The Dramatic Effects of Pitot-Static System Blockages and Failures

by Luiz Roberto Monteiro de Oliveira

Table of Contents

Please also review and understand the disclaimer found at the end of the article before applying the information contained herein.

I - Introduction

This article takes a comprehensive look into Pitot-static system blockages and failures. These typically affect the airspeed indicator (ASI), vertical speed indicator (VSI) and altimeter. They can also affect the autopilot auto-throttle and other equipment that relies on airspeed and altitude information. There have been several commercial flights, more recently Air France's flight 447, whose crash could have been due, in part, to Pitot-static system issues and pilot reaction. It is plausible that the pilot at the controls could have become confused with the erroneous instrument readings of the airspeed and have unknowingly flown the aircraft out of control resulting in the crash. The goal of this article is to help remove or reduce, through knowledge, the likelihood of at least this one link in the chain of problems that can lead to accidents.

Table 1 below is provided to summarize the general effects of Pitot-static blockages. Section II of the article gives a brief explanation of the Pitot-static instruments. Section III provides a general description regarding the possible scenarios outlined in Table 1. Finally, section IV will present a detailed example of each one.

Pitot-Static System Blockage Effects on Airspeed Indicator

Scenario	Blockage Sequence: Static Port	Blockage Sequence: Ram Air	Blockage Sequence: Pitot Tube Drain	Effect on Instrument Indications	Other Sequences with Similar Behavior: Static Port	Other Sequences with Similar Behavior: Ram Air	Other Sequences with Similar Behavior: Pitot Tube Drain
1a	1			Static Port Blocked → **Lower than correct** indicated airspeed **above blockage altitude**. → **Higher than correct** indicated airspeed **below blockage altitude**.			
1b	1	2		+ Ram Air Blocked → Indicated airspeed **drops to 0** and **<u>stays</u> at 0 above blockage altitude**. → Indicated airspeed **<u>increases</u> from 0 below blockage altitude as altitude decreases**. Note: the actual airspeed will have no influence and the indications on the instrument are meaningless.	2 1	1 1	
1c	1		2	Or + Pitot Tube Drain Blocked → No additional effect.	2 1		1 1
1d	1	3	2	Or + Pitot Tube Drain Blocked then + Ram Air Blocked → Indicated airspeed **<u>freezes</u> at current indication.**	2 3 1 1*	3 2 2 1*	1 1 1 1*
1e	1	2	3	Or + Ram Air Blocked then + Pitot Tube Drain Blocked → Indicated airspeed **drops to 0** then **<u>freezes.</u>**	2 3 1	1 1 1	3 2 2
2a		1		Ram Air Blocked → Indicated airspeed drops to 0 and **<u>stays</u> at 0**			
2b		1	2	+ Pitot Tube Drain Blocked → Indicated Airspeed **drops to 0** and **<u>increases</u> with altitude above blockage altitude**. → Indicated Airspeed **drops to 0** and **<u>stays</u> at 0 below blockage altitude**. Note: the actual airspeed will have no influence and the indications on the instrument are meaningless.			
3a			1	Pitot Tube Drain Blocked → No effect			
3b		2	1	+ Ram Air Blocked → Indicated Airspeed **<u>increases</u> with altitude** (from the value when blockage occurred) **above blockage altitude**. → Indicated Airspeed **<u>decreases</u> with altitude** (from the value when blockage occurred) **below blockage altitude**. Note: the actual airspeed will have no influence and the indications on the instrument are meaningless.	1*	1*	

* Blockage would have to be practically instantaneous; an unlikely scenario.

Table 1 Summary of the effects of different blockage scenarios on the Pitot-static system.

Important Note Regarding Table 1

If the blockages are partial (some air can still go through) or intermittent, the actual behavior may be different than the ones outlined in table 1.

II - Pitot-Static Instruments

The airspeed indicator (ASI), the altimeter, and vertical speed indicator (VSI) are instruments that pilots learn to rely on, and they rarely fail or malfunction. Because of this, when they do, the results can be devastating. One of the main contributors to the malfunction of these instruments are blockages by ice or foreign objects in the Pitot-static system.

Transponders with mode C and S are also connected to the Pitot-static system. Blockages can affect the pressure altitude information that the transponder transmits (when interrogated by the radar) back to the radar facility and air traffic control (ATC). As a result, the air traffic controller may receive incorrect altitude information regarding the affected aircraft on their radar screens. Most radars are not able to determine the aircraft's altitude with precision and this is why the transponder transmitted pressure altitude information is so important to the controller.

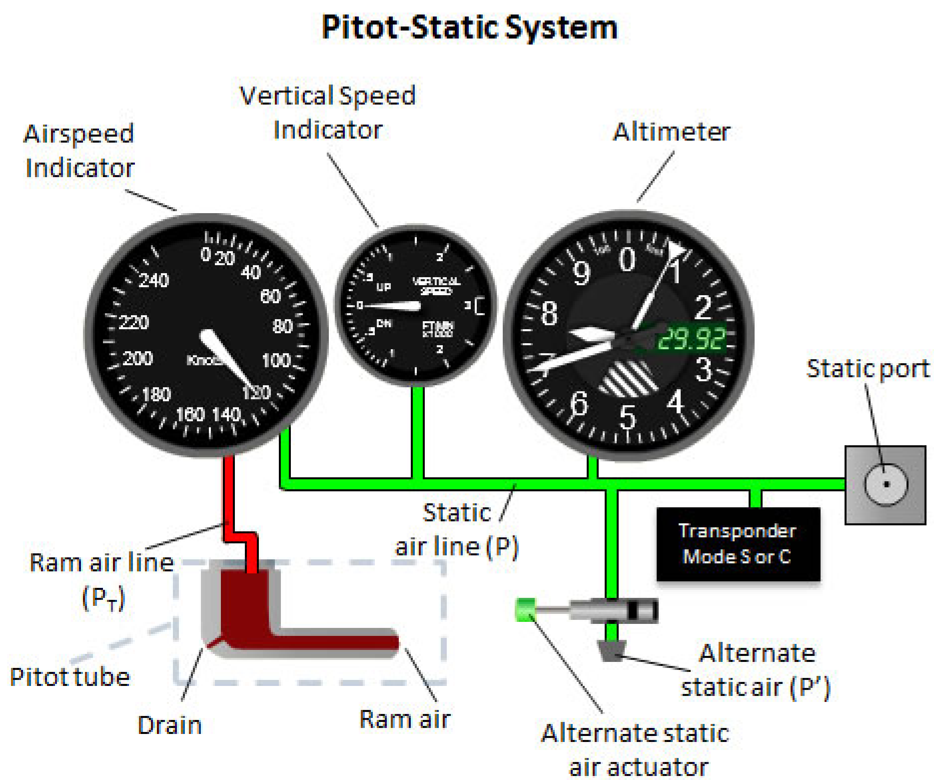

Fig 2-1 The Pitot-static system uses a Pitot tube and static air probe.

The Pitot-static system (Figure 2-1) usually uses three basic openings for its probes which can get blocked. In the Pitot tube there is a ram air opening that faces the airstream directly and a relatively much smaller drain hole that allows moisture to drain out of the Pitot tube. The third opening, which is perpendicular to the airstream, is from the static port. Occasionally the static air port may be integrated as part of the Pitot tube itself making it a Prandtl tube instead of just a plain Pitot tube. Blockages may occur in these three openings in any combination. Examples include water that may freeze, insects that make a nest while the aircraft is parked, other debris that enter the ports, or the Pitot tube and/or static port covers not having been removed before flight. Note there also may be an alternate static air source that can be activated (usually by the pilot) if the static port is blocked and it provides another source for the static air.

Understanding how the instruments that rely on the Pitot-static system are connected helps understand what can happen during a blockage. As previously mentioned, the sequence as well as the combination in which the blockages occur is also important.

Airspeed Indicator

The airspeed indicator (ASI) is connected to the ram air line (see fig 2-1), which measures total pressure (P_T). In addition, the ASI is also connected to the static air line which is connected to the static port. The static port measures the outside ambient pressure or static pressure (P). The airspeed indicator's pressure measurement design is constructed for relative (or gauge) pressure measurements as opposed to measuring absolute pressure. The ASI basically measures the difference in pressure between the total pressure (P_T) and static pressure (P). This difference is the impact pressure (q_c) which the ASI uses to display an airspeed reading based on it. In other words, the impact pressure being measured is given by the equation: $q_c = P_T - P$. You can think of the reason for subtracting static pressure from the total pressure to get the impact pressure is that you want to remove the influence of the ambient pressure in order to get the pressure due only to the impact of the air molecules, at speed, on the ram air opening. The pressure that these air molecules exert is a function of the airspeed .

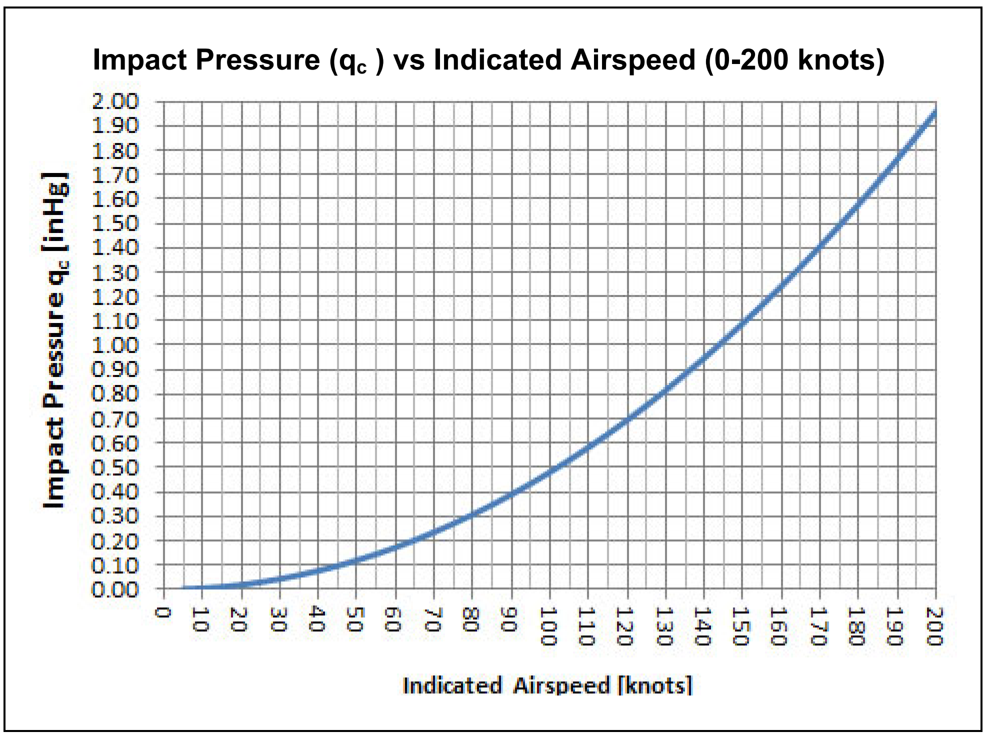

Chart 2-2

The ASI is calibrated so that it would measure true airspeed if the aircraft were flying at sea level in standard atmosphere. Indicated airspeed (IAS) will equal true airspeed (TAS) only in these conditions.

Chart 2-2 shows how impact pressure (q_c) relates to indicated airspeed in these conditions (sea level in standard atmosphere). Note how the impact pressure q_c increases as indicated airspeed increases.

If you were building an airspeed indicator you could purchase a pressure gauge and then use chart 2-2 to obtain the pressure corresponding to each airspeed indication and mark the airspeed numbers on the gauge. You would then connect this gauge to the Pitot-static system so that it would measure the ram air pressure P_T relative to the static pressure P, giving you a measurement of the difference between the two which is q_c. Your indicated airspeed would be read on the markings you made on the gauge.

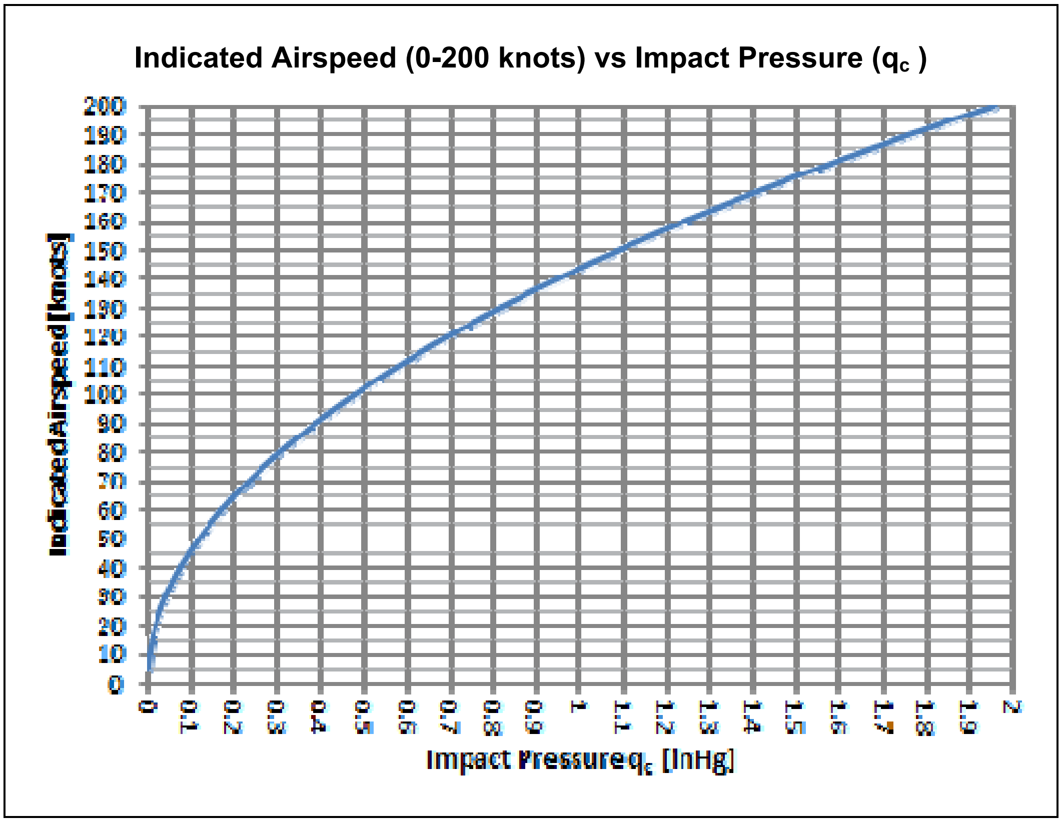

Chart 2-3

Chart 2-3 is the inverse of chart 2-2 and relates indicated airspeed to impact pressure (q_c) at sea level in standard atmosphere. Chart 2-3 will be used later when we discuss blockages and the resulting effects on the airspeed indicator.

Altimeter

The altimeter (essentially another pressure gauge) is connected to the static air port (the port that measures outside atmospheric pressure) and displays an altitude based on the static pressure and the adjustment of the altimeter setting knob (Kollsman window). The altimeter's pressure measurement instrument design will measure absolute pressure (or pressure relative to a vacuum) in contrast with the airspeed indicator that measures relative or (gauge pressure). The altimeter instrument is only affected by a static port blockage since it uses the static air pressure only. This instrument is calibrated so that it would read true altitude in standard atmospheric conditions. The altimeter setting knob provides an approximate correction for nonstandard pressure.

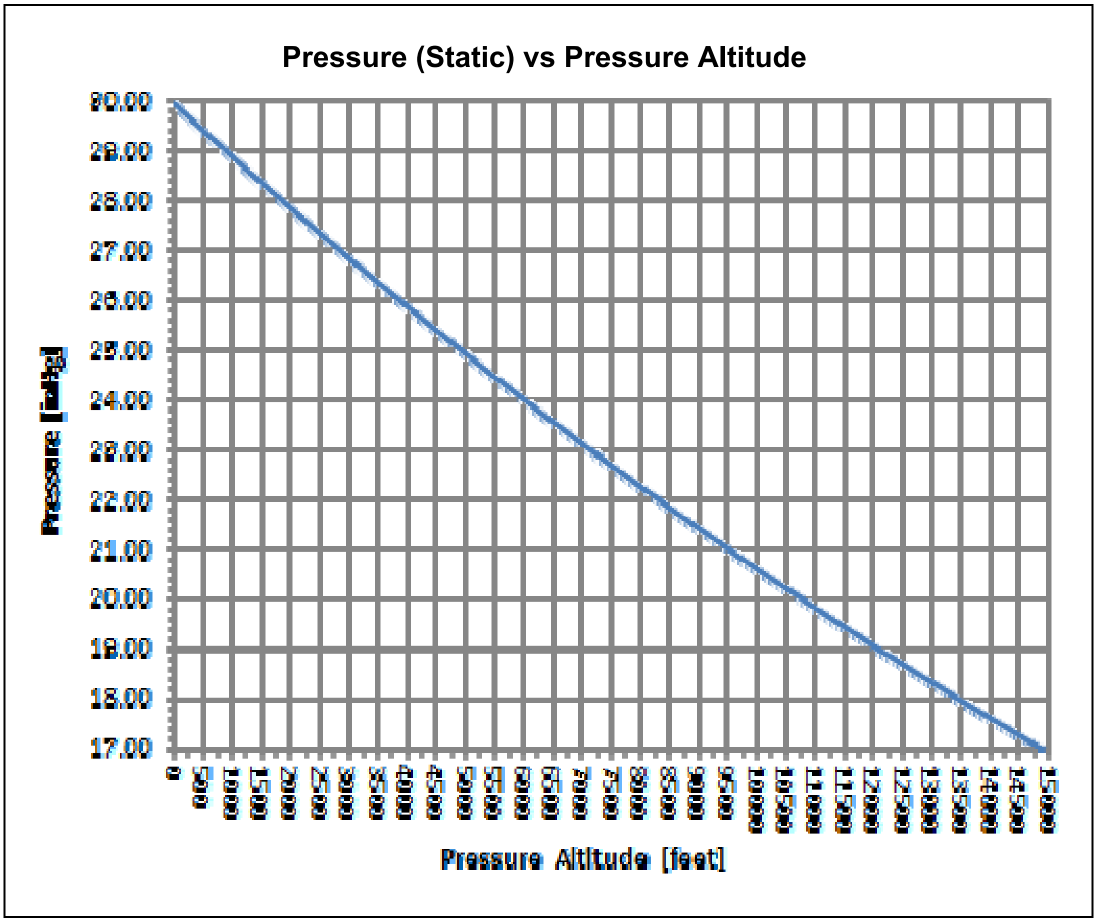

Chart 2-4

Chart 2-4 relates pressure altitude in feet to the outside or static pressure P at sea level in standard atmosphere. This is essentially how the Altimeter is calibrated.

If you were building an altimeter that measures pressure altitude using a pressure gauge, chart 2-4 could be used to mark altitudes corresponding to each of the pressures on the pressure gauge scale. Next you could connect this gauge to the static port and now you have an altimeter which measures pressure altitude. If you wanted however to take into consideration nonstandard pressure, the blue curve on chart 2-5 would show how much you would have to add or subtract to your pressure altitude reading in order to obtain an indicated altitude (pressure altitude corrected for nonstandard pressure). Usually aviation approved altimeters mechanically or electronically offset the altitude scale when turning the altimeter setting knob so that the altitude will be offset according to it.

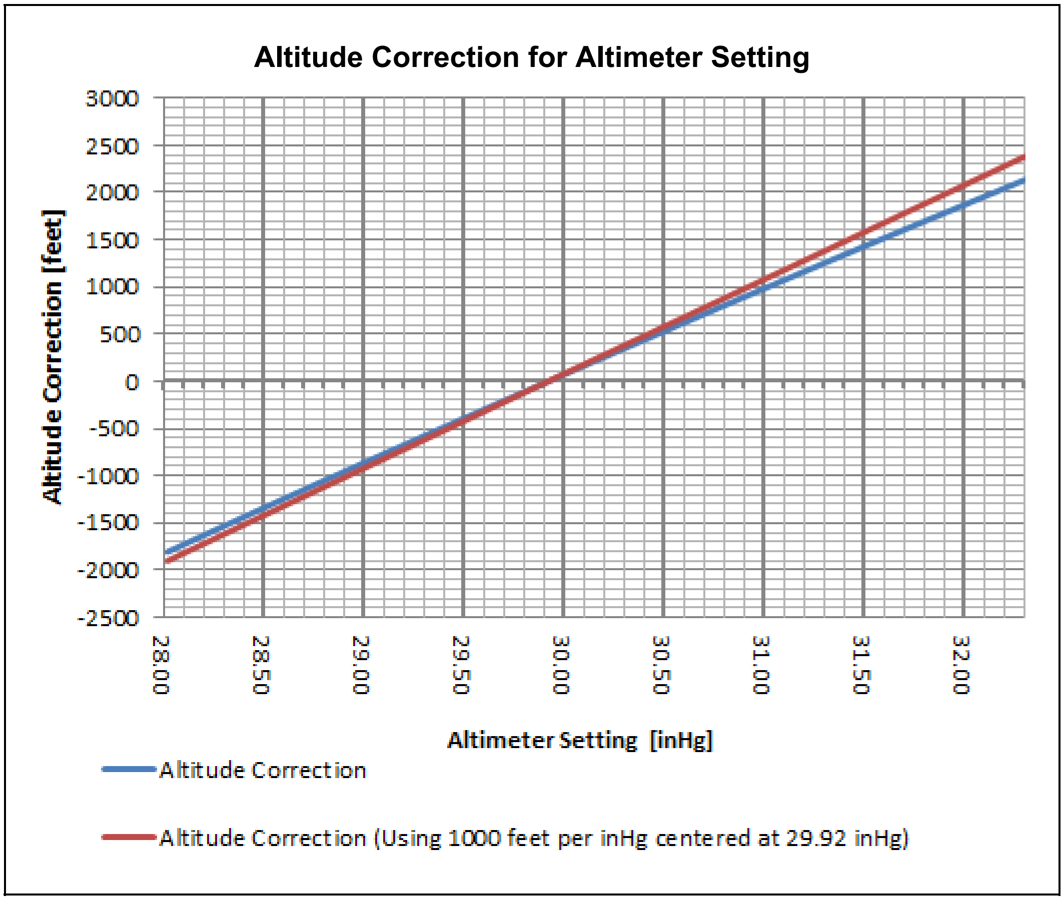

Chart 2-5

Chart 2-5 shows the correction that is applied when inputting the altimeter setting in the Kollsman window. A rule-of-thumb approximation is shown by the red curve which is of 1000 feet for every 1 inHg away from 29.92. Pilots often use this to estimate pressure altitude given the altimeter setting. The altimeter, however is calibrated with the more precise calculation shown by the blue curve.

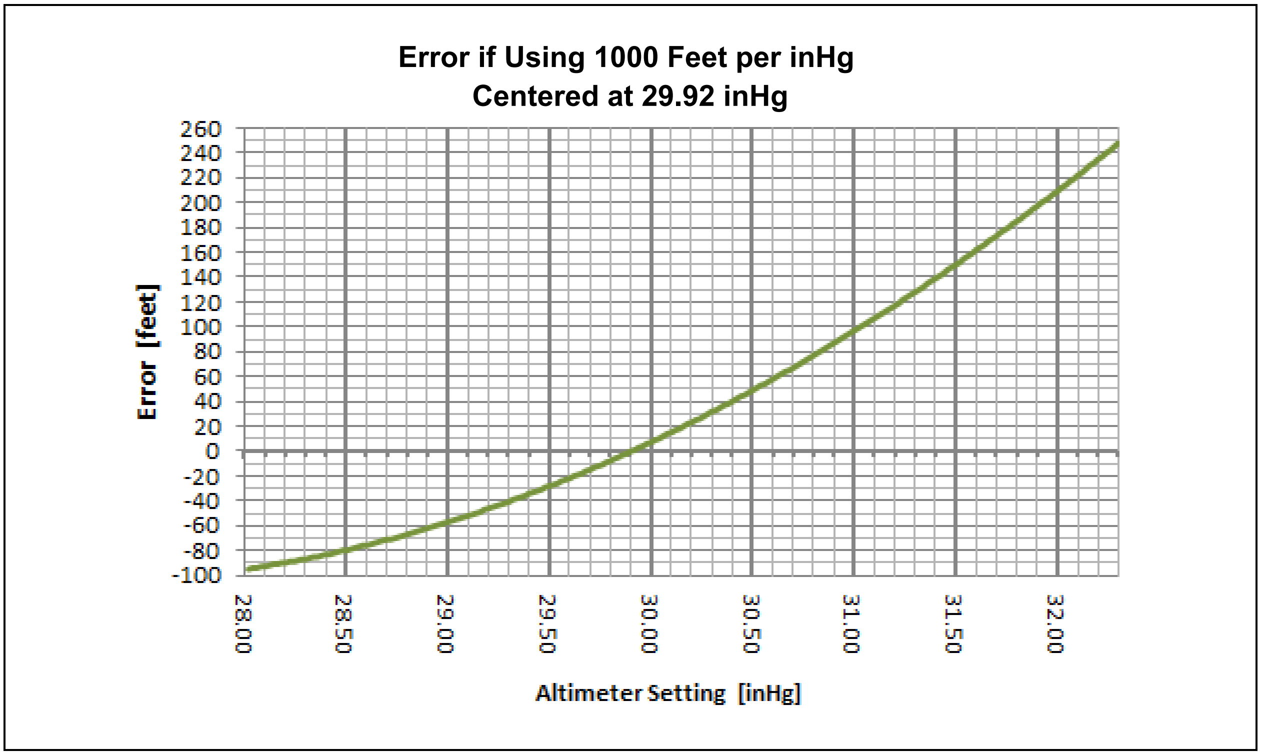

Chart 2-6

For the sake of comparison, chart 2-6 shows the error when the red curve assumption is made in chart 2-5. Record lows and highs are around 28.2 inHg and 32.1 inHg respectively. It can be seen through this chart that at extremely high pressures a pilot could be off by about +250 feet if using the 1000 feet per inHg rule-of-thumb. In extremely low pressures the error could be about -90 feet.

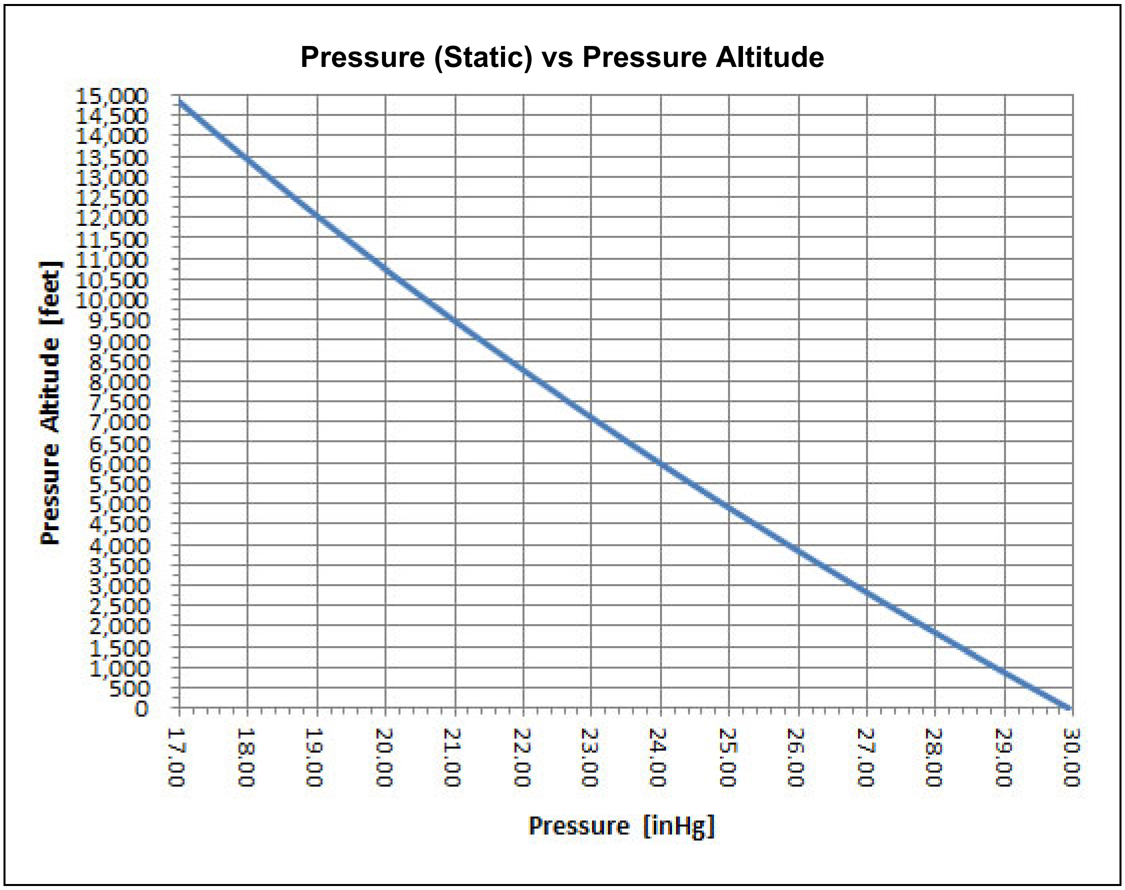

Chart 2-7

Chart 2-7 is the inverse of chart 2-4. It plots the altitude based on pressure for standard atmospheric conditions. Chart 2-7 will be used to later when we discuss blockages and the resulting effect on the altimeter.

Transponders

As previously discussed, because most radars are not precise enough for altitude readings, Mode C and mode S transponders send back information to the radar regarding the pressure altitude. These transponders are connected to a static port usually via the same static line or in some cases an independent static line that is connected to another static port. Transponders are calibrated like the altimeter except that there is no altimeter setting adjustment. If the static port is blocked air traffic control (ATC) may not be receiving the correct altitude from the transponder. If you suspect the static port is obstructed either because the altimeter doesn't seem to be showing the correct indications or for other reasons, the altitude ATC is saying you are flying may not be correct. There is an exception, however, if ATC is using a precision type radar (it also usually requires the aircraft to be close enough to the radar facility) which can measure the aircraft's altitude directly with adequate precision.

Vertical Speed Indicator (VSI)

The vertical speed indicator is also connected to the static air port. It is not as precise as the previous two instruments principally in turbulence. There is also a lag in its response and therefore will not show the change in climb/descent immediately. Regarding blockages in the Pitot static system, it is only affected if the static air port is blocked. The VSI displays roughly the rate at which the altitude is changing based on the difference between the pressure inside the VSI instrument's chamber (P_{VSI}) and the pressure of the static air port (P_{Static}) which is calibrated to show the corresponding climb/descent value on its scale. Note that the symbol P_{Static} and P (as discussed in the previous paragraphs) refer to the same thing. There is a small opening (usually referred to as calibrated leak) between this chamber and the static air port that allows air to gradually flow and equalize the pressure between the two.

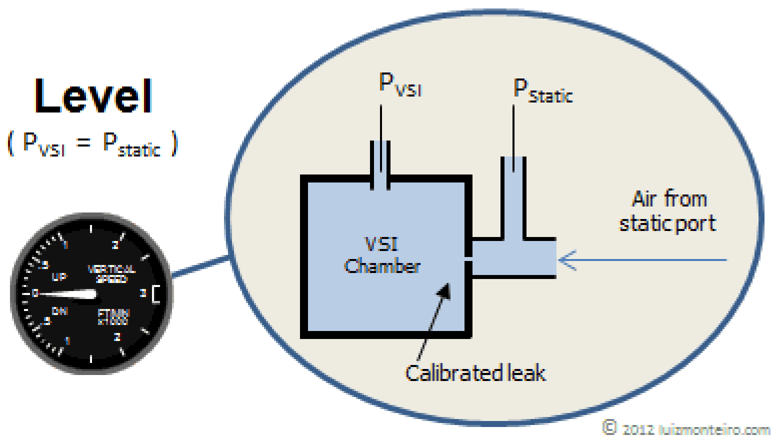

Fig 2-8 Aircraft flying at a constant altitude.

If the pressures are equalized ($P_{VSI} = P_{Static}$) the VSI will read zero (Fig 2-8) since it is essentially measuring the difference between the two pressures.

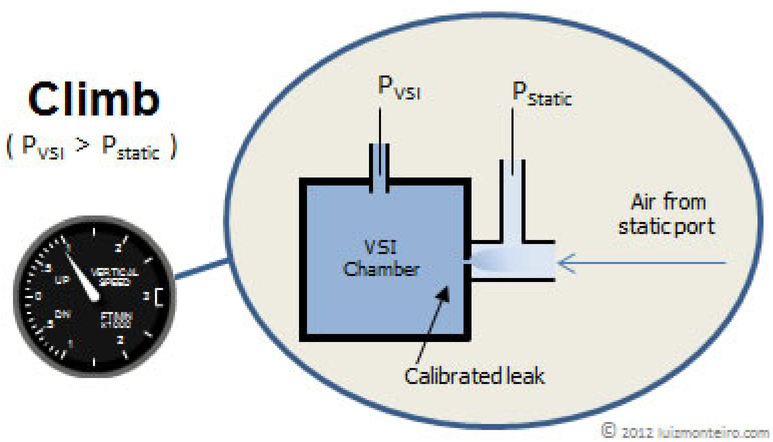

Fig 2-9 Increase in altitude.

If the aircraft is climbing the chamber does not have a chance to equalize and will show a climb (Fig 2-9) because the pressure on the static air port is decreasing ($P_{VSI} > P_{Static}$). Air will flow through the calibrated leak from the VSI chamber to the static air line. Note the calibrated leak is so small that the effect on increasing any pressure in the static line affecting the other instruments that use the static line pressure is negligible.

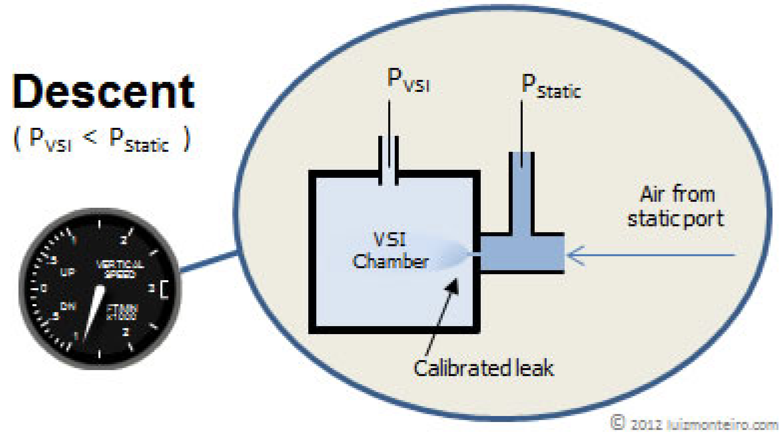

Fig 2-10 Decrease in altitude.

In a descending aircraft the chamber will also not have a chance to equalize since the pressure on the static air port is now steadily increasing (Fig 2-10). Air will now flow through the calibrated leak from the static air line to the VSI chamber. Just as in the climb scenario the calibrated leak is so small that the effect on decreasing any pressure on the static line is negligible.

III - Blockage Scenarios - Description

Note: The scenarios below are generalized for complete blockages. The actual behavior of the instruments may be more complex and confusing if the blockages are partial or intermittent.

1a. Static port blocked, but ram air and Pitot tube drain remain unobstructed.

Effect: The altimeter will stay on the altitude that the blockage occurred regardless if the aircraft climbed or descended; vertical speed indicator will indicate zero climb or descent; airspeed indicator will continue to measure airspeed, however above the altitude where the blockage occurred the airspeed shown by the instrument will be less than it would actually be if there were no blockage, and the opposite would occur below the blockage altitude where the aircraft indicates a higher airspeed. Possible results if the pilot doesn't realize the issue: (a) the pilot flies a lower than normal speed when descending and may stall or have a higher descent rate because of the lower speed, principally on landing. (b) the pilot flies a higher than normal airspeed when the aircraft climbs, resulting in the possibility of over-speeding or high-speed stall.

Some possible* actions that may be taken: (a) recognize the issue and activate the alternate static air port. (b) use the attitude indicator for pitch and fly with the usual power settings and configuration if the alternate static air port doesn't solve the issue. (c) in non-pressurized aircraft depending on the instrument, it may be possible to crack the glass of the vertical speed indicator to allow the cabin air to act as an alternate static air port (note however that the vertical speed indicator will not be usable).

Note: If the ram air then becomes obstructed after the static port, the problem in scenario 1a becomes scenario 1b.

1b. Ram air and static port blocked (regardless of order); Pitot tube drain remains unobstructed.

Effect: The airspeed indicator drops to zero at the moment ram air is blocked; when the static air blockage occurs, both the altimeter (stays at indication where the blockage occurred regardless of altitude change) and vertical speed indicator (indicates zero climb regardless of current climb rate) are affected.

Some possible*actions that may be taken: (a) activate Pitot heat (if this is a blockage due to ice, heat may resolve the issue). (b) if the aircraft is equipped with another airspeed indicator that uses a separate Pitot tube check if that is working. (c) keep flying the aircraft and use the attitude indicator for pitch and the usual power settings and configuration for that flight regime. (d) if equipped, the GPS may provide an idea of what the airspeed is based on its reading of true airspeed (remember that there may be a lag between your actual airspeed and the value provided by the GPS; also be cautious because true airspeed is typically higher than indicated airspeed); (e) recognize the issue and activate the alternate static air port if available. (f) in non-pressurized aircraft depending on the instrument, it may be possible to crack the glass of the vertical speed indicator to allow the cabin air to act as an alternate static air port if one is not available (note however that the vertical speed indicator will not be usable).

Note: If the Pitot tube drain then becomes obstructed afterwards, the problem becomes scenario 1e.

1c. Static port and Pitot tube drain blocked (regardless of order); but ram air remains unobstructed.

Effect: Exactly the same as scenario 1a (will affect the altimeter and VSI). Even with the Pitot tube drain being blocked the pilot should not notice any difference in airspeed indication as long as the ram air remains unobstructed.

Note: If the ram air then becomes obstructed after the Pitot tube drain, the problem becomes scenario 1d.

1d. Pitot tube drain blocked; ram air blocked after Pitot drain; static port drain blocked (regardless of order).

Effect: Until all three are blocked refer to the previous scenarios per the appropriate order of failure. When the blockages are complete (all three), this will cause all of the Pitot-static instruments to freeze at their current readings. Because of this the complete failure may be easier to identify than the previous ones because the pilot will probably notice immediately that there is something wrong since: the airspeed indicator freezes when Pitot tube drain gets blocked followed by the ram air getting blocked; the altimeter freezes when static port is blocked; and the VSI freezes as well when the static port gets blocked.

Some possible* actions: (a) if ice is a possibility, activate the Pitot heat. (b) if the attitude indicator is functional, fly the usual attitude and power for that particular flight regime and investigate. (c) use the GPS indication of speed, if available, to have a rough idea of your airspeed. Remember that the GPS will be showing true airspeed which is usually higher than indicated airspeed, principally at higher altitudes. Workload permitting, use a flight computer to calculate the indicated airspeed based on that true airspeed shown by the GPS. (d) proceed to an airport with visual conditions if possible. (e) ask air traffic control if possible for your current altitude, but remember that if your transponder's altitude function is connected to the same, or a static port that is also blocked, they will probably also have the wrong altitude on their screens. (f) activate the alternate static air port if available. This will allow the altimeter and VSI to work however if the drain port and the ram air port continue to be blocked, this scenario will be as the one described in (3b or 2b). (g) if the alternate static air port is not available or does not function, use the GPS to get a rough idea of your altitude, remembering that the GPS may not be very precise for altitude, particularly on older models and models that are not IFR approved for vertical navigation. When possible fly well above the altitude of any obstacles in the area to compensate for this. Know your GPS's limitations.

1e. Ram air blocked; Pitot tube drain after ram air; static port drain blocked (regardless of order).

This is the same as scenario 1d except that if the ram air gets blocked before the Pitot tube drain the airspeed indication will drop to zero then freeze at zero (as opposed to just freezing at its current indication). The Altimeter and VSI will still freeze at their current indications when the static port is blocked.

Some possible*actions: see scenario 1d.

2a. Ram air blocked, but static port and Pitot tube drain remain unobstructed.

Effect: Airspeed indicator drops to zero; both the altimeter and vertical speed indicator are not affected since they don't use the ram air pressure.

Some possible*actions that may be taken: (a) activate Pitot heat (if this is a blockage due to ice, heat may resolve the issue). (b) if the aircraft is equipped with another airspeed indicator that uses a separate Pitot tube check if that is working. (c) keep flying the aircraft and use the attitude indicator for pitch and the usual power settings and configuration for that flight regime. (d) if equipped, the GPS may provide an idea of what the airspeed is, based on its reading of true airspeed (remember that there may be a lag between your actual airspeed and the value provided by the GPS; also be cautious because true airspeed is typically higher than indicated airspeed)

Note: If the static air then becomes obstructed after the ram air port, the problem becomes scenario 1b. If the Pitot tube drain becomes obstructed as well after the ram air port, the problem becomes scenario 2b.

2b. Ram air blocked first and then Pitot tube drain blocked; static port drain remains unobstructed.

Effect: Similar to the (3b) scenario except that air speed will drop to zero at the moment the ram air gets blocked. When the Pitot tube drain gets blocked next, it will trap air inside the Pitot tube chamber. Above the altitude where the drain gets blocked the airspeed indication will increase from zero. Since airspeed indication will increase with altitude the pilot may pull back on the yoke, just as in scenario 3b, resulting in a possible stall or spin. Also, just as in 3b, the actual airspeed will have no effect on the instrument since the ram air is blocked.

Note: If the static port then becomes obstructed after the Pitot tube drain and ram air, the problem becomes scenario 1e.

Some possible*actions: see scenario 3b.

3a. Pitot tube drain blocked; ram air and static air ports remain unobstructed.

Effect: There should be little to no effect unless the ram air port becomes blocked. This is because the Pitot tube drain is very small compared to the ram air opening. If it is blocked it will just stop draining water that enters from the ram air. Eventually this water could flood the Pitot tube and block the ram air from inside.

Some possible* actions: (a) if ice is a possibility, activate the Pitot heat.

Note: If the ram air becomes obstructed as well after the Pitot tube drain, the issue becomes scenario 3b. If the static air becomes obstructed after the Pitot tube drain, the issue becomes scenario 1c.

3b. Pitot tube drain blocked first; then ram air blocked; static port remains unobstructed.

Effect: If the Pitot tube drain gets blocked, initially there is little difference until the ram air port gets blocked as well. At that moment pressure gets trapped inside the Pitot tube ram air chamber. If the aircraft remains at the same altitude where the two blockages occurred the airspeed indicator will remain at the same airspeed indication regardless of any actual changes in the aircraft's airspeed. If the aircraft descends that airspeed indication will decrease regardless of the aircraft's airspeed. If the aircraft climbs the airspeed indication will increase regardless of the aircraft's airspeed. Basically the airspeed will have an altimeter like behavior, increasing and decreasing with altitude. Of the blockage scenarios this one can be one of the most dangerous. The pilot is used to the airspeed increasing if he/she pushes the yoke forward and decreasing if he/she pushes back on the yoke. The exact opposite happens in this scenario. Â The pilot pushes back on the yoke and because the altitude will increase momentarily, the airspeed will show an increasingly higher indication. The pilot may continue to pull back on the yoke and decrease power thinking that the indicated airspeed will decrease, not realizing that the aircraft is slowing and possibly reaching its stall speed. In the opposite direction, if the pilot pushes the yoke forward the aircraft will start to descend and because of this the airspeed indication will decrease due to the blockages, the pilot then may apply more forward pressure on the yoke and perhaps add more power causing the aircraft to go faster and overspeed or get out of control into the ground. This is particularly hazardous when there are no outside references in IFR. If you notice that the air speed decreases when the nose of the aircraft goes down and increases when the nose goes up this failure scenario should be considered.

Some possible* actions: (a) if ice is a possibility, activate the Pitot heat. (b) if the attitude indicator is functional, fly the usual attitude and power for that particular flight regime and investigate. (c) use the GPS indication of speed, if available, to have a rough idea of your airspeed. Remember that the GPS will be showing true airspeed which is usually higher than indicated airspeed, principally at higher altitudes. Workload permitting, use a flight computer to calculate the indicated airspeed based on that true airspeed shown by the GPS. (d) proceed to an airport with visual conditions if possible.

Note: If the static port then becomes obstructed after the ram air and Pitot tube drain, the problem becomes scenario 1d.

Actions that can help mitigate/prevent the situations above

General actions* on the ground:

a) Make sure the Pitot tube and static port protection covers, if any, are removed before flight.

b) Thoroughly inspect the Pitot tube and static air port in the preflight inspection for any obstruction.

c) Test if the Pitot heat is working. On smaller aircraft it is possible to turn the Pitot heat switch on and then check if the Pitot tube is warming up (it can get really hot and care must be taken not to burn fingers or hand). On larger aircraft an infrared thermometer may be used from a distance pointed at the Pitot tube, or a ladder to feel the Pitot tube while someone in the cockpit turns the Pitot heat on.

d) When the aircraft is parked, use covers when available to prevent debris, or insects from blocking the ports and openings.

e) These blockage scenarios should be practiced in an appropriate simulator. Having experience is crucial to recognizing and acting correctly. Experiencing these in the aircraft for the first time can be deadly.

*These actions may or may not be appropriate, always use manufacturer's recommendations and emergency procedures. Consult a flight instructor that is rated and current in your aircraft as to the particular actions that should be taken for these situations.

IV - Examples of the Various Blockage Scenarios

In the following scenarios the airspeeds will be rounded to the nearest 5 knots for convenience. We will be using the Pitot static system simulator available at: http://www.luizmonteiro.com/Learning_Pitot_Sim.aspx on our site to run them. The simulator is setup like the Pitot-static system in most general aviation airplanes and is similar to the one described in chart 2-1. The transponder is not depicted here for simplicity, but the transponder would have the same behavior as the altimeter when set for pressure altitude 29.92 inHg. The simulator will have a "Simulated System" and a "Reference System". The "Reference System", which is not affected by the blockage scenarios, is used to compare the blockage scenarios we apply in the "Simulated System".

The scenarios are also set to happen in standard atmosphere to make it easier to quantify. Also, the effects of these scenarios are summarized in table 1. In situations other than standard atmosphere, the indications on the instruments will be different, however, the general behavior will be the same.

1a. Static port blocked, but ram air and Pitot tube drain remain unobstructed.

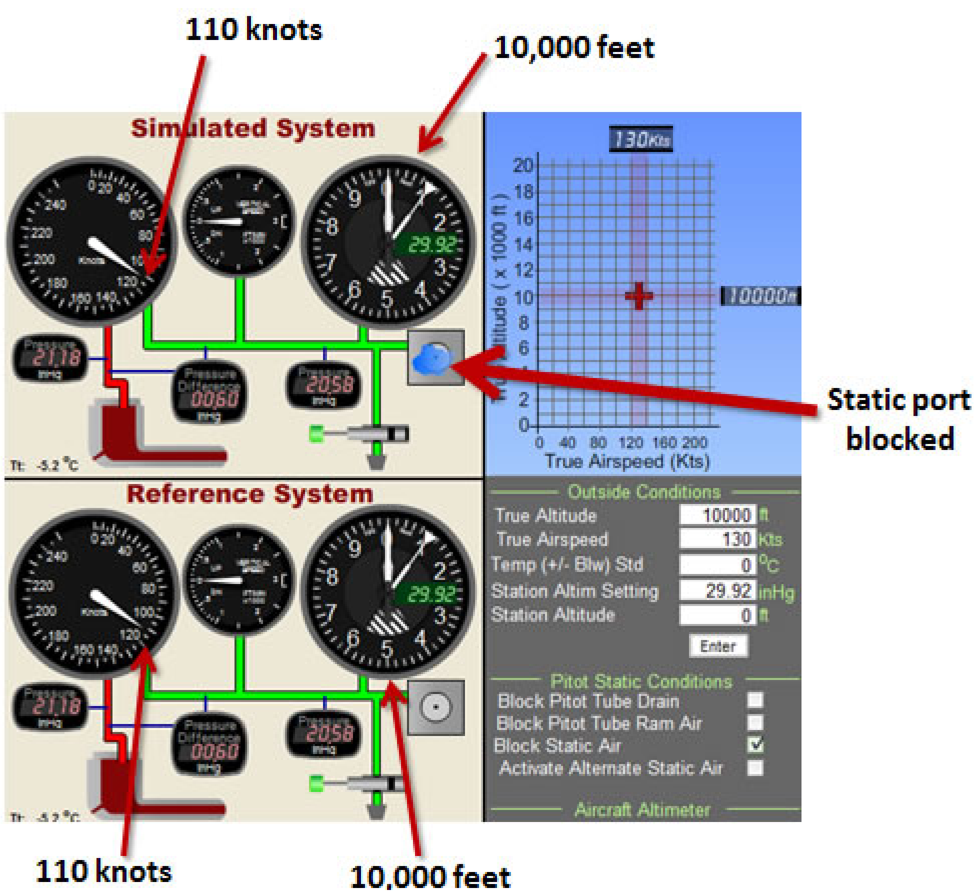

Fig 4-1 Static port gets blocked at an altitude of 10,000 feet and 130 knots.

In this example (Fig 4-1), the aircraft is at an altitude of 10,000 feet and flying at 130 knots (true airspeed). The indicated airspeed is 110 knots (note: due to altitude and atmospheric conditions indicated airspeed is different than true airspeed) and the altimeter reads 10,000 feet. Let's assume now that a blockage occurs on the static port. If the aircraft stays at the same altitude and maintains airspeed there is no difference seen in the instruments. Notice the pressure on the static port air line of 20.58 inHg (inches of mercury). This will be important because now air is trapped inside the static line which will cause an erroneous reading in the airspeed indicator when the altitude changes and will cause the altimeter and vertical speed indicator to freeze at the reading where the blockage occurred. Since the altimeter setting is 29.92 Chart 2-7 will confirm that the altimeter will read 10,000 feet for a pressure of 20.58 inHg. If there was a different altimeter setting the altitude on chart 2-7 would have to be adjusted using chart 2-5.

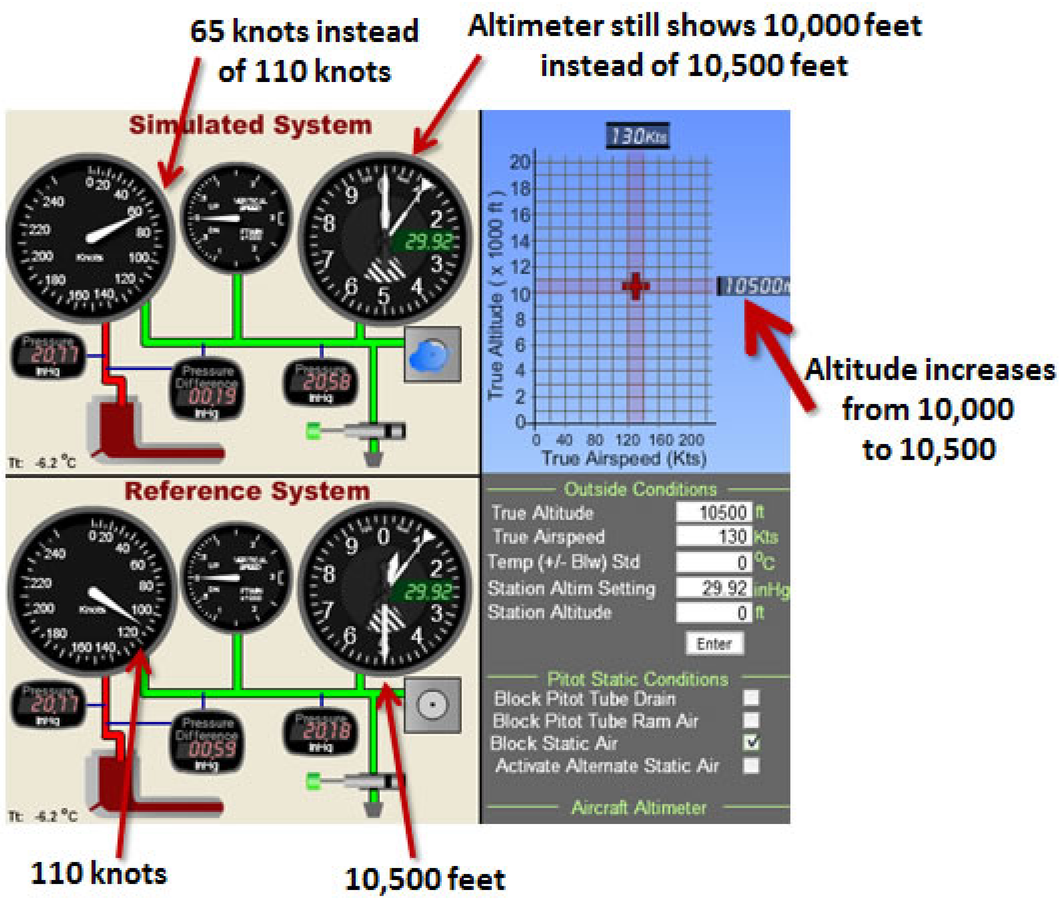

Fig 4-2 Increase in altitude after blockage.

Suppose that the pilot now climbs to an altitude of 10,500 feet (Fig 4-2) without changing true airspeed (the aircraft's actual airspeed). The altimeter and vertical speed indicator don't move because the pressure hasn't changed in the static air line. The airspeed indicator however is now showing 65 knots instead of 110 knots as seen in the reference system that is not blocked. In this scenario at the higher altitude there is less pressure in the outside air and as a result there will be less pressure in the ram air opening for the same true airspeed. Normally this would be compensated by a reduction in pressure P in the static air line which is connected to the static port (measures the static pressure outside). Because it is blocked the difference in air pressure between the ram air and static air (trapped at 20.58 inHg) is reduced: 20.77-20.58 = 0.19 inHg. This corresponds to 65 knots (see chart 2-3) and therefore the indicated airspeed on the aircraft's airspeed indicator is less than what it should be. In this case there is a 45 knot decrease in indicated airspeed with just a 500 foot increase in altitude. The correct difference ($q_c = P_T - P$) as seen by the reference system would be 20.77 - 20.18 = 0.59 inHg which corresponds to 110 knots indicated airspeed (see chart 2-3). Where 20.18 inHg is the static air pressure outside the aircraft at that altitude.

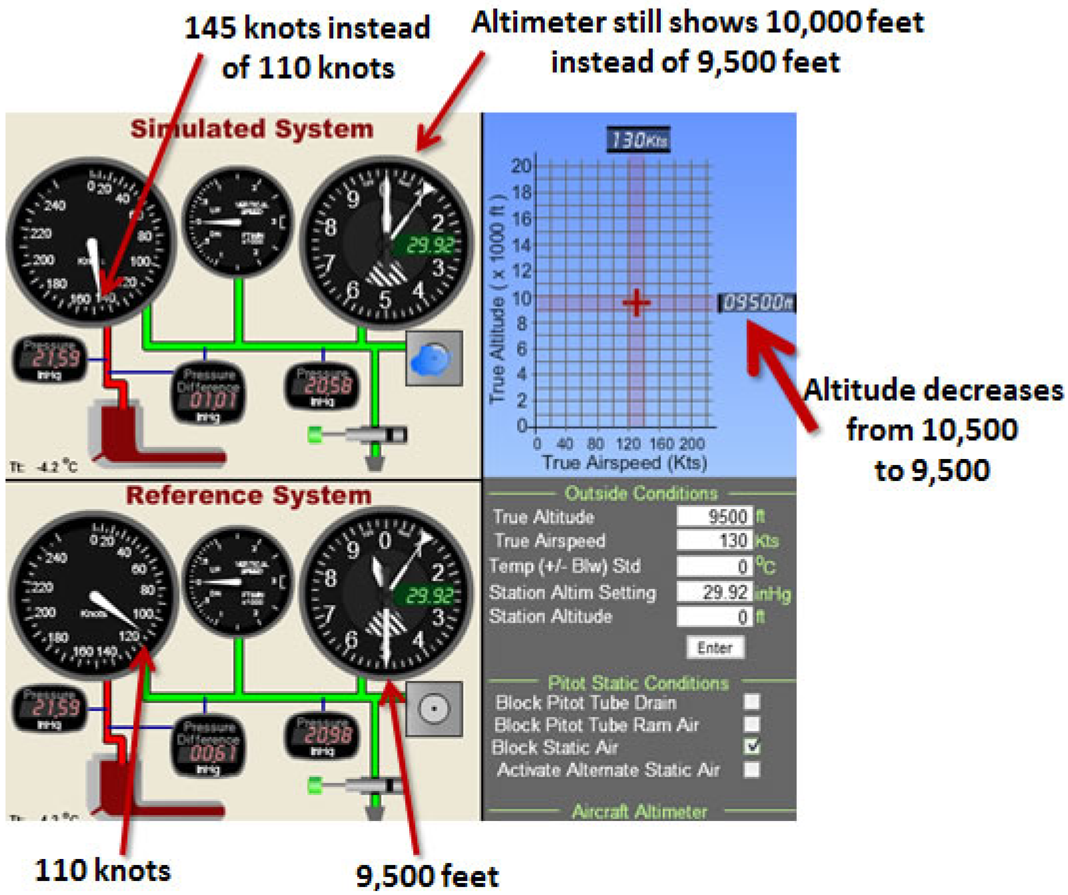

Fig 4-3 500 ft below altitude of blockage.

Now let's see what happens when the aircraft descends to 9,500 feet while maintaining true airspeed. This is 500 feet below the altitude in which the blockage of the static air port occurred (Fig 4-3). Here we have basically the opposite occurring. The indicated airspeed is showing 145 knots (an increase in 35 knots) instead of the correct 110 knots of indicated airspeed. The ram air pressure of 21.59 inHg is accurate because the ram air is not blocked. The pressure in the static air line, however, is still 20.58 inHg instead of the new 20.98 inHg which is the static air pressure at that altitude. Because the airspeed indicator is measuring the difference between the two of 21.59-20.58= 1.01 inHg which corresponds to 145 knots according to chart 2-3. The airspeed indicator displays a higher airspeed as a result. The reference system shows what the correct difference in pressure ($q_c = P_T - P$) would be: 21.59-20.98 =0.61 inHg which still corresponds to approximately 110 knots (see chart 2 -3) on the airspeed indicator. Note that the altimeter and vertical speed indicator will continue to be frozen and will remain that way unless the pressure in the static air line changes.

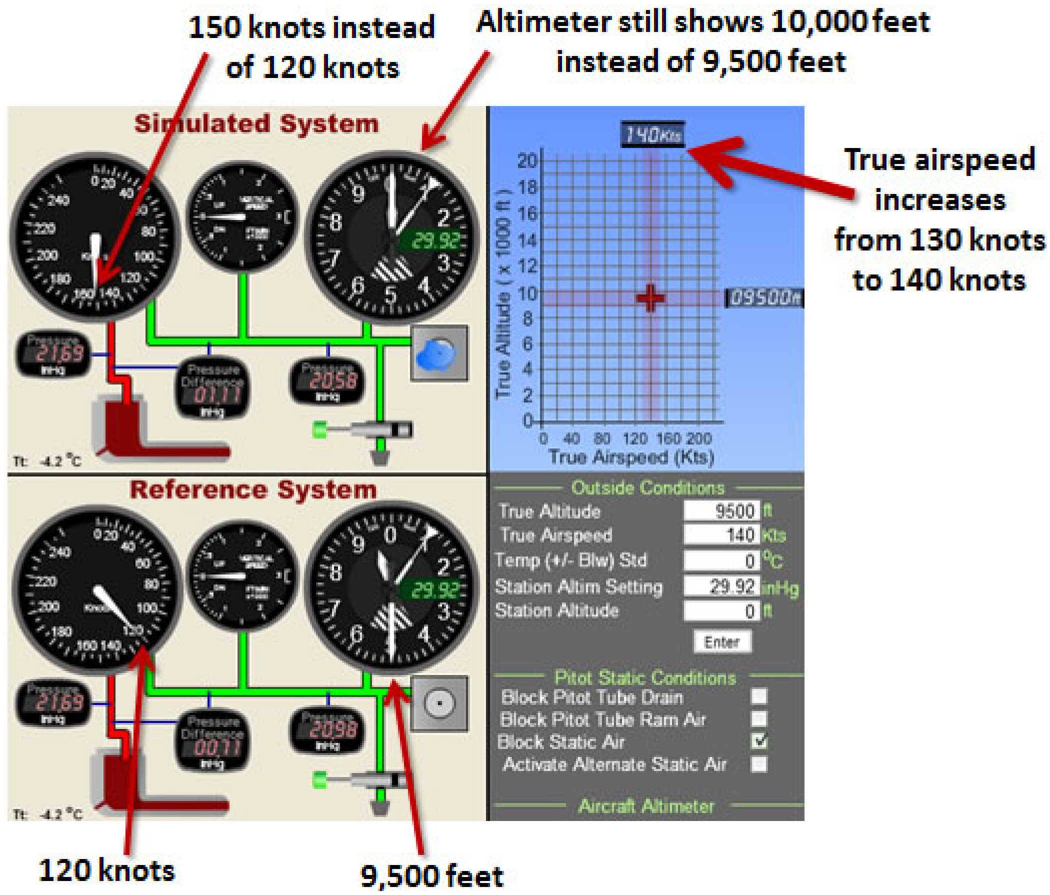

Fig 4-4 Airspeed is lower than indicated but indicated still increases with airspeed.

If the speed of the aircraft increases there will continue to be an increase in the airspeed shown by the airspeed indicator but the reading will be incorrect (Fig 4-4). If the aircraft is below the altitude at which the blockage of the static port occurred, as in this example, the indicated airspeed will be higher than it actually would be if there was no blockage. We have the aircraft flying at 140 knots true airspeed which would correspond to an indicated airspeed of 120 knots at present atmospheric conditions. Due to the blockage the airspeed indicator shows 150 knots instead of 120 knots. You can use chart 2-3 to verify this with the pressure difference 21.68 - 20.58 = 1.11 inHg. The opposite (not shown) would occur if the aircraft was flying above that altitude.

.

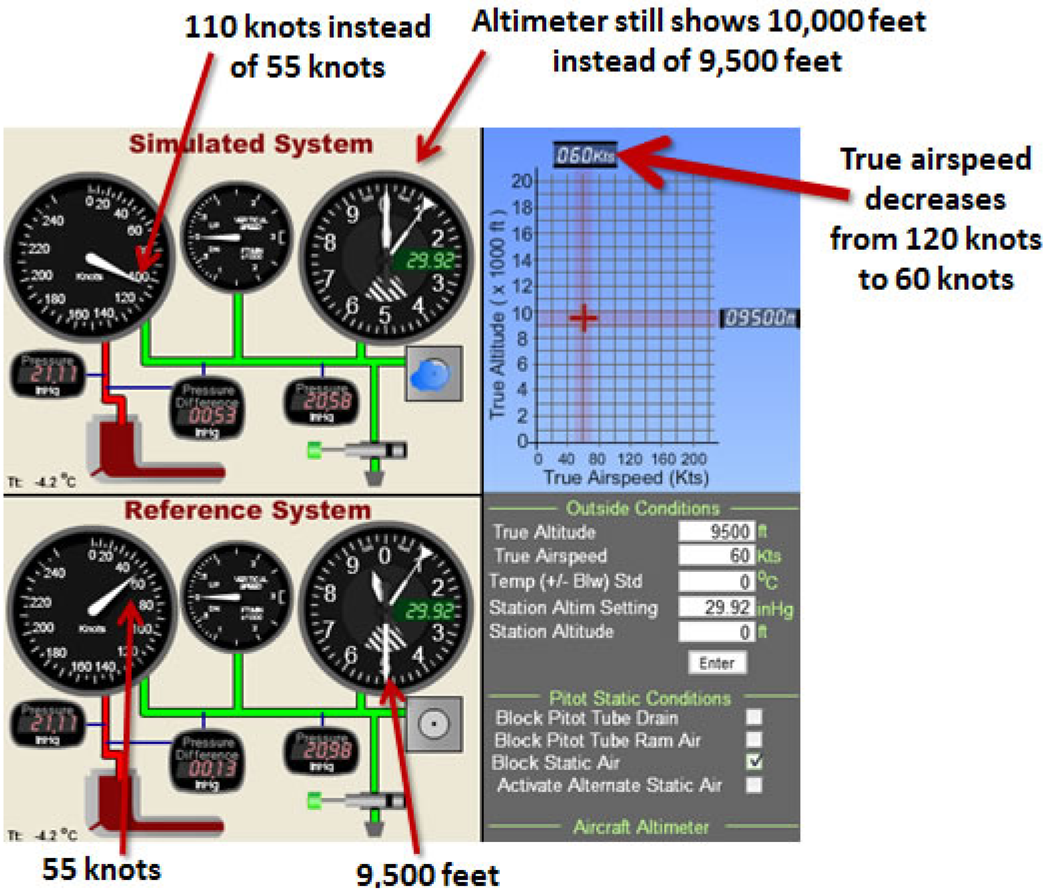

Fig 4-5 Decrease in indicated airspeed to match indicated airspeed before blockage.

If the pilot were to instead reduce the airspeed, perhaps not realizing the problem, the aircraft could slow down too much and stall or spin. Here (Fig 4-5) we have the pilot slowing the aircraft down until the indicated airspeed shows 110 knots (which was the original indication at the time of the blockage). You can use chart 2-3 to verify this with the pressure difference 21.11 - 20.58 = 0.53 inHg. Looking at the reference system we can see that the aircraft is actually at 55 knots indicated airspeed which could be dangerously slow. Chart 2-3 can once again be used to verify this with the pressure difference ($q_c = P_T - P$): 21.11 - 20.98 = 0.13 inHg. Here, a mere 500 feet below the altitude at which the blockage occurred causes the indicated airspeed to be 110 - 55 = 55 knots less than what it should be, or half in this case!

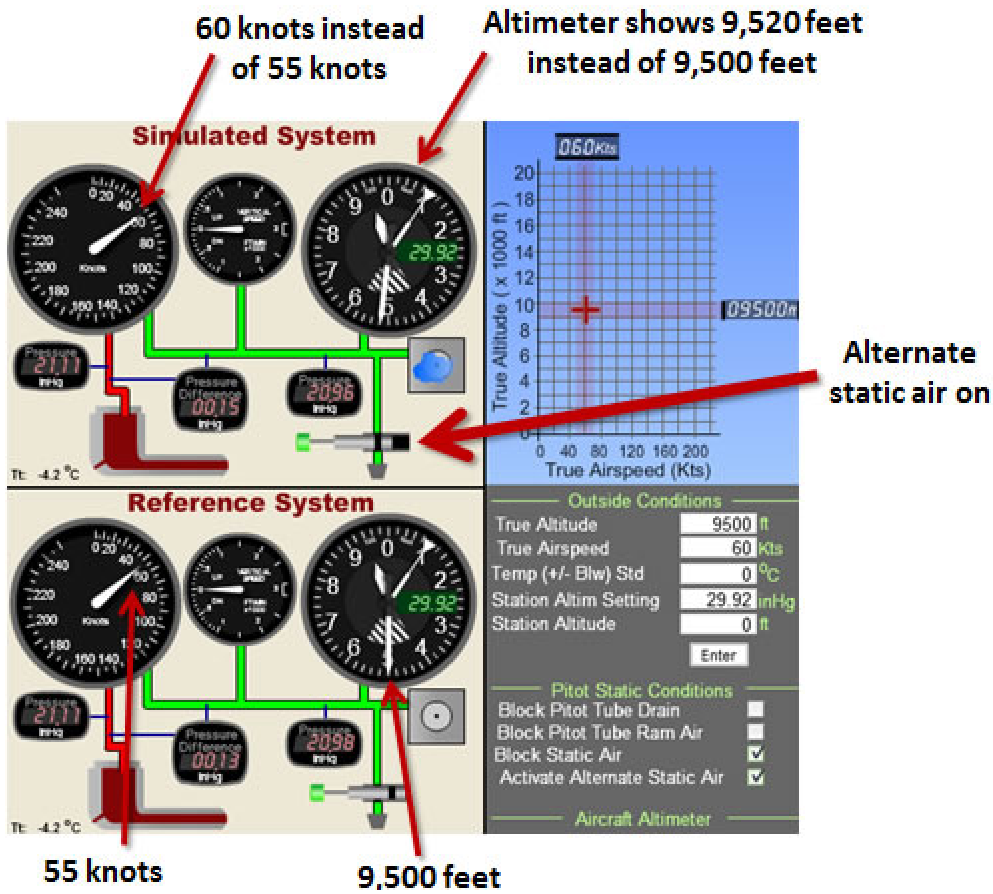

Fig 4-6 Activating alternate static air port.

All this time the altimeter and vertical speed indicator were frozen. If a pilot realizes that there is something wrong and suspects an issue with the static port he/she can activate the alternate static air (Fig 4-6) and get the instruments to work again. There may be a slight difference in reading since the placement of the alternate static air port may cause its pressure to be slightly different than an unobstructed static port. In this our example we will suppose the static port gives a very slightly lower pressure. The indicated airspeed is now 60 knots. Chart 2-3 can again be used to verify this with the pressure difference: 21.11 - 20.98 = 0.15 inHg. This is only 5 knots higher than the airspeed shown in the reference system which is much better than the 55 knot difference the pilot experience before. The aircraft's altimeter is also working and showing 9520 feet (only a 20 foot difference from the altitude in the reference system). The vertical speed indicator would also be working again.

1b. Ram air and static port blocked (regardless of order); Pitot tube drain remains unobstructed.

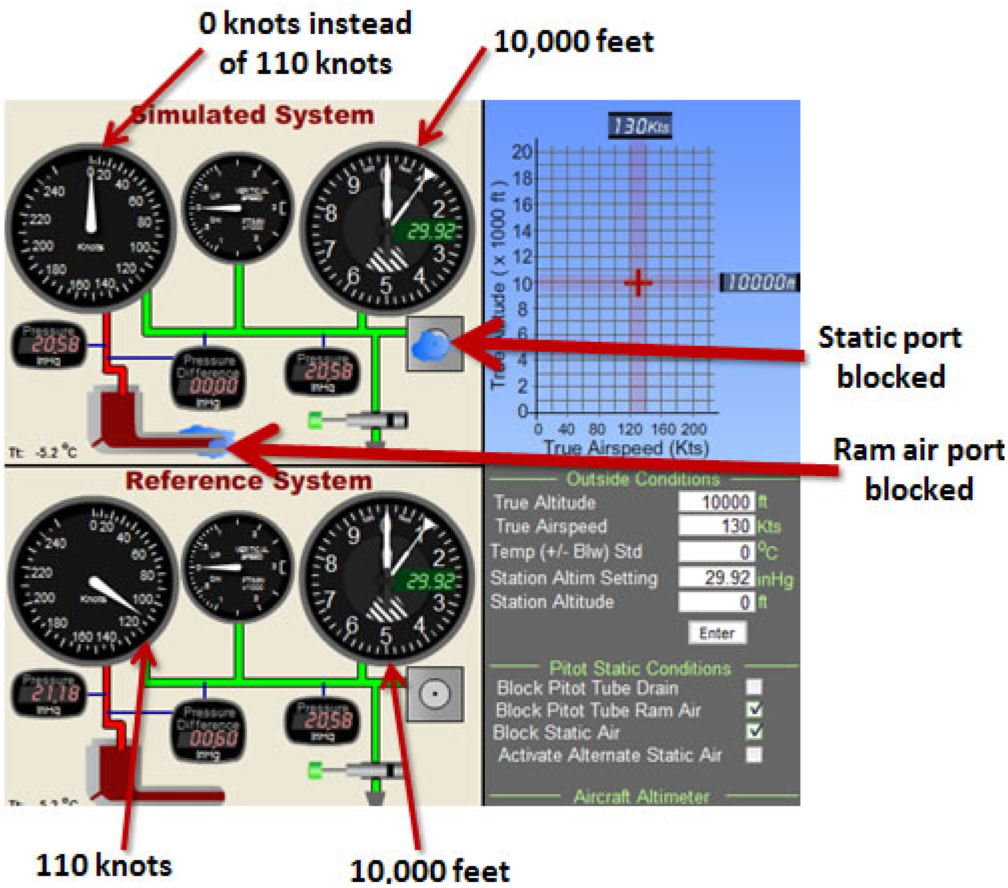

Fig 4-7 Ram air and static port get blocked at 10,000 feet and 130 knots true airspeed..

In this example an aircraft flying at 10,000 feet and having a true airspeed of 130 knots experiences blockages in both static port and ram air. As soon as the static port is blocked both VSI and altimeter freeze at their current readings, the airspeed indicator will show the wrong indicated airspeed if the aircraft is above or below the altitude of this blockage. The pressure in the static air line will remain the same since the air will be trapped. In this case it will stay at 20.58 inHg. When the ram air gets blocked next, the airspeed indicator will go to zero. Now there is no air impacting the opening of the ram air so the pressure inside the Pitot tube will basically be the same as the outside air since air can enter from the Pitot tube drain opening. This causes the pressure difference between the ram air chamber and static air line to be: 20.58 - 20.58 = 0 inHg which corresponds to an airspeed indication of zero (see chart 2-3).

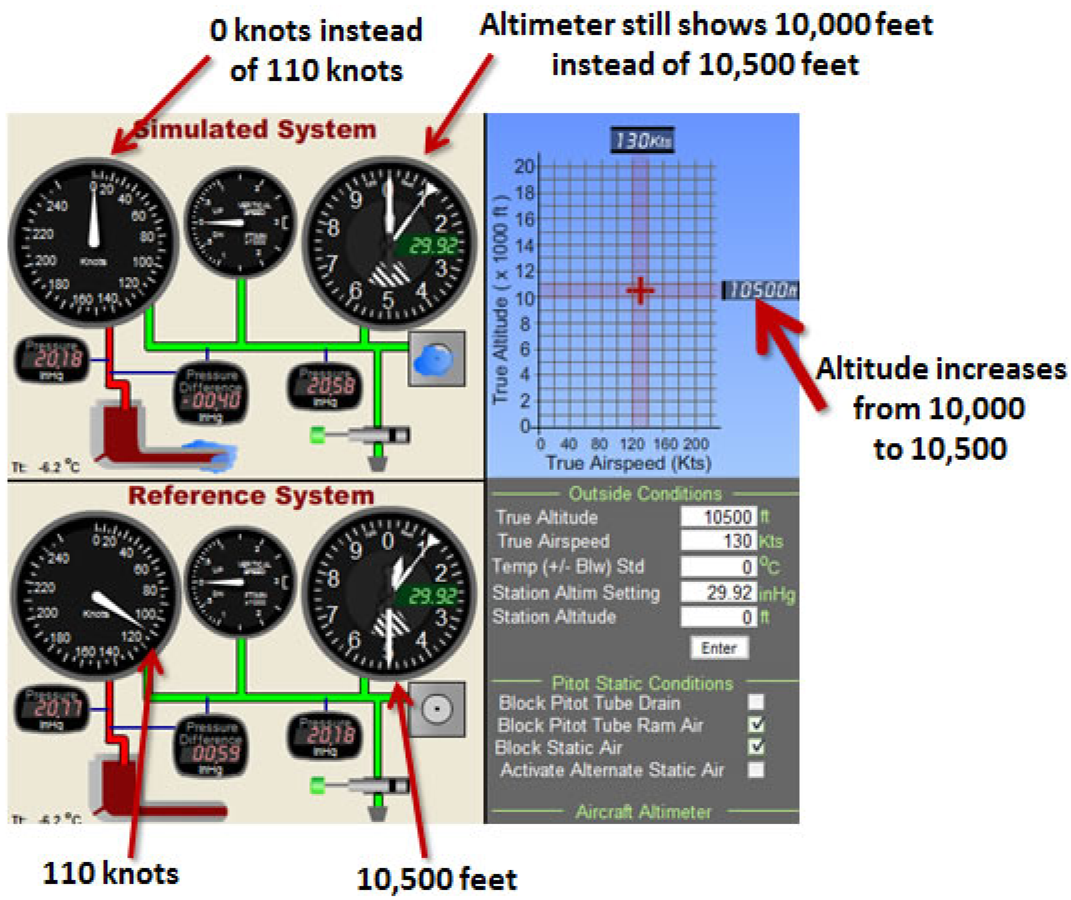

Fig 4-8 Aircraft climbs 500 feet and maintains airspeed.

The aircraft now climbs from 10,000 feet to 10,500 feet. The altimeter is still frozen (due to static port being blocked) so it will continue to show 10,000 feet (the altitude at which the blockage occurred) and the VSI would have stayed at zero during the climb. The airspeed indicator will continue to show zero since the difference in pressure between the Pitot tube chamber and the static air line is less than zero (20.18 - 20.58 = -0.40 inHg). If the pressure is less than zero usually the airspeed indicator will not indicate less than zero because the needle hits a stop. If there were no stop the airspeed and needle would continue to move beyond the zero marking.

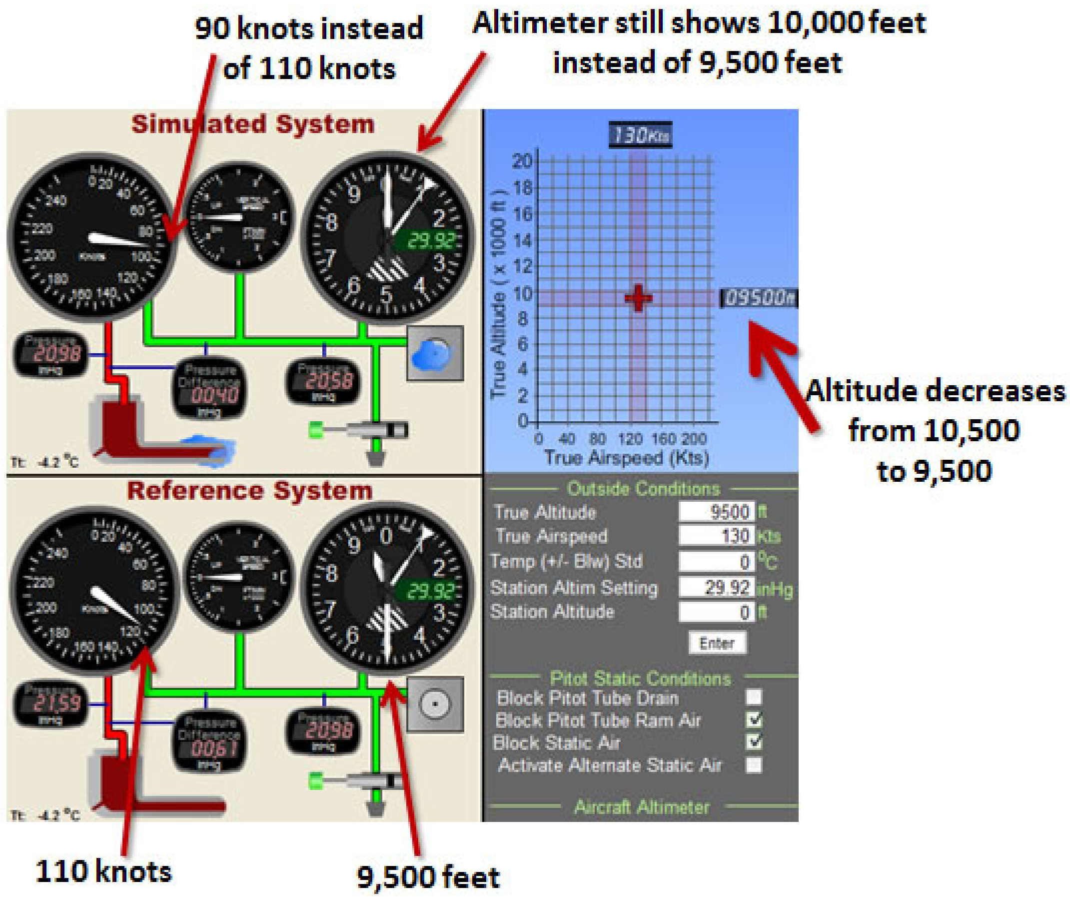

Fig 4-9 Aircraft descends to 9,500 feet (500 below blockage altitude).

Now we have the aircraft descend to 9500 feet (500 feet below the altitude at which the blockage occurred). As before there is no change in either the VSI or the altimeter. The airspeed indicator, however, will now show a positive reading, but this reading will have nothing to do with airspeed. In fact it will not change if the aircraft increases or decreases its airspeed while maintaining altitude. The pressure inside the Pitot tube chamber will be the same as the pressure outside the aircraft (20.98 inHg) because of the Pitot tube drain allowing air to enter from the outside. The difference in pressure between this chamber and the air in the static air line is now 20.98 - 20.58 = 0.40 inHg which is a positive value and will correspond to a positive airspeed indication (see chart 2-3) which in this case is about 90 knots. The reference system shows what the correct reading on the airspeed indicator would be about 110 knots since we have $q_c = P_T - P = 21.59 - 20.98 = 0.61$ inHg (see chart 2-3).

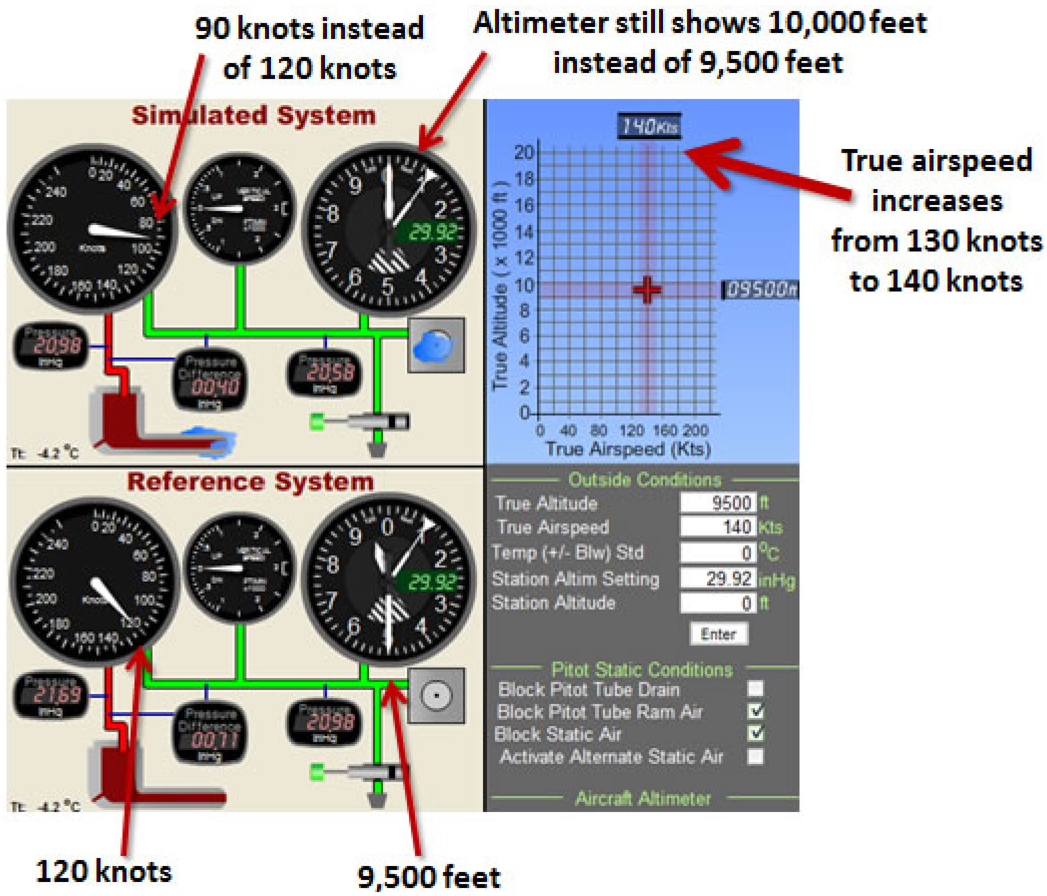

Fig 4-10 Aircraft increases true airspeed by 10 knots while maintaining 9,500 feet.

The aircraft then increases its true airspeed from 130 knots to 140 knots. Since that does not affect the pressure inside the Pitot tube chamber there is no change in what the airspeed indicator shows. In other words the difference in pressure between the chamber and the static line is still 0.40 inHg.

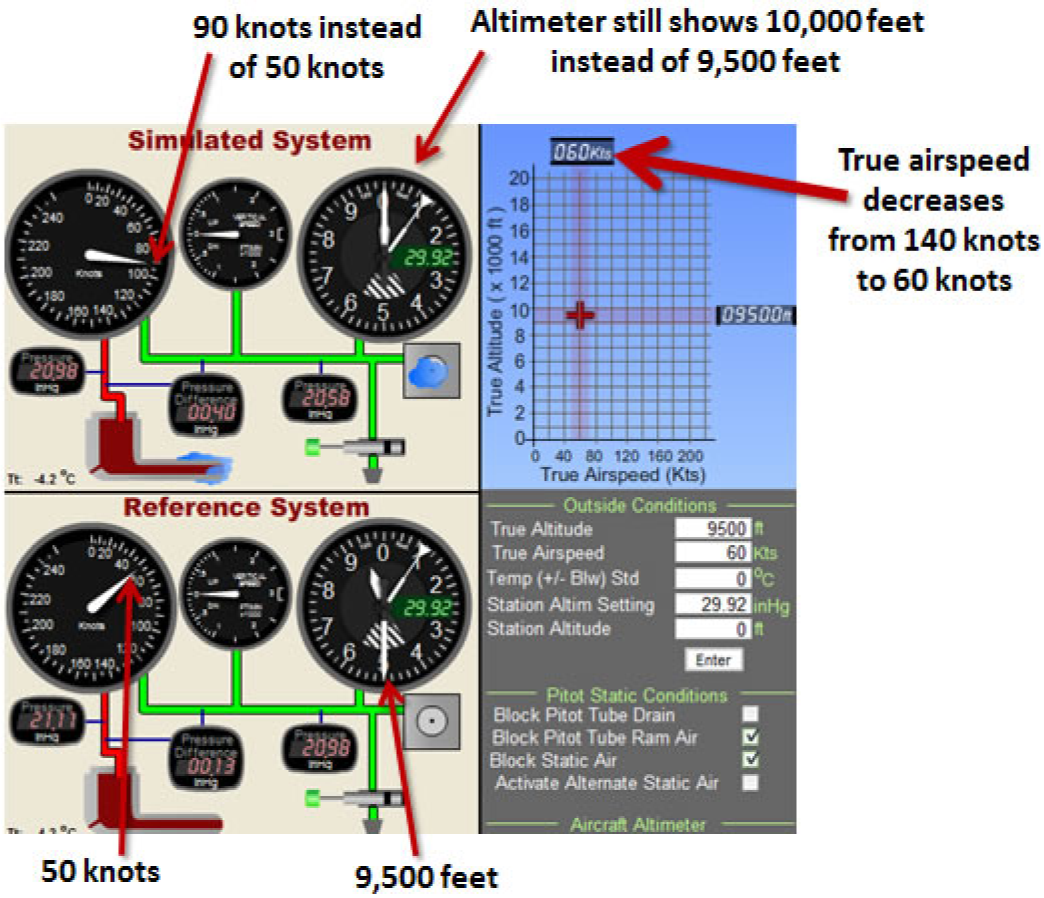

Fig 4-11 Aircraft maintains altitude and decreases true airspeed to 60 knots true airspeed.

The danger of this situation is that the pilot may think a certain airspeed is being maintained and either increase or decrease the aircraft's airspeed to a dangerous amount. Here the airspeed decreases to 60 knots true airspeed which may be below the aircraft stall speed. The indication on the airspeed indicator is still 90 knots (since the pressure difference is the same) when in reality it should be indicating 50 knots (see reference system). In other words the difference should be $q_c = P_T - P = 21.11 - 20.98 = 0.13$ inHg and this is 50 knots according to chart 2-3.

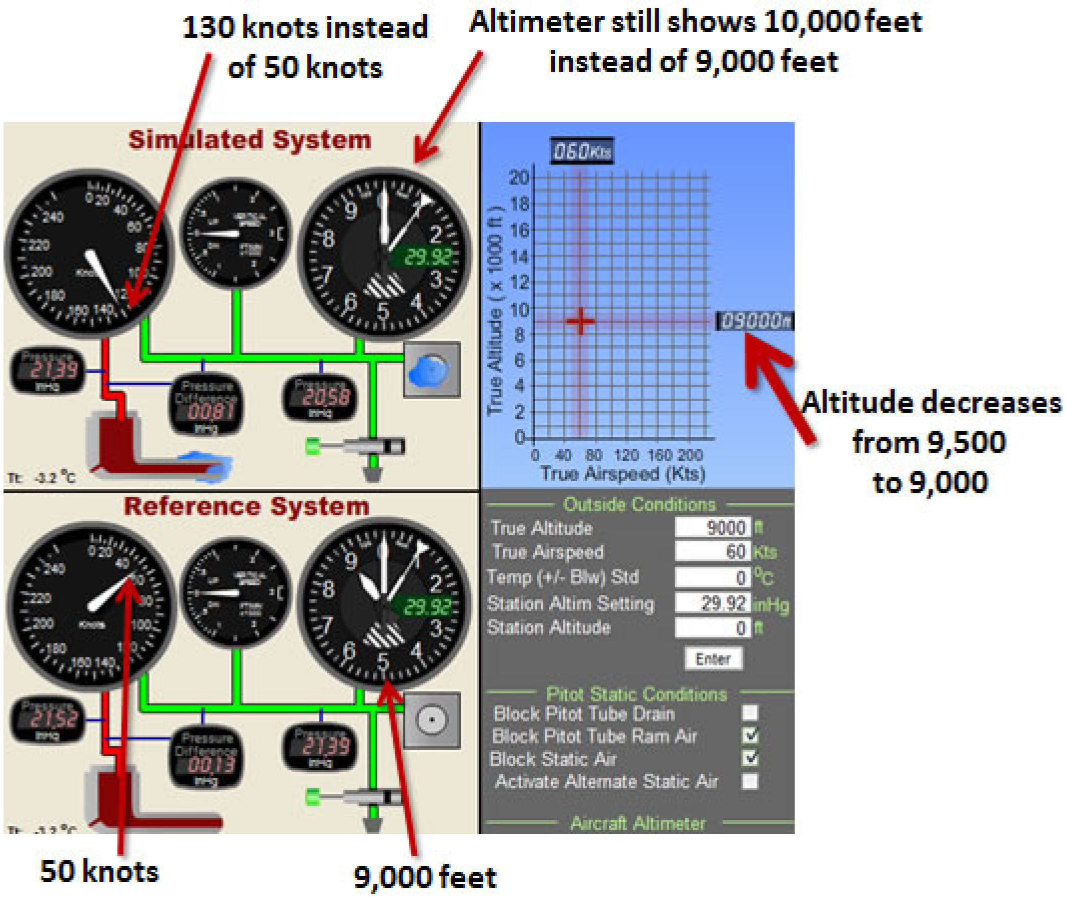

Fig 4-12 Aircraft descends another 500 feet (1000 ft below blockage) and maintains airspeed.

This situation can be aggravated further if the aircraft's altitude decreases. In this case the aircraft descends another 500 feet to 9000 feet while maintaining true airspeed. The pressure in the Pitot tube chamber is now 21.39 inHg which is the atmospheric pressure at that altitude. The difference in pressure between the chamber and of the static air line is now 21.39 - 20.58 = 0.81 inHg which corresponds to a airspeed indication of 130 knots (see chart 2-3). As seen in the reference system, this indication should actually be 50 knots since we have $q_c = P_T - P = 21.52 - 21.39 = 013$ inHg (see chart 2-3). It is possible that the pilot could inadvertently slow down the aircraft even further thinking the 130 knots reading was correct..

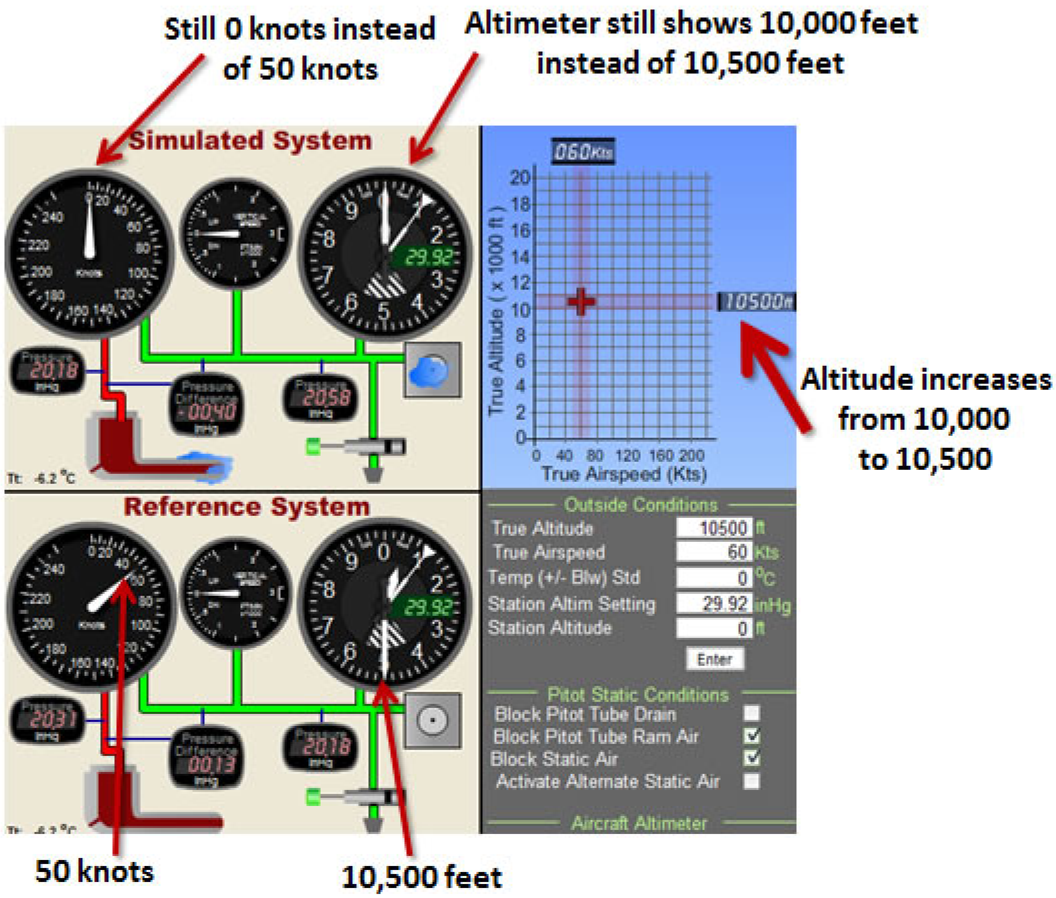

Fig 4-13 Aircraft climbs back to 10,500 feet (500 feet above blockage) and maintains airspeed.

Going back to when the aircraft was at 10,000 feet (blockage altitude), recall that climbing to any altitude above that will cause the airspeed indication to remain at zero. Here we have the aircraft at 60 knots true airspeed climbing from 10,000 to 10,500 feet and maintaining true airspeed.

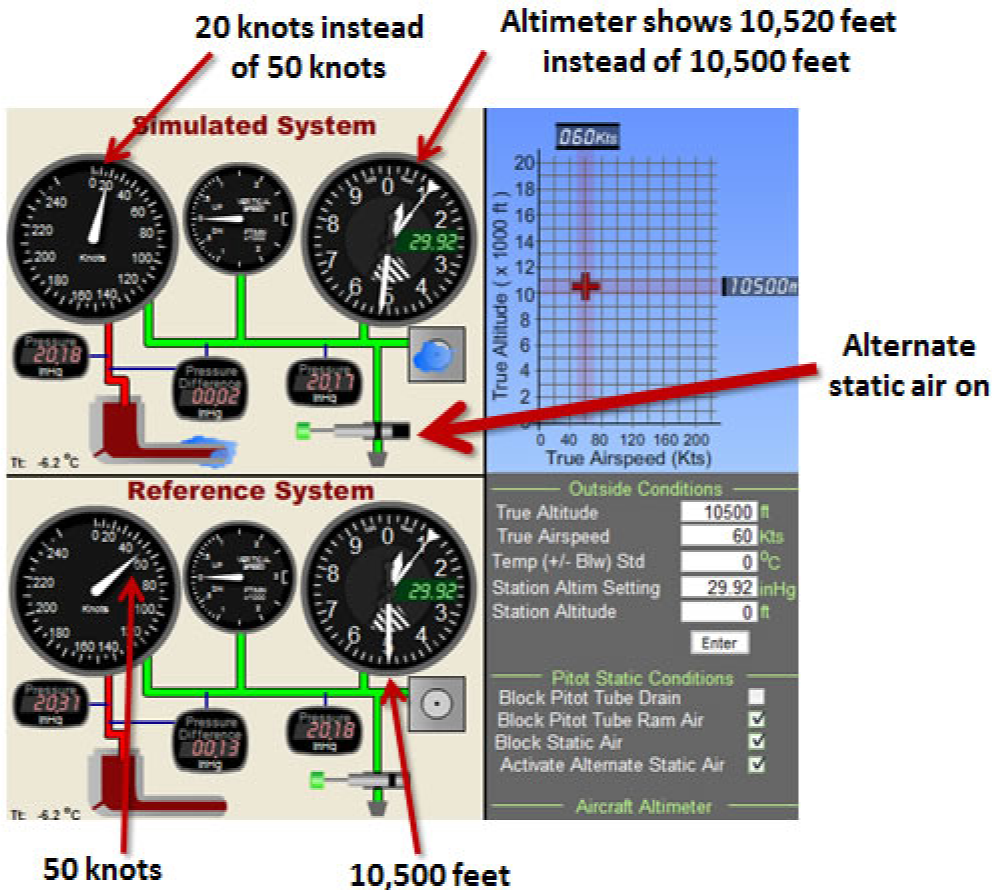

Fig 4-14 Alternate static port activated.

Most of the issue with the VSI and altimeter would be mitigated if the alternate static air is activated (if available). The altimeter may be off by a few feet depending if the static air pressure from the alternate static air is slightly below (higher altitude indicated) or slightly above (lower altitude indicated). In most cases this error is very small. In this example the altimeter shows 10,520 feet instead of 10,500 feet which is a 20 feet difference. The airspeed indicator will still be unusable since it depends on the ram air to be unobstructed. The behavior of the airspeed indicator will now be the same as in scenario 2a.

If the alternate static air does not work or is not available and the Pitot tube drain also gets blocked this scenario becomes scenario 1e. The airspeed indicator, VSI and altimeter will freeze at their current indications.

Note also that if the ram air is blocked by ice then it may be possible to activate Pitot tube heat, if available, to melt the ice and clear the obstruction and allow the ram air to operate once again.

1c. Static port and Pitot tube drain blocked (regardless of order); but ram air remains unobstructed.

Here the behavior is exactly the same as in the example of scenario 1a. The pilot will not notice any difference between the two scenarios as long as the ram air remains unobstructed. If the ram air then becomes obstructed after the Pitot tube drain, the problem becomes scenario 1d.

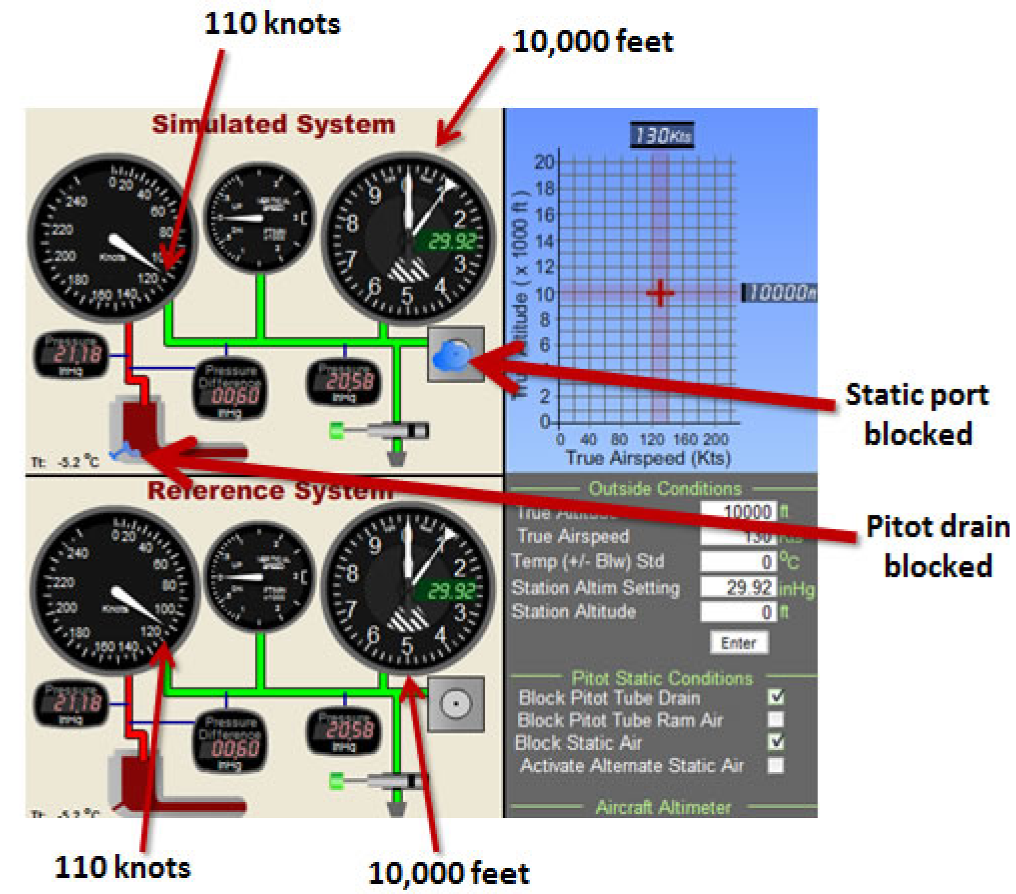

Fig 4-15 Static air port and Pitot drain blocked.

The Pitot tube drain is a much smaller orifice in comparison to the ram air port (located at the front of the Pitot tube). Unless the ram air is also blocked there usually will be no significant additional effect other than the effect of the static port being blocked in this example (Fig 4-15).

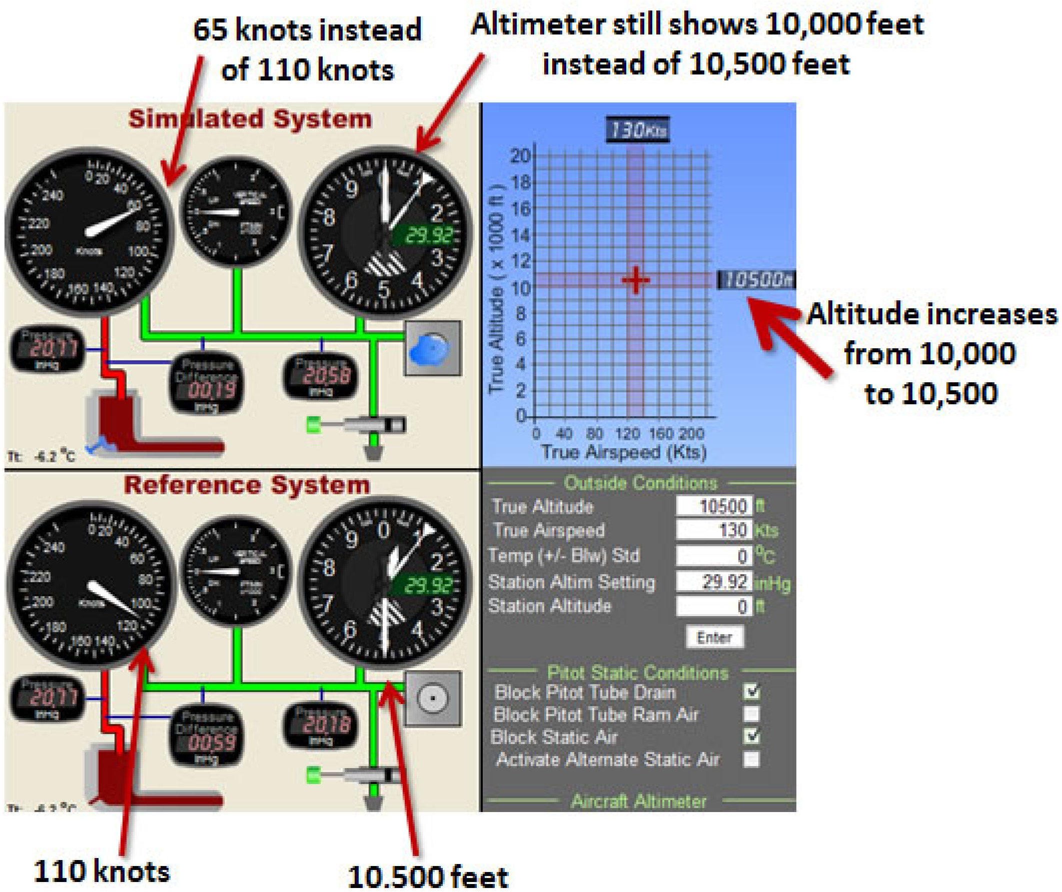

Fig 4-16 Aircraft climbs 500 feet from the altitude where blockage occurred.

When the aircraft climbs 500 feet (Fig 4-16) from the altitude that blockage of the ram air and static port occurred the effect is the same as if only the static port had been blocked. Compare figure 4-16 with figure 4-2 from scenario 1a.

1d. Pitot tube drain blocked; ram air blocked after Pitot drain; static port drain blocked (regardless of order).

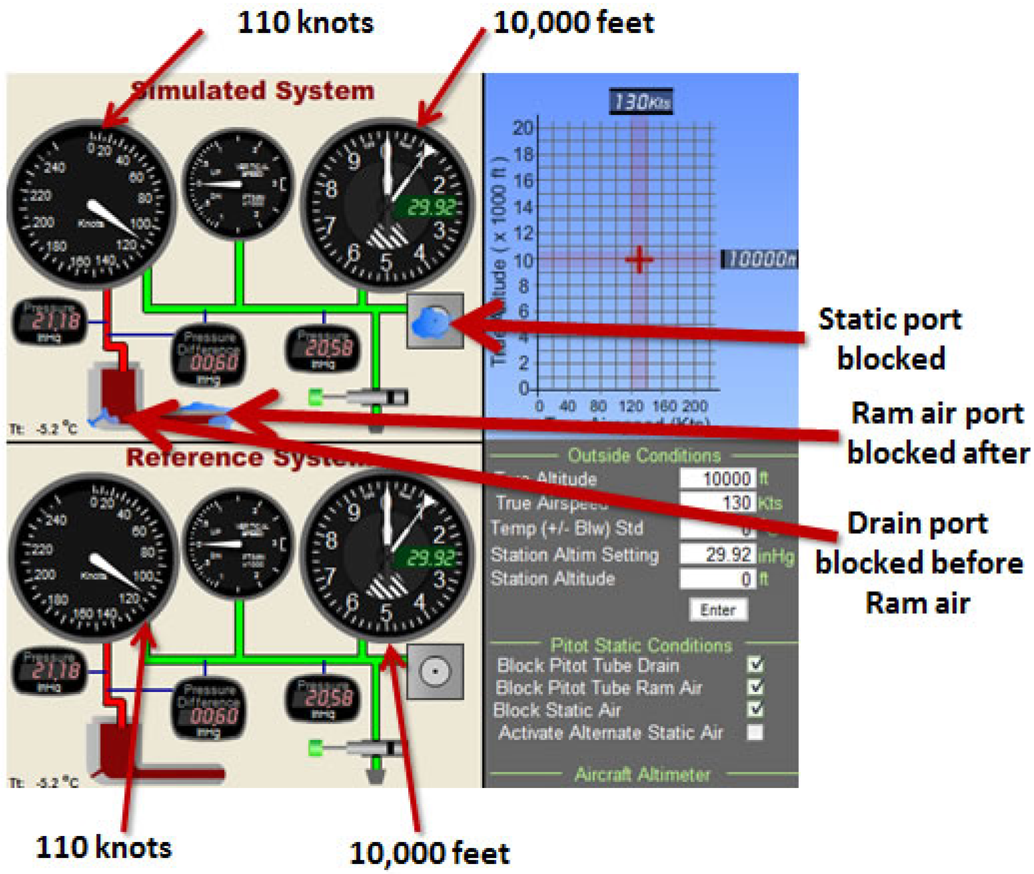

Fig 4-17 Static port blocked followed by Pitot tube drain, then ram air at 10,000 feet and 130 knots true airspeed.

Whenever all three (static port, ram air and Pitot tube drain) get blocked the airspeed indicator, VSI and altimeter freeze at their current indications. It would be somewhat unlikely that all three would freeze at exactly the same time, however if the aircraft maintains altitude and airspeed the result will be the same even if each opening gets blocked at a different time. This will happen provided the ram air gets blocked after the Pitot tube drain (Fig 4-17). In the case the ram air gets blocked before the drain the indicated airspeed would indicate zero. In all cases, including those where the aircraft has changed altitude and airspeed, at the moment all three openings get blocked the Pitot static instruments will freeze at their current readings regardless of what they are. In figure 4-17 the aircraft is flying at 10,000 knots at a true airspeed of 130 knots when all three (static port, ram air and Pitot tube drain) openings are blocked. The pressure is trapped now inside the Pitot tube chamber (21.18 inHg) and static air line (20.58 inHg). The difference between the two will also remain the same and that is why the airspeed indicator also freezes.

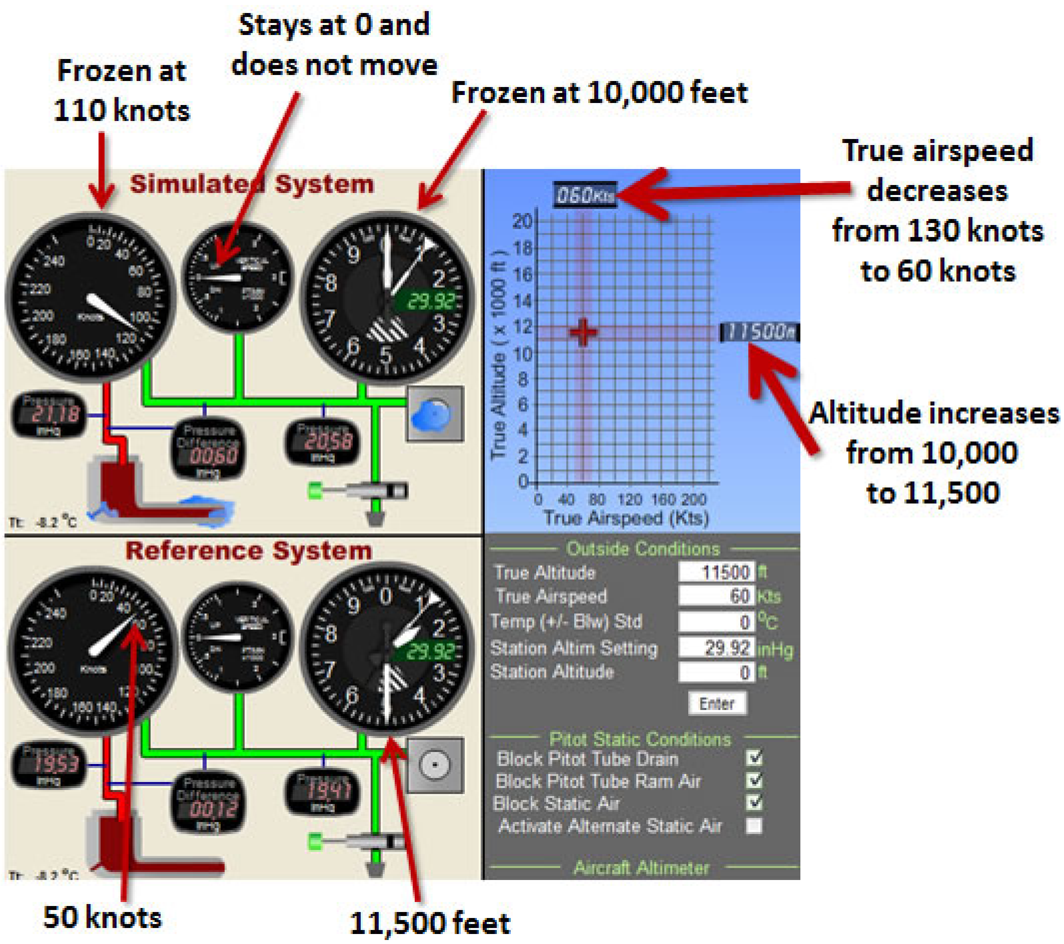

Fig 4-18 Aircraft climbs to 11,500 feet and decreases true airspeed from 130 knots to 60 knots.

Suppose the aircraft now climbs to 11,500 feet and slows down to a true airspeed of 60 knots. Because air is trapped in the system none of the instruments will show any change (Fig 4-18) from the time of the blockages. For comparison, the reference system shows what the correct indications would be if there were no blockages.

1e. Ram air blocked; Pitot tube drain after ram air; static port drain blocked (regardless of order).

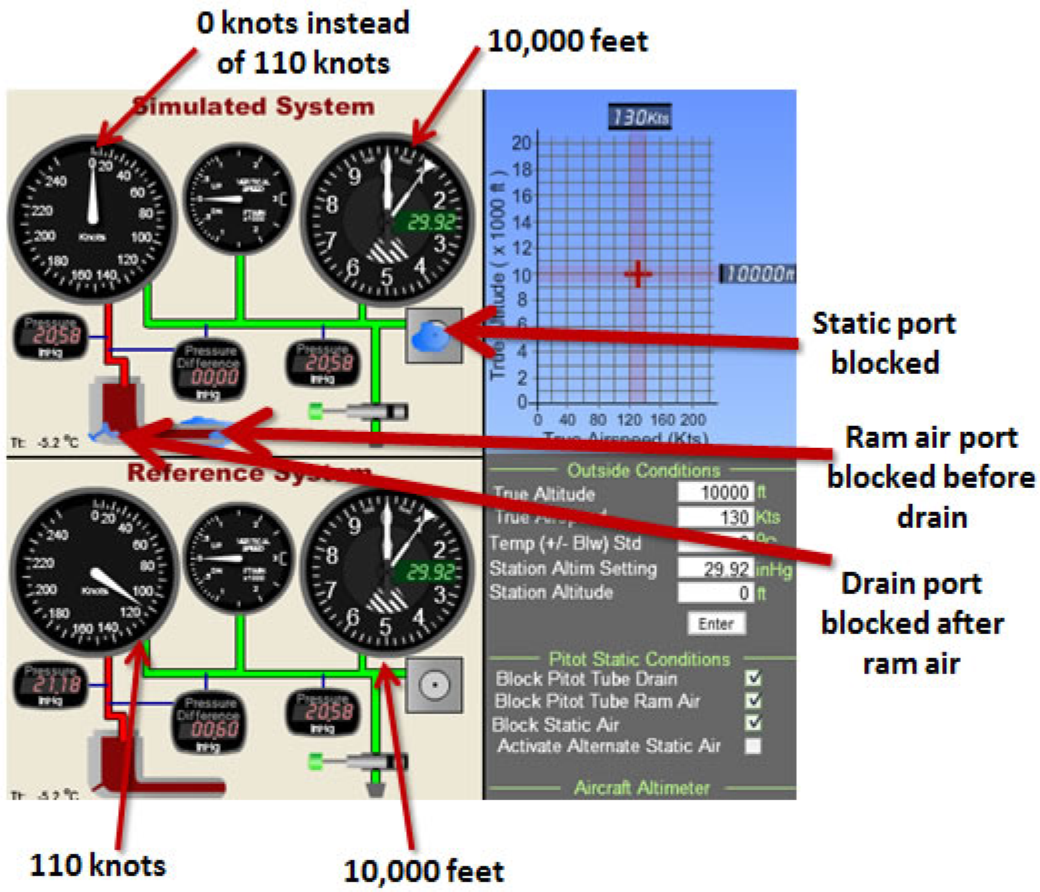

Fig 4-19 Static port blocked followed by ram air then Pitot tube drain, at 10,000 feet and 130 knots true airspeed.

In this example (Fig 4-19) an aircraft flying at 10,000 feet with a true airspeed of 130 knots experiences a blockage in the static port. In addition, the ram air opening gets blocked, followed by the Pitot tube drain opening. As in the previous examples, the static port being blocked will cause the altimeter to freeze at its current altitude and the vertical speed indicator (VSI) to remain at zero regardless of any altitude change. Because the ram air opening becomes blocked before the drain opening in this example, the airspeed indicator will drop to zero. This is due to the air being able to equalize in the Pitot tube chamber (20.58 inHg) with the static air (20.58 inHg) outside before the drain opening gets blocked. The air pressure trapped in the static air line is also 20.58 inHg so we have $q_c = P_T - P = 20.58 - 20.58 = 0$ inHg which corresponds to a zero indication of airspeed (see chart 2-3).

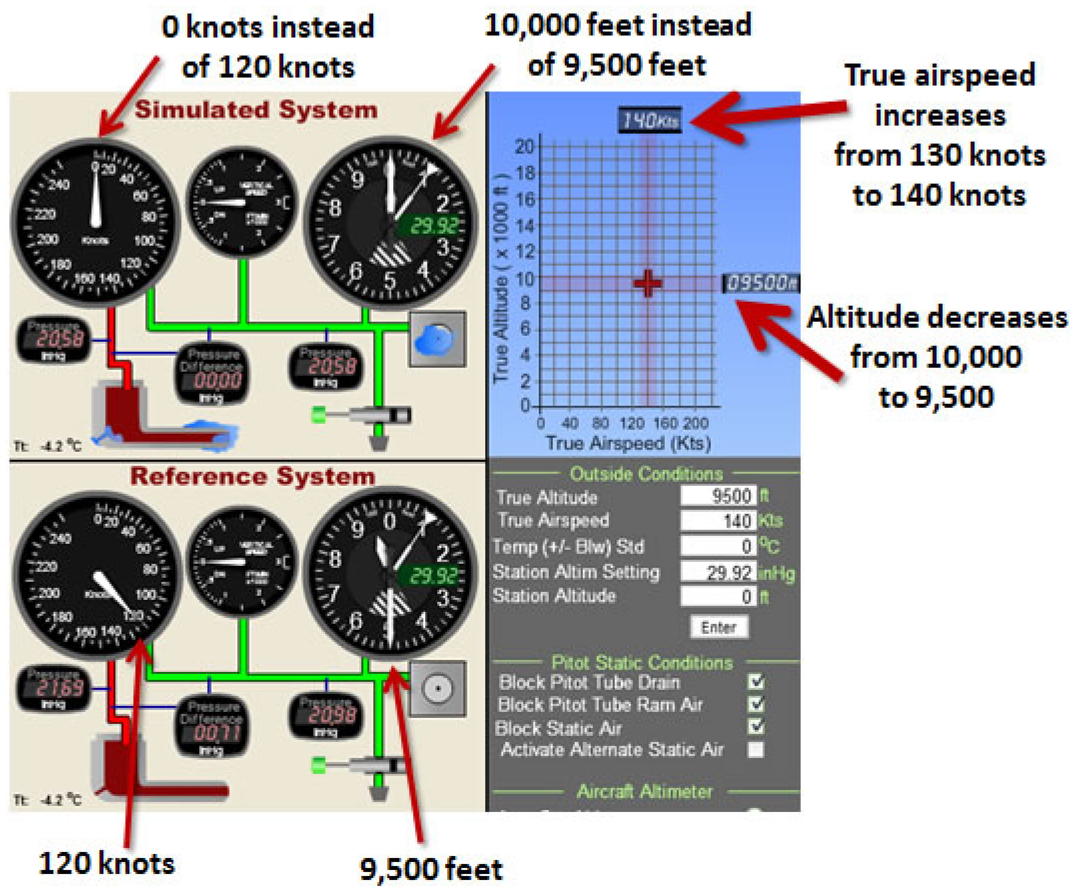

Fig 4-20 Aircraft descends 500 feet and increases true airspeed by 10 knots.

Any time the three openings (static port, ram air and Pitot tube drain) in the Pitot static system are blocked all the instruments will freeze. An increase in true airspeed and a decrease in altitude have no effect on the airspeed indicator, vertical speed indicator and altimeter (Fig 4-20).

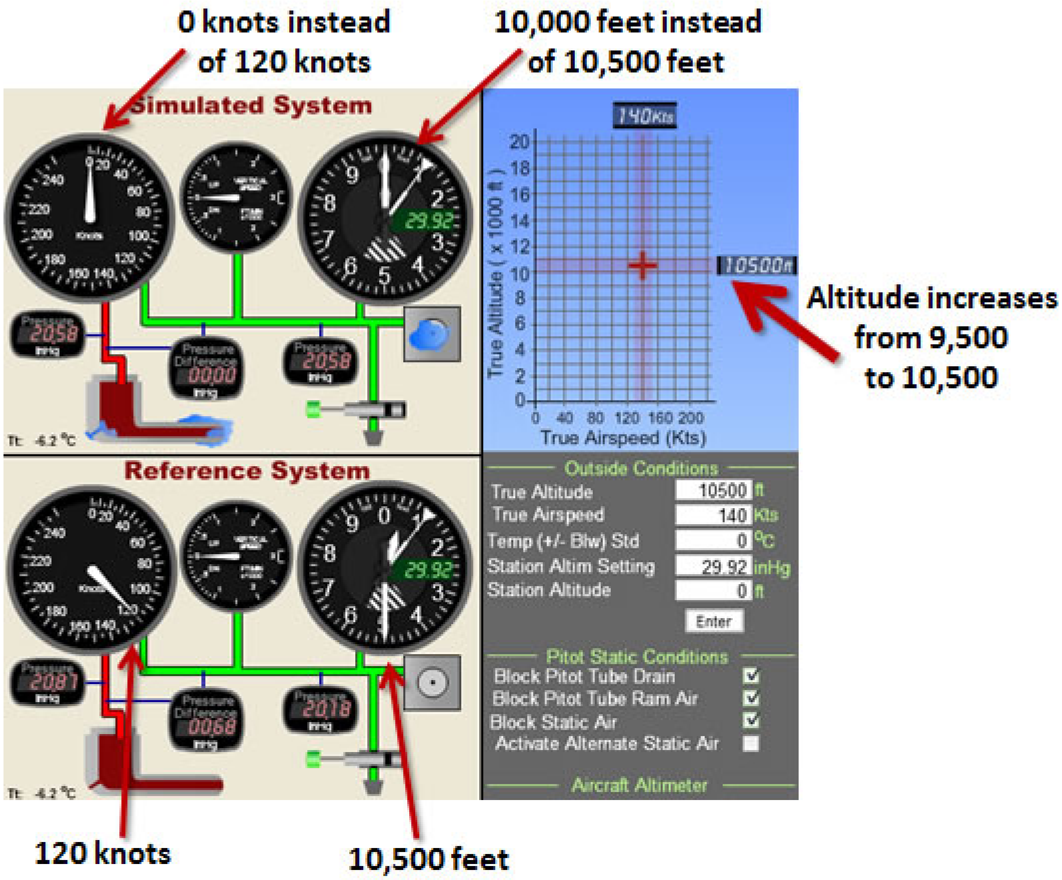

Fig 4-21 Aircraft climbs 1000 feet (500 feet above blockage altitude) and maintains airspeed.

In figure 4-21 the aircraft climbs to 10,500 feet. As expected the change in altitude had no effect since all three openings are blocked.

Possible actions that the pilot can take to clear these blockages include activating the alternate static air port (if available) which should get the vertical speed indicator and altimeter to function with a slight error. If the obstruction of the ram air opening and Pitot tube drain opening are due to ice, the pilot can activate the Pitot tube heat.

2a. Ram air blocked, but static port and Pitot tube drain remain unobstructed.

If only the ram air port (opening) is blocked the airspeed indicator will go to zero. Both the altimeter and vertical speed indicator are not affected since they don't use the ram air pressure. If this port remains the only one blocked the zero indication will remain regardless of any altitude or airspeed change.

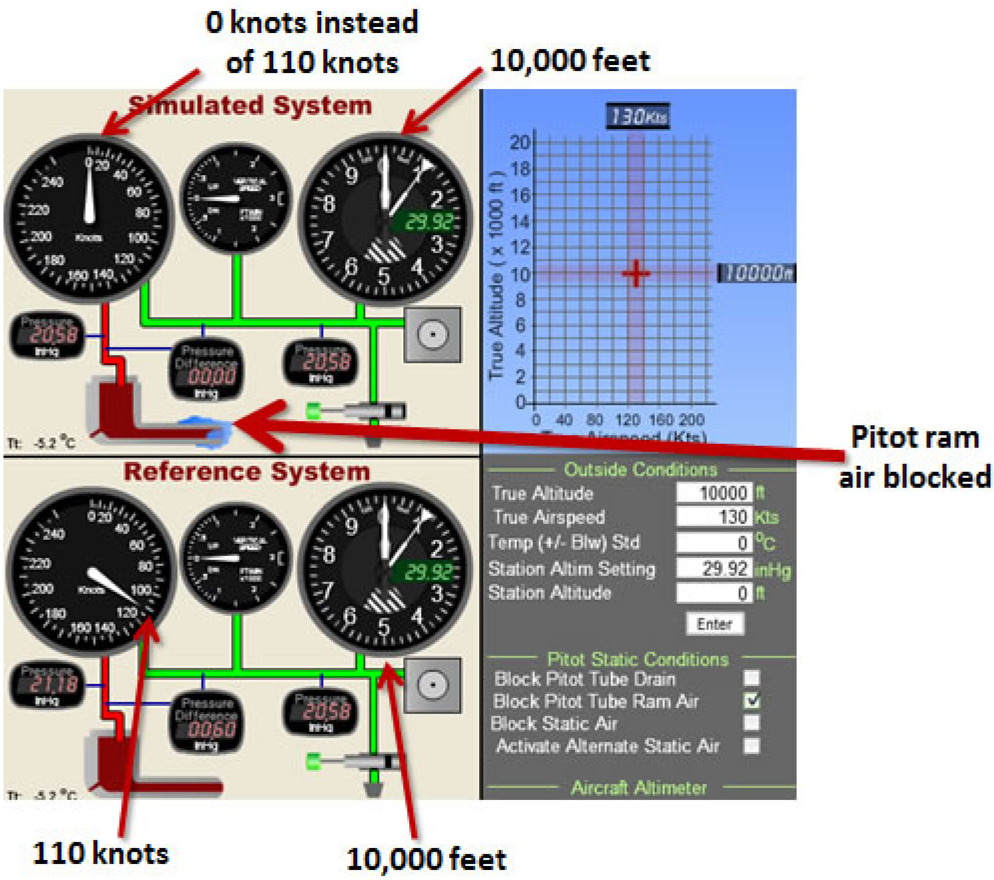

Fig 4-22 Pitot ram air blocked at an altitude of 10,000 feet and 130 knots true airspeed.

In figure 4-22 we have the aircraft flying at 10,000 feet and 130 knots true airspeed when the blockage occurs. The airspeed indicator which was showing 110 knots indicated airspeed before the blockage, now drops to zero. This is due to the difference in pressure between the Pitot tube chamber and the air in the static air line being 20.58 - 20.58 = 0 inHg which corresponds to a zero indicated airspeed (see chart 2-3). The reason for the pressure in the Pitot tube chamber being the same as the outside pressure, is that the Pitot tube drain allows air pressure to equalize with the outside air pressure. The reference system shows what would happen if the blockage did not occur. The correct reading on the airspeed indicator would be 110 knots because we have $q_c = P_T - P = 21.18 - 20.58 = 0.60$ inHg (see chart 2-3).

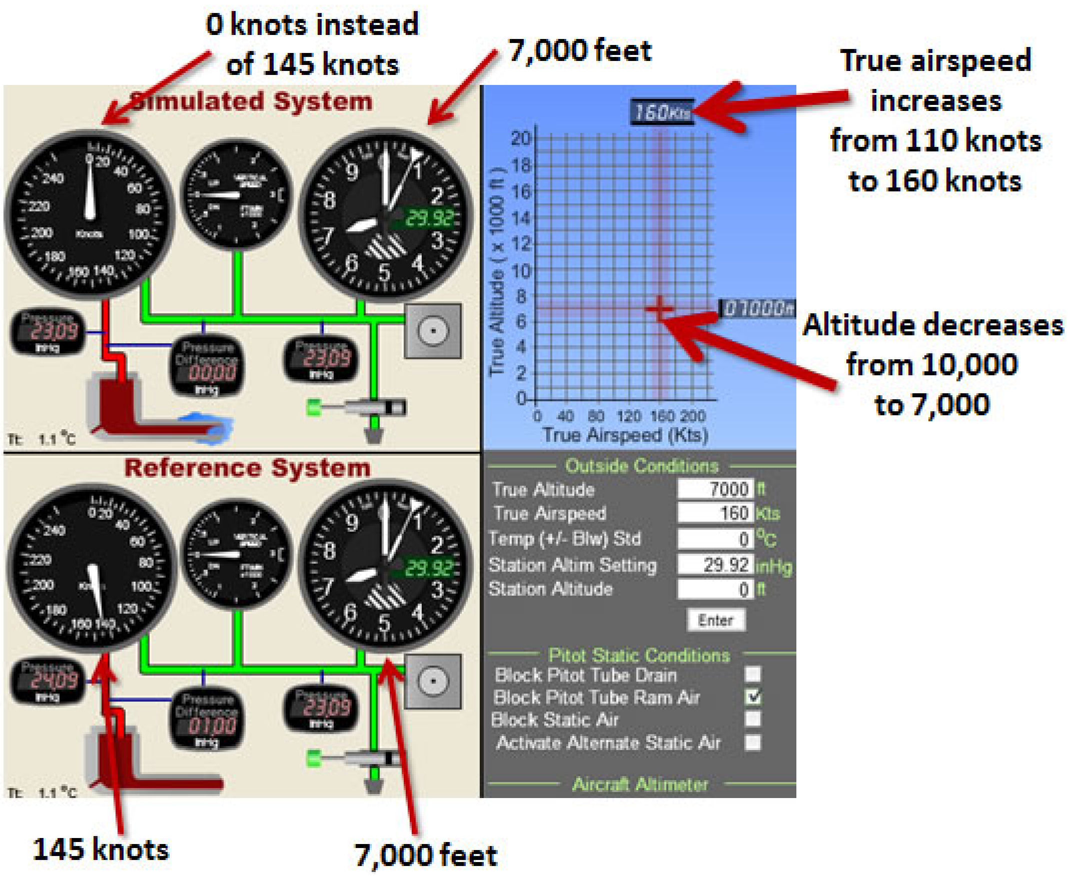

Fig 4-23 Aircraft descends 3000 feet and increases true airspeed by 50 knots.

In this example the aircraft then increases airspeed to 160 knots and descends to 7000 feet. As shown by the simulator (Fig 4-23), the indicated airspeed remains at zero. The pressure inside the Pitot tube chamber will be the same as the pressure outside the aircraft (23.09 inHg) because the drain opening will allow the pressure to equalize with the outside air. The difference in pressure between this chamber and the air in the static air line is 23.09 - 23.09 = 0 inHg which corresponds to a zero indicated airspeed (see chart 2-3). Therefore the airspeed indicator remains at zero even with altitude and airspeed change. The reference system shows that the correct reading on the airspeed indicator would be about 145 knots since we have $q_c = P_T - P = 24.09 - 23.09 = 1.00$ inHg (see chart 2-3).

Note that if the static air then becomes obstructed after the ram air port, the problem becomes scenario 1b. If the Pitot tube drain becomes obstructed as well after the ram air port, the problem becomes scenario 1e. If the static air is not obstructed Scenario 1b becomes scenario 2b when the Pitot tube drain becomes obstructed.

2b. Ram air blocked first and then Pitot tube drain blocked; static port drain remains unobstructed.

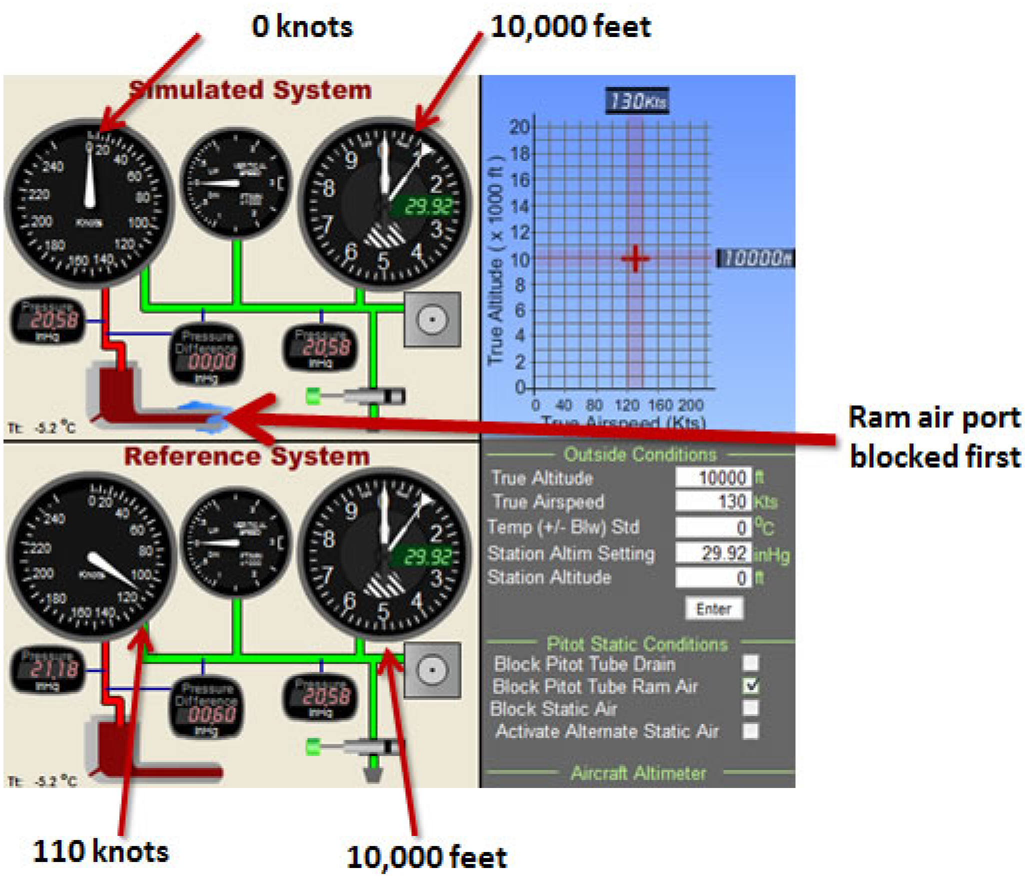

Fig 4-24 Ram air gets blocked while at 10,000 feet and 130 knots true airspeed.

As the aircraft flies at 10,000 feet and 130 knots true airspeed, the ram air port gets blocked. When this happens the indicated airspeed will drop to zero. This is due to the pressure inside the Pitot tube chamber equalizing with the outside air through the drain opening. Now the difference in pressure between the Pitot tube chamber (20.58 inHg) and the static air line (20.58 inHg) is zero inHg which corresponds to zero indicated airspeed (see chart 2-3).

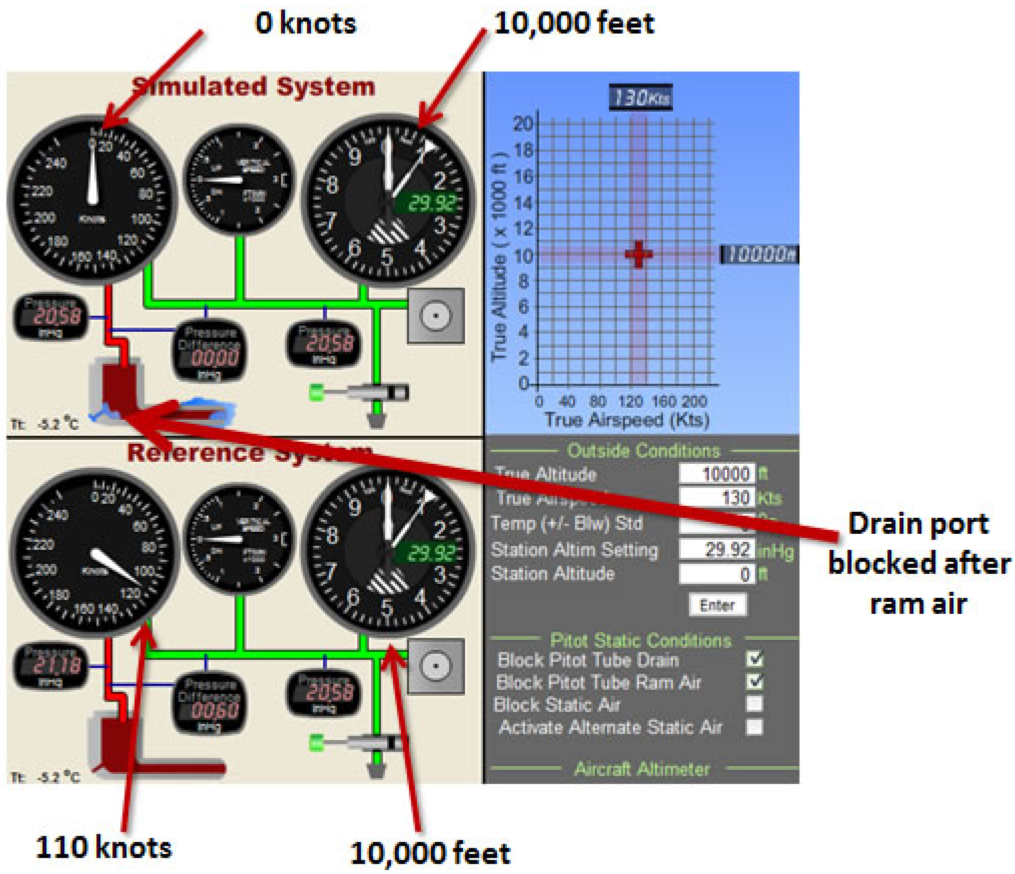

Fig 4-25 Pitot tube drain gets blocked after ram air.

Following the ram air getting blocked, the drain opening also gets blocked. If the aircraft maintains altitude there isn't any additional noticeable change in the instruments when this happens. The air, however, is now trapped inside the Pitot tube chamber (20.58 inHg of pressure) since the drain opening is now also blocked and does not allow any air to get in or out. The airspeed indicator will now behave similarly to the 3b scenario except that instead of the airspeed indicator showing the last indicated airspeed at the altitude where the blockage occurred, it will show zero at that altitude. However it will increase from zero if altitude increases.

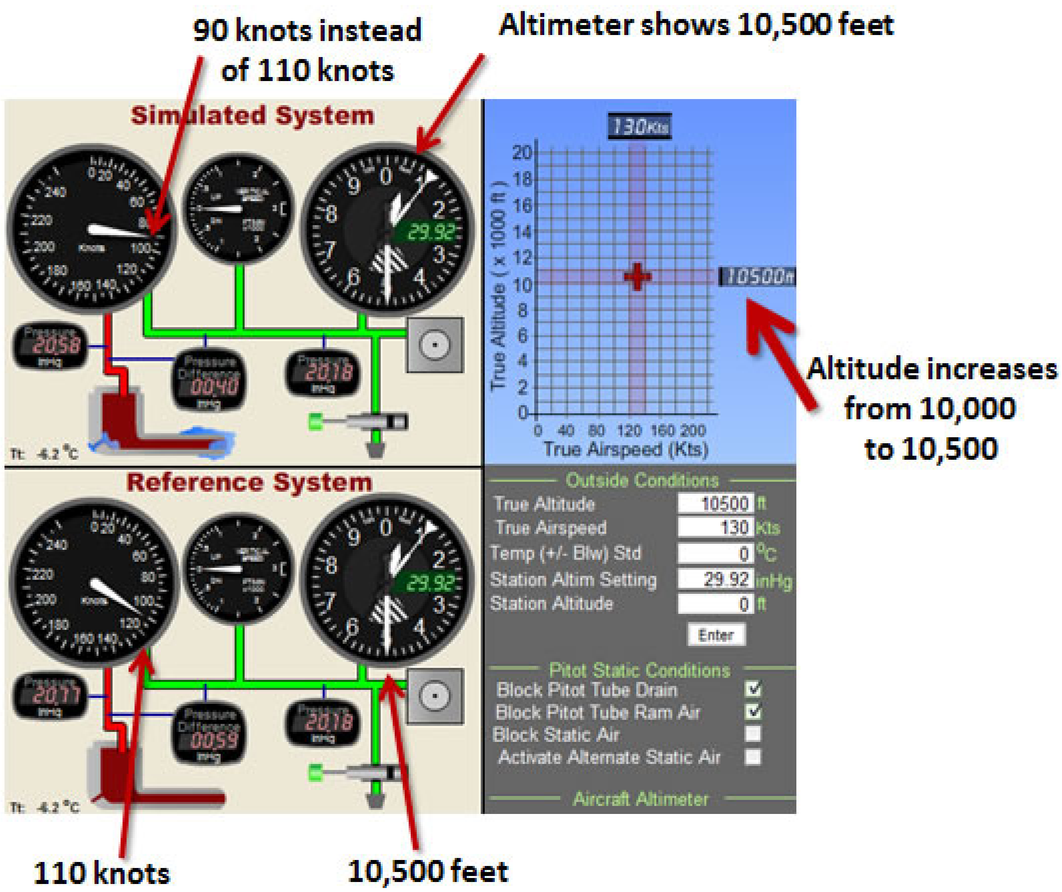

Fig 4-26 Aircraft climbs 500 feet to 10,500 feet while maintaining the same airspeed.

If the aircraft climbs the airspeed indicator will increase regardless of the aircraft's airspeed. Here the aircraft climbs 500 feet (from 10,000 feet to 10,500 feet). the reason for the increase is that the difference in pressure (0.40 inHg) between the Pitot tube chamber (20.58 inHg which is trapped) is compared to a lesser pressure in the static line (20.18 inHg) since the aircraft is at a higher altitude. This difference of 0.40 inHg corresponds to an indicated airspeed reading of approximately 90 knots (see chart 2-3).

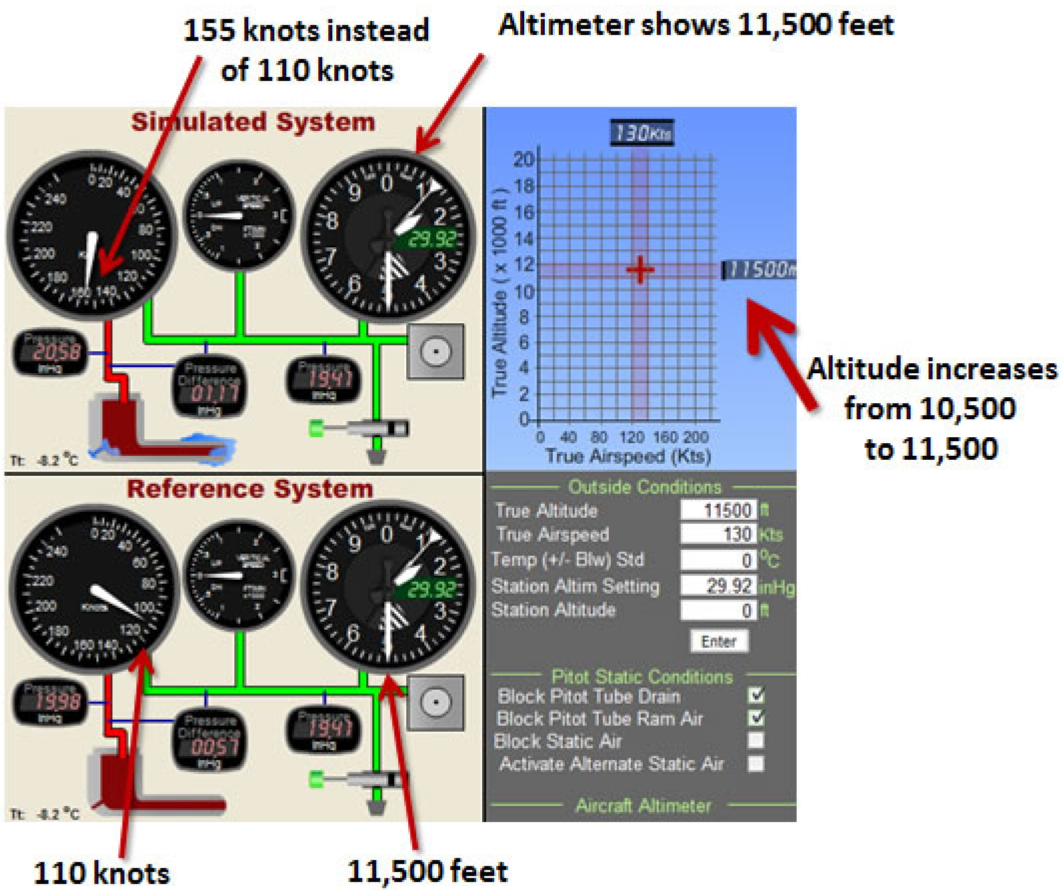

Fig 4-27 Aircraft climbs 1000 feet to 11,500 feet still maintaining the same airspeed.

As the altitude increases from 10,500 feet to 11,500 feet the airspeed indication increases even further. The difference between the Pitot tube chamber (20.58 inHg) and the static line (19.47) is now 1.17 inHg which corresponds to an indicated airspeed of approximately 155 knots (see chart 2-3).

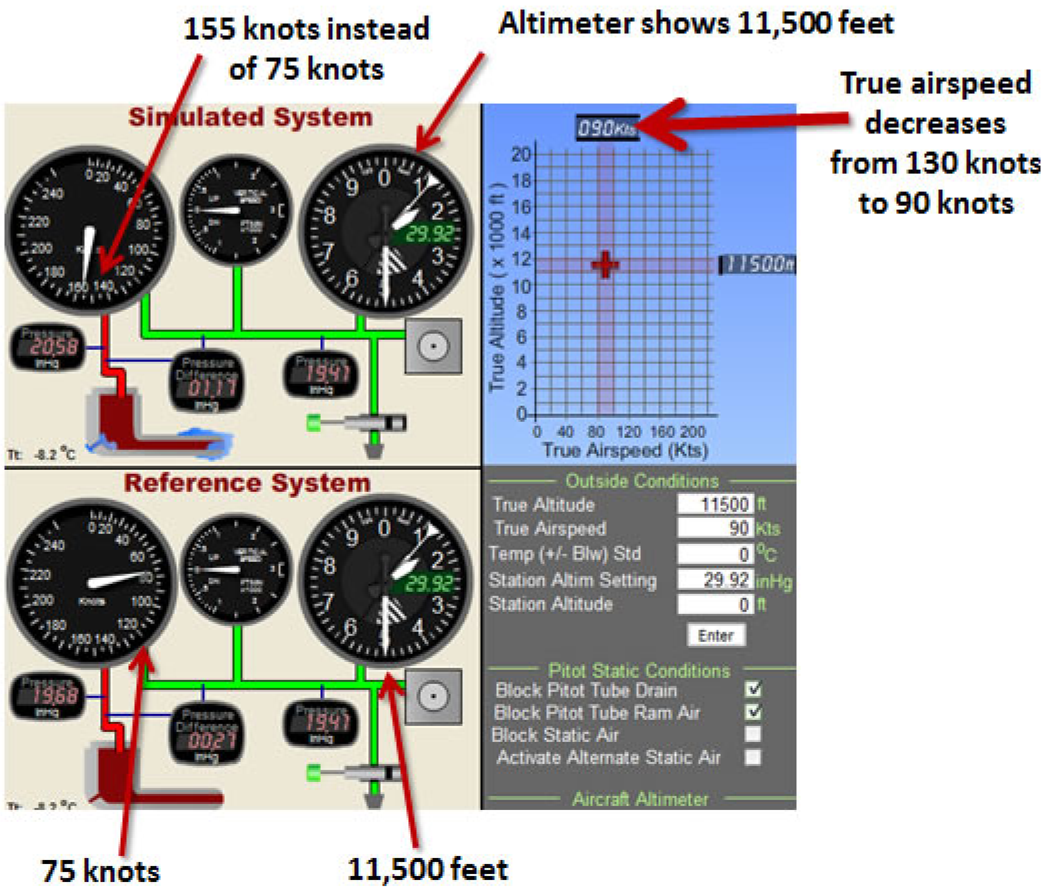

Fig 4-28 The true airspeed decreases from 130 knots to 90 knots while maintaining altitude.

Here the aircraft maintains altitude and decreases the true airspeed from 130 knots to 90 knots. Since the ram air is blocked, airspeed has no influence in the airspeed indication which remains at 155 knots. This indication will only change if there is a change in altitude. Note the difference in pressure remains exactly the same at 1.17 inHg.

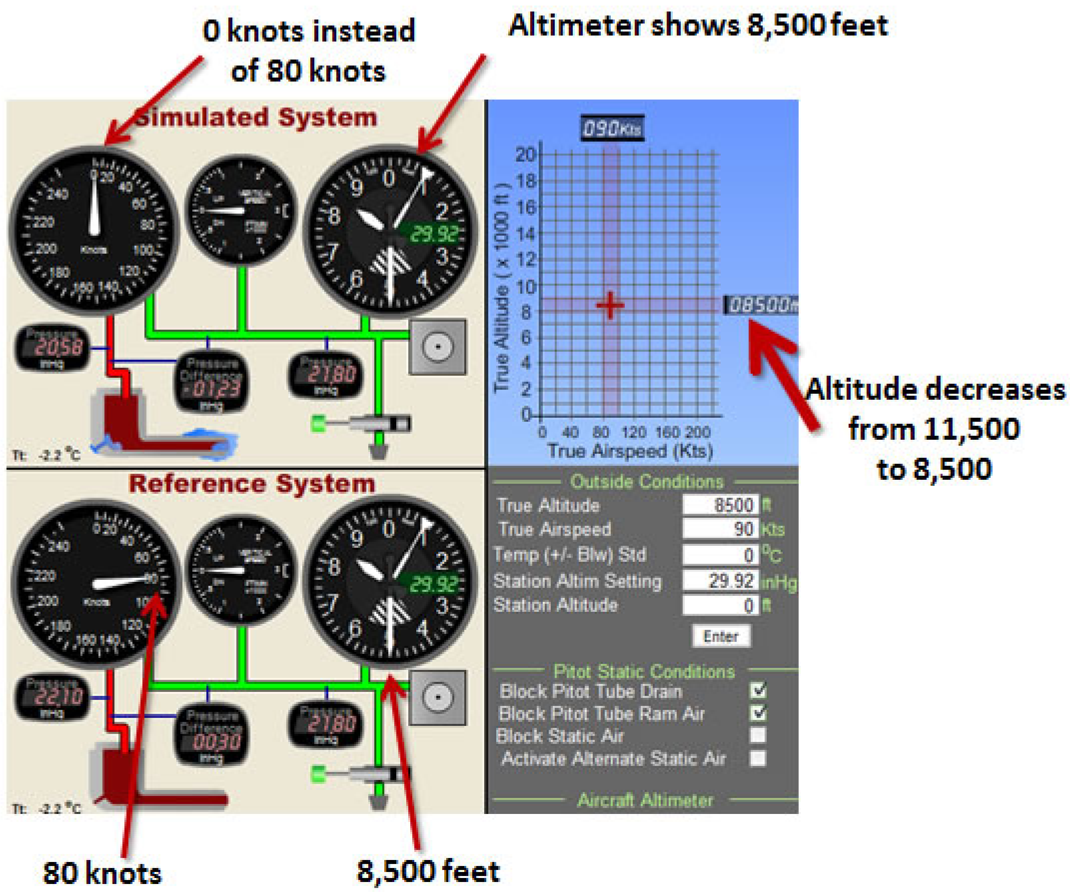

Fig 4-29 Aircraft maintains airspeed and descends 3,000 feet to 8,500 feet.

Any decrease in altitude below the altitude in which the Pitot drain was blocked (10,000 feet in this case) will result in a negative difference in pressure between the Pitot tube chamber and the static line. As a result the airspeed indicator will show a zero indication (assuming there is a stop for the needle, otherwise the needle will go off the scale). Here the aircraft descends 1500 feet below the blockage altitude of the drain and ram air. The difference in pressure between the chamber and static line is now -1.23 inHg.

If the static port also gets blocked this scenario becomes scenario 1e and the airspeed indicator, VSI and altimeter will freeze at their current indications.

3a. Pitot tube drain blocked; ram air and static air ports remain unobstructed.

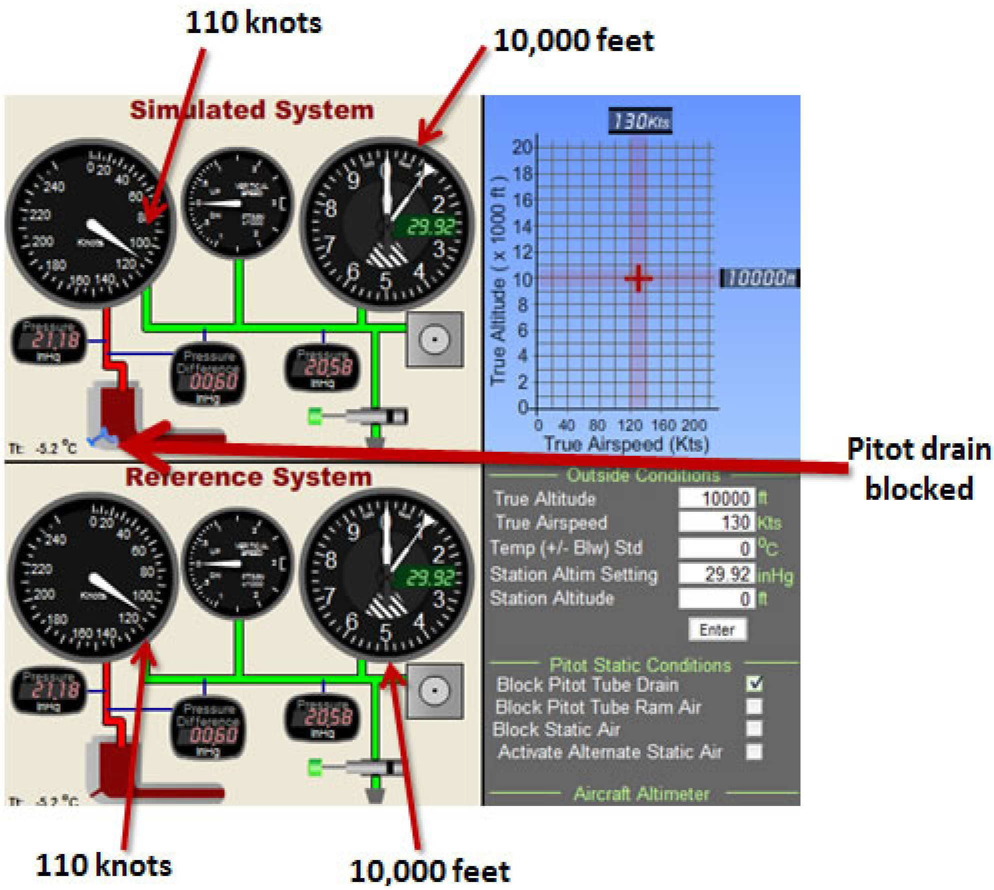

Fig 4-30 Pitot tube drain blocked at an altitude of 10,000 feet and 130 knots true airspeed.

At 10,000 feet and at a true airspeed of 130 knots (which corresponds to 110 knots of indicated airspeed in this case) only the Pitot Pitot tube drain is blocked (Fig 4-30). There should be no effect on the instruments since the Pitot tube drain is too small to affect the pressure of the ram air significantly in the Pitot tube chamber.

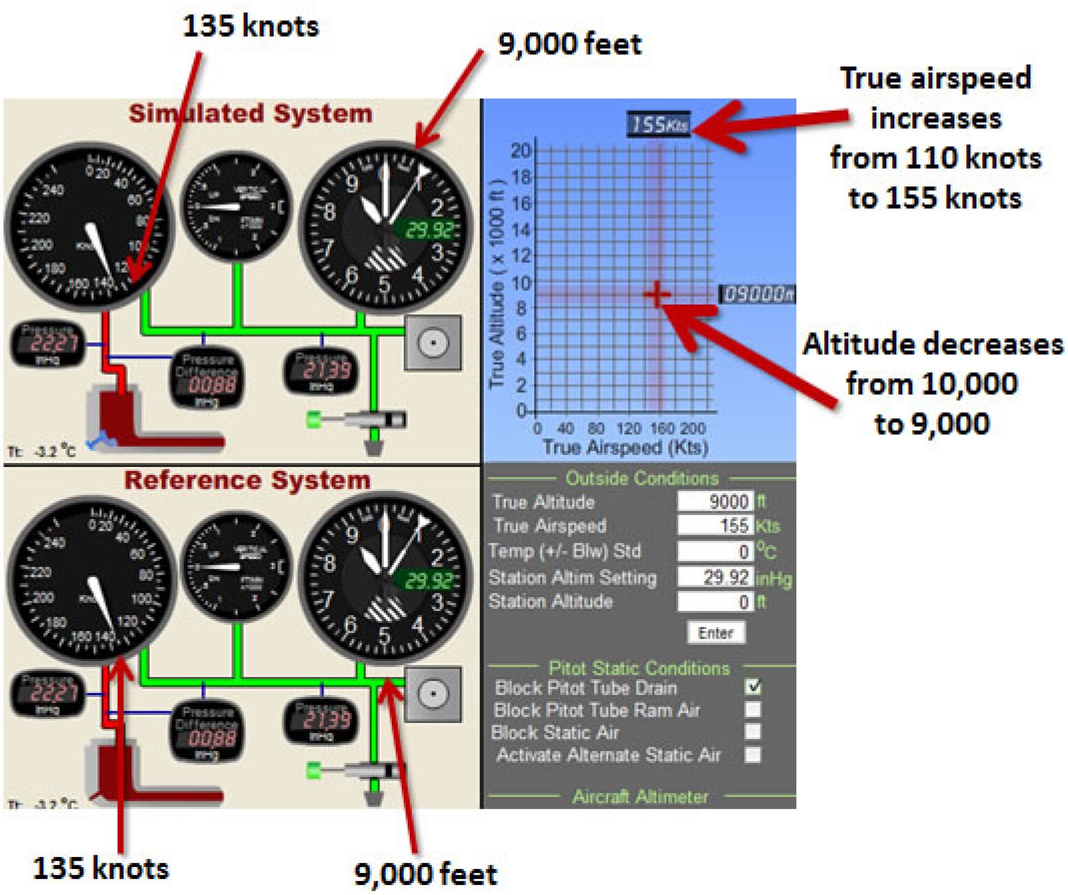

Fig 4-31 Aircraft descends 1000 feet and increases airspeed by 25 knots.

The aircraft then increases airspeed to 155 knots true airspeed (corresponding to 135 knots) and descends to 9000 feet (Fig 4-31). In both the simulated system and the reference system the indications by the instruments are the same. In other words if only the Pitot tube drain in the Pitot tube is blocked there is no effect on the instruments. Note the pressure of 22.27 inHg which is the ram air pressure sensed by the airspeed indicator is not altered by that drain obstruction. In addition, the vertical speed indicator and altimeter are not connected to the Pitot tube where the drain is located and therefore cannot be affected. The vertical speed indicator and altimeter are only affected by static port blockages since they rely on static air.

If the ram air then becomes obstructed after the Pitot tube drain, the problem becomes scenario 3b. If the static air becomes obstructed after the Pitot tube drain, the problem becomes scenario 1c.

3b. Pitot tube drain blocked first; then ram air blocked; static port remains unobstructed.

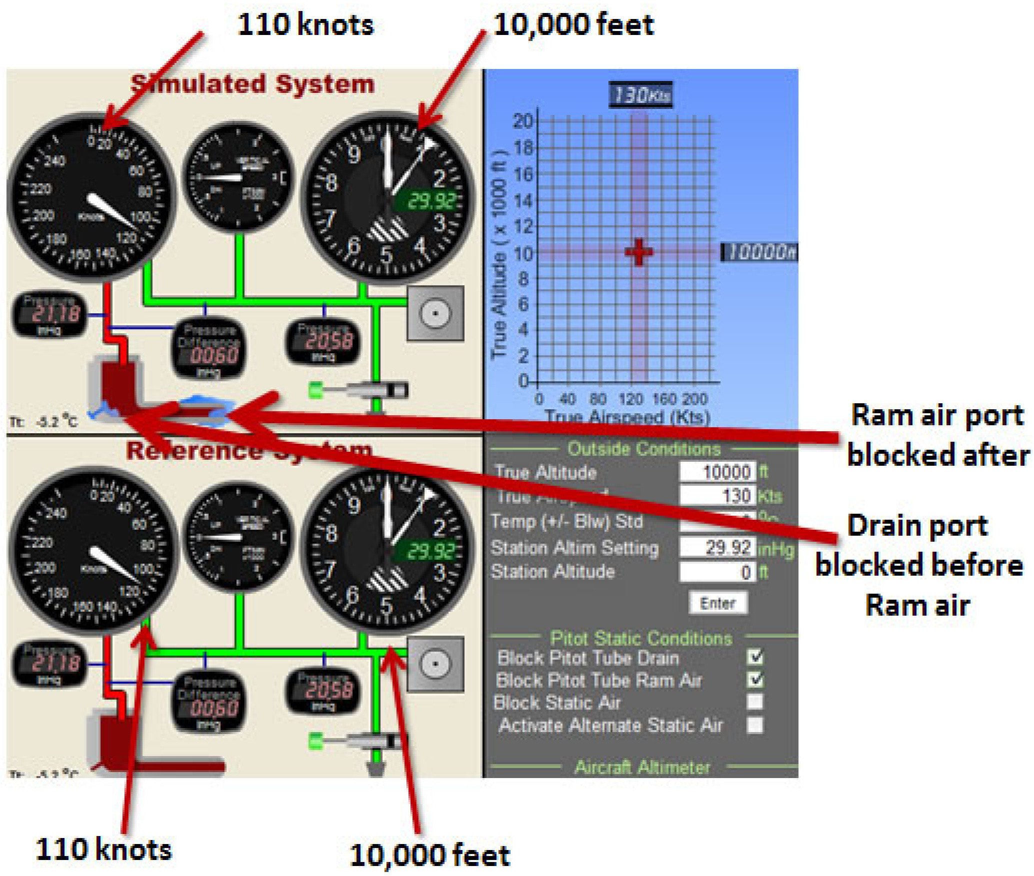

Fig 4-32 Pitot tube drain blocked followed by ram air port at 10,000 feet and at a true airspeed of 130 knots.

Suppose an aircraft is flying at 10,000 feet and is at a true airspeed of 130 knots. The Pitot tube drain then becomes blocked, followed by the ram air port (Fig 4-32). Since the static port remains unobstructed, there is no effect in either the VSI or altimeter. If the aircraft maintains altitude the pilot will not notice any changes in the airspeed indicator even if airspeed changes the airspeed. In this situation, because the air in the Pitot tube chamber is trapped, the pressure (21.18 inHg) will remain the same in this chamber regardless of any airspeed for altitude change. Since the airspeed indicator measures the difference in pressure between the air in this chamber and the static air line, the airspeed indicator will now move when altitude changes because the static pressure will change with altitude.

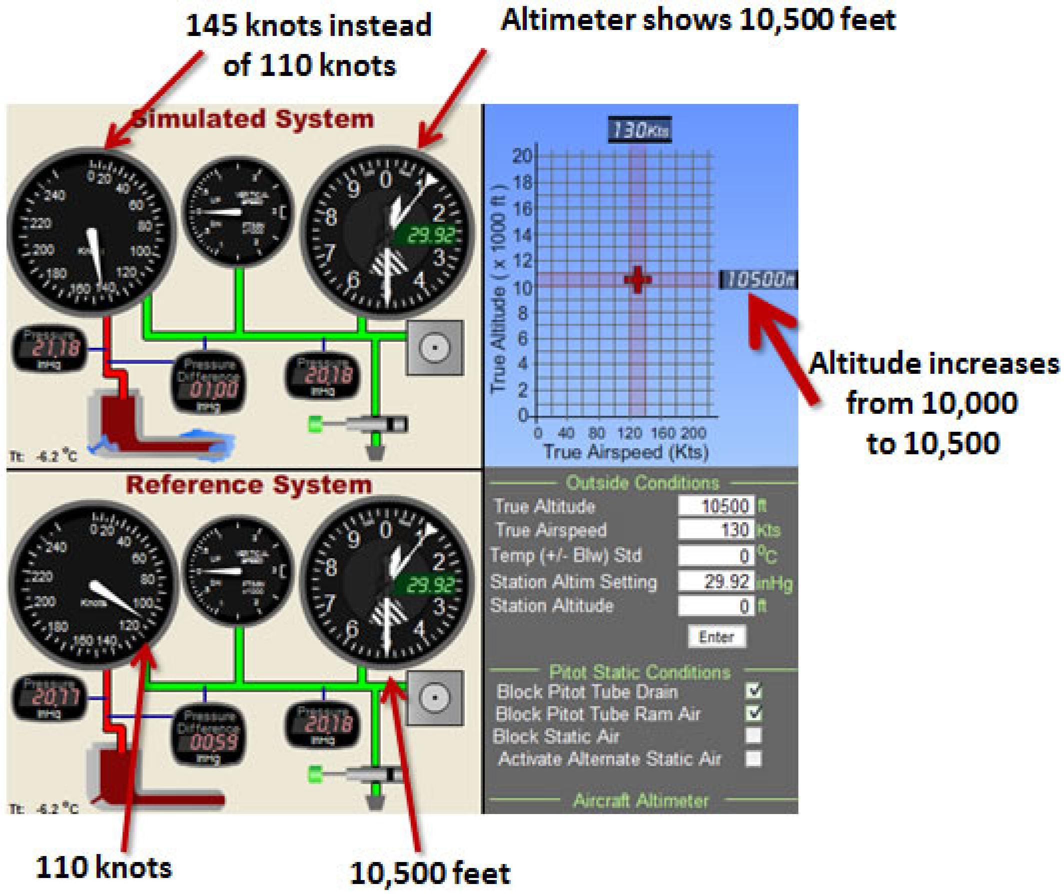

Fig 4-33 Aircraft climbs 500 feet and maintains airspeed.

Let's see what happens when the aircraft climbs 500 feet to 10,500 feet (Fig 4-33). Because the static air pressure decreases with altitude the airspeed indicator will be measuring a greater difference in pressure (21.18 inHg of the chamber and 20.18 inHg of the static air line). The resulting difference of 1.00 inHg corresponds now to approximately 145 knots instead of what it should be showing (110 knots). Looking at the reference system we can confirm that at the correct difference: $q_c = P_T - P = 20.77 - 20.18 = 0.59$ inHg, the indicated airspeed should be 110 knots (see chart 2-3). In other words, in just 500 feet, the difference in airspeed is 35 knots (assuming that true airspeed of the aircraft has not changed, which it hasn't in this example). Notice how the direction in which the airspeed changes is in the opposite direction of scenarios 1a, 1b, 1c and 3a. This is why this situation may be particularly dangerous. Pilots are used to having their airspeeds decrease when pulling back on the yoke which usually results in an increase in altitude. Here the pilot may pull back on the yoke and since the airspeed indicator would show an increase in airspeed, the pilot may pull the yoke back even further. This may lead the aircraft into a stall or loss of control before the pilot recognizes there's a problem, quickly!

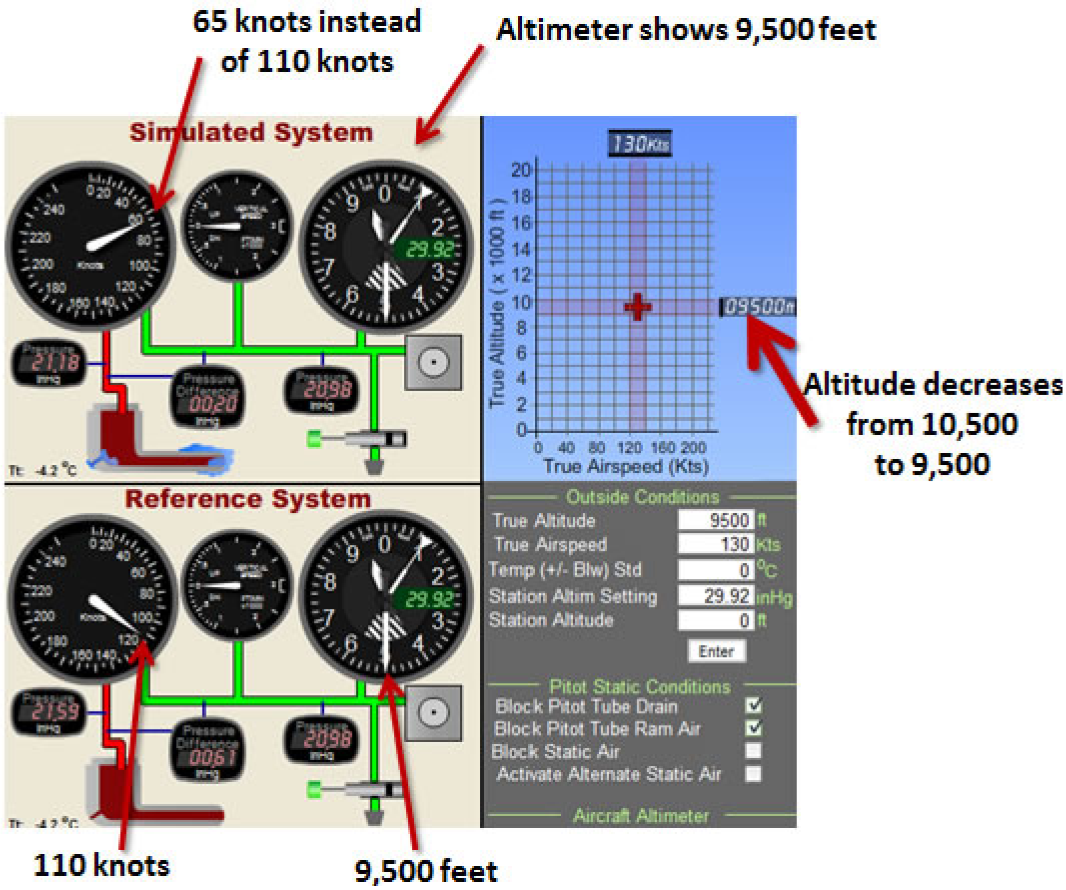

Fig 4-34 Aircraft descends 1000 feet and maintains airspeed.

Here we have the aircraft descending from 10,500 to 9,500 feet (Fig 4-34). As expected, the indicated airspeed decreases. It is said that in this type of blockage situation the airspeed indicator will have an altimeter like behavior. In other words the indication will rise if the altitude increases and will lower if the altitude decreases. Notice that the difference between the air pressure in the Pitot tube chamber (21.18 inHg) and the static air line (20.98inHg) which is now greater, is 0.20 inHg. 65 knots (see chart 2-3) is the indicated airspeed that corresponds to that difference in pressure. Here the altitude of 500 feet below the altitude at which the blockage occurred produces a difference of 45 knots (once again, assuming that true airspeed of the aircraft has not changed, which it hasn't in this example). One of the dangers here is that the pilot sees a decrease in airspeed, pushes the yoke even more forward causing the aircraft to descend more which makes the indication of the airspeed indicator decrease further. The aircraft can easily overspeed, lose control or crash in the terrain below if the pilot does not recognise the problem.

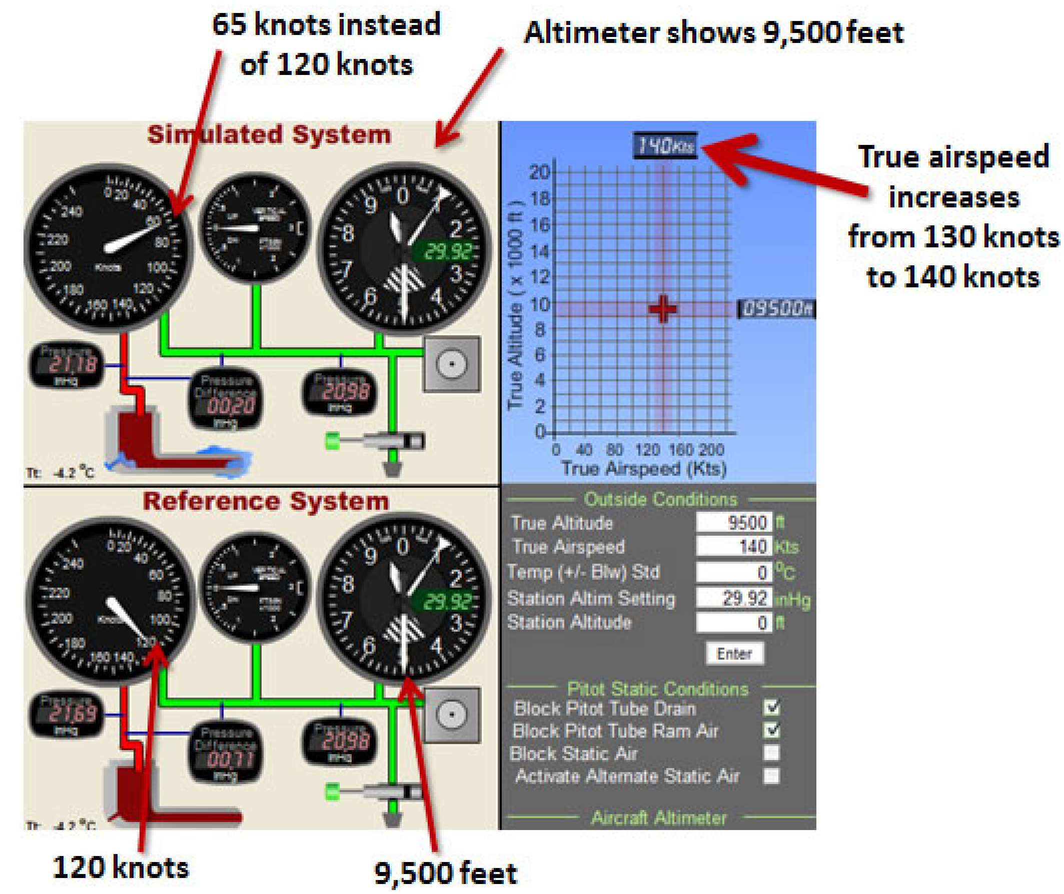

Fig 4-35 Aircraft maintains altitude and increases airspeed by 10 knots.

If the aircraft maintains altitude and increases its true airspeed to 140 knots there is absolutely no effect in the airspeed indicator (Fig 4-35) since airspeed has no effect when the ram air is blocked.

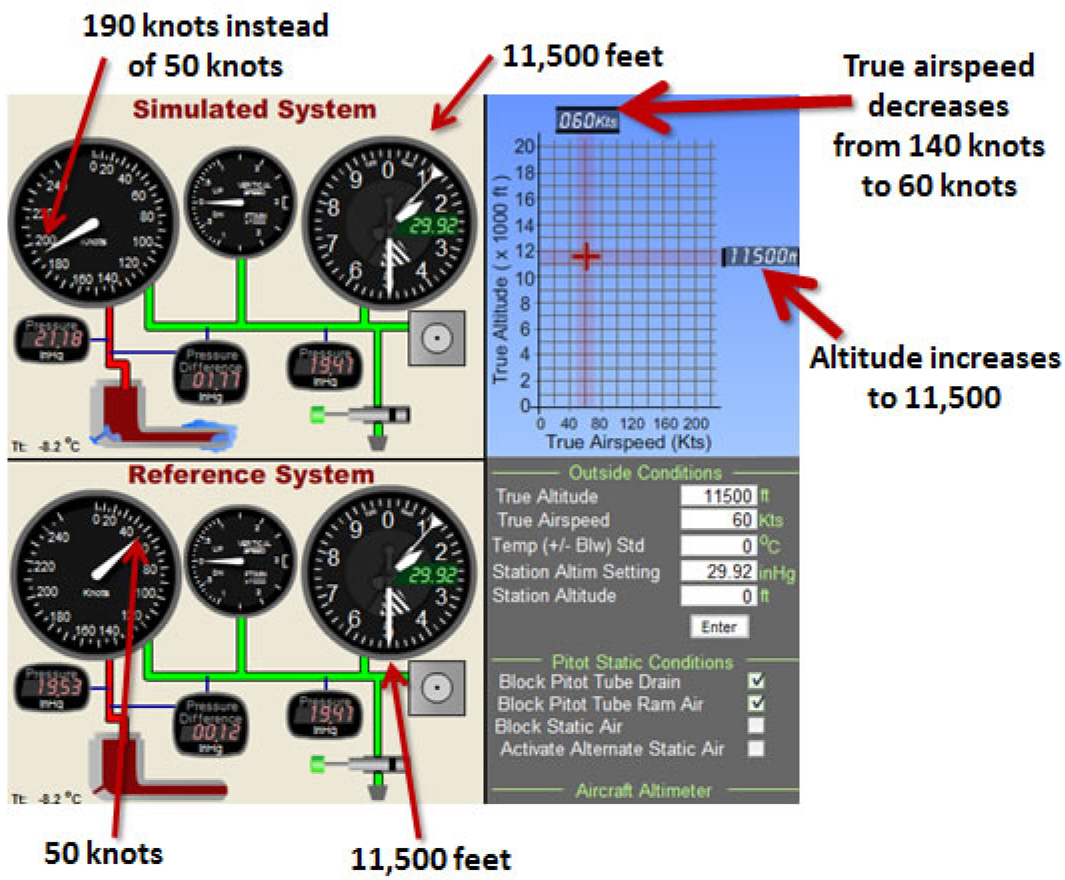

Fig 4-36 Aircraft climbs 2000 feet and reduces true airspeed by 80 knots.

Here in figure 3-36 we have what may happen if the pilot were to pull back on the yoke (causing a climb) in attempt to slow down the aircraft. The true airspeed could slow down to 60 knots as the aircraft climbs to 11,500 feet while the pilot would see an indication of 190 knots instead of the correct indication (see reference system) of 50 knots. The 190 knots (see chart 2-3) corresponds to the difference in pressure of 1.77 inHg between the Pitot tube chamber (21.18 inHg) and the static air line (19.41 inHg).

If the static port also gets blocked this scenario becomes scenario 1d and the airspeed indicator, VSI and altimeter will freeze at their current indications.

V - Disclaimer

IMPORTANT: The statements, technical information and recommendations contained herein are believed to be accurate as of the date hereof. Since the conditions and methods of use of the information referred to herein are beyond our control, luizmonteiro.com expressly disclaims any and all liability as to any results obtained or arising from any use of such information; NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, IS MADE CONCERNING THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specific situations and may not be applicable in certain circumstances. The user should thoroughly test any procedure in an appropriately certified simulator before applying the concepts in real flight. Please also read the general website declaimer at http://www.luizmonteiro.com/Disclaimer.aspx

VI - References

1. 1976 Standard Atmosphere, U.S. Government Printing Office, Washington, D.C., 1976

2. Naval Test Pilot School Flight Test Manual, Fixed Wing Performance, Chapter 2, USNTPS-FTM-No.108, Veda Incorporated
Contract N00421-90-C-0022, September, 1992.