nose of the aircraft ahead). Obviously these features will vary according to aircraft type and can be varied on a specific type to achieve a particular formation shape for special occasions.

35. In line abreast formation, the correct fore and aft position can best be judged by reference to the cockpit of the next aircraft and the lateral position by reference to its size. The plane of the windscreen arch may assist fore and aft positioning but it is difficult to judge whether one aircraft is truly abreast with another and the tendency is to formate a little too far back. It will be difficult to judge the separation between the wing tips of aircraft with highly swept wings and extra caution will then be needed.

36. In line astern formation the correct fore and aft position can be judged by the relative size of the aircraft ahead, or a part of this aircraft as seen relative to the windscreen of the formating aircraft. The amount by which each aircraft must be stepped down from the preceding aircraft varies according to the slip-stream from each type of aircraft, but generally should be as small as possible. Too large a vertical interval between aircraft results in the last member of the formation flying very much lower than the leader and this may cause some difficulty in turns.

Keeping Station

37. All pilots aim to achieve smoothness in their formation flying. This is particularly important when more than a single aircraft is formatting in echelon, line astern or line abreast, since the movement of one aircraft in relation to another is accentuated towards the outside of the formation. If the second aircraft in the formation is flown roughly, the pilot of the aircraft on the outside of the formation will have an extremely difficult task. Sometimes, his only option is to keep station on the lead aircraft instead of the one in between, thereby reducing the ëwhipí effect.

38. To keep his position constant in relation to the leader of the formation, the formatting pilot may be required to adjust his position longitudinally, laterally and/or vertically. A keen sense of anticipation must be developed so that correcting movements are kept to a minimum.

39. Longitudinal Station Keeping. Changes of position in the longitudinal direction are made using the throttle to make small speed changes and this in turn may necessitate a small movement of the elevators to maintain position vertically; thus co-ordinated movements of the two controls are made throughout. To maintain a constant position longitudinally the throttle should be moved in the appropriate direction immediately any change is noticed or anticipated. This movement should be smooth and no more than is necessary to correct errors, large throttle movements will usually result in over-correction, making station keeping difficult and increasing fuel consumption; the latter may be critical on long sorties. It must be remembered that a clean aircraft usually accelerates quickly and decelerates slowly because of its low drag and due allowance must be made for this. Jet engine aircraft may have poor acceleration, especially at low air speeds, and also decelerate slowly; both effects must be anticipated.

40. Lateral Station Keeping. Changes in lateral position are made by gentle movements of aileron, in some aircraft, co-ordinated with use of rudder. Small angles of bank should be used to correct lateral spacing and, when approaching the correct position, opposite bank will be required to return to the leaderís heading and so maintain the new position.

41. Vertical Station Keeping. Position in the vertical plane is controlled by the elevators. At some stages of flight, notably on an approach, in aircraft with highly swept wings, even small changes of angle of attack caused by elevator movement will require some throttle movement to maintain longitudinal positioning. Co-ordination of elevator and throttle is important.

Conclusion

42. Clearly, formation flying has much to offer, and it is an integral part of every military pilotís inventory of skills. By now you should understand what is involved, and will more readily appreciate the performances of those whom you see at air shows and on your visits to RAF stations.

CHAPTER 6

EMERGENCY PROCEDURES

Introduction

1. Emergencies can occur in flight at any time and without warning. Therefore it is vital that all aircrew have a full knowledge of distress action, so that their response to any emergency is swift and thorough. This chapter deals with various emergency procedures and outlines the emergency organisation of the RAF.

Degrees of Emergency

2. Degrees of emergency are internationally classified as being of two standards:

a. Distress. "The aircraft (calling station) is threatened by serious or imminent danger and is in need of immediate assistance".

b. Urgency. "The calling station has a very urgent message to transmit concerning the safety of an aircraft, or of persons on board or within sight".

Emergency Transmissions

3. A transmission to be made in an emergency consists of two parts: the emergency call and the emergency message.

a. Emergency Call. Fig 6-1 sets out the radio telephony (RT) and wireless telegraphy (W/T) versions of the Urgency and Distress calls.

Degree of Emergency	Pro-word (R/T)	Pro-Sign (W/T)
Urgency	"Pan, Pan, Pan" Aircraft callsign (once)	"XXX, XXX, XXX" Aircraft callsign (once)
Distress	"Mayday, Mayday, Mayday" Aircraft callsign (3 times)	"SOS, SOS, SOS" Aircraft callsign (3 times)

Fig 6-1 *Urgency and Distress Calls*

b. Emergency Message. The emergency message should include as much of the following information as time permits:

(1) **P**osition **A**nd **T**ime

(2) **H**eading And **A**ir **S**peed

(3) **A**ltitude

(4) **T**ype of Aircraft

(5) **N**ature of Emergency

(6) **I**ntentions of Captain

(7) **E**ndurance Remaining

Although the information should ideally be given in the order listed, the transmission should not be delayed merely to arrange the details correctly. However, the aircraft's position is at the top of the list, as it is the most important item of information in most emergencies (it is the first thing the rescue services need to know). A useful mnemonic for the emergency message is **PAT HAS ATNIE**.

Emergency Procedure and Fixer Services

4. If an emergency occurs when the pilot is in contact with an Air Traffic Control agency, he should transmit his emergency call and message on the frequency in use. If he is not in contact with an ATC agency when the emergency occurs he should transmit the emergency call and message on 243.0 MHz, with 121.5 MHz being used as a back-up frequency, or on the HF frequency of 500 KHz.

5. Use of Secondary Surveillance Radar (SSR). SSR is also used to indicate an emergency and code 7600 indicates a total radio failure. If an emergency occurs when in contact with an ATC agency, the SSR code already set should remain in use unless advised otherwise by ATC. In all other cases the transponder should be set to code 7700.

6. <u>Final Transmission.</u> When ditching, crash landing or abandonment is imminent, the aircraft callsign should be transmitted and, where possible, the transmit control switch should be left in the transmit position. For W/T the key should be clamped in the transmit position. These actions should not take priority over abandonment if life would be endangered by so doing.

7. <u>UHF Emergency Fixer Service.</u> Within the United Kingdom FIRs a network of stations provide an emergency fixer service. Emergency transmissions on 243 MHz are picked up by stations within range, and a bearing of the aircraft making the transmission from the station is automatically relayed to the ATCC and then displayed on a screen, giving the controller an instant ìfixî on the aircraft. This service is accurate down to 5000 feet for most of the area covered, but the lower limit in the Scottish FIR is 8500 feet. Transmissions from the ATCC to the aircraft are relayed through the forward relay system, thus extending the range of the ATCC communications equipment. The nearest forward relay to the aircraft is selected by the controller.

8. <u>Cancellation.</u> Should the emergency cease to exist it is most important that a transmission be made to cancel the original call on the frequencies on which the call was made.

9. <u>Search and Rescue Satellite Aided Tracking (SARSAT).</u> False Alarms. SARSAT is an alert and location system detecting transmissions on 406, 243 and 121.5 MHz. It is highly sensitive and virtually any transmission on these frequencies may activate the rescue services. Inadvertent transmissions, particularly on 243 MHz, should be reported immediately to the appropriate ATCC in order to avoid wasting search and rescue effort on false alarms.

<u>Emergencies Involving Another Aircraft</u>

10. An aircraft observing another aircraft or personnel in distress should, if possible, take the following actions:

a. Keep the aircraft or personnel in sight and switch IFF/SIF to emergency. At sea, if a surface vessel is in sight and can be contacted without losing sight of the distressed personnel, guide it to the position.

b. If the aircraft in distress is not known to have transmitted a distress message, or if the captain of the aircraft observing the distressed aircraft believes that further help is needed, a message containing all of the relevant information should be transmitted to the controlling ground station on the frequency in use.

c. The captain should then comply with any special instructions given by the controlling authority or remain in sight of the distressed personnel/aircraft until circumstances compel departure.

11. If a distress call or message is heard the captain or crew of the aircraft should take the following actions:

a. If possible attempt to take a bearing on the transmission and attempt to plot the position of the sender.

b. Listen out on the frequency used.

c. If no acknowledgement of the distress message is heard, call the aircraft in distress and acknowledge receipt.

d. Listen out for instructions from the ground and transmission from the distressed aircraft and act as necessary.

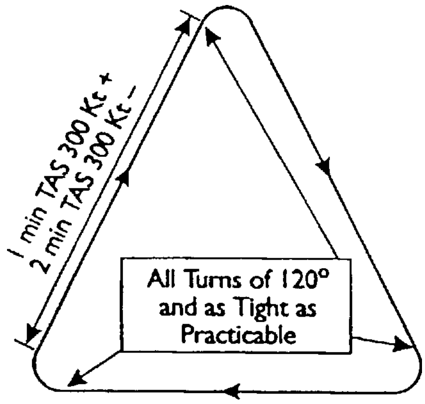
e. At the captainís discretion, proceed to the position mentioned in the distress message while awaiting instructions from the ground station.

Communications Failure

12. Pilots losing 2-way communications should set their transponder to Mode 3A code 7600. Flight conditions then generally determine the procedure. In VMC and in visual contact with the ground, the flight should be continued in VMC to land at the nearest suitable airfield. In IMC, or anticipated IMC conditions, if the aircraft can be safely navigated the flight should be continued in accordance with the current flight plan. In all cases when the receiver only is operative, instructions from ATC should be complied with. If, however, the aircraft is in or above cloud and the pilot is unable to navigate safely, he should reset the transponder to code 7700 and he may elect to fly one of the following patterns to alert a ground radar station:

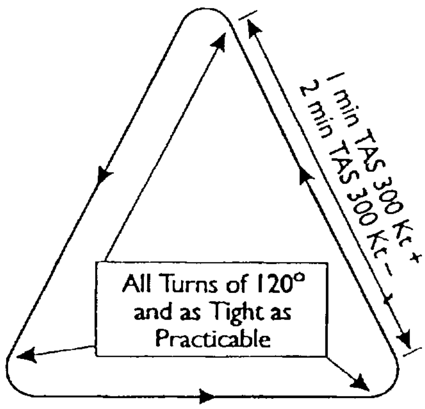
a. If the transmitter only has failed, an equilateral triangle to the right, whilst listening out for instructions. (See Fig 6-2).

Fig 6-2 *Receiver Only Operating*



b. If both transmitter and receiver have failed an equilateral triangle to the left, whilst waiting for interception by a shepherd aircraft (see Fig 6-3). The aircraft in distress should, if possible, remain clear of cloud, be flown for endurance and should have anti-collision lights on.

Fig 6-3 *Transmitter and Receiver Inoperative*



13. When an aircraft is observed flying right hand patterns, the ATCC will attempt to contact the aircraft on the emergency frequency. If an aircraft is observed flying left-hand patterns a shepherd aircraft will, if possible, be dispatched to assist it. The shepherd aircraft should position in front and to the left of the aircraft in distress. The shepherd will rock its wings, which should be acknowledged with a wing rock; the shepherd will then start a slow level turn onto course. An attempt should be made to contact the shepherd on 243 MHz.

14. Speechless Procedure. If an aircraft is above cloud with an unserviceable microphone, or a radio problem which results in an inability to transmit speech, contact can be established with ATC using the speechless code. When the transmit button is pressed a carrier wave will be transmitted and will be observable on the ATC direction finding equipment. Then, by using the speechless code, it is possible to communicate with ATC as follows:

a. For initial contact, make 4 transmissions as for a Morse “H”, meaning “request homing”.

b. One transmission: “Yes” or acknowledgement.

c. Two transmissions: “No”.

d. Three transmissions: “Say again”.

e. Letter “X” in Morse, - • • - : An additional or greater degree of emergency has arisen.

15. Speechless let-down:

a. The transmit button is pressed 4 times as for Morse “H”. The transmission should be made on the emergency frequency where possible.

b. The receiving station will pass a course to steer and the speechless aircraft acknowledges.

c. The aircraft is homed to overhead and given a controlled descent.

d. During the homing the controller determines the aircraft state by questions requiring “Yes” or “No” answers.

e. During the procedure the completion of an instruction, eg steady on heading or height, is indicated by a two second transmission and also when:

(1) Overhead turn complete.

(2) steady on inbound heading.

(3) Intermediate approach height.

(4) At decision height or minimum descent height.

(5) Airfield in sight.

EMERGENCY ORGANISATION

ATCC Distress and Diversion Cell

16. An aircraft in distress may make contact with an ATCC or ATCRU by transmitting an emergency message on the frequency in use, by transmitting on the emergency frequency, by a relay transmission from another aircraft or, if a radio failure has occurred, by flying the triangular patterns described in para 12.

17. When the ATCC has identified an aircraft in distress, executive authority for the handling of the emergency is passed to the Emergency Controller in the ATCC Distress and Diversion Cell. The aircraft in emergency will normally be transferred to 243 MHz or 121.5 MHz. If the emergency occurs when the aircraft is not in contact with an ATCC, but transmits a distress call on 243 MHz, the emergency services may be alerted by SARSAT.

Search and Rescue Services

18. In the event of a crash landing or abandonment the emergency controller will advise the Rescue Co-ordination Centre (RCC) so that the necessary rescue services can be alerted. The RCC co-ordinates the activities of all search and rescue facilities which may include S and R helicopters, lifeboats, long range maritime patrol aircraft, mountain rescue teams and police and ambulance services. There are two RCCs in the United Kingdom; they are situated within the Maritime Headquarters at Plymouth and Edinburgh.

CHAPTER 1

INSTRUCTORS GUIDE

AIRCRAFT MAINTENANCE

Page 34.3.1-1 Para 1

1. The modern aircraft in service with the Royal Air Force are complex and highly developed machines that need thorough inspection and regular servicing to keep them at a high level of operational efficiency. Not only the aircraft itself, but also its weapons and all the mechanical and electrical devices that are an integral part of the aircraft must be checked and serviced at regular intervals by specialist tradesmen.

2. There are very many operations necessary to keep the aircraft airworthy from the times it is received into the service until if finally finishes up on the scrap heap. Some servicing operations may require only the brief attention of one person with a screwdriver. Others will involve a party of trained personnel with much heavy ground equipment and a considerable amount of complicated testing apparatus.

Page 34.3.1-4 Para 8

3. The pilot who is going to fly the aircraft must obviously have some check that all necessary inspections and servicing, together with the refuelling and rearming required for his particular sortie have been undertaken. He first examines the aircraft servicing form (Form 700) in which all work carried out on an individual aircraft is recorded. All servicing, refuelling or rearming are always signed off by the tradesmen and SNCO responsible. No pilot ever takes an aircraft off the ground until he has thoroughly checked this book to ensure that his aircraft is ready. The pilot signs in the Form 700 as an acknowledgement that he is satisfied that the aircraft is serviceable. He then makes a visual pre-flight check of his aircraft. Although the details of the check vary considerably with the type of aircraft, in essence they are all the same. The pilot walks round his aircraft and makes a thorough external check. When in the cockpit he checks the instruments, controls and main services of the aircraft.

CHAPTER 2

INSTRUCTORS GUIDE

GROUND HANDLING

Page 34.3.2-1 Para 4

1. A marshaller is employed to assist the pilot to taxy safely in congested areas, and to indicate to the pilot where he is required to place his aircraft. It often happens that a pilot visits an airfield which is strange to him and he needs some help to find his parking space. To make marshallers easily recognisable to the pilot, they usually wear yellow jerkins and carry two bats shaped like table

tennis bats and painted yellow. The bats are used for day signalling; at night lighted wants are used. The wands are cylindrical and lit from the inside by a torch battery.

2. It must be remembered that a marshaller, like an Air Traffic Controller, is only there to assist the pilot and the responsibility for anything that happens to the aircraft still rests with the captain of that aircraft.

3. If the aircraft is large, or the area is congested, the marshaller often has two assistants who place themselves where they can watch the wing tips. These assistants signal to the marshaller whether or not the aircraft will clear any obstruction towards which it is moving. If there is plenty of clearance the assistant gives a ìthumbs upî signal to the marshaller. If there is no clearance at all, the assistant gives the ìstopî signal to the marshaller. When there is only a small clearance, a metre or less, the assistant hold his arms above his head and indicates the amount of clearance between his hands.

4. At some airports, the aircraft marshallers are equipped with radio which they use to talk to the pilots, it will always be necessary for hand signals to be used at smaller airfields and as a stand

by in the event of radio failures.

5. Apart from his routine guiding aircraft, a marshaller can be very helpful to the pilot in many other ways. marshallers sometimes notice something wrong with an aircraft as it taxies out for take

off. Perhaps a wheel brake may be binding and causing a wheel to overheat, or a fuel leak may show itself from one of the wing tanks. These and many other similar faults may pass unnoticed by the crew inside the aircraft, but an alert marshaller will always stop an aircraft at once and draw the crewís attention to the fault.

6. It will be realised a marshallerís job is a most important one. H is help is invaluable to the pilot who quite often would be unable to move his aircraft but for his skilled assistance. A well-trained marshaller not only speeds the movement of aircraft, but also prevents many thousands of poundsí worth of damage being caused by even the slightest collision between moving aircraft and objects on the ground.

Self Assessment Questions - Answer Sheet

Chapter 1 - Aircraft Maintenance

1. The RAF's maintenance policy is based on a balance of preventive and corrective maintenance.

2. MOD F700 is the 'Aircraft Maintenance Data Form'.

3. MOD F703 is the 'Onboard Software Log'.

4. The MOD F705, 'Flight Servicing/Fuel Certificate', is used for the certifying of flight servicing and fuel states.

Chapter 2 - Ground Handling

1. FOD - Foreign Object Damage.

2. The aim of a marshaller is to assist the pilot in the safe manoeuvring of the aircraft on the ground.

3. Marshall's identify themselves to pilots by energetic waving o the arms in a circular motion.

4. Safety is the responsibility of the pilot.

5. An air quartermaster is responsible for the supervision of loading and security of loads in an aircraft.

Chapter 3 - Preparation for Flight

1. a. Weather conditions and forecast.
   b. Air Traffic Control clearance.
   c. Preparation of maps and charts.

2. Form 3562 is the Flight Authorisation Book.

Self Assessment Questions - Answer Sheet cont...

3. Detailed checks for the type of aircraft are found in the Aircrew manual but will normally include:

    a. External checks.
    b. Cockpit checks before starting engines.
    c. Warming up and running up (piston engines).
    d. Pre-take off checks.

Chapter 4 - General Flying

1. A holding position is a white line across the runway, from which the pilot has a good view of the runway, and the final approach.

2. The first requirement for a good landing is a good approach.

3. The two main advantages of landing into wind are:

    a. The ground speed is reduced to a minimum for a given airspeed.

    b. Drift is eliminated.

4. In all aircraft the use of flap shortens the landing run because it allows a lower touch-down speed and increases drag.

Chapter 5 - Aerobatics abd Formation Flying

1. HASELL stands for:
   Height, Airframe, Security, Engine, Location and Look-Out