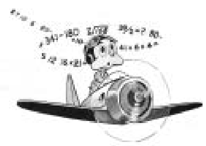
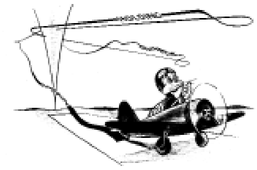


INSTRUMENT FLYING AND RADIO NAVIGATION, THE EARLY DAYS.



By Richard C. Hill

Starting when I was sixteen, aviation has been my life. It really began before that, I was hooked when I read the letters my older brother sent to my father during his World War II Air Corps training.

September 1944, the local airport was reopened. All of the "unnecessary" airports were closed during the war for fear, real or imagined, that the Japanese would steal a plane and bomb some military establishment.

A *Cub* flew over the car while I was driving home from school one evening and I followed it to the airport. There was a sign on the office door that read "PLANE RIDES $2.00." I had been saving a two dollar bill for just such an occasion. At the end of my ride, the instructor, Clarence Gallagher, of Antioc, Illinois, said, "If you decide to take flying lessons, this flight will go into your logbook as your first lesson." Swish, the arrow hit me right in the heart and it is still there, fifty six years later. I'm pleased it carried an incurable disease. I quit high school in my junior year, not being a good student, I spent the remainder of the year working for Wayne Carpenter at his airport in Waukegan, Illinois. Wayne, now 90 years old, resides in Ojibwa, Wisconsin.

In the fall of 1945, I enlisted in the Marines and after completing boot camp in the spring of 1946, was transferred to the Naval Air Station at Atlanta, Georgia. There I was enrolled in classes at the Link Instrument Trainer Instructors School. LITIS was a very concentrated program that provided me with an education that I feel equal to a commercial license with an instrument rating. It covered all of the normal ground school subjects, including Navigation, Meteorology, Civil Air Regulations, Morse Code, ATC procedures and radio communications. The Instrument flight training, included cross country navigation flights that were made using instructor simulated ATC Clearances. (Currently, using advanced simulators, these flights are called LOFTs, Line Oriented Flight Training.) The courses were on a parallel with the regular CAA commercial pilot flight training. The main difference was that all of the flying for the trainee was done in the NAVBIT-45, Link trainer. In May 1946, I graduated from that school while my classmates were ending their high school training.

Above: Dick Hill at the Link Trainer desk during his years at Lewis College, Lockport, Illinois. One hand on the "mike" while watching the movement of the desk top "crab." Note the nose of the extra trainer fuselage parked against the wall. (Photo from authors collec-

After graduating from LITIS, I was assigned to the control tower for six months and obtained dual MOS, Military Operations Specifications. My actual flight training was flown under the World War II GI Bill after leaving the Marines. The required 20 hours of instrument flight training took place at Lewis College, Lockport, Illinois.

Practical instrument flying began in the late 1920s. There had been many attempts and many failures but the real beginning was that first "hooded flight" made in a Consolidated biplane, by Jimmy Doolittle. Most everyone knows that prior to time that Lawrence Sperry invented Gyro stabilized aircraft instruments, operation in the clouds was all but impossible. To this day anyone attempting to operate in the clouds without adequate training, even if the equipment is in the aircraft instrument panel, has only a scant few minutes before control is lost. That is caused by vertigo which is a loss of balance and it is caused by movement of the fluid around tiny hairs in the inner ear and give the pilot sensations conflicting with his visual inpute. One can pick up almost any aviation magazine and read of someone's loss in this deadly duel with mother nature. (To experience induced vertigo, the FAA uses a trainer that is similar to the Link. The pilot sits in the closed trainer as it is spun around. Following instructions from the operator, the pilot is suddenly overcome with a feeling of vertigo and looses control of the trainer.)

In the early days of flight there were almost no man-made obstacles to low altitude flight. "scud running" was the plan for the day when one wanted to go somewhere and the weather was less than really adequate for flying. One of the most famous of these "scud running" occurrences was the crash of the Fokker Trimotor where Knute Rockne was killed.

In today's flight environment there are few areas where a person can safely fly cross-country below one thousand feet above the terrain. All of the "man made" obstacles make earth's surface resemble the hide of a porcupine with the wild proliferation of tall buildings and radio towers. Each day more and more are being extended into what was once the flier's domain. Don't think that one thousand feet is as high as they go. Many are several thousand feet tall. Several years ago the governor of Michigan was killed when the wing of the plane in which he was riding, struck a guywire on one of the tall radio towers in his home state. Current instrument flight operations are carried from the surface, almost to the top of the atmosphere. Even beyond when near one of the space centers. A constant vigil must be kept during flight operations, to keep away from radio towers or from entering some restricted area.

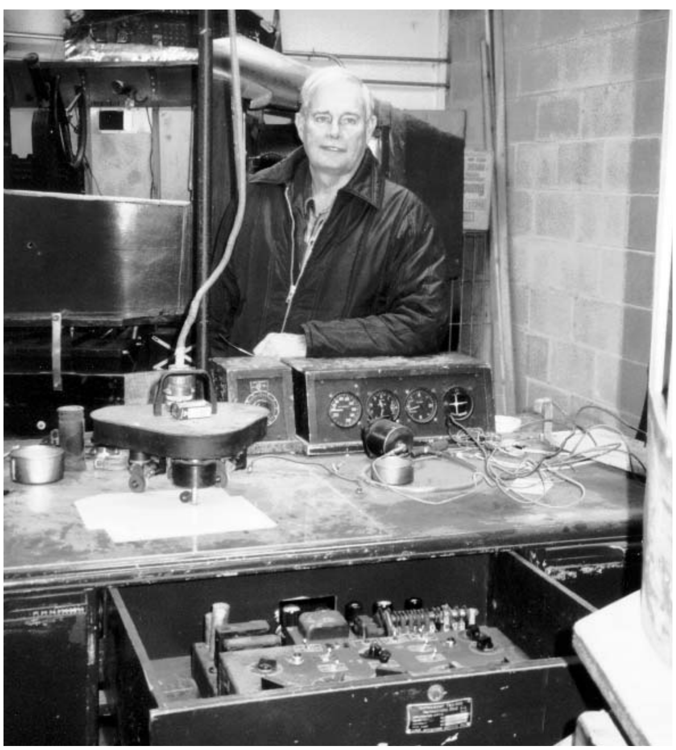
When flying from one area to another, the pilot maintains contact with his position over the earth by various means. Knowing about how long he has been in the air, an estimate of wind direction and velocity, and with a computed ground speed, he can deduce his position within a relatively short distance. The size of that area is reduced to zero when visual contact is made with one of the landmarks. During extended operations over water, there are no visual clues, so the use of all available references, such as speed, time and distance are necessary for estimating an arrival. When Lindbergh crossed the Atlantic, his flight was planned well ahead of his departure. He had plotted his Great Circle route with great care. Compass corrections were made every hour, even though he was always flying in an easterly direction on a constant compass heading would not keep him on course. He knew that these corrections were necessary to remain on the Great Circle route, which is actually a straight line when drawn over a globe. This was not just a casual flight.

Pilots use the shortened term, “Dead Reckoning” when planning and executing a flight when there are few if any visible landmarks along the route. “Dead Reckoning” is pretty much phased out during instrument flight with the use of radios, Inertial Guidance and the other advanced systems. Even that is being supplanted by the Global Positioning Satellite program, GPS. With these modern systems, there is a constant panel read out of the Estimated Time of Arrival, ETA, so one does not have to use a lot of math enroute.

At the dawn of full instrument flight, the various airlines were attempting to extend their hours of flight operation. Aircraft were becoming more reliable and operations were becoming more and more hampered by weather problems. This emphasized the need for reliable radio communications and also accelerated the development of radio navigation. Flight training in aircraft was becoming costly and increasingly dangerous. Time was ripe for an alternate method of teaching the fundamentals of instrument flight.

That was also the dawn of flight simulation. The Flight Simulator actually originated as a carnival ride. Edwin Link had developed a device that was mounted on a trailer. It had a few flight controls and a large fan in the front. One could climb into it and by carefully operating the controls, actually fly the thing through turns and ups and downs. Link was a pilot and he began installing other flight controls and instruments. Eventually he realized that his device had merit as an instrument flight simulator.

Link was from a family that made organs and player pianos. He used the same “vacuum and bellows” system to operate the Link Trainers. He put a hinged hood over the top, added some cockpit lighting and was in the simulator business. Before World War II had even started, his mini airplane on a pedestal was to become known and disliked by most pilots as the LINK TRAINER. It went through several stages and by the onset of World War II the ANT-18 (Army Navy Trainer Model 18.) became the ground trainer for the military services. As a simulator operator, the most common phrase we heard was that “It don’t fly. like an airplane!” It was difficult for the pilots to understand that the Link did not attempt to teach one how to fly, it was built to teach procedures more safely and less expensively than with an airplane.



Above: Dick Hill, standing at the desk of the Link ANT- 18, that is displayed in the EAA Museum at Oshkosh, Wisconsin.
(Photo from authors collection)

The next major improvement in flight simulation came in 1945, when Link produced the Model-45 for the Air Corps and essentially the same unit called the NAVBIT for the Navy. The Model-45, or Navy Basic Instrument Trainer came more completely equipped. It had tunable radios, and a full line of instruments and signals. It had retractable landing gear, flaps and a constant speed propeller, it was configured to operate like an AT-6, or as the Navy identified it, an SNJ. Power settings airspeeds and such were taken from the AT-6/SNJ, they also reflected in the “over the desk” performance of the trainer.

After World War II, several Operational Flight Trainers or OFTs, were built to simulate the actual cockpits of the early jet fighters. When I became rated in the Bell-47B-1 helicopter in 1950, there were no helicopter simulators. The Bell was the only helicopter available to the civilian market. Currently there are several flight simulators for teaching helicopter flight and helicopters routinely operate on instruments.

I was called back to active duty during the Korean War and volunteered to go to Korea flying helicopters, but without a college education, I could not qualify as an officer in the Marine Corps. The Marine Corps did not have a Warrant Officer program such as the Army developed for pilots as early as World War I, however the Marines did have Sergeant pilots as far back as the 1930s and throughout World War II.

While working as a Link instructor I took an additional class in Aerial Navigation including Celestial Navigation. That course was flown in a Link Celestial Trainer- The simulated cockpit of a World War II light bomber was installed in a large “silo” and mounted about 40 feet up. It used the same systems as the Link and a two pilot crew would fly a program with a Navigator/Bombardier in the nose with a sextant or bomb sight and drift meter. He could monitor the progress of the flight on a moving map that was projected on a screen many feet below. With a Drift Meter, he could make necessary course and elapsed time enroute corrections. The sextant was for observations of the stars on a complete night sky that was wired into a routable dome, situated above the trainer. The star positions could be changed to project any area of the worlds night sky. Since planets were not used for navigation, none were projected.

After World War II, other interests soon added more choices to the line of instrument flight simulators. One called the Tranasadyne came into use. It was a stationary machine, as were the OFTs. It was well equipped, used by North Central and several other airline training departments. It was in service for several years. Soon the early jet airliners came on scene and the full flight simulators began to appear. Many of the airline losses in that era happened during in-flight training and made the need for simulation very apparent. Now, the simulators are mounted on long hydraulic legs, using television, advanced computers and provide full flight simulation. Using the actual cockpit of the subject plane, the pilots no longer say that, “It don’t fly like an airplane!” This type of flight training is also available for civilian pilots, provided by such organizations as Flight Safety, Sim-Com and many schools and universities. My introduction to full flight simulation came during the transition from the turboprop Convair to the Douglas DC-9. Then, after ten years of flying that plane and taking six month checks in from an unknown position.

For an instrument approach using the rotable loop, it was necessary to positively locate the station. This procedure was called "Boxing the Station." To Box a station, one would set the loop on the nose and fly toward the station, using the lowest volume that was audible, changes could be quickly noted. If the volume was decreasing, a quick 180 would be made. When the volume began to rise, wind corrections would be made to stay on course. Nearing the station the volume would rise rapidly and then drop off, the indication of station passage. After timing one minute, turn 90 degrees to the right. With the loop set on the wingtip position. Upon hearing the null, time another minute and turn 90 to the right. After this null, once again time one minute. During this portion, request ATC clearance to descend to minimum sector altitude. Note the course from the station to the field. Fly a course perpendicular to it and work around the station, one null at a time, until parallel to final approach course. After station passage, start timing for the distance to the field turn 45 degrees to right, set the loop to 45 degrees off the tail, to the right and descend to decision height. As the null starts to deepen, turn left to approach heading and

Above: Manual Loop Control, from the early days of the Douglas DC-3s. The knob at the top was for selecting the aircraft heading, in this case it is on 180 degrees. The crank was for setting the loop position and moving it to search for the Null. The loop would give a null 30 degrees in front of the wing as it is now set. The protuberance at the lower right corner was for the connection of the flexible cable that ran from the control box to the loop. The parts tags indicate that this unit was from a United Airlines plane that the U.S. Army Air Force conscripted during World War II. (Photo from authors collection)

swing loop to tail. Monitor null. Wind corrections are to be made while descending to final approach altitude.

At the end of the time, either make a landing or "go around." With sufficient fuel, additional approaches could be made unless it was decided that the weather was so bad that additional approaches were not worthwhile. After using this procedure a few times, a pilot could easily get an idea of the wind drift to adjust the time from station passage to the airport. A manual loop approach was a requirement when many of us took the flight test for the Airline Transport pilot rating or the ART as we knew it then. My upgrade was in the DC-3.

Actually, being able to use the manual loop once saved me while flying freight in a Cessna T-50. It was the usual all night operation. A load of automobile battery cables were needed to fill in at the end of a production line run. My copilot and I had both been on duty all day at the flight school and had made the three hour flight to pick up the cargo. As usual the delivery was late and arrived around one a.m. We loaded and took off into a strong headwind for the flight. I decided to fly the first leg and let the copilot take a rest. After about an hour, I woke him and talked to him for a while, told him where we were and what to expect. He was a flight instructor who worked part time at the flight school, and had an instrument rating. The weather was fine, a moonlit night and forecast to be good throughout the trip, so I closed my eyes for a while. When I finally put my earphones back on and looked around, I knew at a glance that he was sleeping with his eyes open. At this time only a few Omni stations had been commissioned so they were no help. There was only static on the low frequency radio. I started turning the crank on the "coffee-grinder" to see what station would give a good signal. All of the stations gave a clear "A" or "N" and I couldn't waste time doing an orientation, Picking the loudest station, I flipped the ADF on and the needle swung to 120 degrees relative. I made a mental note and cranked to the next loudest station, the ADF needle swung right back to the 120 position. The same thing with the third station and I was convinced that the ADF was useless. Starting over with the manual loop, I made the three station checks and determined a track to my destination. We landed with two gallons of gas in each tank.

After the development of the manual rotable loop, the next improvement in the operation of the direction finding system was that of an electrically driven loop. This was called Automatic Direction Finding, or as we know it, ADF. That system operated when the loop was driven by the signal that was received. The signal would progress around the loop in the direction closest to the relative bearing of the station and run the driving motor towards the null. When it passed the center point of the null, the reverse signal would drive it back until the strength was equal. Then the loop would stop with the needle pointing toward the station. There was no ambiguity.

The direction finding system operated on the signals from any radio station that was committed to continuous transmission. Both the commercial radio stations and those installed by the Department of Commerce were used for approaches. In many cases the airlines installed their own stations and they were operated during the times that flights were due to approach. The airborne loop for the ADF was housed in a large football-shaped unit that was mounted on top of the cabin or on the belly of the plane. Surface direction finding operated in much the same manner as the airborne units. The operator of a marine or aviation radio station had a similar controllable antenna and could sweep the area for signals. In the case when a pilot wanted to have his location verified he would be instructed to hold his microphone button down and make a "long count." The pilot would then count slowly to 10 and then slowly back to one. During the count, the radio operator could determine the direction to the airplane. (The aviation historian will remember that Amelia Earhart did not take advantage of this procedure. To save weight, she discarded the powerful "trailing " radio antenna before leaving Florida. Without the proper antenna, and not having established proper communications with the ship that were standing by, she was unable to locate Howland Island and ultimately disappeared.)

With the introduction of radio direction finding to aviation, a new era had begun. The next era used a combination of stationary antenna towers and they were called Radio Range Stations. With the first arrangement a single loop antenna, two intense signal areas could be transmitted. This enabled a pilot to receive a constant signal tone when he was in line with the antenna. With a beam of the stationary loop directed at an airport, the pilot could follow the signal to the field by monitoring the simulator, I was upgraded to the Boeing 757/767. That simulator was far more advanced and even more sensitive than the one to which I had previously become accustomed.

When a pilot completes training in these new simulators, he is a fully qualified and Type Rated Captain. The first time he steps into the cockpit of the actual plane, the chocks are pulled and the plane is pushed back from the gate with a full load of passengers. Of course for safety sake, there is a training pilot in the other seat.

Radio navigation began with the simple “loop” antenna installation. With a loop antenna, radio signals became useful in determining direction. The loop antenna radiated its most intense signal along the plane of the windings and the minimum of signal in the perpendicular direction. This was true for both in transmitting and the receiving the signals. Therefore, if a signal was received, the antenna could be rotated by turning the airplane and it would swing through a maximum and minimum areas of strength. You have probably noticed this same phenomena with small portable radios, to get good sound, it is necessary to rotate the unit and orient it with the transmitter.

With the volume turned down during flight an Aural Null, or absence of sound could be distinguished by swinging the loop. With the loop attached in a stationary position on the airplane, perpendicular to the line of flight, the pilot could fly toward the station while hearing a null. Each radio transmitting station is required by the Federal Communications Commission, or FCC, to identify itself periodically. With a radio station tuned and identified, the pilot could “Home” or fly toward it. However, the pilot had to make the usual wind corrections or the plane would track in an arc toward the station. It would end up drifting around and approaching from the downwind side of

Above: Pilots Radio Control Panel for the ARN-7, World War II to the mid-1960s. Frequency selections were made from three bands, 200 to 410, 410 to 850 and 850 to 1750 Kilocycles. The selection in the window is in the mid-band and at 760 KCs. The crank below the window was used to select the frequency. The pilot would turn the crank to the desired frequency and then move back and forth to get maximum signal on the tuning meter, identify the station and then begin the orientation problem. The function switch is below the Audio control and tuning meter, with the loop drive switch to the right. Both the Audio (volume) control and the loop drive switch, are very well worn from constant usage during navigation and orientations. (Photo from authors collection)

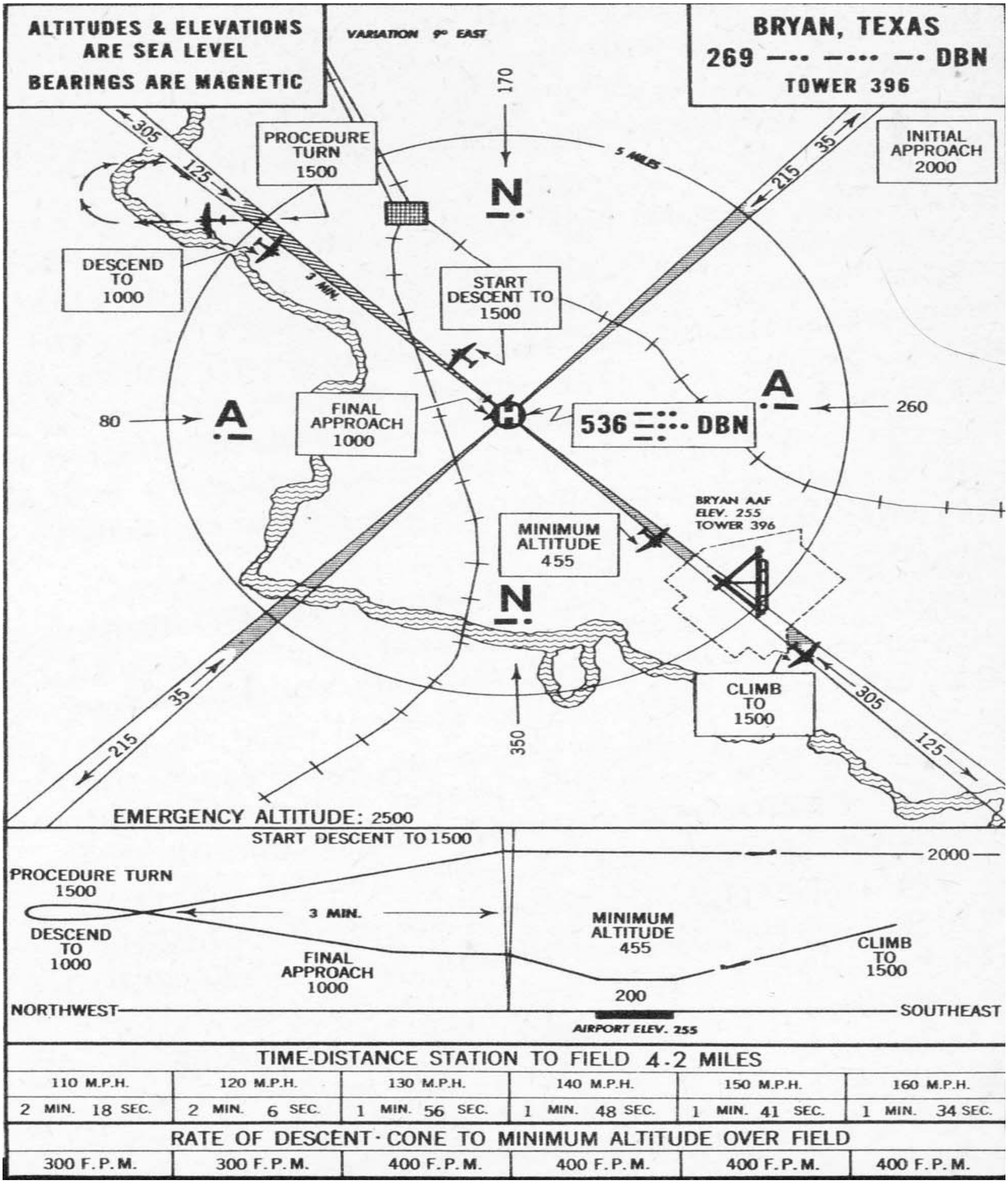
Above: PanAm DC-4/ex-C-54 with a Manual Loop above the nose and an ADF (“football”) below the nose. (Photo courtesy of Boeing Historical Archives)

Right: Instrument Approach Plate showing the “A” and “N” quardants and “Let down” approach. (Page 23 T.O. No. 30-100B-2 “Instructor’s Syllabus Instrument Flying, Advanced” 20 June 1945 USAAF from the Jim Turner Collection)

the station, flying into the wind. This procedure was difficult and to avoid this inefficient tracking around the station, one would “crab” the plane into the wind and listen to the a steady tone signal while making slight corrections. To ease the problems of navigating without being able to track the null, it became necessary to be able to rotate the loop itself so the plane could be flown in a crab while the loop was pointed toward the station.

Photos of early aircraft installations show many instances of those old loops. A streamlined base was attached to the plane and the loop was mounted upon it. A hand crank device was located in the cockpit and for remote operation, a flexible cable was used to turn the loop. In small planes, the loop was located above or below the cockpit and a knob extended into the cabin for use by the pilot. There was a three position switch that read, VOICE, TONE or BOTH. To use the loop one would select TONE. The voice position was for listening to the radio, but it still gave use of the loop as necessary. The Both position was for use if anticipating ATC clearances while listening to the signal. The steady tone was easier to monitor and with a minimum volume setting, changes in sound level could be easily noted. The plate where the crank or knob was mounted had a circle that was numbered from zero to 359 degrees. Zero was situated toward the nose of the plane and the right wing would be marked 90 degrees, the tail 180 degrees and the left wing 270. Those were known as the relative positions of the loop. With a rotable loop the pilot could establish a crab and swing the loop to monitor the Null. The plain loop had a 180 degree ambiguity, meaning that it could not differentiate between the ends of the needle and gave a null from either the tip or the tail of the needle. Ambiguity was solved by merely offsetting the loop from the nose of the plane and turning the plane an equal amount in the opposite direction, then awaiting the change in sound. If the Null moved in the direction that the loop had been turned, the plane was moving toward the station. Conversely, if it moved the opposite, the plane was going away from the station. The manual loop was used for orientation, navigation and for instrument approaches.

The loop orientation was a very cumbersome and tedious operation, but to make a fair assessment of the students knowledge it was necessary to have him make a complete orientation be used depending on the type of station. The "True Fade," or "Fade 90 Orientation" on the radio range, was the most simple to teach and it was adaptable to most situations. As a standard, the quadrant containing True North was also the "N" quadrant. To start a problem for a training pilot, the instructor would put the desk "Crab" in a clear signal area to start the procedure. Ordinarily, a sheet of plexiglass was on the desk. The instructor would select a diagram of the range station, with the airport situated at the proper location. Quite often the instructor would take a sheet of butcher paper, draw out the station planform and tape it to the desk top. That way the pilot could keep the example of his work to review at his leisure. The crab was on three legs. The two in the back were driven by electric motors. They were steered, through a repeater device, by the actual heading of the trainer. The speed over the chart was controlled by the indicated speed of the trainer. Those inputs were transmitted to a box located beneath the trainer, in the base or pedestal unit. This was a very complicated machine with many sets of gears. All of the inputs would be directed into a mechanical "wind triangle." With reference to the old Navigation Manuals, when planning a cross country trip, the pilot would plot his course, then plot the forecast wind line on it. Next a dot was



the beam. The first drawback was that the signal again, was ambiguous. Additionally, it was sometimes almost impossible to determine actual station passage. The pilot could be anywhere along the line and have no real idea how far he was from the loop or which direction from it. (World War II pilots and historians will recall the B-24, "Lady Be Good," whose crew perished after running out of fuel over the Sahara Desert. After completing their bombing mission over Europe, they crossed the Mediterranean and flew over their station without realizing it. Without determining the ambiguity of the radio signals, they flew until the engines quit. They survived the night emergency landing, but succumbed to the unforgiving desert climate).

The next development in radio navigation was the addition of a second stationary loop at that was perpendicular to the first. That development became the known as the Loop Adcock radio station. It was necessary to transmit separate signals for each of the loops. Early station to station radio communication was made by the transmission of a steady C.W. tone or Carrier Wave signal that was broken into readable, alphabetical characters via the International Morse Code. This was done by using a hand operated key or "Bug." To make the continuous airway radio signals automatic, an interrupter that was run by an electric motor was installed. The signals were then broken into a series of Dots and Dashes. These quickly became known in pilot talk as "Dits and Dahs." The "A" and the "N" interlocked and made up the "Beam." The Dit Dah of the letter "A", was transmitted by one loop and the Dah Dit of the "N" was transmitted by the other. With the plane in a position where the maximum signal from both loops was received, it once-again became the steady tone that was known as the beam. Every thirty seconds, the beam signals would be interrupted for the station identification. The keyer would transmit a unique series of Morse Code letters that were incidental to each station.

The aural signals were divided into four quadrants of clear "A" or "N" signals and four of the steady tone beams. Those areas between the beams were divided by the amplitude of the sound, into the "Twilight Zone" on the edge of the beam, the "Bi-signal- Signal" area, where both could still be heard and the "Clear" signal area where only one letter was audible. As the plane was flown on an angle further from that steady tone or beam, the signals Dah Dit or Dit Dah would seem to increase as the background tone would disappear. Then the only audible sound to be heard, other than the continual static, was the repetitious "A" or "N" signal static on these frequencies was always at its worst when the weather was bad, especially bad during thunderstorms, when the need to hear the signals was the greatest.

The actual beams were compressed into just three degrees of width. The width of the twilight, bi-signal and clear areas were determined by the angular distance between the beams. Most station setups spaced the beams 90 degrees apart. But for alignment, some of the beams were swung to one side so they pointed toward another station, or away from a mountain. These were called the "Crow Foot" stations. Another type of station had the beams swung close together, like a pair of scissors and was called the "Scissors" station. For the most part the beams were situated so they lined up with other stations to form the airways. Whenever possible one of the beams would cross the nearby airport to simplify locating the field during instrument approaches.

The Airway Radio System of those days was built around the earlier established Lighted Airways. Initially the visual daylight airways were flown directly from airport to airport. When night operations were added, it became necessary to include a system of lights on the longer routes. At first, a series of bonfires were lighted. That of course was very troublesome. Later on, electric rotating beacons were installed because they were easier for the pilot to see. The rotating beacons were mounted on towers which were placed on the path of the airway, at ten mile intervals. Each tower had an extra pair of directional lights that were aimed along the route and they flashed a Morse code letter so the pilot could know where he was along the route. The series of letters which were used began at the point of origination of the airway and they were: W,U,V,H,R,K,D,B,G,M. The letters were then repeated as necessary for the length of the route segment. The memory device we were taught was - "When Undertaking Very Hard Routes Keep Directions By Good Methods." From an altitude of 5,000 feet a pilot can see approximately one hundred miles, so on a night flight under Contact Flight Rules (CFR), as they were known before the change to VFR when the FAA was established in 1958, with good visibility, navigation would be quite easy. As air travel increased, more and more airways and beacons were added. Soon the flashing lights could be seen in almost all directions. With the increasing reliability of radio navigation, lighted airways were no longer needed. Early in the 1950s, the beacons were turned off. Only a few that were located on some mountain tops were kept in operation.

I very well remember the night they were shut down. I was giving night flying instruction for a school at Streator, Illinois, which had students on the GI Bill. Amber 5, the airway from Chicago to St. Louis ran about twenty miles east of the airport. I always looked at that beacon because it had shined into my upstairs bedroom window, all throughout my childhood. It was not working that night and as soon as we landed, I called the Joliet Radio Station to make the report. They informed me that all of the airway beacons had been turned off that day and an era had ended. Being on a small grass airport, we did not check the Notams, Notices to Airmen, so it was a real surprise. Besides, Notams are about the equivalent of notes on the billboard at a truck stop. There are too many to keep track of and by the time you see them, almost all are obsolete.

The airways of the time were designated by four colors, Blue, Amber, Red, Green and were called Colored Airways. The Blue and Amber airways ran generally north and south. Red and Green, generally east and west. When the Radio Range Stations were phased out by the advent of the Visual Omni Ranges, the colored airways were dropped and the new visual airways became known as the Victor Airway System. Later on the Hi-Altitude routes were called Jet Airways.

To fly the colored airway, one would attempt to line up in the twilight along the right side of the beam. Once established in the twilight area, wind corrections would have to be made to remain there. As the plane moved toward the station, the radio volume would increase. The beam would also narrow, necessitating smaller turns or "brackets," as they were called. When first encountering the beam, the pilot would make a turn of thirty or more degrees to line up and correct for wind. Then each of the turns would be of lesser magnitude, eventually attempting to remain along the edge of the beam with a series of bracketing turns. Approaching the station there would be a rapid increase in volume and if properly aligned, a sudden drop to silence when over the station. That was known as the "Cone of Silence." Since the cone was often missed, another radio transmitter was installed and operated on a different frequency. Airway radios operated within the Low Frequency range of 200 to 400 Kilocycles. The other transmitter, called the "Z" Marker emitted a steady, hi-pitched tone on 75 MCs. that was directed vertically into the cone of silence. These markers will be covered later. When teaching the radio range system, as with the operation of the loop, it was necessary to teach orientation from an unknown position. Several types of orientation could

The " Z" markers and their companions, the "Fan" markers and "ILS" markers, which will be further discussed with the "ILS" system, were operated on 75 megacycles in the VHF band. Communications were in the High Frequency band with 3105, 4495 and 6210 kilocycles as the main civil frequencies. Those were the days before Hertz was honored and the terms like Megacycle and Kilocycle were still used.

The ATC clearances were transmitted by the radio stations on the range frequency, with weather reports every 30 minutes. On weekends at training bases, the radio station crew would be off duty. At those times the tower operator would read selected station reports for pilots enroute. The pilot would make his transmissions on High Frequency and receive clearances on the range frequency. There was a selector in the pilots radio control box marked "Voice-Tone-Both" that would remove the radio beam sounds from the receiver during voice communications.

Air Traffic Control had its beginnings at Chicago's Municipal Airport. It began with a volunteer and a flag at the intersection of the main runways. When radio came into the picture, control towers were operated within the same low frequency assignments as the radio ranges. The standard control tower frequency was 278 KC. When airports and control towers were located close together, additional frequencies were assigned. Receiver frequencies were printed on a circular wheel and were selected by turning a crank on the pilots radio control panel. The pilot could also communicate with both the control towers and the radio stations on the H.F. band if a receiver was on board. The aircraft usually had only a few transmitter crystals, that might cause a manual change of transmitter crystals during a cross country flight. At present all normal communications for civil air traffic are on VHF. Military communications are on UHF.

During World War II, there was an intense effort toward improvement in radio navigation. The Loran system was added for long distance and over water flying. Airborne Loran (Long Range Navigation) was a very complicated and cumbersome system requiring a Flight Navigator. The receivers were large and heavy. They monitored stations all over the world. To plot a location the navigator had to take readings from three stations. Special maps were printed with patterns of interlocking waves printed in different colors for each transmitting station. The charts were much like having three or more weather system charts superimposed on one sheet. Each of these curved lines, like the isobars, was numbered in the proper color. The navigator had to extrapolate the information from his books to determine which stations to monitor. Then locate his position with a plot using signals from three sets of the numbered wave lines. The receiving set was large and heavy, it used a common oscilloscope, much like those seen in the old TV doctor shows. When properly tuned, the navigator had to count the little "chairs" in the "chorus line" on the scope. Armed with readings from the three stations, he could make a plot on the map, showing where the plane was when the readings were taken. On shipboard, there was little difference in the position and the plot, but with the plane cruising nearly two hundred miles an hour, quite some distance might have been flown. Today we can be sure exactly where we are in seconds and all that with no cumbersome books or heavy equipment. We can turn the power on for a little plastic Loran box. This unit is very compact and solves all of the equations. It presents the operator with the same answers as the old manually operated unit with no computations by the operator. The main problem is with holes in the Loran signal system. Signals are blocked or not available in some areas,

Radar also came into play during World War II and with it, the "Ground Controlled Approach". Using the Radar operated Ground Controlled Approach, the weather minimums for the Military were "Zero-Zero." Zero visibility and Zero ceiling. It was this system that made possible a successful "Berlin Airlift" to overcome Russia's blockade and to feed and supply heat to the city.

This was done with mobile units, mounted on trucks which could be hastily installed at any airport large enough to handle the transport airplanes. While in operation the transceiver antennas operated at high speed. The lateral antenna revolved and the glidepath antenna swung up and down through the established line for the glidepath. There were two scopes in front of the controller. On one, the "blip" representing the plane gave the indication of the lateral position of the plane. On the other, the blip gave the relation of the plane to the glide path. The pilot monitored the radio and followed controllers instructions. The controller would say things like, "You are on course, five miles from glide path interception. Drifting slightly, turn left ten degrees. On course turn right four degrees." The patter would continue, replies from the pilot being unnecessary because the controller could watch immediate response to directions. As the plane neared the glide path. "Approaching glide path, begin normal rate of descent. Slipping above glidepath, increase rate of descent. Turn right three degrees. On glide path, adjust rate of descent." And so forth until approaching the runway. "Nearing the landing point, take over visually and touch down. Good approach." Remembering that many of these landings were done with weather so bad that the wheels would touch the runway before the pilot could really see it, gives one an understanding on the importance of the development of radar.

The Instrument Landing System was also developed in that era after having been experimental for some time before World War II. Radar controlled GCA and the pilot monitored ILS, gave us the first practical precision approaches. Until that time, the Loop, ADF, and Radio Range were about all that were available. Those approaches were limited at most airports, to weather conditions of four hundred foot ceilings and one mile visibility, what we now call Non-Precision approaches.

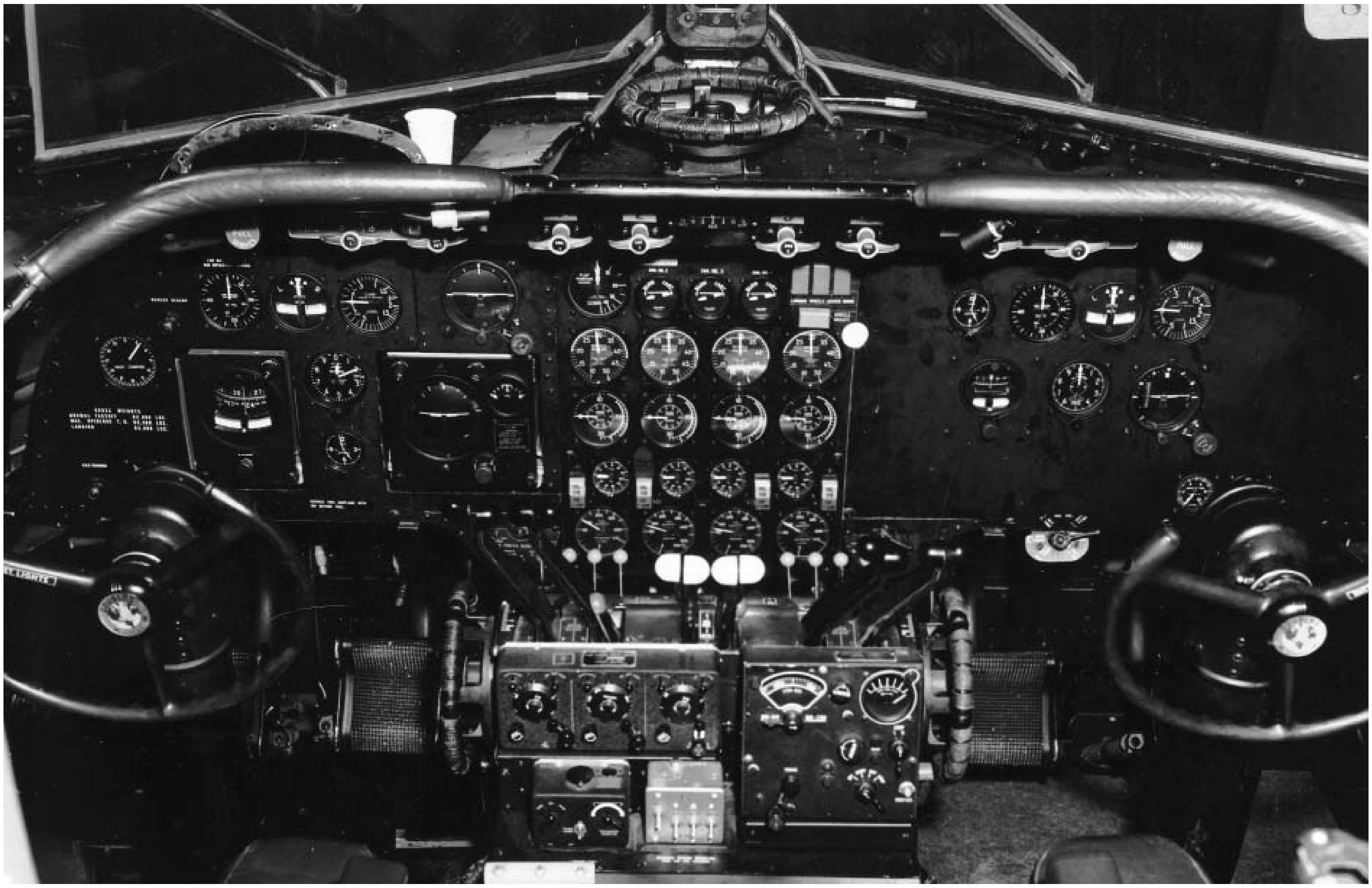
The ILS system brought the approach minimums down to 200 foot ceilings and one half mile visibility. It was hoped that safe flying could soon be done right down to zero ceiling and zero visibility everywhere. With the advent of Auto-land in the latest jet transports, Category III permits virtually that. Jets now land with just a few hundred feet of visibility, with zero ceiling.

The Instrument Landing System or ILS frequency was selected from the Approach Chart. The system consisted of several transmitters, one for the course, one for the glide path and there were others for determining distance from the field while on course. Those were the transmitted on a VHF frequency of 75 megacycles. They, as well as the "Z" markers were transmitted upward in a very narrow pattern. The "Z" marker was formed in a circle to fill the cone of silence. ILS markers were transmitted in an elliptical shape and the additional "Airway" marker was cone shaped. Approaching a marker, an aural signal would begin filtering in. Soon afterward a light on the instrument panel would start flashing.

The Outer marker sounded like a low pitched DOOM, DOOM, DOOM and a purple light flashed. The Inner Marker was more of a high pitched, DIT DAH DIT DAH, DIT DAH with a amber light. The Outer Marker, was located about five miles from the runway end, the Inner Marker about two and a half miles from the runway and an occasional Boundary Marker, at the airport fence. LF Radio Compass beacons were located at the outer and inner markers. ILS brought us down to 200 feet and a half mile. GCA was good to Zero-Zero, but as made at the scale of the airspeed of the plane on the line. Then a fine was drawn from the end of the wind line, to the point of the speed dot on the course fine. The length and angle of that line would be ground speed and the heading necessary to follow the course line. All of these factors were reproduced automatically by the mechanical "Wind Drift Box" in the trainer. The heading and speed of the "Crab" over the chart, was scaled and determined in this manner.

The third leg of the crab rested on a wheel with an ink applicator filled with a red ink. The tracks made would give the training pilot a readout of his struggles with the Link when reviewing his performance. While the pilot was sweating with the Link, the instructor sat at his desk with a radio range tone generator. It had the motor driven station identification keyer and several manually operated controls. The instructor would be seen leaning over the desk, intently watching the movements of the crab and changing the signals to match its position. At the Link department that I managed for two years after World War II, in Tsing Tao, China, I operated three NAVBITS simultaneously. I had connected the intercom systems together and could sit at either desk. I scheduled the pilots so that while the pilot a trainer #1 was practicing a procedure, I could be briefing another in trainer #2 or #3. Having a transport squadron of C-46 pilots, a fighter squadron of *Corsair* pilots, a Navy Tow-Target Squadron and an Observation squadron of L-5 pilots, there was plenty of activity and I would see from eight to ten of them in a normal day. I was also fortunate to be able to fly with some of the pilots during their tow target missions on my days off. Flights were made in the Martin B-26 and the Douglas A-26. In exchange for Link time after hours, I was able to fly with Marine friends who had requested discharge and were civilian pilots for Chennault in his airline, CA T, or Civil Air Transport. They flew the Curtiss C-46s and Douglas C-47s. Previously, when I worked in Navy Atlanta tower, I had made some such flights with the reserves in the SNJs and the SNBs (Twin Beechs).

The Navbit had an automatic system where the "Crab" received signals from a station layout that was placed in the bridge structure over the desk. An improvement over the ANT-18, where the instructor was glued to the desk. With this setup, I could move from desk to desk to observe the progress and serve as ATC for all three trainers. I was also able to select communications with either trainer to provide assistance to a pilot during his individual practice period.



Above: C-54 Panel with ADF mounted on center console right side. Also note flight instruments on both left and right panels 41. (Photo courtesy of Boeing Historical Archives)

To begin a radio range training session, the crab would be placed in an open sector where the pilot would only hear a clear "N" or "A". Several station setups were available and the pilot would tune and identify the assigned station, turn his sound volume to the lowest audible setting and wait for an increase or decrease of sound. If it went down, he would make a 180 degree turn and wait for increase in sound. With an increase, he would eventually enter an area of signal. It could be either an "A" or an "N" and possibly have some "twilight" in the background. He would continue and fly through one of the beams. Then make a right turn of 90 degrees. This turn would identify the course that he was on as depicted in the diagrams and he would proceed to the station after receiving an approach or holding clearance.

Keeping the signal volume at a low setting, the pilot would monitor his progress toward the station. Heading corrections would be made as the signal changed to indicate deviations from the beam, The "right-side" rule was followed and the pilot was to hear a bit of the "A" or "N" signal "twilight" while cruising toward the station.

bars were like miniature wings that the pilot flew to follow indications from the Localizer and Glidepath. Currently, in modern jet transports the flight direction information is computer generated and presented on the TV tubes of the "Glass Cockpit."

Other little known navigation systems were also developed during the final stages of World War II. One such system was used by the Navy to secretly direct the planes back to the carriers. It was simply called "YG." I do not know the derivation of the term but I had to learn the system to teach carrier pilots while giving instruction in the Link Trainer. In that system the area around the carrier was separated into thirty degree quadrants. Each quadrant was given a Morse code letter. For security reasons these codes were changed quite often, so the pilot had to have a copy of the code series for the day before taking off on each flight. If for instance, the code for that particular hour called for an F to be in the North Quadrant, the one on the NNWest might be an R and the quadrant on the NNEast might have an H. Suppose the pilot heard the F, he knew he was North of the ship and need to head South to find it. If an R started to enter in the background of the sound, he knew that he had to make a correction to the left to continue to the carrier.

Jimmy Doolittle's experiments with instrument flight, as noted previously, would not have been possible without the development of the Turn and Bank instrument which Sperry had developed in the mid 1920s. That instrument contained a heavy, brass, gyroscopic wheel that was activated by suction. The back of the wing deicer pump evacuated the air from the instrument case to a suction value of approximately 5.8 inches. That created a hi-speed jet of air that was directed into a series of cups that were machined into the surface of the wheel. It was much like an old "water wheel." However, rotating at a very high speed, it became very stable. Any change of heading would cause the wheel to roll or precession from center making the needle swing to the direction of the turn. The speed of the gyro wheel was set so that when the needle was displaced one width from center, the plane would be turning at a rate of 180 degrees per minute, or three degrees per second. That became the standard and was known as the "Standard Rate Turn" for early instrument flying. In addition to the turn needle, the instrument contained a curved tube that held a weighted marble in a non- freezing solution. It was somewhat like a carpenters level, but inverted so that the ball would normally stay in the middle. During a coordinated turn the needle would be pressed off center, but the ball would stay in place. If the turn was skidded, the bail would roll to the outside and in a slip, it would roll to the inside. We were taught that when the ball was off center, you were to "Step on the Ball." That meant use rudder pressure on the side where the ball had gone to return to coordinated flight. As would be expected, the faster the plane, the larger the circle. (The Turn and Bank instrument was replaced by the Turn Coordinator and now, neither appear in the panels of modern cockpits.)

Using a combination of needle ball and airspeed, the plane could be flown successfully in instrument weather. We were taught to observe the trend of the needle, if the speed started to decrease, lower the nose and, etc. Vertical Speed instruments were included as an aid, as were the compass and altimeter and clock. The wet or as it was known "whiskey" compass, is unreliable during turns due to the northerly turning error. The location of the magnets in the compass caused it to become erratic when passing through northerly or southerly headings. The compass is steady and correct while passing through easterly and westerly headings while turning. To check headings, one would have to maintain a steady position for a while and wait for the compass to settle down for a reading. Then turns or heading corrections could be made at 3 degrees per second.

Using a standard rate turn, the pilot could calculate the time required to reach a desired heading. We were taught that the face of the clock could be used to visualize the compass while making timed turns. Twelve o'clock would be 360, six o'clock 180 and so forth with each number on the clock representing 30 degrees of the compass. After the arrival of the Remote Indicating Compass (RMI), with its circular face, this was no longer necessary.

Eventually the "partial panel" system was phased out by the installation of the attitude and directional gyros. Full gyro panels were in use well before World War II. However, the CAA did not approve of their use in training. The old reliable Turn and Bank remained as an accepted instrument and was required in flight tests until the mid-1950s. Until then, the flight tests required "Needle-Ball and Airspeed," with the low frequency radio. No gyros, or VOR instruments were allowed during that era.

Sperry continued his experiments and developed the Directional Gyro and the Gyro Horizon. Those instruments operate on the principles of stability. When the full gyro panel finally came into play during the thirties, it was necessary to revert and include the old partial panel problems to the syllabus as a safety factor during gyro failures.

The Visual Omni Range or VOR was making its appearance in the late forties. While instructing in the Link Trainer in China during 1947 and 1948, I taught GCA, VOR and VAR in addition to the regular syllabus to pilots who had been on extended tours of the Pacific and the Orient. Since they would soon be transferred Stateside, they needed a "heads up" on current procedures. We had not yet entered the VOR DME or Distance Measuring Equipment stage at that time. The military eventually had its own similar system called VOR/TAC with its Tactical DME.

As an overview of the operation of the Omni range, it transmits navigation signals in the VHF range. The assignments fall just under those for the early television stations, channels 2 to 13. The course lines are called radials as they radiate on all 360 degrees from the station. For a mental image of how the VOR signal pattern works, imagine looking straight North toward a transmitter tower. If the signals were to be visual, one would periodically see two instant flashes. One from a light that could be seen only along that line of position and a rotating flash of light that could be seen from all directions around the tower. Presume that they both occur at the same second while you are racing North, toward the station. Reposition to a spot facing East toward the tower and one would see the flash of light and a period of time later, see the other rotating flash. Using radio energy for the flashes, the Omni receiver computes the milliseconds of time difference and displays it on the panel instrument. VOR as it is known, means that the unit has a visual indication and was omi-directional. The Links did not have Omni equipment installed. To overcome this, I used the ILS instrument. The center needle with a Blue segment on the left and a Yellow segment on the right was the same. The horizontal needle was used to show "TO," by tilting upward and "From," by tilting downward. The TO/FROM indication on actual VOR instruments appears on two little windows and an OFF flag, to indicate malfunctions. To assess the signal value, the pilot must rotate the 360 degree Omni Radial Selector and bring the Blue/Yellow needle on the instrument to the center. For Link simulation, I used the Loop drive and needle for the Bearing selector. In the above description of the Omni function, the needle would center on either 90 or 270 degrees. The pilot would then note the To/From needle to confirm the location with reference to the station. That position, in this case, previously noted, it was only available for the military. The ILS instrument in the airplanes panel used dual needles, the vertical needle indicated the relative position in reference to the runway centerline. The horizontal needle referred to the aircraft position in relation to the glidepath. The pilot maneuvered the plane visually through indications on the instrument and attempted to keep both needles centered. during the approach.

The ILS course narrows as the plane nears the runway and smaller corrections were made to maintain alignment. Those same corrections were required while making a Ground Controlled Approach, but were observed by the controller and corrections were transmitted to the pilot. In some later usage, at civilian airports, the ILS and GCA courses were superimposed. They were installed at a few combined use facilities and the airlines used their own approach minimums. Eventually, the combination was in use at most busy terminals.

The approach controller was able to monitor each ILS approach and if any deviation was noted, one would hear the controller say something like "North Central 252 you are sliding off course, correct left." Or perhaps , "You are slipping low on the glidepath, reduce your rate of descent," much the same calls as were heard from the GCA controller.

Quite often when delays build, it becomes necessary to enter a holding pattern. The original procedure for the pilot was to proceed toward the outer marker or another assigned "Fix," or fixed position. The fix could be the intersection of Airways or airway radio beams. (Currently the intersection of VOR Radials.) Upon arriving at the fix, the pilot would execute a course reversal or fly away from the fix. Then, time out a certain number of minutes, do a procedure turn and return to the fix. for a "procedure turn" while tracking outbound, the pilot would turn 45 degrees to the left. From the first sign of the "twilight" signal, time one minute and then turn 180 degrees to the right, or away from the station or fix and then follow the edge of the beam inbound. This would be repeated until an approach time was issued. The pilot would then adjust the size of the final pattern so as to be at the fix or marker at the proper time for the approach to begin.

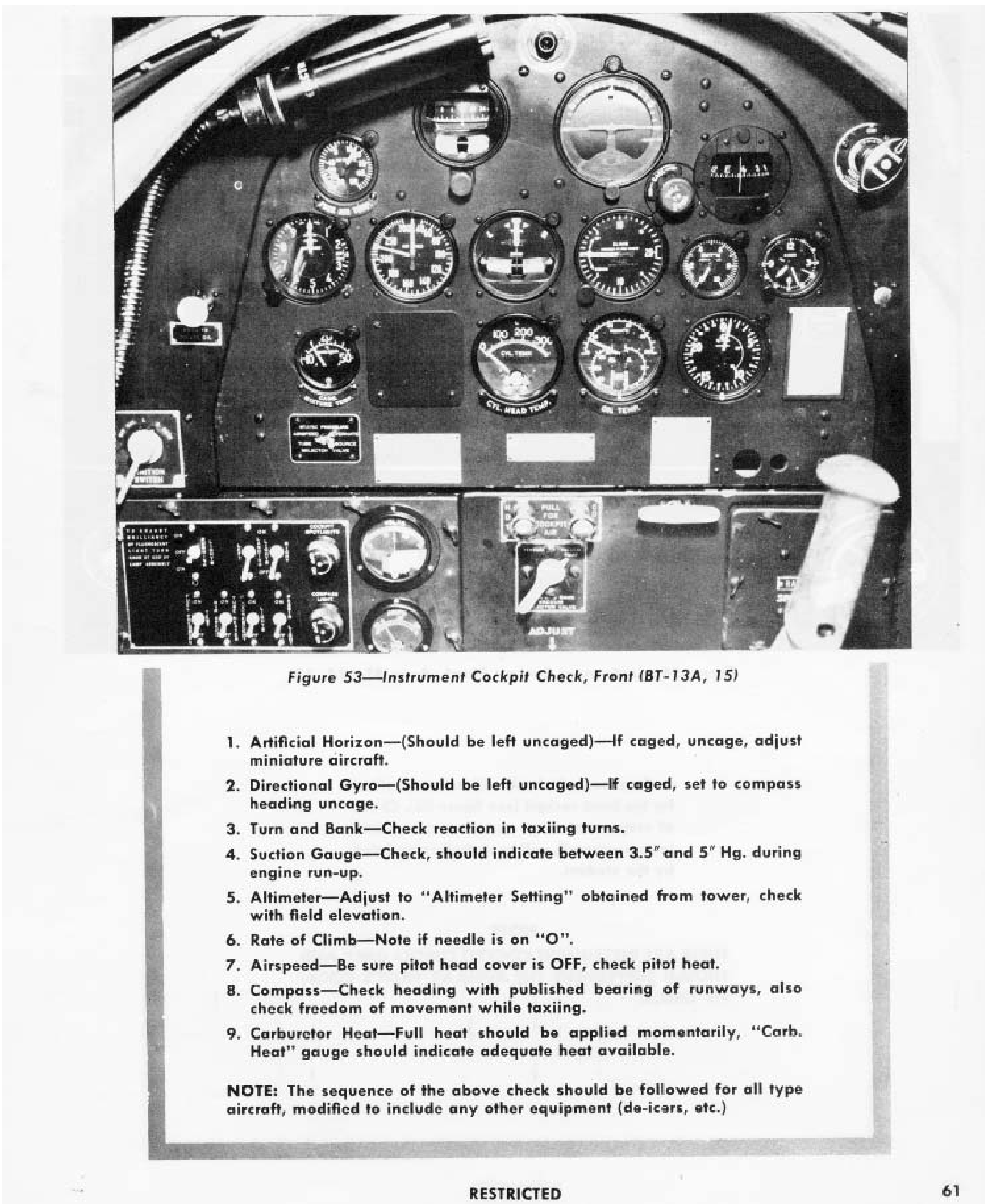


Figure 53—Instrument Cockpit Check, Front (BT-13A, 15)

1. Artificial Horizon—(Should be left uncaged)—If caged, uncage, adjust miniature aircraft.
2. Directional Gyro—(Should be left uncaged)—If caged, set to compass heading uncage.
3. Turn and Bank—Check reaction in taxiing turns.
4. Suction Gauge—Check, should indicate between 3.5" and 5" Hg. during engine run-up.
5. Altimeter—Adjust to "Altimeter Setting" obtained from tower, check with field elevation.
6. Rate of Climb—Note if needle is on "O".
7. Airspeed—Be sure pitot head cover is OFF, check pitot heat.
8. Compass—Check heading with published bearing of runways, also check freedom of movement while taxiing.
9. Carburetor Heat—Full heat should be applied momentarily, "Carb. Heat" gauge should indicate adequate heat available.

NOTE: The sequence of the above check should be followed for all type aircraft, modified to include any other equipment (de-icers, etc.)

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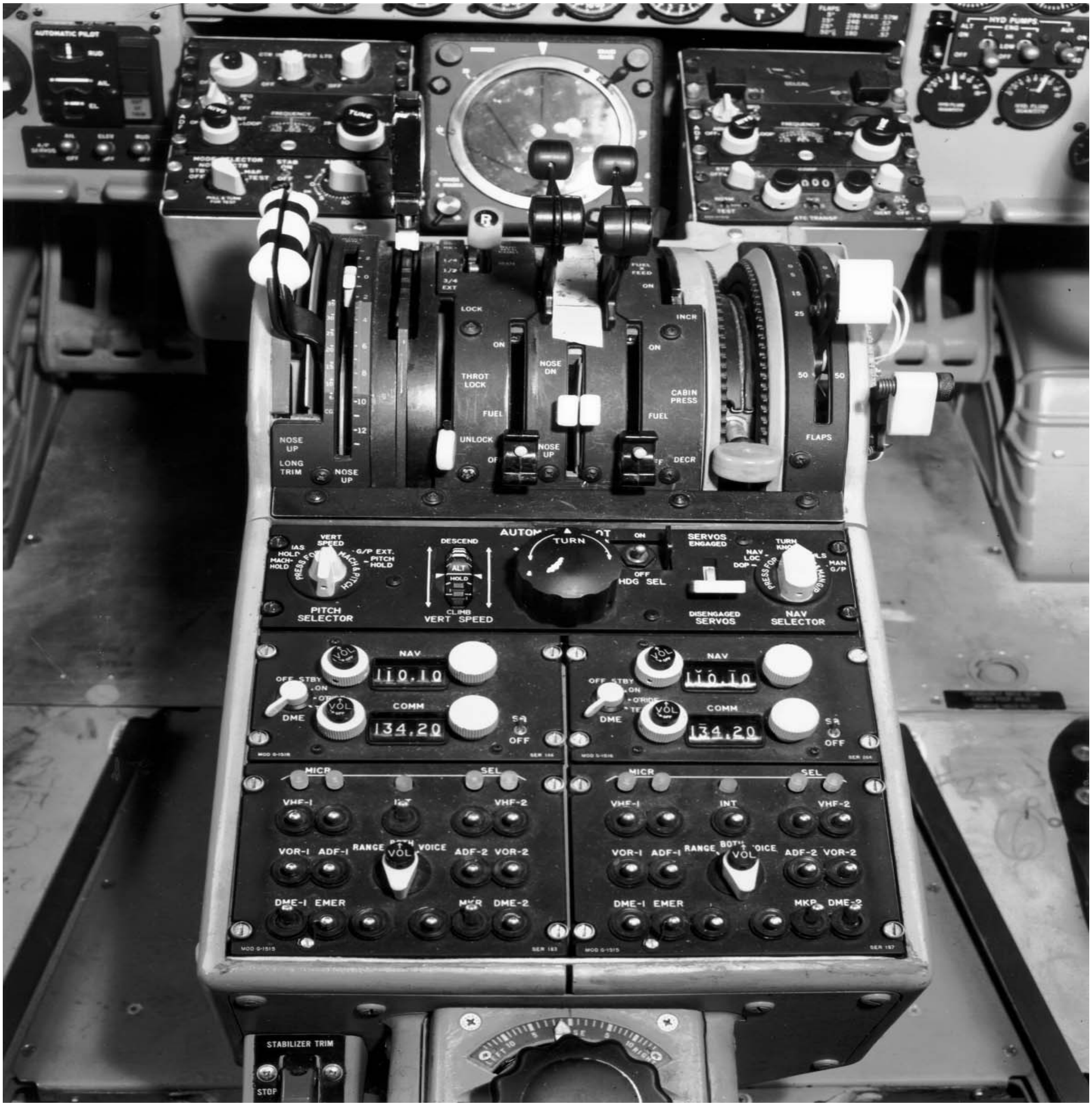
Above: BT-13 Instrument Panel as used for instrument training. (Page 61 T.O. No. 30-100A-1 "Instrument Flying, Basic" 1 June 1943 USAAF from the Jim Turner Collection)

In the times of World War II, a gentleman by the name of Saint invented a short cut procedure that was called the "Saint Stack." For this, the pilot would proceed along the ILS course to the Inner marker and execute a 180 degree turn and then home outbound to the Outer Marker using the ADF. Then once again, turn back to home with the ADF to the Inner Marker. This would be continued until he was given clearances to descend to the Outer Marker altitude and prepare for the approach at the assigned time. Graphically, this appeared the same as the race track holding pattern in common use today. The main difference is that it can now be used at any station or intersection of the airways using standard right turns and one minute outbound from the fix. The locator at the Inner Marker has long since been discontinued, but Saint's "race track" still lives.

When, in the early days, the ILS course was used for enroute navigation the ambiguity situation reappeared and a second, perpendicular aural beam was added. This system was called the Visual Aural Range, or VAR. The ILS course indicator was used for tracking and the pilot had to monitor the aural "A" or "N" signal from the other loop to establish station passage. Few were installed and they didn't last very long. With current use of VOR, DME (Distance Measuring Equipment) and Inertial Guidance, this system was no longer necessary and the ADF locator at the outer maker has become of little use.



Above: MD90 Center Console NAV/COM.Note: VOR/DME settings. (Photo courtesy of Boeing Historical Archives)

The common ILS instrument was eventually supplanted by the Sperry Zero Reader which computed the course and glide-path corrections so the pilot would only have to follow the movement of the ball in the instrument. Using the indications of the ball, the pilot would roll and pitch to follow the ILS. The Zero Reader was replaced by the Flight Director that used " V" bars instead of the moving ball in the instrument. The "V" would be 90 degrees TO or along the 270 radial, as they are considered to radiate from the station. Victor Airways or course lines are located on the map and delineated with reference to Magnetic North, the Magnetic Variation having been corrected when the station was installed. For instance, the Airway from the Janesville, Wisconsin, VOR to Chicago's O'Hare airport, is Victor 97 and it is located on the 108 degree Janesville radial.

When Jimmy Doolittle made his first instrument takeoff and landing, he was under a canvas "hood," in the back seat of a military biplane. Variations of that canvas hood were in use throughout World War II. The North American AT-6 and the Vultee BT-13 were basic instrument trainers and the back cockpits were the scene of countless hours of practice while sweating under the hood. Cabin airplanes such as the Cessna T-50 had a variation with a curtain that was snapped in place in front of the pilot.

The Howard DGA-15 *Nightengale* was used for the Navy's Instrument Flight Instructors School at Atlanta, Georgia. Those IFIS planes were equipped with a third set of controls, a full set of instruments and radios for the student, who sat in the left rear seat. On my flights in that position, I was completely secluded, there weren't any windows for visual contact with the outside world. As would be expected all of the sensations were there. The command pilot would position the plane on the runway. The student would request an ATC clearance, make a Zero-Zero takeoff and fly completely on, what to him was, an actual instrument flight. Those flights were very much like flying in a Link. "But it felt like a plane."

For hood work in the DC-3, a set of "venetian blinds" came into play. A framework that would fit in the area between the glare shield and the overhead panel, was held in place with a piece of bungee cord, Aluminum shutters placed vertically, closed the view for the pilot, but were aligned so that the instructor pilot had good vision. The device could be used from either seat position depending whether training captains or copilots.. Various arrangements like these were used in all types of planes.

For Navy and Marine aviators in the early fighter planes, such as the *Corsair* and *Hellcat*, the blue amber system was used. A set of amber Plexiglas shields were installed inside the windshield and canopy. The pilot wore Blue Goggles and the combination rendered the windows opaque. It seemed that almost no fight even entered the cockpit. Once again, it was much like the old Link, flying at night. The pilot of the training plane would taxi out, request ATC clearance and depart. As soon as a safe altitude was reached, the blue goggles would go on. He would then fly the whole period or trip without being able to look outside. With that arrangement a chase plane flew tight formation and monitored the progress while watching for other traffic. If things went wrong, all the chase pilot had to say was, "Pull the goggles." After completing an approach, the chase pilot would signal for a goaround or for the pilot to pull the goggles.

Blue-Amber was also used in civilian aircraft after World War II. When I took training for the instrument rating at Lewis College, Lockport, Illinois, I wore the blue goggles and the outside visibility was obscured by the amber shields around the cabin of the Stinson *Voyager*. I practiced and took the flight test using needle-ball and airspeed and only the Low frequency radio. That process continued for several years afterward while I was teaching in the instrument flight training program. Blue Amber disappeared in the mid - 1950s when the little plastic hoods came into use. They also brought daylight flying into the program and served to make it a bit simpler and somewhat more comfortable. At that time Low Frequency radios were phased out and the VOR system with the Victor airways became the standard.

Along with Inertial Guidance, the newest navigation system is called GPS, using the Global Positioning Satellites. The GPS, or Global Positioning Satellite Navigation system currently offers world navigation information. It became available to civil use after the Iraq Desert Storm and carries much more information than the VOR/DME. Using the published identifier codes for an airport or navigation facility, a person can locate his position any where in the world. With moving maps, control and warning areas are depicted on the face of the instrument, the newest models provide all that is necessary and with permanent installations in the aircraft panel, are usable for instrument flying, including approaches.

I have lived the American Dream, for a young man from the corn fields of Illinois to be part of the progress in flight training and simulation for over fifty of these important years is a great achievement. Learning to fly in a J-3 *Cub* in 1944, becoming a Link Instructor, Ground Instructor, a Control Tower Operator, Flight Instructor, Flight Test Examiner and Airline Pilot, plus the opportunity to fly all sorts of planes from 37 horsepower *Cubs* to the latest of the jet transports, truly a dream come true. I have been fortunate to fly many planes with many different engines. The oldest of the engines was the pre-World War II Curtiss OX-5, a water cooled V-8. The newest was the Rolls Royce RB-211, three spool Fan Jet in the Boeing 757. ☐

ABOUT THE AUTHOR: Richard C. Hill, retired in 1988 at age 60, after 31 years of airline flying. A Commercial pilot, Airplane Single engine Land and Sea, Multi-engine Land, Rotor craft helicopter, CFII, ATR in Douglas DC-3, CV-240, 340, 440, Allison powered CV-508, DC-9 and Boeing 757/767. Also, he enjoyed 13 seasons of flying passengers in a Stinson "Model T," Trimotor and 3 years of hauling passengers and doing checkouts in a Ford Trimotor. Was a crop duster and sprayer. Towed aerial advertising banners in Stearmans, Bird Biplanes and did the flying to get FAA certification for the towing operation at the EAA's Pioneer Museum. Then flew checkouts for seven other tow pilots in a Travel Air 4000 that had a Continental 220 engine. He and his wife Jeannie own and fly a 37 horse power, E-2 *Cub* that is operated on wheels and skis, a 40 horse J-2 *Cub* that is flown on wheels, skis and floats. Another *Cub* ready for restoration and it will be an F-2, with an Aeromarine, AR-40. A TriPacer and a twin Cessna T-50, "Bamboo Bomber" round out the flying collection. They have a barn, two hangars and basement full of aviation objects, books and memorabilia. Members of several aviation organizations including AAHS, AOPA, AAA, OX-5 Club, EAA and the EAA Vintage Aircraft Association, of which Jeannie is a board member. Also the Midwest Antique Airplane Club, the Illinois Vintage Airplane Club and are currently restoring two Brunner Winkle Bird Biplanes. One Bird will have the 90 horsepower Curtiss OX-5 engine, the other will have a Kinner B-5, 125 horsepower engine. Hill received a liver transplant in July of 1999. That has caused a bit of a slowdown for him, but he's still going strong. In November of 1999 he completed the FAA required Flight Instructor Refresher Course, renewed his Airman Medical Certificate in June, 2000 and still considers himself a, "Student pilot."