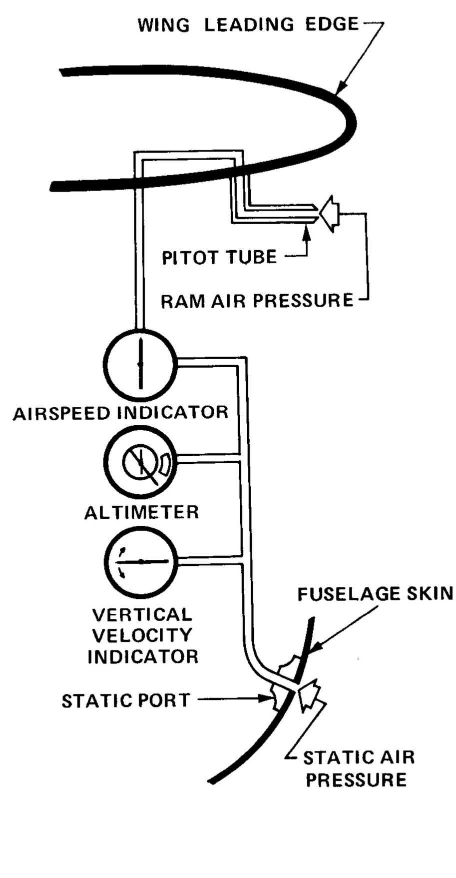
AIR DATA INSTRUMENTS

The pressure instruments are : ASI
MACHMETER
ALTIMETER
VSI

Pitot and Static Sources

The pressure instruments which require consideration for this syllabus are the altimeter, the vertical speed indicator (VSI), the airspeed indicator (ASI), the machmeter, the combined ASI/machmeter and the central air data computer (CADC). As a first step it is necessary to look briefly at the devices which are used to measure the static pressure which is fed to all of the above, and the pitot pressure which is fed to the ASI, the machmeter, the combined ASI/machmeter and the CADC.

Static Pressure



Static pressure is the ambient air pressure at a given point in the atmosphere. Considering an aircraft at rest in still air conditions, this ambient pressure acts equally on all points of the aircraft. Above shows one method of measuring static pressure, using a static head. The head consists of a tube with its forward end sealed and holes or slots cut into the side. The ideal situation is that the head always lies in line with the direction of relative air flow and therefore the pressure sensed is independent of any increase of pressure caused by the aircraft's speed through the air. A static head may be incorporated with the pitot head as shown further on.

Static vents are more commonly used in modern aircraft to detect static pressure. A static vent consists of a smooth plate with a small hole in the middle. The plate is mounted flush with the aircraft skin at a point where the air flow is relatively undisturbed by the airframe structure itself. This is to ensure that, as far as possible, the static pressure sensed at the vent will be pure ambient pressure, which is free of errors caused by the presence of the aircraft or the speed of the aircraft through the air. It is normal to mount two static vents, one on each side of the aircraft, thereby cancelling errors in the sensed pressure caused by aircraft yaw.

It is normal to incorporate an emergency static source into the static line plumbing. In the event that the static head or the static vents become blocked the emergency static source can be selected by the pilot. This alternate source is located at some sheltered position outside the pressure hull. The pressure sensed at this source is unlikely to represent accurately the ambient air pressure, since it will almost certainly be influenced by the aircraft structure.

In some unpressurised aircraft an alternate static source is provided inside the cockpit.

It should be noted that, unless it is otherwise stated in the flight manual for the aircraft, the static pressure sensed within the cockpit will be lower than the true static pressure due to aerodynamic suction. The effect of this artificially low static pressure is that both the pressure altimeter and the airspeed indicator will overread with the emergency static source selected.

Pitot Pressure

The composition of pitot pressure, and the use made of it, is fully discussed in the chapters dealing with the airspeed indicator and the machmeter. If the aircraft is at rest in still air conditions the pressure sensed at the pitot tube will be the static pressure already discussed. A pitot tube like the static head, faces forward into the airflow. In flight the pressure sensed at the pitot tube will be increased due to the aircraft's forward speed. The two elements of the pitot pressure will therefore be:

a. the static pressure, and
b. the dynamic pressure, or pitot excess pressure.

It is the dynamic pressure which is proportional to the aircraft's forward speed.

Since an emergency pitot tube cannot be fitted at a sheltered point of the aircraft, with any hope of success, it is normal to incorporate a heating element into the tube to prevent blockage due to ice formation. Any water ingested by the system is allowed to drain from the tube through drain holes and is prevented from travelling downstream through the plumbing by means of traps and valves.

The incorrect measurement of static pressure is known as position or pressure error. The static head and the combined pitot/static head are more prone to this error than are static vents. The magnitude of the error depends on the airspeed and the aircraft attitude. The error is likely to be largest at high angles of attack when some dynamic pressure is generated at the static sensor. Flight manuals will normally provide correction values for this error for different flap settings.

Manoeuvre errors are the result of temporary fluctuations in static pressure which occur when the angle of attack of the aircraft is changing, principally when flaps and landing gear are raised or lowered. Manoeuvre errors normally cause lag in pressure instruments (including air data computers) and may persist for several seconds after the change of configuration/movement of a control surface has been completed, the higher the aircraft altitude the longer the error will persist. Although changes in pitch attitude are the primary source of manoeuvre errors, rolling and yawing manoeuvres can also give rise to this problem.

THE AIRSPEED INDICATOR (ASI)

White arc	stall full flap to max flap speed
Green arc	from clean stall to normal operating speed
Yellow arc	from normal operating speed to never exceed speed

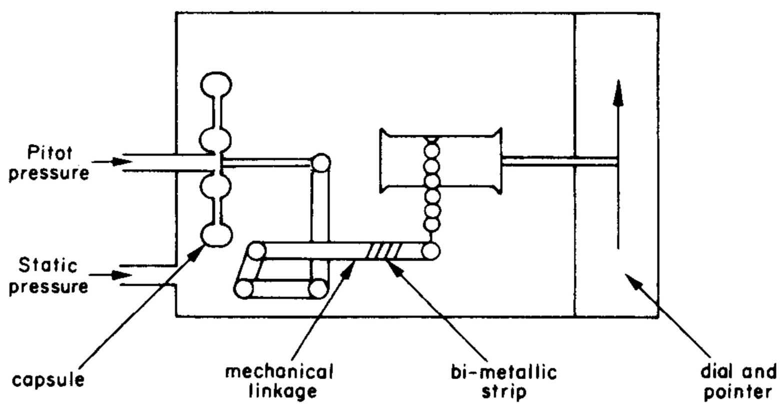
The principle of operation of the ASI is the measurement of two pressures: PITOT and STATIC.

$$P = D + S$$

$$\therefore \quad D = P - S$$

The ASI continually subtracts the static pressure from the pitot pressure giving the Aircraft's airspeed.

DYNAMIC PRESSURE IS DIRECTLY PROPORTIONAL TO AIRSPEED.



The ASI is calibrated according to ISA conditions. Therefore any departure from ISA will cause an incorrect IAS. Most of the time, the atmosphere does not conform to ISA. This is the reason why the IAS and TAS are very often different.

ERRORS

a. Instrument Error

This is due to small manufacturing imperfections and the fact that a small capsule movement gives a large pointer deflection. A correction card is supplied.

b. Pressure / Position Error

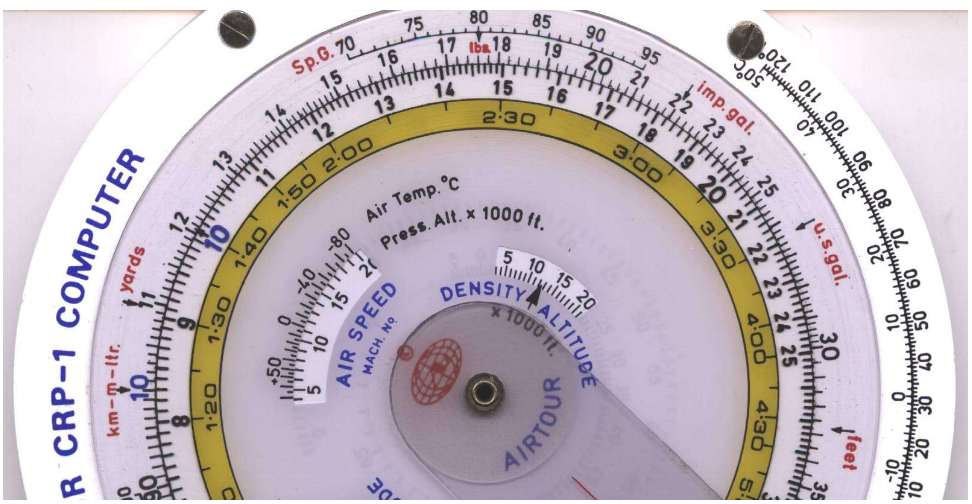
Approximately 95 % of this error can be eliminated by placing 2 static vents (one on either side of the A/C). The location of the pitot tube on the A/C will affect the reading and the type of manoeuvre that is being flown. A correction card is also supplied for this error.

c. Density Error

The ASI as stated before, is calibrated for ISA. Most of the time, the density will not reduce according to ISA. Therefore an error will be present. This can be corrected for by the ARISTO or the PATHFINDER. The pathfinder will do it automatically for you.

PATHFINDER: use the **ACTUAL TAS** function.

P.A. 12000' IOAT. - 8º C RAS 183 KTS <u>TAS = 220ish KTS</u>

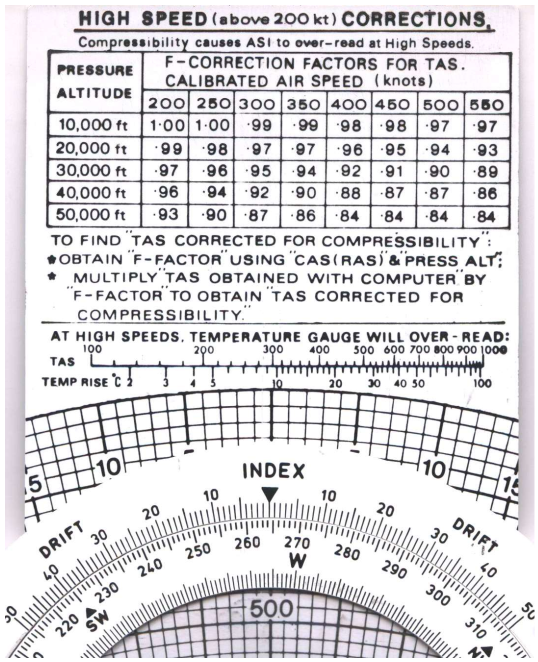


d. Compressibility Error

At speeds above 300 Kts, the air will be compressed. It will cause the dynamic pressure at the pitot head to be greater than it should, resulting in an OVERREAD of IAS. The error is small at sea level (dense air), but increases with altitude.

The temperature of compressed air is higher so a correction will have to be made.

It can be done automatically for you on the PATHFINDER



SUMMARY OF ERRORS

INDICATED AIRSPEED (IAS) ± POSITION/INSTRUMENT ERROR = RAS/CAS

RECTIFIED AIRSPEED (RAS) - COMPRESSIBILITY = EAS

EQUIVALENT AIRSPEED (EAS) ± DENSITY = TAS (TRUE AIRSPEED)

LEAKS

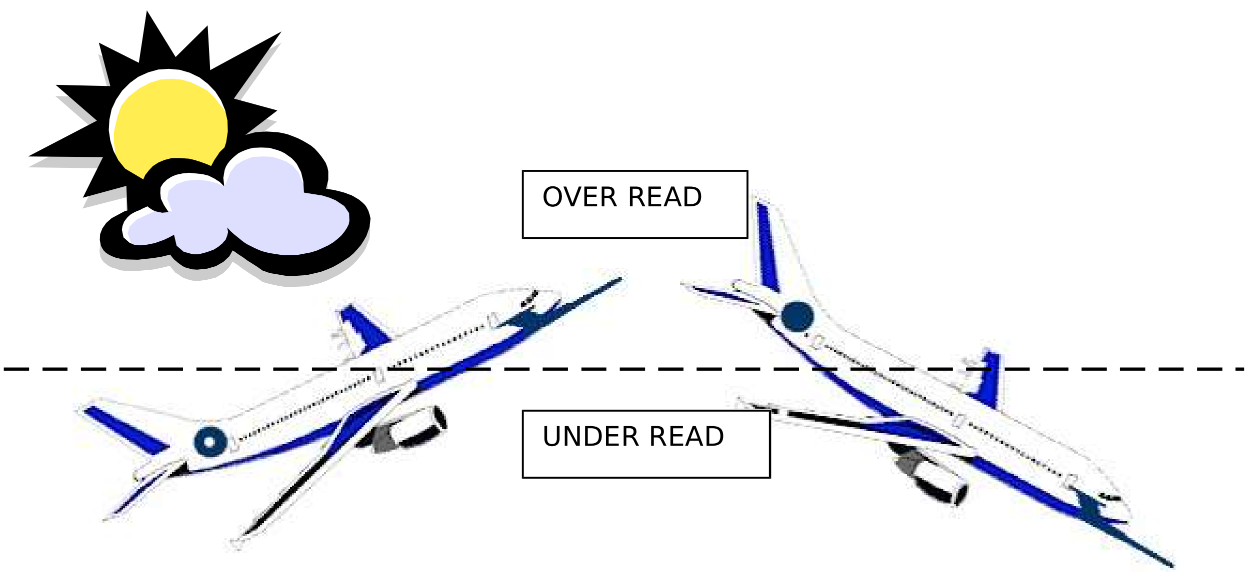
If the pitot tube develops a leak, the ASI will UNDERREAD, because the pitot pressure is too low.

BLOCKAGES

CLIMBING
Pitot Blocked - ASI OVERREADS
Static Blocked - ASI UNDERREADS

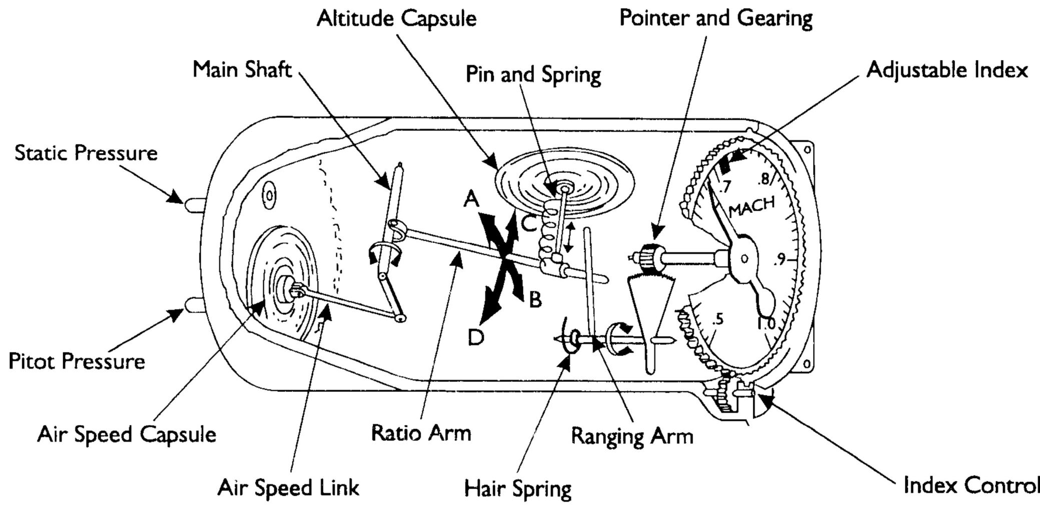
DESCENDING
Pitot Blocked - ASI UNDERREADS
Static Blocked - ASI OVERREADS

A good way to put this to memory is to use the following diagram:



THE MACHMETER

As an aircraft approaches the speed of sound, it experiences severe adverse aerodynamic effects. Thus a pilot needs warning that he is approaching the speed of sound. However, the speed of sound varies with temperature therefore it is different at various altitudes.



The MACHMETER solves this problem because it indicates the ratio of the airspeed to the local speed of sound (LSS) at that altitude (TEMPERATURE).

The result is that the pointer movement is proportional to the ratio of the movements of the two capsules – that is, (P-S)÷S, or Mach number.

$$\text{MACH N°} = \frac{\text{TAS}}{\text{LSS}}$$

$$\text{LSS} = 38.945 \sqrt{\text{COAT} + 273}$$

ERRORS

The only errors are Position/Pressure errors.

Density Error

The density factor appears above and below the equation so it is cancelled out.

Temperature Error

Is eliminated with the density error.

Compressibility Error

This depends on the ratio of Dynamic pressure and static pressure and is catered for in the equation.

LEAKS AND BLOCKAGES

Exactly the same as the ASI.

THE MACHMETER INDICATOR

The machmeter indicator incorporates:

A normal ASI needle.

A machmeter of the rotating drum type.

A Vmo (Max Operating Speed) needle. BARBERS POLE. The Vmo needle (Barbers Pole) adjusts itself to the changing altitude thus giving the correct Vmo for that altitude.

RAS - TAS - MACH Nº RELATIONSHIP FOR CLIMBING AND DESCENDING

Bear in mind:

LSS always decreases with altitude.

$$\text{MACH N°} = \frac{\text{TAS}}{\text{LSS}}$$

ASI UNDERREADS with altitude.

For descending, the results are reversed.

Constant Mach Climb:

LSS decreases
TAS decreases
RAS decreases

Constant TAS Climb:

LSS decreases
MACH Nº increases
RAS decreases

Constant RAS Climb:

LSS decreases
TAS increases
MACH Nº increases

CALCULATIONS

FORMULA

$$MACH^{\#} = \frac{TAS}{LSS}$$

$$LSS = 38.945 \sqrt{COAT + 273}$$

<u>Example 1</u>

LSS = 600 nm/hour

TAS = 450 Kts

$M^{\#}$ = ?

$$M^{\#} = \frac{TAS}{LSS} \qquad M^{\#} = \frac{450}{600} \qquad M^{\#} = 0.75$$

<u>Example 2</u>

LSS = 1100 feet/sec

$M^{\#}$ = 0.73

TAS = ?

TAS = $M^{\#}$ x LSS

$$TAS = \frac{0.73 \times (1100 \times 60 \times 60)}{6080}$$

TAS = 476 Kts

Example 3

A/c A = $M^{\#}$ 0.815 TAS 500 Kts

A/c B = $M^{\#}$ 0.76

a) What is the flight level under ISA conditions?

b) What is the TAS of A/c B?

c) Use the Flight Computer to find the Temperature (-25º C) and TAS (466 Kts) of ACFT B.

d) Then:

Sea level	=	+ 15º C
Flight level	=	- 25º C
Temp Change	=	40º C at 1.98º C per 1000' = FL 202

Example 4

An A/c flying at a constant FL, reduces power that results in a reduction of TAS by 60 Kts and $M^{\#}$ by 0.1. What is the FL?

$$M^{\#} = \frac{TAS}{LSS}$$

$$0.1 = \frac{60}{LSS}$$

LSS = 600 nm/hour

$$600 \text{ Kts} = 38.945 \times \sqrt{COAT + 273}$$

$$\left[\frac{600}{38.945}\right]^2 - 273 = COAT$$

= - 35º C

Sea Level	=	+ 15º C
Flight Level	=	- 35º C
Temp Change	=	50º C at 1.98º C/1000'
	=	FL252

Example 5

A/c at FL 330 COAT - 40º C M# 0.82

The A/c RAS?

(a) RAS 253
(b) RAS 276
(c) RAS 292

First use PLAN M# to get TAS 488 (because it is COAT).

Then use REQ CAS with TAS = 488 CAS = ?.

Example 6

An A/c flies from a warm airmass to a cold airmass at a constant FL and RAS.
The M# will:

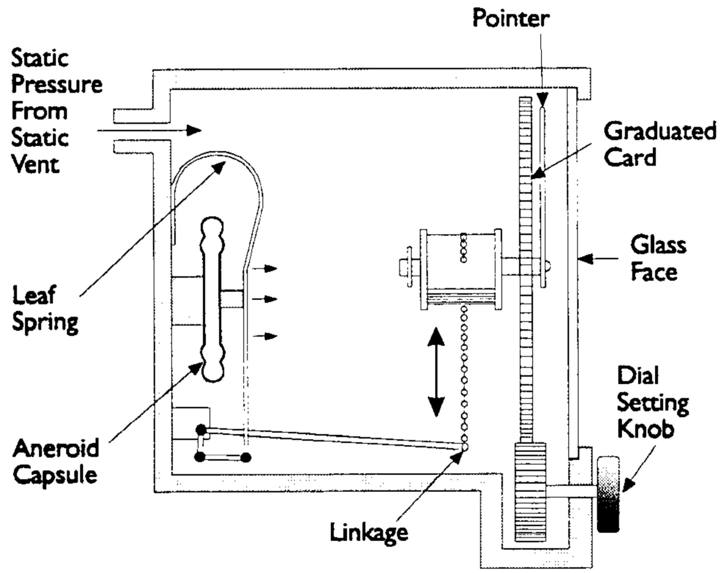
(a) Increase
(b) Decrease
(c) Remain Constant

Answer :

$$M\# = \frac{TAS}{LSS}$$

so as the temperature drops, the TAS and LSS will drop at the same ratio thus keeping the M# constant

THE ALTIMETER



The Altimeter is actually just a simple barometer that has been calibrated at ISA to indicate altitude instead of pressure.

Note the bi-metallic strip to cater for changes in temperature.

A sensitive altimeter is just the same as above, but incorporates a few more capsules to give a greater movement for a given pressure change. A barometer setting facility enables height above any pressure datum to be set.

ERRORS

a. Instrument Error

Because the rate of pressure drop with altitude is not constant, the instrument error is magnified at higher levels. Hence the greater separation at higher Flight Levels (2000' above FL290).

b. Pressure / Position Error

The errors are caused in the same way as the ASI and a correction card is supplied.

c. Barometric Error

This error is catered for by providing a facility to set the QNH on the 'millibar subscale'.

d. Time Lag Error

Gears and linkages cause the altimeter pointer to lag. It takes time for a pressure Change to be registered.

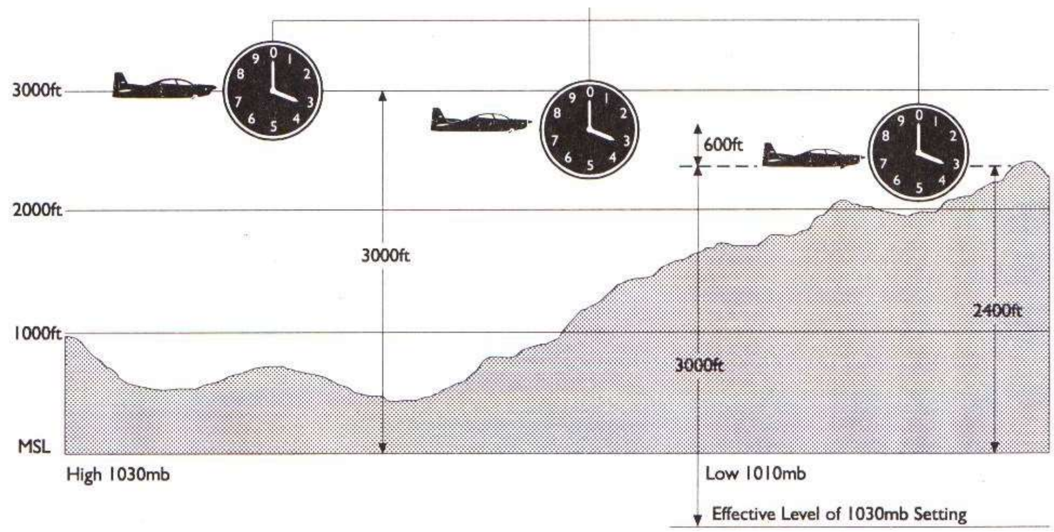
DURING A RAPID CLIMB **THE ALTIMETER LAGS - UNDERREADS.**

DURING A RAPID DESCENT **THE ALTIMETER LAGS - OVERREADS.**

ALTITUDE / PRESSURE RELATIONSHIP

FROM **HIGH** TO **LOW - CAREFUL GO**

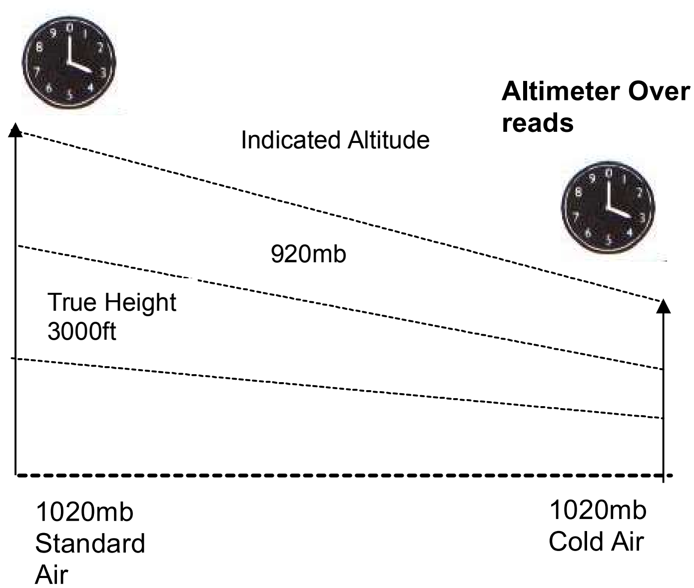
If going from an area of high pressure to an area of low pressure - the altimeter will OVERREAD and you will be lower than indicated.



TEMPERATURE / PRESSURE RELATIONSHIP

FROM WARM TO COLD - DON'T BE BOLD

If going from an area of warm air to an area of cold air - the altimeter will OVERREAD and you will be lower than indicated.



BLOCKAGES

If the static vent blocks, old static will remain trapped and no change in altitude will shown.

PRESSURE SETTINGS AND DEFINITIONS

QNH: Mean Sea level pressure. Airfield pressure reduced to sea level pressure by ISA. 1hPa = 30'.

QFE: Pressure at airfield. QFE set - Altimeter reads HEIGHT above airfield elevation. QFE set on the ground - Altimeter reads zero.

QNE: Pressure according to 1013.25 hPa level. QNE set - Altimeter reads PRESSURE ALTITUDE (Flight level).

NB The Altimeter always reads ALTITUDE/HEIGHT/LEVEL above the datum which you have set on the subscale.

TRANSITION ALTITUDE:

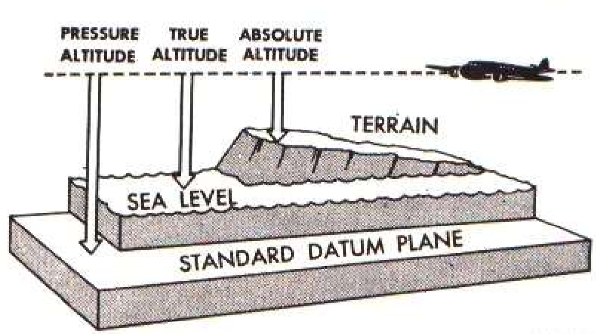
Altitude at which you set 1013.25 hPa in the vicinity of an airfield.

TRANSITION LEVEL:

Obtained from ATC. At transition level, set QNH.

TRANSITION LAYER:

The airspace between the transition altitude and the transition level.



TRUE ALTITUDE

The temperature being different to ISA, will cause the QNH altitude and the True Altitude to be different. (Use the wiz-wheel to calculate the corrected altitude for mean sea level.)

ABSOLUTE ALTITUDE (OR HEIGHT)

The height of an A/c above the surface immediately below it.

Can be read directly off a RADIO ALTIMETER

OR

ABSOLUTE ALTITUDE = TRUE ALTITUDE - GROUND ELEVATION.

DENSITY ALTITUDE

Is the height in the ISA where the prevailing density will occur. It is a function of temperature and is used for A/c performance.

FOR EVERY 1º C ABOVE ISA
D.A. = 120' HIGHER THAN P.A.

D.A. = PA + (120 X DEV from ISA)

ALTIMETER TOLERANCE

± 50' at Sea Level.

± 12' per 1000' of airfield elevation above sea level.

e.g.	J.S. ELEVATION	=	5500'
		=	50 + (5.5 x 12)
		=	116' PLUS OR MINUS

ALTITUDE ALERTING SYSTEM

It is coupled to the Altimeter and provides audio and visual warning.

During climb or descent, the warning goes off 800' before the selected level.

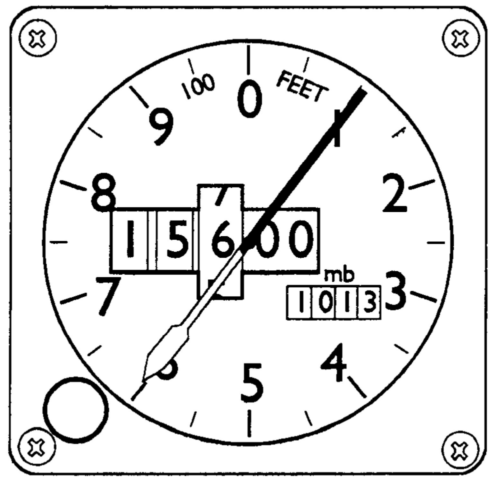
In level flight, the warning will go off when 200' either side of the selected level.

ALTIMETER / TRANSPONDER LINK

The transponder will relay the A/c P.A. regardless of the subscale setting.

RANGE is -1000' PA to 127000' PA.

THE SERVO ASSISTED ALTIMETER



Principle of Operation

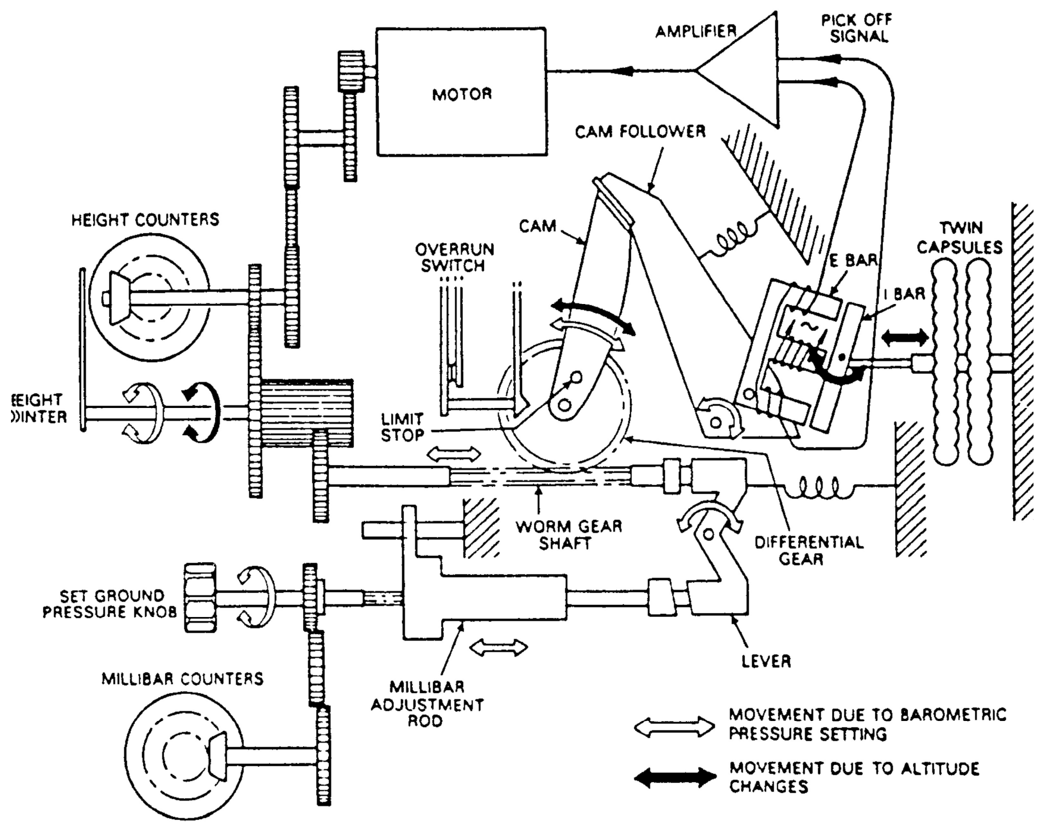
1. Pressure sensing capsules are coupled mechanically to an electrical **E** and **I** pick-off assembly.

2. Movement of the aneroid capsules is transmitted through a linkage to the "I" bar of the E and I inductive pick-up.

3. The amplitude of the AC voltage output from the secondary windings depends on the degree of deflection of the "I" bar, which is a function of pressure change. Polarity of the output signal will depend on whether the capsules expand or contract.

4. The output signal is amplified and used to drive a motor whose speed and direction of rotation will depend on the amplitude and phase of the signal. The motor drives the gear train, which rotates the height digital counters and the pointer. The motor also drives, through gearing, a cam that imparts an angular movement to a cam follower.

5. The "E" bar of the inductive pick-off is attached to the follower. Sense of movement is such that the "E" bar is driven until it reaches a position where the air gaps between "E" and "I" bars are again equal, thus completing the servo-loop.



SUB-SCALE SETTING

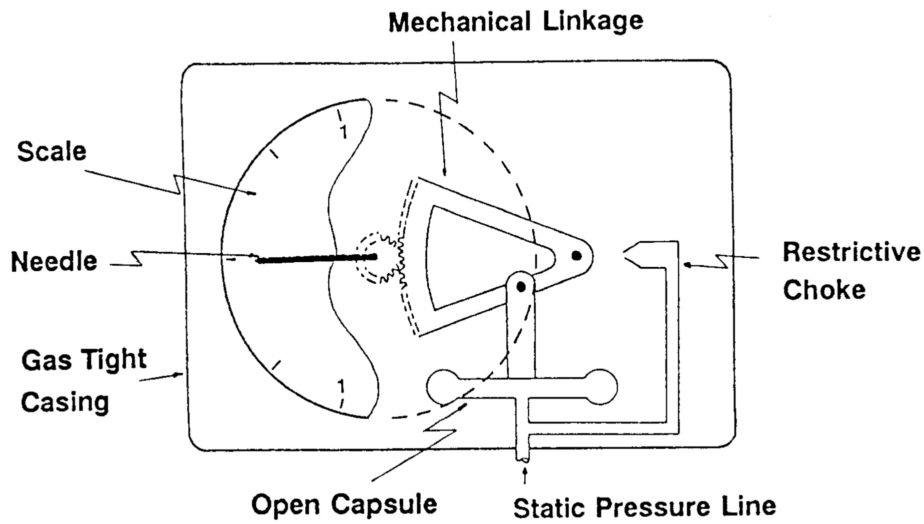
1) Sub-scale setting moves worm - displaces E Bar.

2) Current at E Bar goes to Amp/motor - drives pointers.

3) Motor also drives cam - restores E Bar to null position.

4) Needle now indicates new height above sub-scale datum.

THE VSI



The VSI uses the principle of differential pressure to indicate a rate of climb or descent.

During climb or descent, current static pressure goes to the capsule. But it has to go through the metering unit (choke) to get into the VSI chamber. Thus the static outside the capsule is slightly older - causing a pressure differential. The pressure differential causes expansion or contraction of the capsule. This is fed via a suitable system of linkages and levers to the indicator needle.

ERRORS

(a) Time Lag Error

Is caused by delay of differential pressures being registered.

(b) Pressure / Position Error

During certain manoeuvres, turbulence may reach static vent causing inaccurate readings.

(c) Blockages

Any blockage - VSI reads ZERO.

BEFORE TAKE-OFF

VFR - the VSI may show an error.

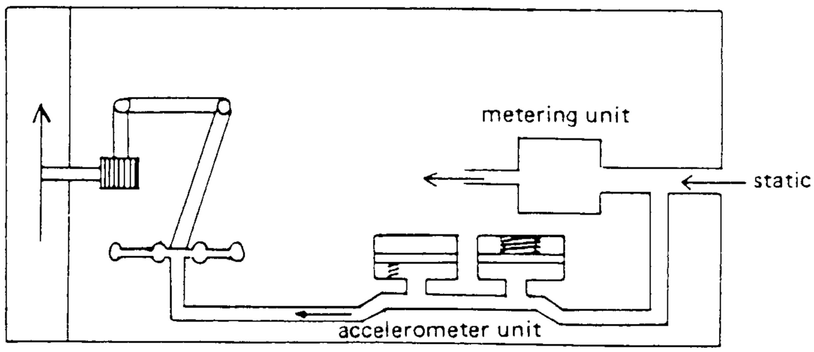
IFR - the VSI must be corrected before T/O.

ALTERNATE STATIC SOURCE

This is for use if the main static source becomes blocked. Usually the source is located in the cabin, but the pressure in the cabin can be up to 10 hPa lower than the true static.

Therefore:
- Altimeter will overread by 300 ft.
- ASI will overread (reduced static).
- VSI will show a momentary rate of climb then return to zero.

THE IVSI (INSTANTANEOUS VSI)



ISVI mechanism

The main function of the IVSI is to overcome the time lag error at the beginning of a climb or descent. The IVSI utilises 2 plungers or accelerometers. These are connected to the static pressure line.

When a climb or descent is initiated, the pistons are displaced by the inertia of the vertical acceleration force and create an immediate pressure change inside the capsule and an immediate indication by the IVSI pointer. The effect is only temporary and the actual static pressure from the metering unit takes over after a few seconds.

Machmeter Questions

1. At flight level 330 the RAS of an aircraft is 285kt. The temperature deviation from the standard is -12°C (JSA). Use your computer to determine:

    1. The TAS

        a) 564 kts
        b) 454 kts
        c) 530 kts
        d) 480 kts

    2. The local speed of sound

        a) 480 kts
        b) 530 kts
        c) 564 kts
        d) 629 kts

3. The mach number

a) .75
b) .80
c) 1.02
d) .85

2. Calculate , without using the computer , the altitude in the standard atmosphere at which 470kt TAS corresponds to Mach 0.82.

a) FL283
b) FL207
c) FL360
d) FL310

3 If a decrease of 0.13 in the Mach number results in a decrease of 77kt in the TAS what is the real speed of sound?

a) 650 kts
b) 394 kts
c) 875 kts
d) 592 kts

4 An aircraft is at FL350, TAS 463kt at Mach 0.79 when the temperature deviation from standard is +9°C . Without using the computer give the temperature deviation at FL 310 which at Mach 0.79 would give a TAS of 463kt.

a) +1º
b) -46º
c) -24º
d) -15º

5 If an aircraft climbs from sea level to 30 000ft in the standard atmosphere at a constant mach number, what would the TAS do?

a) increase
b) decrease
c) stay constant
d) none of the above

6 When climbing in the standard atmosphere at a constant RAS, state whether the Mach number would:

a) increase
b) remain constant
c) decrease
d) non of the above

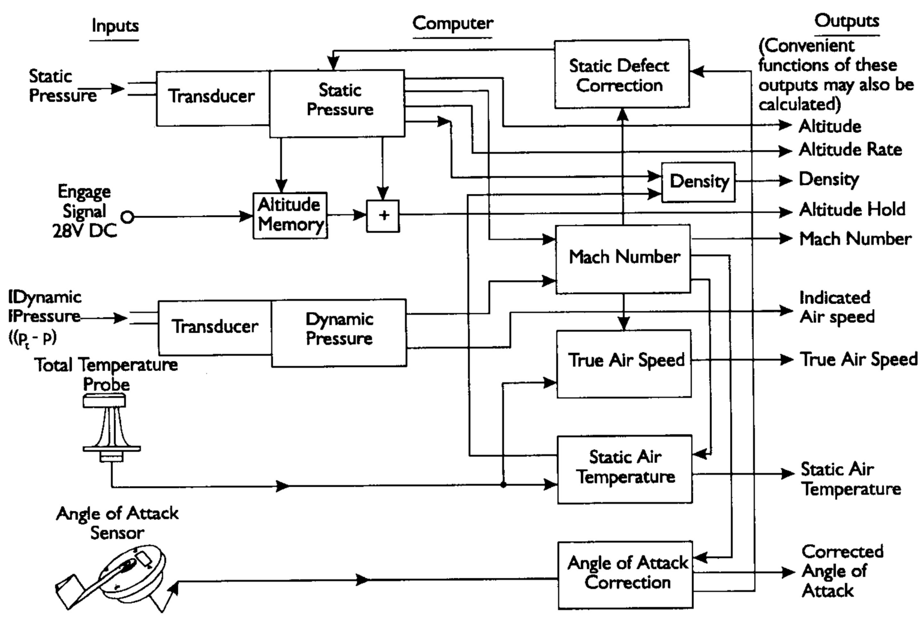
Air Data Computer (ADC)

Although pilots have been provided with information on the instrument panel on the aircraft's speed, altitude, engine performance, etc. by individual instrument dials since the earliest days of flying, from World War Two onwards the outputs of the sensors for these instruments (e.g. the pitot head) have also been tapped for other purposes associated with the conduct of the flight.

The Air data Computer (ADC) is a dedicated item of equipment used specifically to collect and distribute such in-flight measurements. The analogue Air Data Computers introduced into civil aircraft over thirty years ago are now being phased out to be replaced by digital ADC's. The block schematic diagram shows the general input to and output from an ADC.

Pressure sensing is accomplished by two pressure transducers, one sensing static pressure and the other sensing both pitot and static pressures within the computed air speed module. The Mach speed module and true air speed (TAS) module are pure signal generating devices, which are supplied with air speed and altitude data from the respective modules. Static air temperature data required for computing TAS is sensed by a temperature probe and is routed to the TAS module through the Mach speed module.

There is also a facility for a configuration module to be plugged into the circuit to provide information on the specific aircraft type such as V_{MO}, etc. and a switch interlock to isolate control of the ADC's self test feature (see BIT below) unless the aircraft is on the ground. The outputs are to flight deck displays as described later in Electronic Flight Instrument Systems (EFIS), Flight Management Systems (FMS), etc.



Primarily, the equipment is installed in the aircraft's electronic bay where it is cooled by natural convection, but the Built-in-Test (BIT) facility can be operated from a switch on the flight deck when the aircraft is on the ground (sometimes effectively at below a set airspeed) usually protected by a strut switch.

Although Air Data Computers have a high degree of reliability, the function of the BIT facility is to check for the correct performance of the equipment both before and during flight.

Power-up BIT

When power is re-applied to the unit after an interval, this test makes a comprehensive check of the microprocessor, its memory store and the air data functions.

Continuous BIT*:*

The check is carried out automatically, without interfering with the operation of the ADC, and it does so at very short intervals (e.g. once every second) for all stages of the process, from input to output.

Maintenance BIT

The same BIT facility enables a maintenance check to be made when the aircraft is on the ground by the selection on the equipment of a TEST or a TEST/HISTORY switch, to show both current failures and any which may have occurred on the preceding flight(s).

Apart from the BIT facility, used by the maintenance crew on the ground, an Air Data Computer has no user controls or adjustments. It may have a remote flight deck ADC WARN lamp to alert pilots to the appearance of a malfunction flag on the instrument panel.

General Questions

1. If the Pitot Head and Static Vent were blocked by ice, which instruments would be affected?

   a) ASI, Altimeter and Slip indicator.
   b) Altimeter, VSI and ASI would give inaccurate readings.
   c) The ASI would under read.

2. If the Pitot head is blocked, what airspeed indication can he expected?

   a) No change of IAS in level flight, even with large power changes.
   b) A decrease of IAS during a climb.
   c) Constant IAS during a descent.

3. If the static vent became blocked during a descent the ASI would read:

   a) Zero
   b) High
   c) Low

4. If the Pitot opening is blocked, which instruments would be affected (separate static vent)?

   a) ASI, Altimeter and VSI.
   b) ASI and VSI.
   c) ASI only.

5. Rectified Airspeed is:

   a) IAS corrected for instrument and pressure error.
   b) IAS corrected for density error.
   c) IAS corrected for density and compressibility errors.

6. An aircraft is maintaining FL 120 in cloud. The ASI reading falls to zero. The most probable cause is:

   a) Static vent blocked by ice.
   b) Pitot head and static vent blocked by ice.
   c) ASI malfunction.

7. An aircraft is flying from a cold air mass into a warm air mass. The TAS and true altitude will:

   a) TAS increases, true altitude decreases.
   b) TAS decreases, true altitude increases.
   c) Both increases.

8. An aircraft flying from warm air to cold air at a constant TAS. The RAS would:

a) Remain constant
b) Increase
c) Decrease

9. Pressure altitude 10000 feet OAT + 3° C. What is Density Altitude?

a) 11000 ft
b) 12300 ft
c) 9200 ft

10.

Pressure Altitude	15000 ft
QNH Altitude	15600 ft
OAT	+ 10° C

What is true altitude?

a) 15900 ft
b) 16450 ft
c) 17100 ft

11.

Pressure Altitude	8000 ft
QNH Altitude	7500 ft
OAT	+ 30° C
Terrain elevation	5700 ft

The approximate absolute altitude is:

a) 500 ft
b) 1800 ft
c) 2650 ft

12. Airfield Elevation 4000 ft OAT+15°C QNH995hPa

What is Density Altitude?

a) 5000 ft
b) 5600 ft
c) 6200 ft

13. An aircraft leaves FL 160 for an approach and landing at an airfield. The pilot will set QNH at the:

a) Transition Layer.
b) Transition level.
c) Transition Altitude.

14. Transition altitude is obtained from:

    a) ATC or VOR ATIS.
    b) Jeppesen or Aerad flight guides.
    c) 1500 feet above airfield elevation.

15. Transition level is obtained from:

    a) ATC or VOR ATIS.
    b) Jeppesen or Aerad flight guides.
    c) 1500 feet above airfield elevation.

16. The location of the static vent which could provide the most accurate measurement of static pressure under variable flight conditions is:

    a) At the Pitot head which encounters relatively undisturbed air.
    b) In the cockpit where it is not influenced by a variable angle of attack.
    c) One on each side of the aircraft where the system will compensate for variation of aircraft attitude.

17. Pressure Altitude at an airfield is indicated by an altimeter when the barometric sub-scale is set to:

    a) QNH
    b) QFE
    c) 1013.25 hPa

18. If while in level flight, it becomes necessary to use an alternate source of static pressure vented inside the aircraft, with the cabin pressure being lower than static, the following variations in instrument indication would be expected:

    a) the altimeter will read higher than normal, airspeed will not change and the vertical-speed indicator will momentarily show a descent;
    b) the altimeter will read higher than normal, airspeed greater than normal and the vertical-speed indicator will momentarily show a climb;
    c) the altimeter will read lower than normal, airspeed greater than normal and the vertical-speed indicator will momentarily show a climb and then a descent.

19. Assume that an aeroplane at 17000 FT AMSL has a cabin pressure equal to an altitude of 7000 FT. If the pitot static tubes break at a point within the cockpit, the altimeter would read:

    a) 10000 FT (7000 ft + 3000 ft) which is the allowance for pressure differential;
    b) 17000 ft;
    c) The cabin pressure altitude, i.e. 7000 ft.

20. If an altimeter indicates 3500 feet with QNH 1004.7 hPa set, what is the pressure altitude?

a) 3755 ft
b) 3500 ft
c) 3160 ft

21. An altimeter is set to 1010.9 hPa. The aircraft lands at an airfield (elevation 772 feet AMSL, QNH 1016.1 hPa). What will the altimeter read on landing?

a) 932 ft
b) 160 ft
c) 612 ft

22. En route at FL 270, the altimeter is set correctly. On the descent the pilot fails to reset the altimeter to QNH 1026.1. If the airfield elevation is 1300 feet, what will the altimeter indicate after landing?

a) 1700 ft
b) 900 ft
c) 400 ft

23. An aircraft flies from Johannesburg (QNH 1020) to Durban (QNH 995) at FL 100. In the cruise the aircraft is:

a) Descending
b) Climbing
c) Maintaining altitude

24. An aircraft levels out after a rapid descent. The altimeter would:

a) Read correctly.
b) Overread for a brief period.
c) Underread for a brief period.

25. An airfield, elevation 3000 feet, has a pressure altitude of 3500 feet. What is the QNH?

a) 1029.9 hPa
b) 1013.2 hPa
c) 996.5 hPa

What is the QFE?

a) 896.5 hPa
b) 913.s hPa
c) 879.8 hPa

26. An aircraft is flying at FL 120, the QNH is 995 hPa. What clearance has the aircraft over high ground 1982 metres AMSL?

a) 4950 feet
b) 6050 feet
c) 6250 feet

27. An aircraft heading 003 (M), drift 10 left, has to pass over high ground that is 2200 metres AMSL. Minimum clearance over the high ground is 2000 feet, QNH 1025 hPa. What is the lowest IFR flight level?

a) FL090
b) FL100
c) FL105

28. An aircraft maintains a constant TAS of 350 kts in the climb:

a) Local Speed of sound decreases and the RAS decreases.
b) Local Speed of sound decreases and the Mach No. decreases.
c) Local Speed of sound increases and the Mach No. increases.

29. An aircraft flying at FL 330, Mach 0.82 flies into a colder airmass. The TAS will:

a) Increase
b) Decrease
c) Remain constant.

30. An aircraft descends from FL 410 to FL 200 at a constant Mach number. The TAS will:

a) Increase
b) Decrease
c) Remain constant.

31. Climbing at a constant Mach number, the RAS will:

a) Increase
b) Decrease
c) Remain constant.

32. As air density increases, the ASI compressibility error will:

a) Increase
b) Decrease
c) Remain constant.

33. The local speed of sound is 1050 ft/sec. What is the TAS of an aircraft flying at Mach 0.84?

a) TAS 502
b) TAS 512
c) TAS 522

34. Calculate the altitude in the ISA where a TAS of 480 kts equals Mach 0.82.

a) 29000 ft
b) 31500 ft
c) 34000 ft

35. An aircraft is flying at a constant Flight Level. An increase in power results in the Mach number increasing by 0.15 and the TAS by 87 knots, the aircraft is flying at:

a) FL290
b) FL310
c) FL330

36. An aircraft flies from a cold air mass into a warm air mass at a constant FL and RAS. The mach number will:

a) Increase
b) Decrease
c) Remain Constant

37. For an aircraft flying at Mach 0.82 at FL 350, COAT - 35° C, the RAS would be:

a) 251 kts
b) 264 kts
c) 279 kts

38. If the static vent becomes blocked during a climb the machmeter will:
a) overread;
b) read correctly;
c) underread.

39. Ambient static pressure is fed to the ASI in flight to:

a) Cancel dynamic pressure in the pitot tube.
b) Subtract the static pressure from the dynamic pressure.
c) Cancel static pressure entering the instrument diaphragm through the pitot tube.

40. The static vent is blocked. If the glass covering the VSI is broken, the instrument will:

a) Read correctly.
b) Read zero under all conditions.
c) Readings will be reversed.

41. During a pre-flight check the VSI shows 100 ft/min climb. You may:

a) Fly in IFR conditions and allow for the error.
b) Have the VSI adjusted before flight.
c) Fly in IFR conditions and ignore the error.

42. The ASI has a pressure error of + 5 knots at IAS 130 kts. At this airspeed the VSI would:

a) Over read
b) Read correctly
c) Under read

43. The reported QNH of a given station is the:

a) actual barometric pressure measured at the station;
b) actual barometric pressure measured at sea level;
c) Station's barometric pressure corrected to mean sea level pressure.

44. When ambient temperature is warmer than standard at a particular altitude, the altimeter will indicate:

a) higher than true altitude;
b) lower than true altitude;
c) the same as true altitude.

45. ASI compressibility error will increase with increase of TAS and:

a) Increase with altitude.
b) Decrease with altitude.
c) Increase with increase of density.

46. The Principle and Operation of the Machmeter precludes the following errors:

a) Density, compressibility and pressure errors.
b) Position, density and barometric errors.
c) Temperature, compressibility and density errors.

47. An aircraft leaves airfield X (elevation 510 feet) with the QFE 999 hPa set on the altimeter, enroute to Y (510 nm from X) where the QNH is 1025 hPa. A spot height (450 metres AMSL) 114 nm from X is cleared by 2000 feet. What was the altimeter reading over the spot height?

a) 2906 feet
b) 3476 feet
c) 4046 feet

48. Airfield A Elevation 2100 feet QFE930hPa
Airfield B Elevation 1200 feet
A pilot sets airfield elevation on his altimeter prior to take-off from A. On landing at B the altimeter reads 1500 feet. What is the QNH at B?

a) QNH 990
b) QNH 1010
c) 1013.2

49. An aircraft leaves A (elevation 540 feet) with QFE 1008 set on the altimeter, enroute to B (1000 nm from A, QNH 1000 hPa). A spot height 232 metres AMSL, 250 nm from A is cleared by 1500 feet. What was the altimeter reading over the spot height?

a) 1916 feet
b) 2261 feet
c) 2606 feet

50. An aircraft leaves Y, airfield pressure 960 hPa, and the altimeter reads airfield elevation of 1860 feet. The aircraft lands at Z (elevation 1000 feet) where the altimeter reads 1270 feet. What is the QNH at Z?

a) QNH 1013
b) QNH 1022
c) QNH 1031

51. During a pre-flight check the following details were noted:

Airfield Elevation	5000 feet
Apron Elevation	4980 feet
Height of static vent above ground	25 feet
Altimeter reading (QFE set)	45 feet

What is the instrument error?

a) 40 ft under read
b) 05 ft under read
c) 40 ft over read

52. The Instantaneous Vertical Speed Indicator incorporates an accelerometer unit. The pistons of the accelerometer unit are connected:

a) directly to the VSI needle to give an instantaneous deflection when a climb or a descent is initiated;
b) directly to the capsule by a leaf spring which exerts or relieves pressure on the capsule when a climb or a descent is initiated;
c) to the static pressure tube leading to the capsule and their movement creates an immediate pressure change inside the capsule when a climb or descent is initiated.

53. In the servo altimeter the servo motor drives the:

a) amplifier and the induction pick-off;
b) the counters and the cam;
c) the I-bar.

54. By changing from QNH to QNE on a servo assisted Altimeter:

a) The motor drives the "E" bar sensing an error, then amplified and fed to the counter.
b) The anvil moves the worm gear, changing the air gaps between the "E" and "I" bars.
c) The "I" bar moves, changing the air gaps between the "E" and "I" bars.

55. If the static pressure ports iced over while descending from altitude, the airspeed indicator would read:

a) High
b) Low
c) Correctly.