PART 2 : SECTION 4

CHAPTER 5

AEROBATICS

Purpose

1. Although aerobatics, in themselves, are of little operational value they form an essential part of a pilot's training because :—

(*a*) They increase confidence, judgment, and flying ability, and teach the quickest methods of recovering from unusual attitudes or after loss of control.

(*b*) They form the basis of some tactical manœuvres.

(*c*) They harden and accustom the pilot to the high strains imposed on him in combat flight.

(*d*) They give the pilot a means of assessing control qualities of any particular aircraft.

Regulations

2. The regulations concerning aerobatics are designed to safeguard life and property and should be adhered to at all times. They are stated in Air Ministry Flying Orders (A.P. 3296).

Airmanship

3. Before starting any aerobatics, in addition to observing the regulations, the following precautions should be taken :—

(*a*) Ensure that the air space around the aircraft (above, below, and to both sides) is clear of all other aircraft, as aerobatics involve considerable and rapid changes in height and position.

(*b*) Check that all equipment is secure, and that all loose equipment is properly stowed.

(*c*) When possible cage all gyro instruments.

(*d*) Select a prominent landmark on which a position check can be kept, thus reducing the possibility of becoming lost.

(*e*) Bear in mind the direction of the area most suitable for forced landings, as the possibility of engine failure may be slightly increased during aerobatics, since the engine is sometimes subjected to greater strains and stresses than in normal flight. In any case, engine failure may result from fuel starvation caused by negative loading.

(*f*) Check that the undercarriage, flaps, and airbrakes are retracted.

Engine Handling

4. All throttle movements should be made smoothly, especially with gas-turbine-engined aircraft. In piston-engined aircraft the throttle should be closed if the engine cuts after negative loading. This action is a safeguard against the engine overspeeding when it picks up again. Full power should not be used unless the particular manœuvre requires it.

Vertical Attitudes

5. If at any time the aircraft inadvertently reaches a vertical or near vertical nose-up attitude at a low I.A.S., subsequent mishandling can cause a spin. To recover from this attitude, centralize the controls, wait until the nose drops of its own accord and the speed increases, then ease out of the dive. While the aircraft is changing its attitude, the controls can be used cautiously to assist its progress, but the natural tendency of the aircraft should not be opposed by the controls as this increases the chance of spinning.

BASIC AEROBATICS

Recommended Speeds

6. Pilot's Notes detail the recommended speeds for the standard aerobatics. However, as confidence and skill is gained, the same manœuvres can be done at somewhat lower speeds. The commencing speed should be decreased in stages, say 10 knots at a time, until the lowest speed giving sufficient control is reached.

Loop

7. In this manœuvre (Fig. 1), the aircraft starts from the straight and level attitude and returns to it, having flown through 360° in the vertical plane. Positive loading should be maintained throughout, but this varies in amount depending on the position in the loop. The minimum speed necessary depends on the speed lost in the first half of the manœuvre and that required to maintain control at the top of the loop.

8. To do a loop, first choose some line feature on which to keep straight and, if necessary, start a shallow dive along it to gain the required airspeed. During the dive do not re-trim, but check any

nose-up tendency by forward pressure on the control column. Having gained sufficient air-speed, gently bring the nose up by slight backward movement on the control column and maintain this rate throughout the whole of the loop. When in the inverted position the speed will be low (even below the level flight—1*g*—stalling speed) and care should be taken not to stall the aircraft. At the bottom of the loop ease the control column gently backwards and if necessary use any surplus speed to regain height. During the whole of the manœuvre, rudder should be used to prevent yaw and the ailerons used to keep the wings laterally level. On aircraft with manually operated controls, the stick forces required to maintain the loop decrease to a minimum at the top when the speed is low. However, when a power-operated elevator is used, the artificial stick force, which is usually proportional to stick movement, tends to increase as the speed falls off ; the highest force is therefore required at the top of the loop at the lowest speed.

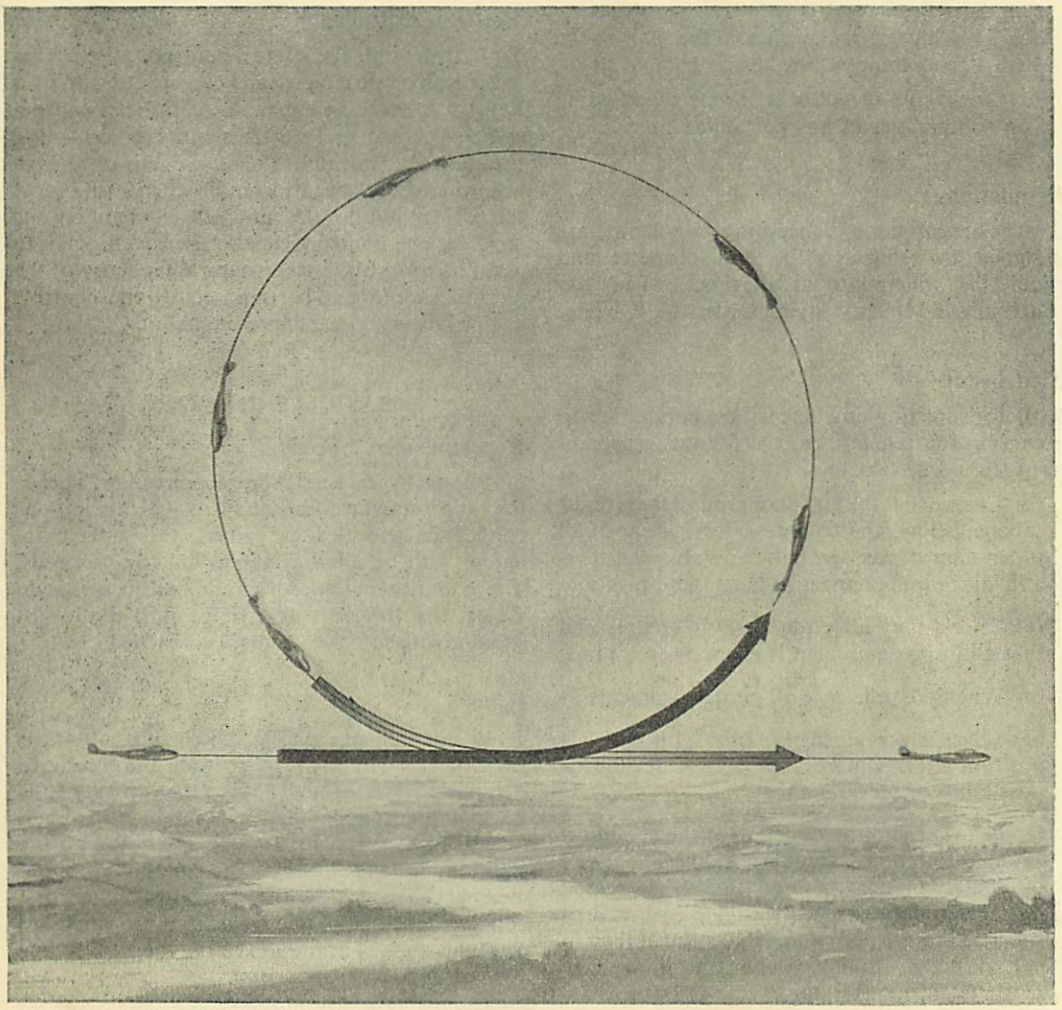

Fig. 1. Loop

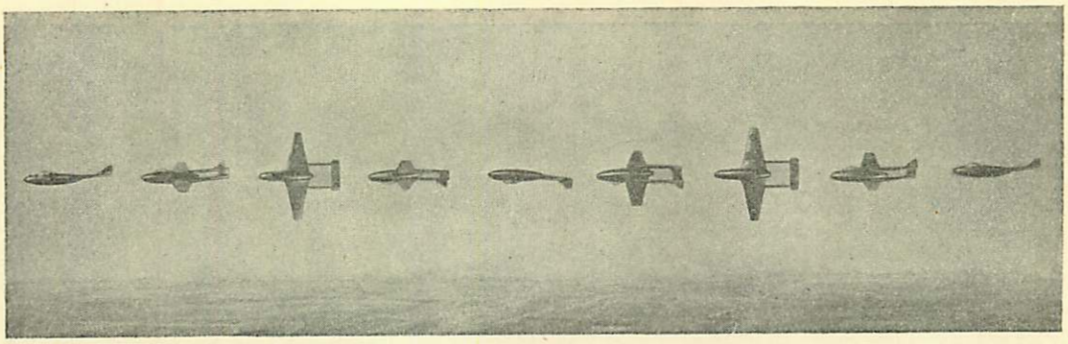

Fig. 2. Slow Roll

Slow Roll

9. An aircraft is said to roll (Fig. 2) when, starting and ending in straight and level flight, it is rotated round its longitudinal axis through 360°. This definition applies to all types of roll. The speed at which a roll is performed is not important, provided it allows a good margin above the stalling speed, and that it is carried out at a safe height. The higher the speed the easier it is to control the roll and less height is lost. If the engine runs when inverted, speed is still less important, for the power assists in maintaining speed *and* height, and controlling the attitude. The rate of roll depends on the amount of aileron used, the speed at which the roll is started, and the type of aircraft.

10. To do a slow roll, choose a point on the horizon on which to keep straight. At the required speed, ease the nose up to slightly above the straight and level attitude, then apply aileron in the direction of the roll together with a touch of rudder in the same direction. Use the ailerons to maintain a constant rate of roll, and elevators and rudder as required to keep the nose on the datum points. As the inverted position is approached, begin to ease the control column forward to keep the nose on the horizon and use rudder to keep straight. As the aircraft rolls out and approaches the vertically banked position apply top rudder as required, and when rolling towards level flight centralize the controls smoothly. With practice a roll can be done without first raising the nose, and constant height and direction maintained throughout.

Stall Turn

11. The stall turn (Fig. 3) is a method of changing direction by 180°. Any normal level flight speed may be used to start the manœuvre, but a high starting speed makes for a more satisfactory manœuvre.

12. To do a stall turn choose a line feature on the ground and fly along it. From level flight, or a shallow dive if extra speed is needed, ease the control column back to bring the nose up into a vertical climb, keeping the wings level by use of ailerons. Check the vertical attitude by reference to the angle made by the wing tips with the horizon, and ease the control column slightly forward to maintain this attitude. As the speed falls off, apply rudder to cartwheel the aircraft round on the wing tip ; throttle back as the nose falls across the horizon and use ailerons as necessary to prevent roll. As the nose approaches the reciprocal heading centralize the rudder and, keeping laterally level by use of ailerons, ease out of the resulting dive. When rudder is applied the control column must be central ; in this position the wing angle of attack is low and there is less chance of an inadvertent spin. If the rudder is applied while the attitude is still being changed (control column rear of central) a spin can result.

Barrel Roll

13. A barrel roll (Fig. 4) is one where the nose of the aircraft is made to travel round a spiral path which is some distance from the axis of the roll. Positive *g* is applied throughout the entire roll.

14. To do a barrel roll, choose a datum axis and fly along it, and then dive around it to one side to obtain the required speed. Gently ease the nose up and roll, aiming to have the wings at right angles when the nose cuts the horizon. Maintain the backward pressure on the stick and continue rolling so that the inverted position is reached at the highest point of the roll. The top half of the roll is made above the horizon and the bottom half below it. Throughout the roll use the rudder to prevent slip or skid, and, as the aircraft approaches level flight, smoothly

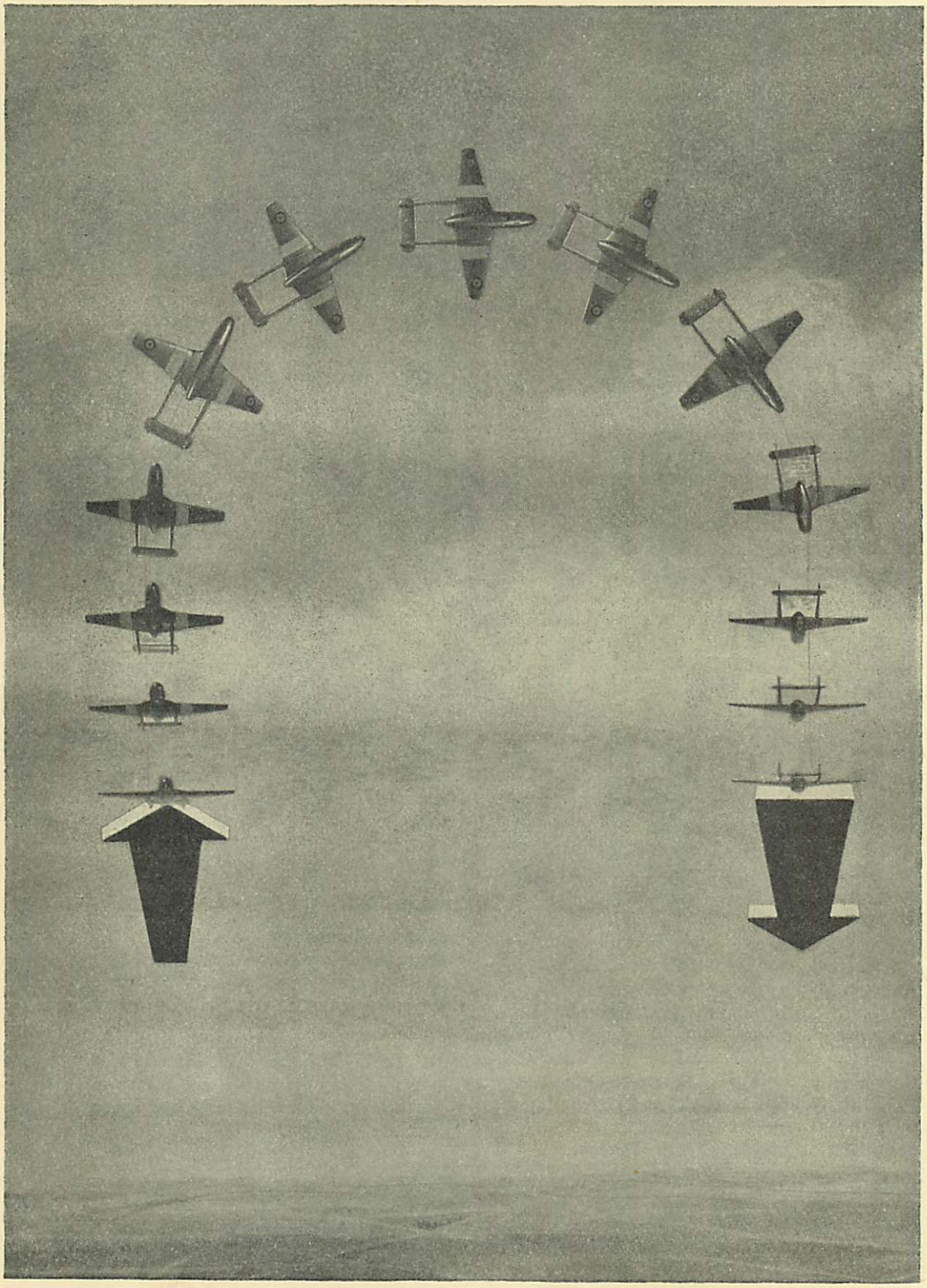

Fig. 3. Stall Turn

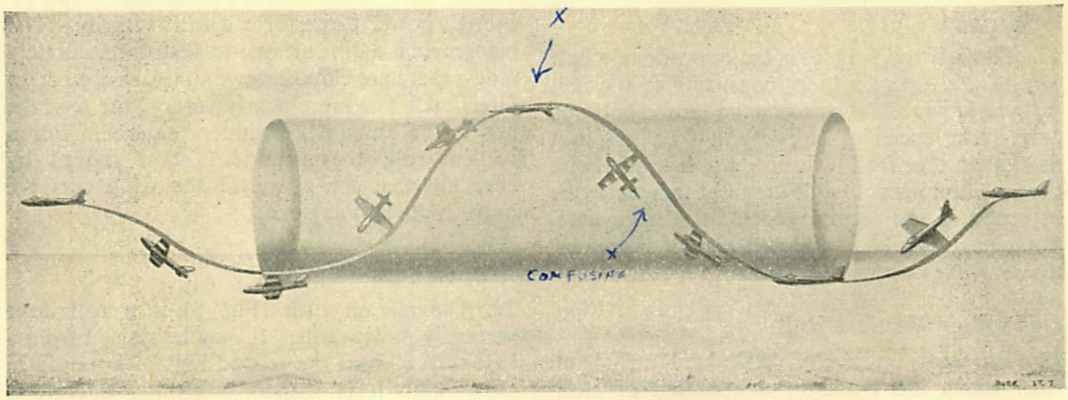

Fig. 4. Barrel Roll

centralize the controls. If the speed changes during the roll, the amount of aileron should be adjusted to keep a constant rate of roll.

FURTHER AEROBATICS

Introduction

15. All other aerobatics consist of variations or combinations of the four basic manœuvres.

Half Roll off the Top of a Loop

16. Half roll off the top of a loop consists of the first half of a loop followed by the second half of a slow roll (Fig. 5). The aircraft reverses direction and gains height. A little more speed is required for this manœuvre than for the loop, so that sufficient speed is available for the half roll.

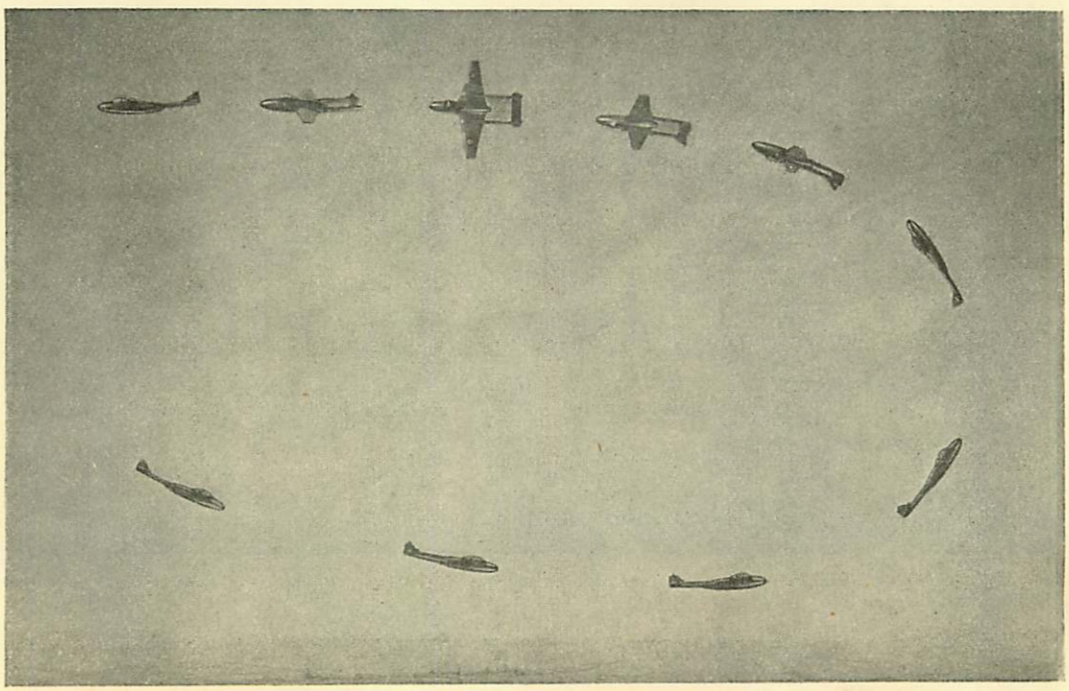

Fig. 5. Half Roll off the Top of a Loop

Half Roll

17. The half roll (Fig. 6) is the opposite of a half roll off the top of a loop, consisting of the first half of a slow roll followed by the second half of a loop. The speed of entry should be low, not more than that for low cruising speed, otherwise the maximum permissible airspeed may easily be exceeded in the second part of the manœuvre. The power should be reduced and, if necessary, the airbrakes opened to limit the speed.

Upward or Vertical Roll

18. The terms upward or vertical roll include all rolls which are made in a climbing or steep nose-up attitude. Such rolls are done in the same way as a normal roll but, since the plane of the roll is inclined, considerably more speed and power is required, some aircraft not having enough power to perform it satisfactorily. The manœuvre is a difficult one to perform accurately unless there are clouds above to use as a guide to direction. The more nearly vertical the roll, the less is the amount of rudder required. For a vertical roll, the attitude is best judged by checking that the chord of the wing cuts the horizon at right angles.

Aileron Turn

19. The aileron turn (Fig. 7) is a roll done vertically downwards. It may be started from a half roll or from the second half of a loop. In either case it is started when the aircraft is pointing vertically down. In this manœuvre, speed mounts very rapidly and considerable height is lost. Power should be reduced and airbrakes opened to control the speed, if necessary.

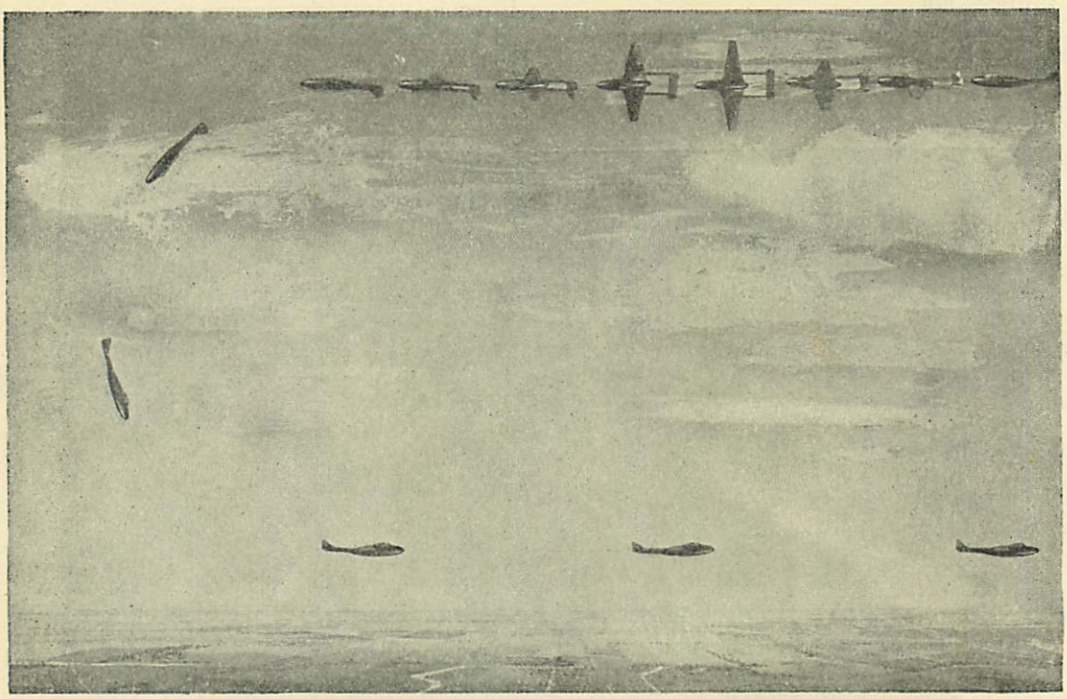

Fig. 6. Half Roll

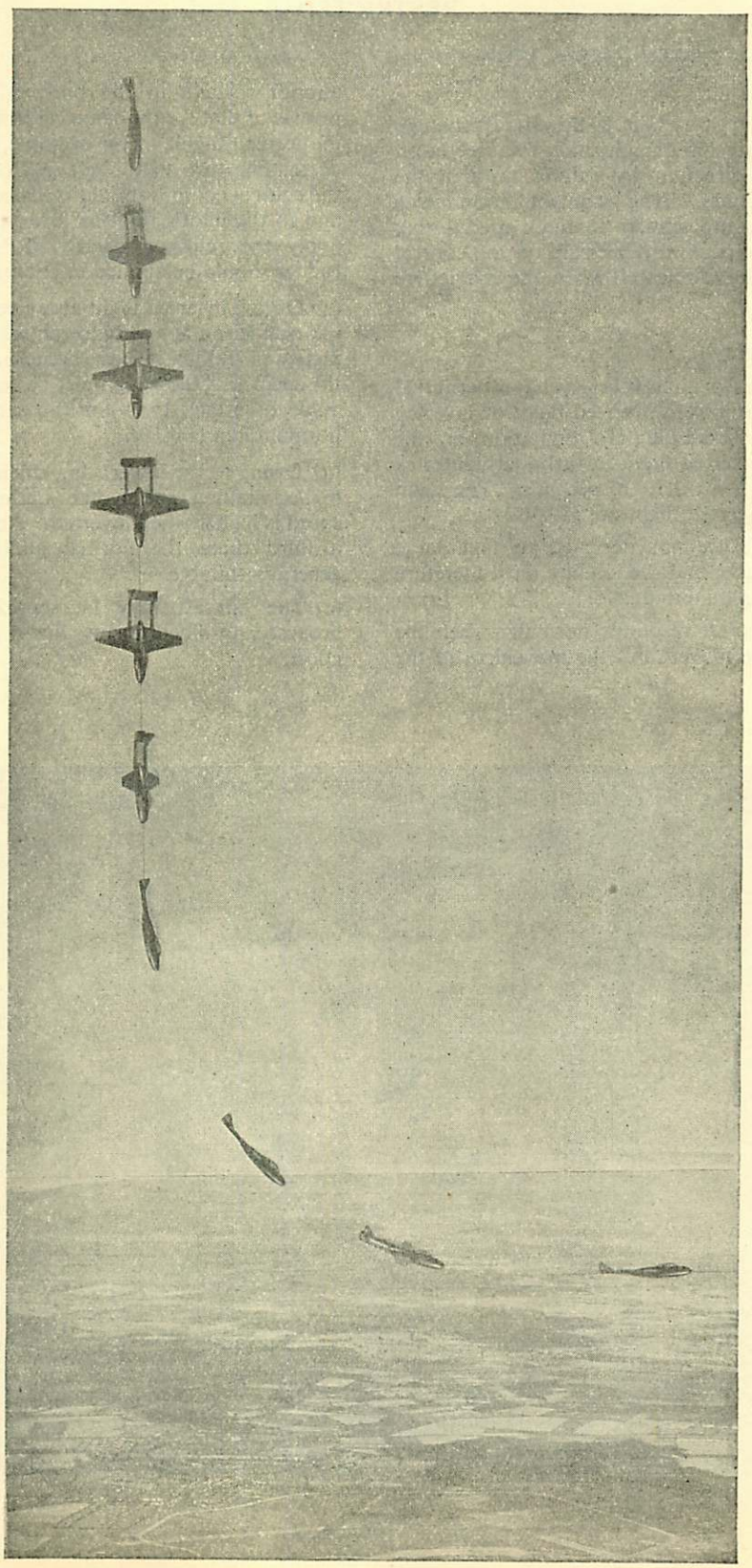

Fig. 7.

Aileron Turn

Derry Turn

20. In the Derry turn (Fig. 8) the aircraft changes from a steep turn in one direction to a steep turn in the other direction by rolling through the inverted attitude. The control movements and pressures are similar to those used during a roll, but the backward pressure on the control column should be released when the manœuvre is started.

Inverted Flight

21. There are few aircraft in which it is permitted to perform prolonged inverted flight or inverted gliding. For example, the limitation on the duration of inverted flight in turbo-jet fighter or trainer aircraft is 10 to 15 seconds. The main features of inverted flight are :—

(*a*) Aircraft are not designed to take large inverted loads, and the loading must therefore be kept to a minimum.

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

(*c*) During inverted flight at a given speed, the lift coefficient is much lower resulting in an increased stalling speed ; because of the lower lift coefficient the wing must be set at a higher angle of attack than for the same speed in normal flight (Fig. 9).

(*d*) Owing to the lower wing efficiency and the higher stalling speed, the optimum gliding speed is higher when inverted. About one and a third times the normal gliding speed is generally suitable.

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

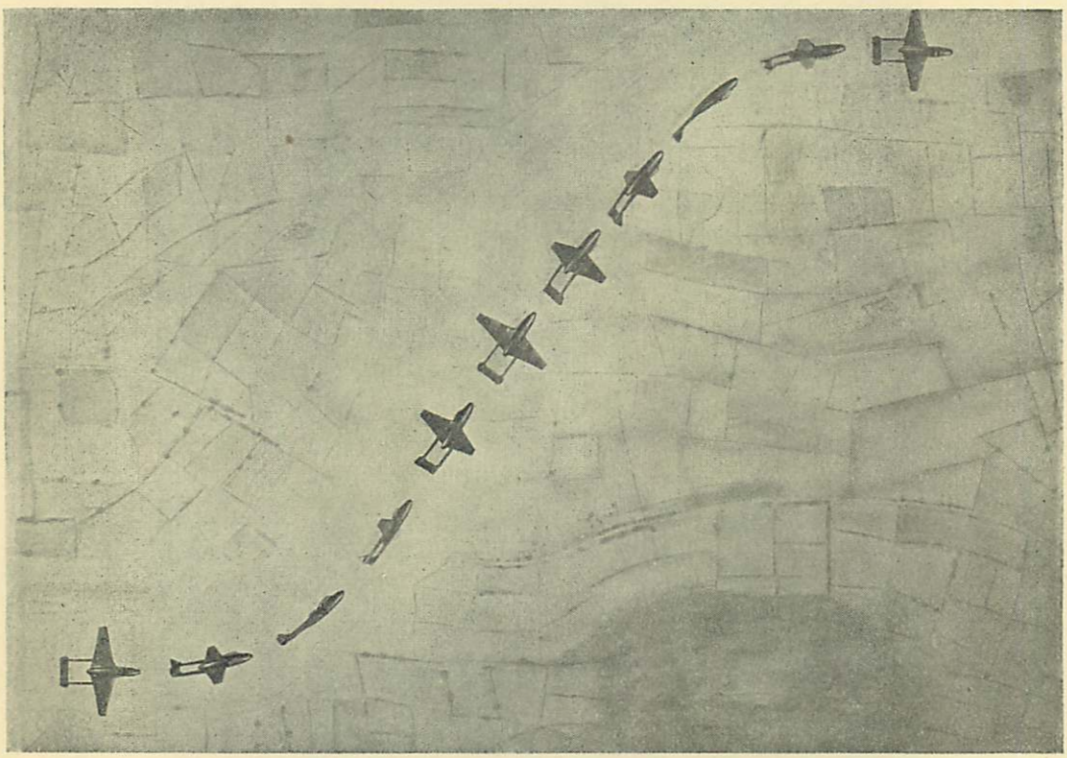

Fig. 8. Derry Turn

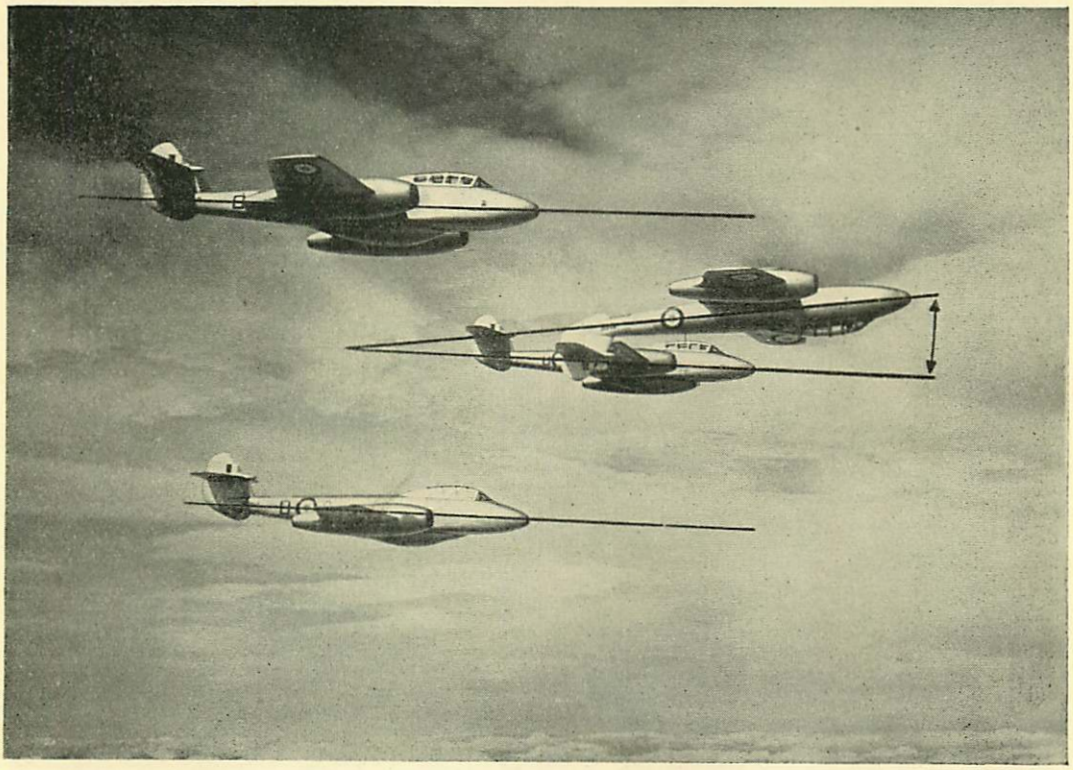

Fig. 9. Inverted Flight

The increased nose-up attitude required for inverted level flight is apparent.

22. It is emphasized that before doing any inverted flying Pilot's Notes should be read to ascertain whether inverted flight is permitted, the maximum permitted duration of such flight, and whether or not power may be used.

Vertical Figure Eight

23. In a vertical figure eight (Fig. 10) much height is gained and lost, and high speeds may be reached. Perform a normal loop and, as the aircraft completes the loop, half roll and pull through into a second loop finishing with a roll off the top. Where sufficient power is available the direction may be reversed by performing the lower part of the manœuvre first. Airbrakes should be used to limit the speed whenever necessary and the power should be low during the descending periods of the manœuvre.

Horizontal Figure Eight

24. For horizontal figure eight, start the manœuvre as for a loop. Hold the loop until the nose is below the horizon on its way down, then half roll and gain sufficient speed for a further loop, and continue the sequence (Fig. 11).

Hesitation Rolls

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

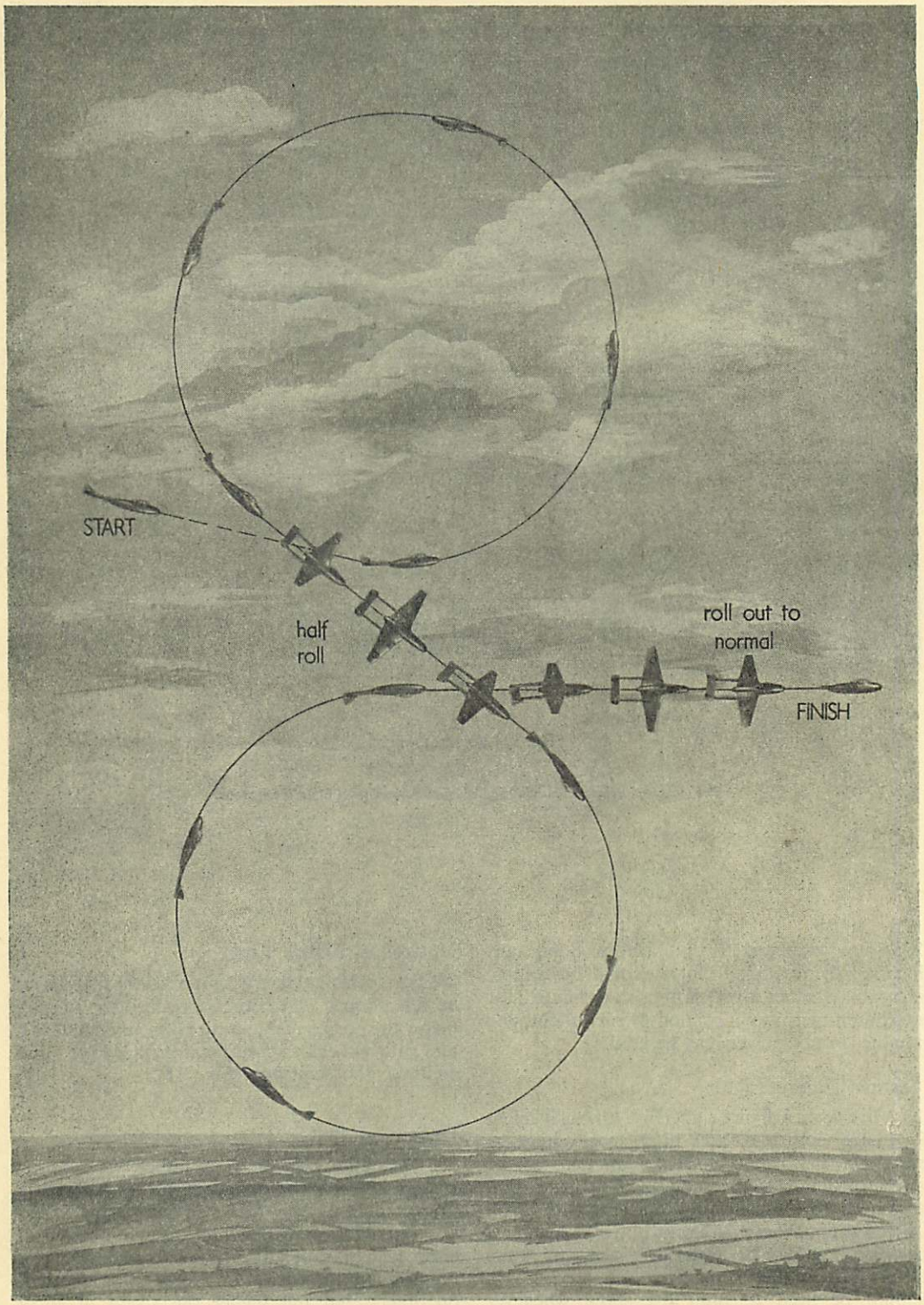

Fig. 10. Vertical Figure Eight

Ideally the start and finish should be at the same altitude. The illustration shows different altitudes for reasons of clarity.

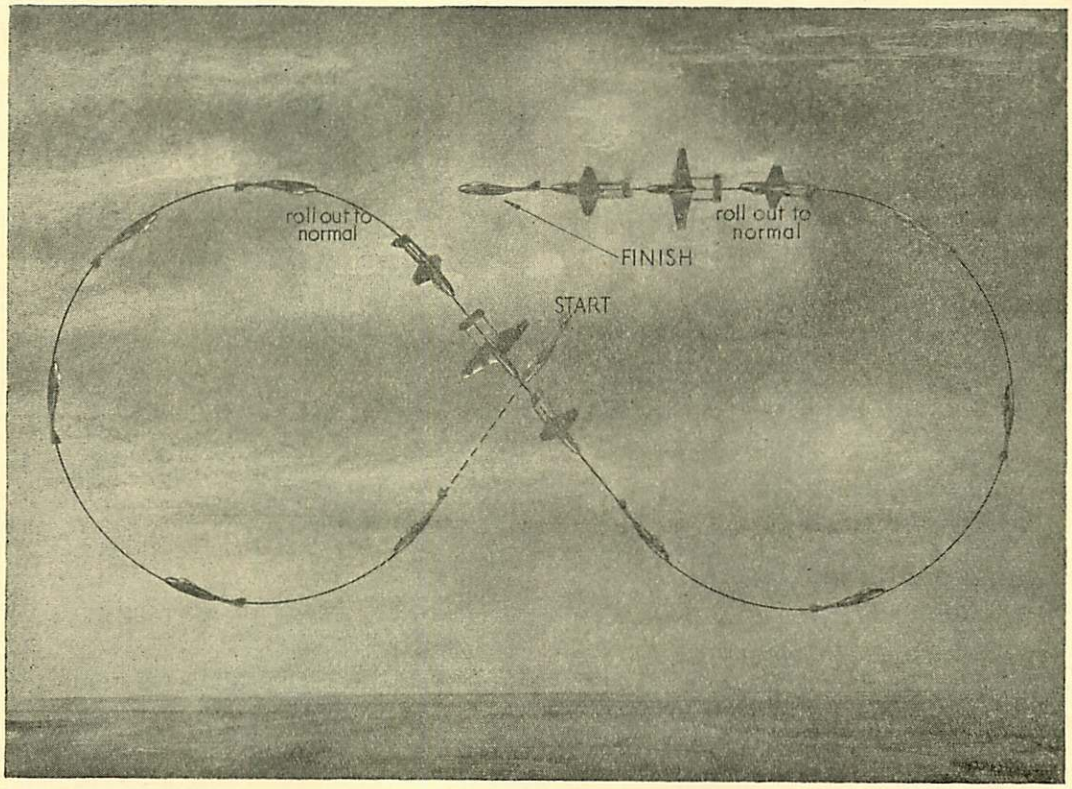

Fig. 11. Horizontal Figure Eight

Ideally the final roll should be made so as to close the figure.