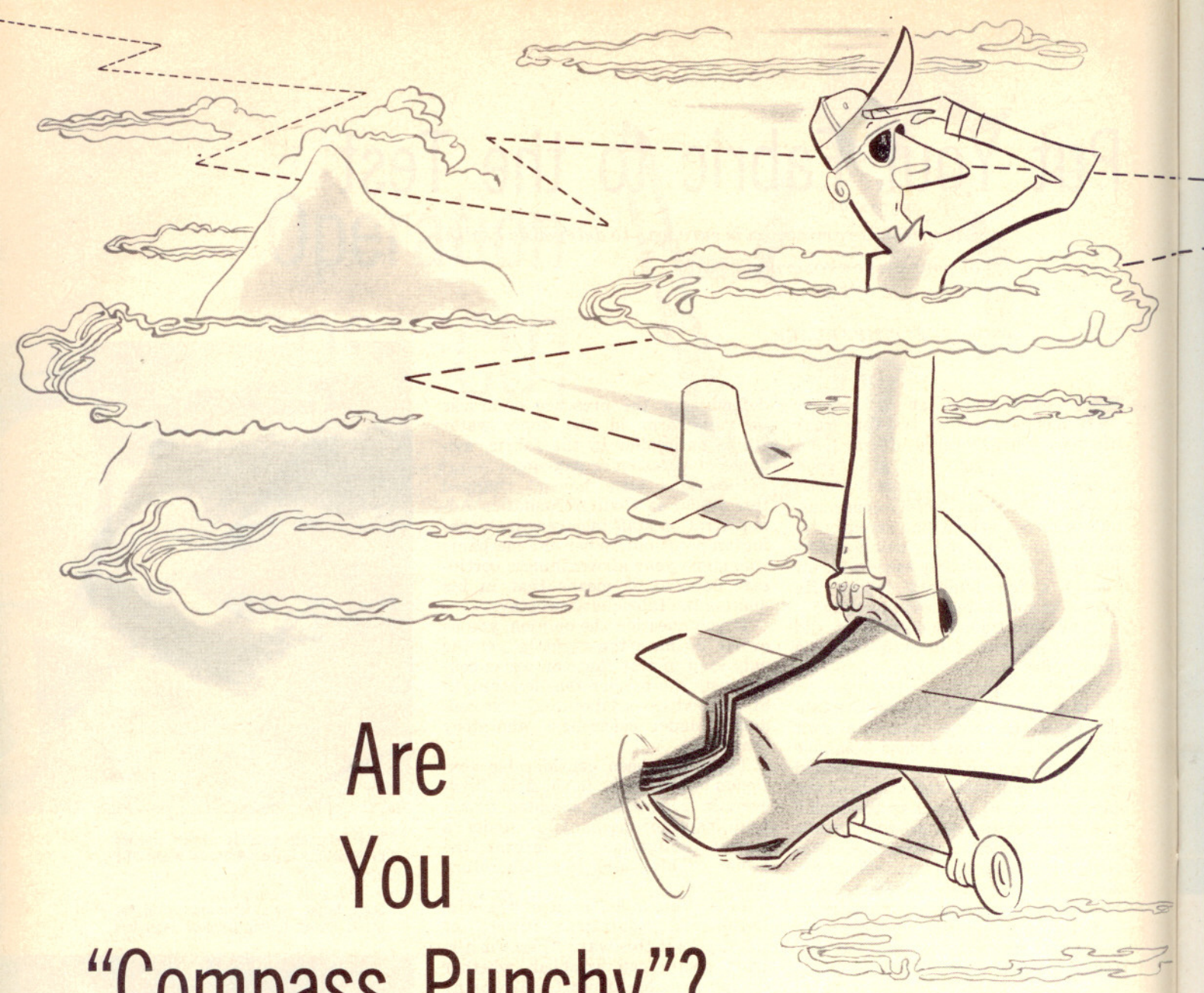

Are You "Compass Punchy"?

Your plane does not have to be a "bird-dog" to get you home if you know the basic rules. AF Captain tells you what they are

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"Let's see, 'East is least, and West is most.' That means you subtract easterly variation and add westerly deviation in changing from compass heading to true heading, doesn't it?"

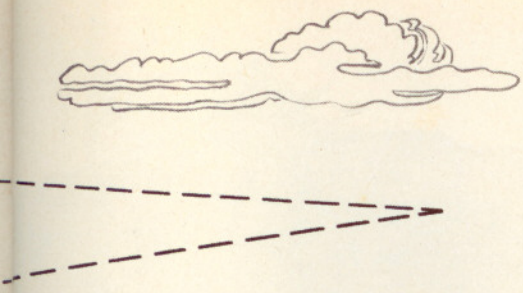
"Oh no, you do that in going from true course to compass heading, I think."

"Aw hell—heading, track, east, west, drift, shmift—let's ask Joe, he'll know."

Ridiculous, isn't it? But it's a rare pilot who hasn't heard this typical balled-up conversation in the lounge of a pilot training school. It is a product of the "quickie" course, the midnight bone-up session with pots of coffee and a pack of true-false questions designed to squeak you through the CAA exam. Whether the pilot be a professional or not, this is a pitiful plight. Why substitute a bunch of tricky memory crutches, easily confused and easily forgotten, for a few simple concepts which, if once understood, will stick with you forever?

If you are a pilot you must likewise be a navigator, and it is easier to be a good one than to bury your bean in the clouds. To make my point, let's consider a simple but often confused subject basic to any navigator, that of "directions."

As a pilot you are interested in four directions, only four, so let's start with a clear understanding of what they are. The first one, "heading," is the direction in which the nose of your aircraft is pointing or heading. For the present let's forget such terms as true heading, magnetic heading, or compass heading. They all refer to the same direction. After



all, it's a scarce bird-dog that can point more than one way at a time, and this "one way" is the heading.

The second direction of interest is "course." Course is the direction you wish to travel over the ground. Let's emphasize again not to confuse such terms as true course, magnetic course, and compass course. They simply indicate different ways of measuring the same identical direction, your course or desired direction of travel.

At this point we should note the difference between course and heading. Your airplane will move through the air in the direction it is heading. However, as we all know, the air itself may be moving in another direction. This causes it to drift or move across the ground in a direction different from its heading. Therefore, in order to make good our desired course, we must anticipate this effect and select a heading which is different from our course. This difference is called the "drift correction."

Sometimes we cannot anticipate the effect of the wind exactly, and our aircraft will move across the ground in a direction different from the desired direction or course. This third basic direction, the one in which our aircraft actually passes over the ground, is called "track." The difference between our track and our heading is the "drift" or actual wind effect, whereas the difference between our course and our heading is the "drift correction" or anticipated wind effect.

Last of all, the pilot may be interested in specifying the direction of points other than his destination such as a radio station or landmark. For this purpose we define the term, "bearing." Bearing is the direction of any one point from some other designated point.

In summary, let us consolidate the four basic directions and their definitions as follows:

(1) Heading—the direction in which the nose of an aircraft is actually pointing or heading.

(2) Course — the direction in which you desire an aircraft to pass over the ground.

(3) Track—the direction in which an aircraft actually passes over the ground.

(4) Bearing—the direction of one point from some other designated point.

The next problem which a pilot faces is that, in order to measure any direction, he must have another known direction, or reference direction, with which he can compare the first. We commonly measure any direction clockwise from our selected reference direction, from 0° to 365°, as shown in figure (1).

Having discussed the four basic directions in which a pilot is interested, it now remains to select appropriate reference directions with which he can compare or measure the basic ones. There are four fundamental reference directions which are useful for aerial navigation. Once the relationship of these four to one another is clearly understood it will be the simplest matter for you to interpret all of the directional terms such as magnetic course, true track, compass heading, et cetera, without relying on confusing memory crutches or slogans for converting from one to the other.

The first fundamental reference direction is "true north." True north is the direction of the earth's north pole from the point where the measurement is made. Since the earth is approximately a sphere an infinite number of great circles, each passing through both the north and the south poles, can be drawn about the earth. These circles are called meridians, and they appear as lines running north and south on the maps which represent the earth's surface. Since these lines extend toward the north pole or true north and since they appear at regular intervals on a map, they provide the handiest reference direction for measuring any other desired direction on a map.

However, once a pilot is airborne, he has no means of directly determining the direction of true north. He must rely on a compass which tends to align itself with the lines of force of the earth's magnetic field. These lines of force closely approximate the meridians in most locations, but unfortunately the two do not coincide exactly. The most northerly direction of these lines of force is called "magnetic north." Since the compass, in the absence of errors, will point toward magnetic north, this becomes a useful reference direction for in-flight measurements.

The relationship between magnetic north and true north is shown in figure (2) where both the meridians and the magnetic lines of force are illustrated. As can be seen here the direction of magnetic north varies from that of true north. This difference is called magnetic variation, or simply "variation." The amount of this variation is dependent solely upon the location on the earth and

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FIG. 1

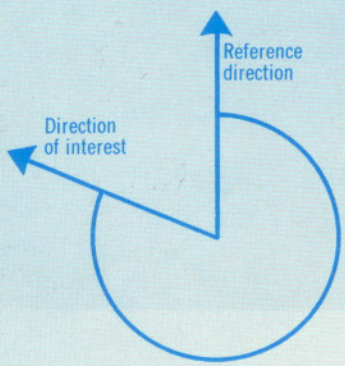
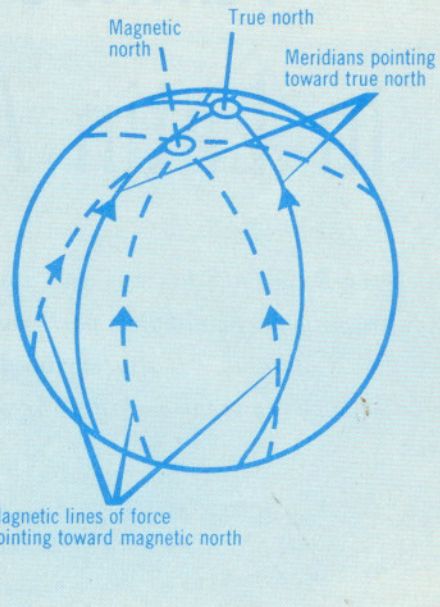


FIG. 2



"Compass Punchy?"

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FIG. 3

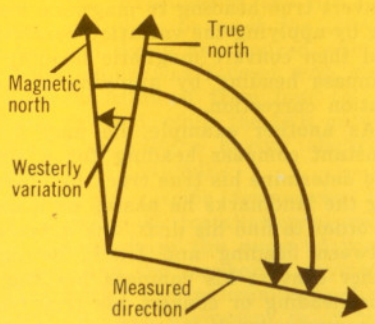
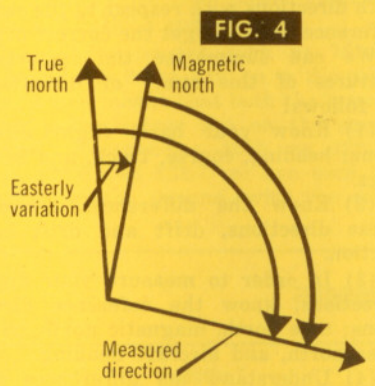


FIG. 4



is not affected by an aircraft or its heading. As is shown in figure (3), if the variation is westerly, viz., if magnetic north is west of true north, then the measure of any direction with respect to magnetic north will be greater than the same measurement with respect to true north. Conversely, as shown in figure (4), if variation is easterly, then measurements with respect to true north will be greater. Of course, the direction being measured is the same regardless of the reference used.

This illustrates precisely the reasoning which should be employed in converting a direction measurement from a magnetic reference to a true reference or vice versa. First determine which is more westerly, magnetic north or true north. Then apply the variation correction, adding or subtracting so that measurements with respect to the westernmost reference are larger and those with respect to the easternmost reference are smaller.

Unfortunately, a compass will respond to other magnetic influences besides that of the earth's magnetic field. Frequently, metal parts of an aircraft's structure become partially magnetized and will cause a compass to deviate from the earth's field or magnetic north. Also, magnetic fields set up by electronic equipment in the aircraft will cause deviation. The direction that a particular compass actually points under these conditions is called "compass north." Since directions, especially heading, are frequently measured with a compass, compass north is a necessary reference direction.

The amount that a particular compass deviates from magnetic north, either in an easterly or a westerly direction, is called compass deviation, or simply "deviation." The amount of this deviation is dependent on the particular aircraft and compass, the location of the compass in the aircraft, and the amount of electronic equipment turned on. Adjustable magnets in the compass are provided to counteract the effect of extraneous magnetic fields, and, in some cases, deviation can be reduced to a negligible amount. If this cannot be done, it is necessary to make appropriate corrections for deviation when changing measurements from a compass to a magnetic reference or vice versa. This procedure is similar to the corrections for variation. First establish whether compass north is east or west of magnetic north. Then apply deviation corrections so that measurements with respect to the westernmost reference are larger.

The fourth commonly used reference direction is that of the aircraft heading itself. The term "relative" is used to describe this reference because the direction is measured relative to the aircraft heading. This reference is used most often for measuring the bearing or direction of some object from the airplane as shown in figure (5). The difference between a relative bearing and the same bearing measured with respect to true north, magnetic north, or compass north is the aircraft heading measured with respect to true north, magnetic north, or compass north, respectively. This is illustrated in figure (6). (See figures 5 and 6 on next page.)

In summary, let us consolidate the four commonly used reference directions and their definitions, as follows:

(1) **True north**—the direction of the earth's north pole from the point where a measurement is made.

(2) **Magnetic north**—the direction of the earth's magnetic lines of force at the point where a measurement is made.

(3) **Compass north**—the direction in which a particular compass actually points.

(4) **Relative**—an adjective indicating measurement of direction relative to, or with respect to, aircraft heading.

Having defined the four basic directions used in aerial navigation and the four fundamental reference directions used to measure them, we can comprehend clearly the terminology for specifying directions. In specifying any given direction we must give both the direction and the reference from which it is measured. This is done with two words, the first an adjective denoting the reference used and the second a noun specifying the direction measured. The adjectives used are "true," "mag-

netic," "compass," and "relative," each denoting measurements with respect to true north, magnetic north, compass north, or aircraft heading, respectively. These adjectives are commonly abbreviated as T, M, C, or R, respectively. The nouns used are the directions themselves, heading, course, track, and bearing which are commonly abbreviated as H, C, T, and B, respectively. The following examples will illustrate how to interpret the various combinations of these terms:

TC—True Course—the direction of intended travel measured with respect to true north.

MT—Magnetic Track—the actual direction of travel measured with respect to magnetic north.

TT—True Track—the actual direction of travel measured with respect to true north.

CH—Compass Heading—the direction in which an aircraft is pointing measured wtih respect to compass north.

RB—Relative Bearing—the direction of some object from the aircraft measured with respect to aircraft heading.

MB—Magnetic Bearing—the direction of one object from another, measured with respect to magnetic north.

In order to navigate, a pilot must perform certain geometrical calculations to determine the relationship between heading, wind, and track or course. Also, in order to fix his position, he frequently plots on a map his bearing from two or more radio stations or other landmarks. The important point to make here is that the pilot must always measure, plot, or denote all of his flight directions with respect to the same reference before he performs any geometrical calculations with them. It makes no difference what reference is used, but it must be the same one for all directions.

FIG. 5

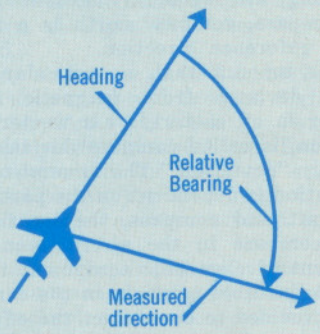
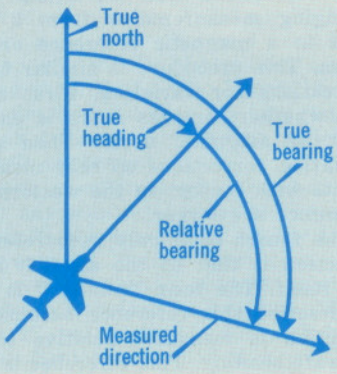


FIG. 6



For example, if a pilot knows his course, the estimated wind, and his airspeed, he may calculate his proper heading by solution of what is commonly called the "wind triangle." If he plots his true course and true wind, he will get his solution in terms of true heading. On the other hand, if he plots magnetic course he should also use magnetic wind (wind direction measured with respect to magnetic north), and his solution will provide the magnetic heading.

As another example, he may plot his magnetic bearing from two points, measuring direction from magnetic north, or he may plot his true bearing from the same two points, measuring from true north. In either case his solution will provide the same identical position. However, if he performs geometrical calculations using directions measured with respect to different references, he will distort the geometrical relationships by introducing errors of variation or deviation, and consequently he will get an incorrect solution.

A pilot must frequently convert various direction measurements from one reference system to another. For example, he may use his true course and wind to calculate true heading. However, to fly this heading, he must use a compass. Therefore, after completing the geometrical calculation, he must convert true heading to magnetic heading by applying the variation correction and then convert magnetic heading to compass heading by applying the deviation correction.

As another example, he may fly a constant compass heading for a while and determine his true track by observing the landmarks he passes on a map. In order to find his drift, the difference between heading and track, he must either convert his compass heading to true heading or convert his true track to compass track in order to compare both directions with respect to the same reference and thus get the correct drift.

We can summarize the important features of this study of directions, as follows:

(1) Know your basic flight directions; heading, course, track, and bearings.

(2) Know the differences between these directions, drift and drift correction.

(3) In order to measure your flight directions, know the reference directions; true north, magnetic north, compass north, and aircraft heading.

(4) Understand the differences between the reference directions, variation and deviation, and use them to convert flight direction measurements to the most useful reference system.

(5) Always convert all flight directions to the same reference system before performing any geometrical calculations.

Now when you tackle that CAA exam you can slyly chuckle as you hand your paper to the chic secretary. That "other guy" will still be mumbling, "East is least, and drift is shmift" while he fumbles with a pencil whose smudgy eraser he has already rubbed to nothing. As for you, you know which way you're going. Bon voyage! END

THE AUTHOR

Capt. John G. Ellis, Jr., author of "Are You Compass Punchy?" earned his private license at a small dirt strip in Martinsville, Va., in 1947. He now is licensed as an airline transport pilot and ground instructor. After joining the U. S. Air Force in 1950, he flew a combat tour in F-86 Sabrejets with the 4th Fighter-Interceptor Group in Korea. From 1954 to 1956, he studied inertial navigation, instrumentation and control systems at the Massachusetts Institute of Technology where he received his Master's degree. Capt. Ellis is assigned to the Air Force Missile Test Center at Patrick Air Force Base, Fla., where he is still active in civil aviation activities. His wife, Barbara (AOPA 52289), is a private pilot and member of the Florida chapter of 99's.