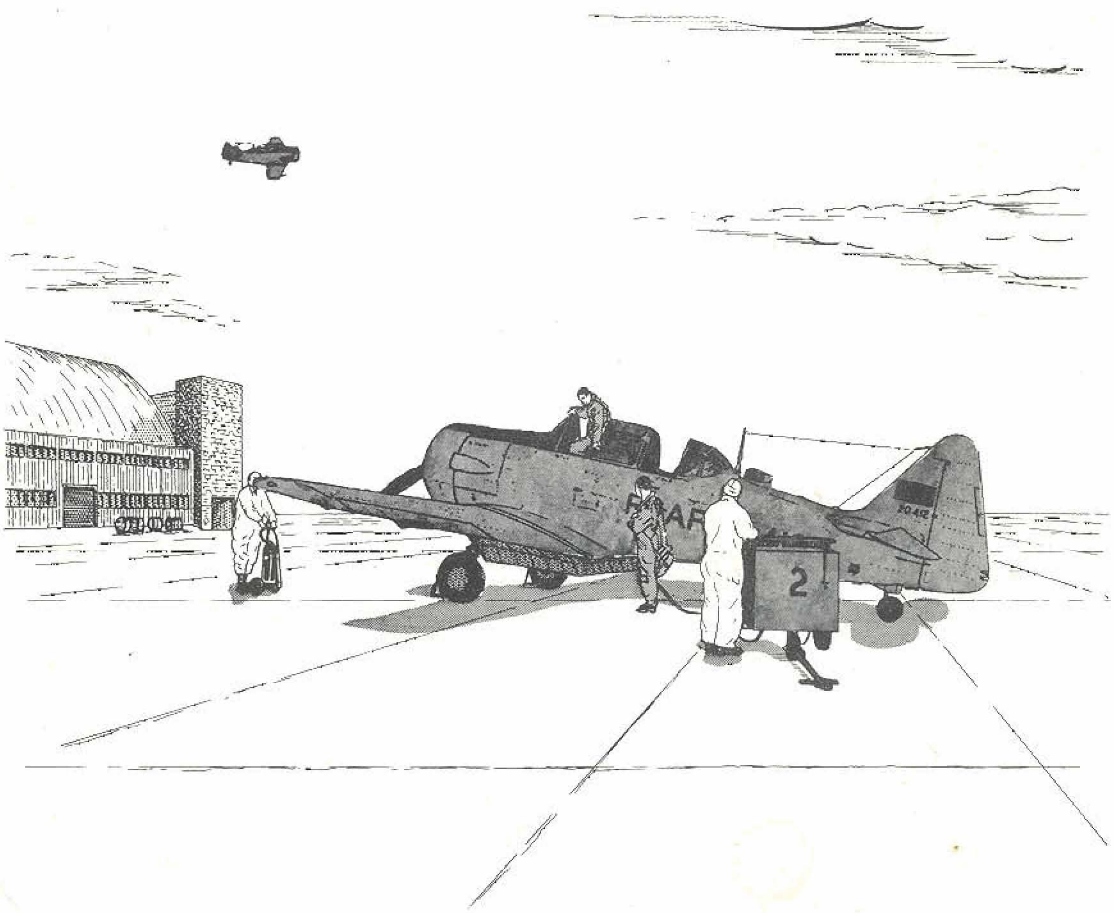
Turbo Tarling

PILOT'S MANUAL FOR BASIC FLYING TRAINING



Preface

Pilot's Manual for Basic Flying Training is the second publication in a series of manuals being prepared for students at flying training schools. This edition supersedes all previous issues of TC-44 and CAP 444, Student's Handbook for Basic Flying Training.

Suggestions for additions or amendments are invited and should be forwarded to Training Command Headquarters, on the enclosed form, at the earliest opportunity.

Jan 62

Record of Amendments

The amendments promulgated in the undermentioned Amendment Lists have been made in this publication:			
Amendment List		Amendments Made By	Date
No.	Date		

Introduction

This publication has been prepared to supplement the flying instruction taught at Flying Training School. It provides study material designed to help the student pilot understand his pre-flight briefings.

Techniques, procedures and manoeuvres are covered in a logical sequence, to give continuity of instruction, and to furnish the student with a background for each successive aspect of his training. Theory has been kept to a minimum and is confined to simplifying the transfer of thought to practical application.

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17 - FORMATION FLYING

Chapter 1

Basic Pilot Training

1.01 - Introduction

(1) Now that you have passed the PFS stage of your Pilot Training, you are ready to move forward, to a larger and faster aircraft. At FTS, you will have an opportunity of increasing your flying proficiency and your knowledge of flying techniques. In Ground School, academic lectures will supplement the flying instruction given on the flight line so that, by the end of the course, you will be skilled in the basic principles and will be ready for the next phase of your training.

(2) You will recall that in Chapter 1 of TC-34, Pilots' Manual for Primary Flying Training, certain obligations which are expected of all students during their training were discussed. These obligations apply equally to FTS, and are repeated here to refresh your memory.

1.02 - Questions

(1) DON'T BE AFRAID TO ASK QUESTIONS. Make sure that you seek a solution to each problem, for no one can learn too much about flying! Pilots with thousands of hours and years of experience ask questions, so why shouldn't you?

1.03 - Be Ready to Fly

(1) Try to make full use of each flying period by being prepared for it. Read and assimilate all the material pertaining to the work to be done, and ensure that your flying equipment is in good order and ready for use.

1.04 - Cockpit Time

(1) Sometimes, while awaiting your turn to fly, you may be without a

specific assignment. Such free time can be used to become better acquainted with the cockpit of the aircraft; however, you should know by this time that you MUST NOT TOUCH ANY OF THE SWITCHES OR THE UNDERCARRIAGE LEVER. All flying training schools have synthetic trainers which duplicate the more important systems of the aircraft, and your instructor will be happy to outline the procedures and policies for their use.

(2) While studying the cockpit, examine your copy of TC-6, Harvard Pilot's Check List and review the prescribed procedures. As you go through the check list, notice the position of each item and try to visualize its function. The sooner you become familiar with the check list, the cockpit arrangement and the aircraft in general, the sooner your whole attention can be devoted to flying the aircraft.

1.05 - Aircraft Operating Instructions

(1) Aircraft Operating Instructions (AOIs) is an Engineering Order containing all the essential information relative to one particular type of aircraft. A copy of the Harvard edition has been issued to you, and should be used as a reference. Each publication is broken down into four parts.

(a) Part 1, describes the controls and equipment, and includes diagrams of the fuel, oil and hydraulic systems.

(b) Part 2, describes the normal handling of the aircraft and the checks which must be carried out.

(c) Part 3, describes the emergency handling of the various systems, and the procedures to be used in case of fire or a forced landing.

(d) Part 4, describes the flying and engine limitations, and includes information on fuel consumption, etc.

You should review the complete AOI frequently to learn all about the Harvard, paying particular attention to Part 3.

(2) TC-6 is basically an extract from Part 2 of the AOIs. It is an essential item in every cockpit, since each step in the operation of the aircraft is listed. This means that you MUST carry your personal copy with you on every flight.

1.06 - Ground Safety

(1) On the ramp there is usually a great deal of activity and noise due to

the passing of fuel trucks, the running-up of engines and the taxiing of aircraft. Because of the noise you must use your eyes constantly; never trust your ears to warn you of the approach of a truck or aircraft. Flying helmets or headsets are not to be worn until you are ready to step into the aircraft.

(2) Sometimes it is difficult to see a rapidly revolving propeller, and you may have the impression that it is not there. Stay away! By the same token, never touch a propeller that is not turning without having personally checked the cockpit to see that the magneto switches are "OFF".

(3) When you are about to go flying keep a lookout for obstructions that you must avoid when leaving the ramp. After the pre-flight inspection has been completed and you are ready to start the engine, ALWAYS be sure that one of the groundcrew is standing by with a fire extinguisher.

(4) When leaving the aircraft after flight, use the same precautions as when first coming out onto the ramp. You may be tired, but this is not the time nor the place to relax. Remember that it was difficult to see ahead in the Harvard when you were taxiing in; therefore, keep a look-out for the other fellow when you are walking on the tarmac. You can see him but he may not see you.

1.07 - Local Flying Regulations

(1) Besides the general flying rules which are covered in this publication, certain local regulations are in effect at each school. These rules are published in Station Standing Orders and FTS Orders, and cover such subjects as flying areas, traffic rules and traffic patterns. They are very important since they have been written to ensure safe, efficient flying. Copies are available in the flight room and you must read them thoroughly. Remember, any violation of a flying regulation may jeopardize your chance to complete the course.

1.08 - Flying Safety

(1) The first rule to be learned before taking to the air is to have a high regard for safety: pre-flight preparation and planning are important. Before take-off, make sure that everything has been completed correctly, including all the necessary checks. A careless pilot is not only a danger to himself, but also to those who are unfortunate enough to have to fly with him. Remember that any item on a pre-flight check, if neglected, can easily become the most important factor in your life: do not take this responsibility lightly. For your own sake, as well as for that of others, get into the habit of making thorough pre-flight checks.

(2) Throughout your entire flying career you are going to be concerned with safety. Start off well by observing this rule:

LOOK AROUND!

To fly with safety, your eyes must be moving continuously. You must:

(a) look up;

(b) look over your left shoulder;

(c) look over your right shoulder;

(d) keep alert;

(e) always look before turning;

(f) never have a rigid neck;

(g) look more than once;

(h) realize that there is a blind spot underneath the aircraft;

(j) never assume that others see you; and

(k) divide your attention!

(3) A most important flying safety requirement during your flying training is a clear and positive understanding of who has control of the aircraft. The procedure for exchanging control is:

Instructor: "You have control".

Student's Response: "I have control".

When your instructor wishes you to relinquish control, the order is given over the interphone as:

Instructor: "I have control".

Student's Response: "You have control".

(4) Control must never be relinquished until both the order and the response have been given.

1.09 - Your Parachute

(1) Although the probability of your ever having to bail out is slight, you

should be familiar with the operation of your parachute so that you can be sure of making a safe landing. Your parachute will open every time, provided it is handled and used properly, because it is given rigid periodic inspections and is re-packed at regular intervals by experts.

(2) The three main parts of a parachute are:

(a) the canopy;

(b) the pack assembly; and

(c) the harness.

(3) THE CANOPY - The canopy, or lifting surface, is woven of high-grade silk or nylon fabric. A framework of lines, known as suspension or shroud lines, connects the canopy to the harness. Each line extends from a connector link on one side of the harness, through a channel in the canopy, to another connector link on the other side of the harness. This arrangement provides maximum strength, because each line is continuous from one connector link to the other, with the lines crossing each other at the apex. Further strengthening is assured by bands of reinforcing tape on the fabric. A small parachute, known as the pilot parachute, is attached to the main canopy to facilitate its opening. When the ripcord is pulled, the pilot parachute is projected into the airstream, where it quickly fills with air, and draws the main canopy out of the pack. The canopy would open without the aid of the pilot parachute, but the opening would be slower and not so positive.

(4) THE PACK - The bottom of the parachute pack is usually fairly rigid and is equipped with fabric loops or rubber bands to hold the folded suspension lines. The sides and ends fold inwards to enclose the canopy completely, and are fastened with a special device which releases instantly when the ripcord is pulled. The ripcord is a flexible steel cable enclosed in a flexible housing; at one end is a grip or "D-ring", and at the other end are pins which serve to lock the closed pack. When the ripcord is pulled, the pins are withdrawn from their locking cones, and elastic cords, known as pack-opening elastics, jerk open the pack permitting the pilot parachute to be projected into the air.

(5) THE HARNESS - The harness is a flexible, webbing framework that secures the parachute to the wearer. It has provision for adjustment to fit any wearer, and a special quick-release fastening for easy removal. The Safety Equipment Section will ensure that you have a perfect fit each time that you go for a new parachute. While you are being fitted for the first one on your arrival at FTS, make sure that you understand how to put your parachute on, and how to work the quick-release mechanism. At the same time you will be shown the approved method of folding your parachute for storage in a bin or locker. If at any time you find that your parachute does not fit as well as it should, DO NOT TAMPER WITH THE ADJUSTING STRAPS; return to the Safety Equipment Section and have qualified persons give you a new fitting.

(6) Be careful when you handle your parachute: do not throw it down on the ground, or leave it where it can become dirty or damaged. Gasoline, oil, grease and battery acid are very harmful to fabrics - keep your parachute away from them. If contamination is unavoidable, return the parachute to the Safety Equipment Section at once, and report the circumstances.

(7) ALWAYS inspect your parachute before and after you wear it. A normal daily inspection should include:

(a) a check that the parachute you are about to wear is your own, (If yours is being repacked, or is being used for some other reason, make sure that the replacement is a good fit.);

(b) an examination of the repacking or inspection date, to ensure that the parachute is not overdue, (Current regulations require that a parachute be repacked every 60 days.);

(c) a thorough inspection of the harness for frayed spots, broken stitching, corroded or distorted metal fittings, and oil, water or acid stains;

(d) an inspection of the pack for damage, checking for pressure and tension of the elastics and the general condition of the pack, including a search for oil, water or acid stains;

(e) a check underneath the flap to examine the condition of the grommets, locking cones and ripcord pins, (The pins should not be damaged, corroded or distorted in any way, and the scarlet safety-thread on the last pin and cone must be intact.);

(f) an examination of the corner flaps, which should be tucked in with a parachute packing stick, if they are pulled out, (If the flaps are very loose and the canopy is protruding, return the parachute to the Safety Equipment Section.);

(g) a check to ensure that the ripcord "D-ring" is securely fitted into its pocket, yet is free to come out easily;

(h) a physical check around the edge of the pack to feel for breaks or damage to the steel frame; and

(j) an inspection to ensure that the pocket at the back of the pack contains

(i) a repacking and inspection record card,

(ii) two plastic-covered cards outlining the ground-air signalling code, and

(iii) a booklet entitled "Emergency Uses of Parachutes".

(8) A parachute is heavy, but can be carried comfortably over the shoulder. The normal method is to grasp the shoulder straps close to the back canvas and throw the parachute over one shoulder with the pack supported on your back. The higher it rides on your shoulder, the easier it is to carry. Having carried parachutes at PFS, however, you may have developed a method of your own, which you should continue to use provided there is no danger of damaging the parachute.

1.10 - Parachute Descents

(1) Your instructor will explain the bail-out technique for the Harvard before taking you up on your first flight. Pay attention to what he has to say, because you may have to leave the aircraft in a hurry one day, and it is best to do so in one piece! In the following paragraphs, it is assumed that you have benefited from your instructor's advice and are clear of the aircraft.

(2) PULLING THE RIPCORD - It is not difficult to make your parachute open. To prepare yourself for the opening shock and to prevent tangling your legs in the harness, straighten your legs and keep your feet together. Grasp the ripcord housing with both hands, looking down at it if you wish. Take the "D-ring" in your right hand and PULL SHARPLY.

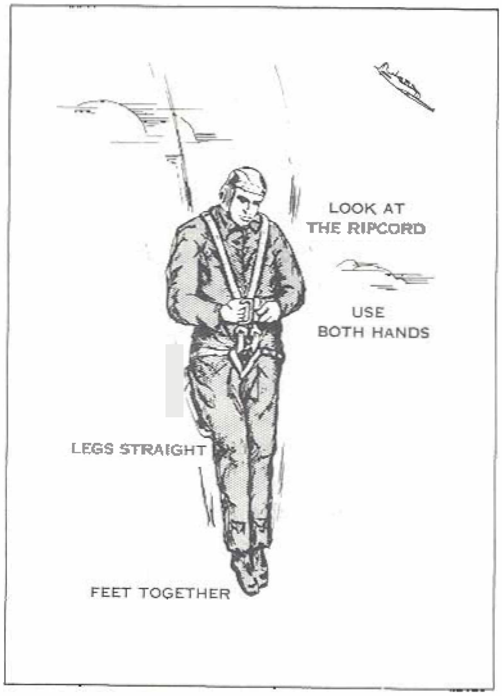

Figure 1: Pulling the Ripcord

(3) THE DESCENT - About two seconds after you have pulled the ripcord, you will feel a sharp, strong tug as the canopy opens and fills with air. Look up to see that the canopy is fully open. If a suspension line is caught across the top of it, or if the lines are twisted, manipulate them to try to remedy the fault. Probably you will swing on the way down, but swinging is normal and should not be checked. Try to estimate your height by looking at the ground and then at the horizon, but remember that you are descending at around 1000 to 1500 feet per minute. Observe drift by bending your neck forward and sighting the ground between your

feet, keeping your feet parallel and using them as a drift meter. Turn your body to face into the direction of drift.

(4) BODY TURNS - You can't steer your parachute, but you can turn your body to face in a particular direction. If you wish to turn to the right, for example, you should:

(a) reach up behind your head and, with your right hand, grasp the two left risers, or connecting straps, between the harness and the shroud lines;

(b) reach across in front of your head with your left hand and grasp the two right risers, (Your hands should be crossed with your right hand towards the rear, and you should have two risers in each hand.); and

(c) pull simultaneously with both hands, to cross the risers above your head and thus turn your body to the right. (By varying the pull, you can turn through 45, 90 or 180 degrees, as desired.)

Study the illustration, and try to practice body turns in a suspended harness, if you can get the chance. During a descent, start your body turn high enough to allow it to be completed before you reach the ground. Remember:

RIGHT turn - RIGHT hand behind

LEFT turn - LEFT hand behind.

(5) LANDING - To get yourself into the landing position, raise your

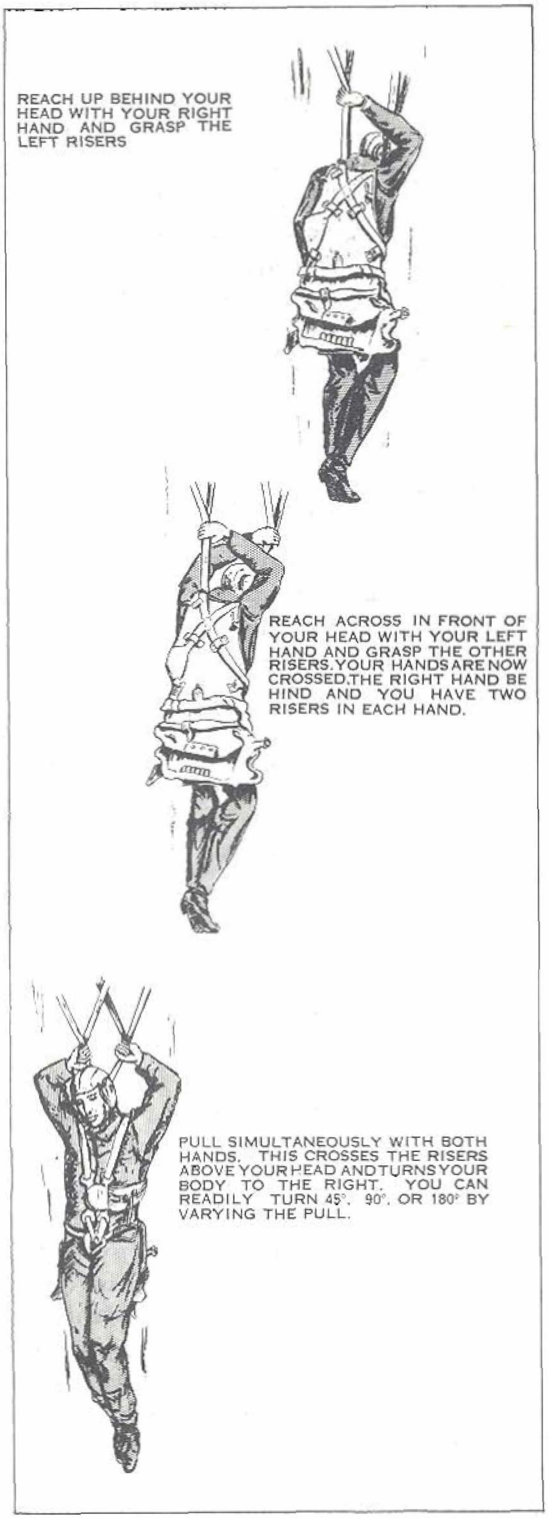

Figure 2: How to Make a Body Turn

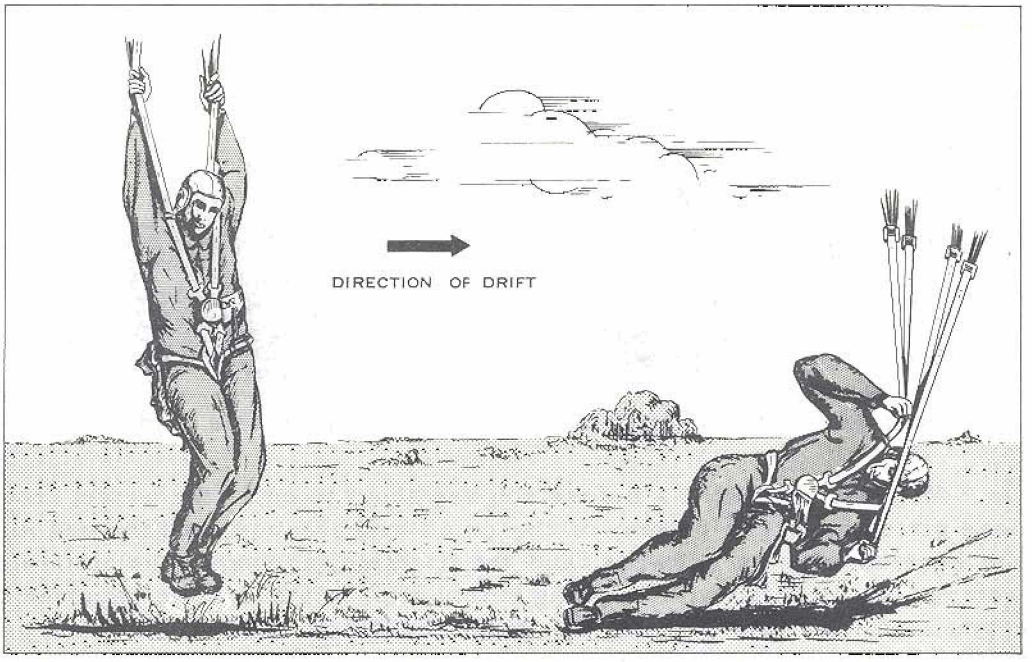

Figure 3: The Correct Landing Position

hands above your head and hold onto the risers. Look at the ground at an angle of 45 degrees rather than straight down. Keep your feet together and bend your knees slightly so that you will land flat on your feet. Try not to stiffen up too much; maintain a normal composure without being completely relaxed. You should be riding towards the ground, drifting sideways downwind. As soon as your feet touch the ground, fall forward or sideways in a tumbling roll to reduce the jar of landing. If, as you near the ground, you find that you are not facing at 90 degrees to the wind and decide to start a turn, hold the turn on as you touch the ground.

(6) HIGH WIND LANDING - The procedure for landing during a high wind is exactly the same as that described above. Once you are down on the ground, however, roll over on your stomach and, hand-over-hand, haul in the suspension lines NEAREST THE GROUND. If you are on your back the same thing applies - ALWAYS pull in the lines nearest to the ground. Keep drawing in the lines until you can spill the air out of the canopy and collapse the parachute. (See Figure 4 overleaf.)

(7) TREE LANDING - Tree landings are quite simple. If you see that you are about to land in a tree, remove your hands from the risers and cross them in front of your face as shown in Figure 5 overleaf. This protects your face and gives you a chance to glance downwards between your arms. Remember to keep your feet and knees together. If you stick high up in a tree, first consider your chances of being rescued. If rescue prospects appear

slight, carefully remove the harness and cut up the suspension lines to make a rope for climbing down.

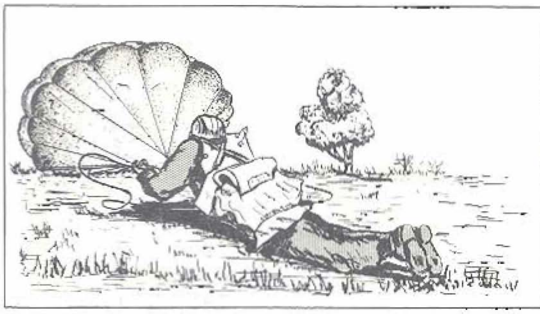

Figure 4: Pulling in the Parachute

Figure 5: Tree Landing

(8) WATER LANDING - Before you are about to enter the water, rotate the face plate, or press button, of the quick-release box until the red mark on the knurled edge is upwards, and the flat side is towards the bottom. If the release box is fitted with a spring safety-clip, this should be removed before you land. As soon as your feet touch the water, squeeze the face plate with your hand to operate the release mechanism. Remember to wait until your feet actually strike the water before releasing your parachute, because depth perception over water is misleading, and you could release yourself several hundred feet above the surface. Once you are in the water, swim away from the parachute so that you don't become tangled in the lines or canopy.

(9) HIGH-TENSION WIRE LANDING - If it appears that you are going to land on high-tension wires, hold your hands on the risers above your head, with the palms flat against the inside. This will keep your arms from touching the wires. At the same time, keep your feet and knees together and turn your head into one shoulder to protect your face. Streamline your body as much as possible and try to fall straight through. On the way through the wires, your parachute may collapse but, once it is clear, it will open again sufficiently to break your fall. Don't worry if the parachute becomes entangled in the wires; silk and nylon are non-conductors.

(10) NIGHT LANDINGS - As soon as your parachute opens, prepare for a normal landing. You can't see the ground on a dark night, therefore, you must be ready to make your landing at any moment. Hold your feet and knees together with your legs slightly bent. Grasp the risers securely and wait for your feet to touch the ground.

1.11 - Flying Clothing

(1) When your flying clothing is issued to you by the Supply Section, be sure that everything fits comfortably. After flying always hang your clothing in your locker to keep the various pieces of equipment aired. Remember, if you take care of your clothing, it will take care of you.

Chapter 2

Ground Operations

2.01 - Inspections, Checks and Procedures

(1) Instructions for inspections, checks and procedures are given in the appropriate places throughout this manual. Along with each check a reason for checking each item, and the method used, is shown. On the flight line and in the air it is not practical to carry EOs or this manual while making inspections and checks, therefore TC-6 has been published for convenience. Carry the check list with you at all times while on the flight line, but remember it is only a reminder of the items to be checked.

2.02 - The External Pre-flight Check

(1) The External Pre-flight Check must be completed before each flight. While standing on the left wing-walk in position (1) as shown in Figure 1 overleaf, check the following items in the cockpit:

CHECK	HOW	WHY
Controls	Manually - Release the control-lock handle at the base of the control column and push the handle forward into a horizontal position.	This unlocks the controls so that they can be checked, individually for movement, at a later stage.
Undercarriage Lever	Visually - See that the catch on the lever is engaged in the slot.	Safety precaution to ensure that the lever is in the "DOWN" and locked position.
Magneto Switches	Manually - Turn fully over to the left to "OFF".	Safety precaution.

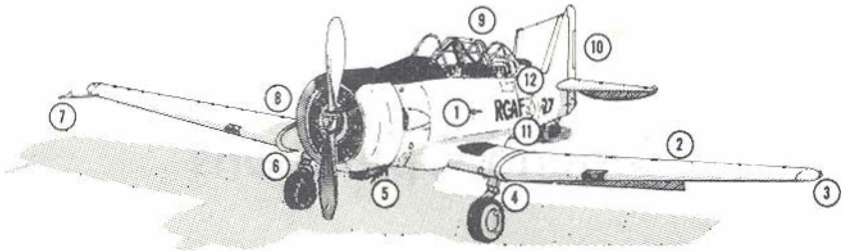

Figure 1: The External Pre-flight Check

CHECK	HOW	WHY
Emergency Maps	Visually.	To ensure that the map case under the front seat contains the requisite maps.
Flaps	Manually - Select flaps "DOWN", and lower by pumping with the hand pump located on the floor to the left of the front seat.	To check the operation of the hand hydraulic pump and to have the flaps lowered for visual inspection during a later part of the external check.
Fuel Gauges	Visually.	To ensure that there is enough fuel for the flight.
Loose Articles	Visually.	Safety precautions since loose objects may interfere with control movement.

(2) While remaining on the wing, check the following items

CHECK	HOW	WHY
Undercarriage Locking-Pin	Visually - Through the perspex window on the top surface of the wing above the undercarriage oleo.	To ensure that the locking pin is in place. If the pin is not in place, the aircraft must be delcared unserviceable.

CHECK	HOW	WHY
Left Fuel Tank-Cap	Visually.	To ensure that the cap is aligned properly and is secure, thus avoiding fuel loss in flight.

(3) Walk clockwise around the aircraft and inspect the following from the positions indicated.

CHECK	HOW	WHY
Left Wing (2)	Visually.	For sign of stress or damage.
Flaps (2)	Visually.	For sign of damage.
Aileron (2)	Manually - Move the aileron fully up and down.	To check the freedom of movement, also to see that the hinge nuts are locked and that the bonding wires are secure. Any damage to the fabric or trim tab should be reported.
Navigation Light (3)	Visually.	Safety precaution to ensure that the light is secure and undamaged.
Leading Edge (4)	Visually.	To ensure that the leading edge and top surface of the wing and the landing lights are not damaged.
Left Wing Undersurface (4)	Visually.	To ensure that the wing is not damaged.
Left Undercarriage (4)	Visually.	To ensure that the undercarriage lights are not damaged; that the oleo

CHECK	HOW	WHY
Left Undercarriage (Cont'd)		has a minimum extension of 1 1/2 inches; to see that the chock is in place; to examine the tire for cuts or damage; to check that the creep line is within limits and to examine the brake line for leaks or damage.
Left Undercarriage Up-lock (4)	Manually - Pull the up-lock forward and release.	To ensure that the up-lock moves and is serviceable.
Engine Drain Tubes (5)	Visually.	To ensure that the tubes are undamaged and not blocked.
Propeller (5) WARNING: ALWAYS TREAT A PROPELLER AS BEING POTENTIALLY DANGEROUS.	Visually.	To check for damage and excessive oil leakage.
Engine (5)	Visually.	To check for external damage, excessive oil leakage and foreign objects.
Bonding Wires (5)	Visually - Inside the cowling.	To make sure that the wires are secure.
Cowling (5)	Visually and Manually.	To examine, and to ensure by touch, that the cowling fasteners are secure.
Carburettor Air Intake (5)	Visually.	To see that nothing is blocking the intake.

CHECK	HOW	WHY
Oil Cooler Scoop (5)	Visually.	To see that nothing is blocking the intake.
Right Undercarriage Up-lock (6)	Manually - Pull the up-lock forward and release.	To ensure that the up-lock moves and is serviceable.
Right Undercarriage (6)	Visually.	To ensure that the undercarriage lights are not damaged; that the oleo has a minimum extension of 1 1/2 inches; to see that the chock is in place; to examine the tire for cuts or damage; to check that the creep line is within limits and to examine the brake line for leaks or damage.
Fire Extinguisher (6)	Visually.	The small window approximately two feet below the windscreen should be RED, indicating that the fire extinguisher is serviceable.
Right Wing Undersurface (6)	Visually.	To ensure that the wing is not damaged.
Leading Edge (6)	Visually.	To ensure that the leading edge and top surface of the wing and the landing lights are not damaged.
Pitot Head (7)	Visually.	To make sure that the cover has been removed, and to check that the vents are clear.

CHECK	HOW	WHY
Navigation Light (7)	Visually.	Safety precaution to ensure that the light is secure and undamaged.
Right Wing (8)	Visually.	For sign of stress or damage.
Ailerons (8)	Manually - Move the aileron fully up and down.	To check the freedom of movement, also to see that the hinge nuts are locked and that the bonding wires are secure. Any damage to the fabric or trim tab should be reported.
Flaps (8)	Visually.	For sign of damage.
Fuel Tank Cap (8)	Visually.	To ensure that the cap is aligned properly and is secure, thus avoiding fuel loss in flight.
Undercarriage Locking Pin (8)	Visually - Through the perspex window on the top surface of the wing above the undercarriage oleo.	To ensure that the locking pin is in place. If the pin is not in place, the aircraft must be declared unserviceable.
Antenna (9)	Visually.	To ensure that the antenna is not broken or damaged.
Ground Wire (9)	Visually.	To see that the wire touches the ground, thus releasing any static electricity which may have built up in the airframe in flight.

CHECK	HOW	WHY
Static Holes (9)	Visually.	To see that the vents are clear, thus ensuring proper operation of the flight instruments.
Tail Surfaces (10)	Visually and Manually - Move the elevator and rudder through their full travel.	To ensure that the controls are undamaged and are working properly, and that the tail-wheel lock is serviceable.
Cables (10)	Manually - Feel the cables.	To ensure that there is a tension on the rudder control cables.
Bonding Wires (10)	Visually.	To make sure that the wires are secure.
Navigation Lights (10)	Visually.	Safety precaution to ensure that the lights are secure and undamaged.
Tail Wheel (10)	Visually.	To ensure that the red line is visible since improper extension of the tailwheel could cause damage and difficult steering; to examine the tire for cuts or damage and to check that the creep line is within limits.
Static Holes (11)	Visually.	To see that the vents are clear, thus ensuring proper operation of the flight instruments.
Baggage Compartment (11)	Manually - Open the compartment door and	The baggage compartment should contain an engine

CHECK	HOW	WHY
Baggage Compartment (Cont'd)	check the contents, ensuring that the door is closed securely afterwards.	starting crank, forced landing instructions, a Very pistol and cartridges. All of these should be properly secured.
Hand Fire Extinguisher (11)	Manually - Open the fire extinguisher door.	To ensure that the fire extinguisher is secure and that the cylinder is charged to the correct pressure.
Medical Kit (12)	Visually.	To ensure that a kit is installed behind the rear seat, and that it is fastened securely.

(4) If flying solo, the following additional points should be checked in the rear cockpit.

CHECK	HOW	WHY
Loose Articles (12)	Visually and manually - Stow the control column, and secure the harness and radio cord. All foreign objects should be removed.	All items must be secure to prevent fouling of the controls.
Gyros (12)	Manually - Cage the Artificial Horizon (AH) and the Directional Indicator (DI).	To prevent damage to the instruments.
Switches (12)	Visually and manually - All switches "OFF".	Safety precaution to ensure that all controls can be operated from the front cockpit.
Canopy (12)	Manually - Close.	Safety precaution since the canopy cannot be closed from the front cockpit.

2.03 - The Pre-start Check

(1) After settling into the cockpit, adjust the seat so that you have two or three inches of head room to the top of the canopy, and maximum forward visibility. In preparation for your first flight, your instructor will help you to find the most suitable seat adjustment, and on each flight thereafter your position should be the same.

(2) The rudder pedals can be adjusted by tripping the small catch on the inside edge of each pedal. Assume a comfortable position with the balls of your feet on the rudders, so that you have full use of the rudder and brake controls. Normally, in the correct position, your knees should be slightly bent. There should be nothing in the way to restrict control movement.

(3) Before starting the engine, the following check must be made

CHECK	HOW	WHY
Harness	Manually - Tighten the seat straps and then the shoulder straps; test the harness lock.	Safety precautions.
Seat	Manually - Adjust.	To give maximum forward visibility.
Rudders	Using the toes - Adjust.	To give full rudder and brake control.
Controls	Visually and manually - Move the control column and rudder through their full travel and note the movement of all flying control surfaces.	To ensure that there is freedom of movement without rubbing, and that the control surfaces move in the proper direction.
Field Barometric Pressure	Visually - Note the manifold pressure reading.	The present field barometric pressure must be known to determine the correct manifold pressure to use for the magneto power check during the run-up.

CHECK	HOW	WHY
Brakes	Using the toes - Press down on top of the rudder pedals, and pull the parking brake handle "OUT". Release the toe pressure, then release the parking brake handle.	The brakes must be "ON" before the engine is started, to prevent the aircraft from moving forward.
Fuel	Visually and manually - Note the contents of the fuel tanks. If there is an equal amount of fuel in each tank, select either "RESERVE" or "LEFT". If the contents are unequal, select the tank with the least fuel.	To ensure that there is sufficient fuel for the coming flight, and that the fuel is switched "ON" for starting.
Carburettor Air	Manually - Move the lever forward to "COLD".	To prevent possible damage if the engine backfires while it is being started.
Throttle	Manually - Open half an inch.	To give the proper setting for starting.
Mixture	Manually - Move the lever fully back to "RICH".	A rich mixture is required for starting.
Pitch	Manually - Move the lever fully back to "COARSE".	To prevent oil from circulating through the pitch-changing mechanism during starting.

2.04 - The Engine Starting Check

(1) When starting the engine, the following check should be made in the order shown.

CHECK	HOW	WHY
Wobble Pump	Manually - Pump until pressure registers on the fuel pressure gauge.	To fill the lines from the fuel tanks to the carburetor, and to provide fuel for the primer.
Primer	Manually - Unlock, pull out and push in for approximately 3-7 strokes depending on the outside air temperature and the size of the primer. Relock when priming is completed.	To supply fuel to the top five cylinders of the engine.
APU or Battery	Manually - When an APU is used, the Battery Master Switch must be "OFF", and vice versa.	A power supply is required for starting.
All Clear	Vocally - Call out "All Clear", and wait for a response.	To ensure that all personnel are clear of the propeller.
Magneto Switches	Visually.	The magneto switches must remain "OFF" while the engine starter is being energized.
Energize/Engage	Manually - Pull the switch back to "ENERGIZE" for approximately 10 seconds.	To build up sufficient power in the starter flywheel to turn over the engine when the switch is pushed forward to "ENGAGE".
Contact	Vocally and manually - Call out "CONTACT" and immediately push the Energize/Engage switch forward to "ENGAGE".	To warn the groundcrew, and to transfer the momentum built up by the flywheel into mechanical energy to turn the engine.

CHECK	HOW	WHY
Magneto Switches	Manually - Turn right to "BOTH" after the propeller has rotated for two turns.	To supply an ignition current to the spark plugs.
Oil Pressure	Visually - Note the reading on the oil pressure gauge.	To make sure that the engine is being lubricated. If there is no pressure within 30 seconds, stop the engine.
Pitch	Manually - Push forward to "FINE" when the oil pressure reads 50 psi.	At 50 psi, the engine is being lubricated adequately, and oil can be diverted to the pitch-changing mechanism.
NOTE: If oil dilution is required after starting, it should be done before the oil temperature reaches 40°C. Local orders determine the time for, and the amount of, oil dilution desired, but if in doubt have your instructor explain the correct procedure.		

2.05 - The Tarmac Check

(1) After starting the engine and checking the oil pressure, signal the groundcrew to remove the chocks. Open the throttle to a suitable rpm so that the generator is charging and the engine can warm up to normal operating temperature. When ready, carry out the following check.

CHECK	HOW	WHY
Generator Switch	Manually - Push forward to "ON".	To enable the generator to supply electrical power for the aircraft services.
Battery Master Switch	Visually - Switch must be forwarded to "ON".	If an APU has been used for starting, the Battery Master Switch will be "OFF".

CHECK	HOW	WHY
Gyro Switch	Manually - If dual - push the switch forward to "ON". If solo - the switch stays "OFF".	The Gyro Switch connects the rear cockpit gyro instruments to the suction line. During solo flight, leaving the switch "OFF" prevents damage to the rear gyros if they become uncaged while the aircraft is doing aerobatics.
Pitot Heater	Manually - Turn "ON". Visually - Check for an increase in the ammeter reading. Manually - Turn "OFF".	To ensure that the pitot heater is serviceable.
Compass Inverter	Manually - Push the switch forward to "ON"	To supply power to operate the magnesyn compass.
Radio Switches	Manually - Push the Radio Master and VHF Audio Switches forward to "ON" and select the desired VHF channel.	To allow the set to warm up.
ARC Switches	Manually - Push the "Comp" Audio Switch forward to "ON" and the ARC function switch to "ANT".	To allow the set to warm up.
Light Switches	Visually - All light switches "OFF". (If you anticipate using lights they should be tested.)	Normally, cockpit and aircraft lighting is not required for day flying.
Circuit Breakers	Visually.	To ensure that each circuit breaker is IN. If a circuit

CHECK	HOW	WHY
Circuit Breakers (Cont'd)		breaker is OUT, current to that specific service is cut.
Fuel	Visually - Check that the fuel selector is at the correct setting.	Safety factor.
Flaps	Manually - Raise the flaps by stages.	To check the operation of the main hydraulic system.
Hydraulic Pressure	Visually - Note the hydraulic pressure reading.	To ensure that there is sufficient pressure.
Trim Controls	Manually - Move the rudder and elevator trim wheels through their full travel. Re-set elevator at 11 o'clock, rudder at 3 o'clock.	To check that there is no restriction to movement.
Throttle Tension	Manually - Adjust.	The throttle should move easily.
Mixture	Visually - "RICH".	Rich is the normal setting while the aircraft is on the ground.
Pitch	Visually - "FINE".	Fine is the normal setting while the aircraft is on the ground with the engine running, and also while taxiing.
Carburettor Air	Manually - Press down on the knob on top of the lever and move the	To ensure that the lever is locking properly in the intermediate positions.

CHECK	HOW	WHY
Carburettor Air (Cont'd)	lever back through its full travel, locking it in various positions.	
Undercarriage Warning Lights	Visually.	To ensure that the warning lights are glowing GREEN.
Landing Light Switches	Visually - Down, "OFF". At night the switches should be tested manually.	To avoid unnecessary use.
Manifold Pressure Drain Cock	Manually - Open the drain cock for approximately 1 minute, by pulling the lever towards you. Return to "CLOSED".	To drain off moisture from the instrument lines.
Magneto Switches (Dead Magneto Check)	Manually - Select "RIGHT" - pause, select "LEFT" - pause, and return the switch to "BOTH".	To ensure that both magnetos are working.
Instrument Panel	Visually - Examine all flight instruments for correct readings and proper settings. Manually - Push-test all warning lights; uncage the gyros and set the DI to the correct heading.	To ensure that all instruments and warning lights are serviceable and properly set for the coming flight. The gyros and DI can be checked while taxiing out.
Primer	Manually - Push in and turn right to "OFF".	If the primer is left "ON", it will cause the engine to run roughly.

CHECK	HOW	WHY
Compass Deviation Card	Visually.	A valid correction card is required for accurate headings.
Radio and ARC	Vocally and manually - Check the VHF and ARC as required by local orders.	To ensure that both are serviceable.

2.06 - Taxiing

(1) Taxiing is the controlled movement of an aircraft on the ground, under its own power. At normal taxiing speed (about the speed of a brisk walk) air pressures on the control surfaces can't be felt. This means that the controls, which are designed for maximum effectiveness in flight, have a very limited use on the ground.

(2) You will notice while sitting in the cockpit for the first time that forward visibility is restricted. This means that the aircraft must be "S-turned" from side to side to provide a clear field of vision down the intended taxiing path. Notice the relationship of the engine nacelle to the horizon: the aircraft is in the three-point attitude in this position. You will have occasion in the future to refer to this attitude during various sequences and landing practice.

(3) Soon after leaving the line and when clear of parked aircraft you must check the flight instruments to make sure that they are working properly. The best way to make this check is to turn the aircraft to the left while watching the instruments. The turn needle should move to the left, the ball should move to the right, the DI heading should be decreasing, the AH should be steady, and the suction gauge reading should be constant. During a turn to the right, the indications should be: needle right, ball left, DI increasing, AH steady and suction constant. If the instruments do not check out properly, the aircraft should normally be placed unserviceable; however, discuss this problem with your instructor until you have a clear understanding of what to do in specific circumstances.

2.07 - Weathercocking

(1) While taxiing, the aircraft has a tendency to nose into wind. This is a result of the weathercocking characteristics which cause the aircraft to

attempt to streamline itself into wind. You must stay alert to counteract any such tendency.

(2) When taxiing into wind, the control column should be held right back and to one side, so that the aileron into wind goes UP. The wind striking the top surface of the raised elevators tends to push the tail down and, similarly, the wing which is into wind tends to remain down. Conversely, when taxiing down wind in a strong wind, the control column should be held forward slightly, and to the side away from the wind.

THE CONTROL COLUMN MUST NOT BE PUSHED TOO FAR FORWARD SINCE THERE IS A DANGER OF UNLOCKING THE TAILWHEEL, THEREBY INCREASING THE DANGER OF A GROUND LOOP.

2.08 - The Steerable Tail Wheel and Brakes

(1) The tailwheel on the Harvard is constructed so that it may be locked or unlocked by movement of the control column. When the control column is back, the tailwheel is locked; when it is fully forward, the tailwheel is unlocked. Connecting links to the rudders allow 15 degrees of movement to either side of centre when the tailwheel is locked so that, when left rudder is applied, the aircraft turns to the left, and vice versa. If it is necessary to unlock the tailwheel to give a smaller turning radius, the rudders must be centralized before the control column is pushed forward. Once the tailwheel is unlocked, a combination of brake and power is used to turn the aircraft. The control column should then be held fully back so that, when the turn is completed and opposite brake is applied, the tailwheel will be re-locked, automatically, by centralizing the rudder pedals.

(2) The brakes work independently of each other when toe pressure is applied to the tops of the rudder pedals, as shown in Figure 2. Pressure on the left brake pedal actuates the left brake, and vice versa. To stop the aircraft, equal pressure must be applied to each brake.

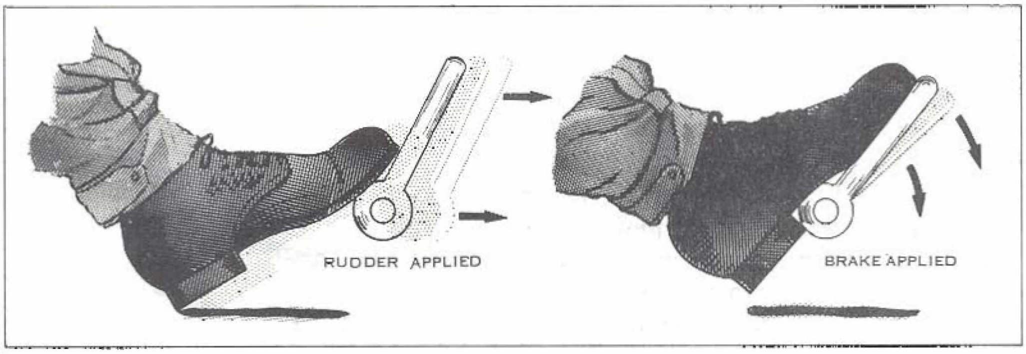

Figure 2: Applying Brake Pressure

2.09 - Taxiing Tips

(1) When you are taxiing an aircraft, position your feet so that brake can be applied instantly should the need arise. The only time that your heels should move off the floor is when you have to apply brake. You should try to brake smoothly and evenly, exercising a reasonable amount of caution, and, using the brakes to stop at any desired point, to maintain a safe taxiing speed, or to make a sharp turn with the tailwheel unlocked. Remember:

ABRUPT APPLICATION OF THE BRAKES MAY CAUSE THE AIRCRAFT TO NOSE-OVER.

(2) If an abrupt application of brakes is made, intentionally or otherwise, and the nose goes down, pull the control column straight back and open the throttle. Provided there is no danger of collision, you should release the brakes. If this action is taken in time, sufficient airflow should be produced to flow over the elevator and force the tail down. You should be particularly careful when taxiing over soft ground, since the aircraft can nose-over very easily.

(3) When you are ready to move out of the line, you will find that some throttle is needed to start the aircraft rolling. Once it is rolling, close the throttle fully and test the brakes, bringing the aircraft to a complete stop. If the brakes are working properly, you can continue to taxi out. Sometimes when taxiing out of the parking line, it is necessary to make a sharp turn to clear objects in front of the aircraft. Usually such turns are made with the tailwheel unlocked, using brakes and throttle in conjunction. A turn should be made, in any case, shortly after leaving the line, to clear the area ahead since it is unwise to taxi straight ahead for any appreciable distance.

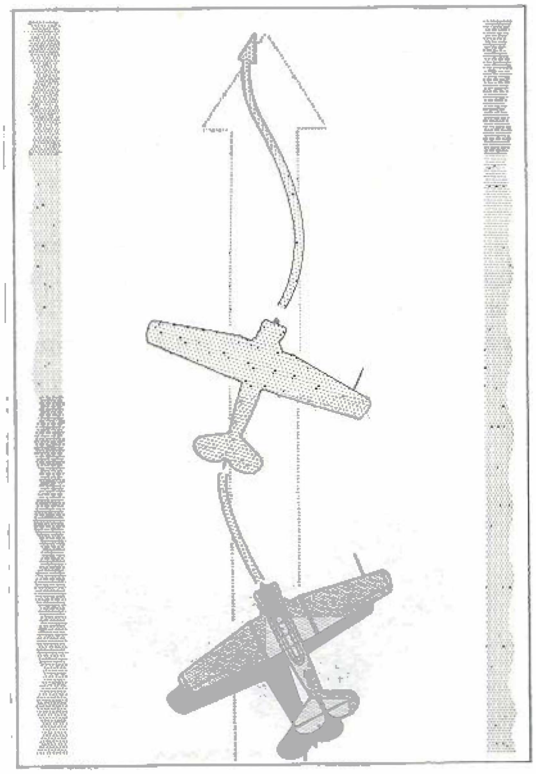

Figure 3: "S" - Turning

(4) During a normal "S-turn", only rudder movement is used to steer the aircraft. Do not use brakes in an attempt to help the aircraft turn, since when the tailwheel is locked, damage can be caused to the steerable tailwheel assembly by individual brake application. When "S-turning", as shown in Figure 3, push one rudder pedal forward until the nose swings round, and the intended taxiing path is visible. As soon as you can see ahead, apply pressure to the opposite rudder pedal to

swing the nose back through the path onto the other side, until the taxiing path is visible once more.

(5) In taxiing, you must learn to anticipate the movements of the aircraft and apply rudder pressures accordingly. Opposite rudder should be applied BEFORE you intend to stop a turn, since the aircraft's response is sluggish and it tends to continue to turn after the opposite rudder is fully forward. The correct moment for the application of rudder when turning can be learned only by practice.

(6) Be alert and look around to make sure that the wings are going to clear all obstructions. If any doubt exists in your mind, STOP and have someone guide you past the obstruction. If no help is available, stop the engine and let the groundcrew move the aircraft.

NEVER TAKE A RISK WHILE TAXIING.

2.10 - Safety in Taxiing

(1) When leaving a parked position, or when parking an aircraft, always make certain that the intended ground path is clear of obstructions: watch for battery carts, fire extinguishers and chocks. When taxiing on the ramp or near other aircraft, the safe taxiing speed is a normal walk. Remember the wings; clear the area on each side as well as in front. In short radius turns; do not turn so that the inner wheel is locked: allow enough room for the tail to clear any obstacles or rough places. In congested areas, be sure to use marshallers to help you to avoid obstructions.

(2) While you are taxiing you should constantly scan the area on each side as well as in front of the aircraft. If you are to scan the area properly, your field of vision must cover an arc of almost 360 degrees. Your neck is a swivel. Use it! Never allow your eyes to freeze on one object; instead, keep a mental up-to-the-second picture of all that is happening around you. Think only of the job in hand and plan each move in advance. Know the location and movements of everything in the taxi path, and be aware of other aircraft taking-off, landing and taxiing.

(3) Other important points to remember while taxiing an aircraft are listed below.

(a) Divide your attention, to the front and to both sides.

(b) Keep at least two aircraft lengths behind the preceding aircraft.

(c) Do not use throttle and brakes in opposition to each other: close the throttle before applying brake to slow down.

(d) Keep in radio contact with the tower.

(e) Use caution in crossing active runways or the landing area.

(f) Use courtesy and common sense in respect to propeller blast: when taxiing on sodded areas, do not blow stones or other material onto the ramp or into other aircraft.

(g) Expect the unexpected.

2.11 - The Run-up Check

(1) After taxiing to the run-up area, select a spot near the edge of the hardstand and, if possible, position the aircraft into wind so that it does not block traffic. Check to make sure that the tailwheel is up on the hardstand and is straight.

(2) When you are satisfied that the aircraft is properly positioned, do the following check.

CHECK	HOW	WHY
Parking Brakes	With the toes - Press the brake pedals. Manually - Pull the parking brake handle out, and release the brake pedals.	To prevent the aircraft from moving during the run-up.
Fuel	Manually - Change the fuel selector to "RIGHT" or to the fullest tank, as applicable.	To check the fuel flow during the run-up.
Temperatures and Pressures	Visually.	To ensure that the readings are within the limits for the run-up.
Throttle Tension	Manually - Tighten by rotating the tension nut clockwise.	To prevent pitch and throttle lever slippage during the run-up.

CHECK	HOW	WHY
Lookout	Visually - Through 360 degrees.	During the run-up you must ensure that the slip-stream blast cannot damage any object to the rear, or if the brakes slip, that the aircraft will not roll forward into another aircraft.
Control Column	Manually - Hold fully back.	To keep the tail down during the run-up.
1500 RPM	Manually - Ease the throttle forward.	This is the best setting for the checks which follow.
Pitch	Manually - Move the lever back to "COARSE" and after the rpm has dropped by 400 rpm, return the lever to "FINE".	To check the operation of the CSU.
Carburettor Ice	Visually - Note the Manifold Pressure. Manually - Pull the carburettor air control back to "HOT" until the temperature gauge reads 50°C, or until there is a rise of 35°C. Return the control to "COLD". Visually - Note the Manifold Pressure.	If on returning the control to "COLD" the Manifold Pressure shows an increase over the original reading, ice has been forming in the carburettor and is now eliminated. This action also indicates whether there is enough heat available to melt any carburettor ice that may be encountered in flight.
Generator	Visually - Note that the ammeter shows a normal charge.	The generator is the main source of power for all electrical services and must be working properly.

CHECK	HOW	WHY
Suction	Visually - Note that the the suction gauge reading is between 4.25 and 4.75" Hg.	A suction reading of at least 4.25" Hg. is required to operate the gyro instruments.
Throttle	Manually - Open the throttle to a Manifold Pressure equal to field barometric pressure minus two inches.	This Manifold Pressure setting is used to check the rpm.
Temperatures and Pressures	Visually.	To ensure that all temperatures and pressures are "in the green".
RPM	Visually.	The rpm must be within + or - 50 rpm of the referenced rpm, compensated for wind and outside air temperature.
Magnetos	Visually and manually - Note the rpm, then switch the magneto switch from "BOTH" to "RIGHT". Note the rpm drop and switch back to "BOTH". Repeat for the "LEFT" magnetos.	The magnetos must be checked individually to ensure that the rpm drop does not exceed a maximum of 100 rpm, and that the difference in drop between the two magnetos does not exceed 40 rpm.
Slow Running	Manually - Move the throttle fully back. Visually - Note the rpm.	The desired idling rpm should be a maximum of 700 rpm.

2.12 - The Shut-down Check

(1) After the air exercises have been completed and the final landing has been made, taxi back to the ramp, observing the same rules as when you

taxied out. Wait for marshalling assistance before moving into the line and, when in position, proceed as follows.

CHECK	HOW	WHY
Parking Brakes	With the toes - Press the brake pedals. Manually - Pull the parking brake handle out, and release the brake pedals.	To prevent the aircraft from moving during the shut-down.
Temperatures	Visually - Note that the engine instrument readings are normal.	The cylinder head temperature must not exceed 205°C for shut-down.
1400 RPM	Manually - Open the throttle.	To ensure that the propeller is revolving at the correct speed before the pitch is changed.
Pitch	Manually - Pull the lever fully back to "COARSE".	The propeller must be stopped in "COARSE" pitch so that, when the engine is re-started, oil will not be diverted to the CSU.
Throttle	Manually - Pull the throttle back until the engine is idling.	To prepare the engine for the next part of the shut-down check.
Magneto Switches	Manually - Select "RIGHT", "LEFT" and "OFF" before returning the switch to "BOTH".	To ensure that both magnetos are grounded.
Mixture	Manually - Move the lever fully forward.	When the mixture control lever is fully forward, the idle cut-off feature on the carburettor is actuated and the engine is deprived of fuel.

CHECK	HOW	WHY
Magneto Switches	Manually - Turn "OFF" after the engine has stopped.	Safety precaution.
Fuel	Manually - Turn the selector to the right, to "OFF".	Safety precaution.
Gyros	Manually - Cage the Artificial Horizon and Directional Indicator.	To prevent damage to the instruments.
All Switches	Manually - "OFF".	Safety precaution.
Controls	Manually - Pull the control column lock up into the vertical "LOCKED" position.	When the aircraft is on the ground, the controls could be damaged if they were allowed to move freely.

2.13 - L-14 Entries

(1) After each flight any unserviceabilities must be entered in the appropriate section of the L-14. Careful thought must go into the composition of these entries since the space on the form is limited, and the symptoms and directions to the ground tradesman must be explicit. If you are in doubt about an entry, ask your instructor for suggestions, or discuss the problem with the ground tradesman concerned.

Chapter 3

Fundamental Manoeuvres of Flight

3.01 - Introduction

(1) Having spent six weeks flying the Chipmunk it should be apparent to you now that, once the fundamentals are grasped, mastering the more advanced manoeuvres is merely a matter of practice and concentration. Like the Chipmunk, the Harvard rotates about three axes, rotation being controlled in exactly the same way by the elevators, ailerons and rudder. Remember to try to think of yourself as the pivot point about which all changes of attitude occur.

(2) At PFS you learned that rough or erratic control movement is a sign of inexperience: gentle pressure is all that is required. The AMOUNT of control column movement may vary however for any given manoeuvre, the higher speed of the Harvard requiring more positive pressure but less actual movement of the control surfaces than for the same manoeuvre in the Chipmunk. Obviously, the amount of control column movement cannot be memorized for each manoeuvre - you must develop a reflex, so that sufficient pressure is used to gain the desired result.

CO-ORDINATION IS THE KEY TO SMOOTH, ACCURATE FLYING.

3.02 - How to Use the Rudder Pedals

(1) Rudder control in the Harvard is the same as in the Chipmunk, except for the operation of the brakes. In the Harvard, the rudder and brake are combined in the foot pedal, but are actually separate components as described in Art 2.08. They may be used separately or together, or may even be applied in opposite directions. When the brake is not being used, your heels should be resting on the catwalks so that brake pressure cannot be applied inadvertently: this allows you to relax in a more comfortable position. The pedals may be adjusted to suit any leg length, and should always be adjusted, not only for comfort, but also to ensure that full rudder or brake pressure can be applied.

3.03 - How to Use the Control Column

(1) The control column should be held lightly with the fingers so that your hand and arm are as relaxed as possible. Sometimes, especially during aerobatics, you may have to grasp the control column more firmly, but most of the time all necessary pressures can be applied with the fingers.

3.04 - Straight and Level Flight

(1) Straight and level flight is that attitude of flight in which the aircraft maintains a constant altitude and direction. The positions of the nose and the wing tips in relation to the horizon, as shown in Figure 1, provide the references for maintaining the straight and level attitude. The Harvard, unlike the Chipmunk, has an adjustable seat which may be raised or lowered to suit the individual, so, unless the seat is set to the same position on every trip, the apparent positions of the nose and wings will vary. After settling into the cockpit, therefore, your first action must be to raise or lower the seat to the most comfortable position. (Art 2.03(1) and (2)). If this is done before every flight, the straight and level reference positions should remain constant.

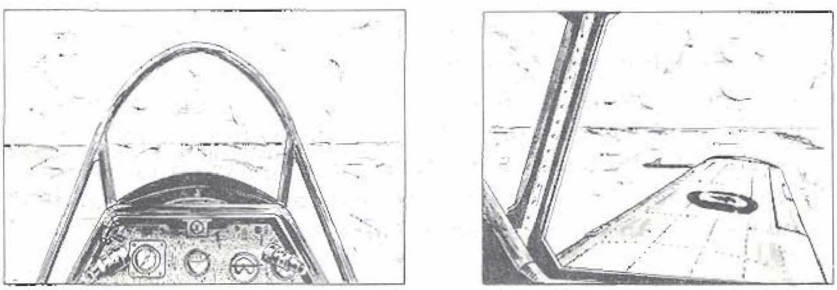

Figure 1: The Level Flight Attitude

(2) Straight and level flight can be achieved at any speed, from just above stalling to the maximum speed of which the aircraft is capable, but, as the speed changes, you must be prepared for the reference points to change. At low speeds the nose is much higher, and vice versa. The normal cruising speed of the Harvard is approximately 125K with the following power settings:

Throttle — 25" MP

Pitch — 1750 rpm

Mixture — Adjusted for smooth running.

(3) As you know, time spent looking down into the cockpit is harmful to visual flying, but periodical checks of the instruments must be made; especially after the basic principles of straight and level flight have been mas-

tered. Occasional references to the instruments at this stage help you to achieve greater flying accuracy. Remember:

THE BETTER YOU KNOW THE COCKPIT, THE QUICKER YOU CAN CHECK THE INSTRUMENTS.

3.05 - Look - Out

(1) So far you have been told that you must watch the positions of the nose and the wing tips in relation to the horizon, and periodically check the engine and flight instruments. Equally important, however, is the need to keep a look-out for other aircraft. Conceivably, a jet aircraft can be approaching, head-on, at a closing speed of over 500K, or flying on a collision course at something close to 400K. Obviously, then, you must stay alert to prevent the development of any situation requiring desperate avoiding action. Good look-out techniques learned NOW can be extremely helpful later. You must remember to look above, below and on all sides at ALL times, and be particularly conscious of other aircraft known to be in the area. Extra caution is needed where there is likely to be traffic congestion, such as in the circuit or in a let-down area.

(2) Before making any change of direction, you must scan your whole circle of vision, paying particular attention to that section towards which you intend to turn. Remember, you must look in ALL directions. Some pilots prefer to look in the direction opposite the turn first, and then in the direction of the turn, but it isn't the method that is important - it is the extent of your look-out and your awareness of other aircraft that count.

(3) Besides watching for other aircraft, you will be expected to keep track of your position relative to the aerodrome, and to stay clear of cloud. For the first few hours, remembering to look in the proper direction at the proper time will keep you busy. Before going solo, however, your awareness should have improved to such an extent that you can see other aircraft in the vicinity; you know your position in relation to the aerodrome; you can check the positions of the nose and the wing tips; and you can check the instruments with a quick glance.

3.06 - Confidence Manoeuvres

(1) Possibly now that you have had a chance to fly the Harvard, you may be slightly apprehensive - you may be finding it difficult to relax. A certain amount of tension is normal at this stage of your training, but with each passing hour in the air your confidence in the aircraft will grow.

(2) The purpose of "Confidence Manoeuvres" is to help you to develop faith in the Harvard, by giving you a practical demonstration of its stability.

Stability in an aircraft is defined as its ability to return to a particular condition of flight, without assistance from the pilot, after having been disturbed by some external force. (See Chapter 14 of TC-23, Manual of Aerodynamics for Aircrew Training.) All aircraft are designed to be aerodynamically stable about their three axes. Your instructor will demonstrate this characteristic by displacing the aircraft from a specific attitude and then allowing it, of its own accord, to return to the original attitude.

(3) First of all, the aircraft must be properly trimmed so that it will fly straight and level without any assistance. This is known as "hands-off flight". By exerting slight back pressure on the control column, your instructor will cause the nose to rise, then both of you will take your hands off the control column. Because of the aircraft's inherent longitudinal stability, the nose will start to drop until the aircraft is in a shallow dive, then it will rise again past the level flight attitude and repeat the movement several times. Each oscillation will decrease in magnitude until, eventually, the aircraft is flying in the straight and level flight attitude. The exercise will be repeated, but this time with the control column being moved forward at the beginning. The recovery is exactly the same.

(4) To demonstrate the Harvard's inherent lateral stability, your instructor will fly the aircraft straight and level "hands-off", and then he will move the control column to one side to cause a wing to drop. The Harvard, having dihedral built into the wings, will slip slightly towards the low wing, but will gradually right itself until it is flying in the straight and level attitude.

(5) Directional stability can be proved by pushing on the left rudder pedal to cause the nose to yaw to the left. When the pressure is released, the aircraft will tend to streamline itself into the relative airflow, thus returning to straight and level flight. There may be several oscillations in the process, but, eventually, straight and level flight will be resumed without any assistance from yourself or your instructor.

3.07 - Turns

(1) At PFS you learned that a turn is a manoeuvre used to change the heading of an aircraft, and that it involves the co-ordinated use of aileron, rudder and elevators.

(2) To refresh your memory, a turn is made by banking the aircraft so that the lift is inclined towards the inside of the turn. When this happens, part of the original vertical lift becomes a horizontal component, called Centripetal Force, which pulls the aircraft around in a circular path. (See TC-23.) Since in a banked attitude of flight the vertical component of lift is less than the weight of the aircraft, extra lift must be provided to keep the nose up. This is done by increasing the angle of attack through backward

pressure on the control column: the amount of back pressure needed is in direct proportion to the steepness of the turn. In precision turns, however, the increase in angle of attack and lift produces a corresponding increase in drag which must be compensated by increasing the power. During the recovery, power and back pressure must be reduced, in co-ordination, to prevent the aircraft from climbing.

(3) If the nose of the aircraft is allowed to drop during a steep turn, an increase in back pressure merely speeds up the turn. To bring the nose back to the correct level, the bank should be decreased slightly while holding a constant back pressure on the control column. Bank is applied as the nose returns to its proper position.

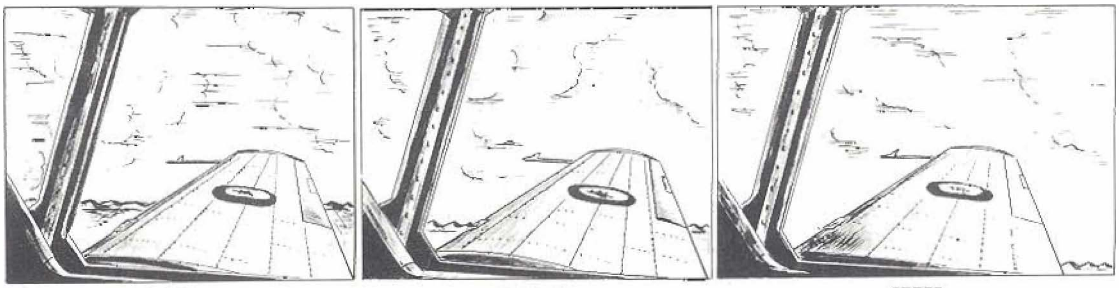

Figure 3: The Wing Attitude in Turns

(4) REFERENCE POINTS - Just as in straight and level flight, reference can be made to the nose and wings of the aircraft for proper pitch and bank attitude. In gentle turns of 15 degrees of bank, the nose should be well below the horizon (Figure 2) while the high wing should be intersected midway between the aileron trim tab and the inboard edge of the aileron. (Figure 3). For medium turns (30 degrees of bank) the nose should be just below the horizon and the high wing should be intersected at the inboard edge of the landing light. For steep turns of 45 to 60 degrees of bank, the reference point for the nose is the horizon itself, and the high wing should be intersected slightly outboard of the wing-joint cover.

Figure 2: The Nose Attitude in Turns

(5) RECOVERY - An aircraft will continue to turn as long as bank is held on, therefore the roll-out should be started before the desired heading

is reached. As a rough guide you can use half the angle of bank, which means that in a 30 degree turn you would start the recovery 15 degrees before reaching the desired heading.

3.08 - Climbing

(1) To establish a straight ahead climb at an airspeed lower than that for straight and level flight, the nose must be raised and the power must be increased. As much as possible, these changes should be co-ordinated. As you raise the nose to the 95K climbing attitude, maintain a constant heading with the wings level, adjust the mixture to the RICH range, move the pitch lever to 2000 rpm and open the throttle to 28" MP. If your movements are in co-ordination, the airspeed should be reaching 95K as the throttle opening is completed. Pressure on the controls caused by the power and airspeed changes must be trimmed out. As soon as the correct attitude and power setting have been attained, relax and have a good look around.

(2) CLIMBING TURNS - When the nose is in the climbing attitude forward visibility is reduced, therefore, because of the danger of collision, straight ahead climbs should never be prolonged. It is important that you always do climbing turns on the way up to your practice altitude: gentle, banked turns are used to maintain a good rate of climb, since the loss of vertical lift becomes greater as the bank is increased.

(3) LEVELLING-OFF FROM A CLIMB - If you wish to return to straight and level flight from a climb, you must start the level-off approximately 50 feet below the desired altitude. The nose is lowered gradually, and you must maintain your original heading with the wings level as the aircraft reaches the level-flight attitude. Sudden lowering of the nose may cause a loss of height, since the angle of attack will be less than ideal for the forward speed of the aircraft. Normally, unless otherwise instructed, you should level-off to normal cruising settings.

Throttle — 25" MP

Pitch — 1750 rpm

Mixture — Adjusted for smooth running.

The airspeed should be approximately 125K once the level-off has been completed. During the level-off, the power should not be reduced until the nose has been lowered and the airspeed has built up to 120K. At this point, the engine controls are adjusted and the aircraft is retrimmed for the new attitude and airspeed. If your instructor has given you a cruising speed other than 125K, the technique is the same - lower the nose gradually and, 5K befor reaching the given speed, reduce power.

3.09 - Descending

(1) An aircraft can descend in a variety of ways, depending on the altitude, the configuration, the area of the descent and the amount of height to be lost. As far as airspeed and rate of descent are concerned, there are few restrictions at altitude, but, if the wheels and flaps are "DOWN" or if you are near the circuit area, certain rules must be obeyed.

(2) Assuming that you are returning to land at your home aerodrome and are five miles out at 4,000 feet above ground level (AGL), you should make the following power changes.

Throttle — As required for the descent.

Pitch — 1750 rpm.

Mixture — Adjusted for smooth running.

When you start the descent there are no airspeed restrictions other than those listed in EO's, so you may simply depress the nose and descend gradually. Remember that, as you descend and the air density rises, the MP increases to an extent where you will find it necessary to retard the throttle to maintain a constant power setting.

THREE MILES FROM THE AERODROME YOU MUST NOT EXCEED 130K UNLESS YOU ARE MORE THAN 1,000 FEET ABOVE CIRCUIT ALTITUDE.

(3) You should plan your descent so that you arrive near the aerodrome at an altitude from which you can join the circuit. The rate of descent and the airspeed depend on the distance to be travelled and the amount of altitude to be lost: sometimes you may have to descend at a low power setting and a high airspeed, while at other times a high power setting with a gentle rate of descent will be required. In planning a descent, a useful rule-of-thumb is that a decrease of 1" MP gives a descent of 100 fpm with no change in airspeed, or an airspeed reduction of 5K with no change in the rate of descent. Always remember that it is poor airmanship to descend at a rate of airspeed in excess of that actually required.

(4) DESCENDING TURNS - During descending turns the nose must be kept in the same attitude as for a straight descent. Aileron and rudder are applied as in a normal level turn.

(5) LEVELLING-OFF FROM A DESCENT - Levelling-off from a descent is comparatively simple, since the engine settings are similar to those of straight and level flight. The level-off is started 50 feet above the desired altitude by raising the nose and adjusting the power for cruising flight. If there is to be a large airspeed change, it is wise to start the round-out sooner.

3.10 - Gliding

(1) A glide is a descent without power or with the throttle in the idling position, in which the weight of the aircraft is providing the primary motive force. Gliding is similar to a normal descent except that the loss of altitude is greater and, since there is no slip-stream effect, the elevators and rudder are less effective. To change to a glide from straight and level flight, the settings are:

Throttle	— Closed.
Pitch	— 1750 rpm.
Mixture	— Adjusted for smooth running.
Undercarriage	— "UP" or "DOWN" as required.
Flaps	— "UP" or "DOWN" as required.

Once these adjustments have been made, hold the level-flight attitude until the airspeed drops off to 90K, then lower the nose to maintain 90K: trim for this airspeed. At 90K the aircraft travels the greatest distance from the ground for height lost.

(2) GLIDING TURNS - With the exception of the steep turn, gliding turns are the same as other turns, apart from the nose-down attitude of the aircraft. In a steep gliding turn, you will have to lower the nose further than usual to maintain airspeed and, as a safety factor, the airspeed must be increased to 100K.

(3) During gliding and gliding turns, particularly in cold weather, the engine cools off rapidly. To avoid any risk of power failure when the throttle is opened, the engine must be warmed, or cleared, every 1,000 feet. This is done by opening the throttle slowly to 25" MP and, simultaneously, raising the nose to prevent the speed from increasing. After a short pause with the power at 25" MP, you can close the throttle and resume gliding.

NEVER ALLOW THE CYLINDER HEAD TEMPERATURE TO FALL BELOW 100° CENTIGRADE.

3.11 - Yaw

(1) Like the Chipmunk, the Harvard swings on take-off and yaws about its vertical axis in the air. The propeller on the Harvard turns in the OPPOSITE direction to the propeller on the Chipmunk however, so the yawing tendency is to the LEFT.

(2) The four factors causing yaw are:

(a) torque effect;

(b) asymmetrical blade effect;

(c) slipstream effect; and

(d) gyroscopic effect.

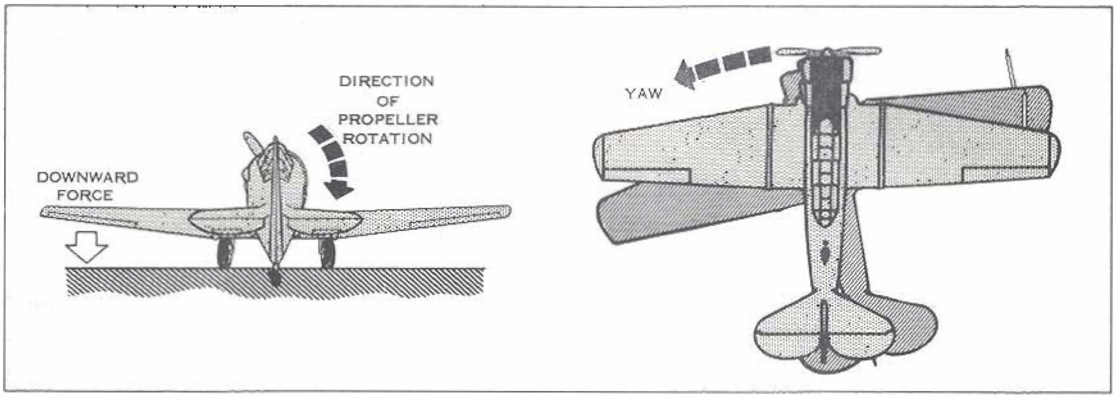

Figure 4: Torque Effect

(3) TORQUE EFFECT - As the propeller rotates, torque effect increases the pressure on one wheel, as shown in Figure 4. The increased friction caused by the force being applied to the wheel makes the aircraft yaw in the direction opposite to propeller rotation - that is, to the LEFT. In the air, torque effect is only a mild annoyance at high speed, but can become extremely dangerous at low speed when close to the ground, if power is applied rapidly. The propeller, owing to its aerodynamic resistance to turning, attempts to rotate the whole aircraft to the left, and this could start a roll with a resulting loss of control.

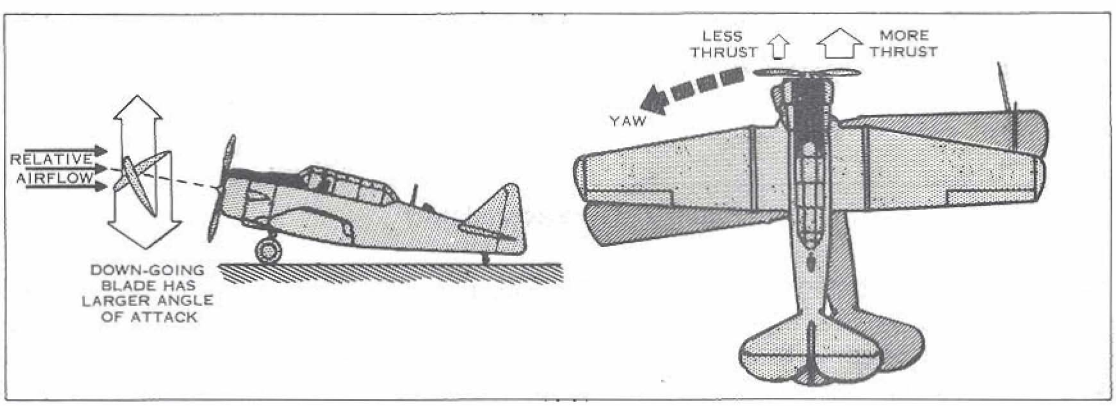

Figure 5: Asymmetric Blade Effect

(4) ASYMMETRICAL BLADE EFFECT - When the aircraft is in the tail-down attitude, the down-going blade meets the airflow at a larger angle of at-

tack than the up-going blade. (See Figure 5 overleaf). The large angle of attack gives increased thrust to the down-going blade, which tends to yaw the aircraft to the LEFT.

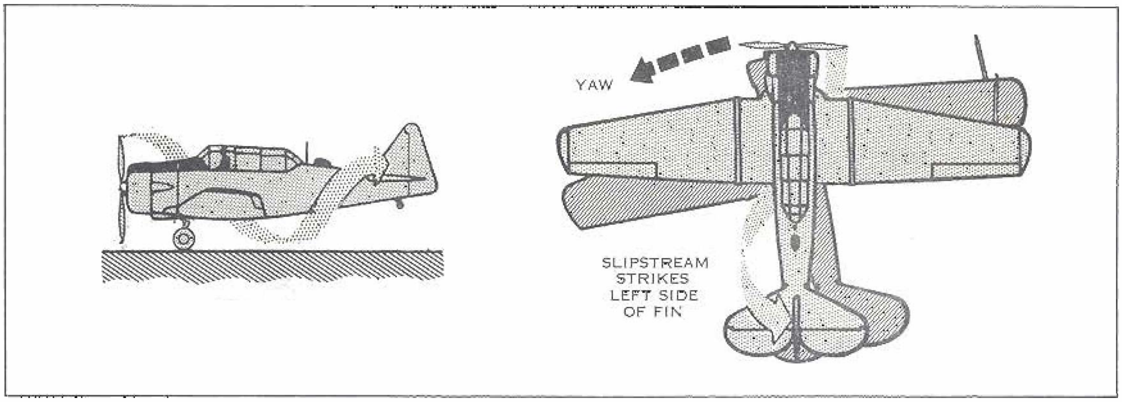

Figure 6: Slipstream Effect

(5) SLIPSTREAM EFFECT - The propeller imparts a rotary motion to the slipstream, in the same direction as its own rotation. (Figure 6) The slipstream strikes the left side of the vertical fin and rudder making the nose yaw to the LEFT. While this yawing effect is counteracted by offsetting the vertical fin to the left, the offset is calculated for cruising speed and power settings, only. When the forward speed is low and the power is high, the offset is insufficient to prevent yaw, so you have to apply RIGHT rudder.

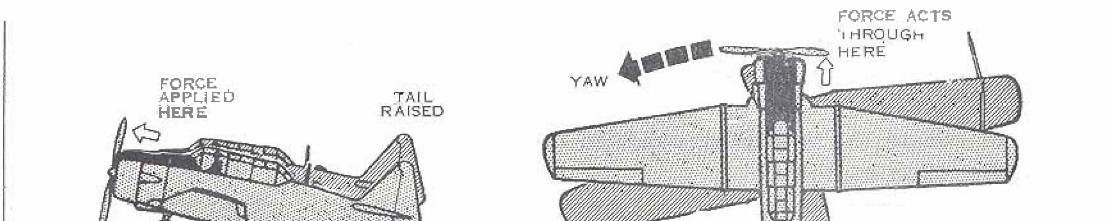

Figure 7: Gyroscopic Effect

(6) GYROSCOPIC EFFECT - Raising the tail on take-off, in effect, exerts a force at the top of the propeller arc which, in accordance with the principles of precession, acts through a point 90 degrees displaced in the direction of rotation and in the direction of the applied force. (Figure 7) On the Harvard the propeller rotates clockwise, therefore the effective force acts on the right-hand side of the propeller and causes a swing to the LEFT.

(7) There is no need for you to worry about memorizing or anticipating yaw. In the early stages, it is sufficient to prevent the nose from swinging when you see it start to yaw: later, you will be able to react immediately.

3.12 - Aileron Drag

(1) As you know, co-ordinated rudder movement is required to counteract yaw and to assist the ailerons to turn the aircraft when you wish to change direction. One of the reasons for using rudder at the start of the turn is to offset the effect of Aileron Drag. (See TC-23) For example, as pressure on the control column is applied to the left, the aileron on the right wing goes down, thus increasing the angle of attack and also the lift and drag. At the same time, the aileron on the left wing moves up, giving an opposite effect. The lift differential on the wings causes the aircraft to roll, or bank, to the left about its longitudinal axis, while the drag differential causes a yaw to the right about the vertical axis. This momentary yaw away from the direction of turn is caused by aileron drag. While rolling into a turn, therefore, extra rudder is needed to counteract the yaw, but, as soon as the turn is established and the ailerons are returned to neutral, the extra rudder pressure must be released. Remember that aileron drag is just as pronounced during the recovery from a turn, and that it becomes more noticeable at high angles of attack.

3.13 - Trim

(1) The Harvard, like the Chipmunk, is fitted with an elevator trimming device which must be used to relieve pressures on the control column during power, attitude or airspeed changes. It is not necessary to memorize the direction of trim movement for any particular condition of flight; merely trimming off the pressure so that the aircraft will fly "hands off" is sufficient. During certain manoeuvres such as steep turns and loops, the elevator trim should not be used, since the feel of the controls is lost and it is possible to overstress the aircraft.

(2) One great advantage that the Harvard has over the Chipmunk is the provision of rudder trim. No longer will you find it necessary to hold on rudder during a sustained climb - now you can trim off the pressures and have the aircraft maintain direction with little effort on your part.

(3) The ailerons are fitted with balancing tabs which cannot be adjusted in flight, but which can be regulated on the ground to correct any wing-down tendency. In addition, the balancing tabs move automatically in the opposite direction to aileron travel, thus reducing the pressures, and making the Harvard easier to bank or roll.

Chapter 4

Take-off and Climb

4.01 - Introduction

(1) Probably your instructor has already demonstrated a take-off, and soon he will allow you to do one on your own. This chapter has been written to help you to prepare for this moment, and to explain why you must check the items listed in TC-6.

(2) A take-off can be defined as the movement of the aircraft on the runway, from its starting point, until it leaves the ground with flying speed. Both ground and in-flight handling are involved, so you must be able to make the transition with smoothness and co-ordination. Skilful handling of the controls while taking-off will help to improve your directional control of the aircraft on the runway.

4.02 - The Pre-take-off Check

(1) The Pre-Take-Off Check should be completed as follows.

CHECK	HOW	WHY
Hydraulics	Manually - Move the flap selector lever to "LOCK". Visually - Note the hydraulic pressure on the gauge. Manually - Return the lever to "UP".	A hydraulic pressure reading of from 800 to 1,000 psi is required for proper operation of the hydraulic equipment.
Hood	Manually - Adjust to fully open or fully closed.	To facilitate abandoning the aircraft if it overturns. With the hood

CHECK	HOW	WHY
Hood (Cont'd)		closed, the emergency exit panel can be pushed out. If the hood were only half open, its metal perimeter would prevent escape.
Trim	Manually - Adjust. Rudder - 3 o'clock. Elevator - 11 o'clock.	To ensure that the trim tabs are at the correct setting for the take-off and climb.
Throttle Tension	Manually - Rotate the tension wheel on the throttle quadrant forward, so that the throttle and pitch levers will remain in any set position. The tension can be checked by moving the pitch lever backwards and forwards, making certain afterwards that the propeller is left in "FINE" pitch.	To prevent loss of power when it becomes necessary to remove your hand from the levers.
Temperatures and Pressures	Visually - Note that the readings are in the "green". Manually - Adjust the oil shutters, if necessary.	To ensure that the temperatures and pressures are within the prescribed limits for take-off.
Mixture	Manually - Pull the lever back and ensure that it is locked in the "RICH" position.	A rich mixture is needed for take-off.
Carburettor Air	Manually - Press down on the locking knob and push the lever forward to "COLD". If the OAT	Maximum power can only be obtained when the carburettor air is properly adjusted. During cold

CHECK	HOW	WHY
Carburettor Air	is below -25°C, pull the lever back fully to "HOT".	weather having the lever fully back to "HOT" helps to provide maximum fuel vaporization.
Pitch	Manually - Fully forward to "FINE".	To provide maximum power for take-off.
Fuel	Visually - Note the contents of all tanks and the position of the selector.	To ensure that there is sufficient fuel for the intended flight.
Flaps	Visually - Check that the flap lever is in the "UP" position and that the flap indicator shows "UP". Manually - If you are about to do a short field take-off, select 15° of flap.	Normally, flap is not needed for take-off. If you are to do a short field take-off, however, 15° gives the maximum amount of lift from the aerofoil and shortens the take-off distance considerably.
Gyros	Visually - Check that the AH and the DI are uncaged. Manually - Reset the DI to the heading shown on the magnesyn compass.	To ensure that the AH and DI are ready for use.
Magneto Switches	Visually - Magneto switches at "BOTH", all unnecessary switches	To ensure that one of the magneto switches has not been switched "OFF" inadvertently, and that the other unnecessary switches are not causing an excessive drain of electrical power.
Harness	Manually - Tighten, leaning forward to ensure that the harness is locked.	Safety precaution.

(2) While you are doing the Pre-Take-Off Check, your aircraft should be positioned away from the live runway, on the nearest and most convenient hard surface. After the check has been completed, and provided there are no aircraft on the approach, you should move to the pre-take-off position and obtain take-off clearance from the tower. (Sometimes a tender is stationed beside the end of the runway to control air traffic in the circuit.) Once the clearance has been received, either by radio from the tower or by an appropriate visual signal from the tender, have a good look all around to be CERTAIN that you are not taxiing into the take-off or landing path of another aircraft. Note particularly those aircraft on the cross-wind leg, on the approach and on the runway and, when you are sure that it is safe to do so, move onto the runway and line-up in the centre.

4.03 - The Take-off

(1) Allow the aircraft to roll forward a few feet to straighten the tailwheel, keeping the same amount of runway on each side of the nose as a guide for directional control during the take-off. Hold the control column fully back, release the brakes and ease the throttle forward to 32" MP: maintain direction with smooth, positive applications of rudder. Remember that the Harvard has a tendency to swing to the LEFT, which can be aggravated if you open the throttle too quickly.

(2) While the throttle is being advanced, move the control column slowly forward to the neutral position and, as the aircraft accelerates, you should feel the weight being taken off the tailwheel. Since the tail surfaces are lighter and have air forced over them by the propeller slipstream, they develop lift first and, as the speed of the take-off roll increases, you should be able to feel the pressures on the rudder and elevators. To assist in bringing up the tail, move the control column slightly forward and then, once the aircraft is in the level flight attitude, return the control column to neutral. Do not attempt to bring up the tail too early, since the decrease in weight on the tail wheel combined with the ineffectiveness of the controls at low speeds will result in poor directional control. At about 70K the aircraft should fly itself off the ground. As this speed is reached, the controls become more and more effective, requiring smaller and smaller corrections to maintain directional control. The wings should be kept level with aileron.

(3) Allow the aircraft to fly itself off the ground: when it is ready,it will fly off smoothly and with adequate flying speed. Just remember to keep the take-off attitude constant during the transition from the ground roll to flight. Do not attempt to pull the aircraft off the ground - if you do, and there isn't enough flying speed, the wheels will drop back onto the runway - if there is enough flying speed, however, you may force the aircraft into an excessively nose-high attitude, which is one of the symptoms of an approaching stall. Forcing the control column too far forward also causes the aircraft to settle back onto the runway, owing to the loss of lift from the decreased angle of

attack. This means that you must learn to hold a constant take-off attitude and allow the aircraft to climb away at the correct airspeed. Once the wheels leave the ground, flying speed builds up quickly.

4.04 - The Post-take-off Check

(1) As soon as the aircraft becomes safely airborne, you must carry out the following check.

CHECK	HOW	WHY
Undercarriage	Manually - Move the lever towards the centre of the cockpit to unlock it, and then pull it fully back to "UP".	To streamline the aircraft, thus allowing the airspeed to build up faster. Also, to prevent the aircraft from nosing over if a forced landing has to be made on rough terrain.
Flaps	Visually - Check the indicators. Manually - Move lever to "UP" if flap was used for the take-off, but ONLY AFTER THE AIRSPEED REACHES 80K.	To ensure that the lift/drag ratio of the wings is at the best possible value.
Throttle	Manually - Move the throttle back to approximately 27" MP.	When reducing power, the throttle is always moved first, before the pitch lever. Later, as the pitch is changed, the MP will increase to approximately 28" MP. This setting should be maintained during the climb by forward movement of the throttle.
Pitch	Manually - Move the pitch control lever back until the rev. counter indicates 2000 rpm.	To give the correct rpm

CHECK	HOW	WHY
Mixture	Visually - Check that the lever is at "RICH" or Manually - Move the lever to comply with local orders.	To ensure smooth engine operation during the climb.
Carburettor Air	Visually - Check that the lever is at "COLD" or, if the OAT is below -25°C, at "HOT".	To ensure that maximum power is available for the power setting being used.
Undercarriage	Visually - Check that the indicators and lights show "UP".	To ensure that the under-carriage is fully retracted.

4.05 - Cross Wind Take-offs

(1) The technique for cross-wind take-offs is similar to that used during the normal take-off, except that aileron pressure is needed to keep the wings level. The aileron pressure has to be applied TOWARDS the direction of the wind as shown in Figure 1. In addition, the take-off run is slightly longer since the aircraft must be deliberately held down until 75K is attained.

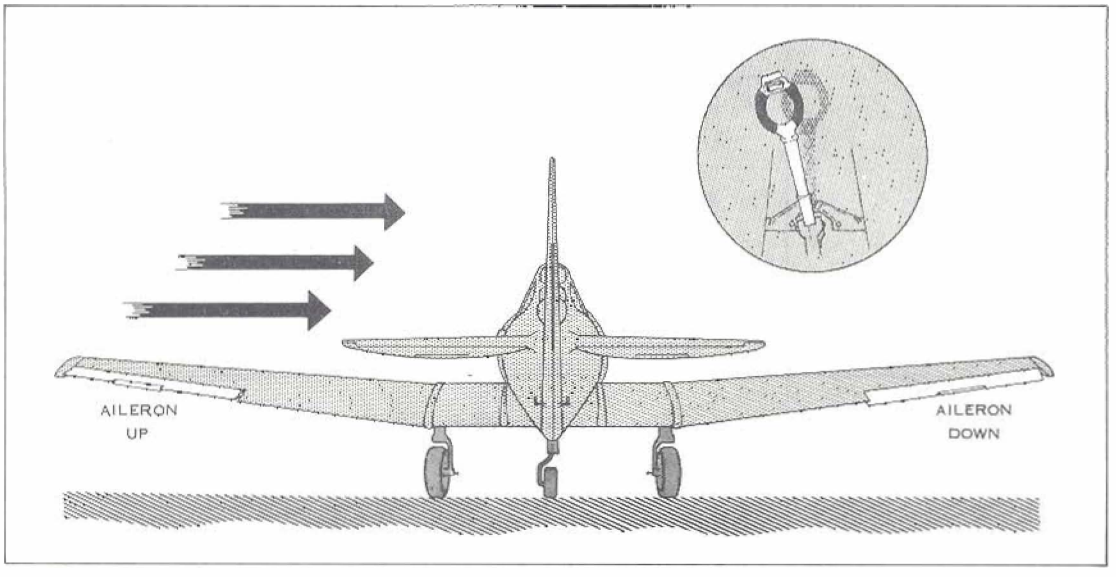

Figure 1: The Aileron Position for a Crosswind Take-off

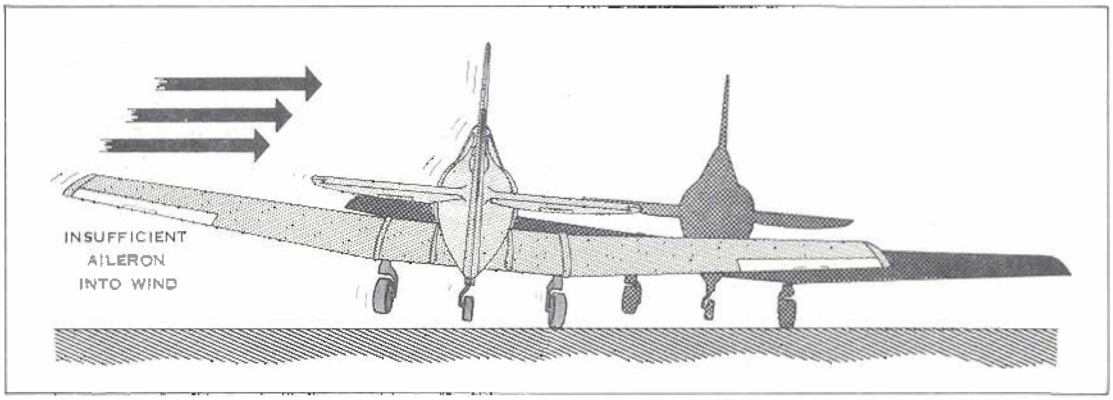

Figure 2: Skipping on Take-off

(2) Before starting the take-off, you should check the direction of the wind so that aileron can be applied at the start of the take-off run, and any weathercocking tendency can be counteracted with rudder. As the airspeed increases and the ailerons become more effective, you will have to ease off some of the pressure to keep the wings level. With increasing airspeed, the greater airflow over the up-wind wing develops more lift.

(3) If the up-wind wing is allowed to rise, thus presenting a greater impact surface area to the wind, the aircraft may start to "skip". (Figure 2) Skipping is caused by the up-wind wing attempting to fly and having to settle again because of the insufficient forward speed. While the wing is up, the wind pushes the aircraft sideways and small bounces develop which impose severe stresses on the undercarriage and airframe. In addition, the tendency for the aircraft to weathercock is increased.

(4) At 75K you should begin to ease back on the control column very gently so that the wheels come off the ground cleanly without bouncing along the runway. Remember to avoid jerking the aircraft off the runway in a high-

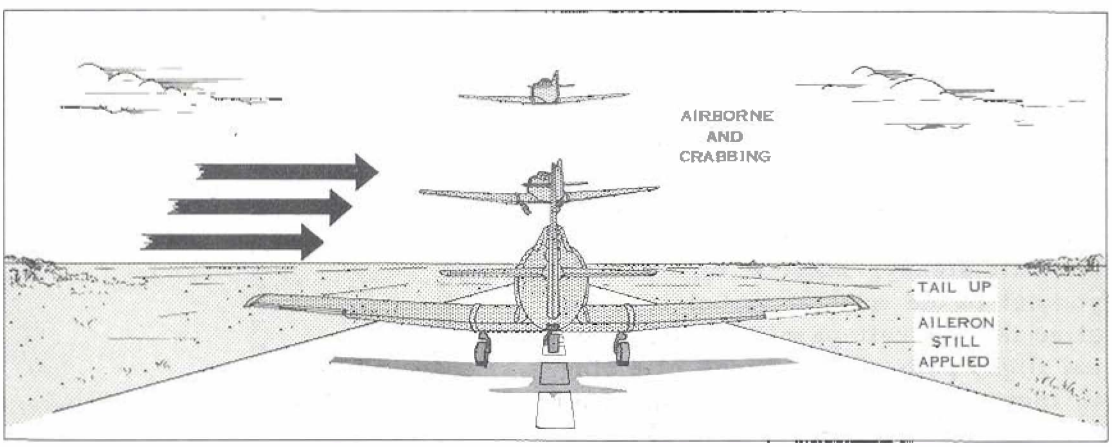

Figure 3: The Crosswind Take-off

pitched attitude. Once the take-off has been completed, allow the aircraft to bank into a shallow climbing turn towards the direction of the wind and the applied aileron pressure. Co-ordinate the turn with rudder. When the aircraft has turned sufficiently to counteract all drift, roll the wings level with co-ordinated rudder and aileron pressures and assume a crabbing track, using the remainder of the runway to establish the correct heading. Continue to climb on this track, keeping the aircraft crabbing into wind as shown in Figure 3 overleaf.

4.06 - After Take-off

(1) During the climb after take-off, the airspeed should be 95K with the nose of the aircraft being higher than it was when leaving the ground. Do not look at the airspeed indicator, but rather watch the climbing attitude in relation to the horizon, and try to keep it constant. Remember that the aircraft cannot accelerate or decelerate immediately with any change of attitude, because of the problem of inertia: you have to wait until inertia is overcome and the speed has settled down to that of the new attitude before checking the airspeed indicator. Once the correct climbing attitude and airspeed have been attained, hold them steady by watching the horizon and outside visual references. Occasionally you may check the airspeed indicator to determine if the attitude is correct; however, you should remember that for every pitch attitude at a constant power setting there can be only one airspeed. If you can learn to establish and hold the correct climbing attitude, the airspeed will look after itself. When you are satisfied with the attitude and airspeed, trim the aircraft to relieve the control pressures.

(2) If another aircraft has taken-off ahead of you, be prepared for prop-wash. If there is little or no wind, or if the wind is blowing directly down the runway, you may fly into an area of severe turbulence. Don't be alarmed! Use firm control pressures to keep the aircraft steady, start a turn to take you out of the area of turbulence, re-align the aircraft parallel to its original flight path, and continue climbing. If there is a cross-wind, make your turn up-wind, since the area of turbulence will be moving down-wind.

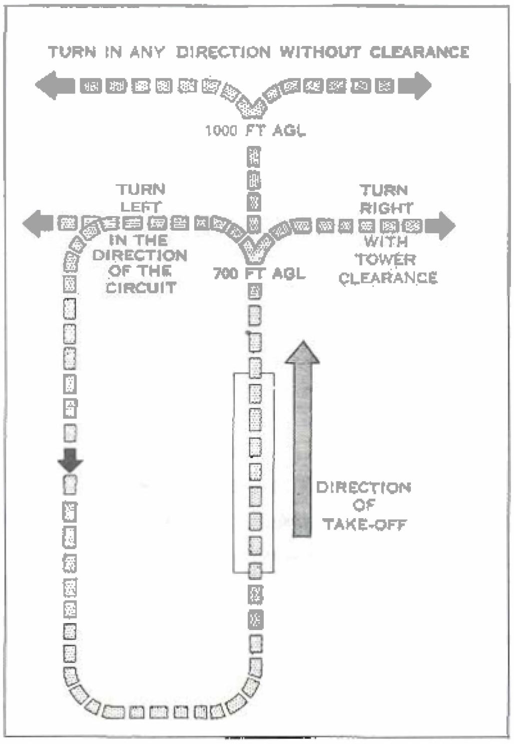

Figure 4: Leaving the Traffic Pattern

4.07 · Leaving the Traffic Pattern

(1) There are three methods of leaving the circuit.

(a) Climb straight ahead until the aircraft is above circuit altitude, then turn either way.

(b) Make a climbing turn onto the up-wind, cross-wind leg and continue climbing through circuit altitude until you are well clear of the circuit, then turn either way.

(c) Obtain clearance from the tower to turn against the circuit traffic below circuit height, but over 500 feet AGL.

(2) Figure 4 opposite, has been prepared to illustrate the three methods of leaving the circuit. Whichever one you choose, you must maintain a careful look-out at all times, especially when you are close to circuit altitude. Always look around before making a turn.

Have you completed the form at the end of this publication?

Chapter 5

The Traffic Pattern

5.01 – Introduction

(1) The traffic pattern flown at FTS is the same as the traffic pattern flown at PFS. It is a means of controlling the aircraft using an aerodrome since, by conforming to established procedure, the risk of collision is reduced. The normal pattern used for all aircraft other than fighter types is rectangular, as shown in Figure 1.

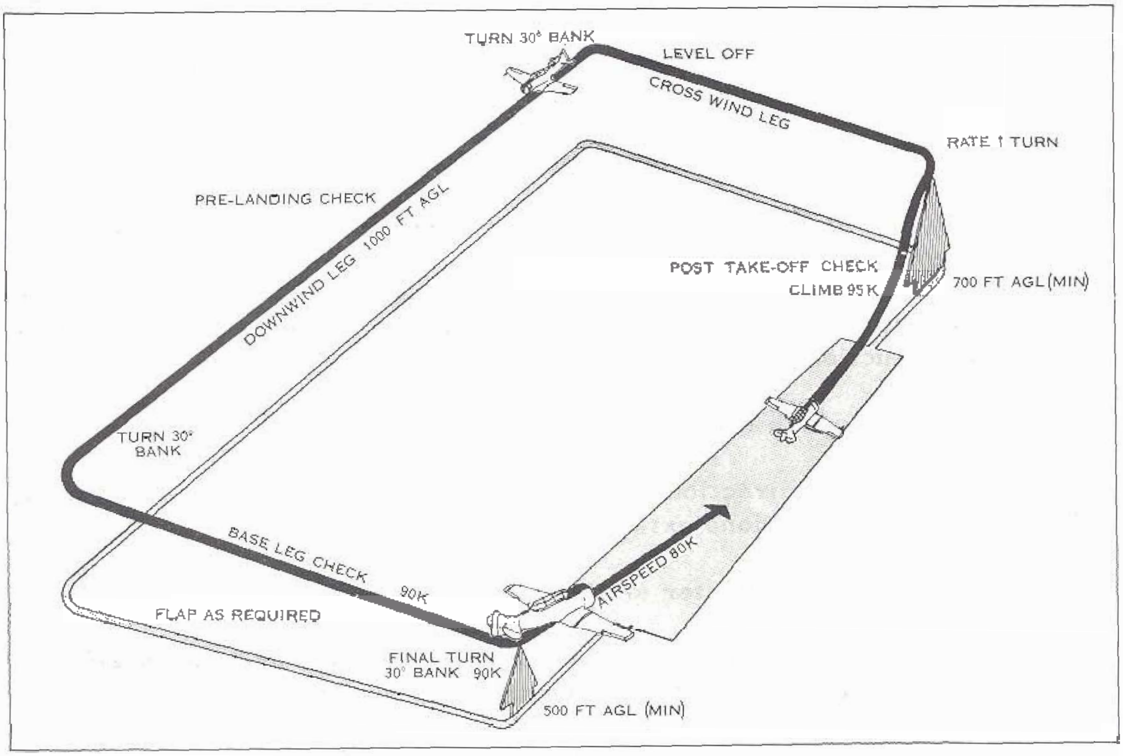

Figure 1: The Traffic Pattern

5.02 - The Entry

(1) The entry is a planned, safe method of letting-down from any altitude or position in the local area, and is designed to provide a clear view at all times of the traffic within the pattern.

(2) Before entering the control area of the aerodrome and letting-down to traffic-pattern altitude, you must ask the tower for landing instructions, and adjust the mixture to the rich range. At altitude a lean mixture is needed for smooth engine performance, but if the lever is left at lean during the descent to a low altitude, fuel starvation and subsequent engine failure may result.

(3) The information which you receive from the tower is of considerable assistance in planning your entry to the traffic pattern and the type of approach and landing. Before starting the descent you should be asking yourself the following questions.

(a) From which direction and altitude am I going to approach the aerodrome?

(b) On which side shall I keep the aerodrome?

(c) On which runway shall I land?

(d) Will I have to correct for drift on the approach and landing?

(e) If I have to correct for drift, in which direction will the aircraft drift?

(f) How much flap should I use?

(g) Is the aircraft liable to weathercock after touch-down?

Most of these questions will be answered for you, or can be deduced from the landing instruction that you will receive. The tower, in reply to your request for landing instructions, will tell you:

(a) which runway to use;

(b) the direction and strength of the wind, and whether gusty conditions exist;

(c) the altimeter setting;

(d) the state of the surface of the runway and the location of any obstructions, if either are applicable; and

(e) that you are clear to enter the traffic pattern.

(4) You must acknowledge receipt of the landing instructions, but not before you FULLY UNDERSTAND everything that has been said. Having completed the R/T procedure, you are ready to fly into the control zone to join the traffic pattern. The methods of entry are the same as they were at PFS, except that the need is even greater for a good look-out, since the other aircraft using the circuit are travelling faster.

ALWAYS KEEP ALERT, ESPECIALLY DURING TURNS AND DESCENTS.

(5) ENTRY DIRECTLY ONTO THE DOWN-WIND LEG - If you are in a position to do so, you can save time by entering the circuit directly onto the down-wind leg. Provided you are more than three miles from the aerodrome,

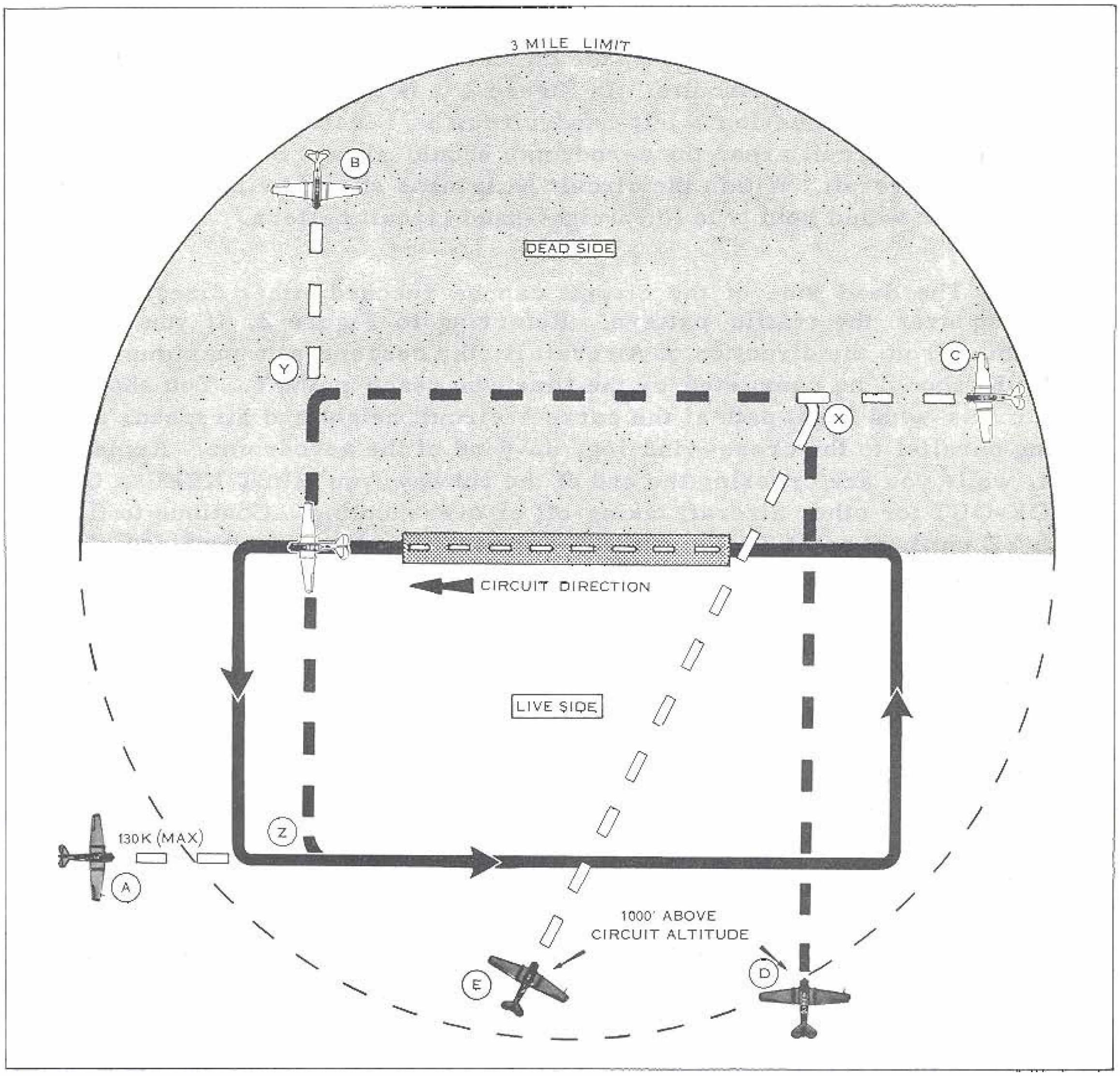

Figure 2: Entry to the Circuit

and are up-wind of the active runway, you may descend to circuit height (1,000 feet AGL) in preparation for joining the circuit. ALL TURNS AND DESCENTS MUST BE MADE OUTSIDE A THREE MILE RADIUS FROM THE RUNWAY IN USE, and any turns in the immediate vicinity of the three mile radius must conform to circuit direction. The maximum airspeed within 3 miles of the aerodrome, and in the circuit, is 130K. Adjust the power to 25" MP and 1750 rpm while positioning the aircraft in line with the down-wind leg on the down-wind heading, and keep wing-tip distance away from the active runway, correcting for drift if necessary. The point at which you join the pattern, as shown in Figure 2 position A, is the intersection of the cross-wind and down-wind legs: consequently YOU MUST KEEP A LOOK-OUT FOR AIRCRAFT ALREADY IN THE CIRCUIT.

(6) ENTRY FROM THE DEAD, OR INACTIVE, SIDE - The dead side of the traffic pattern is all the airspace on that side of the runway which is not being actively used for circuits. (In Figure 2 it is the shaded area.) For the purpose of this discussion a left-hand circuit is illustrated, thus, when approaching the circuit area, the aerodrome should always be on the left of the nose of the aircraft. Within the circuit ALL turns should be made to the left. The opposite would hold true for a right-hand circuit pattern.

(7) The dead side of the circuit can be reached either directly, or by crossing over the traffic pattern. Referring to Figure 2, if you are approaching from the direction of Aircraft B, the descent (at a maximum speed of 130K) should be completed by the time you reach point Y. You should be on a cross-wind flight path at the correct circuit height and airspeed, and be flying parallel to the cross-wind leg, up-wind of the aerodrome. Remember that, while you are crossing the end of the runway, you MUST KEEP A GOOD LOOK-OUT for other aircraft taking-off or overshooting. Continue to fly the path YZ until, at point Z, you can enter the traffic pattern by turning onto the down-wind leg.

(8) The procedure for an aircraft approaching from the direction of Aircraft C is similar, except that the descent is made while flying parallel to the runway, on the dead side. The descent should be timed so that the aircraft is at circuit height and airspeed before turning cross-wind at point Y. The turn is made approximately midway between the up-wind end of the live runway and the point where circuit aircraft are levelling-off from the climb after take-off.

(9) ENTRY FROM THE LIVE SIDE - When approaching the circuit from the live side, as shown by Aircraft D and E, you must be at least 1,000 feet above circuit height while crossing over the traffic pattern. Once point X is reached, a turn can be made parallel to the runway, and you can start to descend as previously described. In Figure 2 the path of Aircraft D, the preferred method of entry, has been shaded to correspond with the shading of the circuit itself.

5.03 - The Cross-wind Leg

(1) The cross-wind leg is that part of the traffic pattern with a ground track at 90 degrees to, and up-wind of, the active runway. It is called the cross-wind leg because, usually, it lies at 90 degrees to the direction of the wind. After take-off, entry to the cross-wind leg may be made from a climbing turn, starting at 700 feet AGL.

5.04 - The Down-wind Leg

(1) The down-wind leg is a course flown parallel to the landing runway, but opposite to the intended landing direction. Normally, its distance from the runway is determined by flying the aircraft so that the inside wing tip follows a line coincident with the edge of the runway. As you should know from previous study, this is known as "Wing-Tip Distance". (Figure 3) The turn from the cross-wind leg onto the down-wind leg should be a 30 degree banked turn, and any drift which is encountered should be eliminated so that the ground track remains parallel to the landing runway.

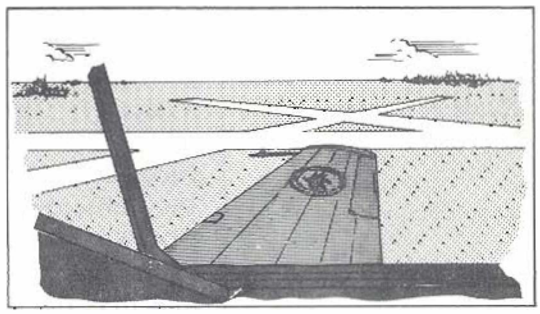

Figure 3: Wing Tip Distance

(2) As soon as the aircraft is settled on the down-wind leg, the Pre-Landing Check should be performed to prepare both the aircraft and yourself for the landing. While you are doing the check make sure that you hold the correct circuit altitude as laid down in FTS orders (usually 1,000 feet AGL), and that the power settings are adjusted to give 25" MP and 1750 rpm.

(3) THE PRE-LANDING CHECK - The Pre-Landing Check should be completed as follows.

CHECK	HOW	WHY
Undercarriage	Manually - Push the lever forward to "DOWN".	To start the undercarriage lowering sequence.
Fuel	Visually - Note the tank contents, the fuel pressure and the position of the selector. If there is less than 15 gallons in the selected tank:	To ensure that there is sufficient fuel available for the landing and a possible overshoot.

CHECK	HOW	WHY
Fuel (Cont'd)	Manually - Change to the fullest tank.	
Brakes	By depressing the tops of the rudder pedals with the toes - Test the feel of the brakes.	If the brakes feel spongy or soft, partial brake failure can be expected. The condition of the brakes must be known before attempting a landing, since faulty brakes mean that you must prepare for a short field approach.
Undercarriage	Visually - Check that the undercarriage lever is locked "DOWN", that the indicators are at "DOWN", that the warning lights are glowing GREEN, and that the pins located under the plexiglass window on the top of each wing are in place.	To ensure that the undercarriage is "DOWN" and locked.
Mixture	Visually - Lever fully back to "RICH".	A rich mixture is needed for low-altitude flight and for maximum power in the event of an overshoot.
Carburettor	Manually - Push the lever fully forward to "COLD" If the OAT is below -25°C, the lever should be left in the full "HOT" position.	To ensure that maximum power is available from the engine.

(4) Once the Pre-Landing Check has been completed, you should have ample time while flying along the remainder of the down-wind leg to correct for drift, to trim the aircraft, and to make minor corrections to your position in relation to other aircraft in the circuit. You may have a tendency to lower one wing towards the runway, in which case you will find the result to be a false wing-tip distance. This can be checked by making constant refer-

ence to the horizon on both sides. If you continue to fly the down-wind leg with one wing down, the aircraft, being banked towards the runway, will move in, making the base leg so short that you will find it impossible to establish the proper attitude before turning onto the final approach. If you are not alert, this may cause you to think that there is an extremely strong cross-wind.

5.05 - The Base Leg on the Approach

(1) The base leg is the transitional, cross-wind part of the traffic pattern between the down-wind and final approach legs. Depending on the strength of the wind, it is flown sufficiently far from the end of the runway to allow the aircraft to be positioned for the type of approach selected. The ground track should always be at 90 degrees to the runway, so the aircraft must be flown at an angle sufficient to overcome drift. The timing of the turn from the down-wind leg onto the base leg varies with the wind conditions and the type of landing, but, usually, can be made just after the trailing edge of the wing has passed the end of the runway. The turn should be made with 30 degrees of bank.

(2) THE CROSS-WIND CHECK - After rolling out onto the base leg, you must complete a Base Leg, or Cross-Wind, Check as follows.

CHECK	HOW	WHY
Undercarriage Horn	Manually - Throttle fully back.	If the undercarriage is unsafe, the horn will blow when the throttle is closed.
Pitch	Manually - Push forward to "FINE".	To ensure that maximum power is available from the engine in the event of an overshoot.
Harness	Manually - Push the locking lever fully forward and then attempt to lean forward. This ensures that the harness is locked.	Safety precaution.
Hood	Manually - Pull fully open or push fully closed.	Safety precaution as explained in para 4.02(1).

(3) After you have completed the check, adjust the throttle to give the desired rate of descent at an airspeed of 90K. Careful control of the pitch attitude with the elevators will regulate the airspeed, once the correct rate of desecent has been established.

(4) When these adjustments have been made, you should have a good look around. You must also decide whether you are going to lower flap - it is good policy to use flap sparingly on the base leg. If some flap is lowered at this time, you must remember to alter the pitch attitude of the aircraft so that the airspeed remains at 90K.

(5) The throttle setting at this stage of the pattern should be such that you can complete the approach at the correct airspeeds without further power adjustment. This requires good judgement, which can only be acquired by practice and experience. You must remember that when power and airspeed are reduced, you will have to trim out yaw and excess control pressures by moving the rudder and elevator trim wheels to the rear. Throughout the remainder of the pattern, you should continue to trim as the pressures change.

5.06 - The Final Approach Leg

(1) The final-approach leg extends from the turn at the end of the base leg to the point of touch-down. It is probably the most important leg of the entire traffic pattern, therefore your judgement must be at its keenest. The turn is started BEFORE the aircraft reaches the final-approach path, thus allowing for the forward movement of the aircraft while the turn is in progress. This means that the entry to the turn must be planned so that, after making due allowance for wind, a 30 degree banked turn will line the aircraft up with the runway heading. As the nose approaches the runway therefore, the roll-out should be started so that the turn is completed as the longitudinal axis is aligned with the runway. For the duration of the turn you MUST MAINTAIN A CONSTANT 90K APPROACH ATTITUDE, and the turn MUST NOT EXCEED 30 DEGREES OF BANK.

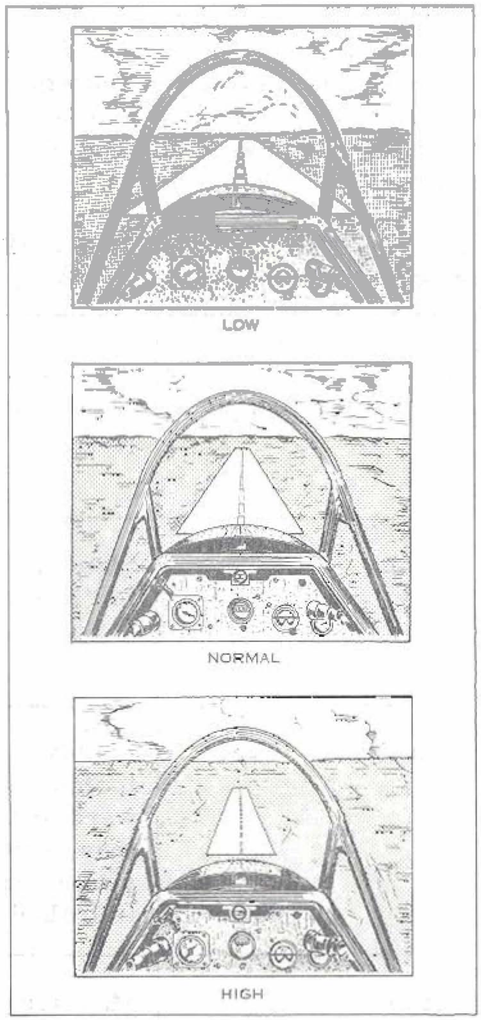

Figure 4: The Final Approach

(2) Owing to drift or poor judgement, you may find that the aircraft is not going to be aligned with the desired track. If you cannot regain track before the altimeter registers 200 feet AGL - OVERSHOOT. Excessive angles of bank must not be used, since steep turns, near the ground, are dangerous when the airspeed is low. If the aircraft were to stall, there would be insufficient room to recover safely.

(3) When the aircraft comes out of the turn in line with the runway, the altimeter should be reading approximately 500 feet AGL, and you should start to make corrections for drift. The pitch attitude should be changed to what you think is an 80K approach attitude for the configuration and, once the airspeed has had time to settle, you should glance at the airspeed indicator to check the actual airspeed. If the reading is higher than 80K, your pitch attitude is too low; if the reading is less than 80K, your pitch attitude is too high. Adjust the attitude smoothly and re-trim, making further adjustments as necessary to maintain the correct approach speed.

(4) If you decide to lower more flap, or increase or decrease power, each change must be followed by a corresponding attitude change to keep the approach speed constant. As before, an approximate attitude change is made, and checked later by reference to the airspeed indicator. ALWAYS adjust the attitude in relation to your outside reference points first, then use the flight instruments as a secondary check. ALWAYS re-trim after each adjustment: the only time within the traffic pattern that an aircraft is not trimmed is during the round-out, the touch-down and the after-landing roll.

(5) All of the adjustments during the final approach, both vertical and horizontal, must be completed at a sufficient height above the ground to allow time for you to plan the round-out. Probably your instructor will insist that you have all the necessary adjustments made by 200 feet AGL. Figure 4 opposite, has been prepared to illustrate a low, normal and high approach from your point of view - i.e. from the front cockpit.

5.07 - The Effect of Wind on the Approach

(1) If it is apparent that your approach is going to be made into a strong wind, you must be prepared for a steeper angle of descent, as shown in Figure 5 overleaf. The attitude of the aircraft remains the same, but if no adjustment has been made to the circuit, more power is required to reach the predetermined spot for the touch-down. The strength and direction of the wind is one of the items in the landing instructions, therefore you should begin to plan your approach leg as soon as landing instructions are received. The strength of the wind will determine when you should turn onto the base leg to allow for a normal final approach.

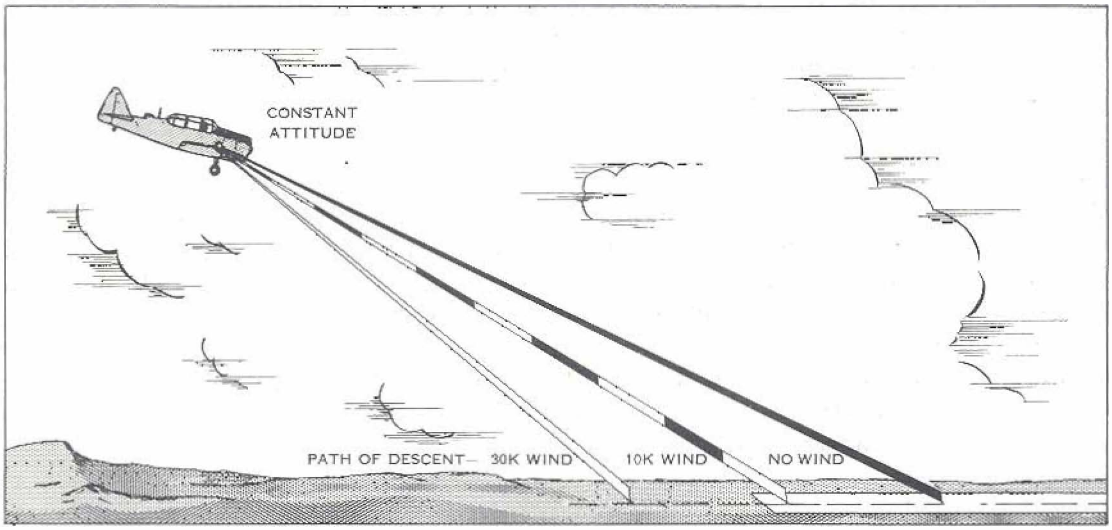

Figure 5: The Effect of Wind on the Approach

5.08 - The Effect of Flaps

(1) In TC-23, the more common types of flaps are discussed in some detail. The split flap, with which the Harvard is equipped, is mentioned as being one of the Lift-Drag types which when lowered, "by increasing the effective camber of the aerofoil section, increases the C_L value without altering the plan area of the wings. The downward deflection, however, has the effect of also substantially increasing the drag." Usually, it is assumed that the first fifteen degrees of flap increases the lift more than the drag, and any subsequent lowering increases the drag more than the lift. On the approach with flap lowered, therefore, the following advantages immediately become apparent:

(a) the increased drag permits a steeper gliding angle without increasing the airspeed;

(b) visibility is improved;

(c) the aircraft has a lower touch-down speed; and

(d) during the after-landing roll, the flaps act as an airbrake and shorten the rolling distance.

(2) The amount of flap used depends on the type of landing which you have planned, and also on the strength of the wind. If you attempt to shorten the approach by diving steeply without flaps, the aircraft will pick up excessive speed and will tend to float along above the ground until the forward speed has been dissipated. By intelligent use of flaps however, you can make

a steeper approach without building up excessive speed and the aircraft, being close to the minimum flying speed at round-out, will land almost immediately. When full flap is used, a greater degree of round-out is needed to reach the correct three-point landing attitude. You should allow for this and time your round-out accordingly. Make sure that you are in a position to land when the three-point landing attitude is reached. Remember that if you are doing a series of landings under constant wind conditions, but with different flap settings, you will be forced either to change the power setting for each landing, or to vary the position of the base leg. The effect of flaps on the gliding angle is illustrated in Figure 6.

DO NOT USE FULL FLAP IN CROSS OR GUSTY WINDS.

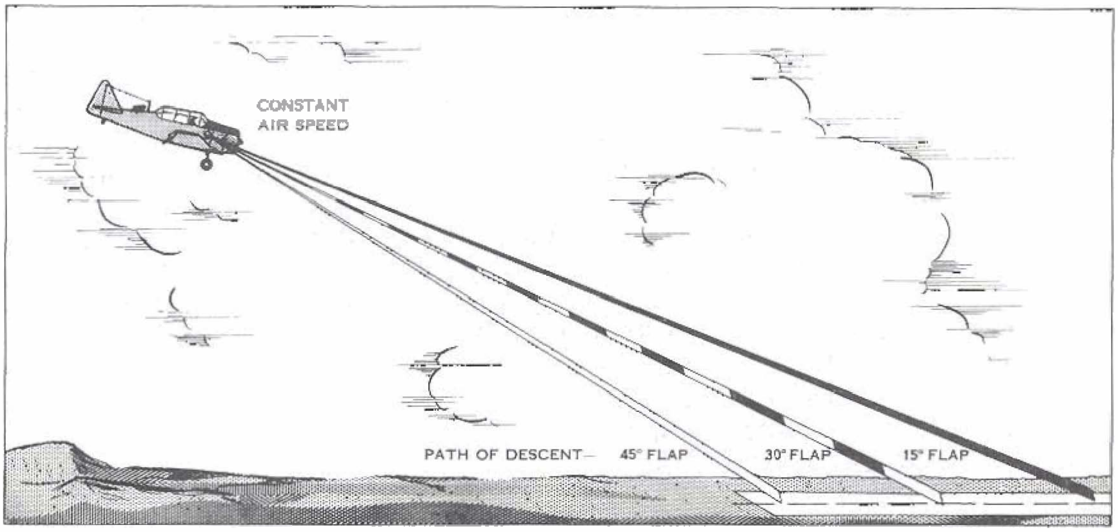

Figure 6: The Effect of Flap on the Gliding Angle

(3) THE GLIDE RATIO - The glide ratio is the distance an aircraft travels forward in relation to the altitude lost. For example, if an aircraft travels 8,000 feet forward while it loses 1,000 feet of altitude, its glide ratio is said to be 8:1. Technically, it is practically impossible for you to know exactly what the glide ratio is going to be because of the many factors which can affect it, but it is important that you have some idea of how far the aircraft is going to glide under certain conditions. Knowing this enables you to plan the turn onto the base leg, helps you to decide when to close the throttle for a glide approach and gives you an idea of when to apply power for a power-on approach.

(4) The glide ratio is affected by all four fundamental forces that act on an aircraft (lift, drag, thrust and weight) as well as by the wing-loading during changes in pitch attitude. If all factors are constant, then the glide ratio is constant. In order to judge the gliding distance of your aircraft therefore, you must make sure that none of the factors change. From your study of aerodynamics you should know that the weight remains the same as long as the wing-loading does not change, so, during the final approach, the weight canbe considered to be constant. Thrust is dependent on the output of the en-

gine at one rpm setting and, since, presumably, the throttle is closed during a power-off approach, thrust is constant. This, of course, applies equally to a power-on approach, provided that the throttle setting is unaltered during the descent. Also, if the aircraft is on the final approach and the attitude is constant, lift will be constant provided the airspeed is maintained at 80K. Drag varies to some extent during the early part of the approach, but should become constant once you have completed the lowering of the flaps.

(5) From the foregoing you should realize how important it is to keep the approach path constant, and to decide on the amount of flap to be lowered as soon as possible after rolling-out of the base leg turn. When the flaps are lowered in the glide, the airspeed will decrease unless you increase the thrust or lower the nose. Since power should not be used during a power-off approach or increased during a power-on approach, you must adjust the pitch attitude to keep the airspeed constant, EXCEPT WHEN YOU ARE UNDER-SHOOTING THE DESIRED TOUCH-DOWN SPOT. If more flap is lowered, the pitch attitude must be adjusted again, to keep the airspeed constant.

(6) Flap must not be lowered on the final approach when the aircraft is close to the ground, since doing so will spoil your judgement of the approach path and, consequently, will spoil the landing. FLAP MUST NEVER BE RETRACTED ON THE FINAL APPROACH. THIS IS AN EXTREMELY DANGEROUS PRACTICE WHEN CLOSE TO THE GROUND, SINCE RETRACTION IS RAPID AND THE SUBSEQUENT LOSS OF LIFT CAUSES THE AIRCRAFT TO LOSE ALTITUDE. THE AIRSPEED IS LOW ON THE FINAL APPROACH AND THE AIRCRAFT COULD STALL.

(7) Normally, the best speed for the final approach is 80K regardless of the amount of flap used. This speed gives a good rate of closure with the runway, provides a safe margin of flying speed above the stall and keeps the aircraft from floating excessively during the round-out. If the final approach speed is less than 80K, the aircraft will settle very rapidly. If you think that you are going to overshoot the spot you have selected for the touch-down, lower more flap or reduce power, and re-adjust the pitch attitude: if you think that you are going to undershoot the spot, apply power and adjust the attitude. If there is any doubt about the approach or the landing, or if you are going to land well past the preselected spot, there is only one thing to do - OVER-SHOOT. It is very important that you be able to determine when to overshoot. The best advice that can be given is that there is no excuse for taking a chance and, unless you feel confident and have weighed up all aspects of the approach, you should overshoot and carry out another circuit pattern.

5.09 - Vision

(1) To make possible a wide scope of vision, and to augment your judgement of height and movement during the final approach and landing, your head should assume a natural straight-ahead position. In the early stages of

landing practice, if you swing your head to look out at alternate sides, you will spoil your judgement because your perspective may not be the same on both sides. With your head straight, you can easily cover both sides of the nose by moving your eyes constantly from one side to the other, and from the ground to the horizon. This allows your brain to record the relationship between the flight path and the various references which you pick out subconsciously. If you concentrate your gaze in an area close to the aircraft, the only result will be a "speed blur" which will lead to confusion, and will normally result in a high round-out. If the nose-high attitude is maintained during the hold-off, the aircraft will stall onto the runway. Taken to the other extreme, if your eyes are looking too far off into the distance during the final approach and round-out, the wheels will hit the runway before you are in the three-point attitude. This will cause the aircraft to bounce upwards in a nose-high attitude. From these two examples you should realize that your eyes must be kept moving all the time, to give a thorough ground coverage ahead of the aircraft, at a range where colour patterns are distinct, and distances and speeds can be judged.

5.10 - Summary

(1) Airmanship and flight safety demand that you remember the following points while flying a traffic pattern.

(a) Ensure that you are on the dead side of the runway before starting a let-down to circuit altitude.

(b) Keep a good look-out for other aircraft in the area, and be sure that there is adequate spacing between your aircraft and the one in front of you in the circuit.

(c) Trim the aircraft constantly as changes in control pressures occur.

(d) Be conscious of drift and try to maintain the correct rectangular track across the ground. Watch for drift on the final approach.

(e) Be alert for the effect of the surface wind during the landing.

(f) Use flap in accordance with your analysis of the surface wind.

(g) Don't take a chance on a bad landing. Be prepared to overshoot, especially if the wind is strong or gusty, or if it is blowing across the runway.

Chapter 6

Landing

6.01 - Introduction

(1) In Chapter 5, during the discussion of the final-approach leg of the traffic pattern, reference was made to the round-out and the touch-down. These two terms along with another term, the after-landing roll, shall be discussed more fully in this chapter.

6.02 - The Round-out

(1) The round-out can be defined as that part at the end of the final approach where the final-approach attitude is changed into the landing attitude. The change is made approximately 40 feet AGL by applying smooth back pressure to the control column and thus slowly increasing the pitch attitude. Although 40 feet is mentioned here as being the ideal distance at which to start the round-out, you must realize that this height varies according to conditions: you must learn to use visual references such as trees and buildings to aid your judgement. Your instructor will show you the height at which to round-out from an 80K power-on approach, and you should use this height as a basis to adjust subsequent round-outs as conditions warrant.

(2) As the nose of the aircraft is raised in a round-out, lift gradually increases and the rate of descent decreases, but, since there is no corresponding increase in thrust to compensate for the higher angle of attack, the airspeed also decreases. In effect, then, when you ease back on the control column you are decreasing the airspeed to touch-down speed, and at the same time you are increasing the lift to let the aircraft sink gently onto the runway. While on the final approach, therefore, you should be planning your round-out point so that the apparent upward movement of the ground gradually decreases until a three-point attitude is attained just above the runway surface.

(3) JUDGING THE SPEED OF THE ROUND-OUT - The speed at which you should apply the control column back pressure depends on the power settings, the configuration, the approach path, the height of the aircraft above the ground and the rate of descent. A high round-out must be made more

slowly than a low one, so that the excess altitude can be dissipated during the movement. Continual practice is the only way to learn how, and when, to round-out, but some guidance can be gained from the fact that your round-out should be made at a speed which is in proportion to the apparent upward movement of the ground. When the ground appears to be coming up rapidly, raise the nose rapidly; when the ground appears to be coming up relatively slowly, raise the nose slowly.

(4) THE USE OF THROTTLE - Power can be used very effectively during the round-out to compensate for errors in judgement. Since power increases both thrust and lift, it can be used to decrease the rate of descent, as well as to prevent the aircraft from stalling. When you reach the three-point attitude and realize that the aircraft is slightly high, hold the attitude and apply just sufficient power to ease the aircraft onto the ground. Just before touch-down, close the throttle so that the additional thrust and lift are removed, thus allowing the aircraft to stay on the ground. Any time that the control pressures feel "mushy" and it is apparent that you are losing control, you should apply power to cushion the landing or, in extreme cases, to execute an overshoot.

(5) THE EFFECT OF FLAP - A normal landing is made with the flaps fully extended so that the forward visibility is increased and the landing speed is decreased. The resulting steeper approach path however, necessitates a greater change of attitude during the round-out than for a flapless landing, or for one made with only partial flap assistance. The height at which the round-out is to begin therefore, depends on the position of the flaps and the experience of the pilot in judging the correct moment. Your instructor will demonstrate the approximate rounding-out heights for various flap settings.

6.03 - The Touchdown

(1) The touch-down is the settling of the aircraft gently onto the runway. As it settles, all three wheels should touch the runway together, thus giving the ideal three-point landing for which the Harvard is aerodynamically designed and stressed. At the point of touch-down the aircraft is not fully stalled, but is settling because of the gradual reduction of lift and thrust brought about by the back pressure applied while rounding-out. When the aircraft touches down in the three-point attitude, the control column must be moved fully back to force the tail wheel to remain firmly on the ground, and to give maximum steerability. During any landing, the longitudinal axis of the aircraft must be aligned with the runway at all times.

6.04 - The After-landing Roll

(1) The after-landing roll is the forward movement of the aircraft on the runway from the point of touch-down to the position in which it has slowed

to taxi speed, or has been brought to a stop. Directional control is of vital importance. Some of the factors likely to have an effect on directional control during the after-landing roll are:

(a) the centre of gravity;

(b) strong cross-winds or gusty winds;

(c) swerves; and

(d) a low oleo strut.

(2) THE EFFECT OF THE CENTRE OF GRAVITY - The Harvard, although a well-constructed and stable aircraft, has a high centre of gravity in relation to the distance between the main landing wheels. This narrow track, as it is called, aggravates the tendency for the aircraft to swing, unless firm, accurate control counter-measures are taken.

(3) THE EFFECT OF WIND - Strong cross-winds or gusty winds may lift one wing to such an extent that the other wing strikes the ground. Special precautions must be taken to prevent this from happening.

(3) SWERVES - Any time the aircraft changes direction, centrifugal force acts through the high centre of gravity, away from the direction of the turn. If the turn is abrupt, the wing on the outside of the turn may strike the ground. The only way to prevent this is to stop a swerve from developing.

(5) A LOW OLEO STRUT - If a lack of pressure in one oleo strut causes the aircraft to go down on one side, there is no immediate effect on the after-landing roll except that, if there is a cross-wind or gusty wind on the side of the high wing, conditions are ideal for the start of a swing. If the wind is on the side of the downed wing, there is less danger, because a wing down into wind is ideal. Another effect of a low oleo strut, however, is the difficulty of taking corrective action if a swing develops in the opposite direction to the downed wing. As you can imagine, the wing tip on the down side is close to the ground already, while centrifugal force is acting outwards. If a swing turns the aircraft in the opposite direction, the wing is forced further down, and may strike the ground unless decisive corrective action is taken immediately.

(6) Five controls are available to help you maintain direction during the after-landing roll. They are:

(a) the rudder;

(b) the brakes;

(c) the throttle;

(d) the ailerons; and

(e) the elevators.

(7) If a swerve develops, do not try to force the nose back to the original heading all at once: concentrate on stopping the turn, and then hold the aircraft steady until you are absolutely sure that you have positive control before attempting a realignment. Even if the aircraft runs off the runway, it is better to do so in a straight line, then to overcontrol and finish up by ground-looping in the opposite direction while remaining on the runway. Remember, there is no substitute for good judgement.

(8) THE USE OF RUDDER - Rudder is used to turn the aircraft, or to stop it turning, rudder effectiveness being dependent on speed. Immediately after touch-down, when the speed is high, effectiveness is greatest because the airflow exerts pressure on the exposed side of the rudder surface and causes an immediate reaction. As the speed decreases, the pressure decreases and the rudder becomes less and less effective for directional control. As the rudder becomes less effective, however, the steerable tail wheel becomes more effective, provided it is firmly on the ground and the control column is being held fully back. During violent swerves at low speeds, counteracting pressure on the rudder-bar is of little value, unless the movement is combined with applications of throttle and brake. In this way a co-ordination of controls helps to maintain directional control.

(9) THE USE OF BRAKES - Whenever you have to use the brakes, it is good airmanship to apply them smoothly and at a constant rate. It is possible to control direction with brake application alone, either to an individual wheel or to both wheels unevenly. But, owing to the excessive wear on the brake shoes and drums and the high degree of skill required, it is more desirable to use brakes in conjunction with rudder for directional control. To use the brakes properly, you should slide your feet up, as shown in Art 2.08 Figure 2, until your toes are on the brake pedals. In this way, you can hold on rudder pressure while applying brake. Thus, if the aircraft swerves at low speed while the rudder is ineffective, correction can be applied with swift, smooth brake pressure.

(10) THE USE OF AILERONS - The ailerons serve the same purpose on the ground as they do in the air, that is to change the lift and drag components of the wings. This means that they can be used to keep the wings level during the after-landing roll, or to lower a wing which has come up owing to the effect of cross or gusty winds. When it is necessary to hold aileron into wind, the amount of the application should be just enough to compensate for the speed and degree of the cross-wind. During sharp, gusty cross-winds, it may be necessary to use aileron somewhat abruptly.

(11) THE USE OF THROTTLE - Applications of throttle increase both the thrust and lift by increasing the amount of airflow over the control surfaces. Thus, these surfaces become more sensitive and effective. During turns and swerves, therefore, opening the throttle pulls the aircraft forward and helps to resist its turning moment. Yaw is increased however, at the same time. This means that, when large amounts of throttle are used, you must be ready to counteract yaw but, if you are prepared, THROTTLE USED IN TIME WILL ALWAYS HELP YOU TO REGAIN CONTROL.

(12) THE USE OF ELEVATOR - The elevators cannot be considered as a direct means of maintaining directional control, but rather as a means of influencing the use of the other controls. Normally, during the after-landing roll, the control column is held firmly back to increase the loading on the tail section. This permits more effective use of the steerable tail wheel and brakes.

(13) The ideal after-landing roll is one in which the aircraft is under positive control at all times, and any swinging tendency is swiftly, but smoothly, corrected. Once the speed has diminished somewhat, brake can be applied to both wheels simultaneously to reduce the forward momentum to a safe taxiing speed.

6.05 - The Post-landing Check

(1) Taxi the aircraft to a position well clear of the active runway, then stop and apply the brakes by pulling the parking-brake lever "OUT". After checking to make sure that the brakes are holding and the generator is charging, perform the following check.

CHECK	HOW	WHY
Flaps	Manually - Lever fully forward to "UP". Visually - Watch the indicator until it returns to "O".	To prevent the flaps from being damaged during taxiing.
Trim	Manually - Set to the "take-off" position. Rudder - 3 o'clock. Elevator - 11 o'clock.	To prepare the aircraft for the next take-off.
Throttle Tension	Manually - Release.	For easy manipulation of the throttle while taxiing.

CHECK	HOW	WHY
Switches	Manually and visually - Ensure that all unnecessary switches are "OFF".	To prevent an excessive drain on the battery.

6.06 - Cross-wind Landings

(1) Since many of your landings will be made in cross-winds at various angles and speeds, you should be thoroughly familiar with cross-wind landing techniques. Two types of approaches are used:

(a) the wing-down method; and

(b) the crab method.

(2) THE WING-DOWN METHOD - If you find that there is a cross-wind as you are coming in on the approach, lower the wing which is into wind a sufficient amount to eliminate drift. (Figure 1) Apply whatever rudder pressure is necessary to keep the longitudinal axis aligned with the runway, and hold this alignment regardless of the amount of cross-wind correction used. If the aircraft drifts off the desired glide path, make the correction to realign it with the runway and alter the degree of bank to compensate for the extra wind strength. Remember that the strength of the wind may vary at different heights throughout the glide path, so the angle of bank must be adjusted accordingly. Also, during the round-out and float period, the airspeed is decreasing, and, since the wind tends to make the aircraft drift away from the centre line, you must apply a correction which has to be gradually increased to keep the aircraft properly aligned with the runway. Keep the into-wind

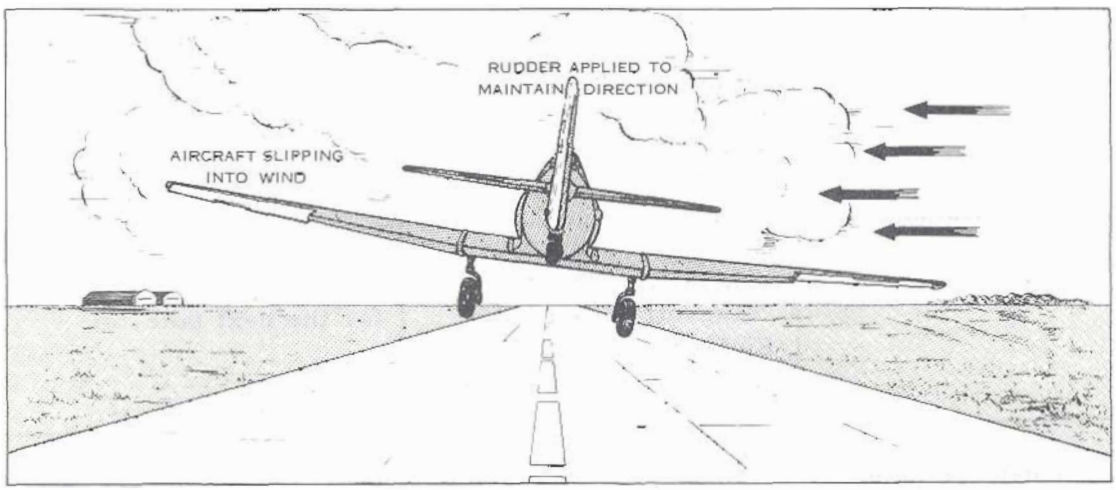

Figure 1: Correcting for Crosswind

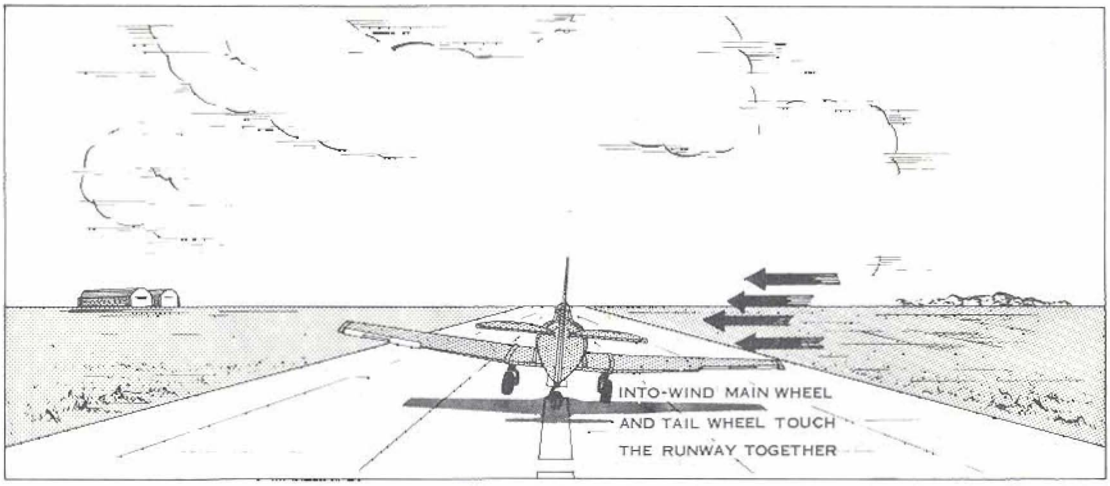

Figure 2: A Normal Crosswind Touch-down

wing down throughout the round-out so that the aircraft touches on the into-wind main wheel and the tail wheel. (Figure 2) As the speed decreases, the out-of-wind wing will drop and the other wheel will settle onto the runway. Maintain direction on the after-landing roll as explained in Art 6.04, and, as well as holding the control column fully back, keep on aileron to hold the up-wind wing down. Since a certain amount of down-wind rudder is being held on during the touch-down, the tail wheel, being turned in the same direction, will cause the aircraft to swerve slightly away from the wind. This is desirable since it counteracts any tendency for a swing into wind.

(3) The merits of the wing-down method are as follows.

(a) Compensation can be made for a cross-wind from either side.

(b) The longitudinal axis can be aligned with the runway throughout the entire approach and landing.

(c) The normal visual references can be used for the round-out.

(d) A correction is already applied during the touch-down and the after-landing roll.

(4) THE CRAB METHOD - Crabbing can only be used on the approach. As soon as the aircraft starts to drift, turn into wind a sufficient amount to make good a track to the runway: the wings should be level, and the nose should be pointed off to one side of the runway. On the way down, adjust the heading to make good a track to the runway. At the start of the round-out, swing the nose round in line with the runway, and at the same time lower the up-wind wing to eliminate drift. From there, the procedure is the same as for the wing-down method.

(5) At the touch-down you must not allow the wings to become level. If you do, the aircraft will begin to drift sideways before it is firmly on the ground and it may cause a swing into wind. In addition, the sideways drift gives the aircraft a tipping or rolling motion, and puts a severe strain on the undercarriage. The effect is similar to skipping on take-off which is illustrated in Chapter 4, Figure 2.

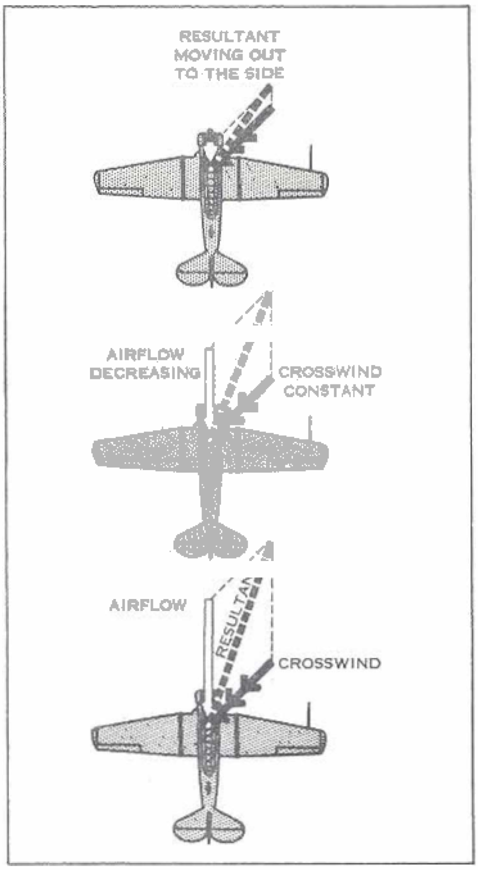

Figure 3: The Effect of Crosswind on the After-Landing Roll

6.07 - Weathercocking

(1) During the after-landing roll in a cross-wind, the relative airflow strikes the aircraft from straight ahead while the cross-wind strikes it to one side. Somewhere between the two there is a resultant component, the angle and magnitude of which depends on the speed and direction of these two airflows. As the forward speed drops, the resultant moves towards the cross-wind component, since the relative airflow is diminishing while the cross-wind is remaining constant. (Figure 3) In the case of the Harvard, which has more side area behind the undercarriage than in front of it, this means that the force of the cross-wind tends to turn the nose into wind. This tendency is called "weathercocking" and becomes more noticeable as the forward speed decreases. Weathercocking is combated by rudder and brake applications to maintain directional control, and by lowering the up-wind aileron as explained in Art 6.04 (10).

(2) Applying aileron, besides preventing the up-wind wing from rising, has the effect of producing a yawing arm to resist weathercocking. This occurs because the lowered aileron on the down-wind wing creates drag and, being located near the wing tip, supplies a counteracting force.

6.08 - Flapless Landings

(1) The decision to make a flapless landing should be taken on receipt of landing instructions, if the wind direction and strength appear to warrant it.

The circuit pattern in such circumstances should be the same size as any normal circuit, but, if you are practising flapless landings in light winds, you will have to extend the down-wind leg to allow a shallower rate of descent on the final approach.

(2) Since the nose attitude is considerably higher during a flapless approach, only a small pitch change is needed to reach the three-point landing attitude. Owing to this small movement, the start of the round-out should be delayed until the wheels are approximately 20 feet off the runway. This reduces the float period and the danger of ballooning. Also, since the landing speed is higher due to the higher stalling speed without flap, the after-landing roll is longer. You should plan to touch down as close to the button as possible, and after touch down the brakes must be used to slow the aircraft down safely.

(3) Flapless landings are recommended when the wind angle added to the wind speed gives a total higher than 30. The techniques for drift elimination has been covered in Article 6. 06.

6.09 - Landing Irregularities

(1) If you make a poor landing, the best remedy is to open the throttle and overshoot. If the irregularity is not serious, however, and you are positive that a good, safe landing can be made, it is permissible to take recovery action. (Figure 4)

(2) BOUNCE - Occasionally, owing to a poorly judged round-out, you may touch the runway prematuraly and bounce. Usually, successful corrective action can be taken as follows.

(a) If the airspeed is still high and the bounce is small, check the backward pressure on the control column until the aircraft starts to sink, then, at the right height, round-out into the landing attitude again.

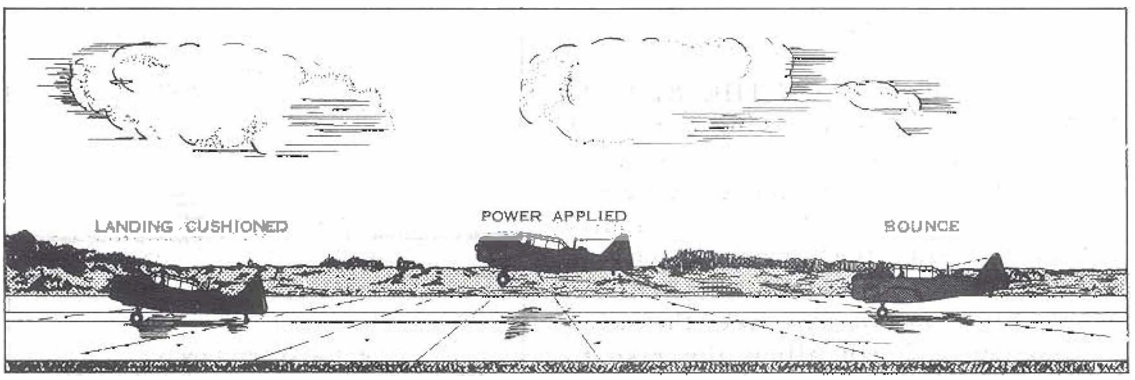

Figure 4: Bounce Recovery

(b) If the airspeed is low and/or the bounce is high, apply power to assist the round-out and to prevent the aircraft from stalling.

(3) If a bounce occurs during a cross-wind landing, the wing which is being held down into wind comes up, as shown in Figure 5, and the wings remain level for an instant. During this instant, you must lower the up-wind wing to keep the aircraft from drifting, and at the same time take action to correct the bounce.

(4) BALLOONING - If you round-out too suddenly, or too early, the aircraft may start to climb and will be too high above the runway for a satisfactory landing. (Figure 6 opposite.) At this point you must BEWARE OF STALLING. Check the backward movement of the control column and allow the aircraft to start sinking towards the ground. If the speed is low, or the aircraft is high, open the throttle to supply enough power to complete a proper round-out. You must remember to close the throttle again just before touch down.

(5) STALL-INS - If you mis-judge the landing and round-out so that the stall occurs before the wheels are on the ground, the aircraft will become a free falling body and will strike the ground hard. Landings are converted to "stall-ins" if you round-out too soon and take no corrective action, or if you use abrupt control column movement instead of slow, smooth back pressure. Correction can be made in the same way as for ballooning.

(6) WING RISE ON THE AFTER-LANDING ROLL - If a wing comes up during the after-landing roll, you must attempt to lower it immediately by applying aileron. The faster the application is made, the sooner it will be effective. You must take IMMEDIATE action as soon as you see the wing coming up and not allow the rise to become too great.

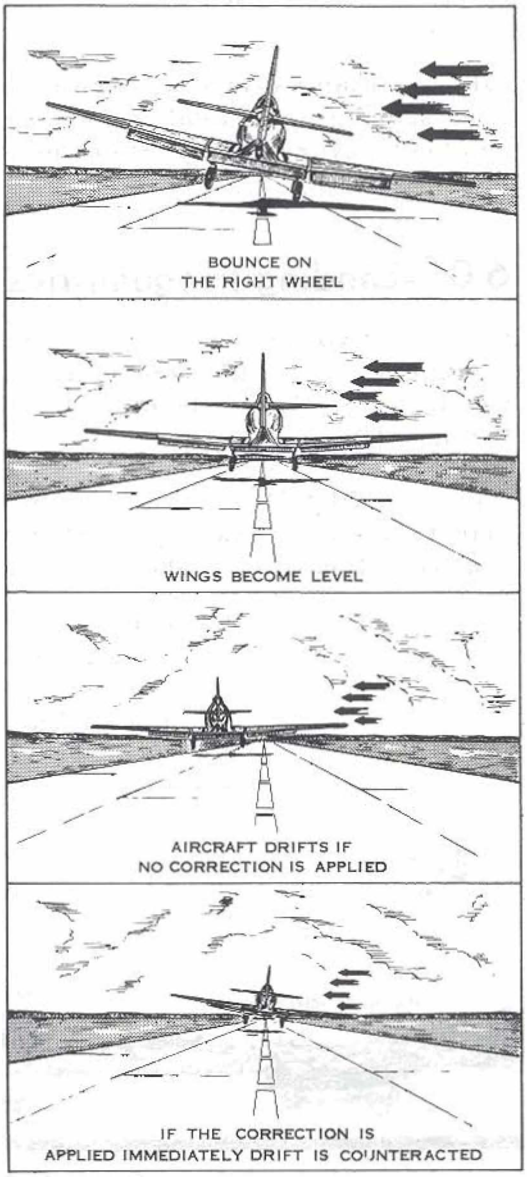

Figure 5: Bounce in a Crosswind

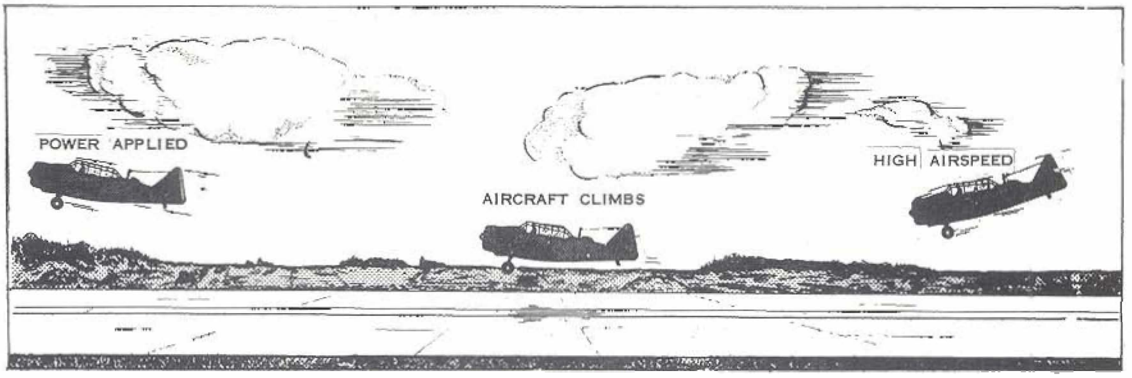

Figure 6: Ballooning

(7) A wing can rise either because of a cross-wind or because you have lost directional control temporarily, and the aircraft is swerving. If it is obvious that aileron is having no effect and the wing is continuing to rise, move your foot up to the brake pedal and brake the wheel under the LOW wing. (Figure 7) The resulting swerve exerts a force through the centre of gravity and brings the wings back to the level position. Naturally, you must regain directional control as soon as possible. If the wing rise is accompanied by a swerve, the brake application should be slightly more severe, to lower the high wing and counteract the swing.

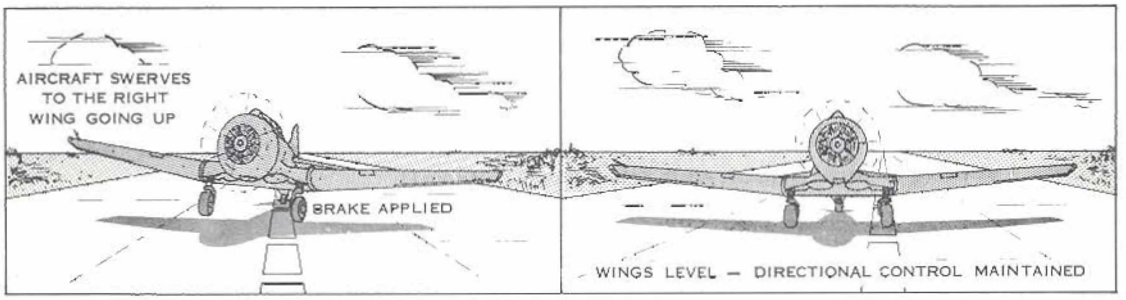

Figure 7: The Use of Brake to Lower a Wing

6.10 - Overshooting

(1) The decision to overshoot because of a poor approach or landing usually rests with the pilot; however, occasionally, the tower may order you to "go round again". During the first part of your training at FTS, your instructor will insist that you be thoroughly familiar with the overshooting procedure so that you know what to do without having to think about it.

(2) As soon as the decision to overshoot has been taken:

(a) open the throttle to 32" MP;

(b) maintain directional control;

(c) re-trim;

(d) climb at 80K;

(e) do the Post-Take-Off Check, adjusting the power to 28" MP and 2,000 rpm as the airspeed approaches 95K; and

(f) re-trim.

(3) If a bad landing is the cause of the overshoot and the remaining portion of the runway is known to be clear of other aircraft, it is permissible to climb straight ahead. If the overshoot is from the approach, however, where it is difficult to see ahead and below, you must start a shallow turn away from the runway, keeping a good look-out for other aircraft. You must look-out BEFORE the turn, DURING the turn and AFTER the turn. When you are clear of the runway and have swept the whole area for other aircraft, roll into another shallow climbing turn and fly parallel to the runway while climbing out to circuit height. On airfields with parallel runways in use, you should turn off to the right when on the right runway, and to the left when on the left runway, keeping a sharp look-out for other aircraft.

6.11 - Touch-and-Go Landings

(1) Touch-and-go landings have been introduced to allow students to complete more circuits and landings in the time allotted. Permission must be obtained from the tower before you can practise Touch-and-Go landings, the request being made while asking for landing clearance.

(2) Having made a normal landing, you should open the throttle smoothly to 32" MP, at the same time keeping the aircraft straight. If the flaps are "DOWN", the aircraft will try to fly before you have reached a safe speed. For safety you should hold the wheels on the runway until the ASI registers 65K. At 65K, only enough back pressure should be exerted to lift the aircraft off the runway and then, once it is safely airborne, you can do the Post-Take-Off Check. Hold an 80K climbing attitude until the flaps are raised, then allow the airspeed to build up to 95K before reducing power.

6.12 - Ground Looping

(1) A ground loop is an uncontrollable turn resulting from over-correcting a swing, or failing to correct a swing, on landing or take-off. A swing may be caused by:

(a) touching-down while crabbing into wind;

(b) allowing the aircraft to drift sideways while landing;

(c) using too much flap in a strong cross-wind or gusty wind;

(d) allowing the up-wind wing to rise;

(e) rounding-out too high and allowing the aircraft to stall onto the runway with wing-drop, (Depending on how advanced the stall becomes, this situation could bring about a rough landing, a bad swing or possibly a crash. Don't take any chances! OVERSHOOT.);

(f) incorrect recovery action for drift after a bounce;

(g) weathercocking;

(h) uneven undercarriage oleos; and

(j) day-dreaming. (ALWAYS KEEP YOUR MIND ON THE JOB from the moment you step into the cockpit, until the aircraft is shut-down.)

(2) To prevent a swing from developing into a ground loop, you must take immediate recovery action: keep the control column fully back and apply opposite rudder. If rudder alone is insufficient to stop a high-speed swing, apply sufficient brake to the wheel under the low wing to stop the swing and to

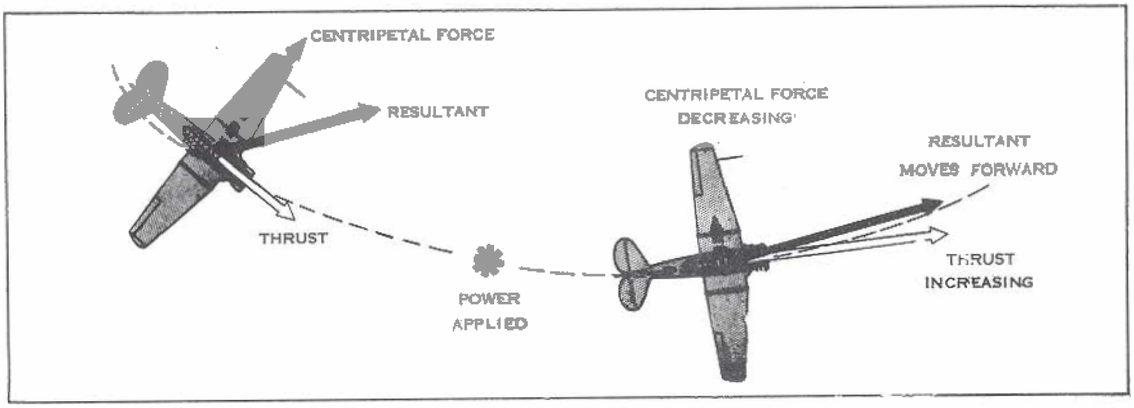

Figure 8: The Effect of Power on a Swing

bring the opposite wing down. Should this fail, open the throttle to full power to make the rudder more effective and to pull the aircraft forward. The effect of opening the throttle is illustrated in Figure 8 overleaf. NEVER attempt to realign the aircraft with the runway until positive control has been regained. Remember, too, that over-correction is just as dangerous as late correction.

(3) If you are in doubt about the landing, or if you seem to be getting into trouble, OPEN THE THROTTLE AND OVERSHOOT. Never take chances!

Chapter 7

Stalling, Slow Flying and Spinning

7.01 - Introduction

(1) The sequences covered in this chapter are taught to familiarize you with the behaviour of the aircraft when it is flown at, and below, minimum airspeed. The methods described for recognition of, and recovery from, stalls and spins should be learned thoroughly, until the recovery action follows automatically on evidence of the symptoms.

7.02 - The Theory of Stalls

(1) The term "stalling" is used to describe a condition of flight in which the lift from the wings can no longer support the weight of the aircraft. Normally, the airflow over the wings is smooth, with some minor turbulence towards the trailing edge. As the angle of attack is increased, the airflow begins to break up and becomes progressively more turbulent, with the area of turbulence thickening and spreading towards the leading edge. Greater angles of attack produce even more turbulence, until a point is reached where there is a sudden loss of a large percentage of the total lift. The wing is then said to be "stalled", and the angle is known as the Critical or Stalling Angle. The indicated airspeed at which the stall occurs is known as the Stalling Speed, but an aircraft can stall at ANY airspeed, in ANY attitude and at ANY power setting, provided the critical angle is exceeded. The most important factors which affect the indicated stalling speed are weight, power, flaps and "G" forces.

(3) One further phenomenon occurs as the angle of attack is increased. The centre of pressure moves steadily forward until the stalling angle is reached, and then it moves sharply back. Thus, two things happen at the stall:

(a) the aircraft loses height; and

(b) the nose drops, sometimes quite sharply.

Usually, in the Harvard, a wing drops at the same time and the nose yaws in the direction of the low wing.

7.03 - What You Must Learn About Stalls

(1) There are four important things to be learned about stalls They are:

(a) recognition of the stall symptoms;

(b) recognition of the stall itself;

(c) the correct recovery action; and

(d) how to prevent stalls.

7.04 - The Symptoms of the Stall and Their Recognition

(1) Once the symptoms of a stall are in evidence, you should know that the aircraft is approaching a critical condition of flight requiring fast, positive corrective action. The following chart has been prepared to help you to interpret the Harvard's stall symptoms.

SYMPTOM	METHOD OF RECOGNITION
Nose high - low airspeed	This symptom is most noticeable when the aircraft is about to stall from the level-flight attitude. Individually, a nose-high attitude or a low airspeed do not constitute the symptoms of a stall, but, WHEN THEY OCCUR TO-GETHER, the aircraft will stall if you fail to take recovery action. Also, during steep turns and aerobatics, if the nose of the aircraft is moving rapidly in the pitching plane, you should prepare to take stall recovery action.
Sloppy controls	If you do not take recovery action when you notice a nose high - low airspeed condition, and the airspeed is allowed to continue to decrease, the airflow over the control surfaces becomes less, making the controls ineffective and sloppy. (This symptom is not

SYMPTOM	METHOD OF RECOGNITION
Sloppy Controls (Cont'd)	always present when the aircraft is stalled with power on, or at high speed.)
Mushing	If you continue to ignore the warning signals, the aircraft will develop a sinking or mushing feeling as it comes close to the stall. This is caused by a loss of lift as the airflow over the wings breaks up. Sometimes this symptom may not be apparent, but it is always present.
Juddering	Immediately before the stall, the turbulent airflow striking the tail surfaces causes the aircraft to judder and shake. The duration of this symptom varies, depending on the harshness of the stall and the airspeed at the time of stall. At high speeds it may be over in an instant, but it is always present as a symptom during any stall.

7.05 - The Effectiveness of the Controls

(1) One important symptom of the stall, and one which is easy to recognize, is the light and sloppy feeling of the controls. When the aircraft stalls the control surfaces lose some, if not all, of their effectiveness in a definite order. The order is: ailerons, elevators and rudder. Effectiveness is regained in the reverse order, whether power is applied or not. All the control surfaces depend on the speed of the airflow for their effectiveness, therefore as the speed diminishes, effectiveness diminishes.

(2) THE AILERONS - Normally, the up-going aileron decreases the angle of attack and therefore the lift of the wing, while the down-going aileron increases the angle of attack and lift. The net result is that the aircraft rotates in the direction of the up-going aileron. At the stall however, the normal effect of the ailerons is reversed and the up-going aileron increases the lift of its wing while the down-going aileron, by changing the effective chord of the wing, INCREASES the angle of attack and aggravates the stall. Thus, if you use aileron during a stall to try to pick up a wing, the condition will only be aggravated. Also, since the ailerons are outside the slipstream, power has no effect on them.

(3) THE ELEVATORS - The elevators are in the line of the slipstream so, provided that some power is on, they remain fairly effective and positive.

In the absence of power, however, they are affected by the spreading area of turbulence from the wings and so lose some of their effectiveness.

(4) THE RUDDER - The rudder is in smooth airflow all the time and is relatively unaffected, provided that there is a flow of air over its surface.

7.06 - Recovery Action

(1) The difference between a good recovery and a bad one is the speed with which the recovery action is completed. The difference is measured in loss of altitude. Your aim should be to recover with a MINIMUM loss of altitude, and to this end the following procedure has been developed.

(a) Move the control column straight forward and simultaneously open the throttle to the maximum permissible power setting for the rpm. For example, if the rpm setting is 1,750, the throttle should be opened to a maximum of 26" MP; if 2,000 rpm - 28" MP; if the pitch is at "FINE" - 36" MP etc.

(b) If a wing drops, apply sufficient rudder to prevent the nose from yawing any further.

(c) When the wings become unstalled, level them with aileron.

(d) Raise the nose slightly above the level-flight attitude to prevent any further loss of height.

(2) The amount of the initial control column movement depends on the airspeed and completeness of the stall. Sometimes a relaxation of the back pressure is sufficient, while at other times a firm, positive forward movement is required. If too much forward pressure is exerted, you will lose too much height; if too little, you will not recover: in due course and with practice you will learn just how much pressure to use. Similarly, when easing out of the dive, if you raise the nose too sharply a secondary stall may result; if you raise it too slowly excessive altitude will be lost.

(3) When power is applied, the aircraft is pulled forward in the direction of thrust and the angle of attack is modified, the effect being in proportion to the amount of power used. On the recovery therefore, provided the power is applied early enough, it may be possible to keep the nose above the straight and level position, thus preventing excessive loss of height. Power is the most important factor, when considering height lost in a stall. This is illustrated if you do two stall recoveries, one with and one without power, and compare the amount of height lost in each.

(4) Normally, unless you are deliberately practising stalls, you will recover as soon as the symptoms become evident. During practice however,

the aircraft is to be stalled completely so that the whole recovery cycle can be learned and understood. Your instructor will demonstrate stalls in a high, nose-up attitude; in conditions approximately level flight; with and without power; and with and without flaps down. He will explain the degree to which the controls are used for recovery from each type. Later, he will show you stalls from gentle turns, and from climbing and descending attitudes. Eventually as you become more proficient, you will be doing stall recoveries from steep turns and aerobatics, until you are thoroughly conversant with their recognition and recovery at any airspeed, attitude or power setting.

7.07 - The Pre-stall, Spin and Aerobatic Check

(1) The following check must be carried out in the order shown before practising stalls, spins or aerobatics.

CHECK	HOW	WHY
Altitude	Visually - Check the altimeter.	To ensure that there is sufficient height available for complete recovery before reaching the minimum height specified in CAP 100 or local flying orders.
Locality	Visually.	Flying regulations and good airmanship dictate that you should NOT be: (a) over an aerodrome; (b) within five miles of and airway; (c) over a prohibited area; or (d) over a town. You should be near a good forced landing field.
Hydraulic Pressure	Visually.	To ensure that sufficient pressure is available

CHECK	HOW	WHY
Hydraulic Pressure (Cont'd)		should it be necessary to operate the undercarriage or flaps.
Undercarriage	Manually - Select "DOWN", if you are to be doing stalls with undercarriage down. OTHERWISE: Visually - Check "UP".	Stalling practice may be carried out with the under-carriage "UP" or "DOWN" as desired. Intentional spins or aerobatics must NEVER be done with the undercarriage "DOWN".
Hood	Manually - Fully closed and locked.	To prevent possible damage during yawing manoeuvres.
Trim	Manually - Set for straight and level flight while doing the check. Do not re-trim after closing the throttle to do a stall or spin.	To eliminate extra pressures on the controls during recoveries.
Temperatures and Pressures	Visually.	Temperatures and pressures must be normal.
Mixture	Manually - Adjust for smooth running.	In the case of stalls and aerobatics, smooth running and the instantaneous availability of maximum power is paramount. The requirements for spinning are dealt with in that section of the chapter.
Carburettor Air	Visually and Manually - While maintaining an exact altitude, note the MP, and pull the car-	If the MP increases, carburettor ice has been forming and has been eliminated. SPINS and

CHECK	HOW	WHY
Carburettor Air (Cont'd)	burettor air control back to "HOT" until the temperature rises to 50°C, or until there is a rise of 35°C, then return the lever to "COLD". Take a second MP reading.	POWER-OFF STALLS are NOT practised in such conditions.
Pitch	Manually - Adjust to 2,000 rpm.	To ensure that sufficient power is available for the recovery.
Fuel	Visually - Selector, contents and pressure.	To ensure that sufficient fuel is available in the selected tank to carry out the exercise, and that the aircraft is not over the maximum weight for aerobatics.
Flaps	Manually - Adjust as required.	Stalls should be practised with various flap settings. Spins and aerobatics should be practised with flaps "UP" to prevent damage during high-speed recoveries.
Gyros	Manually - Cage the AH and DI.	To prevent damage to these instruments.
Switches	Visually or Manually - Check that the Radio Compass is at "ANT" or "OFF", and that the Gyro Switch is at "OFF". Check all other switches.	To prevent damage to the aircraft radio compass and gyros, and to ensure that all other switches are set correctly.

CHECK	HOW	WHY
Loose Articles	Visually.	To ensure that everything is properly stowed and that nothing can jam the controls.
Harness	Manually - Tighten.	Safety precaution.
Look-out	Visually - Clearing turns.	A last minute check is needed to make sure that the area is clear of cloud and other aircraft.

7.08 - Clearing the Area

(1) Before you start to practise stalls, spins or aerobatics, you must make sure that the area is clear of other aircraft. Clearing turns are used to allow you to look above, below and round about, through the whole 360 degrees. The amount of look-out, of course, varies with the type of manoeuvre, but you must satisfy yourself that the area is clear and that it is safe to start the proposed exercise. Remember that as well as looking all around for other aircraft you must aim to keep well clear of cloud. If there are aircraft in the vicinity, turn away and choose another location. Once you have satisfied yourself that the whole area is clear, roll out of the turn and immediately carry out the planned manoeuvre. If you are doing a series of manoeuvres, one after the other, it may be necessary to clear the area after each sequence.

7.09 - Basic Stalls

(1) THE STALL WITH WHEELS AND FLAPS "UP" - The power-off stall with wheels and flaps "UP" is the most elementary type of stall, but one in which you must show proficiency before your instructor can allow you to go on.

(2) As soon as you have completed the Pre-Stall Check and have satisfied yourself that the area is clear of other aircraft, close the throttle to give 10 to 12" MP and raise the nose above the horizon to the three-point attitude. Apply sufficient rudder to keep straight, keep the wings level with aileron and hold the correct attitude with increasing back pressure. At this point you should be recognizing the first symptoms of an approaching stall - a nose-high attitude with decreasing airspeed. Watch for the other symptoms,

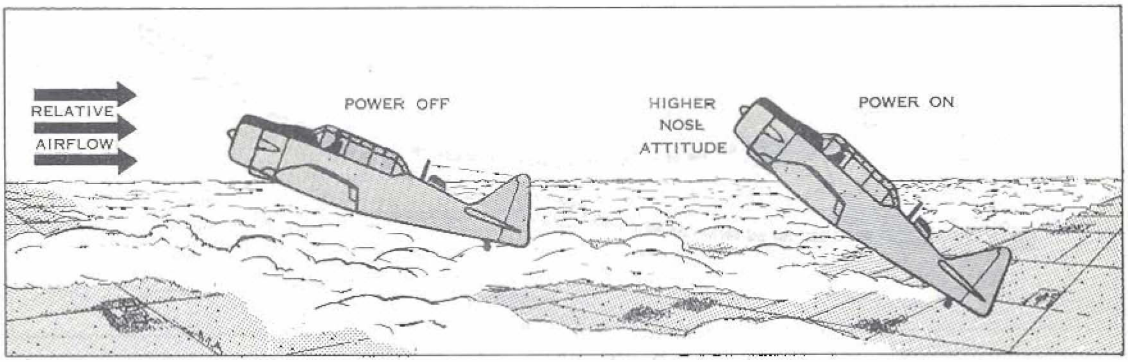

Figure 1: The Attitude in a Stall

until the nose drops. The aircraft is stalled and you should be taking steps to recover as quickly as possible, according to the procedure outlined in Art 7.06.

(3) THE STALL WITH WHEELS AND FLAPS "DOWN" - Lowering flap increases the effective camber of the wing and the coefficient of lift, thus lowering the stalling speed by several knots, depending on the amount of flap used. Drag is also increased proportionately. This configuration simulates stalling on the final approach, the procedure for stalling the aircraft being the same as that described in paragraph (2). Note that, although the stalling speed is lower, the symptoms are the same, except that the nose drops a little further and the recovery takes more time. Usually more height is lost than in the stall with wheels and flaps "UP". When you have become proficient in stalling the aircraft straight ahead, try one from a 30 degree banked turn, to simulate a stall during the final turn onto the approach.

(4) THE POWER-ON STALL - A power-on stall can occur during climbing turns, overshoots, or while practising aerobatics. To practise this type of stall, clear the area and adjust the throttle to give 20 to 25" MP before raising the nose to approximately 40 degrees above the horizon. By raising the nose to this extent, you avoid keeping the aircraft in a prolonged nose-high attitude while waiting for it to stall. The characteristics of the stall are similar to those experienced during the power-off stall, except that, although the nose and wing tend to drop more rapidly, the rudders and elevators retain their effectiveness because of the airflow from the propeller. The stalling speed is noticeably lower, while the nose attitude is considerably higher. (Figure 1) Recovery is effected in the usual way, but the forward movement of the control column does not have to be as great, since the higher power setting enables the aircraft to attain flying speed sooner. The loss of altitude is much less than in the types of stalls mentioned previously.

7.10 - Secondary Stalls

(1) During the recovery from any stall, there is always the danger of

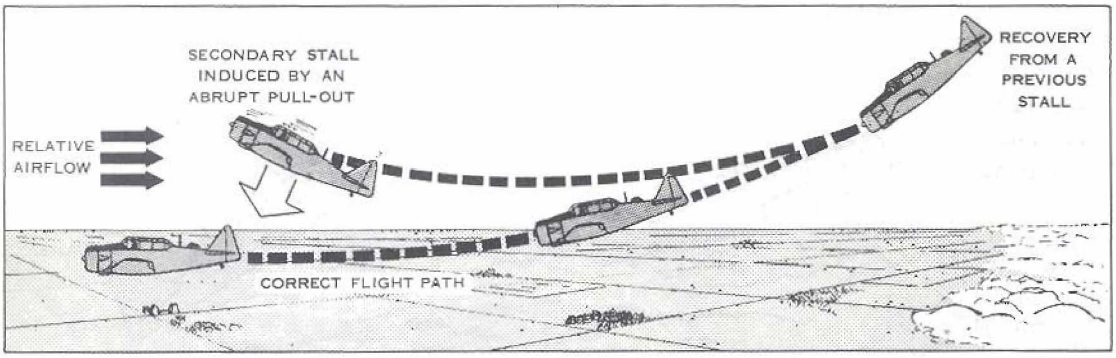

Figure 2: The Secondary Stall

bringing on another stall. (Figure 2) This secondary stall occurs if you attempt to hasten the recovery by raising the nose abruptly. You can practise secondary stalls by allowing the nose to drop slightly below the level-flight attitude during a normal stall recovery, before pulling back on the control column as if to hasten the return to level flight. The recovery is made by using the normal stall-recovery procedure described in Art 7.06. Before beginning the first stall, you should note the altimeter reading so that you can compare it with the reading at the end of the secondary stall. Since the height loss is excessive, practice in PREVENTING secondary stalls is more important than practising the stalls themselves. By practising prevention, you will learn the value of using smooth control column pressures at critical airspeeds, and you should develop a "feel" for raising the nose above the horizon without inducing a secondary stall.

(2) Stall prevention is the main reason for practising stalls and stall recoveries; therefore, when you are proficient at recovering from all types of stalls, you should go on to practice prevention. This simply means that you should recover whenever there is a definite indication of an approaching stall. In time, you will find that you can recover with very little loss of height and without any risk of a secondary stall.

7.11 - Advanced Stalls

(1) Advanced stalls are practised to increase your proficiency in preventing and recovering from stalls from unusual attitudes. To practice these stalls, the undercarriage and flaps must be left "UP" and after completing the clearing turns you should set the throttle to 20 to 25" MP.

(2) STALLS FROM STEEP TURNS - A stall from a steep turn is caused by excessive back pressure being exerted on the control column in a vain attempt to keep the nose up. Although usually demonstrated in a steep turn, this excessive back-pressure stall can occur in any condition of flight when the critical angle is exceeded. The onset of the stall can be recognized by the rapid movement of the nose through the pitching plane, and by the abnormal

"G" if the speed is high. To keep the wing loading within limits, ensure that the airspeed is below 110K before the aircraft stalls. The Harvard usually tends to flick to the right when stalled in a steep turn, therefore you must be prepared to stop this roll if the turn is to the right. In a turn to the left, the tendency to flick right should return the aircraft to straight flight. If the turn is to the right and the roll cannot be stopped before the aircraft becomes inverted, stall recovery action should be taken before completing the roll. Recovery action is basically the same as for other types of stalls except that, instead of positive forward pressure, relaxing the excessive back pressure at the point of judder may be sufficient. The correction of yaw needs minimum rudder unless recovery is slow, because aileron control is regained almost immediately. Remember, the sooner the nose is raised above the horizon, the less is the height loss.

(3) STALLS FROM VERTICAL DESCENTS - The highest airspeed at which a Harvard should be stalled intentionally is 110K, therefore when practising stalls from vertical descents, the downward speed must be controlled. This type of stall can occur when you are attempting to recover from any looping manoeuvre or spin. If you exert excessive back pressure on the control column to bring the nose up, the attitude of the aircraft will change, but the direction of flight will continue downwards, owing to inertia. Within a short time, the aircraft will adopt the new flight path, but in the interval, the resulting mush can be extremely dangerous. The stall itself is not vicious, but if recovery is not effected immediately, the height loss can be considerable. To recover, the back pressure is released, the wings are levelled and the aircraft is eased gently out of the ensuing dive. Power is applied as the aircraft returns to the level-flight attitude.

(4) STALLS FROM AN INVERTED ATTITUDE - A Harvard in an inverted attitude stalls when the critical angle of attack is exceeded, in the same way as it stalls in any other attitude. If you are doing loops and are holding too much back pressure at the top of the loop, the aircraft will stall; if you are holding too little back pressure the aircraft will stall. In the first instance, releasing the back pressure will unstall the wings, while in the second, allowing the nose to drop below the horizon will build up enough airspeed to remove the primary cause of the stall. As soon as practicable the aircraft must be rolled-out into the normal level-flight attitude, but you must be sure that the nose is below the horizon and that the airspeed is high enough to sustain flight. If you allow the nose to drop too far, the altitude loss will be excessive. A looping recovery from an inverted attitude is not desirable because of the height loss, the high airspeed and the possibility of propeller overspeeding.

(5) Sometimes when inverted and subjected to negative "G", the engine of the Harvard may cut out, owing to a loss of fuel pressure. When this happens, the constant speed unit (CSU) tries to maintain the original rpm by going into FINE pitch. If the throttle is left open, the surge of power when the engine picks up again may cause serious damage to the engine and the CSU.

(6) To prevent overspeeding when the engine cuts out in inverted flight, or if overspeeding occurs at any other time, the procedure laid down in EO-05-55A-1 is to be used. This procedure is repeated here for convenience.

(a) Retard the throttle to idle.

(b) Recover with the lowest possible airspeed, aborting the manoeuvre if necessary.

(c) Place the aircraft in a normal climbing attitude.

(d) Slowly advance the throttle when the airspeed has dropped to 110K or lower.

(7) If you have been unable to prevent overspeeding, and the rpm reading has exceeded the maximum permissible figure, you MUST MAKE AN L-14 ENTRY. If the overspeeding has resulted in a "runaway" propeller, you should attempt to bring the propeller under control by placing a load on it. The easiest way to do this is to use a combination of nose-high attitude, low airspeed and low power setting. If further signs of overspeeding occur when the nose is lowered for the descent at the destination, you may have to extend the undercarriage and flaps to allow you to maintain the proper airspeed/attitude relationship. A forced landing pattern should be employed since there may not be sufficient power available for a normal circuit, especially if you misjudge and undershoot the final approach.

(8) STALLS FROM A STEEP CLIMBING ATTITUDE - Stalls from a steep climbing attitude can happen during manoeuvres such as lazy eights, chandelles or steep climbing turns. To practise this type of stall, you should put the aircraft into a steep climbing turn with the nose at an angle of approximately 70 degrees to the horizon and the wings banked to at least 20 degrees. In this attitude, the first symptom of the stall, NOSE HIGH, is present already and it is only a matter of time before the other symptoms appear. The recovery is exactly the same as for other types of stalls.

7.12 - Slow Flying

(1) Slow flying is practised so that you can learn to control the aircraft near the stalling speed. It helps to develop a "feel" for flying and enables you to cope with overshoots, aerobatics and other manoeuvres flown at critical airspeeds. In addition, it is an excellent yaw and trim exercise because the airspeed is low, the throttle setting is high, the angle of attack is high, and the increased yaw must be counteracted with rudder.

(2) Before practising slow flying you must perform the Pre-Stall, Spin and Aerobatic Check, and set the aircraft up for the sequence, in the following manner:

Gyros - Caged (The DI may be used)

Pitch - 2, 000 rpm

Mixture - Adjusted for smooth engine operation

Undercarriage - Down

Flaps - Down

(3) After lowering the undercarriage, you should clear the area before doing anything else because - once the flaps are down, the nose attitude will be too high for you to make a thorough inspection underneath the aircraft. While rolling-out of the second clearing turn, close the throttle to approximately 14" MP and maintain a constant altitude and direction as the speed falls off. When the airspeed reaches approximately 90K, lower full flap. When the flaps go down, the added lift causes the aircraft to gain height and the nose tends to go down. You should feel these changes being transmitted through the control column in time to make corrective adjustments, and thus keep the altitude constant. Also, with the lowering of the flaps, the airspeed drops off rapidly owing to the increased drag, therefore a change in pitch attitude is required to prevent a loss of altitude. While the airspeed is dropping off, the throttle must be opened slowly to keep a 2 to 5K safety margin above the stalling speed. Slight throttle adjustments in co-ordination with elevator movement will be needed throughout the exercise to keep the airspeed and altitude constant.

(4) With the relatively high power setting and the low airspeed, considerable right rudder pressure and right rudder trim must be applied to counteract the effect of yaw. You will find that after the rudder trim-wheel is moved fully forward, some right rudder pressure will have to be held on to keep the aircraft straight. By moving the elevator trim-wheel to the rear, you will be able to relieve the control-column pressures and maintain a constant pitch attitude.

(5) Once slow flying from straight and level flight has been mastered, your instructor will show you turns to the right and to the left. You will learn to use smooth co-ordinated control pressures, and you will notice that greater movements are needed to obtain a desired effect. Also, you will find that some power will be needed to keep the aircraft from stalling or losing height. In any turn, the rate of turn is directly proportional to the degree of bank, and inversely proportional to the airspeed; therefore, in a slow airspeed turn, the rate of turn is greater for a given angle of bank. This rapid rate of turn at comparitively shallow angles of bank obviates the need for steep turns, which at low airspeeds can be dangerous. Your instructor will show you what can happen when you use rough, unco-ordinated control movements, and also the effect of raising the flaps quickly. In each case the aircraft will stall.

(6) After practising slow flying and slow flying turns, you should always recover by doing an overshoot procedure so that you can become more and more familiar with the correct sequence of events.

7.13 - Spinning

(1) Although the Harvard is basically a stable aircraft and mishandling of the controls is necessary to produce a spin, you must be able to recognize the symptoms of a spin automatically and be able to take the correct recovery action. The reason for learning spin recovery early in your training is that the knowledge acts as an insurance while you are practising new manoeuvres. Practice in spinning helps to improve your orientation in unusual attitudes and builds confidence. Like stall recovery, however, the aim of spin recovery is prevention, with immediate recognition and automatic recovery technique being the goal: you must be familiar with the sight and feel of a spin, and know what the aircraft is going to do.

(2) At PFS you were taught the theory of spinning, the method of spinning the Chipmunk and the correct recovery action. Each step is to be repeated here with reference to the Harvard so that there can be no doubt in your mind about spinning.

7.14 - The Development of a Spin

(1) During a spin, one wing is going up while the other wing is going down, therefore, in addition to the normal airflow striking the wing, there is a component airflow due to the up and down movement. Thus, the relative airflow strikes the up-going wing at a small angle and the down-going wing at a larger angle, which means that the up-going wing is less stalled than the down-going wing.

(2) When a wing goes down, the aircraft yaws towards the down-going wing and the nose drops; autorotation begins and the aircraft starts to corkscrew towards the ground, rotating about a vertical axis. This autorotation is known as spinning.

7.15 - The Entry to a Spin

(1) Before putting the aircraft into an intentional spin you must complete the check outlined in Art 7.07, paying particular attention to the look-out, since the amount of height lost will be substantial. The throttle is set at 12 to 14" MP to prevent the butterfly valve from freezing in the fully-closed position; the mixture is moved to "IDLE CUT-OFF" to reduce the risk of fire

due to manifold flooding, and the nose is raised approximately 30 degrees above the horizon. When the airspeed drops to 70K, rudder is applied in the direction of the intended spin and the control column is brought straight back so that it is fully back by the time that the rudder is fully on. The nose should travel across the horizon as the inside wing drops and, after about 90 degrees of yawing turn with the rudder on and the control column fully back, the aircraft will begin to spin. Keep the rudder on and the control column fully back until you are ready to recover; the ailerons should be neutral. Some aircraft may oscillate excessively during the spin, necessitating positive pressure on the controls to hold them in the proper attitude.

(2) An intentional or unintentional spin can be entered from any attitude and with any power setting. Your instructor will demonstrate various entries, and you will practise spin recognition and recovery from each type of entry. Power usually aggravates a spin and makes recovery more difficult; therefore, if you go into a spin with power on, your first action should be to close the throttle. Do not waste time trying to set 12 to 14" MP - just close the throttle. If the wheels and flaps are down, bring them up, and simultaneously go into the recovery procedure.

7.16 - Spin Recovery

(1) Recovery from a spin is ALWAYS the same. The procedure is:

(a) apply full rudder opposite to the direction of rotation;

(b) move the control column steadily forward until the spin stops;

(c) centralize the rudders;

(d) level the wings; and

(e) ease out of the ensuing dive.

(2) Full opposite rudder is applied rapidly to stop the yaw, and the control column is moved forward to unstall the wings. As the control column is being moved forward do not apply aileron, since this may aggravate the spin and cause difficulty during the recovery; also, try not to look down at the control column to see what it is doing - keep it moving steadily forward. As soon as the spin stops, check the forward movement and centralize the rudders. Failure to centralize the rudders may cause an unfavourable yaw, which can overstress the airframe or develop into a spin in the opposite direction. Failure to check the forward movement of the control column, or keeping it too far forward, may give the aircraft a pitching motion which can stop the engine, cause a runaway propeller, make the diving angle excessively steep or build up a high airspeed.

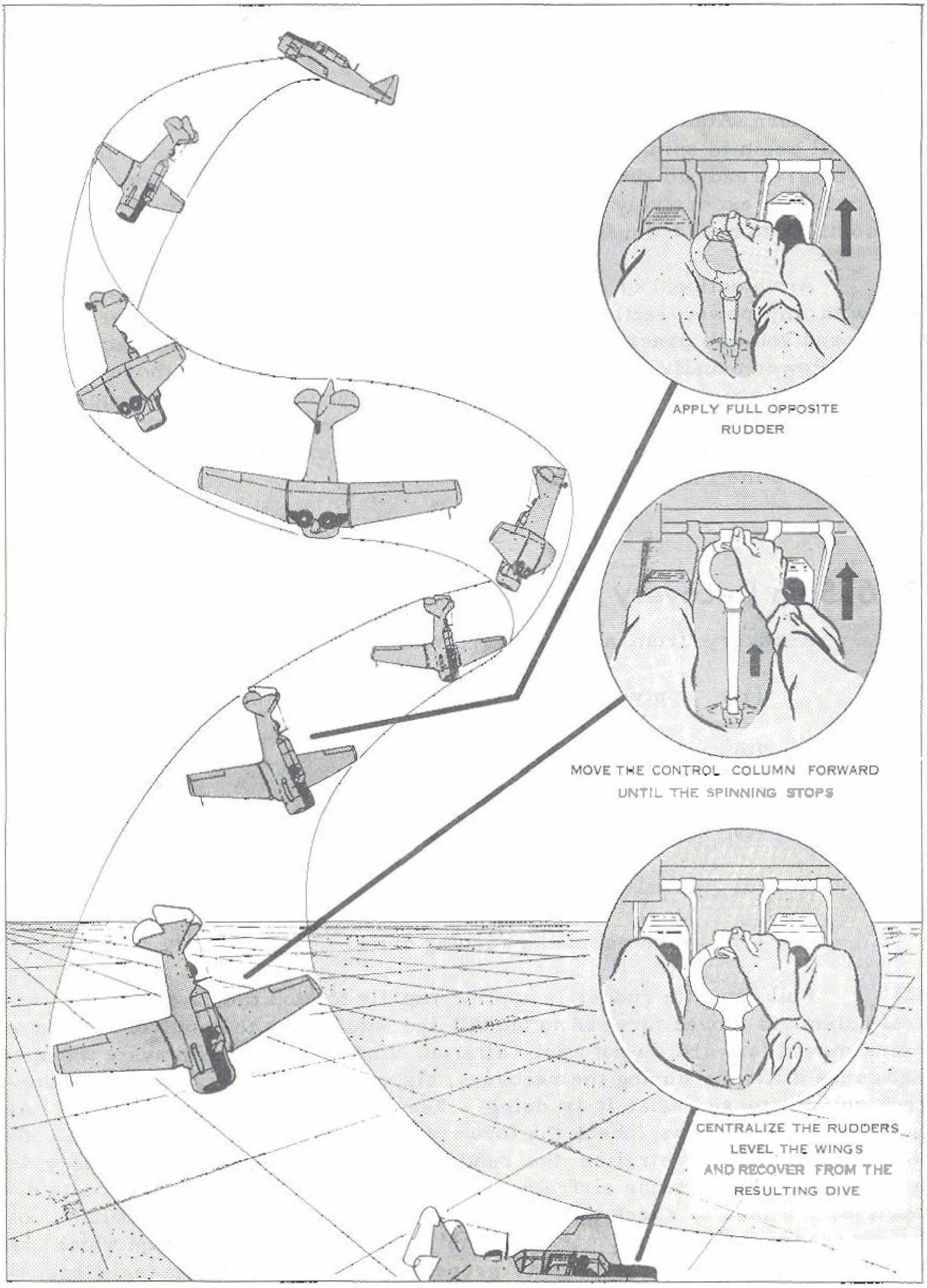

Figure 3: The Spin and Spin Recovery

(3) Level the wings before easing gently out of the dive; remember to ease out GENTLY to prevent a secondary stall and a possible repetition of the stall/spin sequence. When the nose rises above the horizon and the airspeed is slightly below 110K, move the mixture control back to full "RICH" and open the throttle.

7.17 - The Incipient Spin

(1) Immediately after an aircraft stalls and one wing starts to drop, conditions are perfect for the development of a spin. This transitory period between the wing dropping and the start of the spiral flight path is known as an Incipient Spin. The recovery action as outlined below is the same as for a stall when one wing drops.

(a) Move the control column straight forward and, simultaneously, open the throttle to the maximum permissible MP.

(b) Apply sufficient rudder to prevent further yaw.

(c) When the wings become unstalled, level them with aileron.

(d) Raise the nose above the level flight attitude to prevent any further loss of height.

7.18 - Emergency Spin Recovery

(1) Normal spin recovery action should stop the rotation within one or two turns. If the aircraft continues to spin, the following emergency recovery techniques are recommended.

(a) RUDDER - Maintain positive full rudder opposite to the direction of rotation. The slightest slackening of the rudder pressure may give the spin a new lease of life.

(b) ELEVATORS AND THROTTLE - Attempt to induce a pitching motion by holding the control column fully back until 500 feet of height has been lost, then move it fully forward, repeating rythmically and allowing several seconds between each movement. To assist in inducing a pitching motion, the throttle should be opened with the forward movements of the control column, and closed with the backward movements. The elevator trim should be in the neutral position. (Remember that if you are practising spins you will have to pull the mixture control back from "IDLE CUT-OFF" to "RICH" before opening the throttle.)

(c) AILERONS - Aileron applied in the direction of rotation may have some effect.

(d) FLAPS - Since the use of flap may have an adverse effect on the recovery, they should be used only as a last resort.

(2) If after taking emergency recovery action the aircraft does not come out of the spin before reaching the minimum safe altitude as laid down in local flying orders, you must bail-out on the outside of the spin.

7.19 - Dive Recovery

(1) Many of the manoeuvres that you are expected to perform at FTS result in dives, therefore the following information is included here to provide you with a sound knowledge of dive recovery.

(2) Recoveries should always be made smoothly and with a minimum loss of altitude. The maximum speed and "G" limitations of the aircraft must not be exceeded; a red line on the airspeed indicator shows the maximum permissible airspeed as laid down in EOs, but the "G" load can only be estimated. Estimation of the "G" load is simple, since the same factors affect both the aircraft and the pilot. Occasionally, after a particularly tight turn or pull up, you may experience a sensation known as "black out" during which your vision is totally restricted for a short period. This is a normal condition varying from a slight impairment to a complete loss of vision, and is caused by centrifugal force draining blood from the eye tissues, thereby reducing the oxygen content of the retina. If you black yourself out, the aircraft has been subjected to an equal strain, so if you suspect that the airspeed or "G" limitations have been exceeded you must make an entry in the L-14.

(3) During high-speed dives there is a danger of the propeller overspeeding. If the dive is to be made with the throttle closed, the pitch lever must be pulled back to full "COARSE" before the throttle is closed completely. This is in contrast to the normal procedure for a shallow dive, when you would leave the pitch lever at cruising rpm, and throttle back to from 10 to 20" MP. High-speed dives are seldom necessary; however, if you do happen to make one either intentionally or unintentionally you must watch for propeller overspeeding. If overspeeding does occur despite your attempts to avoid it, you must proceed as outlined in Art 7.11(6) and (7).

Chapter 8

Forced Landings

8.01 - Introduction

(1) Engine failure in the Harvard is extremely rare, but every pilot must be prepared for any emergency. The carrying out of a successful forced landing depends on your ability to react promptly and efficiently, without panic - an ability which can only be acquired through conscientious study and practice.

(2) The following paragraphs deal mainly with complete engine failure. In the event of partial engine failure you must be able to make the decision whether to fly to the nearest aerodrome for an emergency landing, or attempt a forced landing. Your instructor will discuss this problem with you and will show you how to reach a decision in various situations.

8.02 - The Loss of Power Check

(1) The Loss of Power, or Fuel-Mixture-Switches (FMS), check is carried out as soon as the engine fails. By doing this check early, it may be possible to determine the reason for the failure and to take action to re-start the engine. The nose of the aircraft should be raised to convert excess speed into height, and, when the airspeed has dropped to 90K, this speed should be held in a gliding attitude. While the airspeed is falling off to gliding speed, you should start a turn in the direction of the nearest aerodrome, close the throttle to prevent the engine from being damaged by any sudden surge of power, and do the following check.

CHECK	HOW	WHY
Fuel	Visually - Pressure.	If the fuel pressure is normal, lack of fuel is not the cause of the failure. If the fuel pressure is low, you should check the

CHECK	HOW	WHY
Fuel (Cont'd)		quantity remaining in the selected tank. If the tank appears to be empty or almost empty, change to another tank and pump with the wobble pump until the pressure is back to normal. If the pressure is low and there is sufficient fuel in the tank, failure of the engine-driven fuel pump is likely. Pumping with the wobble pump may restore the pressure and keep the engine running.
Mixture	Manually - Adjust to the "RICH" range.	Too lean a mixture may have caused the failure.
Carburettor Air	Manually - Select "HOT".	Carburettor icing may have caused the failure.
Magneto Switch	Manually - Check that the magneto switch is at "BOTH".	The switch may have been knocked "OFF" accidentally.

(2) If the FMS check does not rectify the engine failure, you are committed to a forced landing, therefore your subsequent actions must be directed towards achieving a safe landing. Your first step should be to inform someone of your trouble by making a distress call on 121.5 mcs and transmitting your intentions. If you think that you are going to be able to reach the aerodrome, the tower will clear the circuit in expectation of your arrival. The next step is to prepare the aircraft and yourself for the landing.

8.03 - The Forced Landing Check

(1) The Forced Landing Check is basically the Pre-Landing Check, to which "Switches" has been added. When you are doing the Forced Landing Check, each item must be checked consciously so that, for example, if you wish to land wheels-up, the undercarriage lever is left in the "UP" position. The check is as follows:

CHECK	HOW	WHY
Undercarriage	Manually - Select "DOWN", if landing on an aerodrome; otherwise leave in the "UP" position.	A normal wheels-down landing may be carried out on a runway, but, if the aerodrome cannot be reached, then the undercarriage must be left "UP". Leaving the wheels "UP" eliminates the danger of overturning when touching-down on an unprepared surface.
Fuel	Manually - Select "OFF".	To reduce the fire hazard.
Brakes	With the toes - Depress the brake pedals if landing with the undercarriage "DOWN".	To ensure that there is sufficient brake pressure to make the brakes work effectively.
Undercarriage	Visually - Check the indicators and the warning lights.	To ensure that the undercarriage is in the desired position.
Mixture	Manually - Push fully forward to "IDLE CUT-OFF".	To reduce the fire hazard.
Carburettor Air	Manually - Push fully forward to "COLD".	This is the normal procedure for landing.
Pitch	Manually - Adjust according to conditions.	Normally, the pitch lever is pushed forward to "FINE", however, if it is evident that you are to undershoot the desired landing spot, the gliding distance can be increased by moving the lever to "COARSE".

CHECK	HOW	WHY
Harness	Manually - Lock.	Normal safety precaution.
Hood	Manually - Adjust to either fully "OPEN" or fully "CLOSED".	To facilitate abandoning the aircraft after the landing.
Magneto Switches	Manually - Turn to "OFF".	To reduce the fire hazard.
Battery Master	Manually - Switch "OFF" after you have made your last radio transmission.	To reduce the fire hazard.

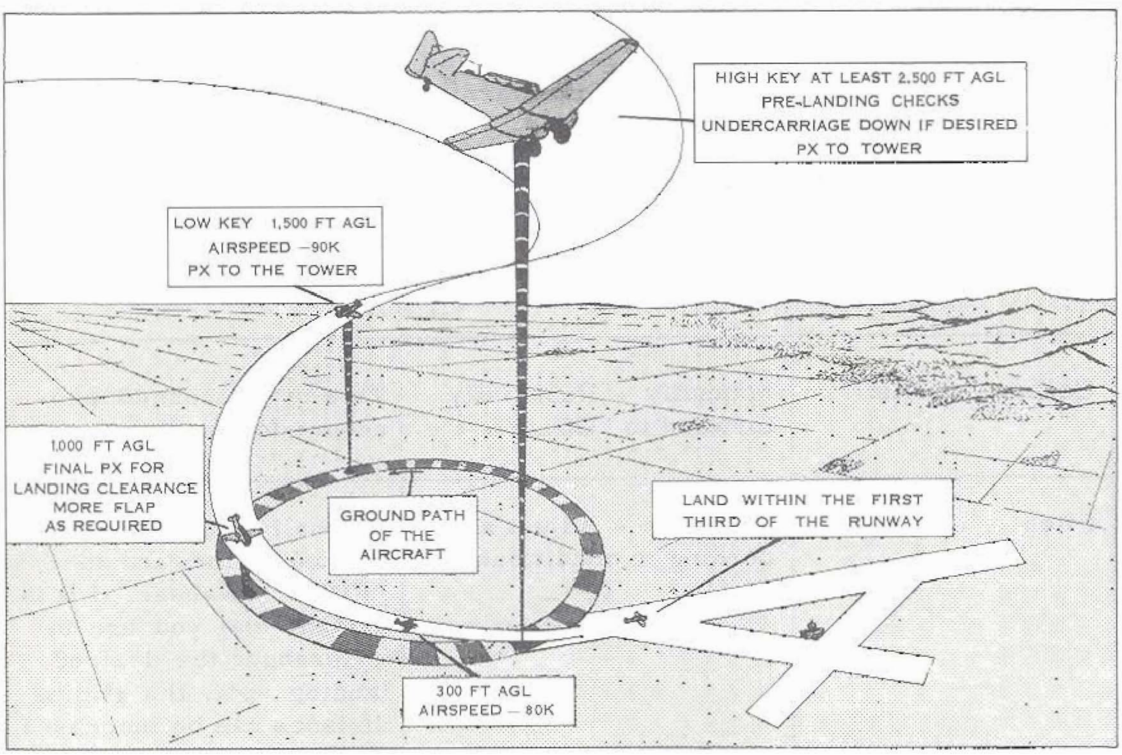

Figure 1: A Forced Landing

8.04 - A Forced Landing on an Aerodrome

(1) If you ever have to do a forced landing in a Harvard, you may be at a height from which you can plan an approach to a nearby aerodrome. While you are running through the FMS and Forced Landing Checks, you should be heading towards the aerodrome in a glide at 90K, regulating your flight path so that the aircraft passes over the button, into wind, at a height of approximately 2,500 feet AGL. This position, as shown in Figure 1 opposite, is known as "High Key". You should be able to judge the rate of descent without difficulty if you remember that a Harvard loses approximately 2,000 feet in a 360 degree, Rate 1 gliding turn with the undercarriage "DOWN". The undercarriage should not be lowered until you have reached a "High Key", but to assist you to lose altitude, it may be lowered sooner.

(2) On reaching "High Key", you must send the tower a position report and at the same time start a 360 degree, Rate 1 gliding turn which will bring you back over the threshold. The rate of turn must be adjusted on the way down to make allowance for wind: depending on the wind strength and direction, you will have to vary the amount of bank used in the turn to avoid drifting too far away, or too close to the runway. The correction for wind during the pattern is shown in Figure 2.

(3) When 180 degrees of turn have been completed, the aircraft should be approximately 1,500 feet AGL in the down-wind position opposite the point of touch-down. As shown in Figure 1, this is the "LOW KEY" position. Here, a second transmission should be made to inform the tower that you are at "Low Key". Any necessary adjustments for wind should be made immediately.

(4) After 270 degrees of turn, with the altimeter reading 1,000 feet AGL, you should ask the tower for landing clearance, and make a decision about the use of flap. The final approach speed should be 80K and you should be aiming to land within the first third of the runway. If flap is to be used to steepen the approach angle, remember that, if you have engine failure, the hydraulic pump will not be working and you will have to pump the flaps down by hand.

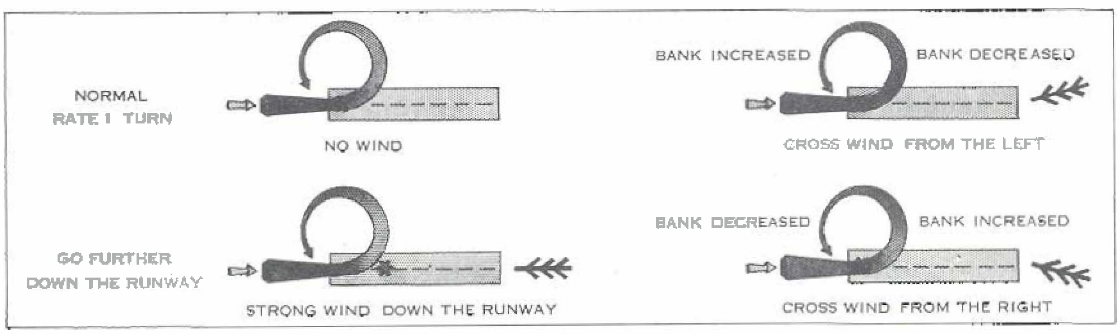

Figure 2: Correcting for Wind on a Forced Landing

8.05 - A Forced Landing in a Field

(1) An alert pilot is constantly on the look-out for suitable forced landing fields. When you find it impossible to reach an established aerodrome, the best location for a forced landing is a level, hard-packed, long, smooth field with no high objects at the approach end or preferably anywhere near it. However, since no guarantee can be given that you are to be near an ideal field when you have engine failure, you must be able to pick out the best available field. Cultivated fields are good, but some fields used for pasturing animals are of doubtful value since they usually contain tree stumps or large boulders. Avoid fields which are crossed by power lines or deep ditches, or which have trees and other natural hazards. If you have a choice, you should select a field near habitation or at least near a road.

(2) When making your choice of a suitable forced landing field, you must take its length into account. If a strong wind is blowing and you land into wind, the space needed for the landing will be comparatively short: if you land down-wind however, this distance will be extended and the field will have to be proportionally longer. Length is only one factor in making the selection: width is equally important. If possible, the chosen field should be wide enough to allow for correction of errors in altitude.

(3) Once the field has been chosen, stick to your choice and prepare the aircraft for a forced landing. Transmit a distress call on 121.5 mcs to let the tower know what has happened, thus enabling them to send assistance as quickly as possible. Carry out the Forced Landing Check, but this time, since you are to be landing on an unprepared surface, leave the undercarriage "UP". A wheels-up landing under such circumstances is good airmanship, since the nature of the field is unknown and there is a danger of the aircraft nosing-over if you attempt a normal three-point landing. The landing pattern should be the same as if you were landing on a runway, but since the wheels are "UP", the gliding distance is greater and an allowance must be made for the extra time it takes to lose height.

(4) If possible, the landing should be made into wind. Nature has many ways of disclosing the direction and strength of the wind, smoke being the most reliable indicator: if smoke rises slowly and drifts off, the wind is light; if it rises and then abruptly drops down close to the earth, the wind is strong or gusty. Grass and grain fields ripple in the direction of wind - dust blows with the wind. If it is impossible to tell from which direction the wind is blowing, land in the direction of the wind at the time of take-off. If it is impossible to land into wind owing to lack of height or a lack of a suitable field into wind, land cross-wind or, as a last resort, land down-wind. Aim to touch down just as soon as the boundary has been crossed, and plan the round-out so that the aircraft touches down in a slightly tail-down attitude. Beware of stalling-in while still some distance above the ground.

(5) The deceleration when landing with wheels "UP" is obviously greater than during a normal landing, but provided you have tightened your harness

securely you should suffer no ill effects. As soon as the aircraft stops, abandon it immediately, since, if the fuel tanks have been punctured, there may be a danger of fire. If after a few minutes there is no evidence of fire, you should remove the forced landing instructions from the baggage compartment, fill out the information requested and, if there is habitation near-by, attempt to notify your unit.

8.06 - Helpful Hints

(1) The following hints are listed to help you carry out a successful forced landing.

(a) If you are landing into wind, the touch-down speed will be reduced by the wind velocity.

(b) If you are landing down-wind, the touch-down speed will be increased by the wind velocity.

(c) When landing anywhere other than on an aerodrome, always leave the undercarriage "UP". This eliminates the danger of nosing-over and shortens the stopping distance considerably.

(d) If you are down-wind of the selected field when the engine fails and you want to lose some excess height before reaching "High Key", you must be aware of the effect of wind on the glide.

(e) The approximate altitudes given in Figure 1 should help you to assess the situation at each stage of the forced landing. Use them to make early corrections.

(f) If you find it impossible to arrive at "High Key" at the height recommended in Figure 1, you should make an attempt to reach "Low Key" at the correct height. Any method you prefer can be used, provided it is a safe manoeuvre and the aircraft does not move too far away from the selected landing place. For example, if you are at 3,500 feet AGL at "High Key", you can glide straight ahead until the altimeter reads 3,000 feet AGL before doing a 180 degree, Rate 1 turn onto the down-wind leg. By continuing on the down-wind leg, you should come to the "Low Key" position at the proper altitude. Similarly, if you cross "High Key" at a height lower than that recommended, your rate of turn should be greater to allow the aircraft to arrive at "Low Key" without losing so much height. If you find that you are low when the engine fails, leave the undercarriage "UP" as long as possible, to improve the gliding range of the aircraft. If you find it impossible to make either "High", or "Low Key" at the recommended heights, DON'T PANIC: concentrate instead on making a good approach at a height which will ensure that you can reach the landing area without stretching the glide.

(g) Use flaps as required to reach the desired landing spot.

(h) Flap may be used at any position from "High Key" down, provided you can be sure of reaching the runway. Remember, however, that it is better to run off the far end of the runway than to undershoot and hit an obstacle on the approach. Normally, the flap lever should be left "UP" until you are turning onto the final approach.

(j) Whatever you do, always remember that you must NEVER STRETCH A GLIDE.

8.07 - Low Altitude Engine Failure

(1) Time is the all-important factor when the engine fails at low altitude. Your own common sense must tell you what to do next, and which checks are most likely to establish the cause of the failure. Keeping the aircraft under control should be your main concern, and a plan of action should be formulating in your brain so that subsequent events occur according to a pattern. To assist you in deciding on a plan of action, some recommendations are given in the following paragraphs; however, you must realize that no two situations are exactly similar, and that your future rests solely in your own ability and judgement. YOU MUST BE ABLE TO REACT PROMPTLY, AND WITH ASSURANCE, IN TIME OF EMERGENCY.

(2) PARTIAL ENGINE FAILURE - With partial engine failure, depending on the amount of power left, you may be able to reach the aerodrome. The decision rests with you, but of course your immediate action must be to find the cause of the failure and try to rectify it. After doing the FMS and Forced Landing Checks, try to maintain altitude if you think you can reach the aerodrome, but keep a constant check on temperatures and pressures for an indication of more serious trouble. If you succeed in reaching the aerodrome, it is advisable to close the throttle and land, using a forced landing circuit pattern. In this way, if the engine fails completely during the landing, you will still be able to make the runway.

(3) ENGINE FAILURE ON THE RUNWAY - If the engine fails on takeoff while the aircraft is still on the ground, close the throttle and apply the brakes. If it is obvious that the aircraft cannot be stopped before it runs off

the runway, and there is a danger of hitting an obstruction, you should ground loop, intentionally. At all costs avoid hitting fences or ditches or similar obstacles which may flip the aircraft over on its back and cause more serious damage. Remember, you can always pull the undercarriage "UP".

(4) ENGINE FAILURE AFTER TAKE-OFF (BELOW 500 FEET) - If the engine fails immediately after take-off, you may only have time to close the throttle, pick a landing path, raise the undercarriage, lower the nose to maintain 80K, and concentrate on making a landing. A slight turn is permissible to reach a suitable, obstruction-free landing path, but it is not wise to turn more than a few degrees either side of a line running straight ahead. Remember that you are attempting to make a SAFE landing: don't worry about too many checks and don't have your head in the cockpit when you should be planning the approach.

(5) ENGINE FAILURE ABOVE 500 FEET (BELOW CIRCUIT HEIGHT) - Engine failure above 500 feet while climbing after take-off gives you a little more time to assess the situation. You should have time to select a suitable field straight ahead, or slightly off to one side. After lowering the nose to maintain 90K, you should close the throttle, complete the FMS and Forced Landing Checks and concentrate on making an approach for a forced landing.

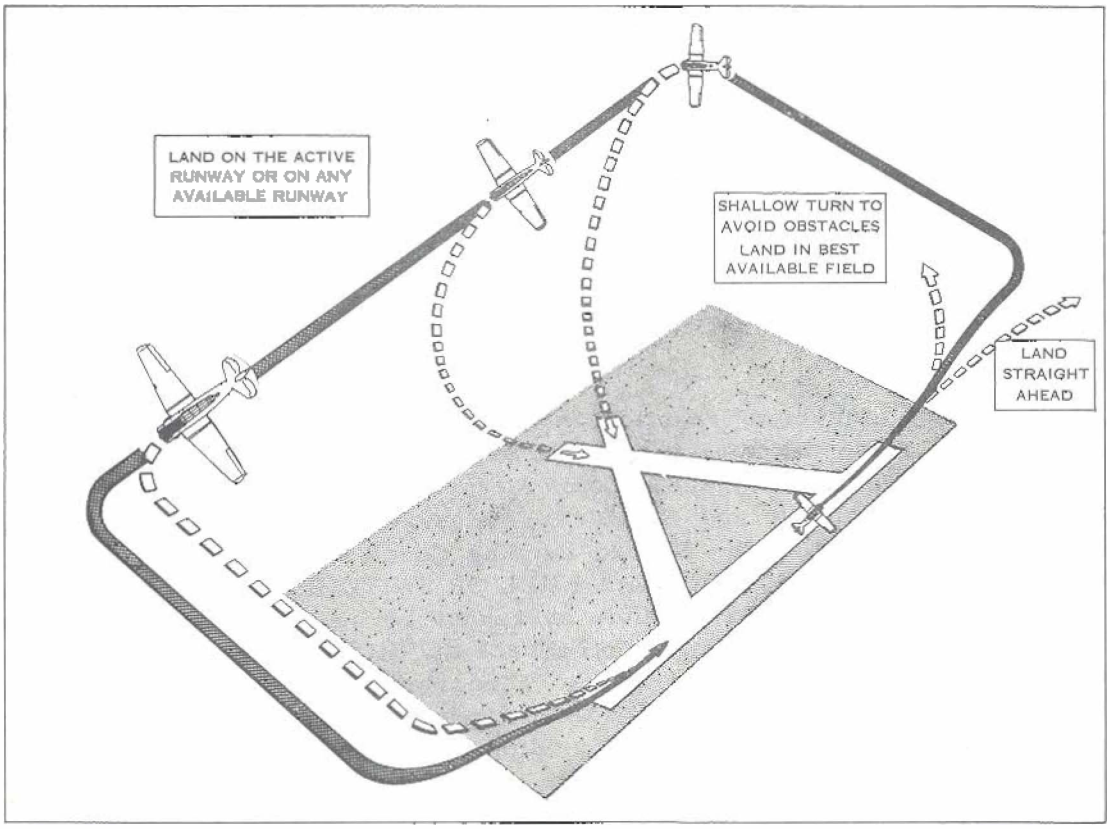

Figure 3: Engine Failure in the Circuit

(6) ENGINE FAILURE IN THE CIRCUIT - When flying a normal circuit, it is highly probable that a forced landing can be completed successfully on the runway in use, or on one of the other runways. (Figure 3 overleaf.) Immediately the engine fails, you should:

(a) lower the nose to maintain 90K;

(b) turn towards the field or runway;

(c) contact the tower and inform them of your intentions;

(d) complete the FMS Check; and

(e) complete the Forced Landing Check.

8.08 - Simulated Forced Landings

(1) Periodically, your instructor will simulate engine failure by closing the throttle and saying "Forced Landing!" over the interphone. These practice engine failures help to prepare you to act promptly and efficiently in any emergency, and are planned to develop accuracy, judgement, planning technique and confidence in your approach to forced landing problems.

(2) To set the aircraft up to give conditions as close as possible to those of a real engine failure, your instructor, after giving you the preliminary warning, will push the pitch lever forward to "FINE", drop 30 degrees of flap and open the throttle to 10" MP. (If the weather is cold, the throttle will have to be set at 12" MP to keep the cylinder head temperature above 100°C.) As the aircraft descends, the MP will increase, but your instructor will make the necessary adjustments to bring it back to the proper setting. The rate of descent with these settings is similar to the rate of descent with engine failure.

(3) Your immediate reaction to the "Forced Landing" announcement should be to raise the nose to convert excess speed into height, and then adopt a gliding attitude at 90K. Complete the FMS check, and at the same time contact the tower and ask for permission to do a Practice Forced Landing (PFL). During the Forced Landing Check you MUST NOT, UNDER ANY CIRCUMSTANCES, TURN THE FUEL OR SWITCHES "OFF"; you should prepare the aircraft for a possible overshoot by switching the fuel to the fullest tank, pulling the mixture control back to "RICH" and checking to make sure that the pitch lever is at "FINE". This change in procedures should not cause confusion during an actual forced landing if you concentrate on what you are doing and above all - THINK! Simply assess the situation and do the checks to meet it.

(4) The final approach on the simulated forced landing is slightly different, owing to the power and flap settings being used to give the relatively

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(4) The final approach on the simulated forced landing is slightly different, owing to the power and flap settings being used to give the relatively

true rate of descent. Having already got 30 degrees of flap down, the remaining 15 degrees are lowered to simulate the first flap lowering, and it is assumed that you have dropped the rest of your flap when you close the throttle.

(5) To simulate engine failure after take-off, your instructor will close the throttle and may give you the audible warning "Forced Landing!": he will NOT make any other adjustments, owing to the proximity of the aircraft to the ground. You will be expected to react IMMEDIATELY as follows.

(a) Adopt a gliding attitude at 80K.

(b) Check that the undercarriage is "UP".

(c) Plan an approach as nearly straight ahead as possible.

(d) Call out the action you would take regarding checks, BUT DO NOT TURN THE FUEL OR SWITCHES "OFF".

(e) Lower flap, when certain of reaching the selected field.

(f) OVERSHOOT when your instructor gives you permission to do so, or WHEN YOU REACH 50 FEET AGL.

Have you completed the form at the end of this publication?

Chapter 9

Accuracy Landings

9.01 - Introduction

(1) Up to this point in your training at PFS and FTS, you have been practising landings without attempting to do more than just concentrate on a safe arrival. From now on, you will be expected to make each landing an Accuracy Landing; ie, each landing will be properly planned so that the aircraft touches down on a fixed spot on the runway. Planning, good judgement and precision flying all contribute to making a landing into an Accuracy Landing, but the development of a high degree of skill can only be achieved by learning a designated technique for each type of landing. Once the air pattern and ground track are fully understood, you can put your new skill to use in making successful arrivals at strange airfields, or in completing a safe, emergency landing. From the beginning you should realize that there is no mystery connected with Accuracy Landings: the spot is selected, and you touch down on that spot.

9.02 - Planning the Landing

(1) When you are coming in to land, your instructor will designate a particular spot on the runway for the touch down, if there isn't a recognized spot-landing mark, he may pick the runway direction figures or a taxi-strip intersection. If you are going to land accurately on this spot, you must start to plan backwards, using the spot as a datum.

(2) Going backwards, the first imaginary point to be selected is the area of the round-out. Its position will vary according to the wind strength, being closer to the touch-down spot if the wind is strong. Remember that there isn't much you can do once you have made the necessary control movements to effect the round-out: you can only carry through the landing to its conclusion. This means that the point of touch down depends wholly on the round-out, hence the importance of making an accurate estimation.

(3) Working back from the round-out, you can plan the position of the turn onto the final approach, as well as where to lower flap and make power

changes. To start with, your judgement may be somewhat less than perfect, but with practice, your proficiency will grow. Within a short time, you will be planning approaches without making a conscious effort to go through each step.

9.03 - The 90° Power-On Approach

(1) The 90° Power-On Approach is designed to increase your proficiency in power-on approaches as used by high-performance aircraft. The term "90° Power-On Approach" is based on the fact that the last power adjustment is made on the base leg, at 90 degrees to the touch down. The circuit is normal until after the turn onto the base leg. After doing the Base Leg Check, you may lower 15 degrees of flap, and select a suitable throttle setting to carry the aircraft to the round-out position. An airspeed of 90K should be held until after the final turn, when a reduction to 80K should be made. Additional flap may be dropped to regulate the descent, but it is not desirable to lower flap too close to the round-out position. NEVER RAISE FLAP ON AN APPROACH.

(2) If the correct power setting has been used and enough flap has been lowered at the right time, the round-out should come at the proper time to allow you to land on the touch-down spot. Estimating the correct throttle setting on the base leg is the main consideration for this type of approach. But judicious use of flap is permissible to help you to make a landing within the limits prescribed. If you find that your judgement has not been good enough and the aircraft is either high or low on the approach, it is pointless to continue the exercise as a "power-on" approach: you should continue to make a normal landing. If the error is too great for you to be able to salvage the approach with reasonable corrections, OVERSHOOT and try again. Try to analyse your mistakes and make suitable corrections on subsequent circuits.

9.04 - The 90° Power-Off Approach

(1) The Power-Off Approach is taught to improve your judgement of gliding angles and distances, and to aid in developing your landing proficiency. A normal traffic pattern is flown to the point on the down-wind leg where you are ready to roll onto the base leg. The turn should be started earlier than for a normal, power-on approach, and the wind speed and direction must be taken into account, along with the fact that the throttle will be completely closed within the next few minutes. Maintain the correct circuit altitude while correcting for drift, and, at a pre-selected position, close the throttle and carry out the Base Leg Check.

(2) As soon as the throttle is closed, you should raise the nose to maintain altitude until the airspeed decreases to 90K, whereupon you should lower

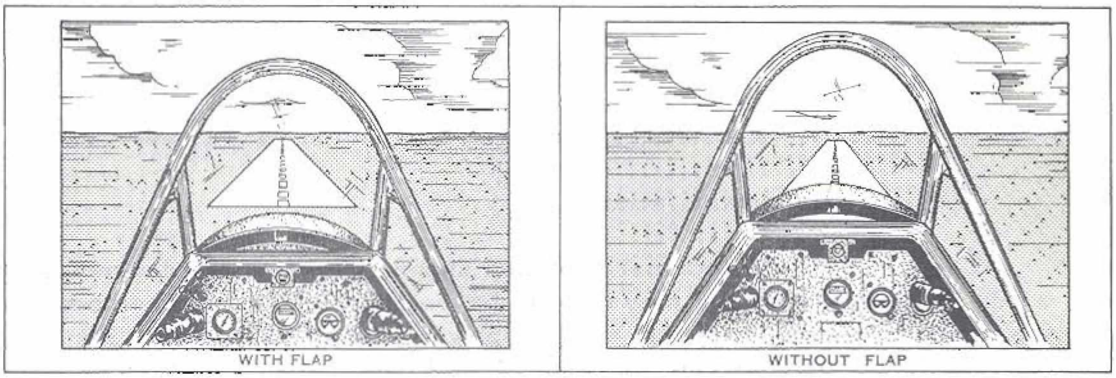

Figure 1: The Power-off Approach Attitude

the nose and trim the aircraft to maintain a gliding attitude. The turn onto the final approach must be judged properly, so that the aircraft is lined-up with the runway on rolling-out. On the final approach, the airspeed should be reduced to 80K. Flap may be lowered if necessary and the aircraft should be retrimmed constantly, according to the various changes of attitude. If you have judged the approach properly to this point, the nose of the aircraft should appear to be aimed just short of the desired landing spot. Naturally, the stronger the wind, the nearer the nose should be to the landing spot.

(3) When you are satisfied that the gliding attitude is correct and that you have enough flap down, concentrate on making a good three-point landing without worrying about the spot. Your actions on the base leg and during the early part of the final approach regulate the location of the landing. During the final stages, therefore, it is better to concentrate on making a good three-point landing two hundred feet from the spot, then to make a bad landing on the spot. After landing you should remember the techniques used and, having analysed your faults, you should try again.

(4) If the wind is light, or if you have turned onto the base leg too soon, you should close the throttle sooner, and vice versa. When there is a cross-wind blowing, you should use the approach techniques described in Article 6.06 to make allowances for drift. The use of flap on the base leg is optional, but should not exceed 15 degrees; a requirement for more flap means that your judgement in turning onto the base leg has been poor, therefore you should delay the turn on the next circuit. You should not lower flap when turning onto the final-approach leg. Figure 1 has been prepared to illustrate the approximate approach attitude, full flap landing versus flapless landing.

9.05 - Short-Field Landings

(1) The Short-Field Landing technique taught at FTS, while not necessarily being the best for the Harvard, is applicable to the high-performance aircraft that you will be flying one day. The object of practising these landings is to:

(a) touch down as close to the threshold of the runway as possible; and

(b) stop in the shortest possible distance, because of

(i) a short, slippery, or obstructed runway, or

(ii) brake failure.

(2) The circuit is of normal size and shape, except that, depending on the wind, the down-wind leg may have to be extended slightly to compensate for the changed angle of approach. The power setting selected at the Base Leg Check should be between 10" and 12" MP and, after the turn onto the final approach, you must lower full flap before reducing the airspeed to 70K. The proper speed and attitude for the final approach must be attained before the aircraft reaches 300 feet AGL. As in other Accuracy Landings, a predetermined spot is selected for the touch down, and you should be aiming sufficiently short of the spot, while making due allowance for wind, to enable the aircraft to round-out and touch down on the spot. The purpose of the lower airspeed and the consequently higher nose attitude is that there is a smaller attitude change during the round-out, and this, in turn, gives a shorter float period.

(3) The round-out and touch down are similar to those of a normal landing, except that as you start the round-out, gradually close the throttle to allow the aircraft to touch down on the desired spot. The time to close the throttle depends on the surface wind: if the wind is light, the longer float period must be expected, therefore the throttle must be closed earlier, and vice versa. Good planning and judgement are paramount at this stage of the landing. The perfect Short-Field Landing is one in which the throttle is closed and the round-out completed at exactly the right moment, so that the aircraft sinks onto the landing spot in the three-point attitude. If you find that you have rounded-out prematurely, it is permissible to open the throttle slightly to delay the touch down. Long, drag-in approaches, or power-off approaches, merely demonstrate poor planning and judgement, as well as failure to grasp the whole purpose of the exercise. If you find yourself in such a position, overshoot and try again.

(4) During the after-landing roll the brakes should be applied, if they are available, to stop the aircraft in the shortest possible distance, but you should remember that the Harvard is likely to nose-over if the brakes are used improperly. When the speed is high, strong brake pressure can be applied - provided the control column is held well back; as the speed decreases, so must the brake application.

Chapter 10

Co-ordination Manoeuvres

10.01 - Introduction

(1) As the name implies, co-ordination manoeuvres are taught to develop your co-ordination: they increase your ability to plan ahead, and foster a sense of timing. All of these attributes are necessary if you are to become expert at flying, and conscientious practice is needed to attain the required standard of proficiency. The two manoeuvres comprising this exercise are the Chandelle and the Lazy Eight.

(2) Before attempting either sequence you must complete the following check.

CHECK	HOW	WHY
Gyros	Manually - Cage.	To prevent damage should the limits of the instruments be exceeded during the exercise.
Throttle	Manually - Set at 25" MP.	"Normal cruise" is the power setting used for this exercise.
Pitch	Manually - Set at 1750 rpm.	"Normal cruise" is the most efficient propeller setting for these manoeuvres.
Mixture	Manually - Leaned.	To achieve smooth running.

CHECK	HOW	WHY
Undercarriage	Visually - Check "UP"	The undercarriage must be "UP" so that the maximum performance of the aircraft can be exploited during these manoeuvres.
Flaps	Visually - Check "UP".	The flaps must be "UP" so that the maximum performance of the aircraft can be exploited during these manoeuvres.

(3) Since both manoeuvres are clearing turns in themselves, no other clearing turns are needed. But a GOOD LOOK-OUT both AWAY FROM and IN THE DIRECTION OF the turn is essential before entering and while performing Chandelles and Lazy Eights.

10.02 - The Chandelle

(1) The Chandelle is a precision 180 degree, climbing turn giving a maximum gain in altitude. From straight and level flight the aircraft is flown parallel to a reference line, such as a straight road or a section line, and is put into a shallow dive. When the airspeed reaches 140K, you must blend aileron, rudder and elevator pressures, simultaneously, to begin a climbing turn in the desired direction. (Figure 1 opposite) Keep the nose rising and the bank increasing steadily until there is 60 degrees of bank at 90 degrees of turn. As you approach this point, the vertical component of lift decreases to such an extent that you must apply back pressure to keep the nose rising at a constant rate.

(2) As soon as the aircraft has turned through 90 degrees, begin to roll off the bank, but still keep the nose rising at the previously established constant rate. With the decrease in bank the vertical lift component increases slightly, and the amount of back pressure on the control column must be relaxed if you are to keep the nose from rising too rapidly. You must time the roll-out so that the wings are level upon reaching 180 degrees of turn, and the nose is at its highest pitch attitude. Hold this attitude momentarily, then lower the nose to level flight before the aircraft stalls. It should not be necessary to lower the nose to prevent a stall before the wings are level.

(3) Proper use of the rudder throughout the manoeuvre is required for true co-ordination. For example, if you are to do a Chandelle to the left, a normal amount of left rudder is needed to offset the effects of aileron drag

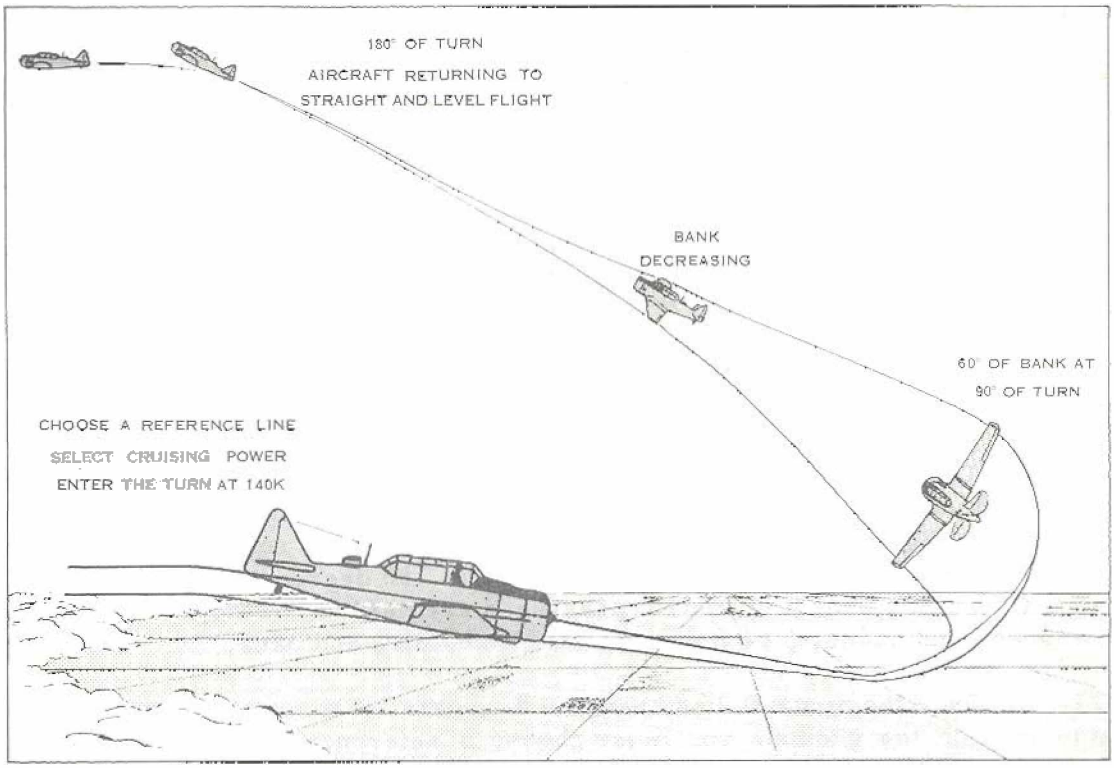

Figure 1: The Chandelle

as you start to roll into the initial climbing turn. Close to the 90 degree point the decreasing airspeed causes the aircraft to have a tendency to yaw to the left, so right rudder is needed to keep the ball in the centre. Later, when you begin to apply right aileron to start the roll-out, the down-going aileron on the left wing causes aileron drag, thus aggravating the yaw caused by the reduced airspeed. This means that still more right rudder is needed to maintain co-ordinated flight. As the control column is centred and the wings become level, aileron drag disappears, but some right rudder must be kept on to keep the ball in the centre. As long as the airspeed is decreasing, the yaw to the left is increasing.

(4) A Chandelle to the right is essentially the same as one to the left, up to the point of 90 degrees of turn. As the airspeed decreases, more right rudder is needed to offset the yaw induced by the decreasing airspeed. When left aileron pressure is applied to start the roll-out, however, the down-going aileron on the right wing causes aileron drag, and tends to yaw the nose to the right. Thus, the two yawing forces oppose each other, and very little rudder pressure is needed for co-ordinated flight: you may even have to relax some of the right rudder pressure previously applied. You must remember however, that when the wings become level aileron drag disappears, necessitating increased rudder pressure to the right, to counteract the effect of the continuing yaw to the left.

(5) You must bear in mind that while the bank increases to 60 degrees and then comes back to level flight, giving 120 degrees of change, the pitch attitude of the aircraft only changes 50 to 60 degrees. This means that the rate of roll into the turn must be at a faster rate than the amount of pull-up applied. Also, if the rate of pull-up is fast, then the rate of turn must be correspondingly fast to reach the 180 degree point before the aircraft stalls. Conversely, if the rate of pull-up is slow, then the rate of turn must be slow so that the 180 degree point is reached before the aircraft stalls. The primary purpose of the manoeuvre is to improve your co-ordination, therefore you must practise it in both directions and concentrate on keeping the controls co-ordinated throughout the entire manoeuvre.

10.03 - The Lazy Eight

(1) The lazy eight is a slow, lazy manoeuvre in which the nose of the aircraft describes a horizontal figure 8 on the horizon, the horizon line bisecting the figure 8 from end to end. The manoeuvre requires continuous changes of pitch and bank attitude through two 180 degree changes of direction. Constantly changing control pressures are needed, owing to the varying airspeeds and changing combinations of climb, dive and bank.

(2) Once the aircraft has been lined-up parallel to a road or other suitable line on the ground, you must choose a reference point on the horizon directly off the wing tip. By blending aileron, rudder and elevator pressures together, you can start a gradual climbing turn in the direction of this reference point. The initial degree of bank should be very shallow to prevent the rate of turn from becoming too rapid. Remember that the rate of turn depends on the degree of bank and the airspeed, therefore, as the nose is raised and the airspeed starts to drop off, the rate of turn tends to increase. Unless the initial turn is shallow, the ensuing rapid rate of turn may cause you to overshoot your reference point.

(3) The pull-up should be timed so that the nose reaches its highest pitch attitude of 45 degrees above the horizon, when there are 45 degrees of bank and 45 degrees of turn. At this stage you should release some of the back pressure to lower the nose towards the reference point. As the airspeed decreases, the amount of yaw to the left increases. Aileron drag is present to a certain extent, depending on the amount of aileron pressure applied, therefore varying amounts of rudder pressure are required to keep the aircraft in co-ordinated flight.

(4) While the nose is being lowered towards the reference point, you must continue to increase the bank until it is approximately 80 degrees as the aircraft cuts through the horizon. At this point the aircraft should have turned through 90 degrees, and a small amount of opposite aileron may be needed to keep the bank from becoming too steep. The lowest airspeed should be attained just before the nose reaches the horizon, and it should be about 60K

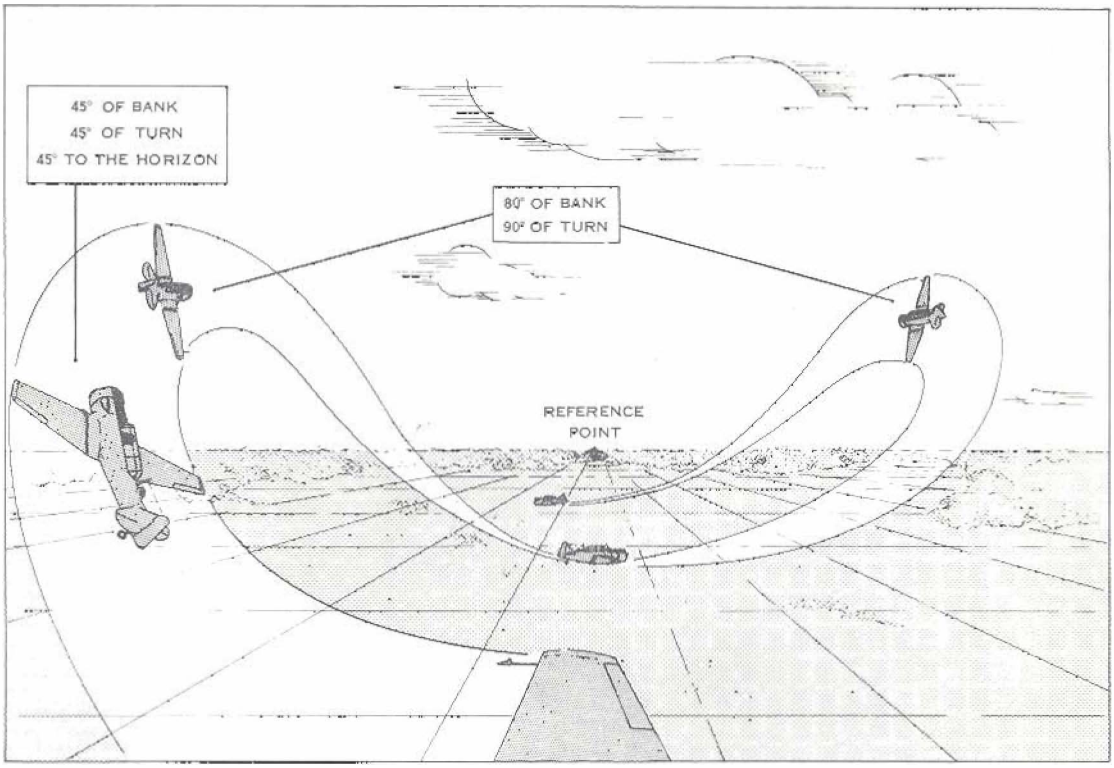

Figure 2: The Lazy Eight

lower than the normal cruising speed used at the beginning of the manoeuvre. From here, the aircraft is allowed to continue down in a descending turn so that the nose follows the same path below the horizon as it did above the horizon.

(5) As the nose passes through the reference point, you must start to decrease the bank and increase the back pressure so that, at the lowest pitch attitude of 45 degrees below the horizon, the aircraft is banked at 45 degrees and has turned through 135 degrees. Continue raising the nose and rolling off the bank until, at the horizon, the wings are level and the aircraft has turned through 180 degrees. As the airspeed increases on the way down in the descending turn, the yaw to the left gradually disappears, but the effect of aileron drag remains as long as aileron is being applied. The correct amount of rudder pressure must be used throughout, to keep the manoeuvre co-ordinated. The only place where the wings are level is at the 180 degree point and, here, the reference point is on the opposite wing tip. In addition, the airspeed should be back to the original reading at which the exercise was started.

(6) The wings should not be allowed to remain level at the 180 degree point, since the lazy eight is only half finished. (Figure 2) Immediately, you should start a climbing turn in the direction of the reference point and complete the second half of the manoeuvre, as described in paragraphs 3, 4 and 5.

At the end, the aircraft should be flying on the original heading at the original airspeed and altitude.

(7) The whole manoeuvre should be accomplished in a slow, lazy manner, without hesitation, and with constantly changing control pressures and flight attitudes. You must not allow the wings to reach the horizontal position before the nose reaches the horizon. Doing so flattens out the end of the Lazy Eight and puts it out of shape. To start with, you should try to fly the pattern correctly, keeping the aircraft in co-ordinated flight and without worrying too much about airspeed or attitude. Later, with practice, you should be able to make the necessary adjustments to attain the proper conditions of flight.

Chapter 11

Aerobatics

11.01 - Introduction

(1) At PFS, near the end of the course, your instructor will have introduced you to the loop and the slow roll. Now you are going to have a chance to perform these solo and, in addition, you will learn to do advanced and multiple aerobatics.

(2) The purpose of teaching aerobatics is to help you to develop a more sensitive feel when handling the aircraft, and to improve your ability to co-ordinate the controls in any attitude of flight. Learning to perform these sequences skilfully should give you more confidence in your own flying ability: you will become more familiar with all attitudes of flight, and you will know how to fly the aircraft to its maximum. You will be taught how to recover from abnormal attitudes and, gradually, your confidence will build up until you have complete mastery over the aircraft. Remember that confidence in the aircraft is just as important as being able to do the manoeuvres themselves.

11.02 - The Pre-aerobatic Check

(1) Before attempting any aerobatic manoeuvre, you must be certain that the aircraft is properly prepared for this type of flying and that the area is clear. The Pre-Aerobatic Check is identical to the one done before stalling or spinning, and is outlined in Art 7.07.

(2) Again, you are reminded of the ever-present danger of other aircraft near you, and of the need to be continually on the look-out. Your instructor will show you how to clear the area according to the complexity of the aerobatic sequences and how to keep a good look-out during each exercise. Remember that there is a minimum altitude restriction of 3,000 feet AGL.

(3) The normal throttle setting for aerobatics is 28" MP, but you should keep your hand on the throttle all the time, so that should the engine cut out you can take the remedial action outlined in Art 7.11 (6) and (7) to prevent propeller overspeeding.

11.03 - The Loop

(1) As shown in Figure 1, a loop is a 360 degree turn in the vertical plane; consequently it is mainly controlled by the elevators; the ailerons and rudder being used for co-ordination and maintaining direction. During the clearing turns you should pick a ground reference, such as a straight road or section line, to keep the aircraft orientated directionally.

(2) To start the exercise the airspeed must be 155K, and the best way to build up this speed is to dive the aircraft through the last clearing turn. As the airspeed approaches 155K, roll out of the turn parallel to the reference line and release the forward pressure, thus raising the nose smoothly to the horizon as the airspeed reaches 155K. Just before the nose reaches the horizon, exert increasing back pressure until the aircraft is moving upwards at a constant rate. Hold the wings level with aileron and keep directional control with rudder. Remember, changing airspeeds require changing applications of rudder.

(3) During the pull-up, centrifugal force will cause you to feel that you are being pressed down into the seat: this pressure can be used to help you to judge the proper rate of movement. If there is very little seat pressure, the rate of pull-up is not fast enough, and vice versa. When you can no longer see the horizon ahead, look out at the wing tips and keep them equidistant above the horizon with aileron. Maintain steady directional control. When the wing tips appear to be vertical to the horizon, move your head back until you can see the approaching horizon on the other side of the loop. Use this new horizon as a datum line for keeping the wings level, and for maintaining direction.

(4) Approaching the inverted position a small amount of back pressure should be released, but not enough to remove the centrifugal pressure. This is done to prevent a stall at the low airspeed encountered at the top of a loop. As the airspeed decreases, right rudder pressure must be increased to counteract yaw and thus maintain direction. Most right rudder pressure is needed at the top of the loop where the speed is lowest. Shortly afterwards, as the nose descends through the horizon, the back pressure will have to be reapplied to keep the nose moving back to the level-flight attitude at a constant rate. As the speed builds-up in the descent, the right rudder pressure must be released to keep the nose parallel to the reference line. Seat pressure should be definite and fairly steady throughout the

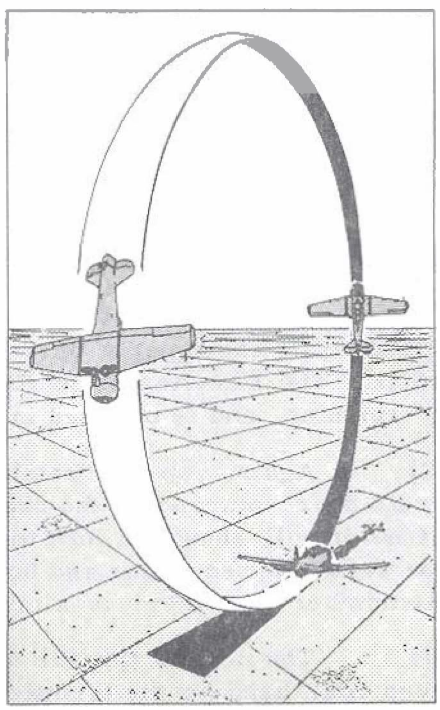

Figure 1: The Loop

entire loop, until the nose returns to the level-flight attitude. The airspeed at recovery should be the same as it was during the entry: 155K.

(5) Remember that the amount of back pressure applied must be just right. If you use too much, the angle of attack will increase too rapidly and the aircraft will stall; if you use too little, there will not be enough momentum to carry the aircraft around the loop, and it will stall. Try to keep the nose moving at a constant rate, fast enough to give a definite seat pressure from the start of the pull-up through to the moment of recovery. Remember, also, that too much back pressure in the final stages of the recovery may precipitate a high-speed stall.

11.04 - The Slow Roll

(1) A slow roll is an aerobatic manoeuvre in which the aircraft, controlled by the ailerons, is rolled through 360 degrees around its longitudinal axis. The rudders and elevators are used to maintain the desired nose position, the nose describing an ellipse on the horizon in the direction of roll.

(2) The slow roll is started by diving the aircraft through the last clearing turn. (Figure 2 overleaf) As the airspeed approaches 140K, a reference point on the horizon directly above the nose is used for direction, and the nose is raised through this point to a position slightly higher than the three-point attitude. As the nose passes through the horizon, the airspeed indicator reading should be 140K. The wings are kept level with aileron. The back pressure is released to stop the upward travel of the nose, and aileron is blended in to make the aircraft roll (Point B in Figure 2). Rudder is applied as needed to co-ordinate the control movements and to counteract any aileron drag. As the bank increases, the nose tends to sink and swing off, a tendency which can be controlled with forward pressure on the control column and a slight relaxation of the rudder pressure (C). Care must be taken to avoid negative "G". (Points D and E.)

(3) A constant rate of roll must be maintained throughout the slow roll. At point F the forward pressure is released slowly, and rudder in the direction of the roll is applied to keep the nose from dropping too quickly and to help in maintaining direction. As the airspeed begins to build up in the last 90 degrees of the roll, you must relax some of the aileron pressure at point H. At the same time a smooth back pressure is substituted for the forward pressure, to bring the nose up to the level-flight attitude. Rudder is needed to co-ordinate the last part of the roll, and to bring the nose back to a position directly under the reference point on the horizon. As soon as the wings become level, all of the controls should be centralized. The illustration in Figure 2 overleaf is of a slow roll to the right, but of course, you must practise rolls in both directions.

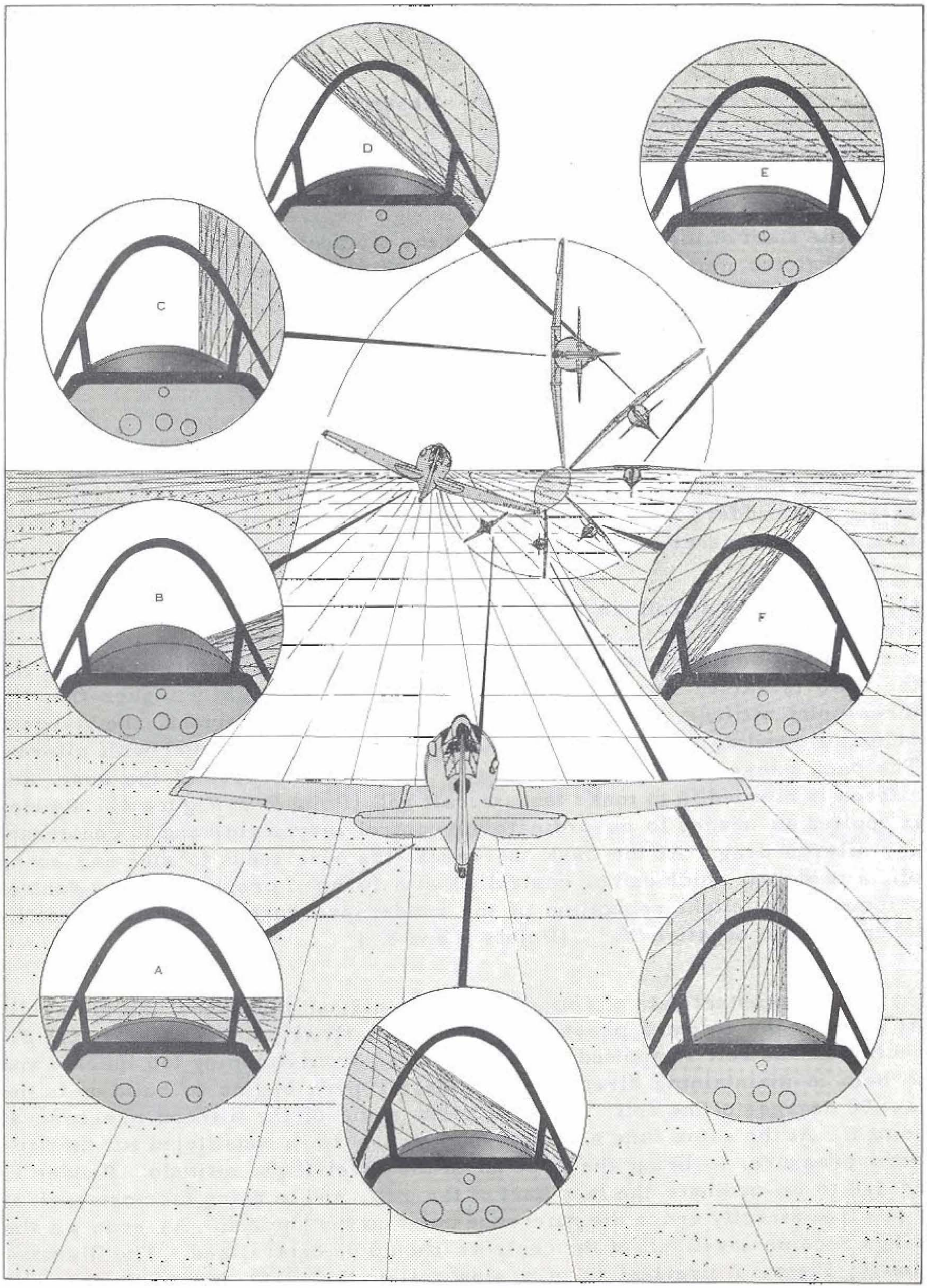

Figure 2: The Slow Roll

11.05 - The Barrel Roll

(1) A barrel roll is a co-ordinated manoeuvre in which the nose of the aircraft describes a circle around a point on the horizon; the roll starts with the nose on the horizon, the wings level and the airspeed at 140K; it ends in the same way.

(2) While flying straight and level (Figure 3, Aircraft A), pick a reference point on the horizon 45 degrees off the nose, in the direction of the desired roll. Dive the aircraft straight ahead and, as the speed approaches 140K, ease back on the control column to raise the nose up through the horizon. As the nose passes through the horizon and the airspeed reaches 140K, blend in co-ordinated aileron and rudder pressures to keep the nose rising, and to bank the wings in the direction of the reference point.

(3) At 90 degrees of roll when the wings are vertical (Aircraft B), the fore and aft axis of the aircraft should be at an angle of approximately 45 degrees to the horizon, giving a nose-high attitude. The roll is continued through Point C, where some of the back pressure should be released, while some aileron pressure is being applied to maintain the constant rate of roll. The rudder pressure should be regulated to keep the aircraft in co-ordinated flight. At the horizon the aircraft should be completely inverted, and you should start to decrease rudder pressure in the direction of the roll.

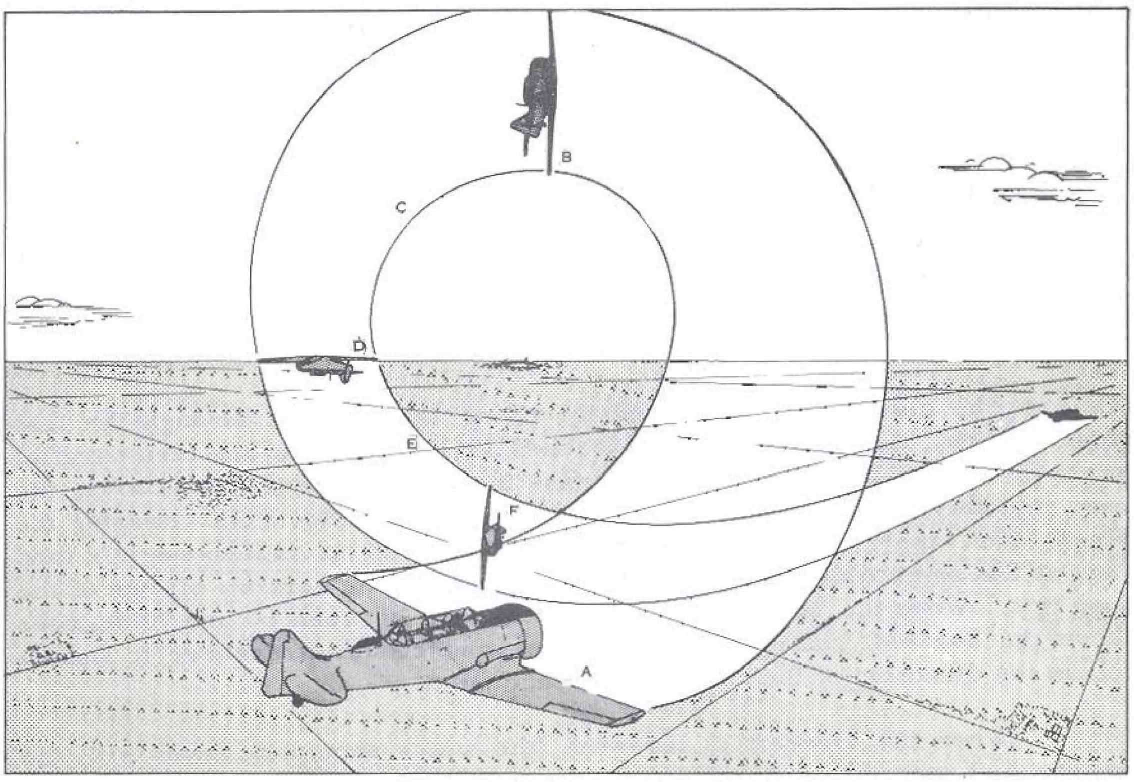

Figure 3: The Barrel Roll

(4) When Point E is reached, back pressure is re-applied so that by the time the aircraft is in position F, the wings are vertical and the nose is at a 45 degree angle to the horizon immediately below the reference point. The aileron pressure is decreased to keep the aircraft rolling at a constant rate until, just as the nose returns to the horizon, the wings become level. The exercise should finish in the same spot relative to the reference point from which it began.

(5) To gain maximum proficiency, you must practise the barrel roll to the left and to the right, until you can do it equally well to either side. It may help you to understand the manoeuvre better if a further examination is made of the important points. Probably you have been asking yourself, "Why must I blend in more aileron pressure when the aircraft is at the highest point in the roll, with the wings vertical?" The answer, of course, is that as the nose is rising the airspeed is diminishing and the ailerons are becoming less effective. If a constant aileron pressure is held, the roll will slow down at this point unless more aileron surface is presented to the airflow. Later, as the airspeed builds up, this extra pressure has to be relaxed to avoid speeding up the rate of roll. Similarly, the control column back pressure is relaxed at Point C to keep the rate of turn constant, and is reapplied at Point E for the same reason. You will recall that the aileron on the outside of the roll is the one that creates most drag and that aileron drag is overcome with rudder. After Point F, the rudder pressure must be relaxed gradually to keep the desired control co-ordination.

11.06 - The Clover Leaf

(1) A clover leaf is a complex manoeuvre in which portions of the loop and roll are combined, as shown in Figure 4 opposite. The basic reference for this exercise is the point at which two ground feature lines intersect at 90 degrees.

(2) The clover leaf is started by diving the aircraft through the last clearing turn. As the airspeed approaches 155K, roll out of the turn parallel to one of the reference lines, and release the forward pressure to bring the nose smoothly through the horizon as the airspeed reaches 155K. Keeping the wings level, apply back pressure to bring the nose up as if to begin a loop and, at the same time, select a reference point on the horizon off one of the wing tips. When the nose is at a pitch attitude of between 60 and 70 degrees above the horizon, you must blend aileron and rudder pressures to start a roll in the direction of the chosen reference point.

(3) When the aircraft is inverted, the wings should be level with the horizon and you should have turned through 90 degrees from the starting point. The back pressure is maintained after the inverted position so that the aircraft is pulled-through parallel to the second ground reference line:

the wings are kept level with aileron and direction is controlled with rudder. Keeping the nose moving at a constant rate, the pull-through is timed so that the airspeed is 155K as the nose cuts the horizon.

(4) The remainder of the clover leaf is a repetition of the foregoing procedure, the aircraft being rolled four times IN THE SAME DIRECTION, so that the exercise finishes on the same heading as it started. Remember that the rate of roll must be constant, so that the aircraft is inverted, with the wings level, immediately over the reference point on the horizon. If the aircraft fails to turn through the complete 90 degrees before it becomes inverted:

(a) the rate of roll is too fast;

(b) there is insufficient back pressure; or

(c) there is too much back pressure.

If it turns through more than 90 degrees, the rate of roll is too slow. You should practise clover leafs in both directions until your co-ordination is perfect and the pattern is uniform.

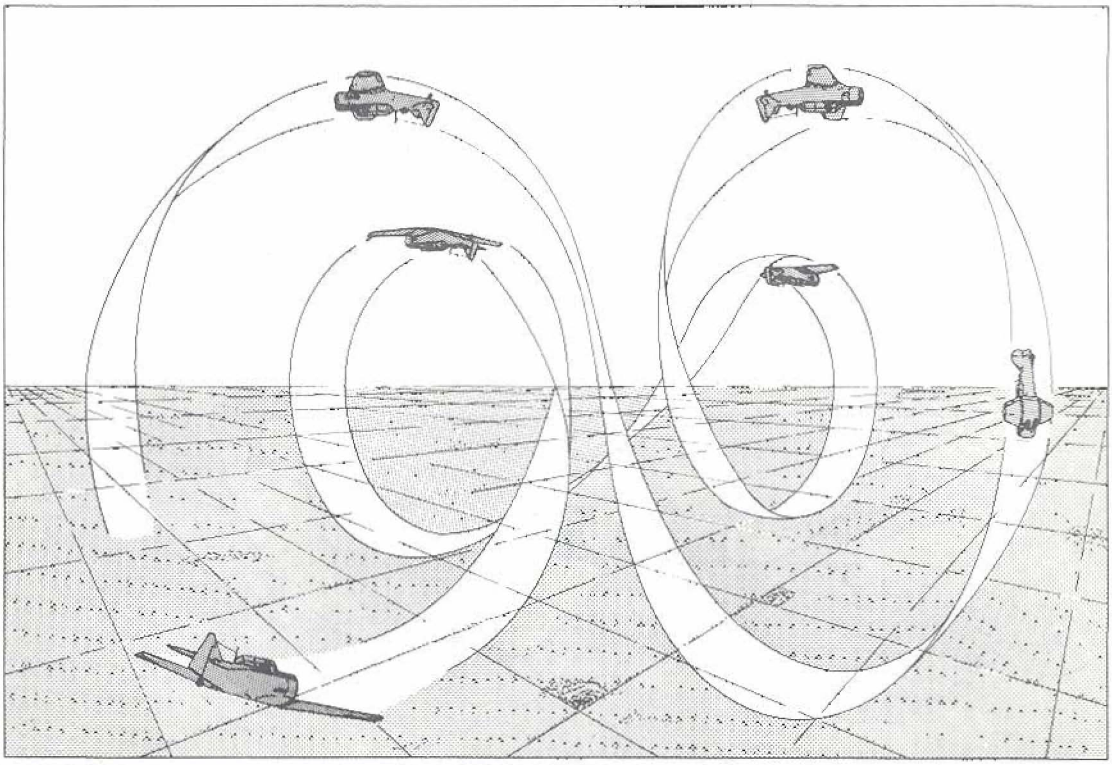

Figure 4: The Clover Leaf

11.07 - The Cuban Eight

(1) A cuban eight is a manoeuvre combining portions of the loop and the slow roll. The airspeed, the method of entry and the initial stages of the exercise are the same as for the loop, up to the point of the aircraft becoming inverted. Here, after checking the approaching horizon, you must look beyond it to a spot approximately 45 degrees lower, and pick a suitable reference point. As the nose nears this point, release the back pressure and begin a half roll around the spot, co-ordinating aileron and rudder pressures. During the roll, as the wings become vertical you will have to apply forward pressure along with gradually increasing top rudder to maintain directional control. As soon as the wings become level, centralize the controls and start a pull-up at a constant rate to achieve an airspeed of 155K as the nose cuts through the horizon. Repeat this procedure, rolling in the opposite direction as shown in Figure 5, and finishing up on your original heading with an airspeed of 155K.

(2) If the airspeed is higher than 155K when the aircraft passes through the horizon, or if excessive back pressure has been necessary during the pull-up, your reference point for the roll-out has been more than 45 degrees below the horizon. If you have had to lower the nose to achieve 155K, your reference point has been too close to the horizon.

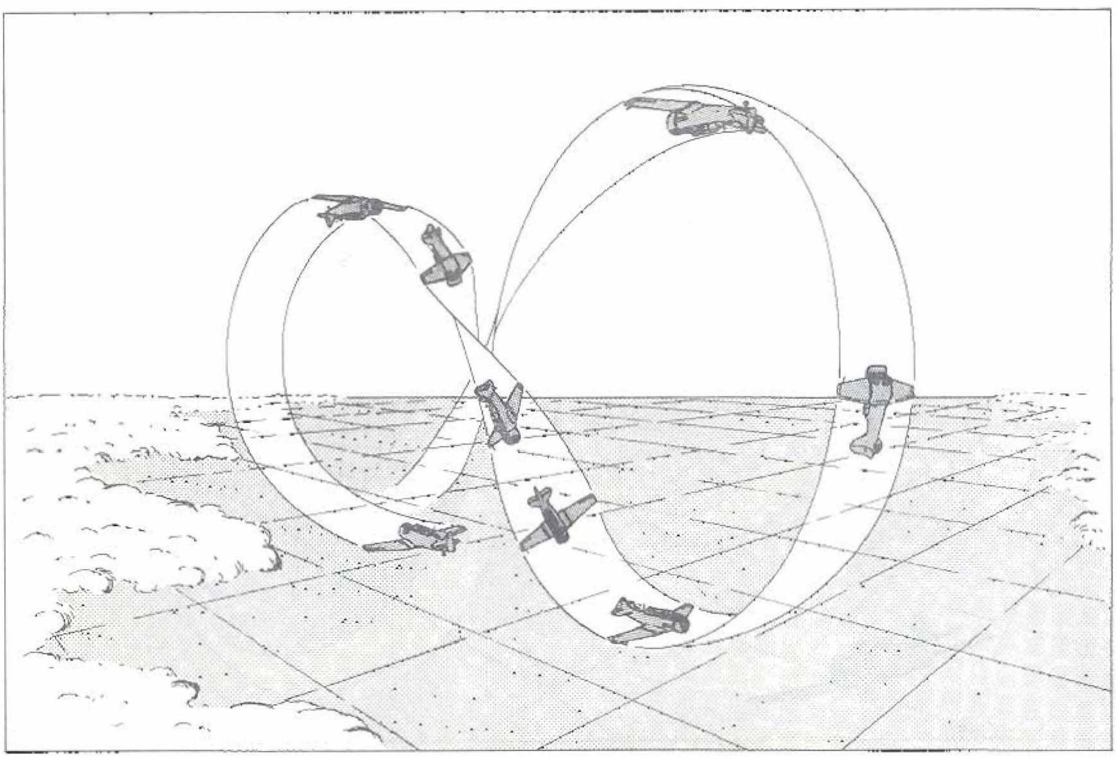

Figure 5: The Cuban Eight

11.08 - The Roll-off-the-Top

(1) A roll-off-the-top consists of the first half of a loop, followed by a half-roll to level flight. The result is a gain in altitude with a 180 degree change of direction, as shown in Figure 6.

(2) The entry to the roll-off-the-top is similar to the entry to a loop, except that as the nose is raised through the horizon, the airspeed should be 175K. The amount of back pressure applied, however, must be slightly greater than for a loop. At the top of the loop, you must watch for the opposite horizon and, as the nose reaches a point approximately 20 degrees above the horizon, you must release the back pressure, and apply co-ordinated aileron and rudder pressures to start the roll. Forward pressure to maintain direction is needed as the angle of bank moves through the vertical. By re-applying the back pressure gradually, the nose can be prevented from descending past the level-flight attitude while direction is being maintained with top rudder. The aileron pressure should be relaxed as the wings become level and, when the aircraft has resumed level flight, all of the controls should be centralized.

(3) Since the aim of this exercise is to recover in a straight and level attitude, you must start to roll the aircraft while the nose is still approxi-

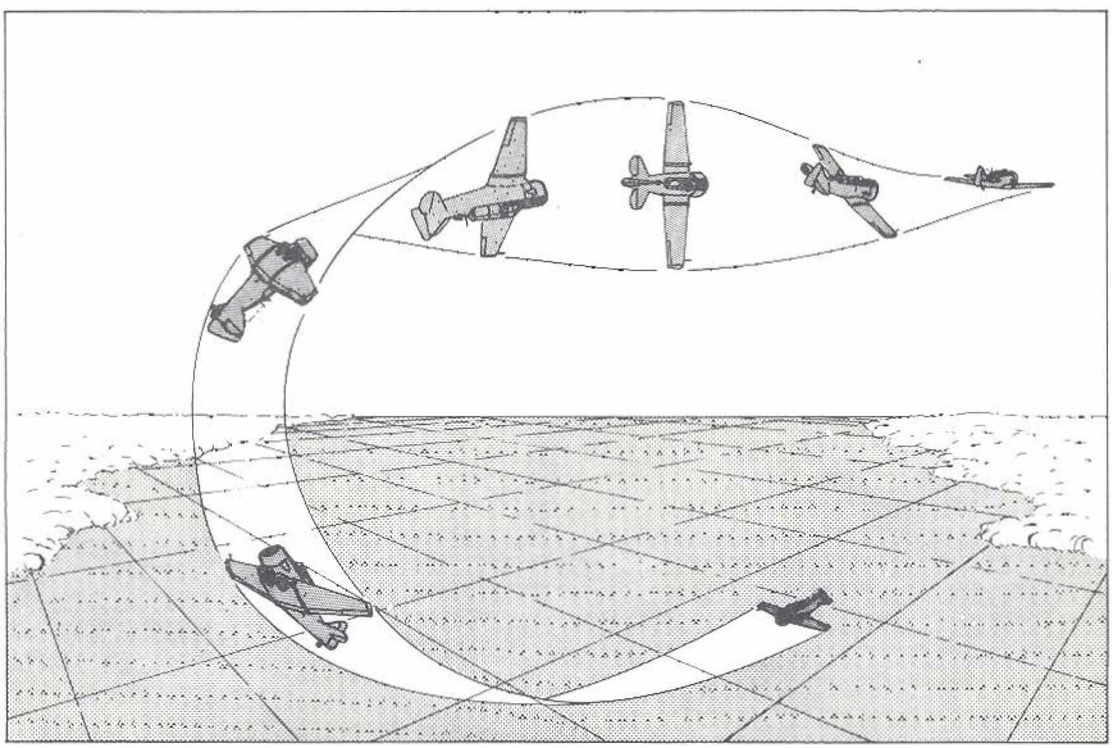

Figure 6: The Roll-off-the-Top

mately 20 degrees above the horizon. Remember that this roll is executed mostly with aileron and you should not attempt to force the roll with rudder or elevator pressures, since the aircraft will only skid outwards and the nose will move off the desired heading. You should practise rolls-off-the-top in both directions, to gain maximum proficiency.

11.09 - The Half-roll and Roll-out

(1) During a half-roll and roll-out, the aircraft is rolled around its longitudinal axis until it is inverted: instead of continuing to roll through to the level-flight attitude, the recovery is made by rolling back in the opposite direction. The airspeed for entry is 140K, and this may be attained by diving through the last clearing turn as you have been doing for other aerobatic sequences. When the airspeed is approaching 140K, choose a reference point on the horizon immediately above the nose, and smoothly raise the nose through this point to an attitude slightly higher than the three-point attitude. The wings should be kept level during the pull-up and the airspeed should be exactly 140K as the nose cuts the horizon. At the correct moment, you must co-ordinate aileron and rudder pressures to begin a roll.

(2) As the wings pass through the vertical, you will have to exert some forward pressure for directional control, but no more than is required to keep the nose above the reference point: in addition, you must be prepared to

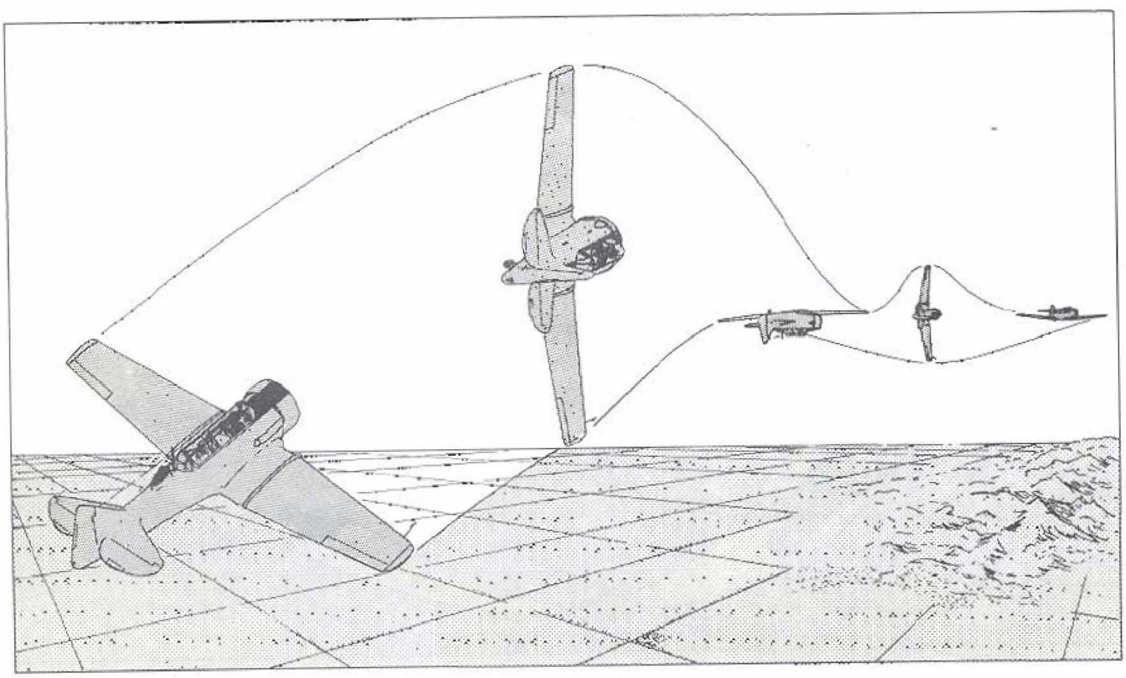

Figure 7: The Half-Roll and Roll-out

prevent the roll from continuing past the inverted position. This is possible only by anticipating when to start a gradual reduction of the aileron and rudder pressures so that they are neutralized by the time the aircraft is over on its back. Some forward pressure can be released to allow the nose to begin dropping slowly, but you mustn't pause in the middle of the manoeuvre: IMMEDIATELY apply co-ordinated pressure to roll the aircraft back, opposite to the original direction of entry. (Figure 7 opposite.) The time taken to reverse the controls and start the roll-out gives all the hesitation needed.

(3) On the roll-out, as the wings reach the vertical position again, you must use sufficient top rudder to keep the nose up, and slight forward pressure to maintain direction relative to the reference point. During the last quarter of the roll, apply rudder to maintain direction and elevators to return the nose to the level-flight attitude. Relax some of the aileron pressure just before reaching level flight to prevent the aircraft from "dishing out". You should not be subjected to negative "G" during this manoeuvre.

11.10 - The Half-roll and Loop-out

(1) In a half-roll and loop-out, the aircraft is rolled into the inverted position, from where it is pulled-through as in the last half of a loop. (Figure 8)

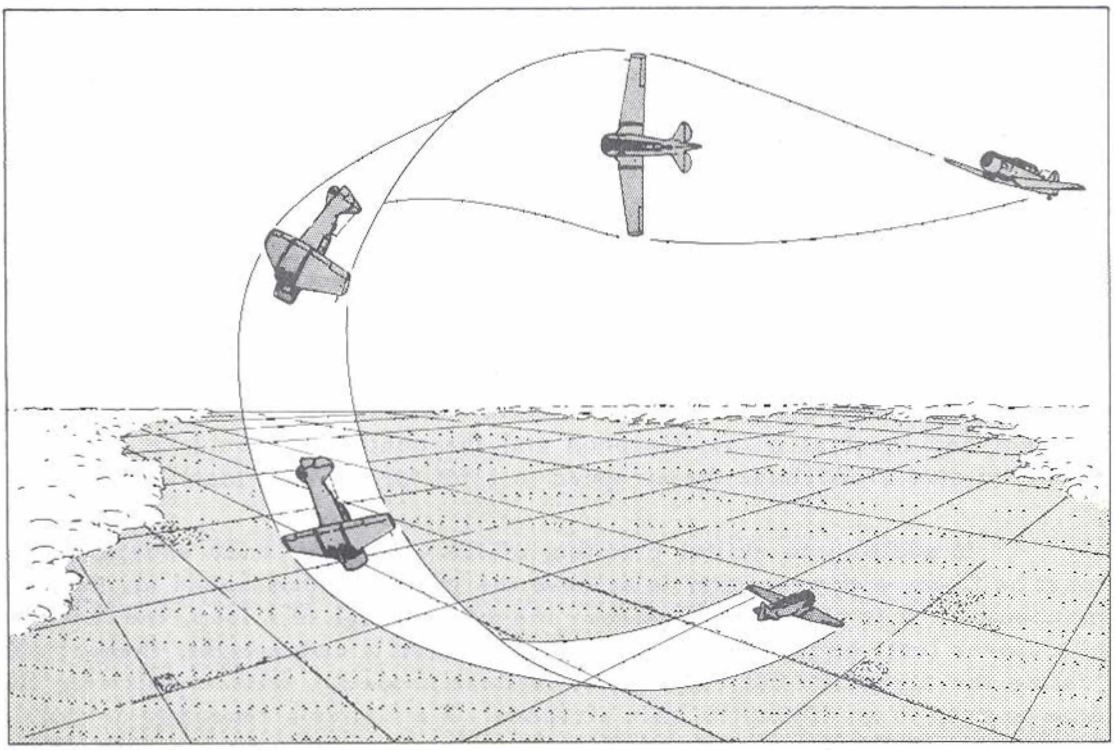

Figure 8: The Half-Roll and Loop-out

This manoeuvre is started by picking a suitable reference line while doing the usual clearing turns and then, with the wings level, raising the nose to the three-point attitude. At approximately 105K roll the aircraft over, keeping the nose directly above the reference point. Exert some forward pressure for directional control as the wings approach and pass through the vertical, and anticipate the inverted position by gradually releasing the control-column pressures as the aircraft rolls onto its back. Maintain direction with the rudders.

(2) You must not pause in the inverted position, but must apply back pressure to cause the nose to arc downwards in a smooth pull-through. You should attempt to judge the rate of pull-through so that, as the nose reaches the horizon in level flight, the airspeed indicator registers a pre-determined airspeed. The back pressure on the control column during the early part of the pull-through should be such that an excessive build up of airspeed, with its accompanying high "G" stresses, is avoided after the aircraft passes through the vertical position. The amount of initial back pressure can be varied until, with practice, you should be able to recover to straight and level flight with airspeeds of 140K, 155K or 175K as desired. The exercise should be practised with initial rolls to the left and to the right.

11.11-Multiple Aerobatics

(1) The term "multiple aerobatics" is used to describe the result of combining several aerobatic manoeuvres into one continuous sequence. The airspace involved is considerably greater than for a single manoeuvre, therefore, you must be certain that no other aircraft is in the area. You must plan the exercise properly so that the minimum altitude restriction of 3,000 feet AGL is respected.

(2) To plan a good multiple aerobatic sequence requires skill in selecting those manoeuvres which can be linked together easily. For example, a loop, a clover leaf and a barrel roll can be combined successfully, but a slow roll, a roll-off-the-top and a cuban eight are difficult to fly with continuity. In the latter example, on completion of the slow roll the aircraft would be flying straight and level at a low airspeed and the continuity would be ruined by having to dive to increase the airspeed to 175K for the next manoeuvre.

(3) In addition to skilful planning of the sequence, each separate part must be flown with precision to achieve the correct entry speed for the next manoeuvre. It is permissible to vary the pull-through of a loop, the last leaf of a clover leaf, or the pull-up of the last part of a cuban eight, thereby adjusting the airspeed, but rolls must be done properly, without allowing the nose to drop in an attempt to gain airspeed. If a higher airspeed is desirable immediately following a roll, the logical connecting link with the next manoeuvre is a half-roll and loop-out.

(4) Repetition of a manoeuvre in a sequence is not good planning, however the same manoeuvre done in the opposite direction is permissible. The purpose of multiple aerobatics is to give you an opportunity to exploit the aircraft to the full, and to do so you must work hard. Constant practice is essential, since the many airspeed variations result in rapid fluctuations in yaw, which must be counteracted with smooth and co-ordinated control movements: practice leads to proficiency.

Have you completed the form at the end of this publication?

Chapter 12

Cruise Control

12.01 - Introduction

(1) Cruise control is the process by which the greatest efficiency is obtained from an aircraft during a particular flight, when all aspects have been considered. The basis of the process is the best possible combination of airspeed, altitude and engine handling for the conditions being experienced When you employ the principles of cruise control, you are aiming for maximum performance, economy and safety.

12.02 - The Airframe

(1) Among the forces affecting cruise control are lift and drag which, themselves, are dependent on:

(a) the shape of the aerofoil section;

(b) the area of the wings;

(c) the air density;

(d) the airspeed; and

(e) the angle of attack.

(2) The first two factors are beyond your control once the aircraft is cruising in straight and level flight, but the third, air density, affects the True Airspeed (TAS). This means that the selection of a suitable altitude plays an important part in cruise control. The last two factors, airspeed and angle of attack, are related to one another, since in level flight there is a certain airspeed for the most efficient angle of attack. These speeds have been worked out for you and are shown in AOIs.

12.03 - The Engine

(1) The pilot has a greater degree of control over the engine than the airframe. While the selection of power settings for maximum-speed cruise control is simple, the more economical types of cruise control require a broader knowledge of power settings.

(2) The Brake Mean Effective Pressure (BMEP) is the average useful working pressure within the engine cylinders. It is a measure of the volumetric efficiency of the engine, and is dependent on the rpm and MP. Since an engine operates most economically at a high volumetric efficiency, a high BMEP obtained from a low rpm and high MP is desirable. AOIs should be consulted for the engine limitations of the Harvard. Lean mixtures are recommended for economy. The carburettor heat should be at "COLD", since having the control in "HOT" results in an expanded mixture being introduced into the cylinder, thus reducing the efficiency.

(3) Air density, which varies with temperature and altitude, has an effect on the engine as well as on the airframe. The higher the air density, the greater the power, which is a valuable asset at lower throttle settings. However, to take full advantage of airframe efficiency for range, it is necessary to fly at higher altitudes. The optimum altitude is Full Throttle Altitude (FTA) at which height maximum BMEP is achieved, owing to the reduced restriction in the throat of the carburettor and the diminished exhaust back pressure.

(4) When a "lean" mixture is required, the desired MP is set before the mixture-control lever is moved forward into the lean range. Sometimes the mixture lever may have to be moved ahead of the throttle. The correct setting is found by moving the lever forward until there is a slight drop in rpm, or until the engine begins to run roughly. These are signs that the mixture is too lean; retarding the lever slightly until the engine runs smoothly will give you the correct setting for lean range. In addition, when you are leaning the mixture, you should always note the airspeed and CHT so that later, if the airspeed decreases in level flight or the CHT increases, you can tell that the mixture is too lean. By making a slight adjustment towards "RICH", the airspeed and CHT will return to normal.

(5) When a "rich" mixture is required, the control lever is moved back into the rich range until the engine begins to run roughly. Easing the lever forward slightly until the engine runs smoothly gives the correct adjustment for the altitude at which the aircraft is flying. Near the ground, as in circuit flying, the mixture-control lever may be pulled fully back to "RICH".

(6) After setting up the aircraft for any form of cruise control, you should do a cockpit check and compute the hours of fuel remaining. This ensures that nothing has been overlooked and that the configuration is correct.

12.04-Types of Cruise Control

(1) The four main types of cruise control are:

(a) maximum range;

(b) maximum endurance;

(c) maximum continuous - rich; and

(d) maximum continuous - lean.

12.05-Maximum Range

(1) Maximum range is the practice of covering the greatest distance through the air on the available fuel (maximum Air Miles per Gallon - AMPG), or using the least fuel to cover a given distance.

(2) The recommended settings for maximum range to give a fuel consumption of approximately 16 gph are:

Pitch - 1,500 rpm

Throttle - adjusted to maintain 110K

Mixture - leaned out

Altitude - FTA.

(3) The optimum IAS for maximum range flying depends on:

(a) the aerodynamic characteristics of the airframe;

(b) the specific fuel consumption, (gals/Horsepower/hours);

(c) the engine characteristics; and

(d) propeller efficiency.

The IAS has been calculated for you and is published in AOIs, but you must remember that it is a speed which has been arrived at by compromise, and therefore is merely a good average speed for the Harvard.

(4) THE EFFECT OF ALTITUDE - The recommended IAS does not change with height. Any increase in height however, up to FTA, results in a higher TAS, which in turn gives more AMPG. You must realize that FTA may not be the best height for maximum range flying; the winds or cloud formation may be more favourable at another altitude and you may find it

more advantageous to fly well below, or well above FTA. If you are flying below FTA, you will have to throttle back to maintain a constant airspeed of 110K, and if you are flying above FTA, you will have to increase the pitch, as required, to a maximum of 2,000 rpm. During the climb to the selected altitude, you should use normal climbing power.

(5) THE EFFECT OF WIND - Both head and tail winds affect the range of an aircraft, but you must always take advantage of tail winds to supplement the AMPG. When flying into head winds, you should minimize the time spent flying into wind, because of the adverse effect on the AMPG. Usually this can be done by descending at a higher airspeed to a lower, more favourable altitude.

12.06 - Maximum Endurance

(1) The maximum endurance of an aircraft is its ability to consume the lowest possible amount of fuel over a given period of time, or to remain in the air for a maximum length of time. Being concerned with TIME rather than distance, maximum endurance is not suitable for specific flights; instead, it is used for such contingencies as re-orientating yourself after becoming lost, or holding near the aerodrome when there are landing delays.

(2) The recommended settings for maximum endurance to give a fuel consumption of approximately 14 gph are:

Pitch - 1,500 rpm

Throttle - adjusted to maintain 90K

Mixture - leaned out

Altitude - as low as possible, consistent with safety.

(3) The recommended speed for endurance flying as published in AOIs remains constant at all altitudes. Theoretically, the object of endurance is to use as little power as possible, but, since positive control is desirable at low altitudes, the recommended speed is higher than the absolute optimum.

(4) THE EFFECT OF ALTITUDE - An aircraft flying for endurance should fly as low as possible consistent with safety. The adverse effect of altitude, resulting from the use of power to maintain the IAS as the TAS increases, is illustrated by the fact that endurance at 10,000 feet is only 7/8th of that at sea level.

(5) POWER SETTINGS - Since the object of flying for endurance is to use a minimum amount of fuel while maintaining a given IAS, certain adjustments become mandatory. The pitch adjustment is 1,500 rpm and, once this has been set, the throttle can be moved to a MP which will allow the air-

craft to maintain altitude at the recommended airspeed. Juggling the throttle merely increases the fuel consumption, therefore slight variations in altitude should be accepted, rather than attempting to hold a constant altitude with ever-changing throttle settings.

(6) THE EFFECT OF WIND - The effect of wind is of no significance to an aircraft flying for endurance, since the aim is merely to stay aloft.

12.07 - Maximum Continuous Rich

(1) Maximum Continuous Rich is a form of cruise control that gives the highest airspeed in level flight while using the highest power setting recommended by the engine manufacturer. The fuel consumption at this setting is high, but after considering the amount of fuel remaining, it may be used for example, if you wish to return to base quickly before the onset of deteriorating weather. The limitations of the engine must not be exceeded and a special watch must be kept on the oil temperature (maximum 85°C) and the cylinder head temperature (maximum 260°C).

(2) The recommended settings for Maximum Continuous Rich to give a fuel consumption of approximately 48 gph are:

Pitch - 2,200 rpm

Throttle - 32" MP

Mixture - rich

Altitude - as required, consistent with safety.

12.08 - Maximum Continuous Lean

(1) Maximum Continuous Lean is used to give a comparatively high, continuous speed with some fuel economy. You would use it, for example, if you wished to return to base quickly when only a limited supply of fuel was left in the tanks. Since a lean mixture is synonymous with increasing temperatures, you must beware of leaning the mixture out too far, and you must keep a constant check on the oil temperature and the cylinder head temperature.

(2) The recommended settings for Maximum Continuous Lean to give a fuel consumption of approximately 23 gph are:

Pitch - 2,000 rpm

Throttle - 26" MP

Mixture - adjusted in the lean range for smooth running

Altitude - as required, consistent with safety.

Chapter 13

Pilot Navigation

13.01 - Introduction

(1) Aerial navigation can be defined as the art of flying from one point to another, making allowances for all variables en route. As a pilot you are required to know only the fundamental principles, but you will be given the opportunity to work out practical problems and to apply the knowledge you gain in the classroom to actual cross-country exercises. As usual you will start off by having dual instruction, from which you will graduate to solo exercises once you have attained sufficient proficiency.

13.02 - Map Reading

(1) The first requirement in Pilot Navigation is the ability to map read. Map reading is the identification of landmarks from their representation on a map, and the application of this information to discover the position of the aircraft. Sometimes on a cross-country flight, the ground may be obscured by cloud for part of the time, and your glimpses of recognizable features may be brief. Your skill in fixing the position of the aircraft under such circumstances depends on your ability to interpret the symbols on your map. This means that you must understand a map and be able to judge the appearance and map reading value of certain features. Your judgement and skill in map reading will grow with experience.

(2) RELIEF - Relief is shown on topographical maps by contour lines and layer tinting which allows you to judge the rise and fall of the land. You should study the contours to find such things as the highest points, and to gain a general impression of the type of terrain over which you are to be flying. Remember that the appearance of the ground varies according to the time of day and the weather. Shadows in the late afternoon, for instance, can distort the shape of hills, and snow on rolling ground can make it look flat.

(3) WATER - Water always stands out, whether it be on a map or on the ground. Lakes, rivers and reservoirs are clearly marked on all maps because of their importance in map reading, and even in winter their outlines

can be seen readily on the ground. In dry country the edges of dried-up lakes and water courses are defined by trees and bushes.

(4) CITIES AND TOWNS - Built-up areas make good check-points because of their size and the number of easily identifiable features surrounding them. In winter they stand out well against the white background. When you are flying over an area with many cities or towns, you must not jump to conclusions as to the identity of any one of the towns. Only by checking each feature can you be sure of the true identity.

(5) LINE FEATURES - Roads, railways, rivers and power lines are all "line features", but unless they are unique in a specific area they are better to be used in conjunction with some other recognizable landmark. In many instances line features lead to built-up areas, thus providing a good map comparison. Others have identifiable details such as tunnels, junctions, bridges and, in the case of rivers, special patterns which can be pin-pointed.

(6) OTHER FEATURES - Maps are usually very detailed and show such features as mines, racetracks, forest-ranger towers, and, in rural areas, even individual buildings when these are remote. Airfields are good check-points, since each has a distinctive shape: the larger ones are shown sometimes in the form of a small chart on the edge of the map.

(7) ORIENTATION - Before attempting to read a map, it must be orientated so that "North" on the map coincides with true North. In this way, the intended track of the aircraft can be drawn on the map and the ground features will appear in the same sequence and position.

(8) SELECTION OF LANDMARKS - When you are studying the route of a planned flight, always select check-points that can be easily identified. In making your choice of landmarks, you should consider their size, the contrast they make with their surroundings, and their position in relation to your intended track and in relation to the height at which you are flying. The best landmarks, of course, are those which are distinctive because they are unique, or those which contrast sharply with the adjacent country. If there are no good features on track, you may have to use check-points that are off track. Estimating the distance between the aircraft and these off-track check-points is difficult, but can be learned by experience.

(9) PLANNED MAP READING - Anticipation is the key to successful map reading. If you know your map, and know when the check-points are due, you can concentrate on flying the aircraft while waiting for each check-point to appear. To achieve accuracy, the "Watch-Map-Ground" technique is helpful. "Watch" is noting the time, and thus anticipating each check-point, "Map" is checking the map when each point is due; and "Ground" is identifying that point on the ground. Do not try to look at the ground first and match up a visible feature with the symbols on the map. It may work once or twice, but you are most likely to finish up declaring an emergency because you are lost. Only by anticipating the check-points can you hope to have enough time to identify them.

(10) CONFIRMATION OF CHECK-POINTS - There is no need to orbit a check-point if it has obvious features which you can recognize. Once the check-point has been confirmed, draw a small circle with a point in the middle to show your exact position on the map; this then becomes a "pin-point". The time of reaching the check-point is printed beside the circle and you are half way to being able to show a "track tendency". One other check-point confirmation, and you should be able to assess your track error.

(11) MAP READING AT UNPREDICTABLE INTERVALS - If you can see the ground only occasionally, or if you have missed your check-points, you may be uncertain of your position. You should know your approximate position however, because you will have been flying on a certain heading for a specific length of time since your last pin-point. When you get into such a situation, draw a circle on the map around the position you would be in if you were on track and on time. The radius of the circle should be 10% of the estimated distance flown since the last confirmed position. Keep moving this circle along your estimated track, gradually making it larger as the distance increases. Study any landmarks that are visible and note their relative positions. Check within the "circle of uncertainty" on your map for similar features and, when you have positively identified one or more landmarks, fix your position. This is one occasion when the "Watch-Map-Ground" rule is not used, and a thorough knowledge of map reading is of immense help.

13.03 - Pre-flight Planning

(1) Good pre-flight planning is the essence of good navigation. With a well-prepared log form, an up-to-date map and a thorough knowledge of the route to be flown, you should be able to fly from one point to another without difficulty. Be sure that you have current maps covering the area on each side of your intended track. When you have drawn a line on the map to show the intended track, and you wish to measure the track angle, always place your protractor on a meridian near the middle of the track line. In this way the error caused by the convergence of the meridians is averaged out.

13.04 - The Flight Log Form

(1) The Flight Log is a record of all the navigational data required to provide a schedule for a flight. The type of Flight Log form used at FTS is shown in Figure 1 overleaf so that you can refer to it as each point is discussed in the following paragraphs.

(2) MAGNETIC WINDS - Magnetic directions are used for navigation. The forecaster always gives the wind direction for specific altitudes in degrees true, with the speed in knots and the air temperature in degrees centigrade. This information should be printed on the back of the log form, and

FTS NAVIGATION LOG

AIRCRAFT NUMBER	PILOT	DATE

MAGNETIC WINDS

STATION	FREQ	IDENT

SAFETY HEIGHTS

1 ST LEG
2 ND LEG
3 RD LEG
4 TH LEG

SPECIAL INSTRUCTIONS

			TAS			TIME OFF			FUEL T.O.		
FROM / TO	ALT	MAG TR	DIST	G / S	IAS	M H / R M H	TIME	S / H / OVER	ETA / RETA	FUEL EST	FUEL ACT

CFL-2 NOV 61

Figure 1: The Flight Log Form

you must interpolate the wind directions and speeds for any other altitudes which you need. Each wind direction is converted from true to magnetic and entered in the space provided on the front of the log.

(3) SAFETY HEIGHTS - The Safety Height for each leg is 1000 feet above the highest obstacle or spot height within 20 nm of track. To find the highest obstacles, run dividers set at 20 nm up and down the track, and look for the highest point. Add 1000 feet to this height and enter the resulting figure in the space for each leg.

(4) STATION/FREQ/IDENT - These headings allow you to note Radio Compass information. At FTS all of your navigation trips will be flown under Visual Flight Rules (VFR) and there should be no need to make use of the Radio Compass. At a later stage of training, however, you will be taught to rely largely on radio aids for navigation so, for practice, these columns should be filled in. The information can be obtained from the Flight Information Publications (FLIPS). Should an emergency develop during your flight, the Radio Compass information will be readily available, obviating the need for you to search your maps just when the time cannot be spared.

(5) SPECIAL INSTRUCTIONS - This space is left for important notes and information relevant to the flight, such as the average variation for the entire trip, or, on long trips, the average variation for each leg.

(6) TAS - In the Harvard the TAS is 130K, and this figure is entered in the TAS column.

(7) TIME OFF - As soon as you are airborne, the air traffic controller will give you your "time off", which is entered in the appropriate space.

(8) FUEL T.O. - Fuel T.O. is the proposed fuel load at take-off after running up and taxiing. You must check the L-14 to see how much fuel is in the aircraft, then deduct the appropriate number of gallons.

(9) FROM/TO - Standard abbreviations are used for the turning points on each leg. For instance, Moose Jaw to Regina is entered as MJ to QR.

(10) ALT - At FTS the altitudes at which you are to fly each leg are selected for you, because each trip is designed to demonstrate different navigational techniques. The limits within which you will fly are the safety height for each leg, and 9,500 feet. Since all of your flying is to be VFR, the altitude chosen will be below cloud level, and consistent with the regulations governing flights as detailed in CAP 100. Altitudes are entered in the log in hundreds of feet: 6,500 feet is put down as 65.

(11) MAG TR - The magnetic track which has been determined for each leg on the map is entered here.

(12) DIST - "Dist" is the number of nautical miles between each two turning points.

(13) G/S - The ground speed is calculated by computing the effect of wind on the aircraft.

(14) IAS - The IAS for each leg is entered in the space provided. It is calculated by converting TAS to Rectified Airspeed (RAS), and applying the necessary instrument correction.

(15) MH/RHM - "MH" refers to the Magnetic Heading which is calculated from the magnetic track and forecast wind; "RHM" is the Revised Magnetic Heading.

(16) TIME - Under "Time" you should enter the length of time that each leg is going to take according to your calculations. Add the times for each leg and enter the resulting figure at the bottom of the column.

(17) S/H/OVER - S/H means "Set Heading" and this space is used for entering the time that the aircraft first turns on course. "Over" is the time that the aircraft arrives over its destination, or at each turning point on a leg.

(18) ETA/RETA - The Estimated Time of Arrival and the Revised Estimated Time of Arrival at the destination, or the next turning point, are entered in the spaces allotted.

(19) FUEL/EST/ACT - "Fuel Est" is the estimated amount of fuel remaining at the end of each leg, and is based on the rated consumption of the aircraft as listed in AOIs. "Fuel Act" is the amount of fuel left in the tanks at each turning point. If the actual amount of fuel left decreases more rapidly than the estimated amount, you should take action to remedy the excessive consumption. You must learn to watch the fuel consumption closely, so that immediate action can be taken to adjust the power settings to give greater economy. If insufficient fuel is left for your return to base, you must divert to an aerodrome within range.

13.05 - Preparing the Map

(1) While filling in the details on the log form, you will have to refer to the map for distances, tracks and other information. The track between each turning point is drawn on the map in black pencil and is measured on one of the meridians near the middle of each leg. Dotted drift lines are drawn 5 degrees on each side of the track, from both the starting point and the destination of each leg. These drift lines are at least 2/3 the length of each leg. (See Figure 2 opposite.)

(2) All along the track on each leg you must draw 5-minute lines at right angles to the track and, with the map orientated, you must mark in the elapsed time to each point.

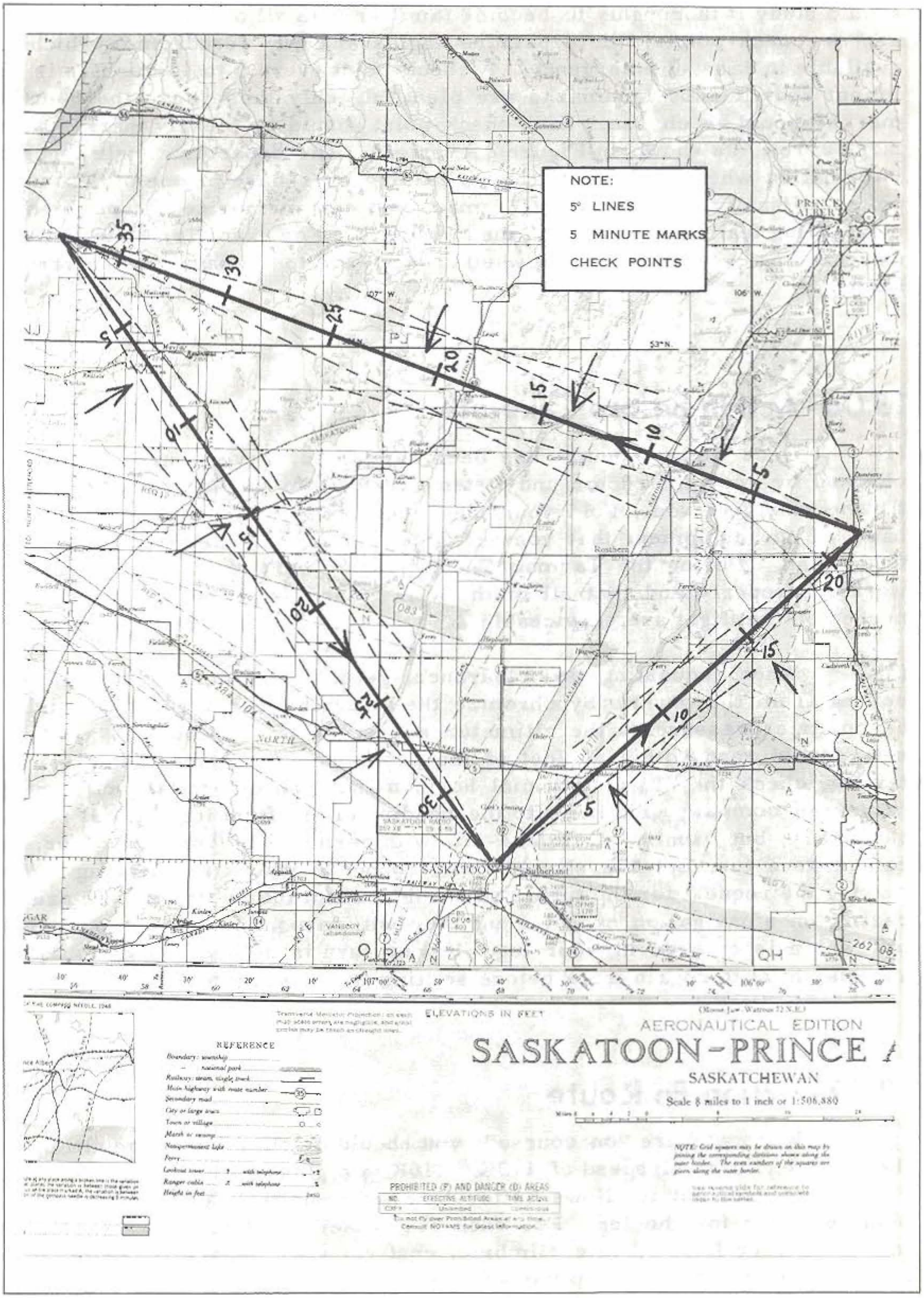

Figure 2: Preparing the Map

(3) When the map has been marked according to these directions, you should study it thoroughly to become familiar with all of the features you can use as check-points, the departure angles and any aerodromes which are available in case of emergency. A check-point every 5 to 10 minutes is sufficient and, if good landmarks are plentiful, only those near the 5-minute marks should be chosen. Each check-point should be clearly marked with a large arrow, as shown in Figure 2 overleaf. The departure angle is useful information when you are setting a heading over base or one of the turning points. Usually, if you study the map, you can memorize the positions of outstanding features relative to the new track. For example, when setting a new heading, you should know whether you have to fly parallel to a river or bisect it.

13.06 - Action Before Take-off

(1) Once your planning has been completed, have your log and map checked by your instructor and listen carefully to any last-minute briefing that he may give you. Fold your map accordian style, make sure that you have all the equipment that you are going to need in the air, and file your flight plan. During the Tarmac Check, ensure that the radio compass is working properly and that all of the VHF channels which are likely to be needed on the flight are serviceable.

(2) When requesting taxi clearance, get a time check and an altimeter setting from the tower. Synchronize the aircraft clock and set the airfield barometric pressure on the altimeter sub-scale. The altimeter, after it is set, should read within 50 feet of the published aerodrome height. While taxiing, check the DI and artificial horizon and, just before take-off, set the magnesyn compass grid lines to the heading of the first leg. Local regulations vary, but usually after take-off, with permission from the tower, you can make a turn-out the shortest way round to your first heading. When making the request for the turn, you should inform the tower that you are departing on a navigation exercise and they will respond by giving you a "time off" which is entered in your log. If your turn is delayed owing to traffic, you may have to regain track before settling into the climb on heading.

13.07 - Action En Route

(1) When you are "on course", you should be climbing to the altitude of the first leg at an airspeed of 110K. 110K is higher than the recommended climbing speed, but it allows better forward visibility, and is closer to the planned speed for the leg. For each 5,000 feet of climb, you should add 1 minute to your ETA. While climbing, confirm your departure angle, make up your log and keep a sharp look-out for other aircraft. Once you reach the desired altitude, level-off and complete a thorough cockpit check.

(2) After the level-off check, the flight becomes a matter of aircraft handling, with precision and accuracy contributing to ease of navigation. You should anticipate each check-point by noting the expected time of arrival and, before this time has elapsed, by checking the map for indentifiable features. When the check-point is due, you should search for the selected features and try to identify the check-point. Do not track crawl; have confidence in your ability to assess and correct any errors. Check the time often, and refer to the five-minute marks: watch for check-points and, as the aircraft passes them, mark the map with the appropriate symbol, inserting the time alongside.

(3) You will have little log-keeping to do. Except for revisions to the heading, ETA, and fuel load at regular intervals, most of your time will be spent map reading. As soon as you record one pin-point, start thinking about the next one. Temperatures, pressures, and fuel contents should be noted at regular intervals and the DI should be checked every 10 minutes.

13.08 - Action at a Turning Point

(1) It is well to have a plan of action for your arrival at a turning point. Usually the order is to:

(a) alter the heading;

(b) check the time;

(c) change the altitude, if necessary;

(d) check the departure angle;

(e) make the new log entries;

(f) give a position report; and

(g) do a cockpit check.

(2) When you are altering the heading, turn directly onto the new heading over the turning point, so that you have a good start on the next leg. Make a mental note of the "Time Over" and the "S/H" time so that you can complete your log and work out ground speeds and ETAs. Off-airways cross-countries are flown at the heights specified in CAP 100, therefore a change of altitude may be needed at each turning point. Make the change as soon as you have turned onto the new heading, using 110K to climb and normal cruising speed to descend. At the same time, check the departure angle to prove to yourself that you are leaving on the correct track. Check the track again. Make your entries once you are satisfied that you are on the correct course and give a position report, if you have been ordered to do so. Before settling down on the next leg and resuming your "Watch-Map-Ground" technique, you should do a thorough cockpit check to ensure that everything is in order.

13.09-Heading and ETA Revisions

(1) Alterations to headings and ETAs are necessary because of inaccuracies or variations in the forecast winds, or because of flying errors. If you do get off track, you should follow a new, corrected track to your destination, rather than try to regain the old track. To do this, since you have no plotting or computing equipment, you will have to work all of your calculations mentally and make fairly accurate estimations.

(2) REVISING A HEADING - A simple and accurate way to revise a heading is by the "opening and closing" method which is based on geometry, and uses the five-degree lines as guides. Assuming that you are off track to the left, and have pin-pointed your position as being about one degree inside the five-degree line, estimate the angle between your present position and your destination. If this angle appears to be about three degrees, then you add the "opening" angle of 4 degrees to the "closing" angle of 3 degrees, and alter course 7 degrees to the right. This method should not be used until you have pin-pointed your position, thus proving that you are off track, and not until at least two pin-point positions have shown a "track tendency" which is at variance with the desired track. A change of heading should not be made early in the leg, except when the track error is more than 5 degrees and it is obvious that you are drifting off track.

(3) The "opening and closing" method can only be used once on each leg, because the drift lines are based on the position of the original starting point, and not from the new off-track pin-point. Succeeding pin-points will show whether the revised heading is going to bring you to your intended destination. If you are still drifting off track, you have to make what is called a "snap" alteration. A "snap" alteration is an estimated heading based on the effectiveness of the first correction. It should bring you within sight of your destination, when a visual alteration can be made.

(4) REVISING AN ETA - Usually ETAs are revised by the "fractional" method. Reference to the five-minute marks from accurate pin-points will give you an idea of the amount of revision needed to the ETA. For example, two minutes late at the mid-point of the leg means that you will be four minutes late at the next turning point; one minute early after the first third means three minutes early at the end, and so on. ETAs should not be revised before you reach one third of the way along a leg, and only after you have positively pin-pointed your position.

13.10-Action When You Are Uncertain of Your Position

(1) The danger of jumping to the wrong conclusion is very real when you cannot recognize expected landmarks. There are times when you will be uncertain of your position, but then all pilots experience the same feeling sooner or later. Such moments require calm reasoning and a recognized procedure. The recognized procedure is to:

(a) hold a steady heading and check the DI with the compass;

(b) check all previous calculations by studying your map and log;

(c) check for a possible wind shift;

(d) draw a circle of uncertainty; and

(e) try to get a Radio Compass bearing.

(2) Usually within a short time you can establish your position and continue the flight, however, you must never assume that you are in a certain position. Check for a possible shift in the wind, by drawing a "circle of uncertainty" as explained in Art 13.02(11). Remember, positive identification of a destinctive landmark is the only way to get back on track. If you decide that you are definitely lost, do not exhaust your fuel by aimless wandering from one heading to another trying to pick up a landmark. Always work to a plan. Notify your base by radio that you are lost, or try to contact any other control agency. When you have established radio contact, transmit your general position, the amount of fuel remaining in the tanks, ask for whatever assistance you need and indicate the action that you propose to take. Usually you will have a rough idea of the direction of base and can turn towards it, while continuing to search for prominent landmarks.

(3) In extreme emergency you should broadcast a "Mayday" distress message on 121.5 mcs giving the aircraft type, the nature of the emergency, the amount of fuel left, the assistance required and your immediate intentions. Listen-out on the same frequency for instructions. If you have no idea of the direction to fly, set up a triangular pattern at endurance power settings, at the highest practical altitude, to alert the radar network. If you have to do a forced landing, save enough fuel to complete the procedure you have been taught, pick an open field near habitation and concentrate on making a good landing.

(4) If no help is available and you have to rely on map reading to find your position, you should:

(a) fly for maximum range if no landmark is visible;

(b) using your "circle of uncertainty", estimate a heading to base or the nearest airfield, and fly that heading until you sight a prominent landmark;

(c) adjust the power settings for maximum endurance and fly a square pattern on cardinal headings around this landmark until you can identify it on the map; (Each leg should be two minutes long and you should be reading from the ground to the map.) and

(d) when you have established your position, estimate a new heading to base, revise your ETA, check the DI and fly normally, pin-pointing your position as you go along.

13.11 - Action When Landing

(1) Whether landing back at base, or at any other airfield, you must adopt a definite procedure. Before entering the airfield control zone, call the tower, state your position and altitude, and ask for landing instructions. Plan your let-down so that you can join the circuit at one of the recognized joining points and, as you are descending, stow your maps and navigation equipment to prevent them from interfering with your flying. Once you are on the ground, if you are unfamiliar with the layout of the airfield, ask the tower for instruction and park the aircraft according to those instructions. Usually, the controller will close your flight plan as soon as you land, but you should check to make sure that this has been done.

13.12 - Mental Dead Reckoning

(1) One of the greatest assets a pilot can have on a cross-country flight is the ability to do rapid, mental calculations. You should practise Mental DR, because you are going to need it and it is invaluable when you have to work problems in the air with only the aid of a pencil, a log form and a map. A few simple formulae and aids to rapid calculation have been developed, and are given here for your information.

(2) THE "ONE-IN-SIXTY" RULE - The "One-in-Sixty" rule is based on one mile subtending an angle of one degree at a distance of sixty miles. (See Figure 3.) If you have had to divert from your prepared flight-plan route and are "making good" a track to a known destination, it is possible to estimate any track error without the help of five-degree lines. All you have to know is the map scale, so that you can estimate the distance you are off track. To convert miles off track into degrees of track error, from which to find the opening angle, you use the following formula:

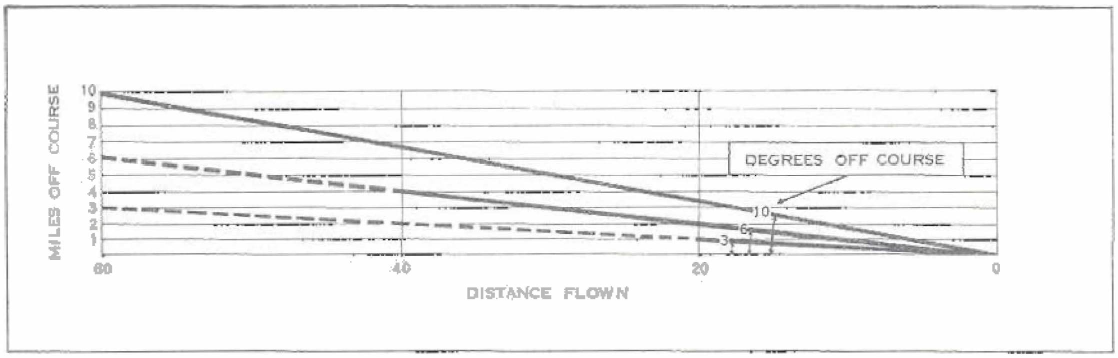

Figure 3: The "One-in-Sixty" Rule

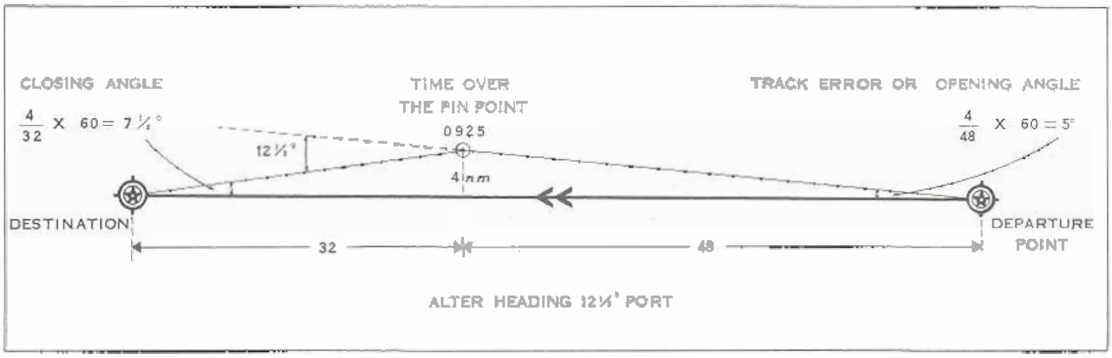

Figure 4: A Heading Change Calculation

$$\frac{\text{Miles off track}}{\text{Miles along track}} \times 60$$

To find the closing angle, the formula is:

$$\frac{\text{Miles off track}}{\text{Miles remaining}} \times 60$$

The result of adding the answers gives the heading change required to reach your destination. **This is shown in Figure 4.**

(3) RECIPROCAL TRACK - Before attempting to fly back along an original track to a point over which you have flown recently, you must be prepared to make an allowance for drift, and possibly track error. If drift could be ignored, you could merely turn onto the reciprocal of your original heading and fly straight back. Usually an allowance for drift is incorporated in the original heading and the aircraft is flying along a TRACK-MADE-GOOD; therefore, before turning to fly back, you must work out a heading which allows the aircraft to fly another "track-made-good" to the destination. To assist you in applying the correct amount of drift to the reciprocal of the original heading, a simple "help-word" has been devised. It is "SAPS" and means Starboard ADD, Port SUBTRACT. The following calculation should help you to understand how to use SAPS.

Your present outbound track is .... 090°

Your present outbound heading is .... 100°

∴ The reciprocal of the track is .... 270°

and, The reciprocal of the heading is .... 280°

Drift is .... 10°P

∴ DOUBLE THE AMOUNT OF DRIFT .... 20°P

now, Since the drift is to PORT, by SAPS ...... SUBTRACT

∴ The new heading is $280^\circ - 20^\circ$ .... 260°

If the wind is not as forecast and you find that there is track error involved, the "One-in-Sixty" rule will give the opening angle and this result can be substituted for "drift" in the above calculation.

(4) MAXIMUM DRIFT - One of the greatest problems in Mental DR is solving the wind triangle in order to apply the correct amount of drift to fly along a certain track. Maximum drift is experienced when the wind is at 90 degrees to track, while no drift is experienced when the wind is ahead of, or immediately behind, the aircraft. In between these two extremes, a percentage of maximum drift can be found by dividing up the intervening space into segments of 15°, and allotting a percentage value to each segment. (See Figure 5.) For example:

$$15^\circ = 30\%$$

$$30^\circ = 50\%$$

$$45^\circ = 70\%$$

$$60^\circ = 90\% \text{ and}$$

$$75^\circ \text{ and over} = 100\% \text{ of maximum drift.}$$

To find the heading to steer if your track is 040°(T), the wind direction and velocity is 010° at 30K, and the TAS is 130K, you have to start by finding the amount of maximum drift. Maximum drift is found by applying the "One-in-Sixty" rule according to the following formula:

$$\frac{\text{Wind Speed}}{\text{TAS}} \times 60$$

$$\therefore \frac{30}{130} \times 60$$

$$= 14^\circ$$

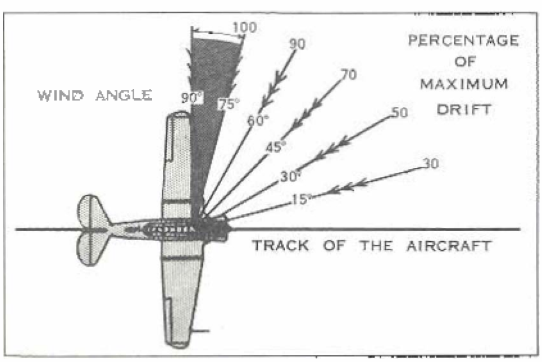

Figure 5: The Drift Table

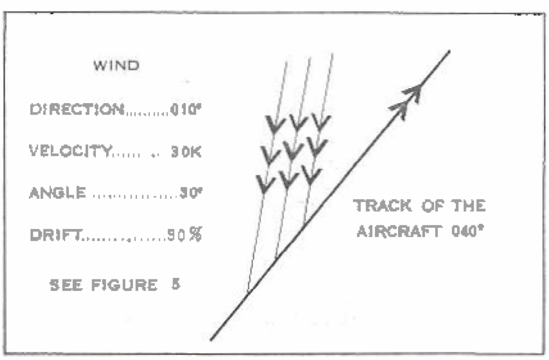

Figure 6: Wind Angle

The wind direction is 010° which, when subtracted from a heading of 040°, gives a wind angle of 30°, as shown in Figure 6 or 50% according to the table in Figure 5.

∴ The amount of drift is 50% of 14,

= 7

∴ The heading to steer is 033°(T)

(5) Since Mental DR is meant to give quick approximations and you don't want to have to wrestle with unwieldy figures, you can disregard fractions and work to round numbers. When using the above method of obtaining drift, remember that a 45 degree angle is 70% of maximum drift, not 50%. Try to remember the table relating angles to percentages.

(6) THE EFFECT OF WIND ON THE GROUND SPEED - The effect of wind on the ground speed is opposite to the effect of wind on drift, in that a beam wind gives maximum drift, but makes no noticeable difference to the ground speed. On the other hand a head or tail wind, which has little effect on drift, has a maximum effect on the ground speed. As before, a percentage of the wind strength will be felt between the two extremes. As an aid to mental DR, a constant has been worked out which, when applied to the wind angle, gives the percentage of wind speed that must be taken into account when calculating the ground speed. The constant is 110, and the formula is:

110 - Wind Angle = % Wind Speed

If an aircraft is flying on a track of 210° at a TAS of 130K, and the forecast wind is 250° at 30K, the ground speed can be found by deciding on the wind angle and working out the formula:

110 - Wind Angle = % Wind Speed

110 - 40 = 70%

∴ 70% of 30 = 21K.

The wind direction is 250° and the aircraft is heading into wind,

∴ The Ground Speed = 130K - 21

= 109K.

(7) Since this formula does not work for small wind angles, anything within 10° of track is assumed to have 100% wind effect. For large angles over 80 degrees, the ground speed is assumed to be the same as the TAS.

(8) CHECKING THE GROUND SPEED - Often in flight you can calculate the ground speed by checking the time taken to fly a given distance between

two check points. By rounding off the figures, you should be able to get answers which are accurate enough for practical purposes. For example, if you fly 22 nm in 11 minutes you can find the ground speed by thinking that:

$$22 \text{ nm in } 11 \text{ minutes} = \frac{22}{11} \text{ per minute}$$

$$= 2 \text{ nm per minute}$$

$$\therefore \text{ The Ground Speed} = 2 \times 60$$

$$= 120K$$

An example of rounding-out figures to get a fairly accurate result is:

$$43 \text{ nm in } 19 \text{ minutes} = \frac{45}{20} \text{ per minute}$$

$$= 2\ 1/4 \text{ per minute}$$

$$\therefore \text{ The Ground Speed} = 2\ 1/4 \times 60$$

$$= 135K.$$

But an even simpler method is to think of the 20 minutes as being approximately 1/3 of an hour:

In 1/3 of an hour the aircraft travels 45 nm

∴ In 1 hour the aircraft travels 3 x 45

= 135 nm.

(9) ESTIMATING TIME - To estimate time you must know the ground speed and be able to think of it in miles per minute. For example, 120K can be thought of as 2 miles a minute, 180K as being 3 miles a minute, and so on. Any ground speed can be converted into one of these simple numbers, with a mental adjustment being made according to whether the actual speed is greater or smaller than the nearest easy division. For instance, if you want to know how long it is going to take to cover 90 nm at 115K, you would immediately think of it taking 45 minutes at 120K, and then you would add two minutes for the slower speed.

(10) ESTIMATING ANGLES - If you have to alter track in the middle of a leg, you can make a mark on your map to show the new track by creasing the paper from your present position to the intended destination. The following tips are helpful in estimating the angle of the new track. The first method is to select a point on the map where the track crosses a meridian or a parallel as shown in Figure 7 opposite. The quadrant in which the track lies is known,

so, by drawing a line perpendicular to the meridian or parallel, a right angle can be made and, by dividing this up, you should be able to judge the track angle fairly accurately. If the track angle is close to 45 degrees, it is possible to tell whether it is more or less than 45 degrees by observing any triangle formed by the track, a meridian and a parallel. The third method is to compare the track with any printed directions on the map, such as the compass rose or a Radio Range leg. You must remember, however, that all angles on the map except Radio Range legs are in degrees TRUE and must be converted to MAGNETIC.

(11) ESTIMATING DISTANCE - Your equipment for measuring distance is usually limited, but there are certain guides which can be used to help you. One minute of latitude is equal to one nautical mile, and on every map there is a line at every tenth minute. Notice that this is LATITUDE and not longitude: longitude is measured in degrees. Another method is to discover how many miles your hand spans, and by remembering this figure, you can always estimate distance with reasonable accuracy. (See Figure 7.) The average hand spans 60 nm on an 8 mile to 1 inch map, but of course, this varies with the individual.

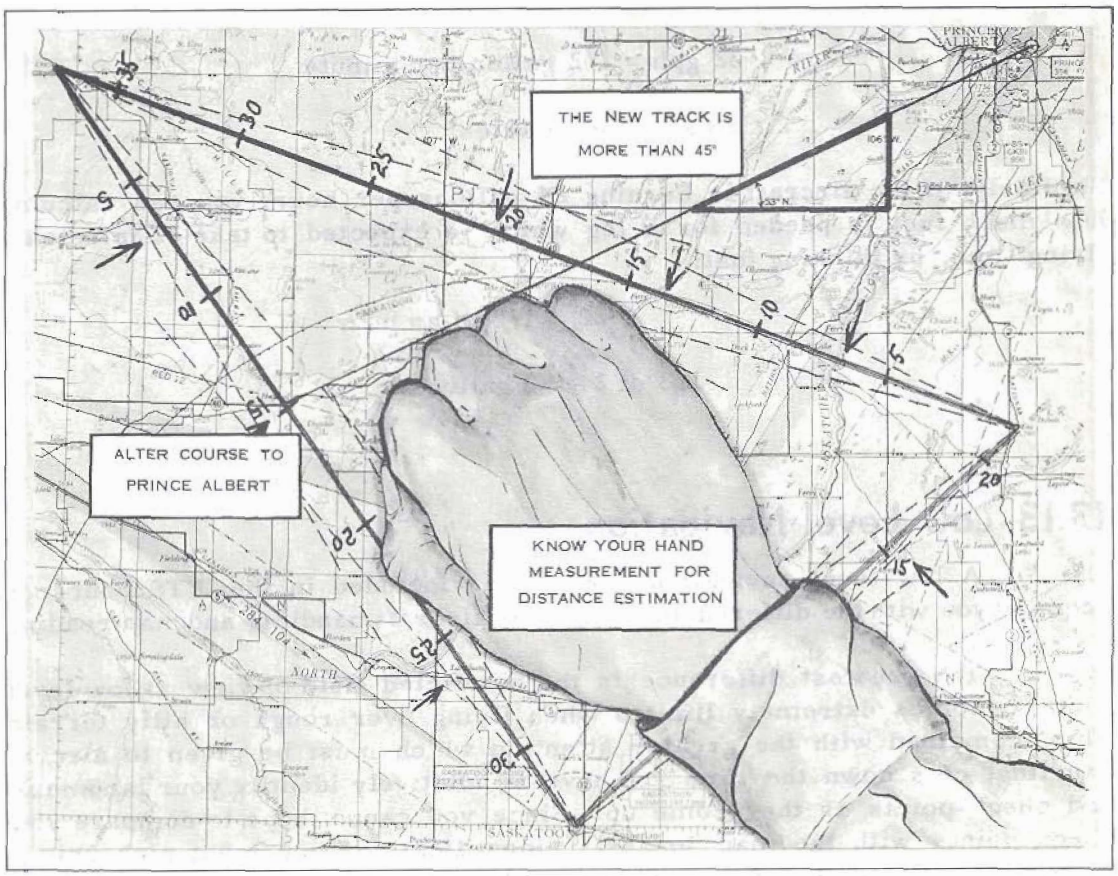

Figure 7: Track and Distance Estimation

(12) REVISING ETA - In Art 13.09(4), the "fractional" method of revising an ETA was discussed. Where fractions are difficult to calculate, a simple formula can be sustituted:

$$\frac{\text{Time early or late}}{\text{Time expected}} \times \text{Total leg time} = \text{ETA}$$

For example, if, on an estimated flight of 70 minutes, a point is reached in 18 minutes which was not expected until 20 minutes, the ETA is revised as follows:

$$\frac{2}{20} \times 70 = 7 \text{ minutes early.}$$

(13) ESTIMATING FUEL - Proficiency in estimating fuel requirements and consumption becomes increasingly valuable as you gain experience in flying. Such calculations are relatively simple, proportional arithmetic giving answers which although not precise are accurate enough for most purposes. For example, if an aircraft burns 32 gallons of fuel per hour and there are 28 gallons left in the tank, you can estimate the remaining flying time by thinking that:

32 gph = 1/2 gallon per minute

$\therefore$ 28 x 2 = 56 minutes.

Similarly, if the aircraft is burning 24 gallons per hour, you can calculate how much fuel is needed for a leg which is expected to take 22 minutes of flying time, by thinking that:

22 = 1/3 of an hour

1/3 of 24 = 8 gallons.

13.13 - Low-Level Navigation

(1) A low-level navigation exercise is included in the FTS course to acquaint you with the different techniques of aircraft handling and map reading.

(2) The greatest difference is the restricted field of view at low level, which becomes extremely limited when flying over rough or hilly terrain. This, combined with the greater attention which must be given to aircraft handling, cuts down the time you have to positively identify your landmarks and check-points as they come up. Since you cannot hope to compare your check-points with the map to assist identification, you must pick unique, easily recognizable features, and learn all you can about them before starting the flight. Line features that run 90° to the track are used as check-points, and those that run to the turning point are used as lead-in lines.

(3) During a low-level navigation trip you have to be on the look-out for obstacles such as TV and radio towers, power lines, factory chimneys and sharply rising ground. Most of these can be studied on the map before the flight so that you know when they are liable to come up, but some that have recently been built may not be shown. The set-heading procedure should be done before descending to the altitude of the low-level leg, and navigation is strictly confined to map reading. Log keeping is disregarded because of the urgent need to keep a good look-out, but alterations of heading and ETA are carried out using normal procedures. Sometimes it may not be possible to follow the route which you planned before starting off, and it may be necessary to work out your new position by Mental DR. If you become uncertain of your position, climb high enough to give yourself an extended field of vision and try to identify a landmark. If this produces nothing, climb higher still and follow the "circle of uncertainty" procedure.

(4) Remember that when you are doing cockpit checks you must not bury your head in the cockpit. Do the check by completing the first item and then pausing to have a thorough look around, complete the next item and look around again; continue in this way until the check has been fully covered. Do not worry if the airspeed varies as you follow the contour of the ground: the speed will average out for the leg as a whole, and it should not be necessary to make power adjustments except during a long climb. If your low-level navigation technique is to be a success, you must develop good handling characteristics, so that most of your time can be devoted to checking your position and look-out.

13.14 - Navigation at Night

(1) Navigation at night is basically the same as day navigation except that most ground detail is indistinguishable. Your choice of check-points is limited to large lakes, rivers, main highways, towns and cities, and other features which are clearly visible at night. You must beware of lighted check-points however, since, owing to lights being visible over long distances, there is a tendency for students to underestimate their range. Accurate timing should alleviate this error. Keeping a good look-out at night is particularly important since you are only one of the many users of airspace, and not all aircraft are equipped with flashing navigation lights.

Chapter 14

Night Flying

14.01 - Introduction

(1) Proficiency in night flying is an important step towards your all-round flying ability. The handling of the aircraft is no different from ordinary day-time flying, but overcoming the visual restriction can be a problem unless you are prepared to study approved methods of improving night vision. Once you have learned how to see at night, you will find that flying can be pleasant: the air is smoother owing to the absence of thermal or convection currents, and the engine seems to run better.

14.02 - Improving Your Night Vision

(1) Your eyes and your mind are a team. To see at night the two have to be working in conjunction, one interpreting the visual impressions relayed by the other. During the day this interpretation is entirely automatic, but at night, the eyes have to be made to see objects clearly enough for the brain to go into action. In daylight all colours are visible while, at night, vision is restricted to shades of gray, except when the light intensity is high enough for the eye to register colour. The discussion of the construction of the eye which follows should help you to understand the problems that must be surmounted.

(2) As an optical instrument, the human eye may be considered to consist of two distinct parts: the cornea with its lens and iris combination to gather and control the amount of light, and the retina consisting of receptor cells to transmit the light image to the brain. The lens and iris combination are often called the pupil. The size of the lens opening through which the light rays reach the retina is controlled by the quantity of light: the lower the light intensity, the larger the lens opening.

(3) The magnification of the human eye in Figure 1 overleaf, shows that the back of your eyes are covered with innumerable light-sensitive nerves in the form of rods and cones. The cones are clustered in the centre of the retina and decrease towards the periphery, while the rods increase in number

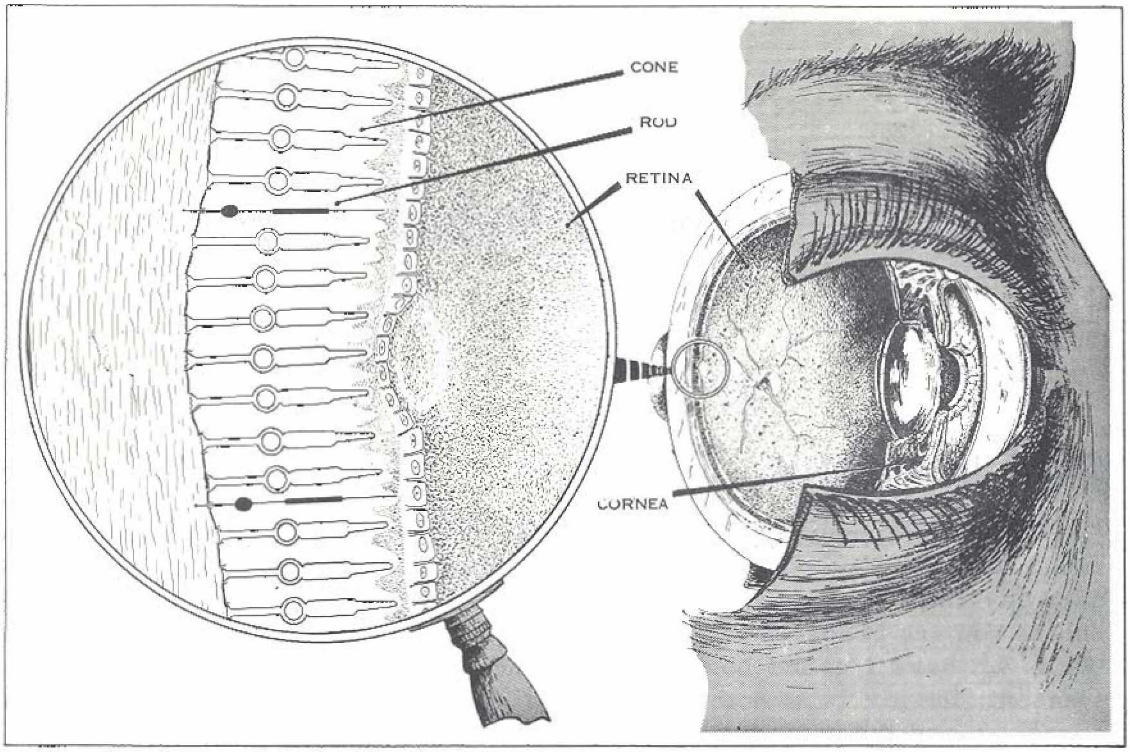

Figure 1: The Construction of the Eye

towards the periphery. The cones are used to see colour, detail and far-away objects: the rods dispersed among them pick up only shades of grey. During the day the use of both rods and cones enable you to see clearly; at night, unless the light intensity is great enough for the cones to function, you have to rely on the shades of gray transmitted to your brain by the rods.

(4) When you leave a well-lighted room and go outside on a dark night your pupils open wide to admit every particle of light that can be trapped. Despite the maximum lens opening however, your vision is restricted almost to the point of total blindness because of the sudden transition and the inability of the retina to register the changed light values. Within ten minutes, the cones of the retina begin to adjust to the dim light and allow you to see to the limit of your sensitivity, which is approximately 100 times better than when you first stepped out. After 30 minutes the rods become adjusted and are 100,000 times more sensitive, enabling you to see well if you have been trained in night vision.

(5) From the foregoing, it is obvious that once your eyes are adapted to the darkness you must keep them that way if you are to be night flying. The reverse process - adjustment from darkness to light - takes only a second or two, and undoes the work of 30 minutes. When you are about to go night flying you could sit in a dark room for half an hour before each flight, but a much more practical method is to wear specially tinted goggles. These goggles have red lenses which, although stimulating the cones of the retina and thus allowing you to read, keep the rods "in the dark" and enable them to adapt to

the dimmer light. Another method is to sit in a room with red lighting. The use of either method between flights keeps your eyes at the correct adjustment for maximum visibility at night. If circumstances prevent the use of aids to night vision, or if the equipment is not available at your school, then all you can do is to avoid white lights and use the red lights in the cockpit until your eyes become accustomed to the reduced light.

(6) Once you are in the aircraft, don't undo the previous 30 minute's work by waving a flashlight around to help you do the cockpit checks. Use only as much light as is absolutely essential, and train yourself to do all of the manual parts of the checks without light. If you must have light, switch on the red cockpit lights and, if that isn't sufficient, shut one eye to preserve its night vision capabilities while using the other to see by the white light of your flashlight. Make a point of studying maps and charts BEFORE setting out on a flight so that you don't have to illuminate the cockpit unnecessarily during the flight.

(7) During the flight, since you are depending on the rods of the retina for vision and they are scarce near the centre part of the eye, you have to look at objects by shifting your gaze slightly off-centre. Your eyes must be consciously directed to make scanning movements in such a way that the image of the object being examined falls on the rods rather than on the central cones. A further characteristic of rod vision is that it fades away completely if the eyes are held stationary for more than a few seconds. This means that not only do you have to make searching movements with your eyes to locate an object, but you have to keep your eyes moving slightly to keep it in sight. The technique of SCANNING is the principle skill to be acquired before you can say that you are capable of seeing at night.

(8) Learn to keep your eyes moving in dim light. As you search, do not sweep the ground or sky at random; scan one small area carefully before jumping your eyes to the next area, then keep your eyes jumping from one area to another until the whole field of vision has been covered. The movement of your eyes should be slower than if you were doing the same search in daylight, and if the image becomes blurred, you should blink, look away and then return to the area of search. Constant practice is the only way to acquire an automatic scanning technique.

14.03 - Night Recognition

(1) In daylight you can see the colour and detail of an object, as well as its size and the contrast it makes with the background. At night, however, even when your eyes are adapted to the darkness, you have to rely entirely on size and contrast to recognize an object. Familiar objects look different in the dark and you have to know how to interpret the smallest clues in order to identify them. A clean windshield and canopy help, since anything that absorbs or scatters light reduces contrast and makes vision difficult. There is

little that you can do about fog or haze on the perspex, but you can clean off oil and dirt, and try to prevent scratches.

(2) Sometimes you may find that you become disorientated. This is caused by the sharp change into total darkness, and can only be overcome by having complete trust in the instruments. A deficiency of Vitamin A can impair your night visions to some extent, and smoking, drinking, fatigue or some of the more common drugs have an adverse effect. A well-balanced diet is essential for the promotion of good night vision, with physical fitness and plenty of rest being paramount if you expect your body to be in top condition. Remember, before you can see and recognize objects at night, you must be in full control of all your faculties.

14.04 - Flying at Night

(1) You may be apprehensive about your first night flight, but remember that the same techniques and procedures are used in day flying. Night flying is more demanding however, and you may have to rely on your instruments to determine the attitude of the aircraft. Also, you must be constantly on the alert for other aircraft.

(2) If you see reflections of flames coming from the exhaust stack, do not worry - the flames are there all the time - even during the day. You may also confuse reflected lights on the canopy with the lights of other aircraft and attempt to take avoiding action, but once you become accustomed to the appearance of everything at night, you will have overcome the biggest obstacle to night flying.

(3) You should try to memorize the location of every switch and control in the cockpit, and be able to find them with your eyes shut. While flying dual at night, use some of the time to check your knowledge of the cockpit in the dark, and to set the instrument lights at the correct brilliance. These lights should always be as low as possible to prevent eyestrain and to reduce canopy reflections.

(4) Your night dual instruction will be comparatively brief. Help your instructor by familiarizing yourself with all of the flight and taxi procedures before your first flight, and DON'T FORGET TO TAKE A FLASHLIGHT ALONG. A flashlight must be carried on all night flights and is used for the external check, as well as being available as an emergency source of light should the aircraft electrical system fail.

(5) In the air you will be shown the airfield lighting and the extent of the local area; your instructor will point out prominent landmarks, including the lights of cities and towns and any other features that may help to keep you orientated. You will be shown night landings with and without landing lights. The circuit differs from a day circuit in that the climb after take-off is made

straight out to circuit height, where a Rate 1 turn is made onto the down-wind leg. To provide proper separation if another aircraft is taking-off ahead of you, you must continue to climb straight ahead until he has completed his Rate 1 turn and has passed your wing tip on his way down-wind. When rejoining the circuit, you must fly up-wind on the dead side at circuit height until all traffic ahead of you has turned down-wind and has passed your wing tip; then start a turn onto the down-wind leg.

(6) Normally all traffic is controlled by radio, but in the event of radio failure, you are expected to know how to use light signals. Local flying regulations deal thoroughly with night emergencies, and part of your pre-flying briefing will be devoted to learning them. Before going solo you will be expected to do at least one over-shoot procedure, using the normal day-time techniques.

(7) When the moment of your first night solo arrives, remember that your instructor has full confidence in your ability. Perform all of the checks carefully and, when you are ready to leave the ramp, turn up the volume of the radio and adjust the cockpit lighting. You should be able to see the instruments without any glare, but since the lights are going to increase in intensity when the throttle is opened for take-off, the adjustment made on the ramp must make allowance for this increase. If reflections annoy you while taxiing, open the canopy.

(8) After you are given take-off clearance, line the aircraft up with the centre of the runway and make your take-off with reference to the runway lights. Once the aircraft is airborne, and before the last light is reached, transfer your attention to the instru-

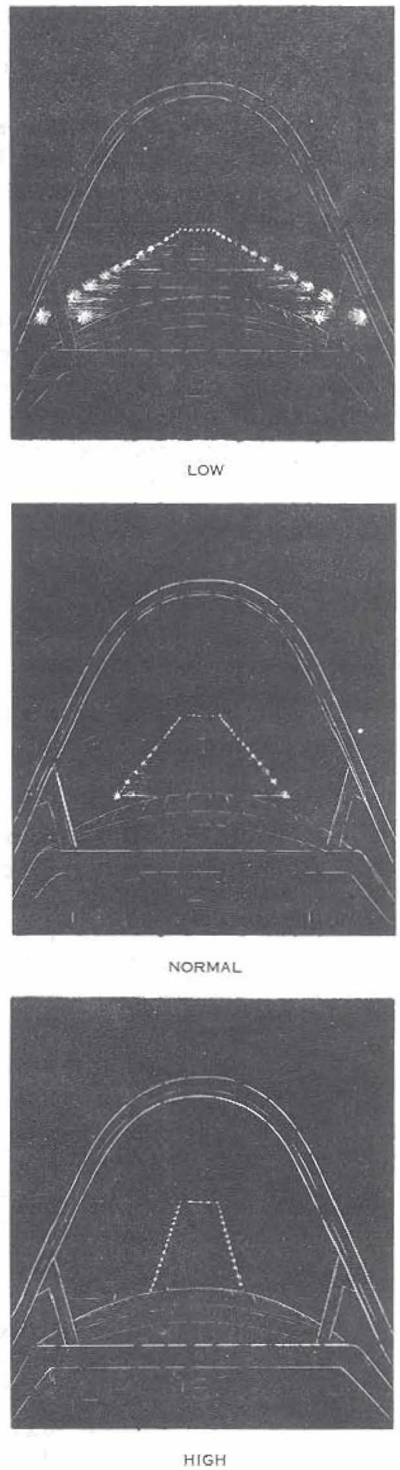

Figure 2: The Approach Angle at Night

ments. Climb away at the normal, safe climbing speed, keeping straight. Do not look back over your shoulder at the runway, since this can lead to disorientation.

IF THE ENGINE FAILS ON TAKE-OFF, LAND STRAIGHT AHEAD.

Refer to Article 8.07 for the suggested procedures in the event of engine failure: above all, NEVER turn back towards the runway - small turns only are, permissible when obstructions have to be avoided. The landing lights can be switched on to illuminate the immediate area, thus helping you to clear large obstacles.

(9) During the pre-night-flying briefing, your instructor will run over night-landing techniques and procedures, making special mention of any local regulations which are in effect. When coming in on the approach, do not switch on the landing light until you are approximately 300 feet AGL. If you find that you are undershooting, open the throttle IMMEDIATELY and overshoot. Do not hesitate. Avoid low, drag-in approaches of the type shown at the top of Figure 2 overleaf.

14.05 - Summary

(1) The following points have been compiled to help you when night flying: pay attention to them because they may prevent you from making serious errors.

(a) Allow yourself extra time before a flight for studying procedures, checks and maps.

(b) While the aircraft is parked, you should idle the engine slightly faster than during the day because of the increased load on the electrical system.

(c) The restricted visibility at night makes it difficult to see if the aircraft is creeping during the run-up. Make sure that the brakes are "ON".

(d) Always carry a flashlight to help with the external check, and also for emergency in the event of an electrical system failure.

(e) Always taxi at a slower rate at night because of the reduced visibility.

(f) When taxiing, never switch on the landing light so that it blinds the pilot of a landing aircraft. If you are in doubt about your position, or if there are obstructions in your path, stop to investigate.

(g) Keep the instrument lights as low as possible.

(h) Fly on instruments as soon as the aircraft is airborne.

(j) Since there is relatively less wind at night, propeller wash from other aircraft is more noticeable. Watch for aircraft taking-off and landing ahead of you and be prepared for turbulence.

(k) DO NOT MAKE LOW, DRAG-IN APPROACHES.

(l) Do not forget to switch the landing lights "OFF" during the Post-Landing Check.

Have you completed the form at the end of this publication?

Chapter 15

Instrument Flying

15.01 - Attitude Instrument Flying

(1) Attitude instrument flying can be defined as the art of controlling an aircraft by reference to flight instruments. Like visual flying, instrument flying makes use of certain reference points to determine the attitude of the aircraft, but instead of watching the position of the nose and wings in relation to the horizon, you have to interpret readings on instruments. Attitude instrument flying is a combination of three distinct abilities.

(a) INSTRUMENT COVERAGE - The ability to cross-check all the instruments.

(b) INSTRUMENT INTERPRETATION - The ability to interpret the information which the cross-check has given.

(c) AIRCRAFT CONTROL - The ability to control the aircraft according to this information.

(2) INSTRUMENT COVERAGE - Even in visual flight the instruments have to be CROSS-CHECKED, so you should be familiar with the term and its meaning. In instrument flying there are no other aids to help you to control the attitude of the aircraft, so constant cross-checking becomes vital. A good instrument pilot cross-checks all the time, and any lack of proficiency in instrument flying usually can be traced to slow or inaccurate cross-checking. Not all pilots cross-check according to the same pattern, but all of them use primary and secondary supporting instruments for each manoeuvre. The primary instruments are those instruments giving the most pertinent information about the attitude of the aircraft. The others are called secondary or supporting, and give additional information from which the attitude can be assessed. Sometimes a supporting instrument is referred to almost as much as a primary instrument, but as you progress in instrument flying, you will develop your own technique of cross-checking. Later you will find that the loss of one or more instruments presents no great problem, except that instrument flying on a partial panel demands even more accurate and persistent cross-checking.

(3) INSTRUMENT INTERPRETATION - Instrument interpretation is difficult to learn. During instrument flight the instruments serve the dual function of indicating the attitude of the aircraft and whether this attitude is to serve the desired purpose. Since precision flying is impossible without accurate instrument interpretation, you should make every effort to reach proficiency quickly. The first step is to know each instrument and what it shows. From there, various instrument combinations in relation to aircraft attitude can be learned until, eventually, quick and accurate interpretation becomes second nature. For example, if you wish to determine the position of the nose in the pitching plane, you should KNOW that you must look at the airspeed indicator, the altimeter, the vertical speed indicator and the artificial horizon. All readings at ALL times must be interpreted in terms of attitude.

(4) AIRCRAFT CONTROL - The aircraft is controlled in exactly the same way as if you were flying visually, except that, instead of outside reference points, the instruments show the attitude of the aircraft at any given time. The elevators control pitch, the throttle controls power, the ailerons control bank and any pressure on the elevators and rudders can be trimmed off, just as usual. In instrument flying, pitch, power, bank and trim are all co-ordinated movements. Relaxation is important - if you are tense it is difficult to fly properly on instruments. Tenseness only makes your control movements jerky and you will probably find yourself holding on a pressure against the elevator trim. Relax! Try to hold the controls lightly and trim the aircraft to maintain the desired attitude.

15.02 - The Instrument Cockpit Check

(1) A basic requirement for successful instrument flying is that the instruments be working and that they be calibrated properly. Before an instrument flight, the Pre-Flight Checks must include the:

- (a) pitot head;
- (b) suction gauge;
- (c) airspeed indicator;
- (d) directional indicator;
- (e) aritificial horizon;
- (f) altimeter;
- (g) turn and slip indicator;
- (h) vertical speed indicator;

(j) magnetic compass and magnesyn compass;

(k) clock;

(l) radios;

(m) publications; and

(n) blind-flying hood.

(2) THE PITOT HEAD - During the examination of the aircraft before flight, you must make sure that the pitot head is undamaged. Later, when sitting in the aircraft, the pitot heat should be switched "ON" then "OFF" while you watch for a deflection of the ammeter needle. You never know when you are likely to run into ice, and pitot heat is essential at such times.

(3) THE SUCTION GAUGE - Since a number of the instruments are dependent on suction for their operation, the suction gauge reading is an important part of the Pre-Flight Check. The indication must be in the range of 4.25 to 4.75" Hg.

(4) THE AIRSPEED INDICATOR - The needle of the airspeed indicator should indicate zero when the aircraft is stationary.

(5) THE DIRECTIONAL INDICATOR - The directional indicator has no direction-seeking qualities, therefore the heading of the aircraft according to the magnetic compass must be pre-set on the instrument during the tarmac check. While taxiing out you should check the directional indicator to make sure that it is working properly; during turns to the left the heading should decrease, and vice versa. At the Pre-Take-Off Check the heading shown should agree with that of the magnetic compass: if the error is large, the instrument is unreliable. The operating limitations of the instrument are 55 degrees of either pitch or bank.

(6) THE ARTIFICIAL HORIZON - The artificial horizon must be uncaged and the miniature aircraft adjusted so that the hairline is barely visible on the staff: this is the approximate position for straight and level cruising flight. If the horizon remains in the correct position for the attitude of the aircraft, or if it begins to oscillate, then slowly corrects itself, the instrument is working properly. While taxiing, you should check that the horizon remains horizontal during left and right turns.

(7) THE ALTIMETER - The altimeter is set to the airfield barometric pressure, as reported by the control tower. If the difference between the published airfield elevation and the height shown on the altimeter is more than 50 feet after this setting has been made, the instrument is unserviceable.

(8) THE TURN AND SLIP INDICATOR - During the Tarmac Check, the turn and slip indicator can be checked by pressing on one side of the instru-

ment panel and watching for a deflection of the needle. You should examine the tube containing the ball to ensure that it is full of damping liquid. While taxiing you should glance at the needle and ball during changes of direction to see if they are reacting properly. If their indications are not positive, or if the needle is sluggish and does not return promptly to the centre mark, the instrument is unserviceable.

(9) THE VERTICAL SPEED INDICATOR - The needle of the vertical speed indicator should point to zero when the aircraft is on the ground. If it reads above or below zero, it can be adjusted quickly by a technician.

(10) THE MAGNETIC COMPASS AND MAGNESYN COMPASS - The magnetic compass can be checked for accuracy by comparing its heading with that of a known heading. The level of the fluid in the instrument should be sufficient for good damping action. The magnesyn compass can be checked in the same way, and the readings of both compasses can be compared. While taxiing a further check can be made to ensure that the indicators are not stuck.

(11) THE CLOCK - During your request for taxi clearance, the tower will give you a time check. Set the aircraft clock to the correct time (GMT) and check that it is working.

(12) THE RADIOS - A radio check should be made to ensure that both the VHF transmitter and the receiver are working efficiently. Tune the radio compass on "ANT" to a known station, identify the station and tune for maximum volume: change to "COMP" to determine if the automatic feature is operating properly: move the switch to "LOOP" and, with the Voice/CW switch on "CW", operate the Left/Right switch to rotate the loop: check for the correct location of the Null: move the Band Selector to each band, tuning in a known station, and check the automatic feature of the radio compass; this will ensure that all frequencies are available.

(13) PUBLICATIONS - If your proposed flight is to be one requiring reference to FLIPS, you must remember to carry them out to the aircraft and stow them where they will be readily available.

(14) BLIND-FLYING HOOD - Before setting off on an instrument flight it is advisable to check that the hood will lock into place and that the release will work. Instances have occurred of instrument flights having to be broken off because of failure to check the hood.

15.03 - Pitch Control in Co-Ordinated Level Flight

(1) In level flight the pitch attitude varies with airspeed. Whenever the airspeed changes you have to alter the angle of attack to keep lift constant; at

low airspeeds the aircraft flies nose high, while at high airspeeds it flies nose low. The pitch control instruments are the:

(a) altimeter;

(b) aritificial horizon;

(c) vertical speed indicator; and

(d) airspeed indicator.

(2) THE ALTIMETER - Usually, the altimeter is the primary pitch control instrument. In level flight, height should remain constant, therefore any deviation from the desired altitude indicates that you must change the pitch attitude. The rate of movement of the altimeter needle tells you how much change is needed. For example, if the movement is slow, the pitch attitude should be corrected with small control pressures; if the movement is fast, greater pressures are needed. Any corrections should be made promptly and with the lightest possible control pressures. You must remember too, that any correction for altimeter deviation must be made in three stages: the first pressure stops the needle movement; the second returns the needle to the desired altitude and the third stage is holding the new altitude. Usually, there is a small lag in the altimeter, but it can be ignored since acceptable results are obtained by following the instructions given above.

(3) THE ARTIFICIAL HORIZON - In instrument flying the artificial horizon substitutes for the real horizon, and gives a direct reading of the pitch attitude of the aircraft. The instrument has no lag, therefore it shows an immediate change in pitch attitude, but it is subject to precession during turns and during acceleration or deceleration. Precession can be detected immediately by cross-checking the other pitch instruments. The instant the other instruments show the need for a correction, the relative position of the miniature aircraft to the horizon bar can be determined, and any adjustment should be made at this position. Provided the miniature aircraft has been set properly during the Pre-Flight Check, it should not have to be re-adjusted in flight. However, if it does not coincide with the horizon bar in level flight at cruising airspeed, you should turn the little knob so that a true level-flight attitude is obtained. Once you have the miniature aircraft set for cruising airspeed, do not make any other changes for variations in airspeed, because you will be unable to get a true picture of the pitch attitude. If the artificial horizon has to be caged in flight, it must be uncaged only when the aircraft is in the straight and level attitude as shown by the other instruments. This ensures reliable readings and maximum toppling limitations.

(4) THE VERTICAL SPEED INDICATOR - The vertical speed indicator is another supporting pitch instrument. Any movement of the needle from the zero mark shows a need for immediate corrective action. This instrument is used in conjunction with the altimeter, any uncorrected altimeter indication being repeated as a gain or loss of height on the VSI. When you see any

movement of the vertical speed needle and take immediate corrective measures, the altimeter usually fails to record a change in height. The initial movement of the needle is instantaneous, but there is a lag in its return, which is directly proportional to the speed and amount of the correction. You should train yourself to use smooth, light control pressures, thus making vertical speed interpretations easier. Over-controlling can be stopped if you relax and allow the pitch attitude to stabilize before resuming your corrective actions. Occasionally, the calibration of the instrument may be slightly out and the needle may not register zero in level flight. If this happens, it is simple to consider the level-flight reading as the zero mark and to make changes of attitude according to this reading.

(5) THE AIRSPEED INDICATOR - The final supporting pitch instrument is the airspeed indicator. With a given power setting and pitch attitude, the airspeed remains constant; if it increases, the nose is too low; if it drops off, the nose is too high. Rapid changes in airspeed mean that large corrections are needed to return the aircraft to the level attitude. There is very little lag in the instrument and any changes in pitch attitude are reflected almost immediately in airspeed changes.

15.04-Power Control in Co-Ordinated Level Flight

(1) At a given airspeed the power setting determines the attitude of the aircraft. Cruising airspeed with cruising power gives level flight but, if the power is increased while the airspeed is held constant, the aircraft will climb. At a constant altitude, the power setting determines the airspeed so, if power is increased and altitude is maintained, the airspeed will go up. During such power and airspeed changes, elevator pressure co-ordinated with rudder pressure is needed to hold the aircraft in the level-flight attitude. The elevator pressures are needed because the aircraft naturally tends to assume a nose-high attitude with power increases, and a nose-low attitude with power decreases, owing to changes in the vertical lift. Rudder pressures are necessary to counteract the tendency of the aircraft to yaw during airspeed and power fluctuations.

(2) To keep a constant height and airspeed in level flight, pitch and power control must be co-ordinated. It is this relationship between height and airspeed which determines the need for changes in power and pitch. If the altitude is constant and the airspeed is high or low, you should change the power setting to obtain the desired airspeed. During each power change, you should interpret the altimeter reading so that any deviation can be corrected by elevator pressure. If the altimeter needle is below, or above, the desired mark, and the airspeed is correspondingly high or low, a change in pitch alone should return the aircraft to the proper altitude and airspeed. If both airspeed and altitude are high or low, then changes in both power and pitch are necessary.

(3) To make power control easy when changing airspeed, you should learn the approximate power settings for the various airspeeds most often used. When a change of airspeed of 10K or more is required, it is recommended that you adjust the throttle to give a manifold pressure 3 to 5" above or below the normal setting for the new airspeed: above if it is an increase, below if a decrease. Obviously, the manifold pressure gauge will have to be included in your cross-check during this process, and the pitch attitude must be altered if you wish to maintain a constant altitude. As the needle of the airspeed indicator comes to within 2 to 3K of the new airspeed, the throttle should be adjusted to hold the new airspeed. This procedure gives a moderate rate of change of airspeed, and provides ample time for co-ordinated elevator and rudder movements.

15.05 - Cross Checking During Co-Ordinated Level Flight

(1) During co-ordinated level flight your cross-check should include all of the pitch instruments. A glance at the altimeter may show that the pitch attitude looks fine, but by switching your eyes to the vertical speed indicator and the artificial horizon, you may notice the beginning of a small deviation. The earlier you find the need for a correction, the less work is involved in taking the necessary corrective action. Any pitch adjustments should be made

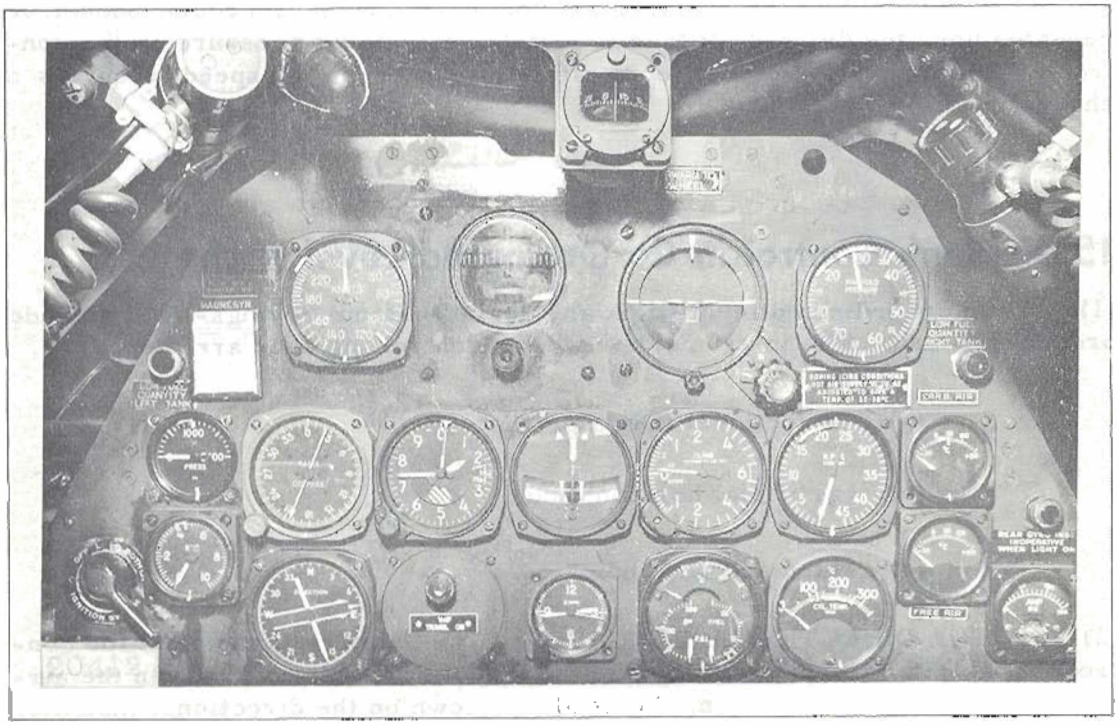

Figure 1: The Instrument Panel

in three stages. After stopping the error with the first adjustment, you should choose a new pitch attitude on the artificial horizon to correct the error and re-adjust to maintain the correct attitude. The vertical speed indicator tells you if the adjustment is taking effect, and another glance at the altimeter shows whether the corrective action you have taken is sufficient. At a constant power setting, a normal cross-check is satisfactory, but during power or attitude changes, you must increase the speed of your cross-check to cover all of the instruments adequately. Figure 1 overleaf, shows the location of the various instruments on the Harvard panel, so that you can practise the cross-checking techniques described.

15.06 - Trim in Co-Ordinated Level Flight

(1) Proper trim techniques are essential to smooth and accurate instrument flying. The rudder and elevator trim wheels should be used to relieve control pressures not to initiate changes of attitude. Sometimes, after trimming and apparently having relieved all of the pressures, small pressures which you cannot feel may have been left on. The best technique is to release the rudder pedals or control column slowly and watch the instruments to see if the attitude remains constant. If the aircraft is not properly trimmed, control corrections can be made to return the aircraft to the desired attitude, and the trim can be re-set with fine adjustments. This procedure should be repeated until the desired attitude is maintained without pressure on the controls. Remember, any change in attitude, power or airspeed requires a change in trim.

15.07 - Bank Control in Co-Ordinated Level Flight

(1) In co-ordinated level flight any deviation from a wings-level attitude produces a turn. The instruments used for controlling bank are the:

(a) directional indicator;

(b) artificial horizon; and

(c) turn and slip indicator

(2) THE DIRECTIONAL INDICATOR - The primary instrument for controlling bank in co-ordinated flight is the directional indicator. When the aircraft banks and starts to turn, the heading shown on the directional indicator alters at a rate proportional to the degree of bank and rate of turn. Co-ordinated aileron and rudder pressures return the aircraft to straight and level flight and, when the directional indicator shows a constant heading and the

ball of the turn and slip indicator is in the centre, you know that the wings are level. To attain a desired heading, the aircraft should be banked at an angle no greater than the number of degrees of the correction, and NEVER more than a Rate 1 turn. Since precession makes the instrument read inaccurately by approximately 5 degrees every 15 minutes, you must compare the heading frequently with that of the magnetic compass. Any precession is removed by resetting to the magnetic compass heading. There is no turning error in the directional indicator.

(3) THE ARTIFICIAL HORIZON - The artificial horizon, besides being a supporting pitch instrument, is a supporting bank instrument. The angle of bank is indicated by the pointer on the banking scale, and also by the attitude of the miniature aircraft. Small angles of bank, which you may not be able to see clearly when watching the miniature aircraft, register on the banking scale and allow you to decide on the exact amount of corrective action. The banking scale pointer moves opposite to the direction of bank and tells you the ANGLE of bank only. To find the DIRECTION of bank, you must refer to the miniature aircraft's relationship to the horizon bar. Any turn shown can be stopped by levelling the wings of the miniature aircraft with co-ordinated aileron and rudder pressures. Pitch and bank can be determined simultaneously since, although the wings of the miniature aircraft may not be level with the horizon bar, the pitch attitude can be seen by noting the relative position of the nose of the miniature aircraft to the horizon bar. Sometimes in a turn the artificial horizon will precess. This can be discovered by cross-checking the other instruments. Precession is usually most noticeable during the roll-out so, if the wings of the miniature aircraft are level, but the turn continues, you should make further corrections to stop any movement of the directional indicator.

(4) THE TURN AND SLIP INDICATOR - The turn and slip indicator is a supporting instrument for bank control. The needle indicates the direction and the rate of movement of the nose of the aircraft around the horizon - not the degree of bank. The rate of turn is in direct relationship to the airspeed and the angle of bank. In co-ordinated flight, when the turn needle is displaced from its normal central position, the aircraft is banking in the direction indicated. A close watch is needed to interpret small deviations accurately. In turbulent air the needle oscillates, so you have to decide on the centre of oscillation and determine the direction of bank from that. If you think that the needle is out of adjustment, fly the aircraft straight and level and watch the other instruments: note the position of the needle and use this as the reference for straight and level flight. You should be able to continue your instrument flying by judging all angles of bank from the new reference point. In any attitude of flight, the "ball" part of the turn and slip indicator tells you when the aileron and rudder movements are co-ordinated. When the wings are level and the ball remains in the centre of the glass tube, the aircraft is in straight flight: slip or skid causes the ball to move away from the centre mark.

15.08 - Cross Checking With Bank Control Added

(1) When you are practising level flight, all of the instruments have to be cross-checked. The directional indicator and the turn needle indicate when the aircraft is turning; the artificial horizon and the ball of the turn and slip indicator show the cause of the turn. Remember that pitch and bank are of EQUAL importance when you want to fly straight and level.

(2) As you learn to interpret each of the bank instruments, you must include it in the sequence of cross-checking carried out previously for pitch attitude only. As the number of instruments increases, the speed of cross-checking must also increase.

15.09 - Turning

(1) Usually instrument turns are made at a definite rate. During your training at FTS, instrument turns will be confined to 15, 30 and 45 degree constant bank turns, for which the artificial horizon is the primary bank instrument.

(2) To enter a constant bank turn, apply steady, co-ordinated pressures to the ailerons and the rudder in the desired direction. As soon as you apply these pressures, the artificial horizon becomes the primary bank instrument and the altimeter becomes the primary pitch instrument. The pitch attitude must be changed to compensate for the loss of vertical lift caused by the banked attitude, but the corrections must not be made until the instruments indicate a deviation from the desired readings. As you raise the nose to hold altitude, you must open the throttle to maintain airspeed: the amount of back pressure applied and the amount of throttle movement required depending, on the angle of bank. Once the proper angle of bank has been reached, you may have to apply slight opposite aileron to stop the banking motion of the aircraft. Holding a constant angle of bank once it has been stabilized is important, since any alteration of bank alters the vertical lift, making it impossible to maintain level flight without a pitch correction. The return to straight flight is accomplished by applying opposite control pressures while watching the artificial horizon. When the wings of the miniature aircraft become level, the directional indicator is the primary bank

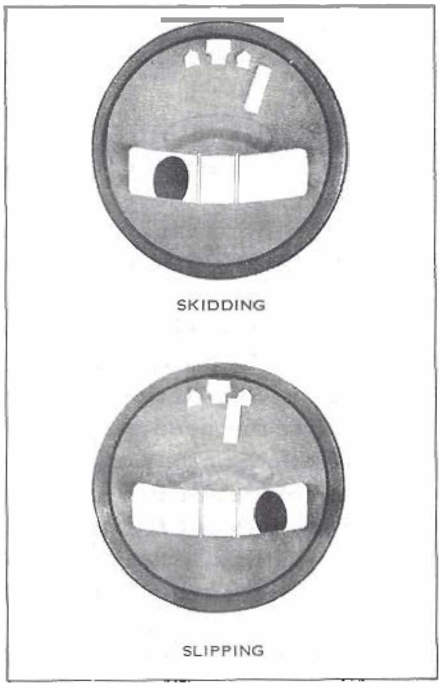

Figure 2: Unco-ordinated Turns

instrument. The rate of roll-out should be the same as the rate of roll-in and, as the angle of bank and the vertical lift change, the pitch attitude should be adjusted. The nose is lowered to maintain the desired altitude and the throttle setting is changed to maintain the desired air speed.

(3) It is possible to go into a turn by using rudder pressure alone, but rather than executing a properly co-ordinated turn, the aircraft skids in the horizontal plane. Similarly, owing to aileron drag, the use of aileron alone causes the aircraft to slip. This means that the ball must be included in your cross-check throughout any turn. Figure 2 opposite shows what happens to the needle and ball when the controls are mishandled in a turn.

(4) TURNS TO SPECIFIC HEADINGS - In co-ordinated flight an aircraft will continue to turn as long as the wings are banked, therefore, to recover on a specific heading, you must start the roll-out early. The amount of lead time varies with the angle of bank and the rate of roll-out, but usually, a satisfactory rule is to use half the angle of bank. For example, if the angle of bank is 30 degrees and you are turning to the right from 360 degrees to 180 degrees, you would start the roll-out at 165 degrees, or 15 degrees before the desired heading.

(5) The roll-out is done in the same way as for a normal recovery. Any small corrections that have to be made must NEVER have a larger angle of bank than the number of degrees of heading error that you wish to correct. During these turns the normal cross-check is used but, as you near the desired heading, you must refer to the directional indicator more often to determine when to start the roll-out.

15.10 - Climbs and Descents at Constant Airspeeds

(1) Many combinations of airspeeds and power settings can be used during constant speed climbs and descents. The primary instruments for these manoeuvres are the airspeed indicator for pitch, the directional indicator for bank, and the manifold pressure gauge for power. Rather than explaining every eventuality, only a few general rules and examples are given below.

(2) If the aircraft is flying at cruising airspeed and you wish to climb or descend at the same air speed, as soon as you open or close the throttle, the airspeed indicator becomes the primary pitch instrument. When you want to change the airspeed, but not the throttle setting, the artificial horizon is the primary pitch instrument to start with, until the desired airspeed is reached. When both power and airspeed changes are required, you must change the airspeed first. This, of course, depends on the indicated cruising speed of the aircraft, the power setting and the new airspeed, and also whether you wish to climb or descend.

(3) For example, if the aircraft is flying at cruising airspeed and you wish to climb at 95K, you must apply gentle back pressure to the control column until the artificial horizon indicates the correct attitude for a climb. As soon as the airspeed approaches 95K, you must open the throttle and start to consider the airspeed indicator as the primary pitch instrument. This does not mean to imply that you should glue your eyes to each of those instruments in turn and ignore the others. On the contrary, your cross-check must be comprehensive, but the artificial horizon and the airspeed indicator, being for the moment primary instruments, must receive a greater percentage of your attention.

(4) If you wish to descend at an airspeed lower than cruising airspeed, you adjust the throttle first and hold altitude by watching the altimeter, until the airspeed has dropped to the required level. During this airspeed change, the artificial horizon is used as the supporting pitch instrument. If you wish to descend at an airspeed higher than cruising airspeed, the artificial horizon is the primary instrument until the new airspeed is reached. If throttle is used to increase the speed, the setting is made immediately and, when the new airspeed is attained, the power is reduced if necessary.

15.11 - Level-off From a Climb or Descent

(1) The level-off from a climb or descent must be started early. The lead time varies according to the technique used, but normally, 10% of the vertical speed is ample. When you reach the pre-determined altitude for starting the level-off, you should use the artificial horizon and the altimeter, together, as the primary pitch instruments. If small correcting adjustments are needed to maintain the level-flight attitude, the altimeter becomes the primary pitch instrument.

(2) The use of power during the level-off depends on the cruising airspeed which you wish to attain, and whether the level-off is from a climb or descent. Depending on the circumstances, power may be adjusted before, during or after the level-off. A knowledge of the approximate power settings for different cruising airspeeds is beneficial during this exercise.

(3) If you wish to cruise at 120K after a normal climb at 95K, you should start by levelling-off to allow the airspeed to build up to almost 120K, and then you should reduce power to the setting that will maintain this airspeed. If no airspeed change is needed, the power and the pitch attitude are adjusted together. If you wish to reduce the airspeed after levelling-off from a descent, you should level-off the aircraft and allow the airspeed to fall before adjusting the throttle to maintain the desired airspeed. For an increased cruising airspeed after a descent, you must increase the power and maintain the attitude on the artificial horizon so that the new airspeed is attained by the time the level-off has been completed. Before any level-off, your actions should be planned in advance so that you reach the new attitude with a minimum amount of correction.

15.12 - Climbing and Descending Turns

(1) The technique used during climbing and descending turns is a combination of those for straight climbs and descents, and constant-bank level turns. The climb or descent can be started before the turn, at the same time as the turn, or after the aircraft has begun to turn. Similarly, the level-off may be completed at any time during a turn, except that the turn should always be made onto specific headings and the level-off should be completed by a pre-determined altitude.

(2) Since climbing and descending turns are done at a specified airspeed and power setting, the airspeed indicator is the primary pitch instrument, the manifold pressure gauge is the primary power instrument and the artificial horizon is the primary bank instrument. The cross-check during this combined manoeuvre must be rapid and thorough, to prevent errors from becoming too large. You should use the same interpretations and control pressures as for level turns and straight climbs and descents.

15.13 - Rated Climbs and Descents

(1) Rated climbs and descents are excellent manoeuvres for developing and improving precision aircraft control: they are essential for instrument let-downs. Having studied climbing and descending at a constant airspeed, you should be familiar with the general principles; these remain the same, except that the vertical speed indicator is now the primary pitch instrument: the directional indicator remains the primary bank-control instrument during this manoeuvre. The entry can be made from any attitude or condition of flight, but here, only an entry from level cruising flight is to be considered. At first you will practise rated climbs and descents with a constant power setting, the airspeed being allowed to reach its own level within safe limits. Later, as your proficiency increases, you will be taught to use the correct proportion of power to vertical speed, thus achieving a specific airspeed during the climb or descent.

(2) To enter a rated climb with a constant power setting, you must raise the nose to the approximate climbing attitude while cross-checking the artificial horizon and the vertical speed indicator. When the desired rate of climb appears on the vertical speed indicator, the pitch attitude must be adjusted to maintain this rate, and the vertical speed indicator becomes the primary instrument for pitch control. As proficiency is gained, you should practise the same manoeuvre adjusting the throttle with reference to the manifold pressure gauge, to give a specific airspeed at the desired rate of climb. The initial throttle movement is based on 1" MP equalling 100 fpm or 5K. After making this preliminary throttle adjustment, the correct rate of climb should be established before making further power alterations to rectify the airspeed. At this point the airspeed indicator becomes the primary power control instrument. The procedure for a rated descent is identical to that of

the rated climb. During both manoeuvres excess pressures should be trimmed out, thus helping to prevent over-controlling in the pitching plane. The level-off is carried out in the same way as a level-off from a climb or descent at a constant airspeed.

(3) Sometimes a vertical speed indicator may be improperly calibrated. This can be checked against the altimeter and the aircraft clock by establishing a rate of climb or descent and comparing the readings every 15 seconds. If you have established a rate of 500 fpm, the altitude change should be 125 feet in 15 seconds: a 1,000 fpm rate gives 250 feet in 15 seconds. When you have decided on the accuracy of the instrument, subsequent rates of climb or descent should incorporate any instrument error.

15.14 - Standard Rate Turns

(1) In a standard rate turn, the nose of the aircraft is turned through a definite number of degrees per second, this being a usual requirement for applied instrument procedures. The Standard Rate 1 turn of 3 degrees per second is the most common.

(2) The rate of turn varies according to the amount of bank and the airspeed, therefore, if you wish to perform a Rate 1 turn you must calculate the angle of bank. A simple method is to drop the last digit of the IAS and add 7 to the remainder:

For example, 120K = 12 + 7

= 19 degrees.

(3) Having found the angle of bank, you can roll into the turn, timing the rotation of the directional indicator to check the rate of turn. The main 30 degree marks are used for this check, the rate being correct if 30 degrees of heading change takes 10 seconds. Minor adjustments to the angle of bank may be necessary to give the proper rate of turn which, once established, should be checked on the turn and slip indicator. The position of the turn needle during a Rate 1 turn remains constant at all airspeeds, and should have a definite relationship to the small pyramids to the left and right of the centre mark. If, after calibrating the instrument in both directions, you find that the needle does not coincide with the pyramids in a Rate 1 turn, you should make an appropriate entry in the L-14 to have this unserviceability corrected.

15.15 - Changing Airspeed in Turns

(1) Changing airspeed in turns is taught to improve your cross-checking technique and to foster accuracy of control. Since the rate of turn depends on

the angle of bank/airspeed relationship, each time the airspeed is changed, the angle of bank must be adjusted, if the rate of turn is to remain constant. In addition, if you wish to hold a constant altitude during these airspeed changes, the pitch attitude must be varied.

(2) Your cross-check while the airspeed is changing must include the altimeter as the primary instrument for pitch control, the turn needle as the primary instrument for bank control and the manifold pressure gauge as the primary instrument for power control. When the airspeed indicator shows that the new airspeed is approaching, the primary power control changes from the manifold pressure gauge to the airspeed indicator.

(3) Two methods of changing airspeeds in turns should be practised: one is to make the change after the turn has been established, and the other is to alter the power setting while the aircraft is being rolled into the turn. In either method, if you wish to decrease the airspeed, you must set 3 to 5" MP less than that required for the new airspeed. During the change, watch the altimeter and the vertical speed indicator, and make prompt pitch adjustments. Cross-check the turn needle at the same time to ensure that the angle of bank is correct. When the airspeed is 2 to 3K higher than the desired airspeed, the power must be adjusted to a setting that will maintain this airspeed throughout the remainder of the turn. Once the aircraft is turning properly at the new airspeed, you can trim off the extra control pressures, and include the airspeed indicator in your normal cross-check.

15.16 - Turning on the Magnetic Compass

(1) The magnetic compass is the only heading indicator which does not become inoperative with failure of the suction or electrical supply. It is important for you to be able to turn the aircraft onto a specific magnetic heading and hold it there for a period of time. To help you to do this, the following points are brought to your attention.

(a) When you turn East or West from a Northerly heading, the needle lags or shows a turn in the opposite direction.

(b) When you turn East or West from a Southerly heading, the needle shows a greater amount of turn than has been made.

(c) No error is apparent during turns from Easterly or Westerly headings

(d) An increase in airspeed during an Easterly or Westerly heading causes the needle to fluctuate towards the North.

(e) A decrease in airspeed during an Easterly or Westerly heading causes the needle to fluctuate towards the South.

(f) On a Northerly or Southerly heading, no error is apparent while climbing, diving or changing airspeed.

To reduce compass reading errors to a minimum, you should check the compass only when the aircraft is flying straight and level at a constant airspeed.

15.17 - Timed Turns

(1) A timed turn is a Standard Rate 1 turn in which the computations of the clock and the turn needle are combined to change the heading of the aircraft through a definite number of degrees. Before timed turns can be practised, the turn needle must be calibrated as explained in Art 15.14(3), and you must know the indicated heading of the aircraft. This can be found by flying a steady course, straight and level, for at least half a minute and noting the compass reading: an average reading must be used, since the compass needle is seldom steady. Assuming that the heading is 270 degrees and you wish to turn left to 090 degrees, you can calculate the time it is going to take to turn through 180 degrees at 3 degrees per second (Rate 1).

(2) In making timed turns, exact timing is extremely important. It is easiest to start the turn when the sweep-second hand on the clock is at "12": at this instant roll the aircraft smoothly into a Rate 1 turn. When the calculated number of seconds has elapsed, recover, making the roll-out smooth and at the same rate as the roll-in. During the turn the cross-check is the same as for a Rate 1 turn, except that the aircraft clock is substituted for the directional indicator. The turn needle is the primary instrument for bank control, the altimeter is the primary instrument for pitch control, and the airspeed indicator is the primary instrument for power control. The importance of maintaining the proper deflection of the turn needle for a Rate 1 turn, and of centring it on recovery, cannot be overstressed: any deviation results in heading errors.

(3) When you reach proficiency in this exercise you should be able to make timed turns to compass headings without having to refer to the directional indicator. In making these turns to compass headings you may find that, owing to flying or timing errors, you have missed the desired heading. The corrective procedure is to note the amount of error and make another timed turn to the desired heading: small corrections may be timed by counting.

15.18 - Steep Turns

(1) Any turn having an angle of bank greater than 30 degrees is considered to be a steep turn. Although they are seldom required in normal flying, steep turns increase your ability to react quickly and smoothly to

rapid changes of attitude. Flying techniques during the turn are the same as for normal turns, except that you may have difficulty in controlling the pitch attitude owing to the loss of vertical lift caused by the large angle of bank. To add to the difficulty, the primary bank-control instrument, the artificial horizon, is liable to precess.

(2) In your cross-check, even though there may be small precession errors, the artificial horizon is the primary bank-control instrument. The need for a correction will show up on the vertical speed indicator or the altimeter, and will be reflected on the artificial horizon sufficiently for you to make a correcting adjustment. After making the adjustment, you can check back to the vertical speed indicator, and the altimeter, to see if the change has been adequate. It is important that you correct the attitude only when the need arises.

(3) During the roll-out three actions have to be taken simultaneously: you must release the back pressure, decrease the bank and, reduce power. The altimeter is the primary pitch-control instrument, but is closely supported the whole time by the vertical speed indicator and the artificial horizon. For the power reduction the manifold pressure gauge is the primary power-control instrument momentarily.

15.19 - Recoveries From Unusual Attitudes

(1) An unusual attitude may result from turbulence, instrument failure, vertigo, confusion or, from carelessness in carrying out a regular cross-check. The airspeed indicator, the altimeter, the turn and slip indicator and the vertical speed indicator are all employed in making a speedy recovery to normal straight and level flight. You must learn to trust the instruments and believe in their readings. Body sensations cannot be relied upon, and they often give a false impression of the actual attitude of the aircraft.

(2) Two procedures are used for recovery from unusual attitudes, the choice depending on whether the nose is above or below the horizon. When you first realize that the aircraft is in an unusual attitude, check the airspeed indicator and the altimeter. These instruments indicate the pitch attitude, and dictate the action required to bring the aircraft back to straight and level flight.

(3) If the airspeed is increasing and height is being lost, the nose of the aircraft is obviously below the horizon. To prevent the build-up of excessive airspeed and the loss of too much height, close the throttle, level the wings by centring the turn needle and ball, and apply sufficient back pressure to correct the pitch attitude. When the airspeed stops building-up and the altimeter no longer indicates a descent, the aircraft is either in, or passing through, the level-flight attitude.

(4) If the airspeed is falling and the altimeter reading is increasing, you can assume that the nose is above the horizon. To prevent a further decrease in airspeed, apply maximum permissible power immediately, lower the nose with pressure on the control column, and level the wings. When the airspeed and altimeter readings are constant, or beginning to reverse, the aircraft is in the level-flight attitude. During such recoveries from nose-high and nose-low attitudes, a close check on the altimeter and turn needle is necessary to prevent over-correction, and to help to maintain the level-flight attitude once the recovery has been made.

(5) RECOVERY FROM A SPIN - You can tell that the aircraft is in a spin if the airspeed is low, there is extreme displacement of the turn needle and height is being lost rapidly. The ball may be displaced in either direction depending on the spin characteristics of the aircraft. The recovery technique is the same as that used during visual flight; that is:

(a) throttle back;

(b) full opposite rudder;

(c) control column forward until rotation stops;

(d) centralize the rudder; and

(e) ease out of the dive as explained in paragraph (3)

The turn needle is the primary instrument during the recovery, for, whenever it flicks over to the opposite side of the dial, you know that the spin has stopped. You must centralize the rudder IMMEDIATELY to prevent the aircraft from spinning in the opposite direction, and take the recovery action outlined in paragraph (3).

15.20 - Overshooting

(1) An instrument overshoot combines the techniques learned while levelling-off from a descent at a constant airspeed, with those used for starting a normal climb. As the overshoot altitude is reached, you must open the throttle to 32" MP if the pitch is at full "FINE", but not beyond 28" MP if only 2,000 rpm has been selected. The Post-Take-Off Check should be completed at this time. When the throttle is opened, bank control is maintained with the help of the directional indicator, while pitch control is checked on the airspeed indicator and the artificial horizon.

(2) During an overshoot with flaps "DOWN", the attitude of the nose as indicated by the miniature aircraft in the artificial horizon should be slightly above the level-flight attitude. The initial part of the overshoot is done at 80K, and, as soon as the Post-Take-Off Check has been completed and the

flaps are "UP", the airspeed can be increased to 95K. While the power change is being made, you should rough-trim the aircraft and, later, when the correct climbing attitude and airspeed have been attained you should re-trim, removing all pressures from the controls. A rapid cross-check is necessary throughout the overshoot to prevent any deviations from assuming serious proportions.

15.21 - Instrument Flying and the Flight Procedure Trainer

(1). At this stage of your basic flying course you should be familiar with the attributes and limitations of the Flight Procedure Trainer. Although there are certain limitations in the simulation of actual flight, the trainer is adequately suitable for teaching attitude instrument flying. You can practise most of the instrument exercises and learn to develop a good system of cross-checking; but for maximum benefit, you must be prepared to study the theory of each problem before attempting it in the trainer. To this end you will find that the syllabus of training for your course has been designed so that each topic will be introduced during ground school lectures, and then you will have a chance to try them out, first in the Flight Procedure Trainer and, latterly, in the air. Conscientious study and continuous practice are the two requirements for skilful instrument flying.

Chapter 16

Applied Instrument Flying

16.01 - Introduction

(1) With a thorough knowledge of Basic Instrument Flying you should be capable of controlling an aircraft without visual reference to the ground or the horizon. This chapter explains the procedures by which your basic knowledge can be combined with radio aids, to allow you to navigate and make landing approaches entirely on instruments.

(2) TC-42, Flight Procedures for the RCAF, is the official guide to Applied Instrument Flying. At FTS some of the methods described in that publication must differ slightly, owing to your stage of training and the limitations of the equipment carried in the Harvard. Thus, while only touching on the theory of the various aids here, some of the procedures are treated expansively to enable you to go through each, step by step. As far as possible the terms used are the standard terms of more advanced stage of flying, these being included to familiarize you with their meaning, and to prepare you for further study in this subject at AFS.

16.02 - The VHF Homing

(1) The simplest method of navigating to your home base is with the help of a VHF Homing. You would use it to obtain a heading if you became lost on a cross-country, or if you were uncertain of your position at any time and wished to set course for base. Under these circumstances, the following procedure is recommended.

(a) Synchronize the directional indicator (DI) with the magnesyn compass and continue to compare the readings throughout the rest of the procedure, re-setting the DI as necessary so that you are sure of flying a correct magnetic heading.

(b) Call the tower and ask for a VHF Homing, including a let-down if you think you will need one. In reply, the controller will most probably ask you to change to a specific homer frequency.

(c) Change to the new frequency and call the VHF Homer operator.

(d) In reply, the Homer operator will ask you to give your present heading, altitude and approximate position.

(e) Following your report, the operator will give you a heading to steer and will follow this up at regular intervals by asking you to "Transmit for Steer". The transmission is made by pressing the "TRANSMIT" button for three seconds, repeating the aircraft number and releasing the button. All other transmissions from your aircraft are used by the operator to check your track and, if necessary, he will give you heading changes from his observations. All heading and altitude instructions must be repeated to enable the operator to check that you are complying with his directions.

(2) The aircraft must be flown accurately throughout the Homing, accuracy being even more vital if, in an emergency, you have to follow the Homing with a let-down. Normally at FTS only Homings will be practised. However if you should have to do a VHF let-down, the operator is capable of bringing you in over the aerodrome at minimum altitude so that you can make a landing. Remember, however, that for a Homing or let-down to be effective YOU MUST FOLLOW THE INSTRUCTIONS GIVEN BY THE OPERATOR.

(3) If there is any danger of not having enough fuel to reach an aerodrome, you must make the necessary adjustments for maximum range. (See Art 12.05) One of the additional advantages of being at FTA, of course, is the increased range of your VHF Homing equipment.

16.03 - The ADF Homing

(1) A Radio Compass is installed in the aircraft, and the best method of homing to a known facility is by using the Automatic Direction Finding (ADF) equipment. The procedure is to:

(a) tune in the radio compass and correctly identify the desired facility;

(b) turn the function switch to "COMP" so that the radio-compass needle points towards the facility;

(c) turn the aircraft towards the facility until the radio-compass needle reads "0", (Figure 1 opposite);

(d) keep the radio-compass needle on "0" by making small changes to the aircraft heading, if necessary, so that you continue to fly towards the facility; and

(e) as the aircraft passes the facility, watch for the radio-compass needle to rotate through 180 degrees, thus indicating "Station Passage".

(2) If the aircraft passes to one side of the facility instead of directly overhead, "Station Passage" is indicated by the radio-compass needle passing through either wing tip, depending on the position of the facility in relation to the aircraft. For example if the facility is on the right, the radio-compass needle will swing through "090°".

16.04 - ADF Tracking

(1) Sometimes you wish to fly a definite track over the ground to, or from, a known facility. Familiarity with such a procedure enables you to complete an ADF let-down, fly along an airway which does not have a Range Leg that can be used for a track check, or fly directly from one facility to another. In Chapter 13 you learned how to make allowances for drift while flying visually on a cross-country: ADF Tracking is this application of similar principles to instrument flying.

(2) TRACKING TO A FACILITY - To regain and maintain a definite track over the ground with reference to the radio-compass needle, you must proceed as follows.

(a) Tune in and correctly identify the selected facility.

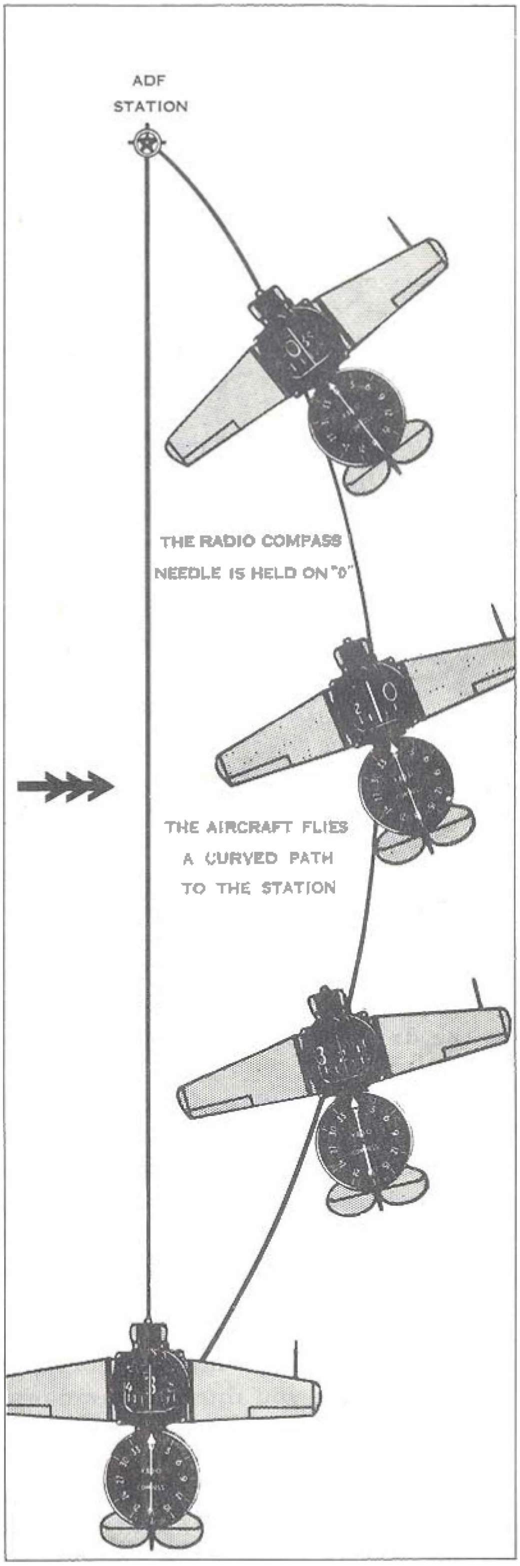

Figure 1: The ADF Homing

(b) Move the function switch to "COMP", so that the radio-compass needle points towards the facility.

(c) Turn the aircraft towards the facility until the radio-compass needle reads "0".

(d) Note the magnetic heading as shown on the DI, this is the course that you must fly to the facility.

(e) Fly this heading until the radio-compass needle is seen to have moved five or ten degrees off "0", thus indicating that the aircraft is drifting.

(f) Alter course 30 degrees towards the facility.

(g) Fly this new magnetic heading until the radio-compass needle opens 30 degrees. (Figure 2 opposite)

(h) Turn back towards the desired track and make allowance for the estimated drift.

(j) Correct the drift allowance until the aircraft remains on the desired track.

(3) Accuracy in estimating the amount of drift correction can only come from experience, but is based on the distance flown before the radio-compass needle begins to deviate. For example, if the radio-compass needle moves away from "0" only a short time after the heading has been set, there must be a strong wind blowing and, consequently, the allowance for drift must be in proportion. Once the allowance for drift has been made, the radio-compass needle no longer reads "0"; instead it should be reading an amount equal to the drift correction, but on the opposite side to the correction. (Figure 2)

(4) If, after regaining track and making an allowance for drift, you find that the radio-compass needle is moving towards "0", the correction has been too small. To regain track you must go through the whole procedure again, making a larger drift estimation. If the radio-compass needle is seen to be moving away from "0" however, indicating that there has been too great a drift correction, you may turn parallel to the desired track and hold this new heading until the aircraft drifts back onto track. When the radio-compass needle shows that track has been regained, you can make a smaller drift correction to maintain this heading. At all times the aircraft must be flown accurately, and you must remember to re-set the DI frequently if you wish to remain on track.

(5) TRACKING AWAY FROM A FACILITY - Tracking outbound is basically the same as tracking inbound, except that the radio-compass needle points to "18" since the facility is behind the aircraft. During "Station Passage" the radio-compass needle may fluctuate, making it impossible to take

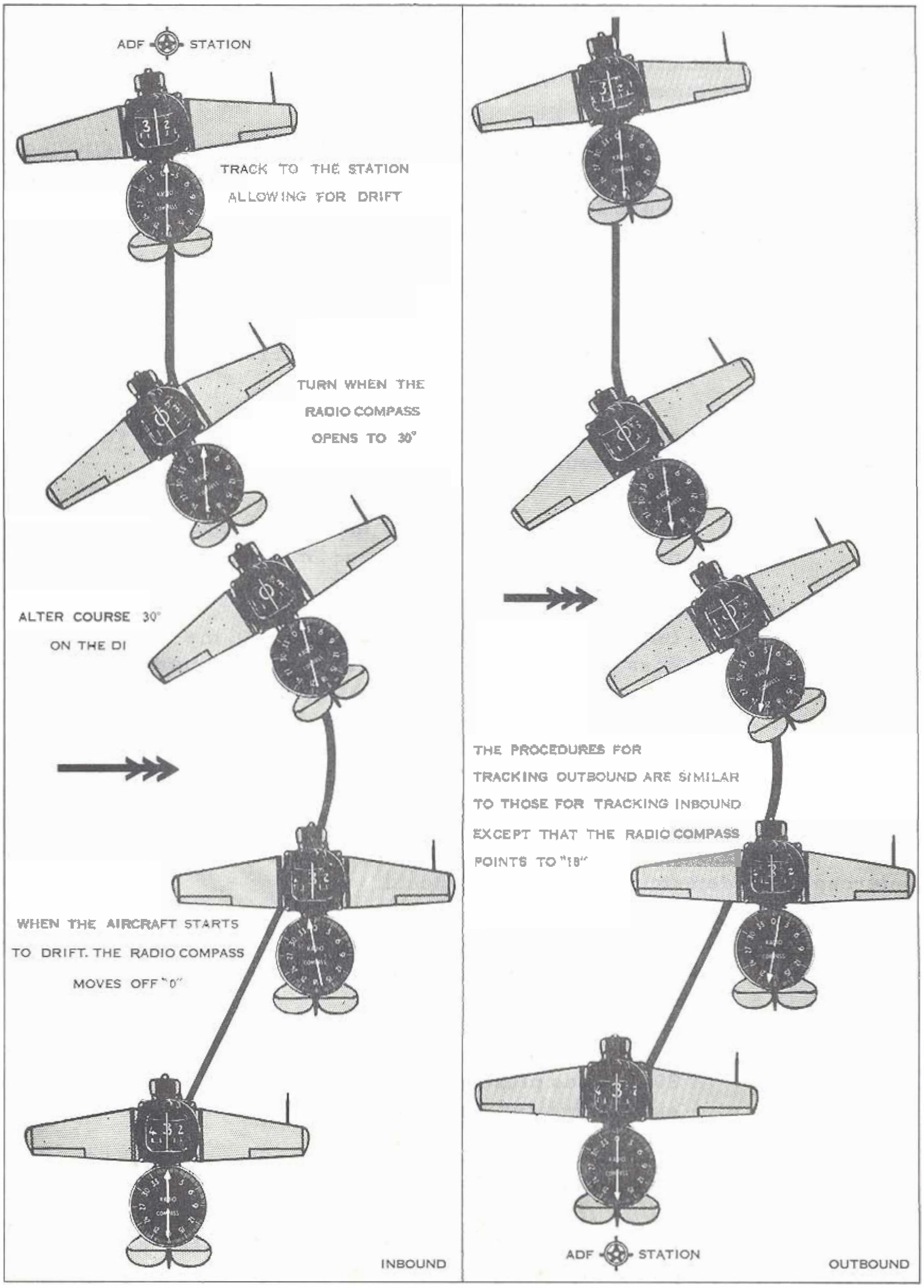

Figure 2: Tracking Procedures

a true reading, but the aircraft can be flown on a DI heading until a proper indication of track error can be obtained. Corrections for drift are made as before; however, since the aircraft is moving away from the facility, any turns to regain track must be made TOWARDS the direction of the radio-compass needle deflection.

(6) INTERCEPTING A PREDETERMINED TRACK - Occasionally, when approaching or leaving an aerodrome, you may be instructed to fly on a designated track. If you are located some distance from this track, you must be able to intercept it, turn onto it and fly it accurately. There are two procedures to follow, the choice depending on your position relative to the facility. To discover which one you should follow, you must:

(a) tune in the radio compass and correctly identify the facility;

(b) turn the function switch to "COMP" so that the radio-compass needle points to the facility;

(c) turn the aircraft towards the facility until the radio-compass needle reads "0", and maintain the resulting DI heading;

(d) turn the moveable heading indicator on the magnesyn compass to the known track that you wish to intercept; and

(e) if the angular difference between the heading indicator and the actual magnetic heading being flown is less than 60 degrees, adopt Procedure 1, while, if it is over 60 degrees, use Procedure 2.

(7) PROCEDURE 1 - When you find that Procedure 1 must be used to intercept a predetermined track, you should:

(a) turn 30 degrees on the DI to intercept the desired track, (The radio-compass needle will open 30 degrees during this turn);

(b) fly this new heading until the radio-compass needle opens 30 degrees plus the difference between the original heading and the desired track; (Figure 3 opposite)

(c) turn onto the desired track, making an allowance for drift, if it is known; and

(d) if the drift is not known, correct for drift as outlined in paragraph (2).

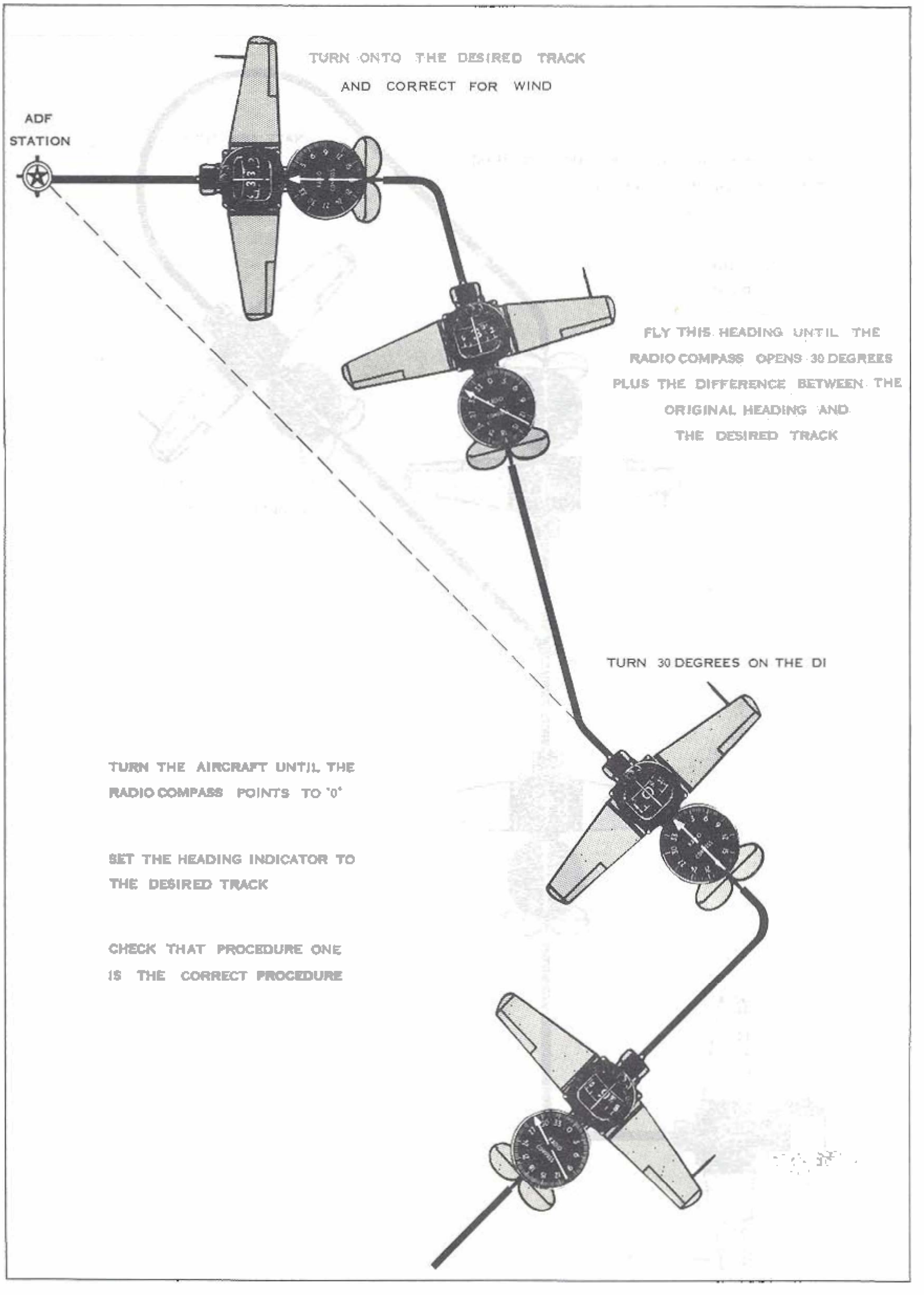

Figure 3: Procedure One

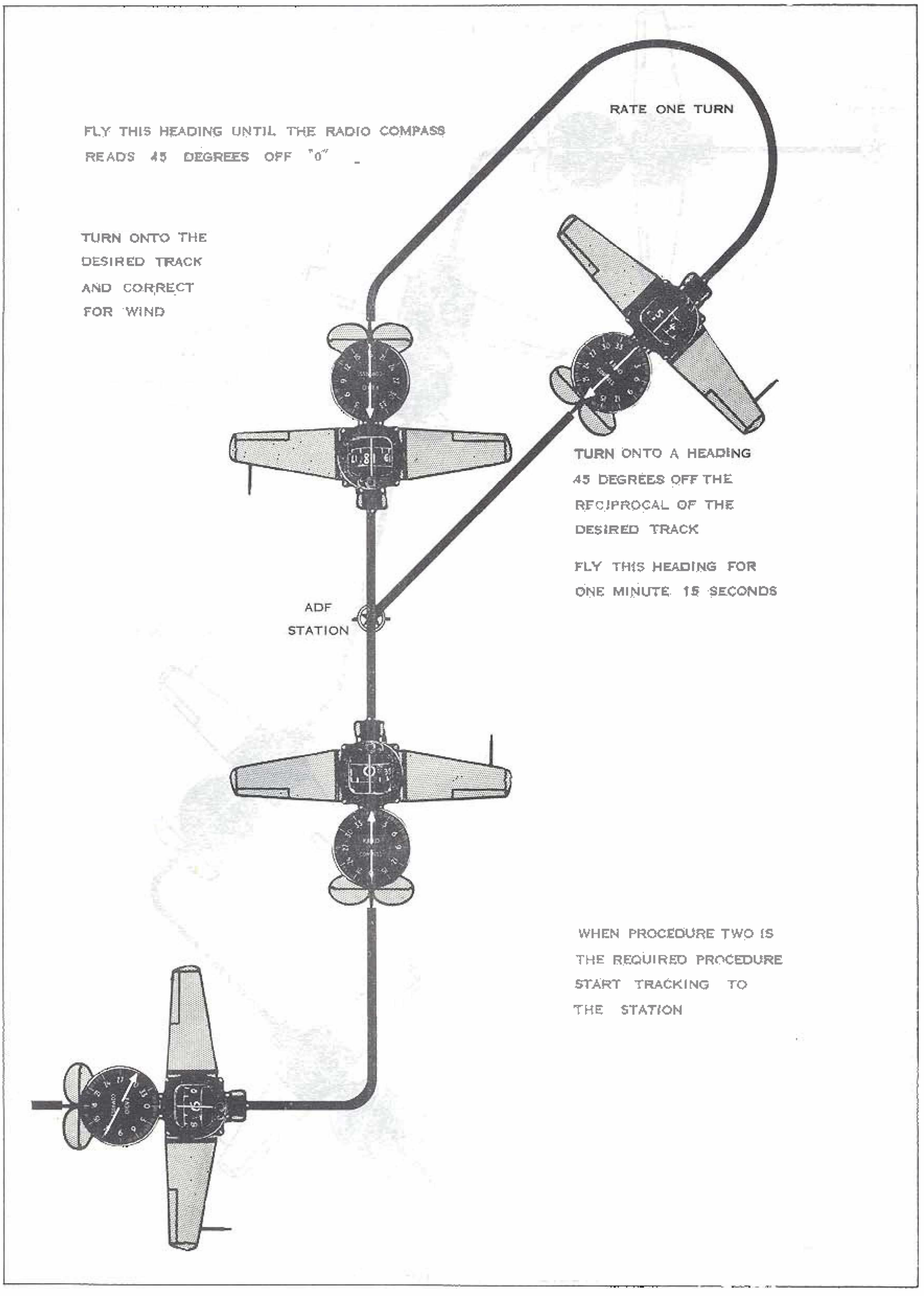

Figure 4: Procedure Two

(8) PROCEDURE 2 - If the angular difference between the reading of the heading indicator and the actual magnetic heading is more than 60 degrees, you must:

(a) continue to track to the facility, correcting for drift;

(b) on receipt of "Station Passage", turn onto the closest heading which is 45 degrees off the reciprocal of the required track, the turn being made the shortest way round, (Figure 4 opposite);

(c) fly the new heading for one minute, fifteen seconds;

(d) complete a 180 degree, Rate 1 turn towards the required track;

(e) fly the resulting heading until the radio-compass needle shows a reading 45 degrees off "0"; and

(f) turn onto the required track and home to the facility, correcting for drift.

16.05 - Time and Distance Calculations

(1) Sometimes, you may wish to know how long a homing is going to take, so that you can give the tower or Air Traffic Control Centre (ATCC) an estimated time of arrival (ETA), or, on a cross-country flight, you may wish to check your distance from a facility: both can be estimated by using the following procedures.

(a) Tune in the radio compass and correctly identify the desired facility.

(b) Turn the function switch to "COMP" so that the radio-compass needle points towards the facility.

(c) Turn the aircraft until the radio-compass needle is at "090" or "270". (Figure 5 overleaf.)

(d) Note the magnetic heading and fly it, noting the starting time.

(e) Continue to fly this heading until the radio-compass needle shows a bearing change. Normally, you should wait until there is a 10 degree change, but, if the aircraft is at a distance from the facility, a 5 degree change is sufficient.

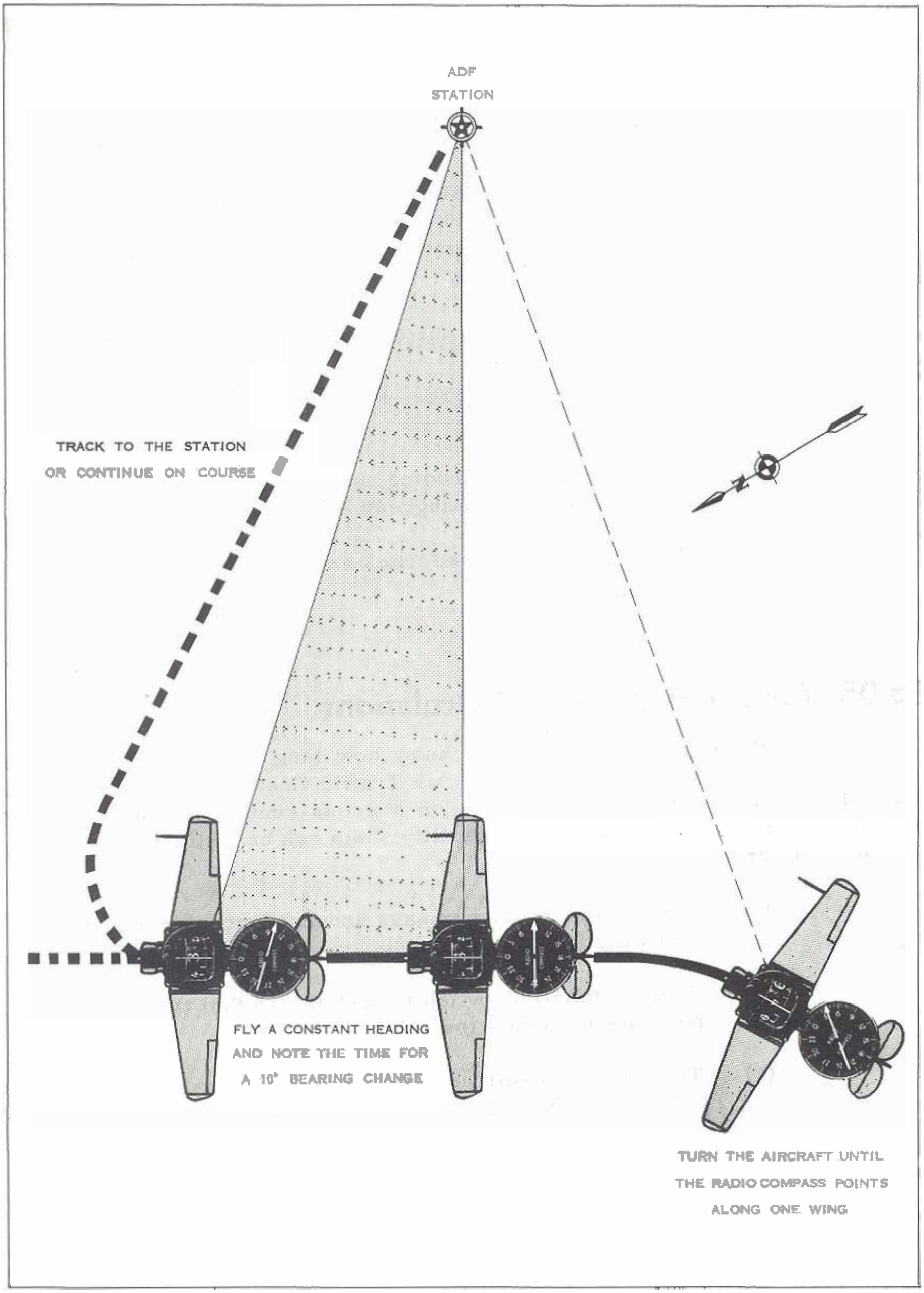

Figure 5: The Time and Distance Procedure

(f) Note the time that the radio-compass needle takes to change.

(g) If you wish to home on the facility, turn towards it until the radio-compass needle indicates "0", and track in eliminating drift; otherwise, continue your original course.

(2) By applying the following formula you can calculate the time it will take to fly to the facility in still air.

$$\text{The Time to the Facility} = \frac{60 \times \text{The Time Flown for the Bearing Change}}{\text{The Amount of the Bearing Change}}$$

If you know the wind strength an adjustment can be made to the answer given by the formula, and this, added or subtracted to the starting time of the homing, gives you an estimated ETA to the facility.

(3) If you wish to find the distance to the facility, the calculation is:

$$\text{The Distance to the Facility} = \frac{\text{TAS} \times \text{The Time Flown for the Bearing Change}}{\text{The Amount of the Bearing Change}}$$

16.06 - The ADF Holding

(1) On a cross-country flight, or when you are approaching a strange aerodrome, the ATCC may request you to "hold" over a facility until cleared to continue your flight. The reasons for a pilot being asked to hold usually concern air safety, and may be to:

(a) provide altitude separation over a facility until each aircraft in turn can be given approach clearance;

(b) delay the approach of an aircraft to an aerodrome by having the pilot hold on a facility some distance from the aerodrome; or

(c) increase the separation between aircraft flying on the same course at the same altitude by having one hold over an en route facility.

(2) THE STANDARD HOLDING PATTERN - The standard holding pattern is shaped like a race track, the ends being Rate 1 turns to the right, and the sides being two minutes flying time in length, corrected for wind effect. Since it is possible for your aircraft to be in any one of a number of positions relative to the facility when you are asked to hold, and since the controller can request that you hold over a facility, on a specific range leg or on a

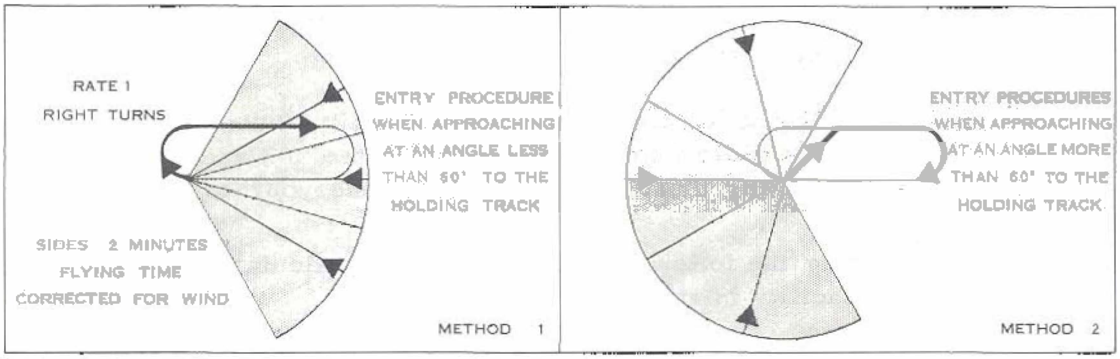

Figure 6: ADF Holding Patterns

specific in-bound heading, it is assumed here that you are being asked to hold on a specific in-bound heading. To begin the holding, therefore, you must home to the facility.

(3) As shown in Figure 6, there are two methods of entering the holding pattern. The one you must choose depends on the relative direction of the aircraft to the specified in-bound heading. For purposes of explanation, you are presumed to have adopted Method 1 and are homing-in to the facility.

(4) As soon as you receive "Station Passage", you should go into the holding pattern by reducing power to 20" MP with an airspeed of at least 100K: the manifold pressure may be adjusted as required to give this airspeed. The lower power setting results in better fuel consumption, while the 100K airspeed ensures that you have good control over the aircraft. A cockpit check is not required at this stage, but you should be aware of the amount of fuel remaining and you should re-set the DI with the magnesyn compass. After "Station Passage" the aircraft must be flown in a Rate 1 turn onto the first out-bound heading: it should be possible to make a rough estimate of drift on this first leg. The timing of the out-bound leg is adjusted to give a time of two minutes inbound. At the end of two minutes you must make a Rate 1, right turn through 135 degrees so that the in-bound heading can be intercepted at 45 degrees. The length of time taken to reach the in-bound heading while flying towards it at a 45 degree angle gives an indication of the amount of drift. A correction can be made while flying down the in-bound heading to the facility so that, by the time you are on the second circuit, all drift has been eliminated. On each circuit you must note the time of receiving "Station Passage" so that your holding may be adjusted if your estimated approach time (EAT) is less than 6 minutes away.

(5) NON-STANDARD HOLDING PATTERNS - Occasionally you may be required to hold on a pattern where all turns are made to the left; or you may be instructed to fly the sides of the pattern for a shorter period than the prescribed two minutes. Such deviations are known as Non-Standard Holding Patterns. When you have been asked to hold, YOU MUST FLY A STANDARD PATTERN EXCEPT WHEN DIRECTED TO FLY A NON-STANDARD PATTERN BY AN ATCC, OR WHEN SPECIFIC INSTRUCTIONS ARE GIVEN IN A LET-DOWN CHART.

16.07 - Let-downs

(1) The purpose of an instrument let-down is to allow the pilot to descend through cloud and position his aircraft for a safe landing. Careful planning and a thorough knowledge of procedures is the basis for successful let-downs, and all pilots, no matter how proficient, must study each let-down in detail before attempting to descend. Although the let-down book in your possession is mainly for the local area, you should be familiar with the regulation pilot's handbook issued to all graduate pilots. If you have not seen one, ask your instructor to show you his, and notice particularly the mass of information which has been accumulated for almost every aerodrome in North America.

(2) Since you are to be flying on instruments during let-down practice, a method has been developed to allow you to concentrate most of your attention on the let-down. To do this while maintaining a safe aircraft configuration, you must remember two facts.

> (a) The maximum speed for lowering the undercarriage is 130K.
>
> (b) The maximum rate of descent is 1,000 fpm.

The power settings should be adjusted to give an airspeed of 120 to 125K in straight and level flight with the undercarriage and flaps "UP", by selecting 1750 rpm and using enough manifold pressure to give the required airspeed. This means that when the undercarriage is extended in straight and level flight, the airspeed is approximately 105K, provided there is no alteration of power. Thus, a PRE-DETERMINED POWER SETTING is used for almost any situation. If you find that you have to reduce power at any time, you may do so, but you must remember to READJUST TO THE PRE-DETERMINED SETTING WHEN LEVELLING-OFF. The rpm setting remains constant up to the point of the Cross-wind Check. If you are to be making a straight-in approach from the let-down, the airspeed should be reduced to below 110K before you reach the minimum approach altitude. This allows you to lower flap safely, when necessary, to carry out the landing.

(3) In planning a let-down, the rate of descent is important: the slower the rate of descent, the easier it is to control the aircraft. If 2,400 feet have to be lost in three minutes, your rate of descent must be 800 fpm, but if only 300 feet have to be lost in the three minutes, the rate of descent would be 100 fpm. The desired rate of descent can be obtained by using one or a combination of the following methods.

> (a) Increase the speed to a maximum of 130K by lowering the nose. At a constant power setting this gives a rate of descent of 100 fpm for each 5K increase in airspeed.

(b) Lower the undercarriage while maintaining airspeed. At a constant power setting, this gives a rate of descent of approximately 300 to 400 fpm.

(c) Reduce power while maintaining a constant airspeed. Each inch of manifold pressure gives a rate of descent of 100 fpm.

(4) Since you are trying to keep a constant power setting, (a) and (b) are preferable to (c). In combination, (a) and (b) give a rate of descent of approximately 600 fpm which, normally, is sufficient for most descents. Each situation varies, however, so you must learn to analyse each problem separately and decide on a course of action.

16.08 - The ADF Let-down

(1) When you receive a clearance to make an ADF let-down and approach, you must home to the facility while letting-down to the initial-approach altitude shown on the let-down chart. On receipt of "Station Passage", you should complete the following "T. T. T. A. C." check.

CHECK	HOW	WHY
T - Time	Visually - Note the time on the aircraft clock.	The time of passing the facility is noted so that you can pass a position report (PX) to the tower, and time the distance to be flown outbound. This length of time varies, and is dependent on the amount of altitude to be lost, the limiting distance detailed on the let-down chart, the wind and the airspeed. If there is a tail wind, the length of time must be shortened, while, if there is a head wind, it should be lengthened.
T - Turn	Visually and Manually - Turn, if necessary, after checking the let-down chart.	If the out-bound track is on a heading other than the one on which you have been homing to the facility, you must turn the shortest way round to intercept the out-bound track.

CHECK	HOW	WHY
T - Transmit	Manually and Vocally - Press the "TRANSMIT" button and call.	A PX is transmitted to the controlling agency, giving the time over the facility. For example, a typical call would be "Penhold Tower, this is Air Force 123, by the beacon at 23, outbound."
A - Altitude	Visually and Manually - Check the let-down chart and start a descent if necessary.	The let-down chart always specifies an altitude for the procedure turn, and you should be at this altitude by the time you intercept the in-bound track.
C - Check	Visually and Manually - Do the Pre-Landing Check. (Art 5.04(3)).	Since you are flying on instruments and are concentrating on a let-down, the aircraft checks must be done early. However, it is permissible to leave the undercarriage "UP" at this stage, if you so desire.

(2) THE PROCEDURE TURN - When the out-bound heading has been flown for the correct length of time, you must turn onto the out-bound heading of the procedure turn as shown on the let-down chart. This heading is flown for one minute, plus or minus sufficient time to compensate for head or tail winds. At the end of this time, start a standard-rate turn to the heading, and in the direction shown, on the let-down chart. When the aircraft intercepts the in-bound track, you must turn and home to the facility on the track shown, descending if necessary to the minimum altitude given for crossing the beacon inbound.

(3) On receipt of "Station Passage" a second "T. T. T. A. C." check must be completed as follows.

CHECK	HOW	WHY
T - Time	Visually - Note the time on the aircraft clock.	The time of passing the facility, inbound, is noted so that you can PX to the tower and check the time required to reach the aerodrome. The let-down chart lists the time to the

CHECK	HOW	WHY
T - Time (Cont'd)		missed approach point at various airspeeds, making it simple for you to choose a time according to your airspeed, but adjustment must be made for head or tail winds, as before.
T - Turn	Visually and Manually - Start a turn, if necessary, after checking the let-down chart.	If the track to the aerodrome is different from that on which you have been homing to the beacon, you must turn and fly along this track to arrive over the aerodrome.
T - Transmit	Manually and Vocally - Press the "TRANSMIT" button and call.	The controlling agency must be informed of your position, therefore a PX is passed in the following manner. "Penhold Tower, this is Air Force 123, by the beacon at 30, inbound."
A - Altitude	Visually and Manually - Check the minimum approach altitude and start a descent to this altitude.	A minimum approach altitude is given on each let-down chart. Your descent to the aerodrome should be planned so that the aircraft is at this altitude by the time the minimum visibility limitations are reached.
C - Check	Visually and Manually - Ensure that the undercarriage is "DOWN" and "LOCKED".	When the runway is sighted and you are in a position to carry out a landing, you must complete the Cross-Wind Check, (Art 5.05(2)) to ensure that the aircraft is fully prepared for the landing.

(4) If the facility is located on the aerodrome, rather than some distance from it, there are two minor differences as follows.

(a) The second "T. T. T. A. C." check is done during the procedure turn, the PX taking the following form: "Moose Jaw Tower, this is Air Force 456 on procedure turn at 35".

(b) The descent to the minimum approach altitude is made while tracking inbound to the facility.

(5) If the aerodrome is not visible at the ETA, you must carry out a missed approach procedure, meanwhile notifying the tower of your action. The "missed approach procedure" referred to here is not merely overshooting according to Art 6.10, but includes following the limitations and patterns outlined in the let-down chart.

16.09 - Radio Range Procedures

(1) BRACKETING - "Bracketing the beam" is the name given to a method of flying down a known radio range leg while gradually eliminating drift. The amount of each alteration of heading, or "bracket", is reduced steadily until a course can be flown which allows a constant beam signal to be received. During the first part of this procedure the aircraft is flown down the "twilight" of the beam, since the "on-course" signal is three miles wide, 60 miles from the radio range transmitter. Half a mile from the transmitter the "on-course" narrows to 132 feet. By flying the "twilight" until the beam narrows, the pilot can be sure of his approximate lateral position and can be sure of having adequate lateral separation from other aircraft using the facility.

(2) STANDARD BRACKETING - A practical method of "bracketing the beam" is to fly the aircraft on a course which intercepts the beam at an angle of 30 degrees. On receipt of the first "on-course" signal, the aircraft is turned to intercept the right side of the "on-course" at 30 degrees. As soon as the beam has been crossed and the first "twilight" signal is received, you must turn onto the magnetic heading of the range leg. If the aircraft begins to drift out of the "twilight", one of two signal changes is possible. If you hear the "on-course", you must alter course 30 degrees to the right, away from the beam heading. On regaining the "twilight", the aircraft is turned to the left an amount estimated to eliminate drift, the procedure being repeated until a constant "twilight" is received. If the aircraft drifts into the "bi-signal zone", the alterations of course are made in the opposite directions until a constant "twilight" is regained.

(3) HOLDING - The procedure for holding on a radio range leg is almost identical to that of an ADF Holding, except that the indication of your position is received aurally rather than visually. Examples of entries and holding patterns are shown in Figure 7 overleaf.

(4) THE STANDARD RANGE APPROACH - The mechanics of the Standard Range Approach are the same as for the ADF let-down. "Station Passage" however is indicated by a "cone of silence" when passing directly overhead, or by a rapid change of signal, if passing close by. The procedure is to follow the beam to the facility until "Station Passage" is received. At this

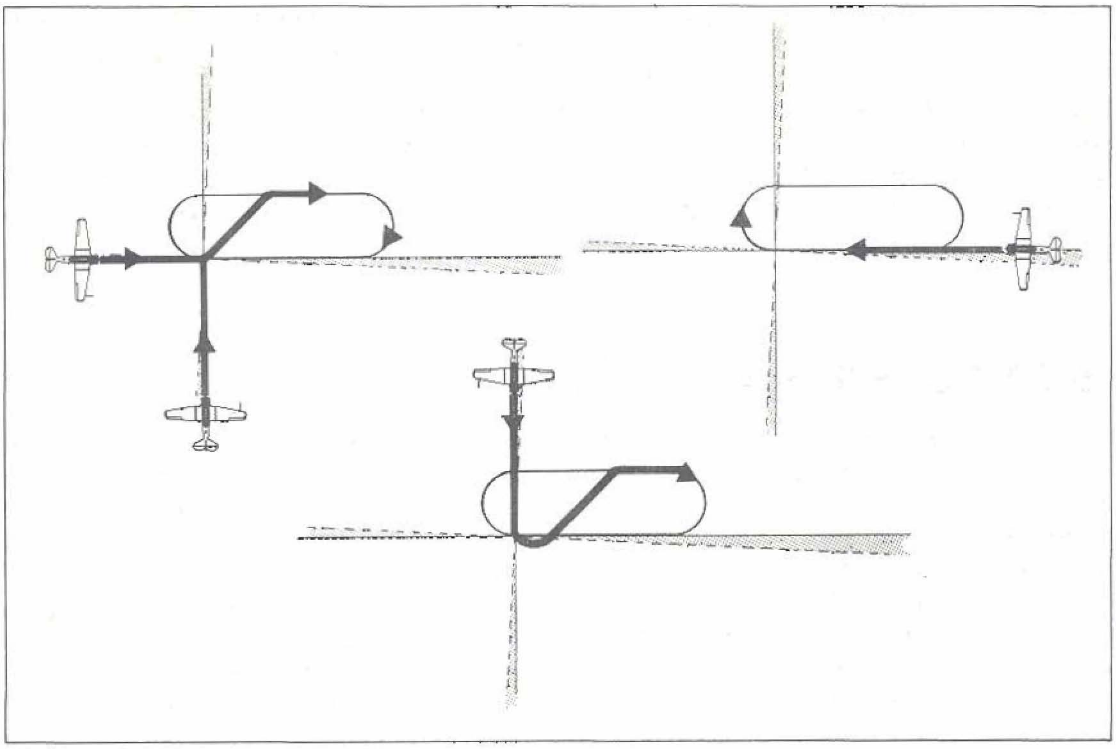

Figure 7: Radio Range Holding Patterns

point the first "T. T. T. A. C." check is performed, and the aircraft is turned onto a heading designed to intercept the out-bound leg of the range. While flying outbound you should start to descend to the procedure-turn altitude and, when you are far enough outbound, complete the procedure turn. Following the turn, you must continue to fly towards the range leg until the "twilight" signal can be heard, then you can turn and start to "bracket" inbound to the facility. On receipt of "Station Passage", the second "T. T. T. A. C." check is completed and a descent made to the minimum-approach altitude detailed on the appropriate let-down chart. If the aerodrome is not visible at the ETA, you must carry out a missed approach procedure.

16.10 - The Final Approach

(1) The ADF let-down and the Standard Range Approach are accurate methods of positioning an aircraft along a known track at a minimum safe altitude. If the visibility is good enough, you should be able to see the aerodrome and, provided that the runway towards which you are flying is the runway-in-use, you should be able to make a straight-in approach. If the runway towards which you are flying is not the runway-in-use, then you must carry out a runway orientation procedure. In the event of not being able to sight the runway, you must make a missed approach.

16.11 - Runway Orientations

(1) The runway orientation procedure is designed to place the aircraft in line with the runway-in-use so that you may make a final approach and landing. There are three different procedures, the choice of the correct one being dependent on the position of the aircraft at the end of the letdown. Since experience helps, you must practise Runway Orientations until you are aware of the benefits of each. Your instructor will supplement the information given here with tips from his own fund of knowledge, but the basic procedures will remain unchanged. Before starting the chosen procedure, you must ensure that the throttle is set to the pre-determined power setting, and you must leave it there until the aircraft is in a position from which you can make a landing. The Cross-Wind Check is completed during the final descent to the runway, and flaps are lowered as required.

(2) FIRST PROCEDURE - If the letdown brings you to the up-wind end of the runway-in-use you should:

(a) fly down the runway;

(b) turn 90 degrees left or right at the button, (As shown in Figure 8, Method 1); and

(c) immediately start a 270 degree turn in the opposite direction to line the aircraft up with the runway.

(3) SECOND PROCEDURE - If you find that you are at 90 degrees to the runway-in-use at the end of the let-down procedure, you should:

(a) fly across the runway on your present heading until, when looking back, you can barely see the runway, (ON NO ACCOUNT MUST YOU LOSE SIGHT OF THE RUNWAY);

(b) turn 90 degrees towards the down-wind end;

(c) fly at wing-tip distance down the runway as shown in Method 2 below; and

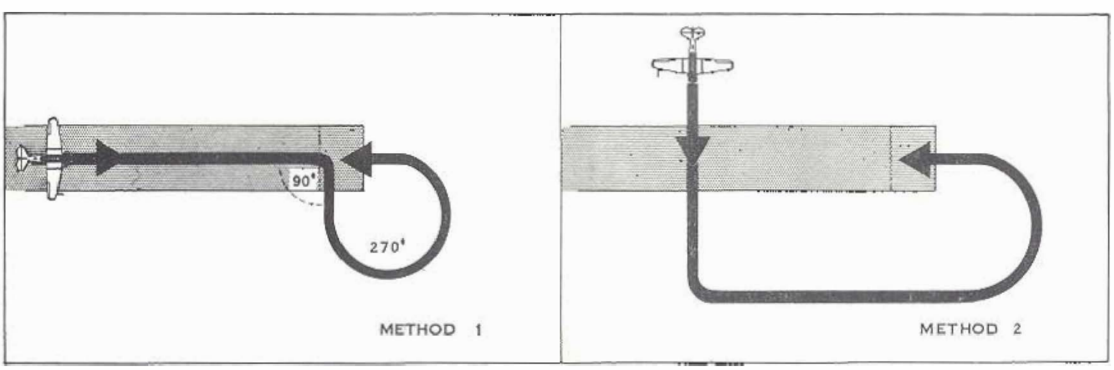

Figure 8: Runway Orientations

(d) when the wing-tip passes the button, start a 180 degree turn towards the runway.

(5) THIRD PROCEDURE - Figure 9 illustrates the action to be taken when you approach the runway at an angle. You should fly towards the button and once there:

(a) fly away from the button at an angle of 45 degrees to the runway heading;

(b) note the time of crossing the button and, making adjustments for wind, fly along the path "AB" for 45 seconds; and

(c) make a 225 degree turn towards the runway.

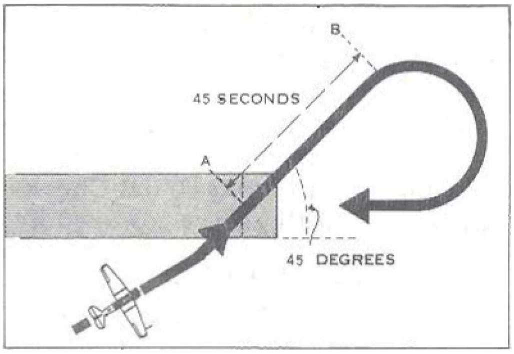

Figure 9: The Third Method

16.12 - The Missed Approach Procedure

(1) If the airfield is not sighted after you have flown for the time specified on the let-down chart, you must carry out a missed approach procedure. The normal power setting is 28" MP with 2,000 rpm, but if there is airframe icing present, you may have to use 32" MP and 2,200 rpm. Once the aircraft has been trimmed into a climb, you should follow the missed-approach instructions listed on the let-down chart, climbing-out to the correct altitude on the heading given. The tower must be informed of your intentions, and you should request further clearance for another approach, or for a diversion to your alternate.

Chapter 17

Formation Flying

17.01 - Introduction

(1) Formation flying at FTS is the introduction to a skill that you will be expected to study and develop during the remainder of your air force career. After the AFS stage of training, you may be required to fly high-performance jet weapons platforms that are capable of inflicting heavy damage on an enemy. Pilots of these operational aircraft are expected to be able to fly in formation for purposes of mutual defence and concentration of firepower. The ability to fly formation well depends on good leadership and strict air discipline, both of which will be stressed during this course.

17.02 - The Pre-flight Briefing

(1) Before each formation flight there will be a thorough briefing; by your instructor for the first few exercises and, for practise, by yourself or a fellow student as the course progresses. The briefing shall detail the plan of the entire flight, and shall include:

(a) assigning a position in the formation to each aircraft;

(b) informing all concerned of the radio call-sign of the formation and the number allotted to each pilot;

(c) choosing a geographical fix for a rendezvous point should one member of the formation be delayed on take-off;

(d) setting an "engine starting time", and specifying the signal to be used as the executive order;

(e) detailing the radio check-in procedure;

(f) detailing the taxiing procedure;

(g) assigning positions on the runway for take-off;

(h) covering all eventualities during the take-off and join-up, such as the procedure when aborting a take-off, when to retract the undercarriage, when to make power reductions and where each aircraft is to join the formation;

(j) selecting a power setting for the leader to use during the climb;

(k) detailing the altitude at which the Post-Take-Off Check will be carried out and the radio channel to be used during the remainder of the flight;

(l) selecting the power setting to be used after the level-off;

(m) informing each pilot of his actions during turns;

(n) detailing the moves to be made by each pilot during echelon cross-unders, and when each move is to be made;

(o) assigning a radio call for a fuel check and outlining the method of reporting;

(p) detailing the procedure when breaking for trail and the spacing to be used;

(q) specifying a procedure for rejoining the formation;

(r) informing all pilots of the items to be checked on the Pre-Landing Check and of the radio channel to be used;

(s) detailing the procedure during the landing break, and giving information as to the location of the break, the time interval, how the break is to be made and the correct spacing to be used;

(t) covering the complete landing, noting the runway to be used, the position of each aircraft on the runway and outlining the procedure for overshooting;

(u) detailing the action after landing or, in the case of an overshoot, the action to be taken to make another approach for a landing; and

(v) detailing emergency procedures in the event of engine or radio failure.

A blackboard and model aircraft for demonstration purposes are invaluable aids during a briefing.

17.03 - Formation Signals

(1) Normally, R/T calls are used by the leader to alert the formation for a particular action or manoeuvre. Each call is prefaced by the formation call sign followed by the order repeated, and an executive command. For example "Red Formation, Finger Left, Finger left - GO". Sometimes, however, it is desirable to maintain radio silence; or one aircraft may have radio failure, making it necessary for the formation to resort to hand signals. All pilots must be able to perform and interpret each signal sequence. The following chart lists the hand signals for each manoeuvre in a normal formation flight.

MANOEUVRE	SIGNAL
Initial power setting of 20" MP prior to take-off.	A circular motion of the forearm held vertically.
Take-off	A cutting down and forward movement of the hand from eye level.
Climb	A forward and upward movement of the hand, palm down.
Level-off	A horizontal sideways movement of the hand, palm down.
Change from Finger formation to Line Astern	A fist clenched behind the head. (Number Three must repeat the signal to Number Four.)
Change from Echelon formation to Line Astern	A fist clenched behind the head. (This signal must be passed on by Numbers Two and Three as it is received.)
Change from Echelon to Echelon (2 Plane)	The leader points to Number Two swinging his hand round to indicate the new position.
Change from Line Astern or Trail to Finger formation	The wings of the aircraft rocked and a turn started in the direction of the Finger to be formed.

MANOEUVRE	SIGNAL
Break from Echelon for landing, or to change to Trail formation.	A circular motion of the hand above the head with out-stretched fingers displayed according to the desired time interval between aircraft. (Numbers Two and Three must pass the signal on when it is received.)
Leader change	An index finger pointed at the new leader then pointed forward.
Radio failure	A hand held on an earphone and the microphone momentarily, then dropped to describe a throat-cutting motion, indicates complete radio failure. Touching the microphone and making a throat-cutting action means transmitter failure only.
Break off	Repetitious crossing of the forearms with the palms of the hands out.

17.04 - The Basic Two-Plane Formation

(1) The basic formation consists of two aircraft and is called an element. The element leader is always known as NUMBER ONE, his duty being to direct the element in an attack, while the other aircraft, NUMBER TWO, is his wingman responsible for keeping a look-out and protecting the leader.

(2) In Figure 1, an element is shown in ECHELON RIGHT which, along with ECHELON LEFT, is the most common two-plane formation. Notice that Number Two is positioned so that the wingtips of the two aircraft have clearance if Number Two over-runs his leader, and that there is clearance between the tail of Number One and the propeller of Number Two. In the correct position, Number Two should be slightly below Number One so that equal portions of his leader's wing is visible above and below its trailing edge.

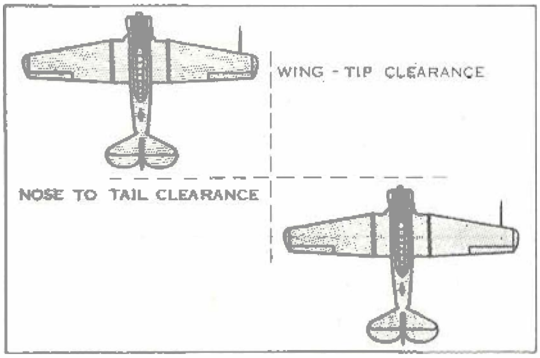

Figure 1: Echelon Right

17.05 - The Two-Plane Take-off

(1) In Art 17.02 covering the pre-flight briefing, mention was made of the leader setting an "engine starting time" and choosing a suitable executive signal. Although practice in this procedure is desirable, since it is an important part of formation flying at AFS, the normal routine at FTS makes it impracticable. Usually the Harvards at FTS are started individually, and each pilot "checks in" at the request of the leader on a pre-selected radio frequency. Any unserviceability which may delay the departure should be reported to the leader at this time. Following the "check in", the leader orders a frequency change before calling for taxi instructions. Each member of the formation acknowledges receipt of these instructions, in sequence, starting with the leader.

(2) When the formation is ready to taxi out they should do so together, whether they be an element of two aircraft or a much larger group. In this way they should move to the take-off position as a compact unit, ensuring that no other aircraft comes between them. The leader obtains any clearances for crossing runways, and for the line-up on the runway after the Run-up Check.

(3) After obtaining take-off clearance, the leader taxis onto the runway, taking the left side if a left-hand circuit is in force, or the right side if a right-hand circuit is in force. He must align his aircraft with the runway and be far enough down to allow the wingman to move into the correct echelon position. There should be ample separation between the aircraft, as shown in Figure 2.

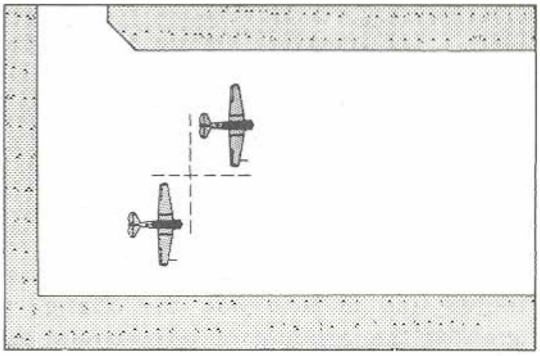

Figure 2: The Formation Take-off

(4) For a formation take-off the throttle is opened to 20" MP while the aircraft is held stationary on the brakes. When the wingman signifies by nodding his head that he is ready, the leader makes the appropriate signal, and both pilots release the brakes together. The leader opens the throttle to 28" MP, while his Number Two applies sufficient power to maintain position. During the take-off run the leader should be particularly careful to keep straight, so that the wingman will not be crowded off the runway. Also, he should allow his aircraft to stay on the ground until it has attained a slightly higher than normal take-off speed. If the Number Two aircraft flies off first, the pilot should hold it just off the ground until his leader is airborne. Undercarriages should be raised independently. If either aircraft aborts after the take-off run is well started, the other pilot should continue his take-off and either fly to the pre-arranged rendezvous point to await the arrival of the other half of the element, or fly round the circuit and land.

(5) Once climbing speed has been attained, the leader should reduce power slowly to 26" MP and 2,000 rpm: the wingman also reduces power,

using 2,000 rpm and sufficient manifold pressure to maintain position. The mixture may be adjusted as required; always in the rich range. At 1,000 feet AGL the leader calls for the Post-Take-Off Check. ("Red Formation, 1000 foot check, 1000 foot check, Go!") Number Two moves out slightly to do the check and then comes back into his correct position.

17.06-Station Keeping

(1) In essence, formation flying is station keeping. As you know the Harvard is a stable aircraft which, when properly trimmed, will stay in one position without deviation. In formation however, you have to contend with an optical illusion created by the dihedral of the wings, and it may appear that you are banking away from the leader when, in reality, the aircraft is flying straight and level. This results in a tendency to hold the inside wing down towards the leader in such a way that outside rudder is needed to keep the two aircraft from colliding. Not only is this a dangerous habit, but a tiring one, and wasteful, since more power is needed to hold position.

(2) Formation flying is comparatively simple once a few fundamental lessons have been mastered. You must remember that every aircraft has inertia and that there is a time lag before a control change takes effect. At first you will find that you have to make almost continuous power changes to keep up with the leader and hold the correct formation position. Later however, as your skill increases you will be able to anticipate many of the leader's movements, and you will find yourself making simultaneous adjustments with him. All adjustments should be made as soon as a need is detected and in this way the change will be small: the longer the delay, the greater the amount of adjustment and the longer the time to regain position. Pay close attention to the tips your instructor will give for acquiring the ability to keep in position, and if there is doubt about any point, ASK QUESTIONS.

(3) At cruising altitude the leader gives the signal for levelling-off and slowly reduces power to 24" MP and 1750 rpm. The wingman's setting is still 2,000 rpm with enough manifold pressure to keep him in the correct position.

17.07-Turning

(1) Formation turns are similar to ordinary turns except that, if you are a wingman, you must watch your leader during the turn and hold the correct formation position. To keep the same rate of turn as the leader, you must use approximately the same amount of bank.

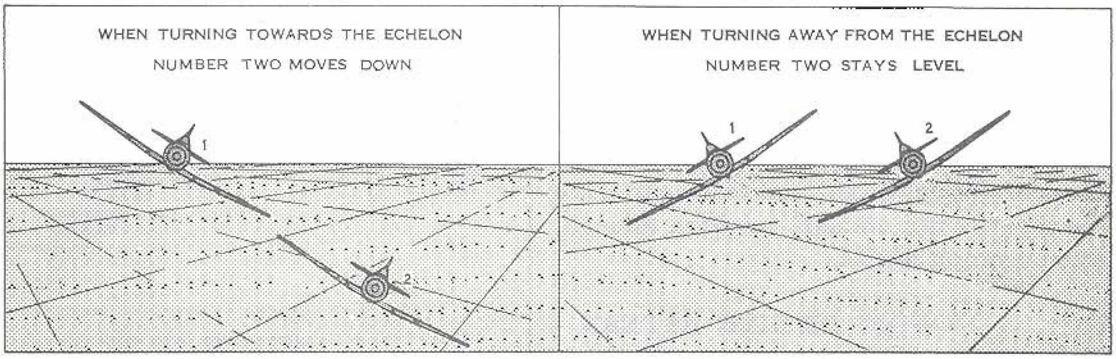

Figure 3: Turns in Echelon

(2) In Figure 3 the relative positions of the two aircraft in turns is illustrated. Notice that in turns towards the echelon Number Two drops down. To do so the throttle must be closed slightly, since the radius of turn is less than that of the leader's. On the roll-out, to maintain position, you must open the throttle in proportion to the rate of roll-out. After some practise you should be able to judge the amount of throttle opening accurately. One tip is to open the throttle wide enough to start the aircraft moving forward, and then to close it to a setting slightly below that needed for normal level flight after the rate of acceleration is satisfactory. Remember, normally no signals are given for turns, so you must be prepared to follow your leader whenever his aircraft shows signs of deviating from the level-flight attitude. When turning away from the echelon, the wingman stays level with the leader. By doing so, the desired effect is achieved with complete safety, and the roll-out can be made with Number Two in the correct position. If you are the wingman, you will have to open the throttle slightly to keep up, since your radius of turn is greater than the leader's. The amount of throttle opening is slight, but, if you intend to keep position, you must counteract the inherent lag by opening the throttle as soon as the turn is started.

17.08 - Changing Position in a Two-Plane Formation

(1) The decision to change position is at the discretion of the leader and is passed to the wingman over the R/T, or by hand signal.

(2) CROSS-OVER TO ECHELON RIGHT - If you receive a signal from your leader to change position from echelon right to echelon left, you should reduce power sufficiently to drop down clear, of his tail. When the propeller of your aircraft is about half an aircraft length behind, and ten feet lower, than the leading aircraft, you can start the cross-over. At this point you must open the throttle to its original setting to maintain position and, at the same time, lower the left wing approximately five degrees. While passing across the leader's tail, open the throttle sufficiently so that, when the cross-over movement has been completed, your aircraft is beginning to accelerate into position. Power and bank are adjusted as required. Past experience has

shown that some students are prone to apply too much bank initially, or that they remove the bank too quickly. This, along with crossing too close to the leader's tail in the area of turbulence from his prop-wash, and failing to open the throttle far enough, or soon enough, are common faults.

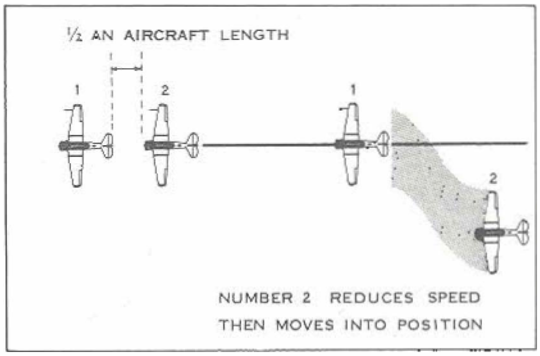

Figure 4: Changing to Line Astern

(3) MOVING TO LINE ASTERN - The control movements for changing from echelon to line astern are similar to those described in paragraph (2). Since the object is to take up a position immediately behind the leading aircraft as shown in Figure 4, the bank and power adjustments must be regulated accordingly. The proper spacing is half an aircraft length to the rear and ten feet below the leader.

(4) REGAINING ECHELON FROM LINE ASTERN - While flying in line astern, if the leader wants you to reform an echelon formation, he will give instructions over the R/T, or will rock his wings and turn slightly in a direction opposite to that of the desired echelon: ie, if he turns left, join on the right. Since you have to move sideways and forward, your first action must be to open the throttle to give the aircraft forward acceleration: at the same time, the wing on the side towards which you intend to move should be lowered approximately five degrees. The whole movement is like the second half of a cross-over in echelon, therefore you must adjust the power and bank to bring your aircraft into the correct position alongside the leader.

(5) MOVING TO TRAIL - In trail formation the Number Two aircraft follows his leader with a separation of five aircraft lengths in the horizontal plane and ten feet in the vertical plane. The movement from echelon to trail is called a BREAK. If your leader wishes you to break into trail formation he will signal, either over the R/T, or by raising his hand above his head and rotating it with two fingers out-stretched. His out-stretched fingers mean that you must wait for two seconds before following him into a level or slightly descending 90 degree turn. The angle of bank should be in the range of 45 to 60 degrees. Usually a time interval of two seconds is chosen because, at the normal cruising airspeed of a Harvard, this gives the approximate spacing for trail (Figure 5). The leader may specify another time interval, however, by holding up another combination of fingers. Since the reason for changing formation to trail usually concerns the manoeuvres to follow, the leader should take the op-

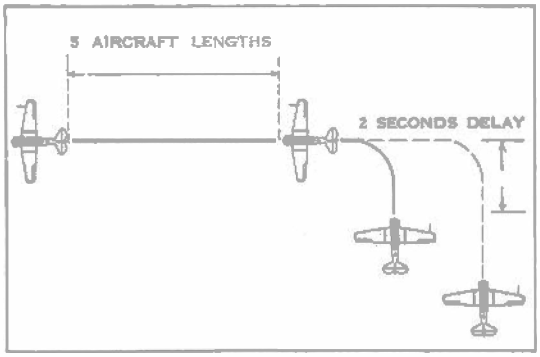

Figure 5: Changing to Trail

portunity of adjusting his power during the break. He should select 2,000 rpm and 26" MP, or the power setting agreed upon during the pre-flight briefing. The wingman will make a similar change of power.

(6) REFORMING FORMATION FROM TRAIL - Normally trail is a formation manoeuvre for more than two aircraft and, when reforming, a FINGER formation is used rather than echelon. However, with only two aircraft, although the manoeuvre remains unchanged, the final position of Number Two results in an echelon formation. The signal for reforming echelon from trail is the same as that for reforming from line astern. Thus, if the leader turns to the left after waggling his wings, you should join up by cutting inside him, crossing behind and below to come up beside his right wing, as shown in Figure 6. If you find that you have used too much power and are overshooting, you should increase the radius of turn by remaining on the outside of the leader's turn. This will allow you to move slowly into the correct position. Aerobatics are not to be carried out in trail formation.

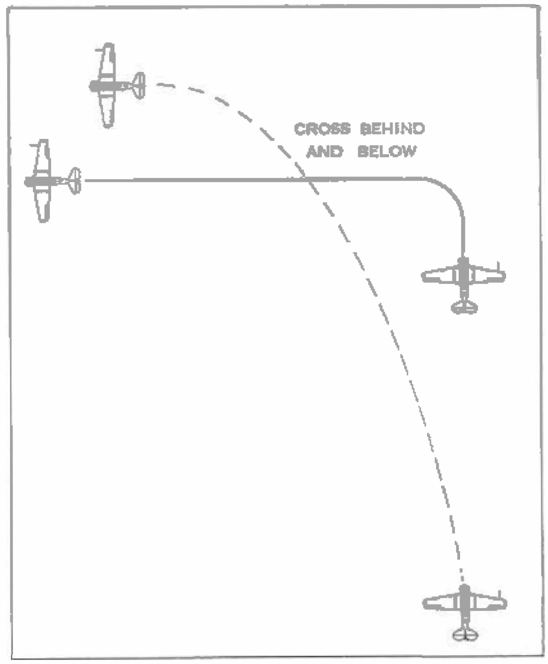

Figure 6: Reforming from Trail

(7) CHANGE OF LEADER - If the leader points a finger at you and motions you forward, it means that he wants you to take the lead. You should pull ahead, keeping your eyes on him until he is definitely behind you and is obviously formating on you: power is adjusted to 24" MP and 1,750 rpm. As leader of the formation, you must remember the following points.

(a) You are responsible for the look-out and the safety of the formation.

(b) All turns must be entered gently.

(c) Power changes must be made slowly.

(d) The wingman must be allowed some margin of power and airspeed, therefore all settings must be average.

(e) You must not climb or turn directly into the sun since it will be impossible for the wingman to see you.

(f) You should call for a cockpit check

(i) at least every 30 minutes,

(ii) before joining the circuit, and

(iii) before designating another member to take over as leader.

(g) You are navigator for the formation and therefore you should be aware of your position at all times.

17.09 - Entering the Traffic Pattern

(1) The entry to the traffic pattern for a formation is the same as for a single aircraft, in that the let-down to circuit height is made on the dead side. The remainder of the circuit is somewhat different, as shown in Figure 7.

(2) The formation enters the circuit area on the dead side in echelon left or echelon right, depending on the direction of circuit traffic. The leader's throttle setting should be 25" MP. At circuit altitude, opposite the

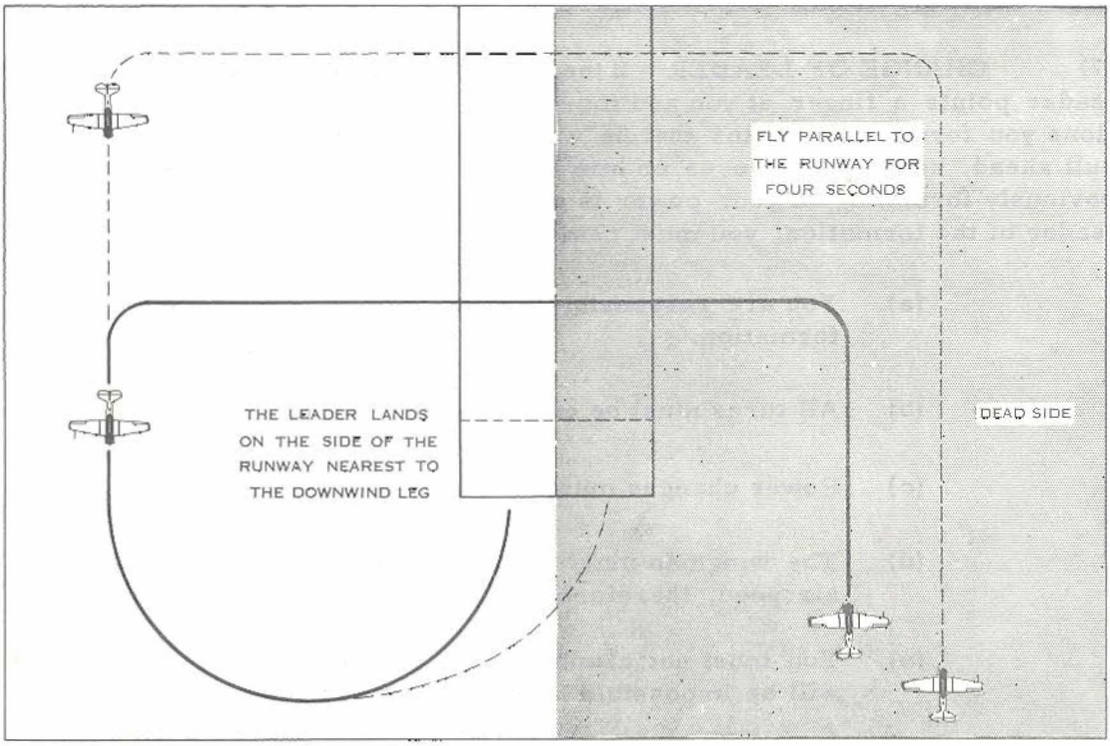

Figure 7: The Two-Plane Formation Circuit

button or further along the runway depending on the strength of the wind and the circuit traffic, the leader breaks according to the procedure agreed upon during the pre-flight briefing. He turns 90 degrees in the direction of the circuit traffic, using approximately 45 degrees of bank, followed by another 90 degrees turn to bring him onto the down-wind leg at wing-tip distance.

(3) As Number Two you should continue to fly parallel to the active runway for four seconds after the leader's break, before following him onto the down-wind leg. Remember that you are on your own after the leader breaks, and that you must keep your own look-out: do not break blindly without checking for other aircraft, and always space yourself properly behind the leader on the down-wind leg.

(4) During the landing the leader takes the side of the runway nearest to the down-wind leg: you should take the opposite side. If two runways are in use, the leader lands on the closer one, while you make your approach to the outside one. If there is any doubt about landing safely on either runway, you should overshoot immediately.

17.10 - The Four-Plane Formation

(1) In Art 17.04(1) you learned that a two-plane formation is called an element. An element always acts in concert, attacking and breaking away together. Usually however, it is more advantageous to have greater fire-power for attack or defence by joining two elements into one unit. The four-plane formation thus formed is called a SECTION: a section may break into individual elements at any time for combat or tactical reasons, but an element ALWAYS acts as ONE and always stays TOGETHER.

(2) The leader of a four-plane formation is known as Number One, while his wingman is Number Two. The leader of the second element becomes Number Three, and his wingman is Number Four. If only one aircraft of the second element is available to make up the section, he is still considered to be an element and is designated as Number Three. While flying as a section, the two elements act as a unit, taking their instructions from Number One. The horizontal, vertical and lateral spacing between the aircraft is the same as for a two-plane formation.

17.11 - The Four-Plane Take-off and Join-up

(1) Preparation for the four-plane take-off is similar to that described in Art 17.05, up to the point of forming up on the runway. After take-off clearance has been received, Number One taxis onto the runway, taking the left side if a left-hand circuit is in force, or the right side if a right-hand circuit is in force. He must align his aircraft with the runway and be far

enough down to allow the other three aircraft to take up their positions. When he is certain that everyone is in place and ready to go, the leader signals for 20" MP, the signal, if it is by hand, being passed down the line by the other pilots. On another signal from Number One, the leading element moves off in a normal, two-plane take-off. (Figure 8) Number Three, as leader of the second element, waits until the first element is halfway down the runway before giving the signal for take-off to his wingman.

(2) After take-off, the leading element climbs straight ahead to 800 feet AGL, where a shallow climbing turn is made in the direction of circuit traffic. This turn is continued until the second element has joined-up, but must not exceed 180 degrees. The signal for a reduction to climbing power is given at the normal time.

(3) When the leading element is starting its turn at 800 feet AGL, the second element should be at 300 feet AGL and should fly an intercepting course to join-up in the turn as shown in Figure 8. The formation so formed is called a FINGER. If you are flying as Number Three, you must check that your element has passed through 300 feet AGL before attempting to turn to intercept the leading element. Also, you must display good judgement in closing on the leading element, and make the reduction to climbing power early enough for your wingman to stay in position. If you find that your element is going to overshoot, you must pass underneath and outside the leading element so that you always have a clear view of the other aircraft. (Figure 9) From a position on the wrong side of the leading element, it is comparatively simple to cross-under into the correct position. NEVER TRY TO SLOW DOWN BY INCREASING THE

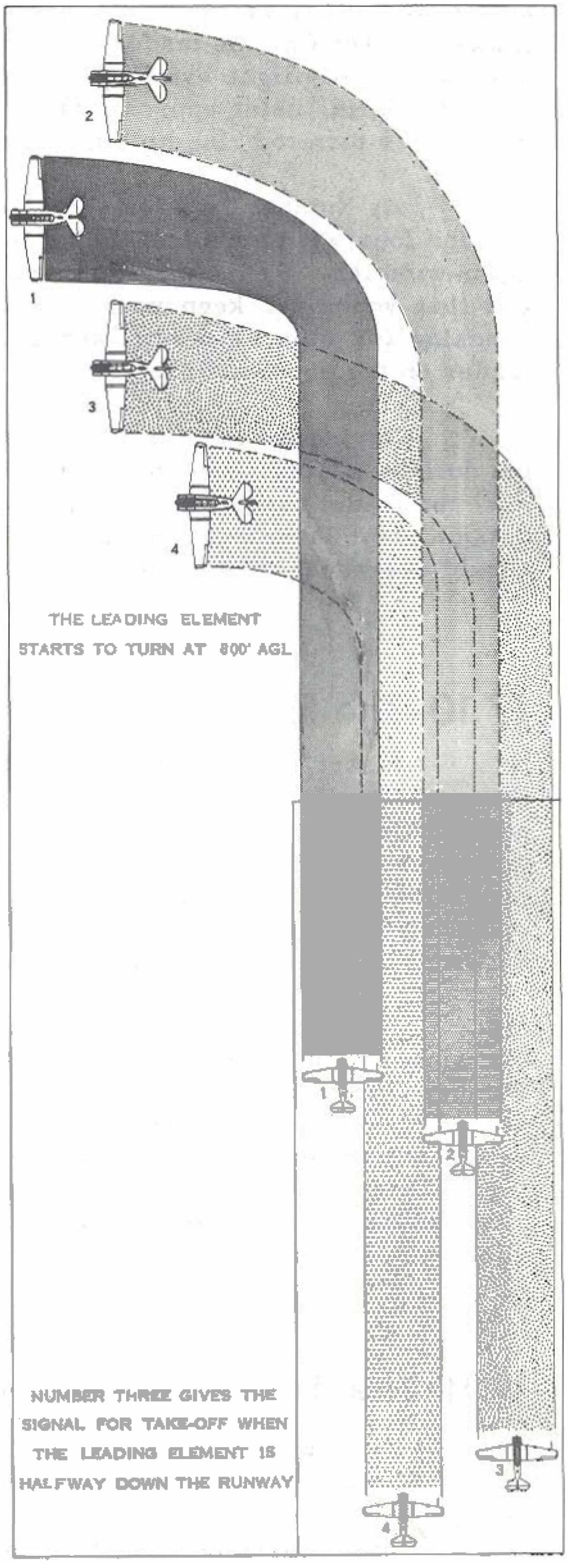

Figure 8: The Take-off and Join-up

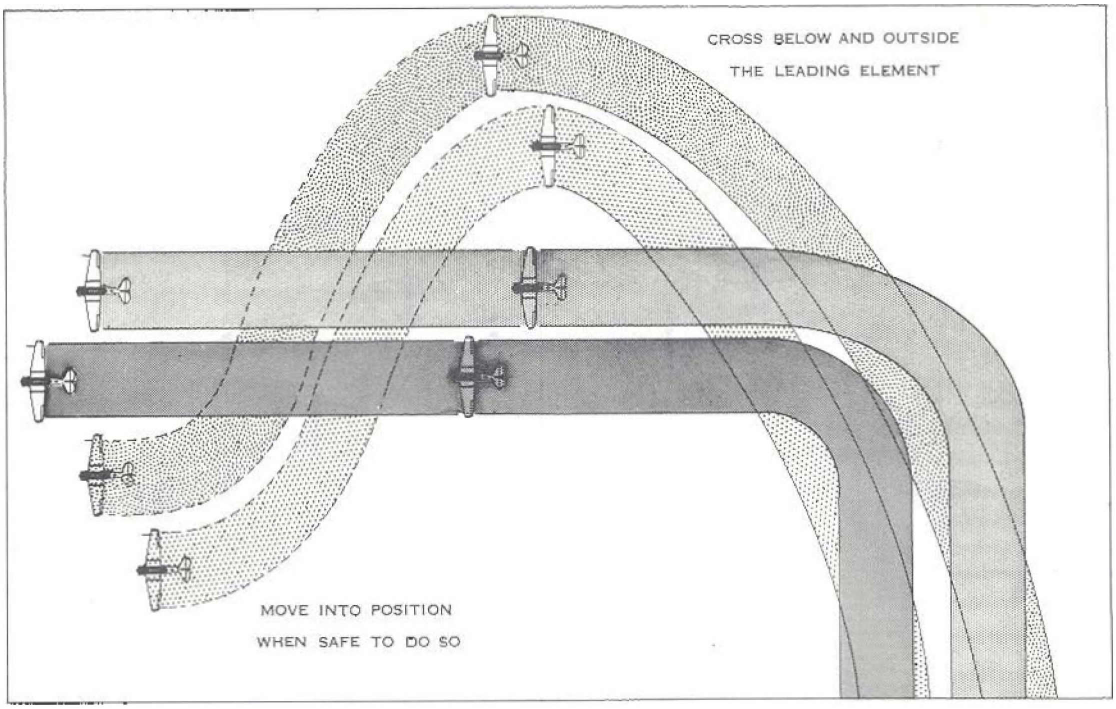

Figure 9: Overshooting on the Join-up

BANK SO THAT YOU "BELLY UP" TOWARDS THE LEADER. This is the unforgivable sin of formation flying, since it is impossible for you to see the other element.

(4) After the join-up Number One calls for the "1,000 foot" check, the other members of the formation moving out slightly to complete their individual Post-Take-Off Checks and then moving back into position. Station keeping in a four-plane formation is the same as in a two-plane formation.

17.12- Changing Position in a Four-Plane Formation

(1) After take-off a four-plane formation is always in either Finger Left or Finger Right, depending on the direction of the circuit. At FTS you are taught to fly in three other positions besides Finger, and you must know how to change from one to the other smoothly, safely and with confidence.

(2) FINGER RIGHT TO ECHELON RIGHT - When Number One wishes to change the formation from Finger Right to Echelon Right, he gives the appropriate signal - "Red Formation, Echelon Right, Echelon Right - Go!". Number Three, with Number Four on his wing, reduces power slightly, moving out, back and slightly down to make room for Number Two. If you are Number Two, you must wait until Number Three has made a space for

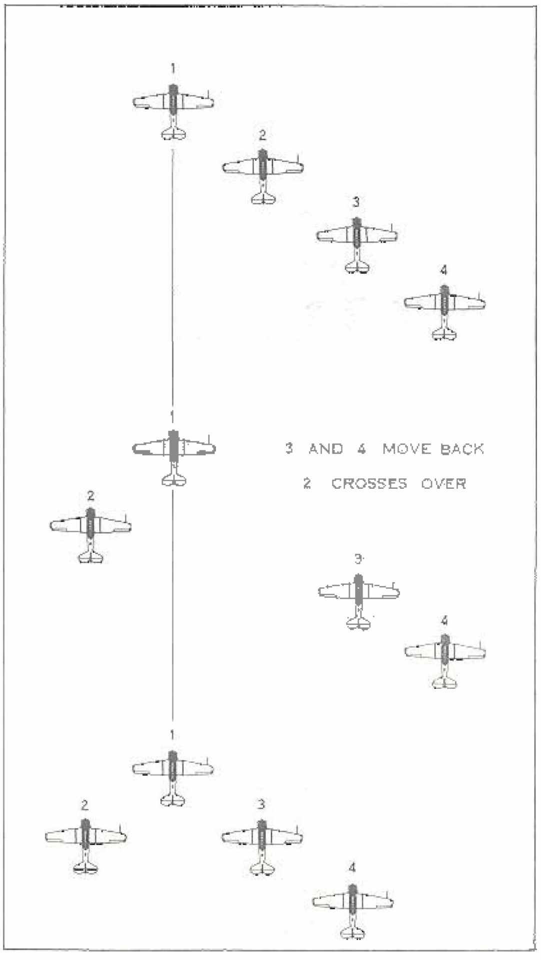

Figure 10: Finger Right to Echelon Right

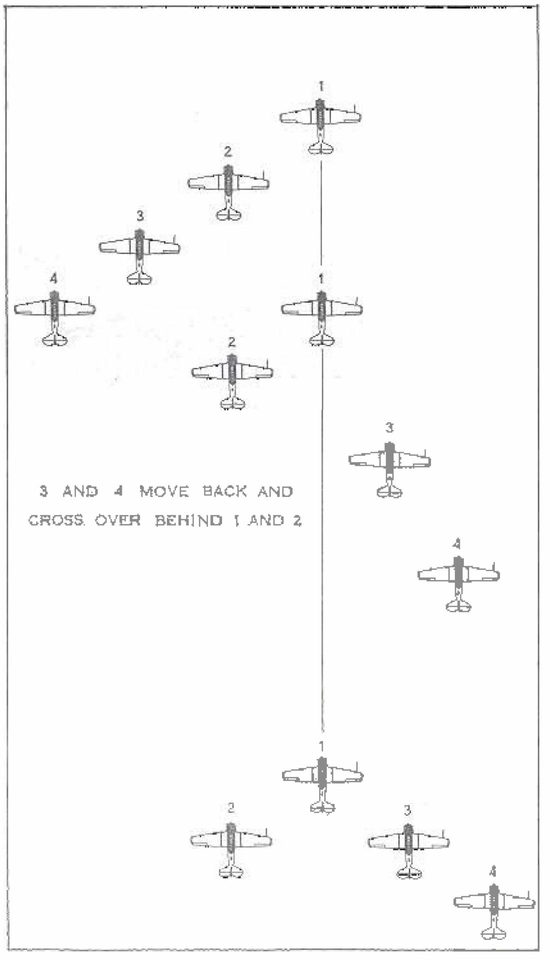

Figure 11: Finger Right to Echelon Left

you, before crossing over, behind and under the leader into your new position as shown in Figure 10. The cross-over should be gentle, Number Three keeping a good look-out to ensure that he has left enough room. When Number Two is in position, the whole formation should close-up until all the aircraft are properly spaced.

(3) FINGER RIGHT TO ECHELON LEFT - On receiving the signal to change to Echelon Left from Finger Right, Numbers Three and Four reduce power slightly and, together, begin to move slowly across behind the leading element. (Figure 11) Number Three must ensure that he has sufficient clearance to cross behind and below Number Two, while Number Four must take similar precautions when crossing behind Number Three. The formation change is completed when Number Three is formating on Number Two, and Number Four is formating on Number Three. The spacing between the aircraft must be equal.

(4) FINGER FROM ECHELON - When the formation is to reform a Finger to either side, the procedure is almost the reverse of that described in paragraphs (2) and (3). The only difference is that when forming Finger Left from Echelon Left, or Finger Right from Echelon Right, Number Two makes the first move, and Numbers Three and Four merely close up the gap.

(5) FINGER TO LINE ASTERN - The hand signal for Line Astern from Finger consists of the leader holding a clenched fist behind his head: Number Three repeats the signal to Number Four, who cannot see the leader. To change formation, Numbers Three and Four reduce power slightly, and move down and back to give Number Two enough space to come over behind Number One. When Number Two is in position, Number Three moves behind him, while Number Four falls into position behind Number Three. (Figure 12) The correct spacing is 10 feet below and half an aircraft length to the rear.

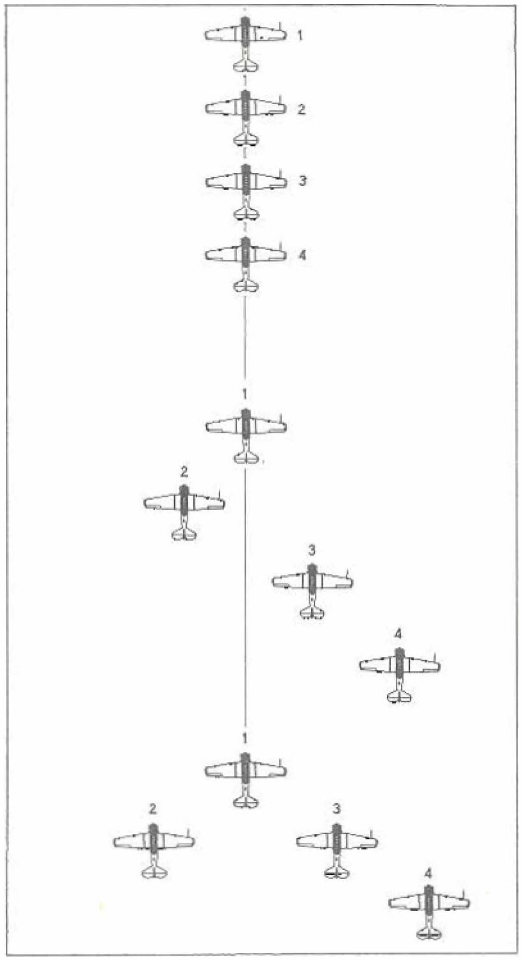

Figure 12: Finger to Line Astern

(6) ECHELON TO LINE ASTERN - The procedure for changing from Echelon to Line Astern has been covered already in Art 17.08. Although only a two-plane formation was considered there, the explanation applies equally well to the four-plane formation. The executive hand signal is again the clenched fist behind the leader's head.

(7) REFORMING FINGER FROM LINE ASTERN - When the signal to reform Finger is given over the R/T, or by the leader rocking his wings and turning towards the Finger to be formed, Number Two applies power and takes up position on the OUTSIDE of the turn as described in Art 17.08. Numbers Three and Four turn inside Number One on an intercepting course, as shown in Figure 13 overleaf, and close-up to form the Finger.

(8) BREAKING FOR TRAIL - Before a four-plane formation can break for Trail, it must be in Echelon. The signal for the break is given either over the R/T, or by the leader raising his hand above his head and rotating it with the equivalent number of fingers extended according to the time inter-

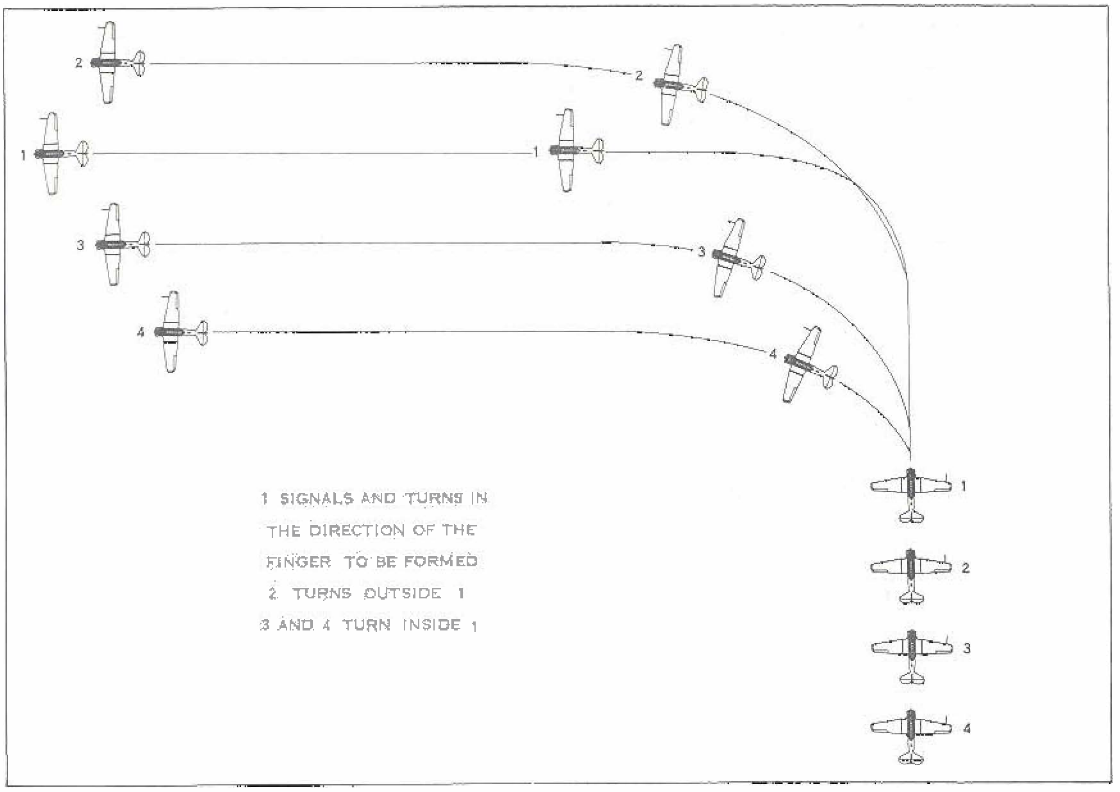

Figure 13: Reforming Finger from Line Astern

val desired. (Normally 2 seconds.) After giving the signal, the leader goes into a 90 degree, level turn using 45 to 60 degrees of bank. The remainder of the formation breaks at the specified interval and forms up behind the leader with five aircraft lengths between aircraft. In Trail, the formation can climb, descend, do shallow lazy eights and go into steep turns: AEROBATICS ARE NOT TO BE CARRIED OUT. To prepare for the manoeuvres to follow, the leader should change his power setting in the turn to 2,000 rpm and 26" MP, or to the power setting agreed upon during the pre-flight briefing. The rest of the formation will make a similar power change on receipt of instructions from the leader. During the manoeuvres in Trail, each pilot must keep the aircraft in front of him in view at all times. If one member of the formation loses sight of his immediate leader, he must break away, notifying Number One of his action and requesting permission to rejoin.

(9) REFORMING FINGER FROM TRAIL - Before signalling the formation to reform a Finger from Trail, the leader should reduce power to normal cruising settings. This gives the other aircraft a reserve of power during the formation change so that they can catch up with the leader. To go into Finger, Number Two opens his throttle and moves under and outside Number One's turn, while Numbers Three and Four turn inside to intercept Number One. When all of the aircraft are together, they close-up to form a properly spaced Finger as shown in Figure 13.

17.13 - Changing Leaders

(1) In operational formation flying, the leader of a four-plane formation is always one of the element leaders. At FTS, however, to give everyone a chance to lead without having to break off the exercise, it is permissible for the wingmen to take turns. At the pre-flight briefing for an exercise in leader changing, each member must understand the procedure thoroughly, and must be fully aware of the system of renumbering.

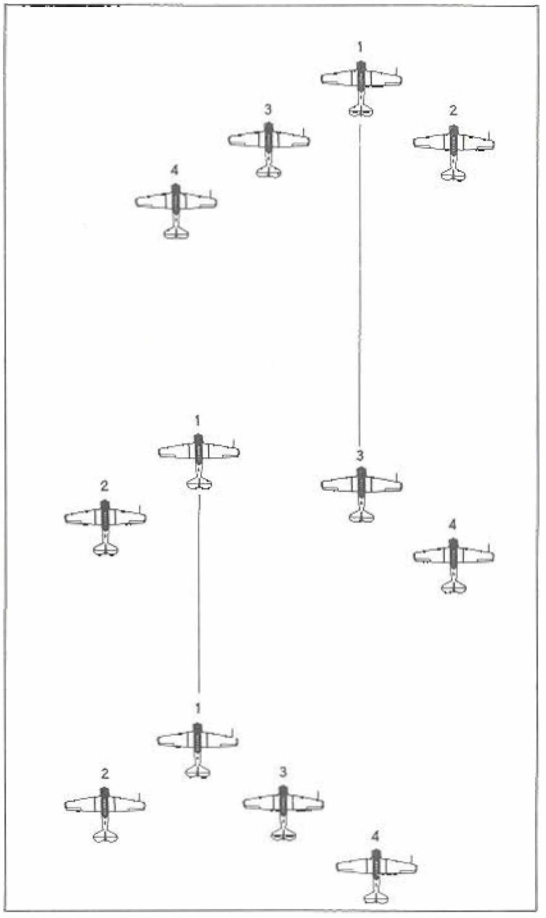

Figure 14: Changing the Section Leader

(2) SECTION LEADER CHANGE - With the section in Finger formation, Number One indicates to Number Three that he should take the lead. Number Three, with Number Four formating on him, opens his throttle and moves slightly out and ahead of the first element, keeping his eyes on Number One until it is obvious that Number One is in position. An immediate power reduction is made to 1, 750 rpm and 24" MP to allow the other members to close-up into Finger formation on the opposite side, as shown in Figure 14. As soon as the section has reformed, the new leader calls "Red Formation - Renumber, Renumber - Go!". Each member checks in in turn giving his new number as follows.

(a) "Number Two", given by the old Number Four.

(b) "Number Three", given by the old Number One.

(c) "Number Four, given by the old Number Two.

(3) CHANGING LEADERS WITHIN THE FIRST ELEMENT - The method of bringing Number Two up into the lead is illustrated in Figure 15 overleaf. When Number One orders Number Two to take the lead, he does so with the section in Finger formation. Number Two adjusts his power settings to enable him to pull ahead of Number One, thus putting the formation into Echelon. After reducing power to allow the other members to close-up, the new leader requests the formation to renumber. Each member checks in, giving his new

number as follows.

(a) "Number Two", given by the old Number One.

(b) "Number Three", given by the old Number Three.

(c) "Number Four", given by the old Number Four.

(4) If it is desired to have Number Four take the lead, the section must go through the step outlined in paragraph (2) and then the step in paragraph (3).

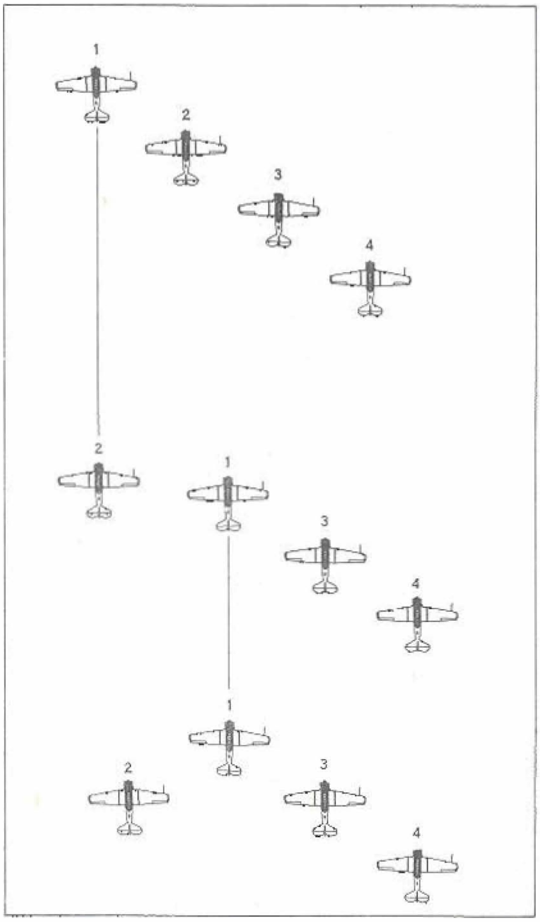

Figure 15: Changing the Element Leader

17.14 - The Traffic Pattern

(1) Before entering the circuit area the section must be in Echelon formation so that each aircraft can break at the proper time. The entry and let-down are made on the dead side, with the section flying into wind, parallel to the runway in use. The leader breaks as described in Art 17.09 (2), followed by each member of the formation at the end of his designated time interval. (Figure 16.)

(2) Having completed the break, and having turned onto the down-wind leg, each pilot has an individual responsibility for spacing his aircraft correctly, and for flying the regulation traffic pattern at the altitude specified in local orders. The leader for his part must make his initial break early enough to give the last man time to follow, in turn, before passing the up-wind end of the runway.

(3) Landings are to be made on alternate sides of the runway, or, if two runways are in use, on alternate runways, the leader always taking the side, or runway, nearest to the down-wind leg. If any pilot fails to line-up with his designated landing path, he must overshoot and complete another circuit. Before turning-off across the runway, each pilot must look back to see that the runway is clear, and that he is not being overtaken by another aircraft landing behind him. Normally at FTS, local orders prohibit two aircraft landing in stream on the same runway.

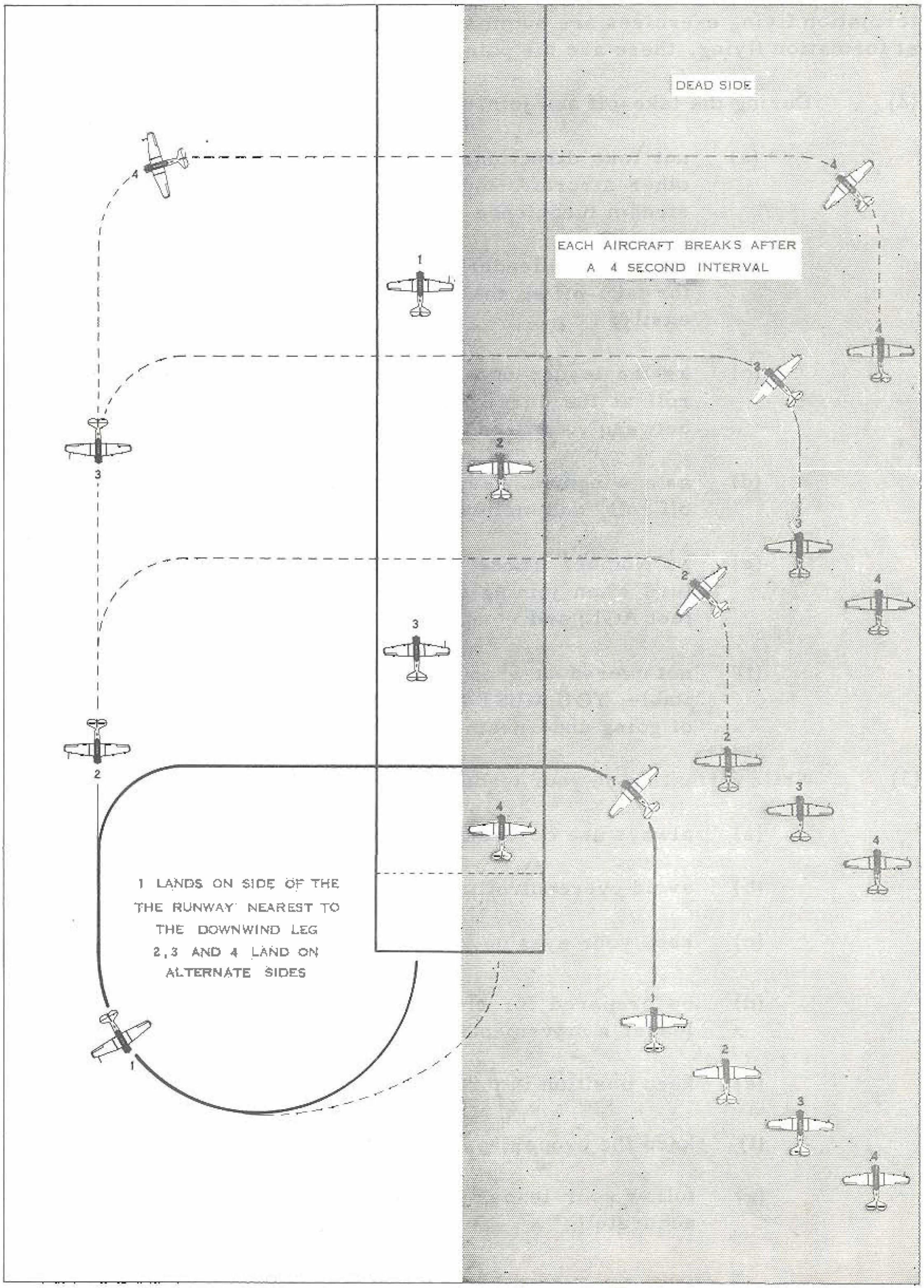

Figure 16: The Four-Plane Formation Circuit

17.15 - Common Faults in Formation Flying

(1) In this Article some of the more common faults of students during formation flying exercises are summarized. If you wish to become proficient at formation flying, these are the points to watch.

(2) During the take-off and join-up, you must:

(a) not lose directional control on take-off or cut in front of other aircraft, thus subjecting them to hazardous slip-stream turbulence at a time when airspeeds are low;

(b) as a section leader, use just the right amount of throttle for take-off so that the rest of the formation can catch up easily;

(c) as the leader of the second element, start your take-off roll at the correct moment, keeping the proper spacing between your aircraft and the first element;

(d) as a wingman, keep up with your leader during the take-off roll, and maintain position during the climb;

(e) as Number Three, lead your element inside the leader's turn when joining-up, but only after passing through 300 feet AGL; and

(f) not overshoot when joining up or, if the overshoot is inevitable, YOU MUST NOT "BELLY UP" on the leader instead of going underneath him.

(3) While formating on your leader, you must:

(a) always use co-ordinated control movements;

(b) avoid overcontrolling;

(c) keep your eyes on your leader;

(d) be prepared for changes of attitude by anticipating your leader's movements;

(e) keep position in turns;

(f) keep the proper spacing in Line Astern and Trail;

(g) follow your leader in Trail, carrying out all manoeuvres accurately;

(h) maintain lateral spacing in Echelon;

(j) break after the required time interval;

(k) keep your head out of the cockpit while doing checks;

(l) know all of the hand signals;

(m) move out of position only after understanding the signal given by the leader;

(n) when in trouble, inform your leader and ask permission to break formation;

(o) break formation down and away from the other aircraft;

(p) ask permission before rejoining the formation; and

(q) use your head.

(4) As a leader, you must:

(a) keep all movements of power and attitude within the capabilities of the other members of the formation;

(b) be aware of the responsibilities involved; and

(c) arrange for a leader change over a known landmark or on a course towards base.

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