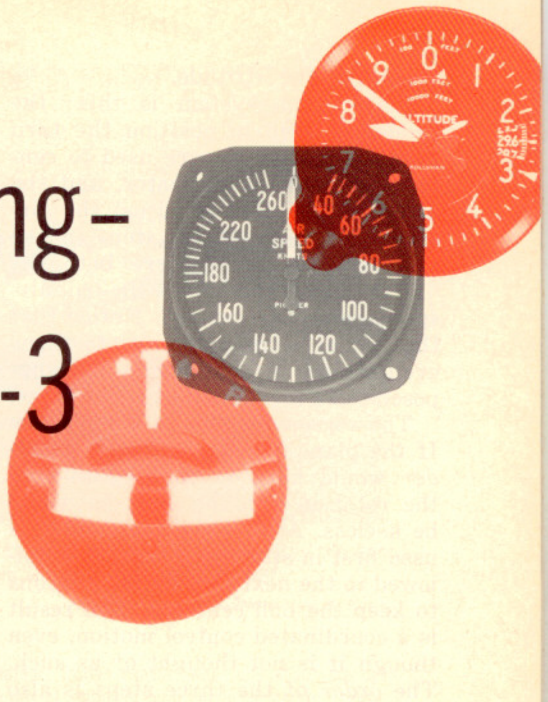
Basic Instrument Flying—As Easy As 1-2-3



Proper use of the rudder, ailerons and elevators is the key to simple instrument flight—but that is only the beginning

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Now that the FAA is requiring all applicants for pilots' licenses to demonstrate some proficiency at instrument flight, it is a good time for all pilots, student or veteran, to learn at least the basic principles of "flying the needles" for his own safety and satisfaction.

While becoming a proficient instrument pilot by today's standards is an involved and expensive affair, one can learn to keep himself upright in emergency instrument conditions after only a few hours of flight time under the hood and an occasional practice session. And even a basic trainer can be equipped for emergency instrument flight with the addition of a single instrument, the turn and bank indicator.

If you think you have the necessary "feel" to fly without reference to the natural horizon or to the instruments, you might as well get that out of your head right now.

During the first two decades of powered flight, pilots prided themselves on their ability to fly by the "singing of the wires" and looked down on those who insisted on referring to airspeed indicators and inclinometers. However, they soon found that fog flying was not possible without instruments, and the so-called rate instruments were developed to indicate the plane's motions to the pilot.

Merely having the instruments was not enough to allow instrument flight, though. Some method had to be developed for determining from the instrument indications the proper control motions to insure safe, positive control of the aircraft. Early aviation pioneers experimented with various systems of control in the late 1920's, and from their results the basic "1-2-3" system of instrument flight was developed and refined. This is the method of instrument flight to be described in this article.

As instrument flying progressed, it became evident that the indications of the "rate" group of instruments were not sufficient to allow the precision instrument flight required by blind landings, etc., and the "attitude" instruments were developed to complete the cockpit presentation. These attitude instruments are the directional gyro or gyrocompass and the artificial horizon, or attitude indicator.

Once the attitude instruments were perfected, a new technique of instrument flight was developed and called the attitude method. In this system the pilot learns the plane's *attitude* relative to level flight directly from the artificial horizon in much the same way that he would from the natural horizon in VFR conditions, and he controls the plane in the same manner as he would if he saw the natural horizon. Since there is so much similarity between attitude instrument flight and visual flight, and because it affords more precise control of the aircraft, the attitude method is now used almost exclusively for routine instrument flight and advanced training.

Since there is a possibility of failure of the attitude instruments in flight, and since the attitude instruments temporarily become useless after any violent maneuver such as temporary loss of control, every instrument pilot must be able to control his aircraft in an emergency by the "1-2-3" system of instrument flight. Our objective here is not to discuss the advanced topic of precision instrument flight but rather to present a safe, reliable means of controlling an airplane under instrument conditions. Therefore the attitude method will not be discussed further and the "1-2-3" system will be described in more detail.

The "1-2-3" system or needle-ball-airspeed system of instrument flight uses only the altimeter, airspeed indicator, and rate-of-climb indicator operated from the pitot-static system and the gyro-operated turn and bank indicator. Since none of these instruments tells the pilot *directly* what he wants to know about the attitude of the airplane, the pilot uses a purely mechanical relation between the instrument indications and the control forces he will use to maintain the desired flight attitude.

Briefly, the system is this: the rudder is used to position the turn needle, the ailerons are used to center the ball-bank indicator, and the elevators are used to adjust the airspeed. From the three steps in the system it is clear where both the "1-2-3" name and the needle-ball-airspeed name are derived. Notice that the rudder is used to initiate turns even though an airplane is not supposed to be turned with rudder alone.

The reason for this is a good one. If the plane were spinning, the *rudder* would have to be used to stop the rotation and the ailerons would be useless. Also, while the rudder is used first in starting a turn, it is followed in the next step by the ailerons to keep the ball centered. The result is a coordinated control motion, even though it is not thought of as such. The *order* of the three steps is also important. In a graveyard spiral, the most prevalent instrument flying hazard, it is necessary to stop the turning motion *before* the nose of the airplane is pulled back up. Any attempt to raise the nose while in a steep spiral will only make things worse.

Now that we have seen the general idea of the "1-2-3" system and some reasons for it, let us look at some specific techniques used in flying by this system. The first step is the control of the rudder by reference to the turn needle. This is the vertical pointer in the turn and bank indicator, and it is gyro-operated to tell the rate of turn of the airplane about its vertical axis. When the pointer is centered, the plane is not turning. But a standard turn of 3° per second (or two minutes for a complete 360° turn) will produce a deflection of one width of the needle (two needle widths on some types with additional index markings) in the direction of the turn. Thus, for straight flight the rudder is used to keep the turn needle centered. This is easy to do in calm air, except that you have to keep at it pretty closely to avoid wandering off course. For instance, allowing the pointer to drift just 1/16-inch off center for just five seconds will result in a 6° change in heading. In rough air it is impossible to keep the turn needle from swinging back and forth, and it is necessary to average out the swings and try to keep the needle on one side about as much as it is on the other.

Remember that the turn needle does not indicate the amount of turn but only the *rate* of turn. Thus, even if you do a pretty good job of keeping the needle centered, you cannot expect to fly for more than a few

(Continued on page 57)

Basic Instrument Flying

(Continued from page 28)

minutes at a time without drifting off course a few degrees. To avoid this, the compass should be consulted occasionally to find out what correction, if any, is necessary to stay on the desired heading.

It should be remembered that any reading of the magnetic compass is valid only if the plane has been in *straight and level flight* for the past several seconds. Once the error has been determined, a turn should be made to get back on the desired heading. A good rule to remember is "left is less," meaning a turn to the left will decrease the heading while a turn to the right will increase it.

Turns may roughly be divided into two categories, big ones and little ones. Any turn less than about 10° should be made slowly but positively with rudder corrections alone and no particular effort made to bank the plane or to make the turn at standard rate. Larger turns are made by turning at standard rate as indicated by the turn needle, and judging the amount turned by timing the turn. Since a standard rate 360° turn takes two minutes, it takes one minute for a 180° turn, 30 seconds for a 90° turn, 10 seconds for a 30° turn, etc. For this maneuver it pays to learn to count to 60 in one minute, plus or minus five seconds.

The turn is executed by first noting the time (or starting to count), then applying a firm rudder pressure in the desired direction of turn until the turn needle indicates a standard rate turn. The needle is then held at this point by the rudders until the required time has elapsed, then recovery is executed by applying pressure to the opposite rudder until the turn needle is centered. Note that recovery is not started until after the proper time has elapsed. This allows the time spent recovering from the turn to compensate for the time spent entering the turn, providing the rudder pressures used to enter and recover from the turn are the same. After the turn is completed and the compass has had time to settle down, notice what error still exists from the desired heading and correct it with a small additional turn.

Two things that should be remembered about turns: (1) never make a turn at more than standard rate except for training purposes, as steep turns are very hard to control; (2) pay particular attention to the turn indicator right after a turn has been completed: there is a strong natural tendency to roll back into the turn without knowing it.

The next instrument read in the "1-2-3" system is the ball-bank indicator. It consists of a ball in a curved glass tube with some damping fluid, and is mounted in the same case with the turn needle. The name is somewhat misleading, since the instrument does not measure bank directly but only the *error* from proper bank in straight flight or a turn. Thus it is sometimes called a "slip and skid" indicator. In a properly coordinated turn or in straight flight the ball should always be centered, and if it drifts off center it is because that wing is low. Thus, the ball on the left indicates the left wing is low and should be raised by applying right aileron. This is always so, whether you are in a left or right turn or in straight flight. Since the ball is referred to right after the turn needle, any rudder action will be coordinated with ailerons for smooth flight. For instance a turn entry is started with rudder, but keeping the ball centered with the ailerons results in a properly coordinated turn. At first the rudder and aileron actions will be clearly separate, but with a little practice the actions will follow each other so closely that they will appear as one motion.

Since it takes a while for the plane to bank after the ailerons are applied and since the ball is highly damped, the response of the ball to aileron motion is rather slow. Don't overcontrol, just give the ball a chance to respond. It might also be noted that precise control of the ball is not necessary for safe flight. The entire travel of the ball only represents a few degrees of bank error, so the aileron control may be considered satisfactory if at least part of the ball is kept between the lines marking the center of the tube.

Finally, we come to the third step in the "1-2-3" system: control of the elevators by reference to the pitch instruments. Because an error in pitch shows up first in the airspeed indicator, that instrument is used as the primary reference for pitch control. In all maneuvers, except the special case of level flight, the stick is moved so as to keep the airspeed at the desired value. When the airspeed is high the stick is pulled back, and when it is low the stick is moved forward. However, unless one is careful, it is quite easy to overcontrol by doing this. In an extreme case either a severe stall or a steep dive may result. To avoid this it is necessary to make very small corrections with the stick and to take into account not only the error in airspeed, but also whether the error is increasing or decreasing. If, for example, the airspeed is high but decreasing, it is not proper to pull back on the stick because the airplane will be placed in a nose-high attitude.

A good procedure to avoid overcontrolling is to pull back on (or push) the stick only until the airspeed stops increasing (or decreasing) and just begins to go back toward normal. At this point the airplane is approximately level, and if the stick pressure is relaxed, the airspeed will settle down nearly to normal. If the stick pressure is held until the airspeed returns to normal, hopeless overcontrolling will result. Keeping the airspeed under control is probably the hardest single thing to learn about instrument flying. A fair amount of practice will be required before you master it.

In the special case of level flight, it is not only necessary to maintain a safe airspeed, but the desired altitude must be maintained as well. In this case, once the desired altitude has been reached and the plane settled down to cruise, the stick is used to hold the cruising altitude. If the altimeter drifts off slightly, make a very slight correction in the stick to move it back toward the desired reading. Never make a major correction (over 100 feet) solely by reference to the altimeter, and never apply more than light pressures to the stick when correcting the altimeter. It takes considerable effort to keep the altitude within 50 feet of the desired value, but it will pay off in safe and smooth flying.

Climbs and descents are made with reference to the airspeed indicator as the primary instrument, although the altimeter and possibly the rate-of-climb indicator are used to gauge the climb or descent and to determine where to level off. To enter a climb or glide, adjust power with the throttle and then use the stick to adjust the airspeed to the desired value. This airspeed must then be held within about one m.p.h. (especially in glides) to keep the rate of climb or descent constant. Then check the rate-of-climb indicator to make sure the rate is that desired. If not, make a slight (one or two m.p.h.) change in airspeed and again check the rate-of-climb indicator. Do not try to fly by the rate-of-climb indicator directly; overcontrolling will result. Rates of climb or descent in excess of 500 f.p.m. should not be attempted. In the absence of a rate-of-climb indicator, the altimeter may be used as an estimate, remembering that at 500 f.p.m. the hand will move through 100 feet in 12 seconds. Pilots of large aircraft prefer to trim the plane to fly hands off while in the climb or glide, but it is probably better for lightplane pilots to keep the plane trimmed for cruise while climbing or gliding. To return to level flight, simply reset the throttle to cruise power and then relax pressure on the stick to return to the trimmed cruise airspeed.

While the altimeter and rate-of-climb indicator are used to supplement the airspeed indicator readings in normal flight maneuvers, the airspeed indicator should be returned to as the primary pitch instrument whenever the pitch attitude begins to get out of control, or when large corrections are to be made. To avoid overcontrolling, keep the elevator pressures light and take into consideration whether the airspeed is increasing or decreasing before applying a correction. If you get tense and start to overcontrol, just relax your stick pressure and let the plane return to trim speed by itself. If properly trimmed, the plane will do a pretty good job of maintaining a safe airspeed all by itself. (This is the basis of the AOPA 180° Rating system.)

The technique of flying the "1-2-3" system is simply to go through the three steps in order, then go through them over again, continuously. Adjust the turn needle, center the ball, and adjust the airspeed (or altimeter). Go through these steps every few seconds and do not allow your attention to become fixed on one instrument while the others wander off center. If the airplane gets severely out of control relax all control pressures, then remember the "1-2-3" order, center the needle with the rudders, center the ball with the ailerons, and finally use the elevators to obtain a safe airspeed.

A little knowledge can certainly be a dangerous thing when it comes to instrument flying. Just because you can fly for a few minutes in smooth air with a safety pilot beside you does not make it safe for you to venture into real instrument conditions; besides it's illegal. However, if you happen to find yourself in instrument weather for some reason, a little training can be put to good use. The best bet is to make a 180° turn, as the AOPA 180° Rating procedure preaches, and go out the way you came in.

If this doesn't work, get on the radio and call the nearest FAA Flight Service Station and tell them your situation. The longer you wait to do this, the more lost and confused you will get; and this just makes everybody's job that much harder. Tell the controller what degree of instrument proficiency you have, your fuel on board, and your best estimate of your position. Then follow his instructions. He will probably ask you to check your position by a radio fix, then give you a heading to steer to get back into VFR weather or to an airport where you can make a safe letdown.

An instrument let-down may range anywhere from descending on a low frequency range leg to a complete Ground Controlled Approach (GCA) where the radar controller gives continuous precise directions to guide you down the glide slope onto the runway. In any case keep calm, rely on your instrument indications, and follow the controller's instructions, and you should be guided safely out of trouble.

Although this article is intended to give you some knowledge of instrument flying and the techniques used, it is no substitute for experience. The time to get some instrument flight experience is *now*. A couple hours of time with a qualified instructor is well worth the expense, and after you get the feel of it you can gain experience in simulated instrument flight with only a private-rated safety pilot next to you. It will only take a little while to learn the fundamentals of "flying the needles," and after that an occasional session of brushing up with another pilot should keep you in shape. If your plane is not equipped with a turn and bank indicator, get one. They are reasonably inexpensive (under $100 installed), and it adds an important safety factor to your flying that has no substitute. That, combined with some instrument flight experience on your part, can make the all-important difference when the going gets rough. END

THE AUTHOR

C. Nicholas Pryor is an electrical engineer at the U. S. Naval Ordnance Laboratory, Silver Spring, Md., and began flying at College Park (Md.) Airport in 1957. He obtained his private license the following year and since then has been studying the history and techniques of instrument flight. Pryor has written several articles for electrical engineering journals, but this is his first contribution in the field of aviation.

Step door, new rudder and fin, longer nose gives famed Cessna aircraft new appearance. Cabin modified to take six seats in Bay State conversion

Venerable T-50 Gets Face-Lifting

When Henry Ford changed from the old Model T to a completely different approach, the song of the day was "Henry Made a Lady Out of Lizzie." Something comparable has been done by Wiggins Airways, Norwood, Mass., to the venerable Cessna T-50 (or *Bobcat*, UC-78, *Bamboo Bomber*, *Jane Russell Cub*, or whatever else the famed twin-engine Cessna has been called).

The first such conversion is shown above. It was made by Wiggins for John C. Van Arsdale (AOPA 39636), owner and operator of Provincetown-Boston Airline and Naples (Fla.) Airlines.

Most obvious external changes include a new rudder and fin (strongly reminiscent of the Cessna 195 series), a step door, one-piece bubble windshield and (to be added shortly) a longer nose and three-bladed Hartzell full-feathering props. The engines are 245-h.p. Jacobs.

Internally, the cabin was modified to take six seats, including the pilot, in a 2-2-2 configuration. All except the pilot's seat are quickly detachable. So are the stair door and its surrounding panels, making the airplane quickly convertible to handle large pieces of cargo.

The entire conversion job, including the cost of recovering the whole airplane, cost about $15,000. The modification has FAA certification. Further details are available from Fred Valentine, Service Manager, Wiggins Airways, Norwood, Mass.

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