Douglas DC-8 (Photo - United Air Lines)

AVIATION INSTRUMENTS

PART 4 by ROBERT H. SCHEPPLER

This is the final portion of the series on the history of aircraft instruments prepared by Member Robert H. Scheppler, and covers the Post-WWII period. Mr. Scheppler takes a brief look at the future also, with a predication that the "black boxes" will some day become all important, to the virtual exclusion of manual control.

POST WORLD WAR II 1946-1960

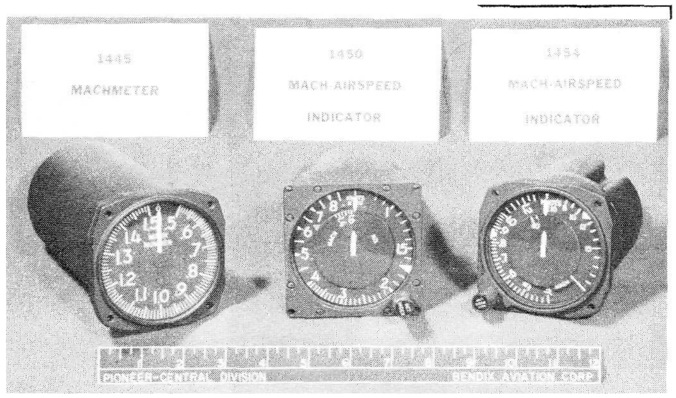
In the development of aircraft instruments the general pattern of the post World War II period followed that of the similar period after World War I. Tremendous amounts of surplus equipment and spare parts were available to the armed services and through surplus outlets to commerce. To all appearances the entire airplane and instrument industries were entering a period of stagnation, a period soon disrupted by the introduction of the jet engine and its resultant increase in speeds, altitudes and engine performance. This one event did much to obsolete most of the military aircraft instrumentation and promised to do the same for the commercial equipment in the near future.

To cope with the new problems many new and improved instruments had to be developed such as machmeters, powerloss indicators, turbine vibration indicators, air data computers, take off monitors and various forms of blind flight indicators. But in 1946, much of this was unknown. Though the requirements of inertial guidance, Doppler radar and navigational computers were to some extent anticipated they had not proceeded into the development phases.

At the close of World War II the trend had been toward use of a greater number of instruments and corresponding complexity of the display. The instrumentation designers realized that pilots of larger aircraft were already being overburdened with the numbers, types and assorted sizes of instruments. They reverted in principle to the trend initiated during the Post World War I period and attempted to develop multipurpose, vertical scale, smaller instruments. A few of the instruments developed or improved during the period from 1946 to 1950 were:

MACHMETSRS

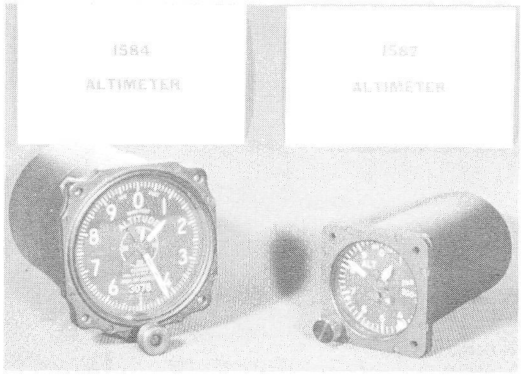
This diaphragm and aneroid instrument is a refined airspeed indicator which shows speed as a percent of the speed of sound. This percent is known as Mach Number and is shown as .6, .7, 1.0, etc. For essential pilot control an airspeed dial is also used for the slower periods of flight such as take off and landing. The mach instrument used mainly to indicate the approach to the point of compressibility or the speed of sound. Flight at or close to this speed usually imposes severe loads on the aircraft and could be dangerous.



Machmeter

ALTIMETERS

This well known instrument was still an aneroid type in 1946 but its range was being extended to cope with the high altitudes being flown, and in some cases its size was decreased. Accuracy was enhanced and in some



Altimeter

models the method of display was changed to give a numerical indication of feet similar to the mileage counter in an automobile instead of a pointer-dial indication. Further refined versions of altimeters, known as compensated altimeters, were introduced which automatically made corrections for temperature and speed effects as well as other slight errors.

TURBINE VIBRATION INDICATORS

Due to the extremely high rotational speeds of the turbines in jet engines any small unbalance could cause engine failure and even complete loss of the aircraft in a short time should, for instance, a turbine blade leave. To provide a constant check on the condition of the engines a vibration indicators was developed and is in use on most jet aircraft of today.

During the postwar period, airplane design was rapid; improvements came in all ways such as speed, altitude, load capacity and reliability. For the early portion of this period up to 1950 instrumentation design and development kept pace with that of aircraft. Design was concentrated on eliminating pilot fatigue and error and on developing the necessary new instruments required by jet aircraft. Many famous flights took place but, from an instrumentation standpoint, one stands out above all the rest:

> Between Sept. 20 and Sept. 22, 1947, Col. J. M. Gillespie and a crew rode as passengers in a Douglas C-54 named BIG PUSH from Wright Field, Ohio to Brize Norton, England and return with no one at the controls. The airplane was automatically controlled the entire round trip distance with the crew serving only as standbys to the instrumentation.

Trends developed toward all-electronic instrumentation. Specialized instruments were developed for different members of flight crews, such as pilot, flight engineer, navigator, and radar operator- Many small light, standby instruments were developed for emergency use only. But from about 1950 to 1955 instrument development appeared to lag. Some specific examples will illustrate this.

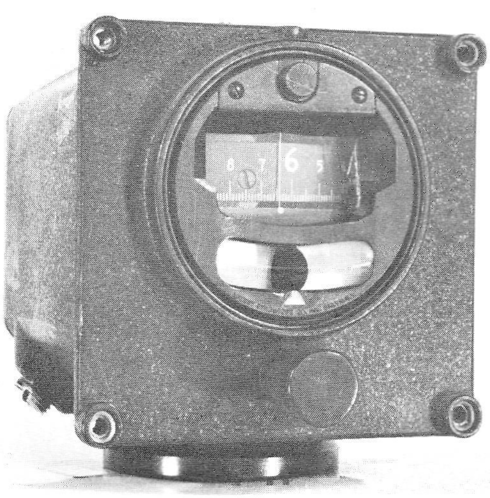
Rate of Climb instruments, now usually called Vertical Velocity Indicators were usually scaled for 0 to 2000 feet per minute with some later models going to as high as 0 to 4000 fpm. This was much too slow for modern jets fighters which, in a near vertical climb or dive, could easily exceed 4000 fpm.

Altimeters had reached the point where three separate hands or pointers were needed. The first one covered 1000 ft. per revolution, the second 10,000 ft. per revolution and the third 100,000 ft. per revolution. This produced a confusing display for the pilot which could be, and sometimes was, misread with disastrous results.

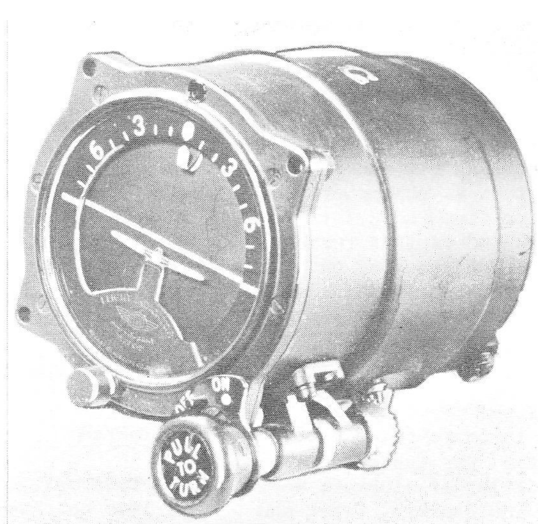
Automatic pilot equipment was designed for use at reasonably normal flight altitudes, as gyros "tumbled" or became inoperative at angles of bank over 60° and pitch or climb angles over 20°. Obviously high angle climb outs or dives and inverted flight could not be performed on automatic pilot.

Airspeed indicators were becoming harder to use due to the fact that planes were flying at higher altitudes and corresponding lower temperatures. Both of these environments require greater corrections to be applied to the indicated airspeed to provide true air speed. The original uses of an airspeed indicator were to provide data for navigation and to warn of a decrease in speed approaching the stalling speed. Navigation had by now become almost exclusively a function of radio and radio-controlled instruments. Stalling speed, which varies with the angle of attack, air density, total weight of the airplane was no longer a comparatively fixed speed, but varied considerably from start to completion of a flight. Thus the airspeed indicator was no longer completely useful to its original function.

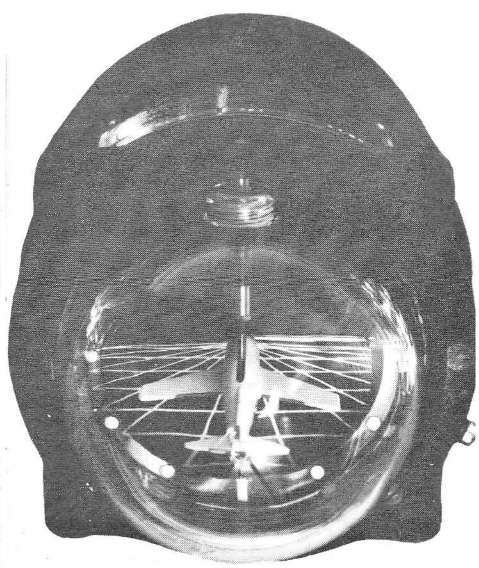
Machmeters had been developed to indicate to jet aircraft pilots the approach of Mach 1 or the speed of sound, at which point extreme turbulence and increased air loads would be applied to the airplane. As the dangers of compressibility became known and understood and aircraft started flying at speeds in excess of the speed of sound, the machmeter began to be used only as an approximate true airspeed indicator. The mach reading multiplied by 10 equals true airspeed in nautical miles per minute. As an example, Mach .7 x 10 = 7 nautical miles per minute or 420 knots. (1 knot is



Directional Gyro



Artificial Horizon



3-D Version of Artificial Horizon

1 nautical mile per hour). This conversion is exact at 26,000 ft. altitude, but properly corrected for temperature effects would be accurate at all altitudes.

By 1955 instrumentation was being criticized by pilots for readability, confusion of display, lack of uniformity of display between different manufacturers, and overall poor lighting for night flying. In an accelerated effort to combat the various drawbacks of instrumentation of the early 50's the instrument companies began serious development of more sophisticated instrumentation. Some of the types under development during 1955-1960 came into being as:

POWER LOSS INDICATORS

With the advent of multi-Jet aircraft it became apparent that the lose of an engine could go undetected for short periods of time, especially critical at take off. A Power Loss Indicator was introduced and first installed on the British "Comet IV". Basically it measured and indicated the pressure in the exhaust cone of the engine.

TAKE-OFF MONITORS

A few serious drawbacks exist in the use of Jet engines: They are slow to accelerate, cannot be shut down as rapidly as reciprocating engines, and are more dependent upon air temperature and density conditions. It became increasingly apparent that accidents could easily occur due to pilot errors during take-off. The take-off monitor was developed to show the pilot, both pictorially and with indicator lights, his exact status until he is airborne. The temperature, runway length and condition, and the aircraft weight are manually dialed into this instrument before starting the take-off. Throughout the take-off run the pilot is shown by the instrument the point where take off should occur, the amount of runway left and the distance required to stop the aircraft in case the take-off is aborted.

AUTO PILOT INSTRUMENTATION

This type of instrumentation consisted of so many different types and models that it would be difficult to describe them. Each manufacturer, Bendix, Collins, Lear, Sperry, Kollsman, and others produced and sold their own equipment using their own favorite principles of operation and method of display.

It appeared that the industry was again going into a period, starting about 1956, which would be notable for divergence of opinion concerning pilot's requirements and preferences. This was much the same as the early 1920's when instruments were semi-circular, circular, or vertical in shape, with black on white or white on black numerals, sized from 2 to 6", in combination or single units, etc. Between 1956 and 1960 there were both white and red lighting, 1-7/8", 2-3A", 3", and 5" diameter sizes, moveable background with stationary miniature aircraft and stationary background with moveable miniature aircraft In auto pilot equipment, combination and separate instruments, small standby or duplicate equipment, digital readout or dial-type indication, and circular and vertical scales. But much of this confusion was eliminated through the efforts of the Air Force and the Navy toward standardization.

Toward the end of this period four basic systems of navigation and instrumentation began to emerge from the chaos of the 1946 to 1955 era. These systems were actually in addition to the normal radio navigational aids and instrumentation used during and after World Wall.

These four consisted of Inertial Guidance, Doppler Radar, Navigational Computers, and Star Tracking. As far as airline navigation is concerned they are still relying on basic radio navigation consisting of radio aids over known populated areas and celestial navigation augmented with dead reckoning over water. Obviously these methods are not acceptable to the military, as under war time conditions friendly radio aids would not always be available and for security reasons a minimum of transmitting or receiving of signals by the aircraft is desirable. Changes are also becoming mandatory on airline aircraft partially due to the same reasons as the military and partially because of the greater lengths of flights. No commercial or military aircraft under consideration after 1953 could be designed as merely a combination of airframe and powerplant. Navigation equipment has to be considered as equally important as the choice of a power plant.

Three of the four new concepts and the accompanying instrumentation are briefly described. The fourth system, Star Tracking, is not feasible in its present state for use on manned aircraft but is being developed for long range space flight, which is an entirely new and separate phase of navigation.

INERTIAL GUIDANCE

This system is the most accurate conceived to date and has the supreme advantage over all others of neither sending nor receiving external signals. Its use therefore, cannot be detected, nor can it be disrupted or Jammed by external means, a factor of vital importance to its military uses. Development of operational versions of this system was started in 1955 and it is now in limited use for both military aircraft and missiles and is under test for commercial use. Details of the system are still highly secret. The basic principles and components can, however, be described.

The principle of inertial guidance is based on Newton's second law which, loosely stated, is "Velocity is the rate of change of distance with time" and "Acceleration is the rate of change of velocity with time." The inertial system maintains a complete history of the accelerations of an entire flight from start to finish, including those periods of steady state where neither acceleration nor deceleration is taking place. The outputs of this system are shown directly to the pilot and are also fed into a navigational computer. The output information consists of latitude and longitude or bearing and distance, depending upon the type of system. These outputs can, by mathematical means in the navigational computers, be made to read out to the pilot as distance traveled in a given time, deviation from a predetermined track, time, distance and course to destination, and estimated fuel remaining at destination.

Mechanically, the system consists of a stabilized platform containing two or three accelerometers, three gyros, a clock, a first and second integrator, a computer section and a position indicator. The accelerometers are devices which accurately indicate any displacement from a steady motion in one plane. One is used for each plane of motion, that is North/South, East/West, and vertical. The vertical accelerometer is less important in manned aircraft applications and in some cases may be eliminated.

The attitude in space, of the stabilized platform, is maintained by three gyros, each one controlling the position of one plane. The platform is also automatically maintained parallel to the surface of the earth. Electrical output signals from the accelerometers are fed to an integrator which converts the information mathematically into an electrical signal representing velocity as a function of time. The signals are then fed into a second integrator which mathematically eonverts the information into distance traveled in relation to time. These signals are finally fed into a computer mechanism which combines and converts the signals and transmits them to the position indicator. This indicator is the display unit seen by the pilot and, as stated previously, the display is read out as latitude and longitude or distance and track.

Many minute corrections are required by the inertial guidance system in order to obtain the desired accuracy. The clock mechanism rotates the accelerometers on the stabilized platform at a rate exactly corresponding to the earth's angular velocity. This is 15° per hour. This rotation-counteracts the rotation of the earth as it must be remembered that a gyro aligned platform will remain stable in space and not in relation to a semi-fixed item such as the earth.

Corrections are applied for longitudinal position since changes in longitude are dependent upon latitude. For instance, at the Equator a 60. mile distance is equal to 1° longitude while at a 45° latitude position (roughly that of the North American Continent) 60 miles equals l.4° longitude. The accuracy required by this system can be visualized when it is known that, by tilting the platform through 1 minute of arc, (l/60 of 1°) it will result in an error of 12 miles in a typical one hour flight. Corrective action must be taken to correct errors introduced by other corrective actions. To illustrate, if the stabilized platform drifts from its predetermined setting during a certain period of time, for instance ten seconds, it must be correctly repositioned by the gyros, and an equal and opposite drift is automatically initiated for an equal ten second period to effectively erase the original error. Correction is also made to allow for the earth's having a slightly greater diameter at the equator than at the poles. This correction is in the neighborhood of l/l0 of 1%.

DOPPLER RADAR

The Doppler Radar system was developed to determine the two most important functions of aerial navigation, ground speed and drift. It was initiated in 1933 by the U.S. Wavy with a study contract. In 1945 a test system was flown. By 1946 a major program had been developed and improved equipment was being flight tested in 1948. The principle upon which this system operates is basically the same as radar in that a high frequency radio beam is sent out and reflected from the earth to the aircraft. The reflected signal will show a change in frequency proportional to the speed of the aircraft due to the age old Doppler principle. This can best be illustrated by noting the way an auto horn or train whistle tends to rise in pitch as it approaches the listener and drops in pitch as it recedes. The change in pitch is an apparent change in the frequency of the sound waves. When approaching the listener the object emitting the sound is overtaking the sound waves thus increasing the frequency and when receding the object is sending out sound waves opposite in direction to its motion thus decreasing the frequency. For those whom I have now completely confused, I suggest that you refer to a High School Physics or General Science book under Doppler Principle.

In aircraft systems a two-beam signal is transmitted, one forward of the plane and one rearward. The transmitting antennae sending the signals is swivelled until the doppler shift is identical for both. The antennae is thus aligned perfectly with the flight path of the aircraft. The amount of doppler shift, or change in frequency, between transmitted signals and reflected signals will indicate aircraft ground speed while the alignment of the antennae will indicate direction of flight. Comparison of the antennae alignment with the course indicated by the magnetic compass will show the actual track being flown.

The output of the Doppler radar system is shown to the pilot as true ground speed and heading. These outputs, like those of the inertial guidance system, are fed into a navigational computer.

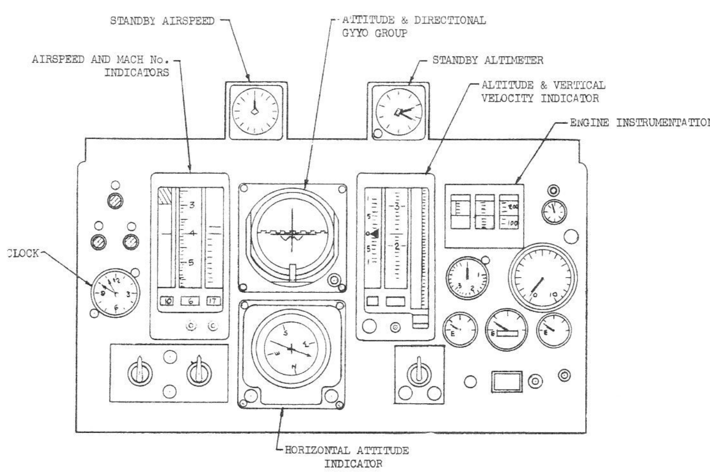
NAVIGATIONAL COMPUTERS

To enable the pilot to perform the multiple calculations required for aerial navigation, more quickly and accurately, various forms of electromechanical navigational computers have been developed. All use the same principles in that they make use of the various data such as airspeed, direction, altitude, etc., to mathematically determine the aircraft position and course to be steered. Inputs to the computers can be manual or automatic or a combination of both. The increasing tendency is to submit the required inputs automatically, thus eliminating additional sources of human error and decreasing the time required for operation of the computer.

The output signals from Inertial Guidance or Doppler Radar systems are used as inputs for navigational computers. However, they still require additional accurate inputs on true airspeed. To provide this information in its most accurate form a further computer mechanism known as an Air Data Computer is used. This gives accurate information about the atmosphere to both the autopilot components and the navigational computer. Most air data computer systems make use of static and pilot, or total, air pressure, outside air temperature, and angle of attack. These inputs are combined thru a series of gear trains, cams, and clutches to provide corrected data to the navigational computers and to the various cockpit indicators. Due to the complexity of these mechanisms and the accuracies desired the various forms of air data computers currently being manufactured are actually tailored to particular models of aircraft.

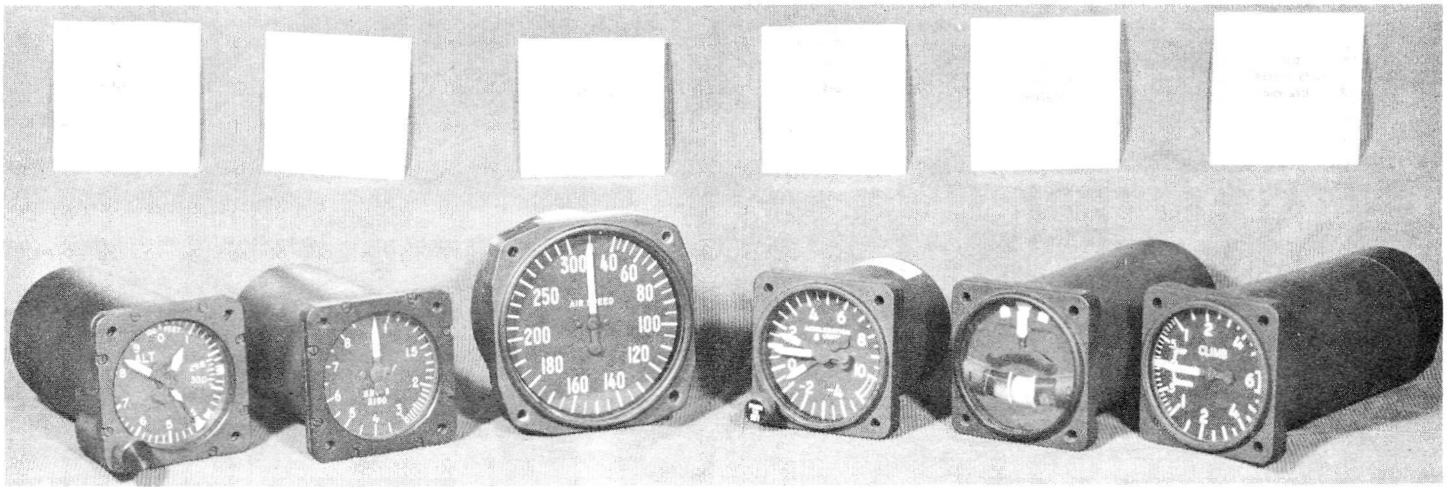
During this last several years not only were new instruments and new navigational systems being introduced but also the overall instrument display was being improved. Relationship of one instrument to another, proper location in relation to importance of information, and time required to mentally absorb the displayed information were a few of the major fields investigated.

Two typical examples of integrated display panels will be discussed. Shown here is a sketch of one type of panel under development by the Wright Air Development Center, Flight Control Laboratory. This general type of panel was planned for use in the Convair F-106, Republic F-105, North American F-108 and North American B70. By proper design and location of individual instruments the panel provides the pilot with two basic reference lines named as the "forward looking view" or horizontal line, and the "downward looking view" or vertical line.



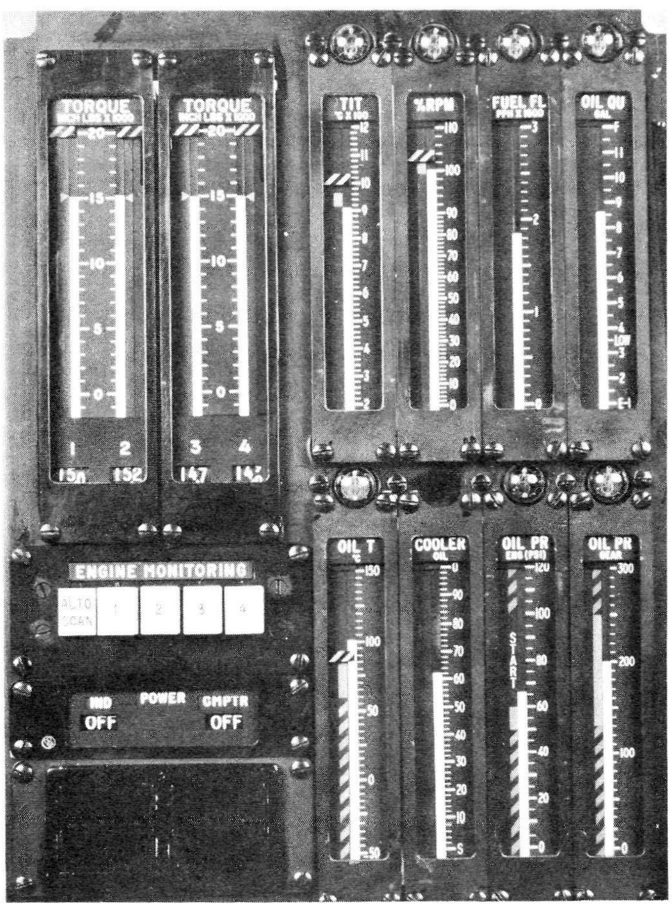
Parameters displayed along the horizontal line include airspeed, rate of climb, altitude, angle of attack and rate of acceleration. Along the vertical line are displayed aircraft heading, turn and bank rate, and navigational information. The concept of "fixed aircraft and moving horizon" was adopted for the attitude direction indicator, and insofar as possible, the parameters previously displayed on separate instruments were combined into a minimum number of instruments. Some of the instruments were vertical-scale types using a moving tape. Flight testing of this panel has been going on for about five years and many of the improvements developed and tested therein have been already incorporated in the latest military aircraft.

Another approach to an integrated panel can be seen on Page 201. This is a complete engine instrumentation system developed by Eclipse Pioneer Div. of Bendix Corp. for use on the C-130B aircraft. At first glance it appears to be a neat compact grouping of engine instruments, all vertical in shape and all using vertical



Typical Instruments of 1946-1960 period

tapes. However, an entirely new approach is used. Though this panel is for a four-jet engine aircraft, most of the parameters including Turbine Inlet Temperature, % of RPM, Fuel Flow Rate, Oil Quantity, Temperature, and Pressure are only shown singly. The instrument system continually monitors all four engines and displays the condition existing in the one engine which deviates most from the optimun value. The small tubes above each indicator, known as "nixie tubes", then display the number of the engine being monitored. In other words only the conditions in the engine furthest from its operating mean are displayed as that is all the pilot really needs to know. In addition, by means of the numbered selector switches, the pilot can select any one engine and have all parameters for it displayed whenever he chooses. This system occupies



Integrated Engine Instruments

only 2/3 of the space previously required for comparable four engine instrumentation, is easier to read, and provides a more useful display to the pilot.

During the entire period from 1946 thru 1960 there were so many new airplanes designed that it would be impossible to list all of them. I have listed just a few typical planes of the transport category to illustrate the instruments in use and the changes in instrumentation during this period.

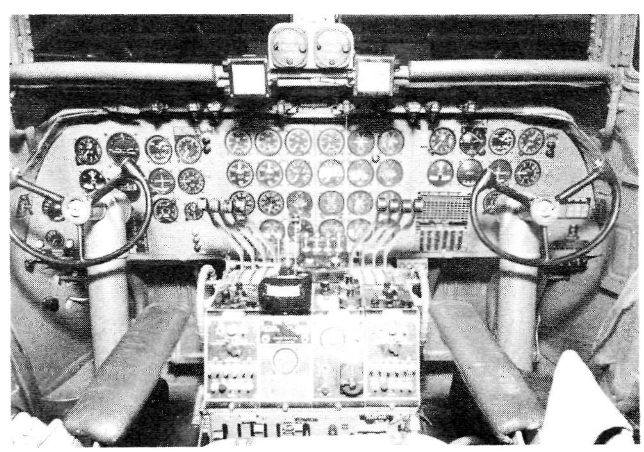
1946 Douglas DC-4. Commercial version of C-54 four engine transport, used all remote reading types of engine gages, Sperry A-2 auto-pilots, and air driven gyros.

1947 Douglas DC-6. Commercial version of wartime C-56, used electrical gyros, all electronic Pioneer PB-10 auto-pilots, remote fluxgate compass, and electrical capacitance fuel gauges. Airborne radar was developed on this aircraft.

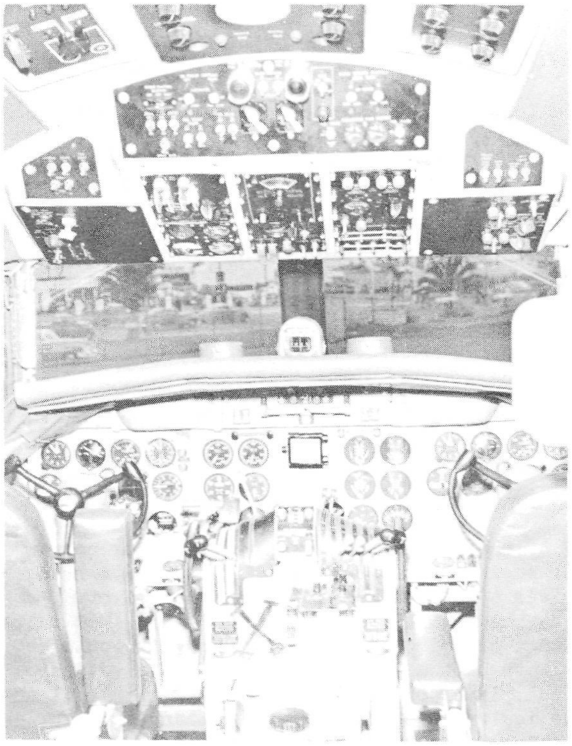
1949 Convair 340 Twin-Engine transport for short range flights. First transport to be equipped with weather radar as standard equipment.

1953 Douglas DC-7. Improved longer range, larger and faster version of the Douglas DC-6. First transport to make full use of navigational and auto-pilot instrumentation combined into an integrated system. Also made great use of miniature instruments.

1956 Lockheed "Jetstream Constellation". Last of the piston engine airliners. Used polar-path compass allowing scheduled airline flight over area adja-



DC-6 Panel



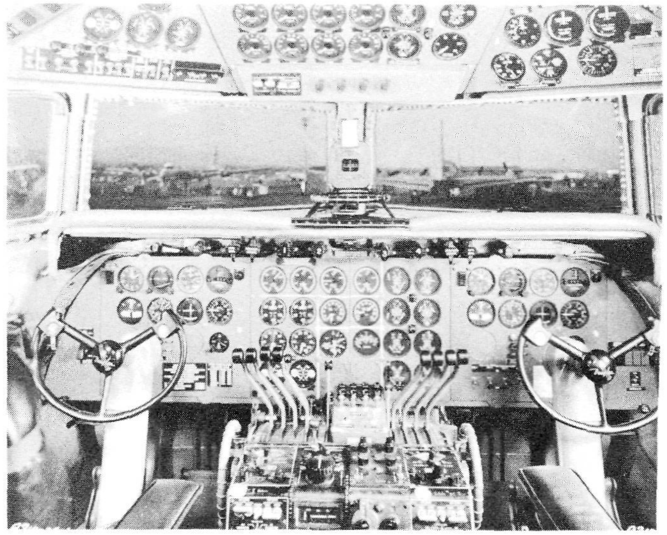
Convair 340 Panel

cent to North Pole. Also introduced use of mach airspeed indicators on transport equipment.

1958 Boeing 707. Commercial version of Air Force jet tanker. Used machmeters, true airspeed indicators and angle of attack indicators plus all instrumentation required for jet engines.

1959 Douglas DC-8. First jet transport designed primarily for commercial use. Used basically the same instrumentation as Boeing 707.

It may appear that so much improvement and progress has been made in the design of aircraft instruments from



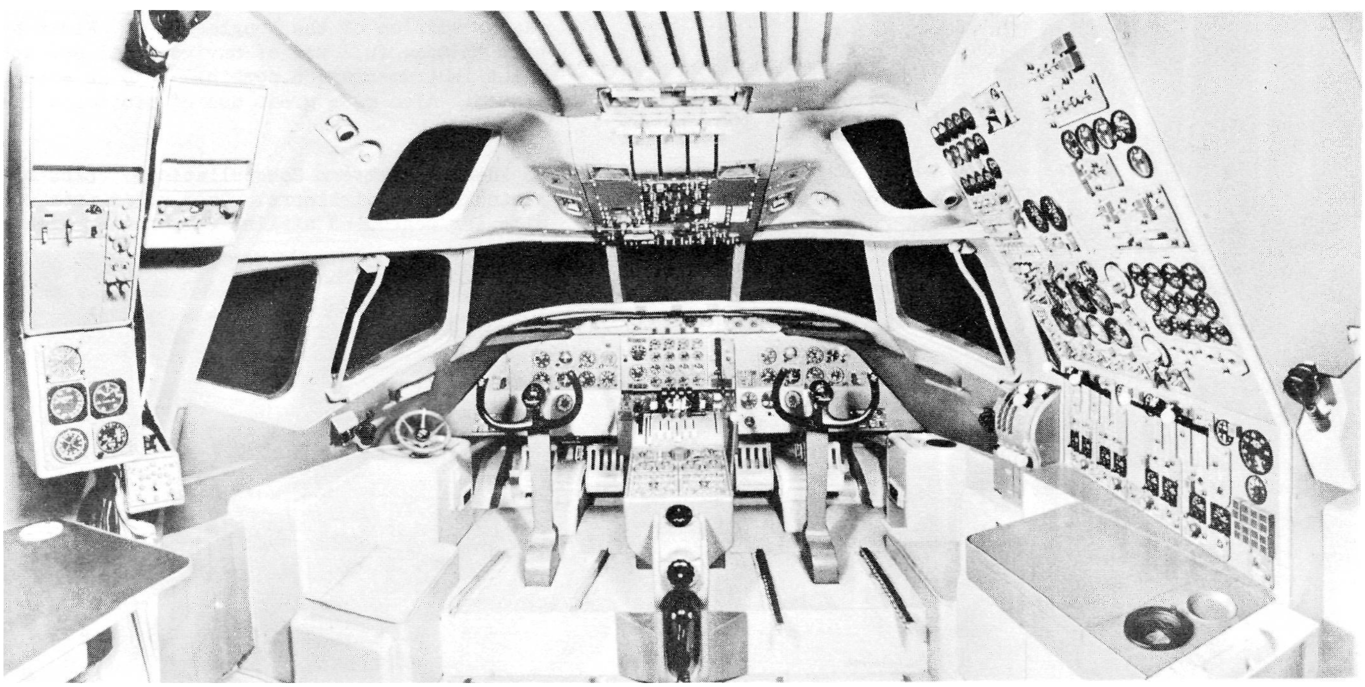
DC-7 Panel

1930 to 1960 that little remains for the future. But as has happened so often in the past when designers become complacent about today, tomorrow overtakes them and the problems of space navigation now come to the front. As we leave the present to speculate on the future, I would like to close this section with this thought, that instruments were developed because man wanted to see the invisible, hear the inaudible, and feel the untouchable. Without instruments there could be no modern aircraft. But seldom are these little gages and black boxes, or their designers assigned their true position in influence over events past or the shape of things to come.

THE FUTURE 1961 - 1980

At the risk of being proven wrong, I would like to discuss a few of the anticipated problems and solutions in the field of manned aircraft instrumentation during 1961 to 1980 period.

First, it must be understood the aircraft field has become so broad that it is almost impossible to discuss it in generalized terms without specifying the particular phase or type of aircraft under discussion. The



DC-3 Panel

standard types of private sport planes, feeder line transports, trunkline jet transports and military support aircraft will probably remain basically the same for many years to come. The motor car never obsoleted the horse, it merely placed it in a different category. Neither will rockets, ICBM's or spacecraft obsolete our present forms of earth bound transport. But further change in our aerial transport and pleasure flying aircraft will be slow. Let me then, for the remainder of this discussion, concentrate on instrumentation for the manned, long-range bomber or transport and touch lightly on spacecraft.

The trend in instrumentation will be to display as few parameters as possible solely for monitoring purposes as almost all functions of flight must eventually become automatic or ground controlled. Much effort has been expended in recent years to develop instrumentation and control systems leading toward the so called "Orangoutang pilot approach" whereby complete flight is automatic and all decisions, even those involved in emergencies, are automatically programmed in advance into the controls. This general approach is being altered, as being too advanced, to that of a "Pilot Manager" concept whereby the skill, background, experience, and thought processes of the pilot are used to monitor the flight procedures and apply corrective action as required in emergencies. This means that decisions are still left to the pilot but routine functions are handled automatically. " Under these conditions the operation of instruments as well as the displays provided will change somewhat from that commonly in use prior to 1960.

Actually a new concept of flight is being formulated and from an instrumentation standpoint this means a redetermination of what to display and how to display it. The old basic values of altitude, speed, and attitude are no longer valid for the type of flight being planned after 1960. Altitude in thousands of feet would be astronomical. It will probably be displayed in miles or possibly time to point of impact, or even in angular measurement in relation to celestial bodies. Speed will certainly be useless in relation to the ground especially during vertical or near vertical climbs and dives. It will have to be related to some dimension without earth boundaries such as Mach number (percentage of the speed of sound) or even a percentage of the speed of light.

Attitude in relation to the gravitational pull of the earth will hold little meaning. It will be more important to display it as a function of the anticipated landing position, line of flight, or perhaps in relation to an artificial gravity effect within the vehicle itself.

All future instrumentation must be coordinated to supply instantaneous information. The days of the individual indicators supplying one item of flight information are disappearing. A picture of the aircraft attitude, speed, altitude and position must be continuously presented, together with the identical information for the immediate future. No longer can the pilot rely on mental calculations of conditions of the moment to determine future positions or attitudes. Instruments will show current information together with "command" information, i.e., the proper altitude and speed required to make good a predetermined line of flight. The pilot will not need numerical indications, merely percent of error indications between the actual and 'command" conditions.

Almost all instrumentation will be electrical due to the distances from the point of measurement to the point of indication, the ease of converting indications into easily measured electrical quantities such as voltage, amperage, and frequency, and the requirement for instantaneous indications. The "command" approach lends itself readily to the "Null Balance" type of electrical indication whereby a "percent of error" signal is balanced out by a fixed or known signal. The amount of deviation from the command condition will be continuously apparent as well as the immediate effect of any corrective action. Most normal in-flight corrections necessitated by the differences shown on the indicators between actual and "command" conditions will eventually be made automatically since human pilots will not be able to interpret the data and apply the necessary corrections in time. In some respects this point has already been reached.

To illustrate this, consider the officially listed head-on approach speed of two 1960 F4H-1 "Phantom II" fighters. It is over 4000 f.p.s. This means that if these planes were 15 miles apart and flying toward each other on a collision course when you started reading this <u>paragraph they would have already collided</u>.

Another example is well brought out by a recent General Electric advertisement which states "At dash speed the B-70 will fly a mile for every breath you take. From 13 miles up the pilot will be able to direct his "Valkyrie" (B-70) across continents in an hour and a half."

Obviously the pilot will only be needed to monitor the corrective action as it is automatically applied during flight, and to provide some control in the face of unforeseen problems. Be will long be needed for taxying, parking, and for a relatively shorter period, for a portion of the landing and take off. He will also serve as a symbol of control in passenger carrying aircraft for many years. However, before we realize it the instrumentation presentation to the pilot at normal conditions as we know them today, will no longer be necessary. Like the pilot, instruments will be carried long past their period of usefulness. As long as pilots inhabit aircraft some form of display instrumentation will be used, if for no other reason than to occupy their long periods of boredom between periods of packing, taxying, and computing income tax on their various jutside activities. . The concept of the "Orangoutang Pilot" may be too advanced for 1961 but it will corns eventually.

In the meantime, from 1960 to 1980 many new instruments already in the design or prototype stage will become common. Some of these are:

<u>HORIZONTAL SITUATION DISPLAY</u>

This unit will display the exact location of the aircraft in relation to a navigational map. This type of instrument, though it has many inherent difficulties to be overcome in its present prototype state, will eventually become completely reliable. It will provide for insertion of the proper map portion covering the planned trip and will be electrically operated. It will probably be controlled by a series of accelerometers (devices which can record extremely small variations of motion of the aircraft in any direction) which will feed their data to a computer device which will in turn integrate the three dimensional data and display it as a constantly moving pointer on the map. It is possible that the operation may be partially or completely controlled by some form of automatic star-plotting device. In either case the accuracies required of the mechanisms will be fantastic by todays standards.

<u>COLLISION OR PROXIMITY WARNING DEVICE</u>

Various forms of collision warning devices to warn a pilot of the approach of another aircraft on a collision course are under development. Some operate on radar principles while some use infra-red detection systems. The problems involved are far greater than originally anticipated: to name a few, actual identification of another aircraft as opposed to rain clouds, snow, birds, and electrical disturbances such as Aurora Borealis, and pickup of the warning signals in sufficient time to allow corrective action. It has not been determined what system will eventually prove the best but within a few years this instrument will be in general use.

'METEOR AVOIDANCE DETECTOR

This instrument, for use by space vehicles, will be a natural evolution of a collision warning device and will probably be of simpler construction, an assumption is based on the fact that space flight will be past the area of earthly disturbances either electrical or meteor logical. It will indicate the approach and closing speed of dangerous meteors to the space craft in sufficient time to prevent collision. •

RADIATION WARNING INDICATORS

These instruments will be used on military aircraft to warn of areas of dangerous radioactivity and to measure the radioactivity level of the air through which the aircraft is flying. These units will be similar in operation to the storm warning radar systems already in use.

FUEL SYSTEM INDICATORS

Normal liquid level indicators, as used in today's aircraft, will soon outlive their usefulness. It will be necessary to know the quantity of fuel remaining and the rate of usage of each propulsion unit very accurately. Problems will present themselves as the aircraft will not always be in a normal horizontal attitude and, at least in spacecraft, the flight will be in a "zero G" condition. This means that liquids will no longer follow normal patterns but will float around the fuel tanks in large bubbles or masses. Obviously pressurized fuel systems will be required and the gages will show the range of the craft probably in increments of time at existing flight conditions. They will also provide a constant record of the actual fuel usage as compared to the preplanned usage so that corrections can be made as required.

AIRBORNE TELETYPE

It has been recently predicted in a national magazine that within ten years all airlines will be using airborne teletype instruments. At present the F.A.A. (Federal Aviation Agency) is evaluating two types of instruments. They will be used for ground-to-air-to-ground communications. Messages will appear immediately as transmitted in a lighted window on the instrument panel. Advantages of these instruments will be their ability to transmit air traffic control data to individual planes or groups, the fact that various languages can be used, and coded meteorlogical symbols and data can be transmitted without chance of error due to noise interference, misunderstanding due to various accents, or garbled pronouncements. Also the messages can be retained for later reference rather than relying on memory of a previous radio message.

WINDSHIELD DISPLAY SYSTEMS

A new approach to the problem of display of data is in the prototype stage. It's basic element is a small cathode ray tube similar in operation to a TV picture tube and a lens system which presents either directly or by reflected image the airspeed, altitude, aircraft attitude and relation of the aircraft to an artificial horizon, all on the windscreen directly in front of the pilot. The display is completely transparent and does not interfere with the normal view of the pilot. This eliminates the pilot's refocusing and lowering his eyes each time he wishes to check the instrument readings. When coupled with a method for automatically regulating the brightness of the readings in relation to the outside light conditions this system holds great promise, especially for use at critical periods such as landing on aircraft carriers, and descending through overcasts preparatory to landing.

In looking back over the history of aircraft instrumentation, it can be seen that there have been some periods of great progress and other of lethargy. The future can only be surmised but if the plans and developments of the present are any indication the whole field is due for tremendous change in the next 20 years. The airplane driver is headed for the passenger cabin where he will join us passengers relying completely on the "little black boxes."

We are hoping to persuade the author of this series on Aircraft Instruments to write a further series concerning their development from the viewpoint of the men who evolved them; in other words, the men behind the machines, with recognition for those who pioneered blind flying, the G.C.A., high altitude and cold weather instruments.

PHOTO CREDITS:

Page 197 - Machmeter, Pioneer Central Div., Bendix Corp.
Page 198 - Altimeter, same.
Autopilot Instruments,. Aircraft Components, Inc.
Page 201 - Typical instruments 1946-50, Pioneer Central Div., Bendix Corp.
Integrated engine instruments, Eclipse Pioneer Div., Bendix Corp.
DC-6 panel, United Air Lines
Page 202 - Convair 340 panel, United Air Lines
DC-7 panel, Douglas Aircraft Co.
DC-8 panel, Douglas Aircraft Co.

MARTIN BOMBER

(Continued from Page 194)

Hartz, R.S. Col., Report to Director of A.S., Round the Rim Flight (13 Nov 1919, Museum file C71.6/2.

Pearson, Lee, letter to author, (24 July 1961).

Smith, Paul V, letter to author, (10 Feb. 1961).

Mitchell, William, Winged Defense, p 45 - 46.

AIR SERVICE SERIAL NUMBERS OF MARTIN MB-2 AND NBS-1 BOMBERS

A.S. 64195 through 64213—Martin built, one serial number of the Martin contract for 20 machines has not been identified.

A.S. 68437 through 68471--L.W.F. built.

A.S. 68478 through 68527—Curtiss built.

A.S. 22-201 through 22-225—Aeromarine 'built.

Note on GMB serial numbers; the following have been identified as GMB (MB-1 serial numbers: 39055, 39056, 39057, 39053, 39059, 62949, 62950, 62951. Two serial numbers are missing, would appreciate hearing from anyone who can supply them. Merle Olmsted.

The CAPTAIN and The KIDS

The above was the nickname of a B-24 of some model, with miniature bombs painted on the fuselage indicating 41 missions. Member Leo J. Kohn, of 925 S. 91st St., West Allis 14, Wisconsin, has others; PUDDLE JUMPER II, WILD ASS RIDE and PACIFIC PASSION. PUDDLE JUMPER II had 18 missions, and the name, S. Levis, painted above the miniature bombs. PACIFIC PASSION had 32 missions.

Leo wants Information concerning these, where the photos were taken and the disposition of the aircraft. Apparently all pictures were from the same source.