THE COMPLETE ADVANCED PILOT

A COMBINED COMMERCIAL & INSTRUMENT COURSE

SIXTH EDITION

Bob Gardner

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AVIATION SUPPLIES & ACADEMICS
NEWCASTLE, WASHINGTON

The Complete Advanced Pilot: A Combined Commercial & Instrument Course
Sixth Edition
by Bob Gardner

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CONTENTS

3 Performance

4 Navigation

5 Weather

9 Arrivals

10 Instrument Approaches

FOREWORD

As an aviation educator and journalist, I receive an abundance of e-mail asking aviation questions, often-complex ones. My answers are always prompt and wonderfully informational because an airline Captain knows everything. I confess: Two things I know readily are what bookshelf Bob Gardner's books are located on for easy reference, and I know Bob Gardner's phone number. Together with my own 39 years of experience that encompasses "knowing just about everything."

In reading the Foreword written several years ago complimenting Bob's *The Complete Advanced Pilot*, I'm tempted to underline many comments, but not alter anything. The latest edition amplifies in some areas, updates to current procedures, corrects a couple minor errors and is another outstanding exhibit of Bob's mastery of aviation academics.

The addition of color pages makes it possible for Bob to just scratch the surface of all that is new with graphic weather reports and forecasts. Like peeling an onion, each new web page exposes more information for planning.

Therefore, from the previous Foreword, I repeat with utmost sincerity:

In a long and rewarding friendship, Bob Gardner has always delighted me with his multitude of talents. Foremost in my inventory, he is a total gentleman, a giving and caring person who is driven to share all the knowledge he's accumulated throughout a diverse and impressive career.

His aviation experience is abundant: a flight instructor, charter pilot, corporate and freight Captain, ground school instructor, splendid speaker and dedicated educator. He has again documented decades of accumulated knowledge in another brilliantly organized instructional adventure: *The Complete Advanced Pilot*. As with all of his books, Bob's organized mind carves a route for you to reach complex destinations of understanding through simple road maps of educational travel.

To make the complex simple is the accomplishment of the capable teacher. The need to share and give and uplift are attributes of a person of quality. I find Bob's book exceptionally readable, splendidly sectioned for ready reference for virtually any topic, and supplemented with the caliber of personal experience that integrates "technique" into "procedure" with mastery.

Someone once defined for me the specifics of the "good" and the "bad" teacher. The latter always held back, denied to others some ingredient of his personal knowledge, retained and guarded some educational asset that set him above the bunch. Bob Gardner has always met the "good" definition, wanting you to know everything he's learned, in ways you can employ it, and to gain the confidence that you have become an enlightened and safe pilot by having absorbed all that this good man can give to you.

I'm grateful for the opportunity to review and comment upon the latest educational achievement by Bob Gardner. As my peer, friend and fellow educator, Bob never fails to earn my applause and endorsement.

Capt. Dave Gwinn, TWA-Retired
June 2008

About the Author

Bob Gardner has always been an admired member of the aviation community. He began his flying career as a hobby in 1960, during his time in the U.S. Coast Guard in Alaska. By 1966 Bob earned his Private land and sea, Commercial, Instrument, Instructor, CFII, and MEL. Over the next 16 years he was an instructor, charter pilot, corporate and freight Captain, and served as Director of ASA Ground Schools.

Bob holds an ATP certificate with single- and multi-engine land ratings; a CFI certificate with instrument and multi-engine land ratings; and a Ground Instructor's Certificate with advanced and instrument ratings. He has been a Gold Seal Instructor and has been flight instructing for many years, with an impressive list of additional accomplishments as a well-known author, journalist, and airshow lecturer.

Books by Bob Gardner

The Complete Private Pilot

The Complete Multi-Engine Pilot

The Complete Advanced Pilot: A Combined Commercial/Instrument Course

Say Again Please: Guide to Radio Communications

INTRODUCTION

Just what is "an advanced pilot"? My definition is a pilot with a commercial certificate and an instrument rating. This certificate and rating will allow you to have a long and enjoyable career in aviation. Sure, a multi-engine rating is valuable, but thousands of pilots have flown thousands of revenue hours without ever flying a twin. And if the Airline Transport Pilot Certificate is the Ph.D. of aviation, the commercial and instrument tickets represent the bachelor's and master's degrees.

Most private pilots aim for the instrument rating first, knowing they can get started right away while their brains are used to studying. They also know that the ability to fly in the clouds will speed up the progress of acquiring the 250-hour minimum for the commercial pilot certificate (Part 61). Many pilots have no interest in getting a commercial certificate but want the instrument rating so they can free themselves of VFR restrictions.

All of these pilots face knowledge examinations—one in the case of the noncommercial aviator, two for the pilot who wants to fly for money. Some of the required information overlaps; for example, both examinations test your knowledge of weather, weight and balance, and regulations. I'm going to handle that by having two sets of review questions where appropriate—read all of the text and then check your understanding by doing the review questions for the proper knowledge test. All review questions for this edition have been taken from FAA test databases.

Where information is unique to instrument flight or to commercial operations I will make that clear, and of course there will be whole chapters that apply to only one of your immediate goals. I will lead off

with the instrument rating information because that applies to all of you, and finish with what you need to fly for hire.

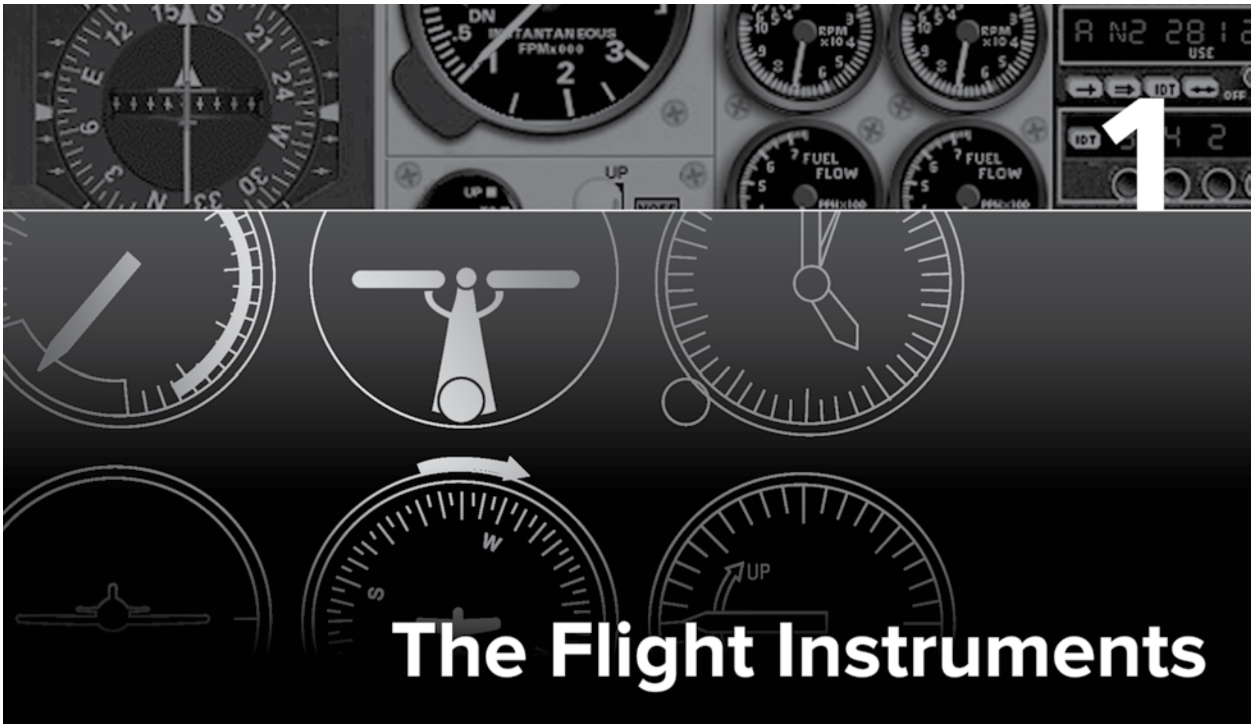
Some of the information may seem basic. There are two reasons for this: Many prospective commercial pilots earned the private certificate many years ago, so some review is helpful; also, the commercial knowledge exam explores some operational areas in more depth than did the private pilot knowledge exam. However, I am not going to cover all of the private pilot information that you have needed to know in order to fly safely up to this point. If it has been a long time since you reviewed the knowledge requirements of a Private ticket, it might benefit you to review *The Complete Private Pilot*.

This introduction has implied a heavy emphasis on knowledge exams, but that is not my style as an instructor. What you need to know for the knowledge test represents less than half of the text—the rest is solid information you must have but the FAA doesn't ask about. To ace the test, use the appropriate ASA test preparation book.

You will also note an emphasis on computers, the internet, and the worldwide web. Most pilots are to some extent technically oriented, and it is estimated that well over half of all pilots use home computers for flight planning, acquiring weather information, maintaining their logbooks, etc. Accordingly, I have included access information wherever it is appropriate. As web surfers know, if you can find one webpage you will find links to dozens of other pages ready to be accessed with the click of a mouse button. You can reach me at bobmrg@comcast.net; I am also active in several internet forums such as AOPA, and Pilots of America.

The world of aviation is constantly changing and new information comes to light between editions of this book. Stay ahead of the game by going to www.asa2fly.com for resources and text updates. When I run across an article that expands on a subject beyond what I have written in this book, I upload it to the "Reader Resource" page there: www.asa2fly.com/reader/cap.

One final word: I am a flight instructor, and flight instructors love to talk. You should hear my voice in your ear as you read. Also, I know that it aids in understanding if some information is presented in different contexts—so if you see the same material in more than one section it is not due to poor editing but is intended to carry out an instructional purpose.



1 The Flight Instruments

You and Your Flight Instruments

The FAA will test your knowledge of the flight instruments on both the commercial and instrument knowledge examinations. The material in this chapter applies to both.

When you begin training for the instrument rating you must make a mental commitment to believe the indications of the flight instruments and to ignore physical clues to flight attitude. The days of instrument flight by "the seat of your pants" never existed. It takes commitment and concentration to sit in a cockpit with nothing to look at but a collection of gauges and to feel comfortable and confident in your ability to control the airplane, to know its position in space, and to guide it safely to your destination. It's an ego trip. Pilots are a special group, and instrument pilots are the cream of the crop.

It's difficult to place your faith in an instrument unless you know how it works, where it gets its information, and how to use its indications to control the airplane. We'll begin with how the flight instruments work and then examine the systems that allow them to function. In the next chapter, we will discuss how to develop the most efficient method of scanning the instruments.

The six basic flight instruments are divided into two groups by source of power or input: pitot-static and gyroscopic. Your knowledge of how each instrument derives its input will help you troubleshoot any erratic indications and isolate the instrument or system which has failed.

It's a Whole New World

For the immediate future, FAA Knowledge Exams will assume that your trainer has analog instruments, an arrangement known to pilots as a six-pack, and questions will be based on that assumption. Although there are a lot of whiz-bang new airplanes with digital instrumentation, chances are that you will train in an older plane with a six-pack. Your knowledge test will include questions about satellite navigation regulations and requirements but you will not be asked to interpret a display.

An electronic flight display, when compared to the legacy analog instruments, offers new capabilities and simplifies the flying task. The following sections will discuss where and how those instruments get their inputs. (To learn more, go to www.faa.gov and search for the *Advanced Avionics Handbook*, FAA-H-8083-6.)

Digital instruments get information from an Attitude and Heading Reference System (AHRS), a collection of solid-state or micro-electromechanical systems (MEMS) providing pitch, heading, and yaw signals to an electronic display. The errors inherent in analog instruments, which I discuss in detail, are vanishingly small in digital displays…until the power fails, in which case you must fall back on the required analog instruments: attitude indicator, airspeed indicator, and altimeter, all of which, hopefully, have power sources independent of ship's power.

The avionics industry has developed a number of battery-powered digital systems, some handheld, to solve this problem. I recommend that you invest in one.

One step up from the AHRS is the air-data reference system (ADHRS), which incorporates positioning information from a Global Positioning System (GPS) navigator plus airspeed and altitude into the basic AHRS.

Pitot-Static Instruments

The pitot-static system consists of a pitot (pressure-sensing) tube, a static (zero pressure) source, and related plumbing and filters. The pitot-static instruments are the airspeed indicator, the altimeter, and the vertical speed indicator; they measure changes in air pressure caused by the airplane's vertical and horizontal movements in the atmosphere (*see* Figure 1-1).

Airplanes equipped for instrument flight have pitot tube heaters, virtually identical to the resistance elements in your kitchen toaster, and they soak up a prodigious amount of electricity. Airplanes approved for instrument flight in commuter or on-demand operations must have pitot tube heaters. The pitot heat should be turned on before you fly into visible moisture, so that ice has no opportunity to form on the pitot tube. If water gets into the pitot plumbing it will cause erratic indications or worse. When the tubing connecting the pitot head to the airspeed indicator is blocked by ice, the air trapped between the point of blockage and the diaphragm in the instrument will expand as the airplane climbs, and the airspeed indicator will react as an altimeter, indicating higher airspeeds as altitude increases. A cross-check of the other instruments (especially the altimeter and VSI) will quickly pinpoint the ASI as having failed.

As a professional pilot or as a private pilot with a professional attitude, you should know what airspeed will result from a given pitch attitude and power setting; that is, you should be able to fly the airplane without an airspeed indicator if that becomes necessary in an emergency.

The static port is located where the airplane's motion through the air will create no pressure at all: on the side (or both sides) of the fuselage or on the back of the pitot tube. The airspeed indicator is calibrated to read the difference in pressure between impact air and still (static) air—both inputs are required.

If either the pitot tube or the static port is blocked the system will be useless, much like trying to get electricity from only one side of an electrical outlet. Blockage of the static system would disable

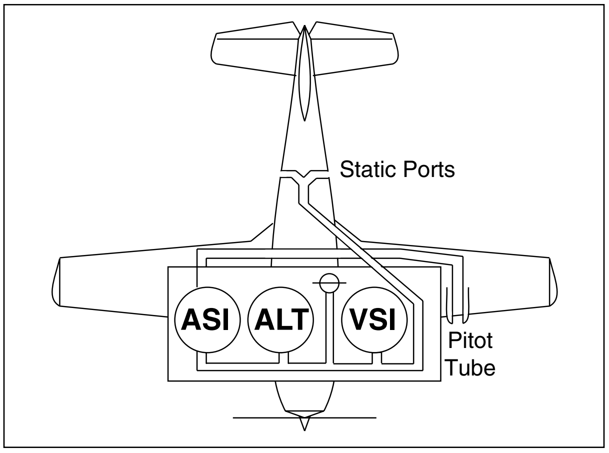


Figure 1-1. Pitot-static system

Situation	Airspeed	Altimeter	VSI
1. Blocked pitot.	zero	works	works
2. Blocked pitot and drain hole. Open static.	**high** in climb **low** in descent	works	works
3. Blocked static — open pitot.	**low** in climb **high** in descent	frozen	frozen
4. Using alternate cockpit static air.	reads high	reads high	unreliable
5. Broken VSI glass	reads high	reads high	unreliable

Table 1-1. Pitot-static system failures

the airspeed indicator, the altimeter, and the vertical speed indicator because no pressure differential would exist.

Depending on the location of the static source or sources, structural icing might cause such a blockage, and many all-weather airplanes are equipped with electrical static port heaters to eliminate this hazard.

Although an alternate static source is not required by 14 CFR 91.205 for noncommercial instrument flight, most IFR airplanes are equipped with one. (Part 135 requires an alternate static source for passenger-carrying flights operating under instrument flight rules.)

The alternate static source is a small valve or petcock at the pilot station which, when opened, vents the static system to the cockpit. When it is in use, the altimeter and airspeed indicator read slightly high; the vertical speed indicator will indicate correctly after momentarily reading in reverse. Opening the cabin vents will affect the readings of pitot-static instruments by slightly pressurizing the cabin when the alternate static source is being used.

If you are flying in icing conditions and your airplane does not have an alternate static source, water freezing in the static plumbing will put the pitot-static instruments out of commission. Your only option is to open the system to cabin pressure by breaking the glass on the vertical speed indicator. That will render the VSI pretty much useless but save the day for the airspeed indicator and altimeter. The VSI isn't a required instrument anyway.

The Federal Aviation Regulations require that the altimeter and static system of any airplane used for instrument flight be inspected every 24 months, and that the logbook endorsement indicate the maximum altitude to which the system has been tested. For unpressurized airplanes this altitude will far exceed the service ceiling of the airplane.

Airspeed Indicator

The airspeed indicator requires input from both the pitot (pressure) and static (unchanging) sources. Air from the static port fills the airspeed instrument case, while air from the pitot tube is led to a diaphragm. As airspeed changes, the pressure exerted on the diaphragm also changes and the movement of the diaphragm in response to these changes is transmitted to the indicator needle. The designer tries to locate the pitot tube so that it registers pressure in free air and is not affected by local airflow around the supporting structure. The airspeed indicator is the only instrument that uses air pressure from the pitot tube.

At the start of the takeoff roll there is no difference in pressure between the pitot and static inputs, and the airspeed indicator will read zero. As the airplane accelerates, the pressure in the pitot tube increases and that pressure is transmitted to the airspeed indicator needle. The designer cannot completely isolate the pitot and static inputs from the effects of airflow around the wing or fuselage, so an airspeed correction table is provided. The needle on the airspeed indicator reads indicated airspeed (IAS); when corrected for installation or position error, it becomes calibrated airspeed (CAS). Note in Figure 1-2 that the greatest difference between indicated and calibrated airspeed occurs at low speeds which require high angles of attack, and that as the angle of attack is reduced and speed increases the difference between IAS and CAS becomes negligible. The colored arcs on the airspeed indicator are usually based on calibrated airspeed; other operating speeds may be based on indicated airspeed. Check the operator's handbook to be sure.

It takes a pressure of about 34 pounds per square foot on the pitot side of the airspeed indicator's diaphragm to make the airspeed needle register 100 knots at sea level—that's how the instrument shop calibrates your ASI. As the airplane climbs to altitude, the air becomes less dense. The airplane will have to move much faster through the less dense air at altitude to develop a pressure of 34 psf in the pitot

FLAPS UP												
KIAS	50	60	70	80	90	100	110	120	130	140	150	160
KCAS	55	63	71	80	89	99	108	118	128	138	147	157
FLAPS 10°												
KIAS	40	50	60	70	80	90	100	110	120	130	---	---
KCAS	50	54	62	71	81	91	100	110	120	130	---	---
FLAPS 30°												
KIAS	40	50	60	70	80	90	100	---	---	---	---	---
KCAS	47	54	62	71	81	90	101	---	---	---	---	---

Figure 1-2. Airspeed calibration

tube, so the true airspeed will be faster than 100 knots when the airspeed indicator shows 100 knots. Your flight computer will allow you to make accurate calculations of true airspeed using IAS, pressure altitude, and temperature, but as a rule of thumb true airspeed increases by 2 percent per 1,000 feet of altitude. At sea level, under standard conditions, indicated and true airspeed will be equal; at 10,000 feet MSL, at the standard temperature for that altitude, an indicated 100 knots means a true airspeed of approximately 120 knots. When the ambient temperature rises above standard while indicated altitude is constant, pressure levels rise and both true airspeed and true altitude will increase.

Note: Glass cockpit airspeed indicators (and altimeters, Page 1-5) take their inputs from air data computers, and their displays are vertical tapes and digital readouts, not needles. Some "glass" airspeed indicators provide a "trend vector," showing what the airspeed will be in six seconds if acceleration/deceleration does not change.

At airspeeds in excess of 240 knots, heating caused by the compression of the air in the pitot tube must be taken into consideration in calculating true airspeed. Equivalent airspeed is calibrated airspeed corrected for the compressibility of the air, and should be of no concern at speeds less than 240 knots. Equivalent airspeed and calibrated airspeed are equal at sea level on a standard day—it is at high altitude and high airspeed that they differ.

You will use true airspeed in flight planning, but most airspeeds that you will use in actual flight are indicated airspeeds. You will always use the same indicated airspeeds, regardless of altitude. For example, if you are taking your flight training at a sea level airport and find that 110 knots indicated is the correct final approach speed, you will use 110 knots indicated airspeed on final when you fly to an airport at 5,000 feet above sea level as well. Your true airspeed will be 121 knots (2 percent times 5 = 10 percent, 1.1 times 110 = 121). Because the airplane approaching the airport at 5,000 feet is moving faster through the air to have an indicated airspeed of 110 knots, its ground speed will be higher and landing roll will be longer. A pilot who adds a few knots "just in case" while on final approach at a high altitude airport may have difficulty getting stopped on the available runway, especially if it is wet. Flying at the manufacturer's recommended airspeed will have predictable results.

A useful memory aid for the various airspeed corrections is "Ice Tea upside down." That is,

True (equivalent corrected for nonstandard temperature)

Equivalent (calibrated corrected for compressibility)

Calibrated (indicated corrected for installation or position error)

Indicated

Pilots of light aircraft can safely ignore equivalent airspeed.

Most modern IFR airplanes are equipped with an airspeed indicator capable of being set to indicate true airspeed when the outside air temperature and pressure altitude are set in a window at the top of the instrument. True airspeed is read within the white arc at the bottom of the instrument. The inside calibrations on this type of instrument will still be indicated airspeeds, one in miles per hour and one in knots. *See* Figure 1-3. Some glass cockpit airspeed indicators display true airspeed in addition to indicated airspeed. These high-end units take input from an "air data computer" that measures air density and temperature.

Every airplane has a design maneuvering speed (V_A), which is the optimum speed in turbulence at maximum gross weight. Maneuvering speed

Figure 1-3. Airspeed indicator with TAS window

is reduced as weight is reduced; get rid of ten percent of your payload weight and maneuvering speed will be reduced by five percent. Flight at or below maneuvering speed ensures that the airplane will stall before damaging aerodynamic loads are imposed on the wing structure.

The manufacturer may designate other speeds, which you will find in the Pilot's Operating Handbook and possibly placarded on the instrument panel. Landing gear extension and retraction speeds, maneuvering speed, and speeds for partial flap extension will be found in the operating handbook and not on the airspeed indicator.

You will be asked to interpret a velocity/G-load diagram, used to determine V-speeds, on the commercial pilot FAA knowledge examination. That subject will be covered in Chapter 2.

Angle of Attack Indicators (AOA)

The airspeed indicator can be considered a form of angle of attack indicator, since indicated airspeed is dependent on both angle of attack and power setting. Several manufacturers provide actual angle of attack indicators, however, which are calibrated to measure the actual angle between the chord line and the relative wind and provide you with angle of attack information by some form of "safe-unsafe" or "fast-slow" instrument reading. One such instrument compares air pressure changes both vertically and horizontally and measures sink rate. *See* Figure 1-4.

Angle of attack indicator installation requires only a mechanic's logbook entry. Legally, it does not replace the airspeed indicator; operationally, if you have an AOA indicator you will never look at your airspeed indicator again.

In every case, you need only keep the instrument's needle in the "safe" area and no interpretation is required.

Go to the Air Safety Institute's website (or YouTube and search for "margins of safety") and watch videos on angle-of-attack indicators.

Figure 1-4. Angle of attack indicator

Altitude and Altimeters

You may recall Figure 1-5 from your private pilot training. Absolute altitude is your airplane's height above the ground as it might be measured by a radar altimeter. True altitude is your airplane's height above sea level; that's what it reads when you set the Kollsman window to the local altimeter setting. If you set it on the ground, indicated altitude should be within 75 feet of the published airport elevation; if it isn't, the altimeter needs work. Before you enrich the instrument shop, however, make sure that your airplane is not parked at a spot higher or lower than the airport reference point. Pressure altitude is measured above the standard datum plane of 29.92" Hg and is used at all times above 18,000 feet (Flight Level 180). You also use pressure altitude extensively in making performance calculations.

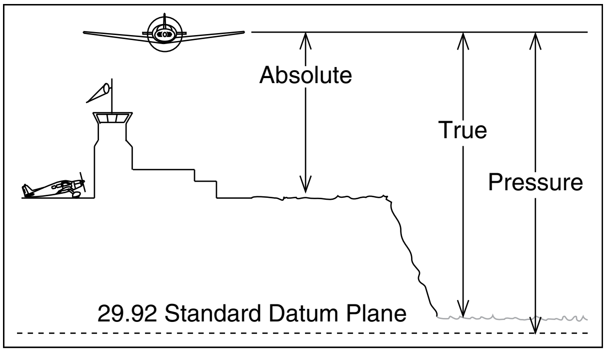


Figure 1-5. Altitude definitions

Aircraft altimeters are aneroid (dry) barometers calibrated to read in feet above sea level (true altitude). The altimeter gets its input from the static port, which is unaffected by the airplane's movement through the air. An aneroid barometer contains several sealed wafers with a partial internal vacuum, so as the airplane moves vertically and the outside pressure changes, the wafers expand and contract much like an accordion. This expansion and contraction is transmitted through a linkage to the altimeter needles.

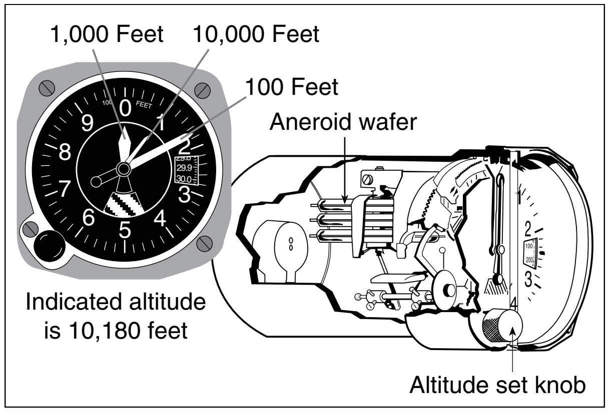


Figure 1-6. 3-Needle altimeter

Barometers provide a means of weighing the earth's atmosphere at a specific location. At a flight service station or National Weather Service office, an actual mercury barometer may be used, and on a standard day the weight of the atmosphere will support a column of mercury (Hg) 29.92 inches high at sea level. Inches of mercury are the units of measure for barometric pressure and altimeter settings. The equivalent metric measure is 1013.2 millibars.

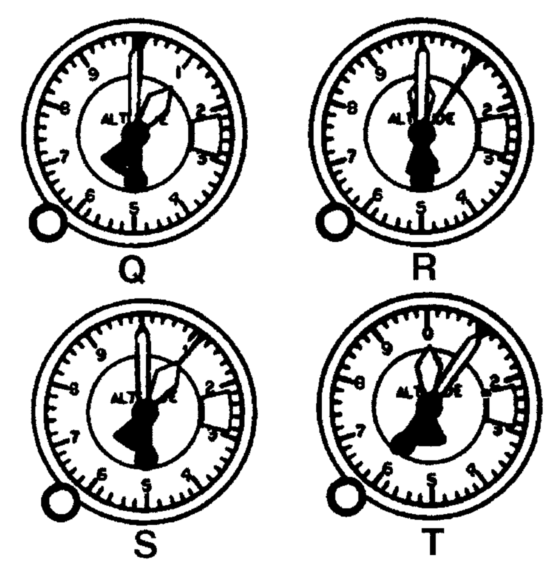


Figure 1-7. Reading 3-needle altimeter

Up to 18,000 feet, altitude is measured above sea level, and sea level pressure will normally vary between 28.50" to 30.50" Hg. The *Aeronautical Information Manual* contains specific procedures to be followed if cold weather causes an altimeter setting of 31.00" or more. If the barometric pressure is less than 28.50", both you and your airplane should be protected from hurricane-force winds.

Your altimeter has an adjustment knob and an altimeter setting window, and you must enter the sea level barometric pressure (altimeter setting) at your location as received from a nearby flight service station or air traffic control facility (each time you are handed off from one ATC controller to another, you should receive an altimeter setting). You can only use field elevation when nothing else is available, and even then you must get an altimeter setting as soon as possible. The altimeter will, when properly set, read altitude above mean sea level (MSL). *See* Figure 1-6.

Figure 1-8. Drum-pointer altimeter

As you increase the numbers in the altimeter setting window, the hands on the altimeter also show an increase: each .01 increase in the window is equal to 10 feet of altitude, each .1 is 100 feet, etc.

Misreading of altimeters has caused several accidents. The indication of the 3-needle altimeter found in many aircraft can be misinterpreted by 10,000 feet if the needle on the outside rim of the instrument is ignored or misread. In Figure 1-7, which instrument depicts 10,000 feet? Instrument R is correct. The 10,000-foot needle reads one, and the 1,000-foot and 100-foot needles read zero. What are the readings of instruments Q, S, and T? Check below for the answers.*

The drum-pointer altimeter is encountered quite often in light aircraft and is the altimeter of choice as you move up to more expensive flying machines. It has a single needle and a drum counter similar to an automobile's odometer. As the needle rotates, the drum reads the altitude directly in easily understood numbers. Each rotation of the needle causes the counter to increase 1,000 feet. *See* Figure 1-8.

With a glass cockpit, altitude is displayed using a vertical tape with a digital readout. Some high-end units display height above ground level (for example, "2320B" on the Chelton display means 2,320 feet above the ground, measured by barometry).

Pressure Altitude

You will need to determine pressure altitude to convert indicated airspeed to true airspeed or to calculate density altitude using your flight computer.

There are two ways of accomplishing this: first, note your indicated altitude and altimeter setting, then turn the altimeter setting knob to 29.92; the altimeter needles will read pressure altitude. Write down the pressure altitude and return the altimeter setting knob to its original position. The second method requires some mental gymnastics: determine the difference between your present altimeter setting and 29.92 and add a zero. This will give you the difference in feet between your indicated altitude and the pressure altitude. Then add or subtract this value to (or from) the indicated altitude to get pressure altitude, remembering that the altimeter needles always move in the same direction as the numbers in the setting window.

For example, assume that you are cruising at an indicated altitude of 7,000 feet with the altimeter set to 30.15, and you need to know pressure altitude for a flight computer calculation.

The difference between 29.92 and 30.15 is .23, or 230 feet. If you turned the altimeter setting knob to lower its setting to 29.92, the needles would move counterclockwise 230 feet, so the pressure altitude is 6,770 feet. The advantage of this method is that there is no danger of resetting the altimeter incorrectly.

Above 18,000 feet the altimeter must be set to 29.92" Hg; you will be reading your altitude above the standard datum plane. By international agreement, a standard day at sea level is defined as having a barometric pressure of 29.92 (with the temperature 15°C), and by setting your altimeter to 29.92 it will read altitude above that standard level. Below 18,000 feet, having the correct altimeter setting will keep you out of the trees, while above 18,000 feet (where there are no trees or mountains in this part of the world), the common altimeter setting of 29.92 provides altitude separation for IFR flights. Pressure altitudes of 18,000 feet and above are referred to as Flight Levels: "I'd like to file for flight level 220." *See* Figure 1-9.

**Q = 1,000 feet; S = 11,000 feet; T = 10,100 feet.*

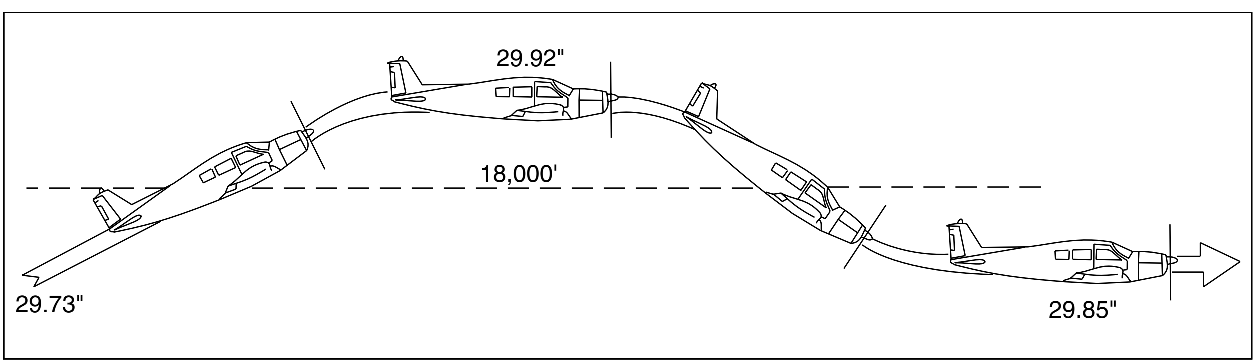


Figure 1-9. Change to pressure levels above 18,000 feet MSL

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"If the Airline Transport Pilot certificate is the Ph.D. of aviation, the Commercial and Instrument tickets represent the bachelor's and master's degrees." Author Bob Gardner so defines the advanced pilot; ***The Complete Advanced Pilot*** is written for the many pilots who streamline their efforts by preparing for the instrument rating and the commercial certificate simultaneously.

An FAA Knowledge Exam is required for the instrument rating and the commercial certificate. In using the FAA tests as the premise for learning, Bob Gardner applies practical information so readers are not only prepared for the exams but also for the cockpit. The required aeronautical knowledge is augmented by his specific tips and techniques, checklists and mnemonic devices, and sound advice from personal experience. Each chapter concludes with sample FAA test questions, and a comprehensive glossary and index are included as well as an approach chart legend appendix. This practical application of the FAA Knowledge Exam is not available in any other text!

With the author's conversational yet concise explanations, readers will quickly grasp the subjects, pass the required tests and checkrides, and have an operational understanding of flight they can take to the cockpit as newly-minted commercial pilots operating under instrument flight rules (IFR). Includes helpful internet resources for weather charts, full color examples of those weather charts, updated review questions and resource website links.

Also by Bob Gardner in The Complete Pilot Series:

The Complete Private Pilot
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