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# INSTRUMENT FLYING

## AIM

To teach the student to fly the aeroplane accurately without external visual reference.

## INSTRUCTIONAL GUIDE

Pilots tend to fly by reference to the natural horizon. Instrument flying is an extension of this technique. In instrument flying the natural horizon, and the attitude of the aeroplane with reference to that horizon, must be visualized through the flight instruments. This principle of attitude interpretation which must be emphasized by the instructor to show, that by interpreting the aeroplane's attitude through the flight instruments, the same principles apply whether conditions are visual or otherwise.

The student must interpret the aeroplane's attitude and then, as in visual flight, change the attitude until the desired performance is obtained. The controls are used in the normal way, but the aeroplane's attitude must be interpreted as a whole instead of 'chasing' the individual pointers.

Ensure the student does not have a grip on the controls that is too tight, thus preventing any 'feel' for what the aeroplane is doing.

If at all possible, given the many legal restrictions, expose the student to some actual instrument flying conditions

Essential training considerations are discussed under the following headings:

- Flight principles
- Demonstrations in the clear
- Sensory Illusions
- Cross reference
- Relationship between Control, Attitude,
- Power and Performance
- Control technique

**Flight Principles.** The student must have a good basic knowledge of the forces involved in flight. The effects of inertia particularly must be appreciated. Inertia causes a delay in response to any control change and must be considered when interpreting pitch attitude through the pressure instruments. For example, on entering a climb from level flight the change in nose position does not reflect itself immediately in the indications of the pressure instruments. These instruments will eventually 'catch up thus indicating the new nose position.

**Demonstrations in the Clear**. In learning and teaching instrument flying it is desirable that all practices be performed by reference to the natural horizon before being repeated on instruments alone. Attitude interpretation through the instruments and the relationship of attitude to performance, are all appreciated more readily by noting the instrument indications while the demonstration is being done in the clear.

**Sensory Illusions.** To avoid any confusion which may be caused by physiological sensations, the pilot must be aware of the sensations likely to be experience in instrument flight so that they may be recognized and disregarded.

The unusual sensations experienced by a pilot when flying on instruments are often very strong, completely misleading and confusing. Even very experienced instrument pilots must at times make very conscious efforts to disregard these sensations. Often a pilot's senses will insist that the aeroplane is doing quite the opposite to what is in fact the case. The pilot might believe that the aeroplane is turning when in fact it is straight and level, or that the aeroplane is upside down when it is doing a gentle turn. Students must be fully briefed to ignore these sensations and believe the instrument indications.

**Cross Reference**. The student must learn to pay attention to all instruments and not concentrate on any one, so that at any moment the information is portrayed as a whole and not confined to a certain aspect of the attitude. Lack of cross reference and concentration on only one or two instruments is a serious failing and only by constant practice can the speed of cross reference be increased.

**Relationship between Control**, Attitude, Power and Performance. The student must know how to control the aeroplane's attitude in visual conditions, and from experience in controlling its performance, know the relationship of attitude to airspeed, height and direction.

Of special significances is that for a given aeroplane weight and configuration a given attitude combined with a given power setting will always result in the same flight path relative to the air. This flight path or performance, may be straight, turning, level, climbing or descending, but so long as the appropriate attitude and power setting remain unaltered the performance will be unaltered. Any change in attitude and/or power setting will result in a change of performance, i.e. the airspeed, rate of climb or descent, rate of turn, or all three may change.

In teaching instrument flying, the instructor must develop in the student a keen appreciation of the importance of time. For objective precision flight there are three main requirements -direction, airspeed and time. It is important to appreciate the time factor for, as the student progresses to more advanced aeroplanes and procedures, the pilot's speed of instrument coverage must increase. The instructor must cultivate in the student the habit of including time in instrument coverage, and for this reason the clock should be positioned near, or be part of the instrument panel.

**Control Technique.** Every instrument flight manoeuvre is the result of correlation of the picture shown by the instruments and the control movements. A change from one flight manoeuvre to another involves the following control sequence:

- Visualizing the new desired flight performance
- Selecting attitude and power appropriate to the new desired performance
- Waiting until the aeroplane settles down to the new performance
- Correcting and adjusting attitude and power until the new performance equals the desired performance
- Trimming and balancing the flight

In brief terms this can be stated as CHANGE - CHECK - HOLD - ADJUST - TRIM. This is the control technique that should be followed in making alterations of performance in visual flight and is nothing more than an application of the basic flight principles taught in early training.

There is an alternate and valid view, slightly different to the above which is held by some experienced instructors i.e.:

- Select what is believed to be the correct attitude
- Hold this attitude
- Trim to this attitude
- If the attitude is incorrect repeat the first three steps

## PRE-FLIGHT BRIEFING CONSIDERATIONS

The student must have a good appreciation of the points discussed in the Instructional Guide.

Attitude is the position of an aeroplane's longitudinal and lateral axes relative to the natural horizon, and the student must be briefed on how pitch and bank attitude are visualized through the flight instruments and the limitations of these instruments.

## INSTRUMENTS - INDICATING PITCH ATTITUDE

The four instruments which show pitch attitude or nose position are:

**Attitude indicator.** This should be regarded as the master instrument since the position of the index aeroplane relative to the horizon bar gives a direct picture of the aeroplane's attitude in pitch within the limitations of the instrument. The limitation in pitch (before the instrument topples) in a light training aeroplane is normally at least 60°.

If the index aeroplane is adjustable, the student must be aware of how to set it relative to the horizon bar in straight and level flight.

The use of the caging mechanism, if fitted, must also be explained to the student.

**Altimeter**. The altimeter is used not only to determine height, but also to indicate pitch attitude. While constant height is being maintained, the nose position is correct for level flight for that power. Increasing or decreasing height indicates a nose position that is respectively too high or too low.

**Airspeed Indicator.** The student must understand that this instrument may also be used to indicate nose position. If showing the desired airspeed, the instrument indicates that the nose position is correct for the power being used. Indication of increasing or too high an airspeed, or decreasing or too low an airspeed, shows a nose position that is respectively too low or too high. When cross referred with the altimeter, the ASI will show the correct nose position for level flight at the power being used. The student must be briefed that owing to inertia an aeroplane takes time to change speed and therefore, the airspeed must be held constant for some time before it can be regarded as an indication of the attitude of the aeroplane. If this is not stressed the student will 'hunt' (or chase) the airspeed, resulting in an undesirable fluctuation in airspeed.

**Vertical Speed Indicator**. In level flight the instrument indicates zero. Any sustained departure from zero therefore, shows that the nose position is too high or too low for level flight. It must be understood that while it indicates fairly accurately steady rates of climb or descent it gives no direct indication of attitude. It does give very useful confirmation of other instrument indications and also provides a convenient check on required rates of climb or descent.

### INSTRUMENTS - INDICATING BANK ATTITUDE

The three instruments which show bank attitude or wing position are:

**Attitude Indicator.** As with pitch attitude this instrument should be regarded as the master instrument, since the position of the index aeroplane relative to the horizon bar and the position of the pointer on the angle of bank scale, together give a direct picture of the aeroplane's attitude in bank or roll within the limitations of the instrument. The limitation in roll (before the instrument topples) is normally at least 90°.

**Turn and Balance Indicator.** This instrument shows the rate and direction of turn. Therefore, in balanced flight any indication of turning means that the aeroplane is banked, and a constant zero reading means that the wings are level.

**Direction Indicator.** If the flight is balanced a constant heading indicates that the wings are level. If the heading is changing then the wings are banked in the direction of the turn. It is important to stress the limitations of this instrument which are normally at least 55° in both the pitching and rolling planes.

Brief the student that if the type of direction indicator in use is not slaved to magnetic north, it will need to be re-set with the magnetic compass at regular intervals and after aerobatic flight.

Having ensured that the student has been thoroughly briefed on the points raised in the Instructional Guide and on the principle of attitude interpretation, the instructor should now brief the student on the methods and techniques to be used in the following air exercises.

### INSTRUMENT– INDICATING YAW

**Turn and balance indicator.** The aeroplane is out-of-balance if the (balance) ball is not centered. An out-of-balance indication is not indicating yaw if the heading is constant.

## AIR EXERCISE

- Attitude - pitch
- Attitude - bank and direction
- Attitude - effect of changing power
- Climbing and descending
- Turning
- Climbing and descending turns
- Steep turns
- Recovery from unusual attitudes

### ATTITUDE—PITCH

This demonstration will teach the student to interpret correctly the indications of all instruments which show the aeroplane's attitude and its movements in the pitching plane.

Because it is impossible to discuss more than one thing at a time, in the following paragraphs each instrument must be introduced in turn. Bear in mind that the ultimate aim is continual cross-reference of all instruments.

This exercise, though apparently very simple, must not be cut short in any way. It forms the foundation for instrument interpretation of all manoeuvres involving changes of attitude in the pitching plane.

Throughout this demonstration maintain a constant power setting, which is usually the cruise power setting.

## IN THE CLEAR

**Attitude Indicator** (AI). Settle the aeroplane in straight and level cruise flight and then raise and lower the nose above and below the horizon. Point out to the student that the instrument immediately shows the change in pitch attitude, but owing to its small size normal changes in attitude are shown as quite small movements of the index aeroplane relative to the horizon bar. Point out also that on returning the aeroplane to its straight and level position in relation to the natural horizon the instrument also reflects the aeroplane's actual attitude.

**Airspeed Indicator** (ASI). From level flight raise or lower the nose position using the 'Change - Check - Hold -Trim' technique described in the Instructional Guide, i.e. change the attitude to start the nose moving to the desired position, check when the desired position is thought to reached, then hold it and trim the aeroplane. Point out that whilst the airspeed starts to change as soon as the nose position is changed, it takes time to settle at a new figure owing to the aeroplane's inertia. Show that if the nose position is held constant, the airspeed settles at a constant new figure, i.e. constant new performance for a new attitude at that power. Demonstrate, by changing the pitch attitude at varying rates, how the rate of change of airspeed is proportional to the rate of change of attitude. Point out that in order to change the airspeed, the student should always anticipate the required airspeed slightly, and should then always wait for the airspeed to settle after the change in attitude. Ensure that the student understands that any change from a constant airspeed indicates a change in pitch attitude.

**AI and ASI.** Now demonstrate some simple cross-reference between these two instruments. Firstly, raise the nose relative to the natural horizon into an attitude which will result in an appreciable fall in airspeed. Point out that the change in attitude is confirmed immediately by the AI. Show that the airspeed starts to decrease and after a short time will remain at a constant figure. Repeat for a nose down attitude. Ensure that the student appreciates that while the AI gives an immediate indication of pitch attitude the same information can be interpreted through the ASI.

**Altimeter.** From level flight demonstrate that by raising and lowering the nose that the altimeter indicates a change in pitch attitude. Point out that just as constant airspeed means constant attitude, so constant height means constant attitude. Demonstrate changes of pitch attitude at different rates pointing out the altimeter's response. Point out that the instrument possesses an inherent lag error during rapid changes, this being particularly applicable to high performance aeroplanes.

**AI, ASI, and Altimeter.** Bring the student's attention to all three instruments. Change the attitude as before showing that the change is immediately apparent on the AI, and that the change is confirmed by the indications of the ASI and altimeter.

**Vertical Speed Indicator (VSI).** Stress that this instrument gives accurate indications only when the aeroplane is in level flight or in a steady climb or descent. Demonstrate by raising or lowering the nose, that whilst the indications of the instrument may not be very accurate, it does have great value in showing a trend thus indicating a change in pitch attitude. Point out that in turbulent conditions its indications are likely to be erratic. Some modern VSIs over read when 'g' loadings are applied.

**AI, ASI, Altimeter and VSI.** Now demonstrate that by cross-reference to all these instruments a complete picture of pitch attitude is available. Fly level and show by reference to the natural horizon that a constant attitude and performance means constant instrument indications on all these instruments. Now raise the nose. Point out that the AI will show the change in attitude directly; the ASI will show a decrease in airspeed proportional to the rate of change of attitude until a steady performance is reached for the new attitude; the altimeter will show a change in height and thus a change in attitude; the VSI will also show a change in attitude.

## THROUGH INSTRUMENTS

When the student appears to be cross-referring to all the pitch attitude instruments satisfactorily and has grasped the fundamentals of pitch attitude instrument interpretation, carry out the following exercises involving pitch changes only.

**Full Panel.** Have the student cross-refer to all the pitch attitude instruments using the AI as the master instrument.

Do not worry the student unduly about keeping straight at this time. When the student is keeping the pitch attitude reasonably constant, have the student decrease the airspeed by some 20 knots or so. Point out that this change is made by altering the pitch attitude by reference to the AI, holding the new attitude until a constant speed is reached, and then adjusting the attitude in small increments until the desired speed is attained. Point out that in making these final small adjustments the student must remember the effects of inertia and must wait for performance of the aeroplane, i.e. airspeed, to give a steady indication before changing the attitude. Repeat the exercise for a slightly nose-down attitude to give an airspeed of some 20 to 30 knots more than cruise flight.

Note: There is a view held by some instructors that limited panel training should not be introduced until the student is proficient with all aspects of 'full panel' instrument flying.

Limited Panel. When the student is reasonably proficient on the full panel, carry out the same exercise with one or more of the four pitch attitude indicators covered. Cover the AI first and allow the student to practice pitch attitude interpretation through the indirect indicators - ASI, Altimeter and VSI. Ensure that the student employs the 'Change - Check - Hold – Trim - Adjust' technique. Stress that you must cross-refer to all available instruments. The aim should be to change the attitude in pitch and change from one constant airspeed to another. Repeat the exercise with other pitch attitude instruments covered.

## ATTITUDE - BANK AND DIRECTION

This demonstration will teach the student to interpret correctly the indications of all instruments which show the aeroplane's attitude and its movements in the rolling and yawing planes.

Remember that, although the instruments are dealt with individually, for instrument flight they must be continually cross-referred.

Here again any tendency to cut short this relatively simple exercise must be resisted.

As before, maintain a constant power setting throughout the demonstration.

## IN THE CLEAR

**Attitude Indicator.** From straight and level flight bank the aeroplane to the natural horizon. Point out that the instrument gives an immediate and direct indication of the position of the wings relative to the natural horizon. Stress the importance of the fac point out that the angle of bank is shown in the correct sense by the angle of the index aeroplane to instrument horizon bar and by the pointer which moves over the angle of bank scale. Show that when the aeroplane banks it turns in the direction of bank. Stress that in balanced flight bank and turn are inseparable and any change in lateral wing position means a change in direction.

**Turn and Balance Indicator.** Fly straight and level by reference to the natural horizon, point out that if the aeroplane is correctly trimmed and flight is balanced the instrument shows zero rate of turn and no slip or skid. Stress that this indicates that the wings are level. Bank the aeroplane and demonstrate that when the aeroplane starts to turn the turn needle shows a turn in the direction of bank. Demonstrate that if the bank is increased the rate of turn is increased. By decreasing the bank show that the rate of turn decreases until when the wings are level it returns to zero.

Before going on to practice cross-reference of those instruments which indicate bank attitude, make sure that the student is aware of the correct co-ordination of the controls with the turn and balance indicator. Point out that as an indication of turn means that the aeroplane is banked, the aileron is the control which must be used to level the wings. Let the student be convinced of this visually by applying bank and then returning to level flight by reference to the turn needle and use of ailerons. On the other hand the balance indicator, whether it be of the needle or ball type, is controlled by rudder. Demonstrate to the student that any sustained displacement of the balance indicator can be corrected by applying rudder in the same direction as the balance indicator displacement. Alternatively it may mean easing pressure applied by the other foot i.e. when leveling off from a climb. Give the student plenty of practice at maintaining level balanced flight through this instrument before proceeding further. Point out that in turbulence there may be considerable oscillation of the indicators. In these conditions the indicators must not be chased but the oscillations should be kept roughly equal on either side of the zero. This will result in the wings remaining level.

**Direction Indicator.** This instrument provides another indication of bank attitude. From level flight bank the aeroplane and point out that the resulting turn is shown as a change in direction. Show that a return to level balanced flight results in a constant heading. It can therefore be stated that a constant heading signifies a level wing position and any sustained movement of the DI implies bank - within the instrument's limitations.

**AI, DI, and Turn and Balance Indicator.** Before proceeding to instrument flight practice, have the student try simple cross-reference exercises utilizing all the wing position indicators. Have the student fly straight and level, noting how the AI, DI and Turn and Balance Indicator all show level balanced flight. Then have the student bank the aeroplane and see how all three instruments give an indication in the correct sense of the change of attitude.

## THROUGH INSTRUMENTS

Now carry out the following exercises with the student under simulated instrument conditions.

**Full Panel.** The aim now is to interpret attitude through all instruments, in all three planes of movement. Have the student settle down to cruise flight and then, by using all the instruments in constant cross-reference, maintain a steady attitude for level flight in a given direction. When the student can do this satisfactorily, have the aeroplane banked in both directions and returned to the same direction of straight and level flight. Then have the student change pitch attitude whilst remaining directionally straight.

**Limited Panel.** Repeat the exercise with one or more instruments covered. First cover the AI and have the student maintain constant height, airspeed and direction by cross-reference of the remaining instruments. Then cover or cage the DI and have the student practice keeping the wings level through the turn and balance indicator alone, keeping a check on direction by reference to the compass. Then nominate a new airspeed and have the student change the pitch attitude to achieve and maintain this airspeed at the same power setting while keeping as steady a direction as possible. The ultimate aim is for the student to have confidence in controlling pitch and bank attitude with any of the instruments out of action.

## ATTITUDE - EFFECT OF CHANGING POWER

During this sequence the student will learn to interpret the instrument indications of changes of attitude due to power variation, and to appreciate the importance of correct trimming.

During this sequence the instructor must watch for constant instrument coverage and full cross-reference of all instruments. This is the last sequence dealing solely with changes of attitude. In future sequences the interpretation of attitude will be assumed.

During this sequence the student should aim to keep a steady direction throughout. The instructor should insist on reasonably precise performance in height, airspeed and direction, and therefore accurate instrument flight must be the objective from now on.

## IN THE CLEAR

**Change of Attitude and Airspeed with Change of Power at a Constant Height**. While in straight and level flight change the power setting and point out how with increasing power the nose tends to rise, and with decreasing power tends to drop. Thus the attitude is changed without movement of the elevator control surfaces. Return to straight and level flight and increase power. At the same time lower the nose slightly to maintain constant height by reference to the altimeter, and point out that the change of attitude is shown directly by the attitude indicator and indirectly by an increase of speed on the ASI. Point out that although speed is increasing, because of inertia it takes time for the aeroplane to steady at a new airspeed. Point out that it is necessary to re-trim to relieve control pressures. Now reduce the power to below the straight and level figure and demonstrate that to keep constant height the nose must be raised until a new constant airspeed is reached. Again point out that because of inertia this takes time. Show that re-trimming is essential. Allow the student to practice changing power at a constant height until competent at cross checking the altimeter and AI as indicators of the correct nose position.

**Change of Attitude and Height with Change of Power at Constant Airspeed.** Introduce this sequence from straight and level flight. Increase the power and show that to keep the airspeed constant the attitude must be changed. Point out that the change in attitude must be made fairly slowly and show that there is an increase in height. Stress that re-trimming is necessary. Return to level flight and reduce power to below cruising, pointing out that this time it is necessary to lower the nose to keep the airspeed constant. Stress the re-trimming when the aeroplane has settled down to its new performance. Practice changing power at constant airspeed until the student is competent at cross checking the ASI with the AI as indicators of the correct nose position. Stress that any necessary adjustment of attitude should be small, and a small interval of time must elapse before the aeroplane finally settles down to its new performance.

**Effect on Directional Control of Changing Power.** Although the student should be aware of this effect from an early lesson it is as well to re-emphasize it. Make considerable changes in power setting and point out that any tendency to bank and/or yaw can be readily 'seen' through the AI, DI, and Turn and Balance Indicator. Stress that the student must be prepared to correct for this effect whenever power is altered.

## THROUGH INSTRUMENTS:

### FULL PANEL

**Changing Airspeed at Constant Height.** Have the student settle the aeroplane in straight and level flight before increasing power and use all the instruments to settle down at a new constant airspeed while maintaining a constant height. Point out that this should be done by changing the attitude by direct reference to the AI, confirming the correct nose position by reference to the altimeter and then making small adjustments as necessary. Ensure that the student re-trims to eliminate control pressures. Repeat the exercise for a decrease in power.

**Changing Power at Constant Airspeed**. Again from straight and level flight have the student increase power and change the attitude to maintain a constant airspeed. Point out use of the AI as the direct indicator of attitude and the ASI to confirm the correct nose position. Do not allow the student to 'chase' the airspeed. Point out the need for smooth control movements and allow for inertia to all instruments. effects. Ensure that the student is cross-referring

### LIMITED PANEL

Now cover one or more of the instruments and repeat the above sequences until the student is able to control the aeroplane through changes of power with any of the instruments out of action. Point out that without the aid of the attitude indicator, inertia effects appear to be even more marked. Particularly during sequences on the limited panel the 'Change - Check - Hold - Trim – Adjust' technique must be used and the tendency to chase needles must be avoided.

## CLIMBING AND DESCENDING

During this demonstration the student will learn how to interpret the instrument indications during climbing and descending, entering a climb or descent, and of resuming level flight.

A constant direction should be maintained during each sequence and aim for a fairly high degree of precision.

## IN THE CLEAR

**Initiating a Climb.** From straight and level flight increase the power to the climbing figure and raise the nose to the correct attitude. Point out that the new attitude is shown directly by the AI, that the airspeed begins to decrease, that the altimeter shows a gain in height and that the VSI shows a rate of climb. Wait until the airspeed has settled down, emphasize this waiting period, and then make any minor adjustments necessary to obtain the correct attitude for the climbing power selected. Demonstrate that the aeroplane must be re-trimmed. Maintain steady climbing flight by constant cross-reference to all instruments and point out that, although all instruments provide an indication of the aeroplane's attitude, the ASI is the instrument that confirms the correct attitude for climbing as shown by the AI.

**Leveling off from a Climb.** The student must understand that to level off at any desired height, the aeroplane's nose position must be lowered towards the cruising flight position before that height is reached, the amount of 'lead' depending on the rate of climb. From a climb demonstrate and point out to the student that the technique is to select a particular height and slowly start changing attitude before reaching that height, about 10% of the rate of climb, in advance of the selected height. Point out that to maintain constant height while leveling off, the altimeter must be referred to as speed is gained to ensure that the correct nose position is being assumed. Reduce power as cruising speed is approached and then point out the small adjustments of power and attitude necessary to obtain the required level flight performance. Show that all instruments give an indication of attitude but the **altimeter** is the instrument which confirms the correctness of attitude as shown by the AI when leveling off. Point out that it is necessary to make allowance for the inherent lag of the VSI when leveling off.

**Climbing and Leveling Off Without Using the AI.** Repeat the above sequences with the AI covered and, drawing the student's attention to the natural horizon, point out that:

(a) When climbing, the ASI gives the most direct indication of pitch attitude

(b) When leveling off, the altimeter gives the most direct indication of pitch attitude

In both cases it should be stressed that due allowance must be made for the effects of the aeroplane's inertia.

**Initiating a Descent.** Carry out this demonstration from level flight, reduce power and, by maintaining the aeroplane's attitude, allow the airspeed to fall until it reaches that desired for the descent.

Then lower the nose position and observe how the ASI confirms the attitude of descent that is indicated on the AI. Re-trim and ensure that flight is balanced. Demonstrate that to achieve any desired rate of descent the power and attitude must be adjusted, i.e. to increase the rate of descent reduce power and lower the nose as necessary to maintain airspeed; to decrease the rate of descent increase power and raise the nose as necessary to maintain airspeed. In both cases point out that the rate of descent is checked by reference to the VSI or altimeter and clock.

**Leveling Off from a Descent.** Point out that as when leveling off from a climb, to level off at any desired height the aeroplane's attitude must be changed before that height is reached. The amount of anticipation depends largely on the rate of descent but is usually 10% of the rate of descent. While descending select a particular height and before reaching it increase power to the setting for cruising flight and slowly change attitude to attain level flight at the selected height. Note that in this case it is the **altimeter** that confirms the correct level flight position as shown by the AI. Demonstrate that it is necessary to wait for a steady performance to be reached and then adjust power and attitude to give the required airspeed at the required height and re-trim.

**Descending and Leveling Off Without Using the AI.** Repeat the above sequences with the AI covered and point out by reference to the natural horizon that:

(a) When **descending**, the **ASI** gives the most direct indication of the correct pitch attitude

(b) When **levelling off**, the **altimeter** gives the most direct indication of the correct pitch attitude

In both cases an allowance for inertia must be made when making attitude changes.

## THROUGH INSTRUMENTS

If the student has practiced the previous climbing and descending sequences in the clear and is familiar with the instrument indications, there should be no difficulty in practicing the exercises solely on instruments. Give the student practice on full and limited panel in climbs and descents at various rates. Use the clock and altimeter to confirm the indications of the VSI and ensure that the student is competent at leveling off accurately at a desired height. Emphasize that the VSI can only be relied upon to give an accurate rate of climb or descent if the vertical speed of the aeroplane is steady.

## TURNING

During this demonstration the student will learn how to interpret the instrument indications during turns and to make precision turns on to given headings.

Precision sequences should be introduced at this stage. The element of time is also brought into the instrument coverage. A time piece is very important in precision instrument flight, and should now be regarded as part of the flight panel.

A constant height should be aimed for throughout the following sequences.

## IN THE CLEAR

**Turning Flight.** Stress the three essential elements of an accurate turn. These are:

- a constant amount of bank
- balanced flight i.e. correct use of rudder
- the correct nose position to maintain altitude.

The first is achieved by co-coordinating aileron and rudder and the third by the use of elevator. Thus for turning flight the use of all controls must be co-coordinated and the attitude interpreted from all instruments.

From normal straight and level flight enter a turn and demonstrate that any faulty co-ordination of aileron and rudder (i.e. incorrect balance) is shown as a slip or a skid on the balance indicator*. Point out that the AI gives a true indication of the aeroplane's attitude in pitch and bank and that this can be checked against the indications of the altimeter, ASI, VSI, and turn needle. *Demonstrate that the amount of rudder required during the entry to and exit from the turn is dependent on the rate of application of aileron. When the turn is stabilized rudder is used simply to balance any residual yaw. On recovering from the turn, point out that all the instruments will again indicate the correct attitude for level flight. Have the student practice entering, sustaining, and recovering from turns of 30° angle of bank until satisfied with the ability to co-ordinate control movements with the interpretation of attitude from the full panel.

**Precision Turns at a Definite Rate on to a Definite Heading.** Demonstrate that the aeroplane does not come out of a turn immediately action is taken to reduce the angle of bank. (Even though this fact should have been thoroughly demonstrated during the fi rst lesson on turning.)

Point out that the 'lead' or anticipation of the new heading is achieved by commencing the roll out at about half the bank angle e.g. for a 30 degree banked turn commence the roll out about 15 degrees before the nominated heading.

Ensure that the student is aware of the direct relationship between true airspeed and angle of bank to rate of turn. As airspeed increases bank must increase for any given rate of turn. For a standard rate one turn (3° per second) an approximate angle of bank may be obtained by adding 7 to the first two digits of the true airspeed in knots, e.g., a rate one turn at 95KT requires 9 + 7 = 16° angle of bank.

The rule of thumb is for balanced flight only.

Have the student practice precision turns at rate one onto nominated headings. When the student has grasped the principle of turning by angle of bank, rate of turn and time have the student turn on to definite headings with the DI covered or caged, checking on the accuracy of the turn by cross-reference to the compass.

**Precision Turns Without the AI or DI.** Before starting turning under instrument conditions, have the student try a few turns in the clear with the AI and DI covered. In these conditions (which would be expected with the failure of an engine driven vacuum pump) the angle of bank (about rate one or less) can be interpreted from the turn and balance indicator and the nose position from the altimeter, ASI and VSI. Watch for any tendency to over bank. Point out that the student must allow for compass error. Ensure that the student always waits for the compass needle to settle down before correcting any errors in heading.

A good rule of thumb for small heading changes is to use a bank angle of no more than the number of degrees to be turned through divided by two.

## THROUGH INSTRUMENTS:

**Full Panel.** If the student has had little difficulty with the preceding sequences there should be little difficulty in going ahead with turns and then precision turns under instrument conditions. Have the student first practice turns on to definite headings. Ensure the student is cross-referring to all instruments, pointing out that this is essential to maintain a precise performance. When the student is fairly competent at this introduce timed turns at rate one through varying numbers of degrees.

**Limited Panel.** With the student flying the aeroplane repeat all the fore-going exercises with firstly the AI and then the AI and DI covered. Stress that control movements must be small but firm, and that constant cross-reference to all the available instruments must be maintained. Watch for any tendency to chase the compass. It is most important for the student to understand that on completing the turn it is a must to fly straight and level and wait for the compass to settle. The student must then estimate the amount of error, make a correction and then wait again for a steady indication of heading.

## CLIMBING AND DESCENDING TURNS

The student should now learn to interpret the instrument indications during climbing and descending turns, and to make these turns at specific rates through the instrument indications.

Having reached this stage do not let the student be satisfied with being 'just good enough'. The student should by now be able to fly within the limits of ± 200FT, ± 5° and ± 10KT.

It is even more important in these sequences to cross-refer to all instruments continually to attain the correct airspeed, vertical rate and direction, and confirm the rates of climb and descent by timing and altimeter.

## IN THE CLEAR

**Climbing Turn from a Climb.** Set up normal climbing flight, roll into a climbing turn and point out that the AI indicates the correct attitude in pitch and bank relative to the natural horizon, while all other instruments confirm that the aeroplane is climbing and turning. Check the angle of bank for the required rate of turn and ensure that flight is balanced. Point out that as in the straight climb it is the ASI which confirms the correct pitch attitude, and that the turn indicator confirms the bank attitude. Have the student practice climbing turns on to definite headings adjusting attitude as necessary to keep the desired performance. Repeat the sequence with some of the instruments covered and ensure that the student is able to interpret the aeroplane's attitude correctly from the instruments which give an indirect indication of attitude.

**Climbing Turn from Level Flight.** This is a combination of the climbing and turning exercises. From level flight increase power and roll the aeroplane into a turn, at the same time raising the nose to the approximate position for the climb. Point out the angle of bank for the required rate of turn and adjust as necessary. Demonstrate that as the airspeed approaches climbing speed it may be necessary to adjust the angle of bank to maintain a constant rate of turn and that constant cross-reference to the ASI is necessary in adjusting pitch attitude. Practice leveling off from the turn on a specific heading and height. Have the student repeat these sequences with the AI and DI covered, pointing out with reference to the natural horizon how the attitude can be interpreted, although direct instrument attitude indications are not available.

**Descending Turn from a Descent.** From a normal descent roll into a turn and point out that, as with a climbing turn, the correct pitch attitude relative to the natural horizon is confirmed by cross-checking the ASI and the AI, and the correct bank attitude by cross-checking the rate of turn indicator with the AI. Have the student practice descending turns on to specific headings, stressing that he should interpret the instrument indications, adjust the attitude as necessary and then by reference to the natural horizon verify the correctness of his interpretations. Cover up the AI and DI and allow the student to interpret the aeroplane's attitude as before from the remote indicating instruments.

**Descending Turn from Level Flight.** Point out to the student that it is necessary to co-ordinate the descending and turning exercises in the same way as initiating a climbing turn from level flight. Again it is the ASI which confirms the pitch attitude.

**Precision Climbing and Descending Turns**. Before proceeding to the practice of climbing and descending turns through instruments alone, have the student practice co-coordinating turns through a specific number of degrees while gaining or losing a specific amount of height, e.g. a rate one turn through 360° while climbing or descending 1,000FT at 500 feet per minute over a time interval of two minutes. This will ensure that:

(a) the student understands the technique of regulating vertical speed with power while making changes inattitude to maintain a constant airspeed; and

(b) the student can maintain constant cross-reference to all instruments depicting attitude, power, performance and time.

## THROUGH INSTRUMENTS

The student should practice all the foregoing manoeuvres through instruments alone. On full and limited panel practice climbing and descending turns from steady climbs, descents and level flight and turns at specific vertical rates.

## STEEP TURNS

It is rarely necessary to turn at large angles of bank during instrument flight. However, the increasing speeds of modern aeroplanes are demanding quite high angles of bank even for moderate rate turns. This sequence is of great benefit as an exercise in co-ordination, as it requires rapid and effective cross-reference and a high standard of attitude interpretation to achieve even moderate precision.

In practicing these turns the student should aim for a sustained turn at an angle of bank of 45°.

## IN THE CLEAR

From level flight, roll slowly into a turn with about 35° angle of bank, and point out the instrument indications which show the aeroplane's attitude in pitch and bank, the balance and rate of turn and the gain or loss in height and airspeed. Hold the turn and point out how the nose position relative to the natural horizon is slightly higher than for level flight, and is confirmed by the AI. Also point out that back pressure may be required on the controls to prevent the nose from dropping. Now increase the bank, pointing out that more power will be needed to maintain height and airspeed again note the nose position and increased back pressure on the controls. Roll out of the turn reducing power as necessary, and stress how the lower nose position for level flight is confirmed by the AI. The altimeter will confirm the need to lower the nose, otherwise a gain in height will be experienced. When the student has practiced this sufficiently, demonstrate the errors which can occur.

Roll into a steep turn but allow the nose to drop. Point out the increase in airspeed and loss of height. Demonstrate that if the attitude is not checked immediately, a spiral descent develops. When this has developed, point out that recovery by elevators alone is difficult and may even be impossible. Show that with a reduction in angle of bank by reference to the AI the nose can easily be brought back to its correct position.

Allow the student to practice steep turns, pointing out that even in the clear with all instruments available you are compelled to refer to his altimeter, ASI and balance indicator for accurate assessment of the quality of the turn. The same is true for a turn by instruments alone and any change of attitude must be corrected immediately it becomes apparent.

## THROUGH INSTRUMENTS

**Full Panel.** Have the student roll into the turn slowly and smoothly, to an angle of bank of about 45°.

Ensure cross-referring to all instruments and making adjustments to attitude even as the turn is entered. Prompt the student to think in terms of attitude and to make control corrections for errors exactly as would be done in a visual turn. Stress particularly that to raise the nose position, quite a heavy back pressure is required, while to lower it all that is necessary is to relax the back pressure slightly. During the recovery, point out the necessity to prevent the aeroplane climbing. During this exercise the physiological sensations experienced by the student may well be much stronger than in previous exercises. The student must still ignore these sensations and trust the instruments implicitly.

**Limited Panel.** Steep turns with the AI and DI covered must be approached gradually. Start with a small rate of turn, gradually increasing this as confidence and skill are gained. The most common failing is to allow the nose to go down, together with a tendency to over-bank.

## OTHER USEFUL COORDINATION EXERCISES – FULL OR LIMITED PANEL

1 From straight and level flight commence a rate one level turn (left or right) and, whilst maintaining height, reduce the IAS to a nominated speed about 10KT above the stall speed. When that speed is reached reverse the direction of the turn and accelerate the aeroplane back to the original IAS and roll out of the turn when the speed is reached. Repeat or continue for as long as required.

2 From straight and level flight commence a climbing turn (left or right). Each time the aeroplane passes North or South (or any other chosen opposite headings) reverse the direction of the turn. When the aeroplane has climbed through 1000FT commence a descending turn (30° angle of bank FP, rate one turn LP), still reversing heading passing North or South and recommence the climb at the start altitude. Repeat or continue as long as required.

## RECOVERY FROM UNUSUAL ATTITUDES

The aim in this sequence is to recognize any unusual attitude of the aeroplane by interpretation of the instrument indications and to recover from such attitudes in the minimum time with the minimum loss of height.

Just as steep turns by instruments called for correct and rapid attitude interpretation, recognition and precise recovery from unusual attitudes demand immediate assessment of attitude from all available instruments.

The physiological sensations experienced in these sequences are usually most disconcerting. The instruments are invariably more reliable and the student must learn to ignore these sensations and believe the instruments.

These sequences must be practiced. However, the more severe attitudes cannot be practiced in non-aerobatic aeroplanes. Normally a pilot will not enter unusual attitudes while in instrument flight. They can occur however, through poor instrument interpretation or faulty technique. Severe turbulence or wake turbulence may cause an unusual attitude to be assumed.

For simplicity in presentation the sequences are divided into two general types of unusual attitude:

(a) Those characterized by a low airspeed (two recovery techniques)

(b) Those characterized by a high airspeed

## IN THE CLEAR:

### UNUSUAL ATTITUDES AT LOW AIRSPEEDS

**Full Panel**. From normal level flight raise the nose position to an unusually high attitude, at the same time applying a steep angle of bank. Point out the instrument indications with reference to the natural horizon. Stress the rapid decrease in airspeed then show that by returning the index aeroplane of the AI to the horizon bar, level flight is easily regained (i.e. a simultaneous 'push forward' [elevator] and 'roll wings level' [aileron]. Point out that the airspeed may still be low even when level flight has been gained and that it builds up slowly to the normal cruising figure.

**Limited Panel.** Cage (or cover) the DI and AI. Point out now that pitch attitude is determined by the ASI and altimeter; the steep pitch attitude is shown by a rapid decrease in airspeed and rapid increase in height. Now use the controls to return the aeroplane to normal level flight attitude and compare the indications of the ASI with the aeroplane's attitude relative to the natural horizon. Stress that, **at the moment the airspeed ceases to reduce, the nose position is approximately that for level flight. (Similarly, the approximate level attitude is also obtained when the altimeter 'stops moving'.)**

Before continuing further give the student plenty of practice at 'finding the horizon' through the ASI and then holding level flight through the altimeter while the airspeed slowly builds up to normal.

Again from level flight, put the aeroplane into a steep nose-up attitude and apply a steep angle of bank. Point out that the turn indicator shows which wing is lowered. To regain level flight, the aeroplane must be rolled level until the turn indicator returns to the centre. In an extreme wing low situation the ailerons need to be centralized when the turn needle 'leaves the stop'. The nose position is adjusted as before and the rudder is used to control slip or skid. Point out that as a further aid to regaining a level attitude, the student should, if the DI is toppled and spinning, cage and uncage that instrument.

To summarize:

(a) The regaining of laterally level is of primary importance, as forward pressure on the controls when the aeroplane is on its side may aggravate the situation

(b) Increase power if the attitude is steep and the speed is very low – see following explanation

(c) Cage and uncage the DI when the aeroplane is roughly in level flight to assist in maintaining lateral level

## LIGHT AEROPLANE - STANDARD NOSE HIGH RECOVERY TECHNIQUE

**SIMULTANEOUSLY**

- Airspeed rapidly approaching or below maximum angle climb speed – APPLY FULL POWER (Otherwise leave power as is.)
- ROLL WINGS LEVEL
- EASE FORWARD ON CONTROL COLUMN TO LEVEL ATTITUDE

## LIGHT AEROPLANE – STANDARD NOSE VERTICAL RECOVERY TECHNIQUE

Flight controls ineffective and IAS near zero:

- Close throttle
- Tight grip on control column, feet firmly on rudder pedals to prevent possible control snatch during tail slide
- Nose pitches down
- Level wings and ease out of dive

**Stalling and Recovering.** When the student is competent at recognizing and correcting low speed, unusual attitudes take the low speed situation to the extreme, i.e. to the stall, pointing out the instrument indications. Demonstrate this by reducing power and raising the nose. As the aeroplane approaches the stall, point out how the indications of increasing height change, until at the point of stall a loss of height will be shown. Apply full power as this stage is reached and take normal stall recovery action. If the wing drops at the point of stall and the ailerons on the type are not effective at this point, stress that the principle of using the aileron to control wing position through the rate of turn indicator must be changed. In this case the yaw towards the lowered wing should be controlled with rudder, and only when the aeroplane is unstalled can aileron again be used to control the turn needle.

## UNUSUAL ATTITUDES AT HIGH AIRSPEEDS

**Full Panel.** From level flight dive the aeroplane steeply, both with the wings level and with bank applied. Show that all the instruments are operative and will allow the student to interpret the nose-down and banked attitude. Stress that in the case of an unusual attitude at high airspeed it is essential to level the wings before pulling out of the dive. A combination of nose-down attitude and bank results in a spiral dive and any attempt to recover without first rolling the aeroplane level will only tighten the spiral and aggravate the situation. By reference to the AI show that it is a simple matter to roll the aeroplane level and then ease out of the dive to regain level flight. Throttling back assists in keeping height loss to a minimum, and the student must have it emphasized that at any indication of a high speed diving spiral he should throttle back and level the wings simultaneously.

**Limited Panel.** Put the aeroplane into a straight dive with the AI and DI covered. Point out the increasing airspeed and loss of height. Throttle back and ease out of the dive, laying great emphasis on the indications of the ASI compared with the aeroplane's attitude relative to the natural horizon. **The moment the airspeed stops increasing the aeroplane is approximately in the level flight attitude**. As when leveling off from a steep climb, maintain level flight by reference to the altimeter as speed decreases, and increase power as normal cruising speed is reached.

Dive the aeroplane again, this time applying bank so that the aeroplane commences a spiral dive. Point out that the turn needle shows the direction of the spiral and that as before, it is essential to roll the aeroplane laterally level before pulling out of the dive. During the recovery the wings will be approximately level when the turn needle 'leaves the stops'.

To summarize:

(a) Before easing out of the dive, regain lateral level by taking off bank until the turn needle is central

(b) Reduce power to minimize the loss of height

(c) Cage and uncage the DI when the aeroplane is approximately in level flight to assist in maintaining lateral level

## THROUGH INSTRUMENTS

The above exercises should be repeated under simulated instrument conditions. It is essential to once again stress that the physiological sensations that the student will experience are very disconcerting. These sensations are strongest when there is any uncertainty as to attitude and they must not be allowed to influence either the recognition of attitude or the subsequent recovery action.

## LIGHT AEROPLANE – STANDARD NOSE LOW RECOVERY TECHNIQUE

**SIMULTANEOUSLY**

- Airspeed rapidly approaching or exceeding maximum maneuvering speed – CLOSE THROTTLE (Otherwise leave power as is.)
- ROLL WINGS LEVEL

Then

- EASE OUT OF DIVE

**COMMON FAULTS**

Failure to cross-refer to all instruments is a frequent weakness. Emphasize the importance of using all the instruments so as to get a comprehensive picture of the overall situation.

Note: There are divided views regarding when instrument flying should be taught. One approach is for the instructor to draw little attention to the AI until after initial circuit training. This approach is thought to enhance a student's perspective of pitch attitude as well as bank angle judgement. However, another view is to relate instrument indications during the teaching of basic sequences. However, individual school policy on this matter will depend on what is stated in the company operations manual or other appropriate document.