reference. In the air, however, speeds become higher, so that a comparatively slow rate of turn is accompanied by high centrifugal forces, forces which must be overcome by banking the airplane, including its occupants. Hence, the axis of rotation no longer corresponds to the vertical axis of the body, and complex flows of the fluid in all three canals of the ear give rise to simultaneous vertigoes to confuse us. Gravity no longer gives us an accurate plane of reference, for, due to centrifugal force, down always feels like the direction of the seat beneath us, even though we may be making a very steep turn. After a few seconds of smooth, continuous turn, either steep or shallow, one becomes absolutely unaware of any rotation. Only changes of rate of turn will register, generally incorrectly, on our senses.

When we have without reservation accepted these inevitable limitations upon our sense of balance, we have overcome the first obstacle to learning to fly blind. Never, repeat, *NEVER, rely upon any manifestation of your sense of balance* unless you can see ground, horizon, or astral body. Modern instruments are reliable, if not infallible, and will always give faithfully accurate information under normal conditions.

We have digressed at some length already in an endeavor to demonstrate the frailty of the sense of balance with which nature has endowed us. To supplement this inherent weakness, we must rely upon man-made devices.

The one indispensable instrument of all blind flying is the gyro. Most common, simplest in form, and most valuable of the various gyroscopic flight instruments is the turn indicator. Though artificial horizons, directional gyros, gyropilots, and other gyroscopic luxuries are fine for larger aircraft, they are inessential to soaring, and our present discussion will limit itself to the turn indicator, included in which it is customary to place a lateral inclinometer, or ball, to show any evidence to skid or side-slip. *Never attempt blind flight without a functioning turn indicator.*

Next in ratio of importance is the variometer, about which so much is known, and an instrument so indispensable to general thermal soaring, that it is doubtful that a flight would reach the blind flying stage unless it had been intelligently employed. Any blind flight is impossible without a turn indicator; any successful soaring flight is improbable without a variometer.

A reliable airspeed meter is valuable; nearly, but not quite, essential. The airspeed meter is standard equipment in all aircraft, and a legal requirement, but in the event of its incapacitation due to ice, rain, cold, or mechanical derangement, a good pilot suffers no great handicap, for the sound of the wind rushing by affords an excellent indication of the speed.

In decreasing order of importance are altimeter, preferably sensitive, clock, and compass. None of these latter instruments are essential, least of all the compass. For reasons to be given shortly, the latter instrument should be used very cautiously in cloud flying, is of no value in turbulent air. When a pilot naively relates that he "flew a compass course out," rest assured that he blindly stumbled out, and was probably plenty bewildered by the crazy antics of his compass as he blundered along. Wolf Hirth's excellent treatise, "The Art of Soaring Flight," is replete with pilots' accounts of flying blind by compass. It is also replete with ". . . then everything went wrong. The airspeed began to increase and I was forced violently down in my seat, the ship began to scream and shudder, and the speed was terrific, although the stick was fully back. . . ." Such phraseology is the inevitable reward to blind faith in the compass without respect for its very severe limitations. *Consult your compass only after the turn indicator has been steadily centered for at least five seconds in smooth air.* Even a slight turn will cause the compass to oscillate and give very false readings. *Never follow the direction of turn of the compass;* nearly half of the time it is turning opposite to the direction the plane is moving, and continues to turn somewhat after the turn is completed on certain headings.

Now that we have enumerated the required instruments, let us examine their workings. The turn indicator registers, by deflecting its pointer, the direction and rate of turn. If the pointer is $\frac{1}{8}$" to right of the center index, you will normally be making a shallow right turn. $\frac{1}{4}$" deflection means a turn whose rate is twice as great. Pointer deflected its full amount in either direction indicates a very steep and rapid turn, imposing high accelerations on the aircraft, and leading to high airspeed.

The inclinometer ball, confined within a curved glass tube in the face of the turn indicator, functions somewhat like an inverted spirit level. It does not indicate, however, the bank of the wings, as one might casually deduce, but merely indicates whether a given rate of turn is accompanied by proper bank. In level flight, or in any turn, the ball should remain within the center of the two marker wires used to bracket its neutral position. Ball opposite pointer indicates skid, ball on same side as pointer, a slip. The ball will follow same direction of movement as aileron; right stick moves ball to right. *Never attempt to control ball by rudder; always control ball by aileron exclusively.*

The airspeed meter indicates, of course, speed. Its value exceeds, however, mere speed information, for it indirectly indicates the longitudinal attitude of the airplane. Increasing speed means that the nose is down; decreasing speed that the nose is too high. Speed stationary at any reasonable figure indicates a level longitudinal axis. The airspeed meter does not have lag, but the aircraft has, due to its inertia, so an appreciable time will elapse between the application of control and the corresponding influence on the airspeed meter. Continual attention to airspeed is essential to proper longitudinal control.

The use of the variometer depends upon accurate speed control. If speed, and hence altitude, is permitted to vary, the variometer registers rates of ascent or descent which may be entirely due to dives and zooms of the aircraft itself. Master the art of speed control, then use the variometer just as you do in contact soaring.

It is beyond the scope of this article to endeavor to teach blind flying. One might as well teach juggling by a correspondence course. Only by patient hours of intelligent dual practice can one become sufficiently proficient to pit one's skill against the turbulent interior of a cloud, the most difficult conditions under which instrument flight can be attempted. It is more a desire to impart information which might foster the desire to attain blind flying skill than an attempt to offer a short-cut to cloud soaring. A complete mastery of instrument airwork is pre-requisite to cloud soaring.

(*Continued next month*)