TWENTY FIRST EUROPEAN ROTORCRAFT FORUM

Paper no. IX - 3

COCKPIT LAYOUT - OPERATIONAL ASPECTS

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Abstract

The development of aircraft instrumentation and cockpit layout have followed guidelines and ideas of design engineers and manufacturers, and to some degree, the specifications of the armed services. This has resulted in somewhat arbitrary development of cockpit layout which have mostly followed trends and fashions rather than scientific guidelines. This has caused operational problems for commercial operators, especially smaller helicopter companies which have to satisfy market demands. In order to stay competitive these operators are forced to let pilots be qualified on several types. Since all these different helicopter types have different cockpit layout, it creats operational safety problems for the operators.

European Helicopter Association (EHA) have recognized this problem and have developed an EHA Cockpit Layout Guidelines paper which may be a future tool for manufacturers and operators in developing more user friendly cockpits.

1. Introduction

Generally the aircraft manufacturers design the cockpit layout based on primarily the ideas and views of their design engineers and test pilots, in addition to certification requirements. Only large customer organizations like the armed forces or larger commercial customers can afford to customize their new aircraft based on company developed standards. Such company standards are based on operational requirements, company safety programmes, safety experience, logistics and economy. However, for smaller companies such investments are difficult to justify, and the most likely result is that their pilots have to adapt to, and live with different cockpit layouts and standards. This is particularly the case with helicopter operators. The fixed wing world has over the years become pretty much standardized, up to recently. The introduction of integrated cockpit displays has interrupted this trend and the industry is now again searching for the optimum cockpit lay out. In the helicopter world it is more difficult. Traditionally the helicopter manufacturers are very militarized and are little receptive to commercial customer requirements. They are even less interested in looking to the competition to learn. In this way the operator may find that the new helicopter he ordered is hampered by a deficiency which had previously been experienced on a competing design. Even though the operators meticulously evaluate competing helicopter types before a new investment, the final choice may in the end be decided on by the customer. Most helicopter operators are charter operators and the customers normally have the final word. Since the different customers may have different requirements, a large operator will inevitably find himself operating a mixed fleet of helicopters. This will create problems regarding pilot training, logistics and maintenance. The larger operators have to various degrees been able to standardize their cockpit layouts and avionics.

This is, however, becoming more and more expensive, and with the introduction of integrated cockpits, this practice will be impossible in the future.

This is the background for European Helicopter Assosiation's (EHA) interest in the subject. If EHA succeeds in convincing the helicopter manufacturers of the benefits of standardizing cockpit layouts, different new helicopters of various sizes and shapes may be equipped with cockpit layouts which are quite similar. The benefits to the operators are obvious, both operationally and logisticly. Due to the required flexibility in helicopter operations, it is good economy to have pilots dual or triple qualified. This may only be done safely if the company have standardized cockpits, good checkout training programs and annual recurrency training programs. It is the operators who have the greatest experience in operating the helicopters of all the manufacturers. Hence, the operators through EHA, should be consulted by the manufacturers long before the design is frozen. The EHA cockpit layout guidelines are ment to be a baseline for continued development and standardization and hence of benefit to the whole industry.

2. Historical Trends

It may be of interest to review the development of cockpit layout by some significant military and civil organizations.

U.S. Army Air Force.

USAAF developed instrument flying during the 1930's. This development was partly based on the trial results from the work performed by the Daniel Guggenheim Foundation for the Promotion of Aeronautics. The test flying was performed by the famous James H. Doolittle (Army Air Corps Lieutenant 1929), who was the first in USA to take off and land with reference to instruments only.

Needle-Ball-Airspeed System.

The first method for instrument flight was the socalled "1-2-3 System for Aircraft Control". This system was based on three successive steps: (1) center the turn needle with the rudder, (2) center the ball with aileron control, and (3) control the airspeed with the elevator.
Although this system of control was not coordinated nor did it take advantage of the pilot's natural ability to fly by visual references, it was a way to keep the aircraft's wings level and to maintain straight flight when visibility was restricted.
The US Army Air Corps soon adopted this system and called it the Needle-Ball-Airspeed System. It was taught in US Army flight training schools for many years as the standard method of aircraft control for instrument flight. However, due to its many limitaitons, this system was used only for cloud breaking and unintentional Instrument Meteorological Conditions (IMC) encounter enroute.

Attitude Instrument Flying.

During the mid 1930's, a new instrument that would revolutionize the art of instrument flying began to appear on the panel. This instrument, called the "artificial horizon" contained a gyroscope which was used to give the pilot a plane of reference. Together with the sensitive altimeter, sensitive airspeed, "rate of climb" and "directional gyro", the "full panel" of flight instrumentation was a reality. This caused the old system of Needle-Ball-Airspeed System of control to be changed. Now, for fully coordinated flight, the pilot had to center the needle with aileron and center the ball with rudder, and as before, control the airspeed by elevator. This method of control was called "Attitude Instrument Flying".

In spite of these advances in instrument technology, military instrument flying was very limited, and at the start of World War II, the average pilot had only a limited knowledge of the art of instrument flying.

In 1942 the US Army Air Force became vitally interested in instrument flying qualifications of its graduating pilots, now being called upon to fly combat missions in a variety of weather conditions throughout the world. Hence, the instrument flying training was intensified at the flight schools and now according to the new method of "Attitude Instrument Flying". This method of instrument flight control became the international military and civil accepted standard, and is the basis for FAR 25/29 and now also JAR 29 instrument layout.

USAAF Standard Instrument Panel.

The P-51D panel of 1945 represented the US Army Air Force (USAAF) standard of instrument panel layout during the World War II years. This was the general standard panel but space and shape could alter this somewhat. The US Navy panel was slightly different. Here the Airspeed and Altimeters changed positions and the engine instruments were placed close to the flight instruments on the left side of the panel. This was due to the criticality of good engine operation during the left turning final approach to the carrier. This is a practice which has continued to this day. US Air Force (USAF) and other services normally have the engine instruments placed on the right hand side of the instrument panel.

The wartime USAAF instrument standard was carried over to the Lockheed P-80 which was the first operational US jet fighter.With the second and third generation of jet fighters in USAF the basic World War II instrument standard was maintained, but now including newer developed instrument types, like the electric Attitude Indicator and gyrostabilized Heading Indicator, as on the F-84 and F-104 instrument panels. With the introduction of the socalled "Century Series" fighters like the Republic F-105 and Convair F-106 the Vertical Strip (tape) instruments and Integrated Flight Instruments were introduced.The main reason for this development was the increasing problem of panel space. The Integrated Flight Instruments (IFI) with vertical strip instruments saved panel space.The IFI system was based on an analogue Air Data Computer and the instruments were electromechanical. However, even though the IFI was a nice engineering product they had their operational limitations. Hence, these instruments were not installed in newer aircraft types after 1970.

By now USAF had standardized on the Basic-T arrangement which was also the civil Federal Aviation Administration (FAA) standard, as illustrated by the Northrop T-38A panel. The "vertical strip" instruments were once again disbanded in favour of the "round dial" instruments and all the new USAF aircraft introduced in the 1970's had this type of instruments.

Royal Air Force Basic Six.

It appears that RAF's ideas of instrument flying was in line with USAAF, as the primary RAF trainer, the De Havilland DH 82A Tiger Moth of 1940 was equipped with a typical Needle-Ball-Airspeed type of panel. However, looking at an operational fighter like the Supermarine Spitfire Mk1 of 1939, it appears that RAF was a step ahead of USAAF. This would only be natural by thinking of the European weather conditions. Hence, it appears that RAF and Royal Navy had developed a workable instrument panel layout by the outbreak of World War II and equipped most of their combat aircraft with the panel of the Basic Six; Airspeed, Attitude, Vertical Speed, Altitude, Directional Gyro and Turn and Slip indicator. The benefits of service standardization are quite obvious as indicated on the RN Seafire and RAF Vampire panels. An interesting deviation from the standard RAF Basic Six is shown on the picture of a RAF Mustang panel from 1944. This contains a modified USAAF standard instrument panel. Why the RAF did not specify their own standard of the Basic Six lay out in the Mustang is puzzling, and must have been a challange for their pilots in transition.

German Luftwaffe 1940-45.

The cockpit layout of the two models of the Messerschmitt fighters, the Me109 and Me 262 illustrates the problems of Luftwaffe's lack of standardization. These pictures of two fighters in the same service and from the same manufacturer, illustrate the difficult task of achieving cockpit standardization. Another interesting observation is that the Me 262 panel is very close to the RAF Basic Six.

Pilot Adaptation.

Aircraft designers have often designed the cockpit layout mainly based on their own ideas. However, they will always get pilots to fly their aircraft. This may be due to two main reasons; most pilots love to fly, and they consider it a challange to control the aircraft the way it is designed. The more difficult an aircraft is to control, the harder will the pilot try to compensate and learn to master the difficulties. And with training he will succeed. The danger is, however, that one day he will be caught with his guard down.

The task of adaptation may be illustrated by student pilot experience from the Royal Norwegian Air Force (RNoAF). The student pilot was first introduced to the instrument panel of the Svenska Aeroplan Aktiebolaget SAAB 91B Safir trainer with an instrument panel very close to the RAF Basic Six. After basic training in either a Royal Canadian Air Force Harvard or Tutor, or a USAF T-37A, the student was introduced to the T-33A instrument panel which had the panel of USAF's second generation jet fighters. Then came the operational aircraft like the Republic RF-84F. Here, due to limited panel space, the flight instruments were completey disorganized. Then further on to higher performance aircraft like the Lockheed F-104 with even more limited panel space.

By the mid 1960's this pattern was broken when USAF adopted the Basic-T lay out as installed in the Northrop T-38A and F-5A instrument panels.

Civil Instrument Layout 1931 - 80.

As mentioned earlier, "Jimmy" Doolittle was the first in USA to take-off and land with references to instruments only. It is therefore of interest to note the layout of his Super Solution Bendix Racer of 1931. This was before the introduction of the "Artificial Horizon" and the most important attitude instrument was the Needle and Ball.
Hence, this instrument is placed at the top center. If we substitute the Needle and Ball with the later developed Artificial Horizon we are close to the present Basic-T lay out.

The Douglas DC - series aircraft played a big role in development of scheduled all weather passenger flying. It is interesting to note the apparent lack of instrument layout standardization as shown on the panels of DC-3 and DC-7. While the DC-3 had the standard wartime USAAF instrument layout, the DC-7's layout apparently was designed by "new people with new ideas". Finally, with the introduction of passenger jet aircraft the civil standard instrument layout became the Basic-T as illustrated on the Lockheed L-1011 Tristar of 1980.

3. Instrument Development

The "Pioneer" Instrument Panel of 1925 shows some interesting features. The layout and position of the Airspeed and Altitude is acceptable even of todays standard. The panel includes an early type of Attitude or Flight Indicator. Otherwise it is interesting to note the vertical tape engine and flight instruments.On the previously addressed layouts of the wartime USAAF and RAF standard instrument panels we can also see the typical vacuum driven Attitude and Directional gyros. On the Mustang panel we see the US developed Turn and Slip indicator, VSI and three pointer Altimeter. With the exception of the gyro instruments, we may find the same type of instruments in todays cockpits, but now arranged according to the Basic-T lay out.

The trend during the 1950's and 1960's was to increase the sizes of the Attitude and Bearing indicators. During the 1950's, 60's and 70's the flight instruments developed continuously.

Attitude Indicator.

The general development of attitude indicators followed the trend in USAF, like the all black J-8 Attitude Indicator which was the most common attitude indicator in NATO during the 1950's and 60's, followed by the black and white A1. During the 1960's the Flight Director (FD) was introduced. This led to the Attitude Director Indicator (ADI), which also in many cases included the Turn and Slip Indicator. The most advanced ADI was the "three-axis" indicator. This instrument replaced three of the older Basic Six instruments (Attitude, Heading and Turn and Slip). This ADI was installed in the Canadian CF-104 which were flown in the RNoAF and pilot's impression was very favourable. In a dynamic flight environment this display was very effective in keeping situational awareness.

The ultimate development in electromechanical ADI is the Sperry ADI installed in the Boeing Vertol 234LR Chinook helicopter. This instrument includes four basic instruments (Attitude, Turn and Slip, Radar Altimeter and Instrument Landing System (ILS) Localizer and Glide Slope Indicators) in addition to the Flight Director Command Bars. This is the most sophisticated electromechanical ADI ever developed, and one of the best ADI installed in a helicopter.

A combination of the "three-axis" and the Sperry ADI display would improve it even further. With the introduction of digital Electronic Flight Instrument Display (EFIS) this should be possible. One important detail on ADI is the bank pointer. The most common practice is to have a "sky pointer" instead of an "earth pointer". It is important that this detail is standardized, and EHA has recommended the adaption of the "sky pointer". The idea is that in a situation of disorientation the "sky pointer" points skywards and safely away from the dangerous earth surface.

Barometric Altimeter.

The "three pointer" Altimeter has been in continuous use since the 1930's, in spite of its inherent trap of possible misreading. The most common type of misreading is the 10.000 ft. mistake. However, it may also be misread by 1.000 ft. In all cases of misreading this was previously looked upon as "pilot error" and not as "human factor" as of today. This altimeter is still the most widely used altitude indicator (in private and GA aircraft), primarily of economic reasons since it is definitely the less expensive. Through the 1950's, 60's and 70's the Altimeter developed further into the Counter - Pointer, and the Counter -Drum-Pointer type. The Counter-Pointer introduced a new type of trap which led to misreading altitude by a 1.000 ft. This type did not survive long. The next altimeter development was the Counter-Drum-Pointer type. The first versions indicated in 100's of feet. This was later improved by adding two zeroes to the drum values. This altimeter is the type least susceptible for misreading and is recommended by EHA. An interesting consept was the strip type altimeter developed for USAF in the 1950's and 60's. This was not a success and was not installed in the new aircraft of the 1970's.

Airspeed and Vertical Speed Indicators

The Airspeed and Vertical Speed indicators have not changed much through the years. This is probably due to their good "human" characteristics from the start. Here also USAF introduced vertical strip indication together with the vertical strip altimeter. An interesting feature was the downward increasing airspeed and mach indication. The concept is logical though, by comparison with the "fly-to" concept of Flight Directors Command Bars. With the command indicator below the reference line you "fly to" the command bar. Another way of thinking is that by pushing the stick forward you increas the speed. This concept is worth adopting also on modern digital displays. Here again, the vertical strip airspeed indicators faded away together with the vertical strip altimeters.Their main deficiency was the difficulty of instant interpretation in a dynamic flight environment.

4. Strip Display

Strip type display of aircraft instruments have been used during different periods of the aviation development. It seems that types of cockpit displays follows the laws of fashions. If someone important fashion leader introduces an idea and manages to market this idea, the rest of the industry will follow. So also with strip type instruments which were first introduced during the 1920's. Ref. the Pioneer instrument panel of 1925. By 1940 the use of strip display was almost distinct. Ref. RAF Spitfire and RN Seafire instrument panels. During the late

1950's the increased complexity of aircraft systems caused the panel space to become so cramped that other methods of indications were necessary. Once again the strip instruments were introduced by USAF, but now driven by analogue computers. This also introduced the method of "command" flying where the pilot selected command values of airspeed and altitude and used this command values to keep his references. The system was based on the newly adopted Basic-T consept, and the "fly-to" principle where the pilot would move his controls in the direction of the selected "command value". This display system was called the "Integrated Flight Instrument System" (IFIS) and was used on most of the new front line U.S. fighters, bombers and transports developed during the late 1950's and 1960's (F-105, F-106, B-58, RB-66, C-141, C-5, etc.). The system was also chosen for the Space Shuttle.

Even though the system was a dream for the display engineers, allowing them maximum flexibility within a limited panel space, the system had its clear operational limitations. Strip displays are more difficult to read quickly than conventional dial and pointer instruments. One can always detect the approximate angular position of a pointer on a circular dial. no matter how blurred it might appear due to vibrations. The pointer's position on a strip instrument is far harder to sense, and usually will have to be very carefully read since it is more difficult to detect linear movements and positions than angular ones.

These lessons appear to necessitate relearning at certian intervals (in the order of 30 years; 1930's, 1960's, 1990's). By 1975 USAF had disbanded use of strip displays for primary flight displays but retained the strip display for Head Up Display (HUD) symbology. At this time the HUD's were only used to enhance weapon aiming under visual conditions and were not used for instrument flyging. However, the idea of using HUD as primary flight references became more and more acceptable during the late 1980's and early 1990's, even for civil use. However, once again the lessons of strip display limitations are being relearned. Even though most new aircraft with Electronic Flight Display (EFIS) have strip displays, USAF has once again concluded from test results that round dials and pointers are superior to strip displays. USAF has sponsored several evaluations of HUD symbology during recent years. The result is that USAF is leaning towards a new standard of HUD display, including round dials and pointers for airspeed and altitude displays.

In fighter aircraft it is of vital importance for the situational awareness to quickly asess altitude and airspeed,.and the USAF conclusion is that round dials and pointers are best suited for this purpose. The same conclusion is previosly reached by SAAB factory regarding the flight display in the Gripen combat aircraft. It is also interesting to note that the same conclusion was reached by Westland/Agusta and Royal Navy/Italian Navy for the EH 101 Merlin/Heliliner. In a dynamic flight environment as applicable to fighters and helicopter, often manoeuvering at low level, the quick asessment of airspeed and altitude is quite critical.

5. Electronic Flight Instrument Displays (EFIS)

The Cathode Ray Tube (CRT) type of cockpit display was introduced during the 1980's. Their introduction was a natural consequence of the developments in electronics and computer technology during the 1970's. However, here again the laws of fashion were predominant to the more scientific research results. Even though some studies were performed in UK and USA, as indicated on the BAC 111 Advanced Cockpit Layout and Lockheed L-1011 EFIS which both included round dials airspeed and altitude, most manufacturers joined in on the strip display fashion line.

This is still the trend as indicated on the new AS 332L2 Super Puma Mk2 and the Cessna Citation V cockpits displays. This fashion driven development, in spite of the lessons learned, is unfortunate as the pilots are not given the optimum, ergonomic flight displays. It is hoped that the recent USAF evaluation results will set a new trend as often experienced in the past. It is here worth mentioning the importance of international organizations like EHA, which through their Cockpit Layout Guidelines may influence the development of cockpit layouts.

6. Helicopter Flight Displays.

The trend in helicopter flight display development has generally followed the trend in fixed wing developments. There is one important exception, however, namely the Sikorsky S-61N. The S-61N was the first real IFR equiped public transport passenger carrying helicopter. It is uncertain who decided upon the layout of flight instruments, which were contradictory to international standard. It is believed that the display was selected by Sikorsky test pilots and accepted by the then (1960's) fledging helicopter IFR pilot community, mainly the North Sea helicopter operators. The panel is a mirror image of the now internationally accepted Basic-T layout.

One theory behind this arrangement is that the helicopter pilot in command was seated in the right hand pilot seat and had a requirement for looking at the airspeed indicator during hover operation. This sort of misconseptions have resulted in some bad solutions during helicopter developments. Otherwise the development of helicopter cockpit layout has followed the trend in fixed wing developments. This trend was cemented by the development of the Federal Aviation Requirement FAR 29 which clearly defines the arrangement and visibility of instrument installation, based on the Basic-T layout. The beforementioned S-61N layout was in violation of the FAR 29. All new helicopter designs are of course, certificated according to FAR 29 as represented by the panel of the Bell 412.

The new Joint Aviation Requirement JAR 29 which was in effect from November 1993, is similar to FAR 29. The positions of the Torque and Rotor RPM indicators are still not standardized among the manufacturers, as shown on the previous panel display. Both FAR 29 and JAR 29 states that "rotor tachometers and the indicator most representative of engine power, must be grouped and centered as nearly as practicable about the vertical plane of the pilot's forward visison". In spite of this, recent new helicopter instrument panels show vastly different practice among the manufacturers which causes problems for the operators.

7. Control Grips.

Another area of concern to the helicopter operators are the different types and shapes of control grips. The different location and functions of the switches may contribute to serious incidents, like unintentional jettison of external loads or disconnection of Automatic Flight Control System (AFCS) during high workload situations. For more than 40 years both fixed wing and helicopter pilots have been used to the socalled Bendix stick grip as used in most US jet fighters and helicopters, in addition to most British and French helicopters. When a manufacturer then suddenly decides to change stick grip to a completely different type like in Eurocopter AS 332L1, this is bound to cause problems. When Eurocopter first introduced the new AS 332L2 it was offered with the new type of stick grip. This was not accepted by the customers and now the helicopter is produced with the previous cyclic stick grip (which may now be called the EHA stick grip).

This is a well proven and functional stick grip which adheres well to the golden rules of "if it aint broke, dont fix it" and "you cannot argue success".

These rules ought to be remembered by design engineers and test pilots. Similar thoughts can be expressed concerning the shape and layout of collective grips. The manufacturers should listen more to the experience of the operators. Two examples of well designed and functional collective grips are the Sikorsky S-76 and the Eurocopter AS 332L2 grips. We can clearly see the potential of standardization between the US and French collective grips. Such standardization is very cost effective for customers who operate both types.

8. EHA Cockpit Layout.

When the second generation of North Sea helicopters were introduced in 1982, like the Aerospatiale AS 332L and the Boeing Vertol BV 234LR, the problem of cockpit layout standardization became acute. The dilemma was whether one should stick to the then adopted standard of Sikorsky S-61N layout (which in some companies also was the model for Bell 212 layout) or accept the then FAR 29 standard. The conclusion among most operators was that the best approach was to follow international standard.

During this process Helikopter Service of Norway conducted some evaluations among its pilots during simulator flying. After the sessions in the simulator the pilots were questioned of the relative locations of the airspeed indicator and altimeter. The results showed that about 50% of the pilots gave the wrong answer. This was an indication that as long as the intruments were located within the frame of the Basic-T, and "centered as nearly as practicable about the vertical plan of the pilot's forward vision" (FAR 29) the left and right locations were not critical.

The Torque and RPM indicators were located in various positions, according to the individual manufacturer's preference and diffuse guidance from the FAR 29. Helikopter Service decided on a new company standard, based on the FAR 29 Basic-T layout, combined with the previous S-61N layout of Torque and RPM indicators, located below the airspeed indicator.

EHA Performance Committee.

During the mid 1980's, the EHA Performance Committee was established. The main task was the work on the new European performance standards, but among additional tasks was the work of establishing EHA recommended guidelines for Cockpit Layouts and Flight Manuals. These guidelines were approved by the EHA council in 1990. Unfortunately these guidelines are still without influence on the manufacturer's choice of cockpit layout. An illustration of this are the different instrument layouts of AS 332L1 and AS 365N2 which both are produced by Eurocopter. This illustrates the strong influence of individuals in the design and flight test departments.

In 1993 Helikopter Service started negotiations with Eurocopter regarding purchase of the new AS 332L2 Super Puma Mk2. This is a modern aircraft with an integrated cockpit and EFIS. As previously stated the possibility for the operator to change cockpit layout is very limited, but Helikopter Service wanted the cockpit layout to be as close as possible to the EHA recommended guidelines.In addition it was important that the layout was as close to the layout of the company AS 332L, as possible. This layout is also in line with the EHA layout.

Due to the integrated displays of the AS 332L2, the only possible changes were regarding the layout of the standby instruments, the center and overhead consoles. The standby instruments were regrouped based on the principles of the Basic-T and EHA cockpit layout guidelines. The Torque and RPM indicators were positioned on a vertical line close to the Pilot's position. An additional Torque indicator was located in the Copilot's position. The requirement for two Torque indicators was based on redundancy and safety. This choice have been confirmed by failures of the computed power limitations, when reference to the Torque indicators are required. In addition Helikopter Service required a standby Radar Altimeter indicator. This choice has also been proved by inflight failures of the EFIS.

Regarding the center console, it was possible to design a layout in line with the EHA guidelines and very close to Helikopter Service company standard layout of the AS 332L/L1. This allows Helikopter Service pilots to be current in all three variants of AS 332L/L1/L2 Super Puma.

This illustrates the most obvious advantages to cockpit standardization, in addition to gains in safety. This is the background and incentive for the development of EHA recommended Cockpit Layout Guidelines. It is important that the operators and manufacturers join forces in developing the new helicopters, based on operational and economical requirements. This will benefit the whole rotorcraft industry, including our customers who will get safer and more economical helicopter transport.

9. Conclusions

- The evolution of cockpit instrumentation and layout have been governed more by fashion trends than scientific research.

- The aircraft operators have been too willing to accept the manufacturers ideas of cockpit layout.

- Larger aircraft operators and certification authorities like USAF and FAA have a large impact on cockpit layout development.

- Smaller operators, especially helicopter operators have little influence on cockpit layout development.

- The vast differences in cockpit layout philosophies between the helicopter manufacturers create problems of safety, logistics and economy to the operators.

- Recent studies indicate that strip displays of primary flight instruments are deficient to round dial and pointer type instruments in a dynamic flight environment.

- CRT displays present unlimited possibilities for optimum standardized flight displays.

- The EHA developed Cockpit Layout Guidelines may help in developing more user friendly cockpits for commercial operators.

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5. European Helicopter Association, EHA Cockpit Layout Guidelines, Issue 2, 1994.

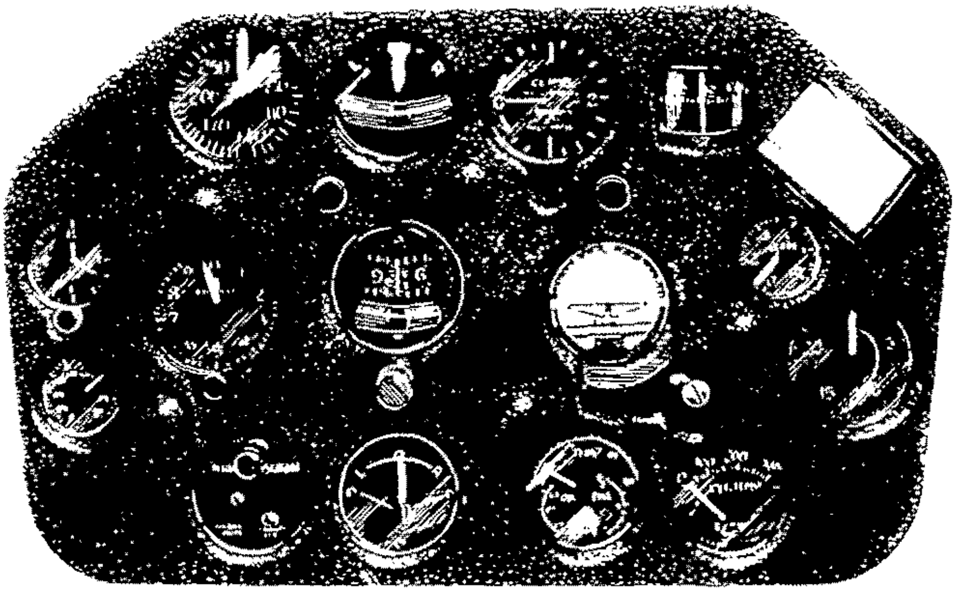
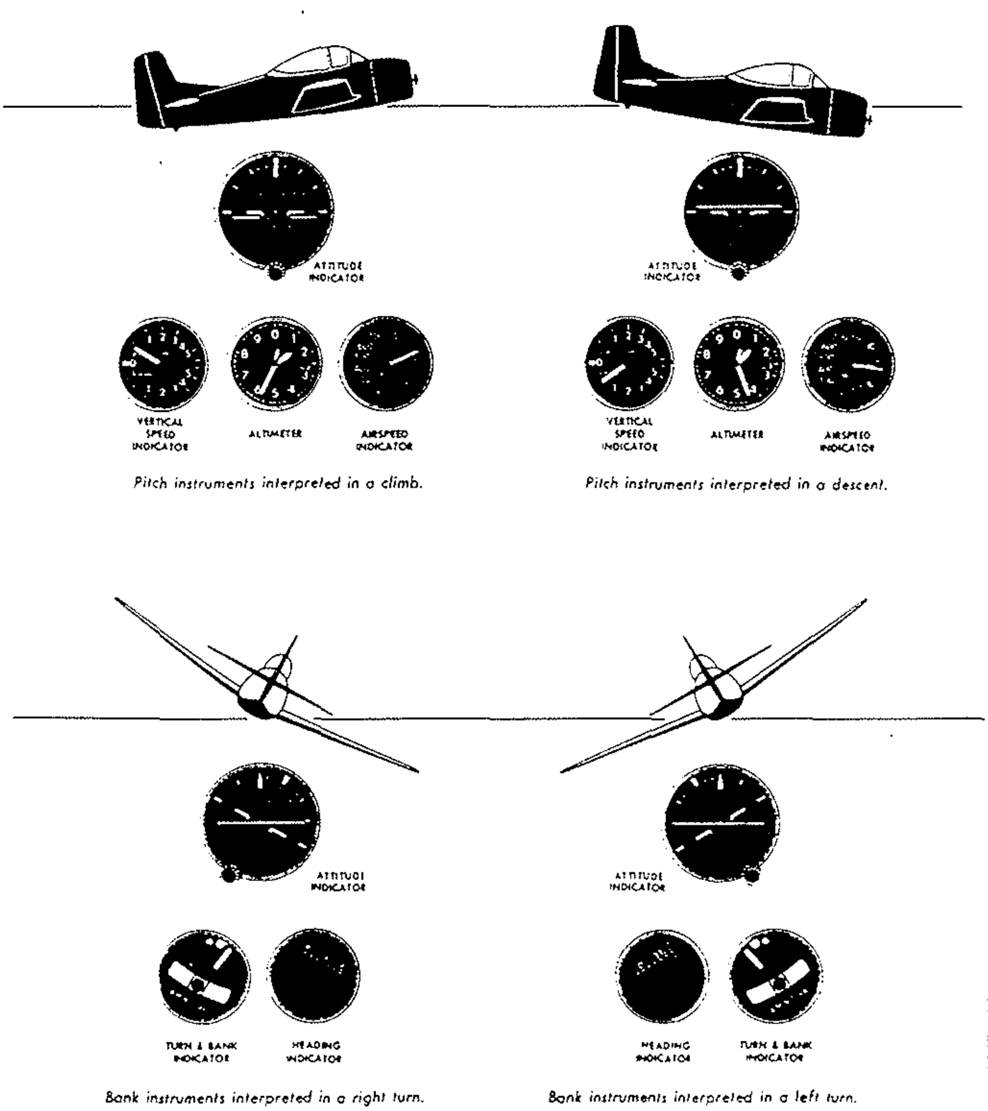


FIGURE 1. USAF BT-9 INSTRUMENT PANEL (1936)



USAF AFM 51-38 (1954)

FIGURE 2. USAF ATTITUDE INSTRUMENT FLYING

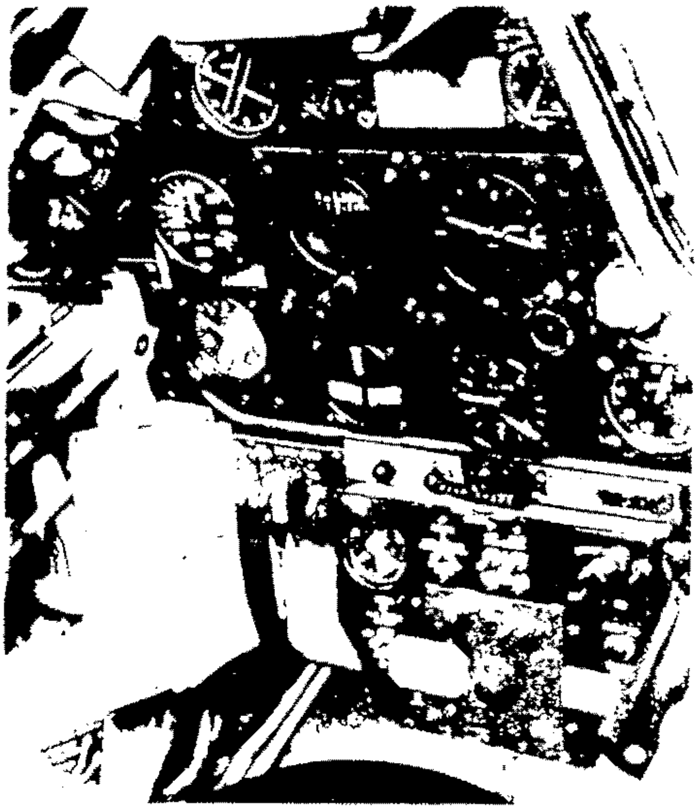


FIGURE 3. USAF P-51D INSTRUMENT PANEL (1945).

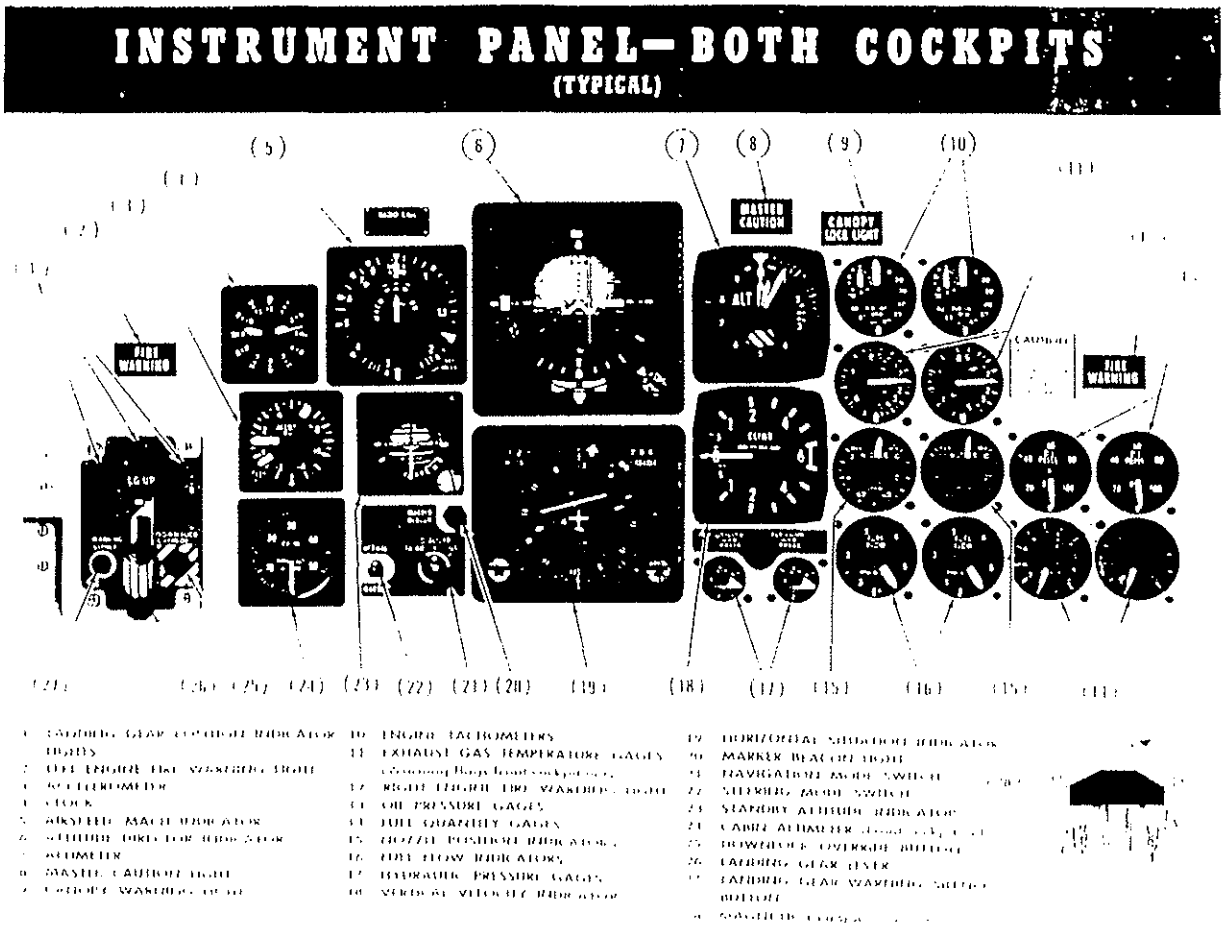


FIGURE 4. USAF T-38A INSTRUMENT PANEL (1963).

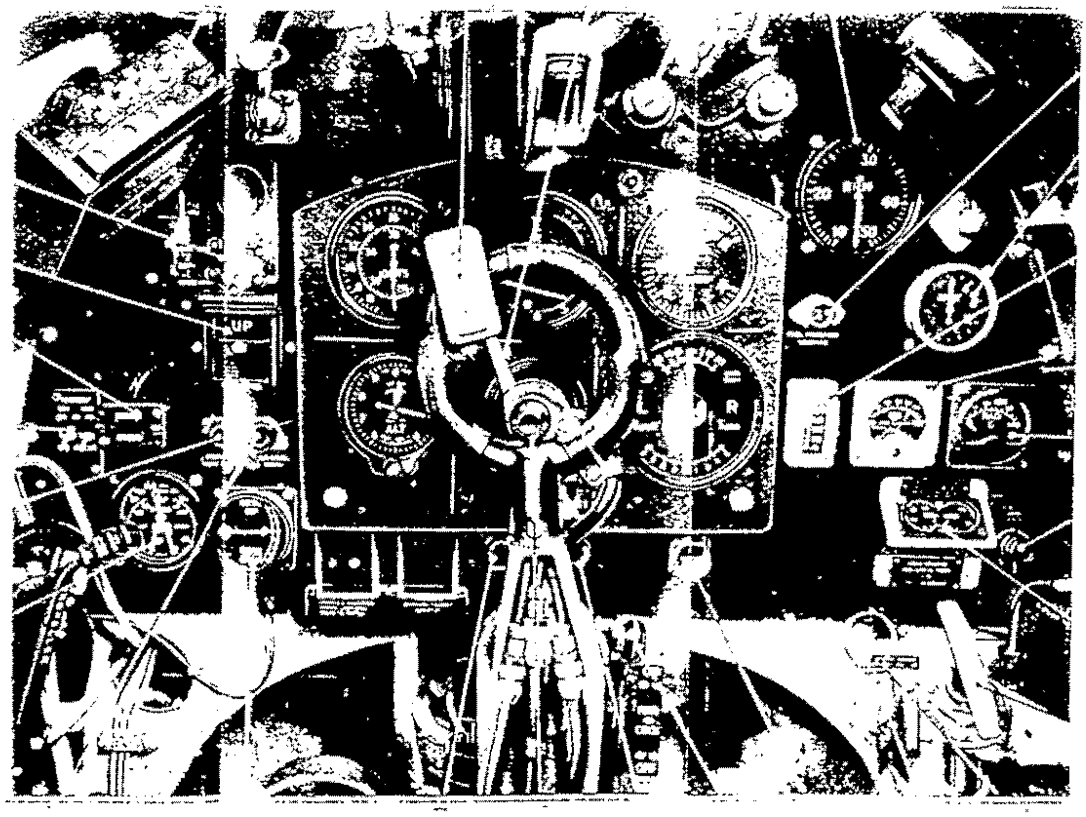


FIGURE 5. ROYAL NAVY SEAFIRE INSTRUMENT PANEL.

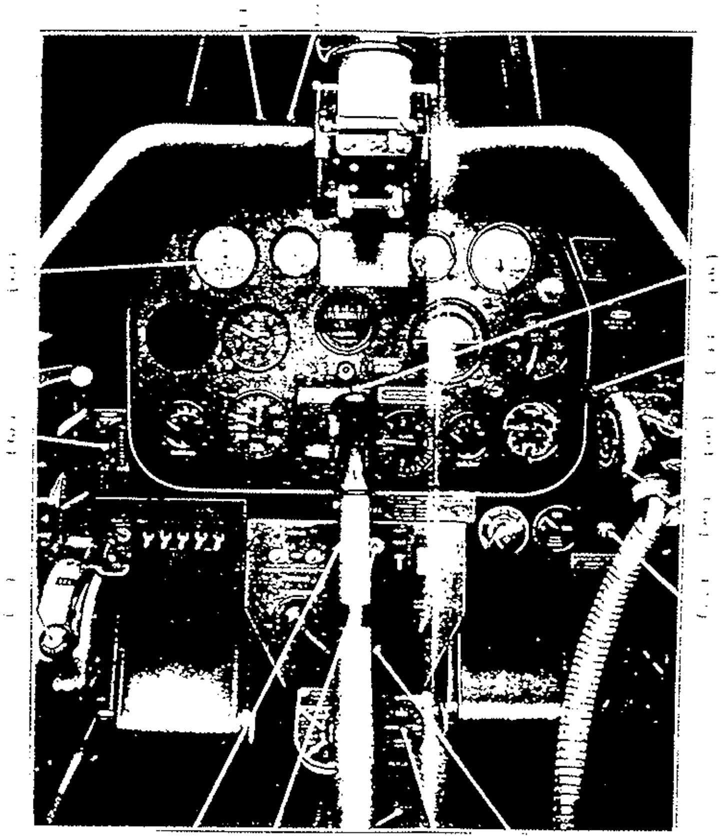


FIGURE 6. RAF MUSTANG INSTRUMENT PANEL.

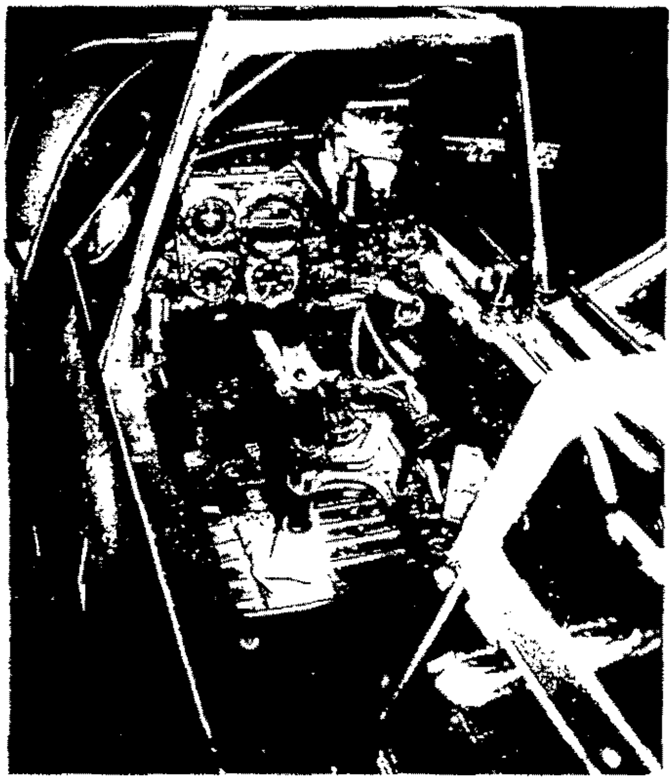


FIGURE 7. LUFTWAFFE ME 109 INSTRUMENT PANEL.

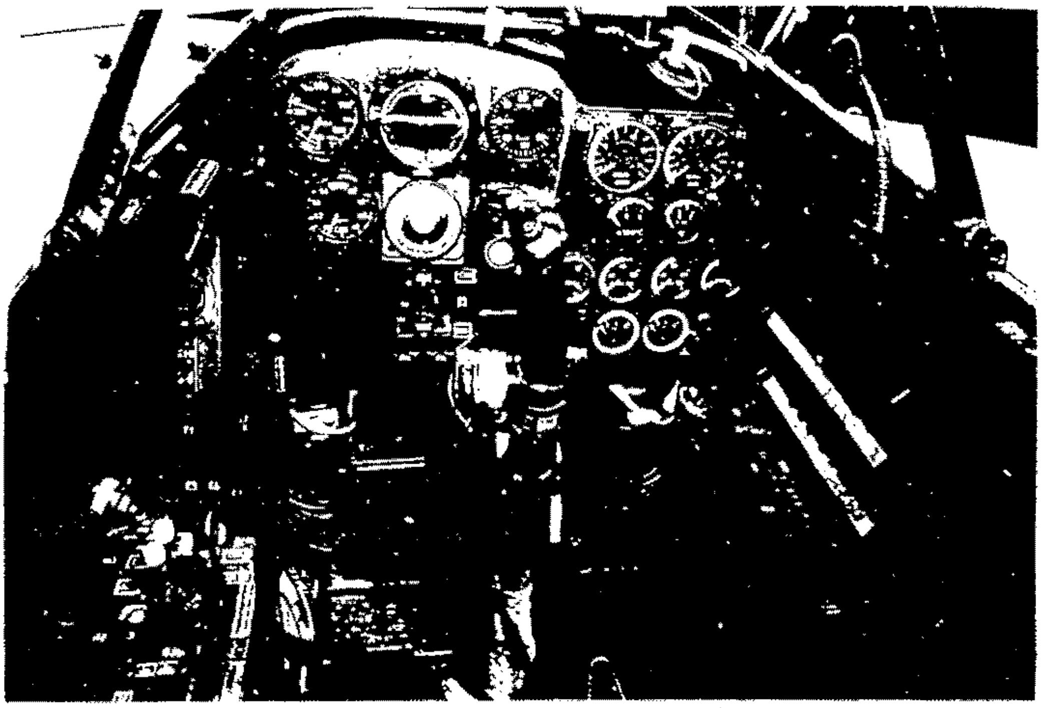


FIGURE 8. LUFTWAFFE ME 262 INSTRUMENT PANEL.

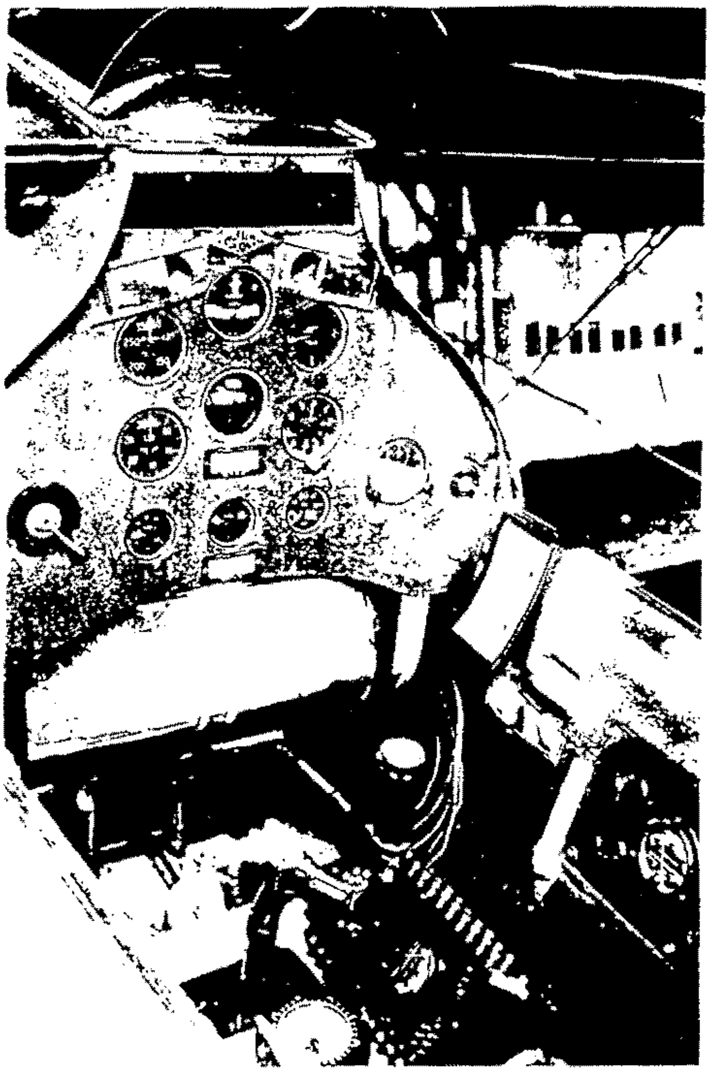
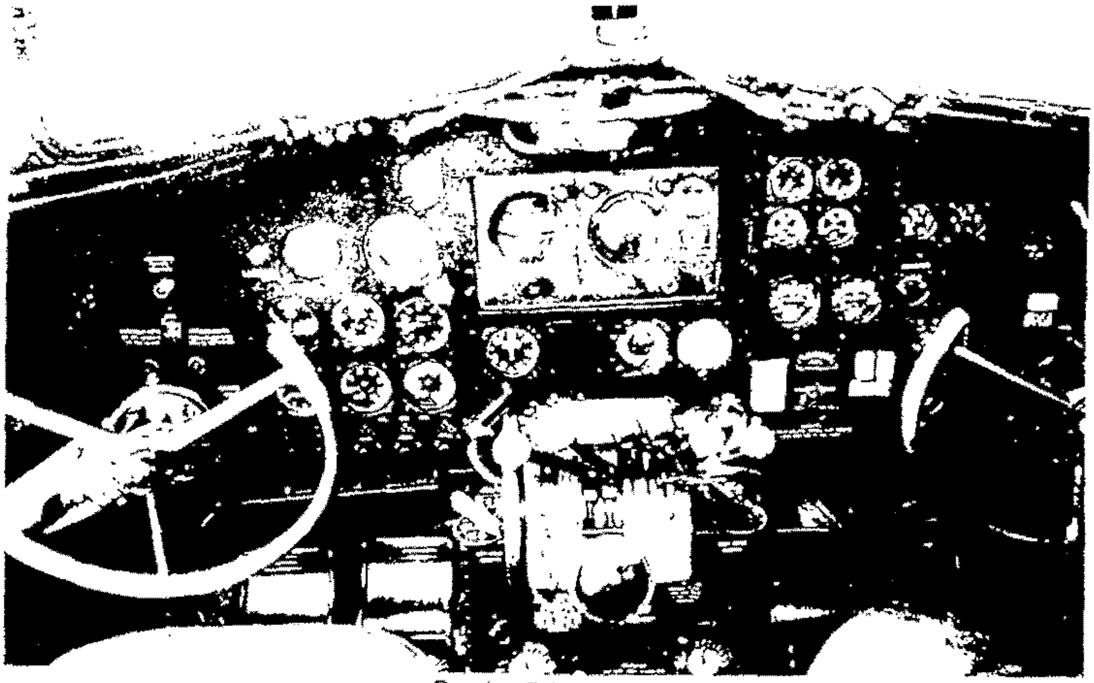
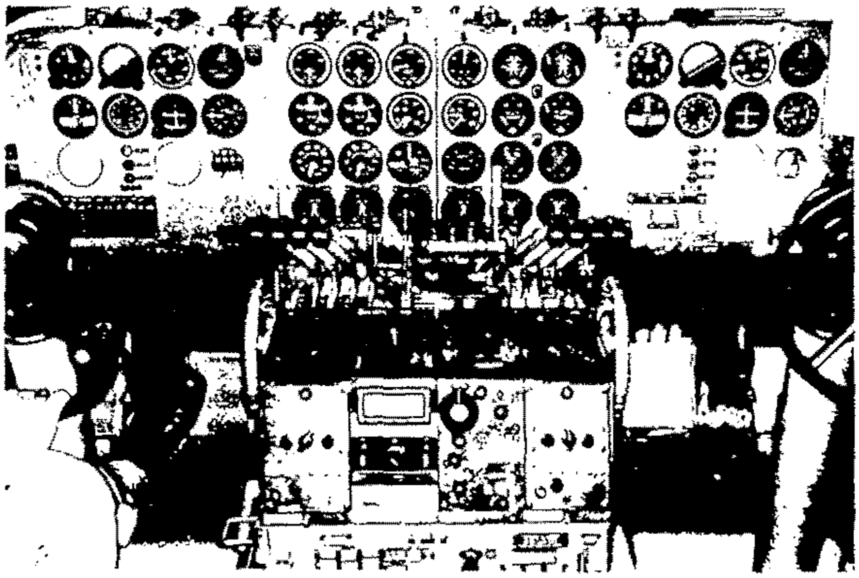


FIGURE 9. DOOLITTLE INSTRUMENT PANEL (1931).



Douglas DC-3 (1945)



Douglas DC-7B (1955)

FIGURE 10. DOUGLAS INSTRUMENT PANELS.

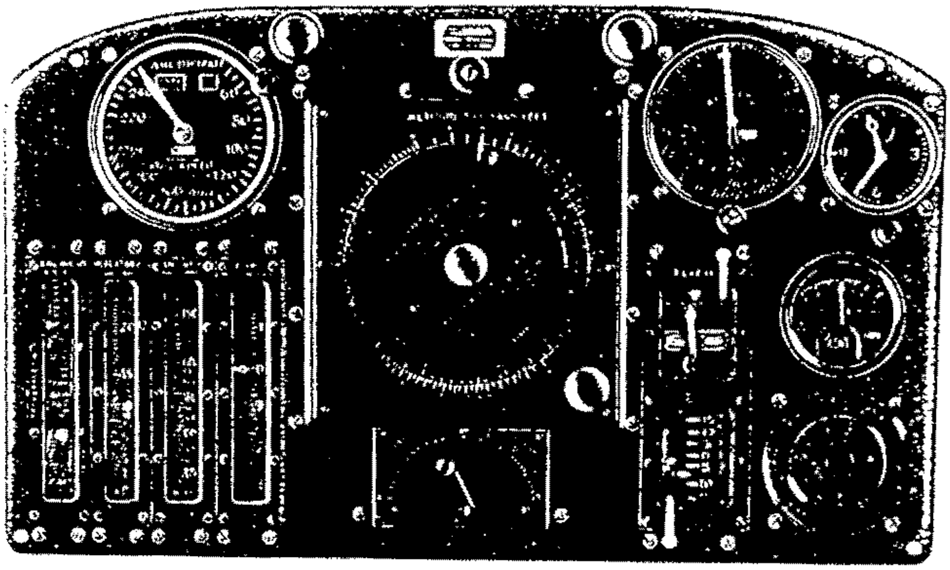
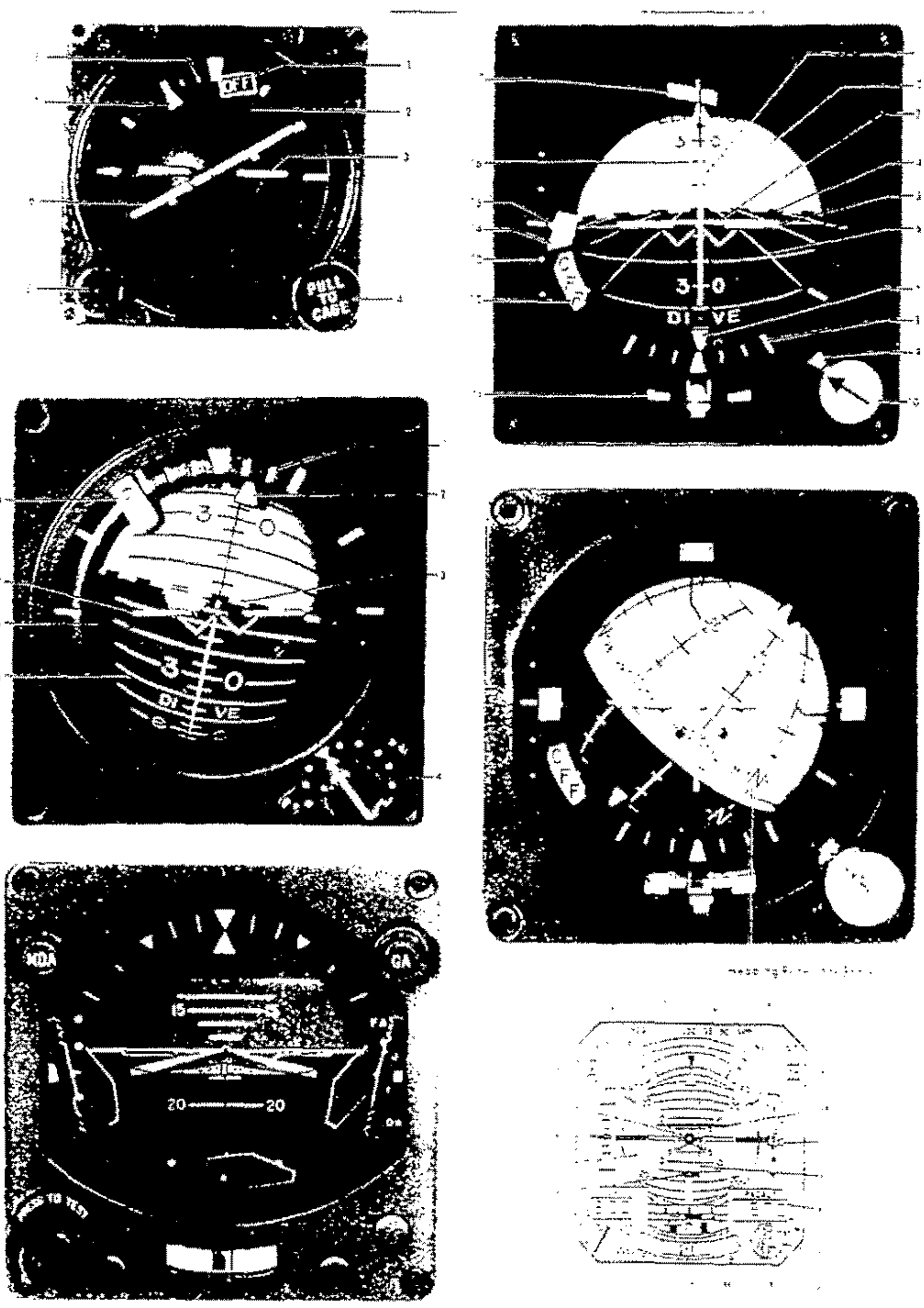
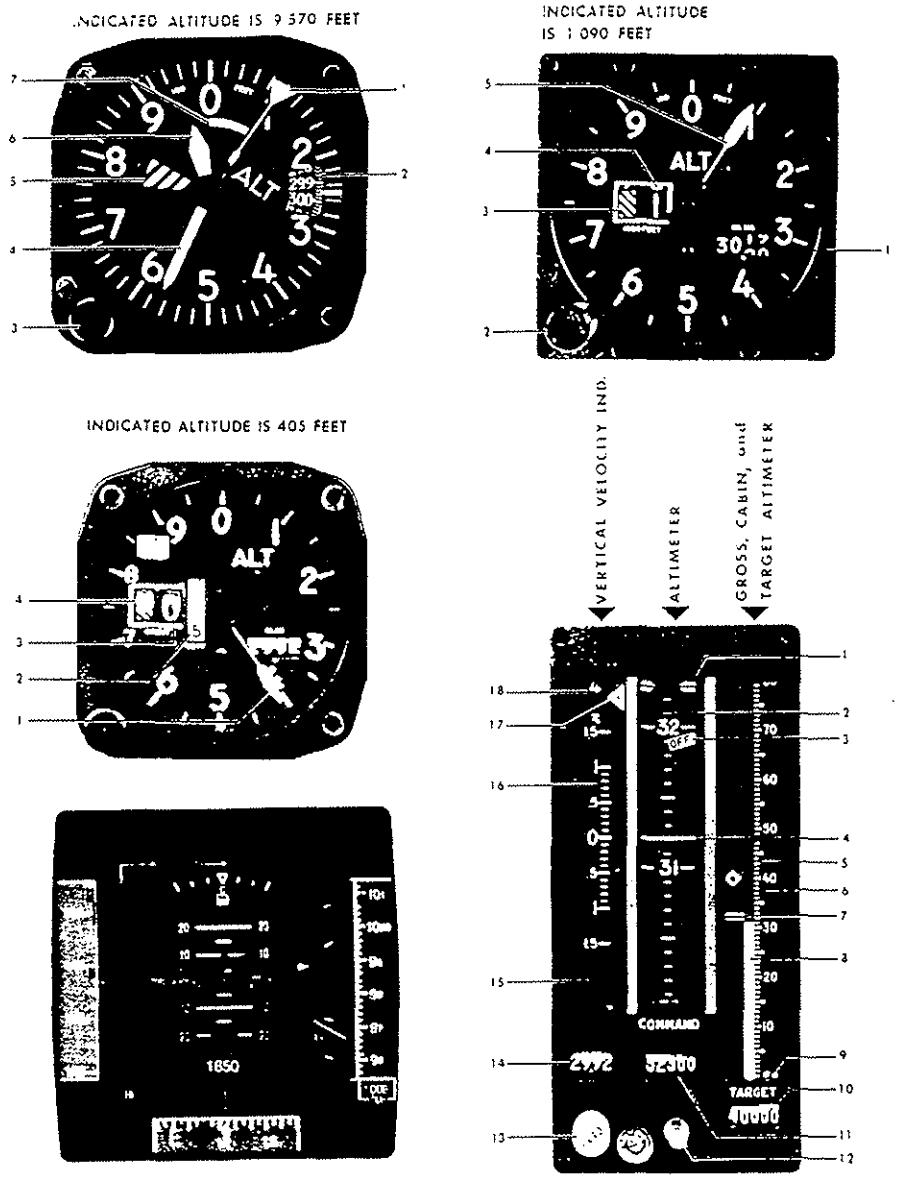


FIGURE 11. PIONEER INSTRUMENT PANEL (1925).



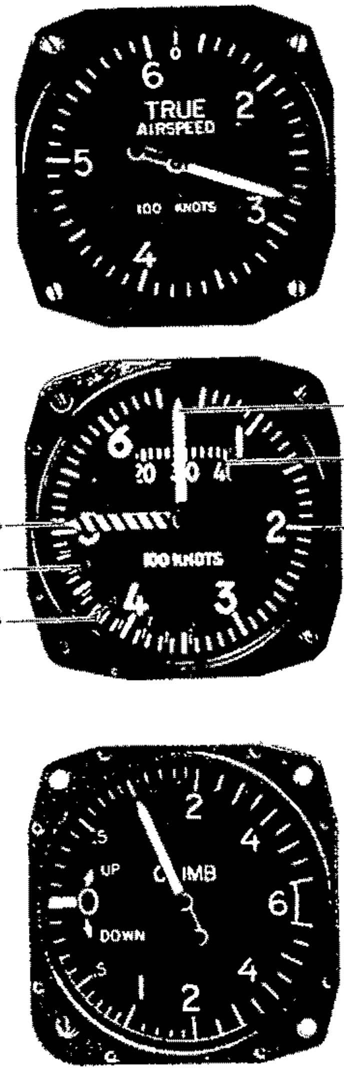
Attitude Indicators

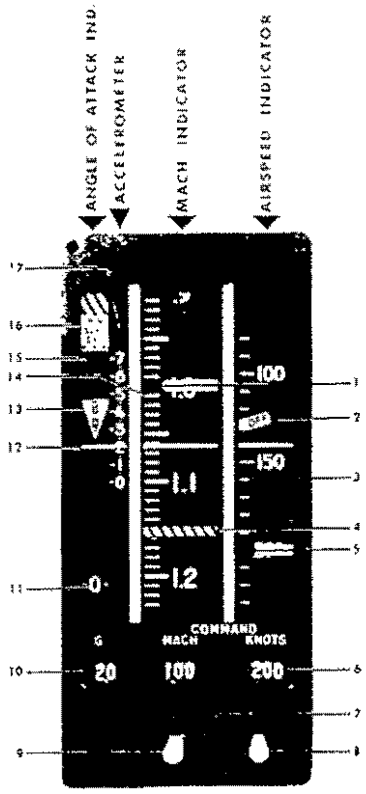
FIGURE 12. ATTITUDE INDICATORS.



Altimeters

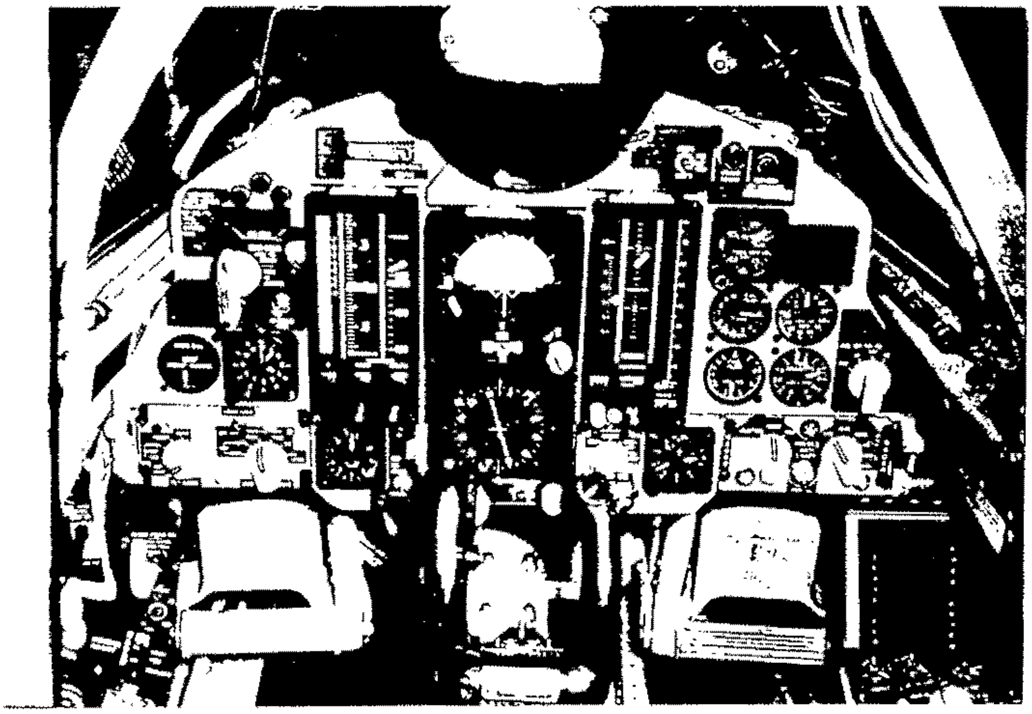
FIGURE 13. ALTIMETERS.





Airspeed Indicators

FIGURE 14. AIRSPEED INDICATORS.



USAF Convair F-106 (1960)

FIGURE 15. USAF CONVAIR F-106 (1960).

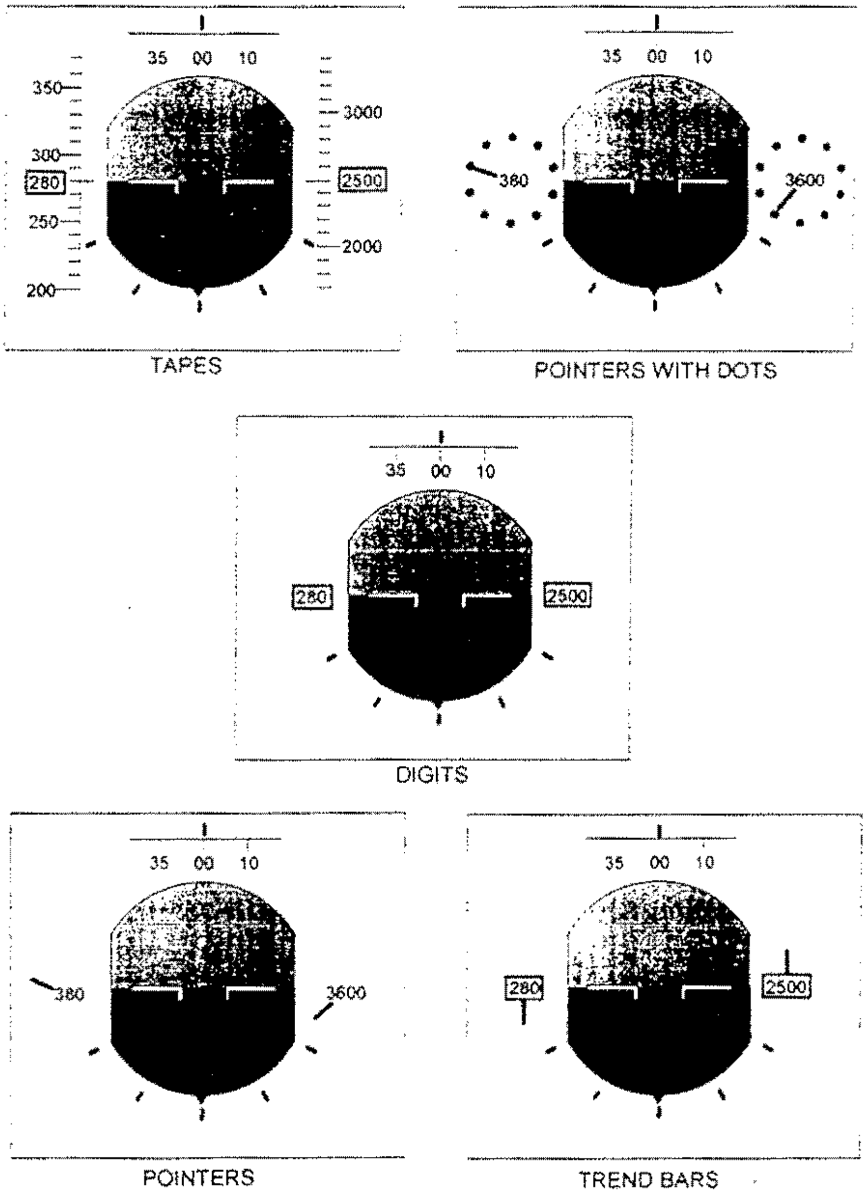


FIGURE 16. AIRSPEED/ALTIMETER DISPLAY FORMATS.

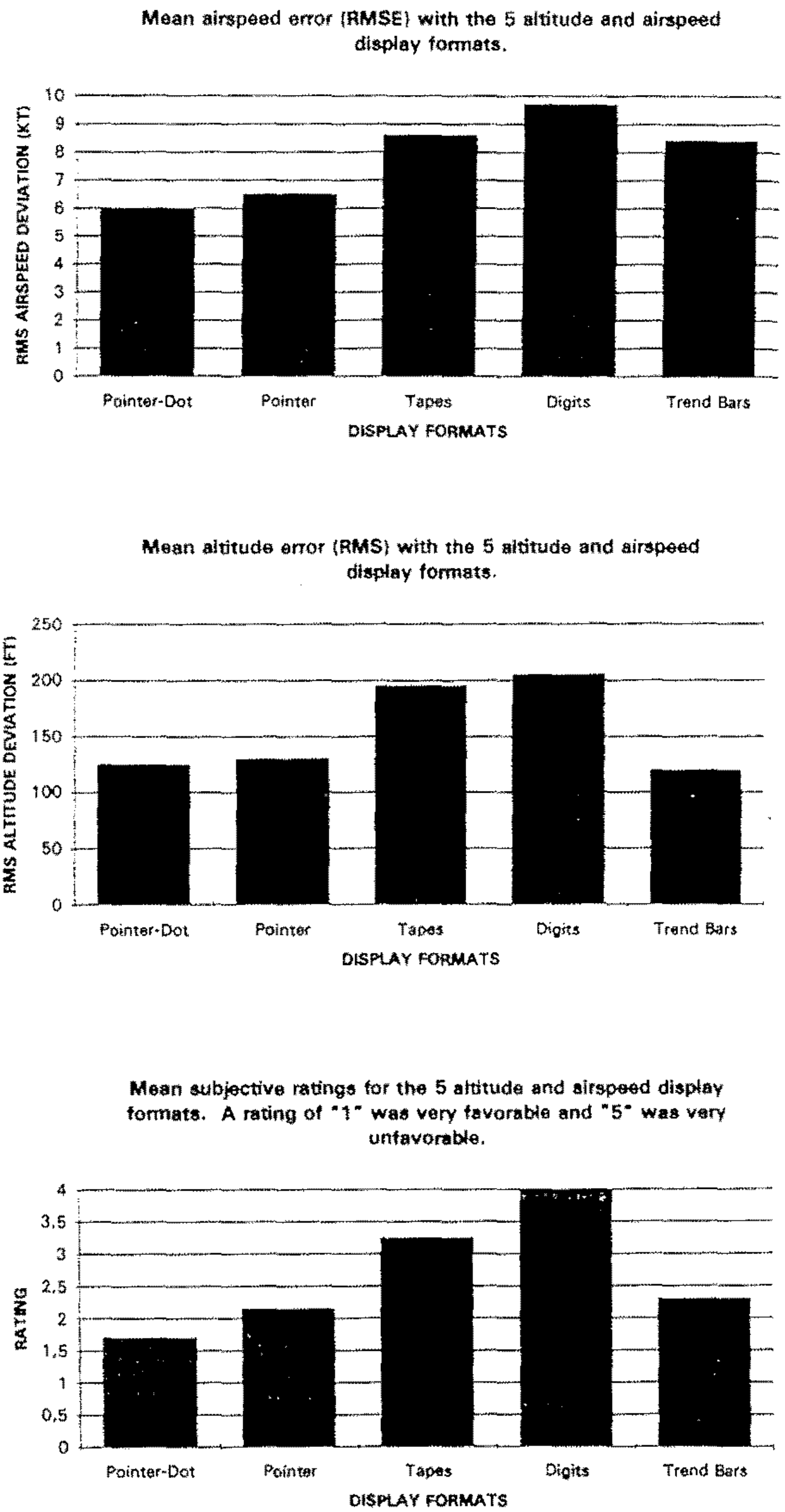
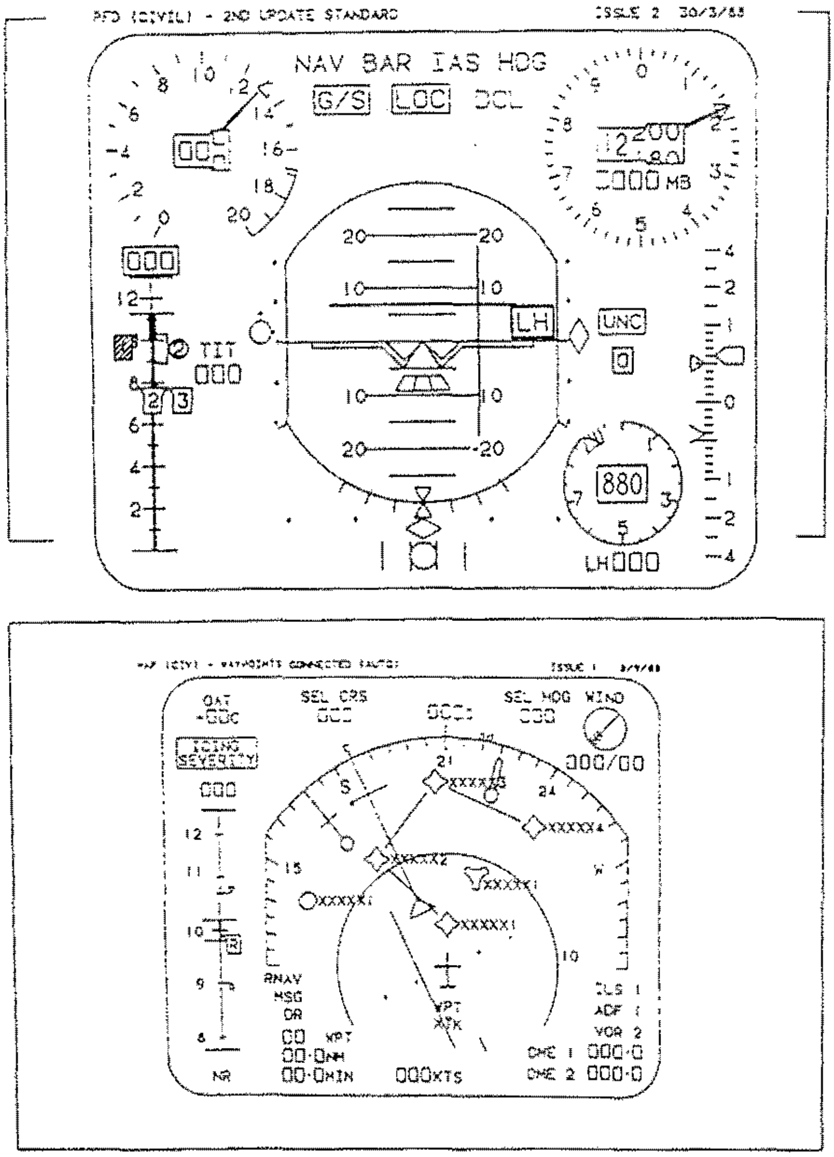


FIGURE 17. READABILITY OF DIFFERENT AIRSPEED/ALTIMETER DISPLAY



EHI EH 101 (1988)

FIGURE 18. AUGUSTA/WESTLAND EH 101 EFIS.

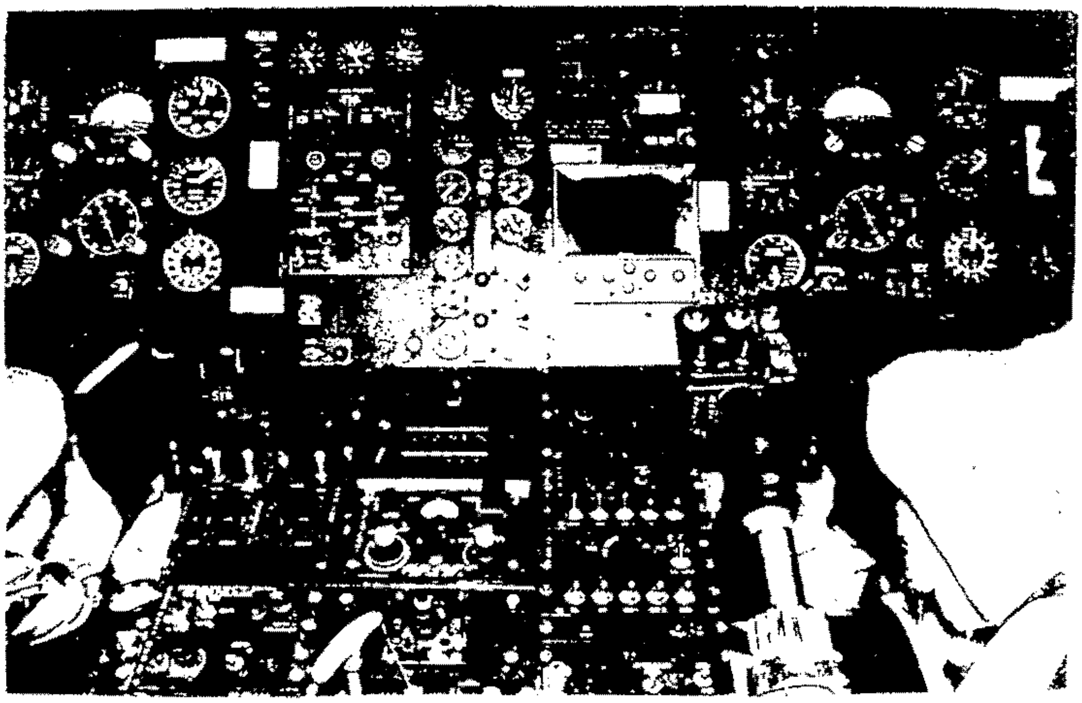
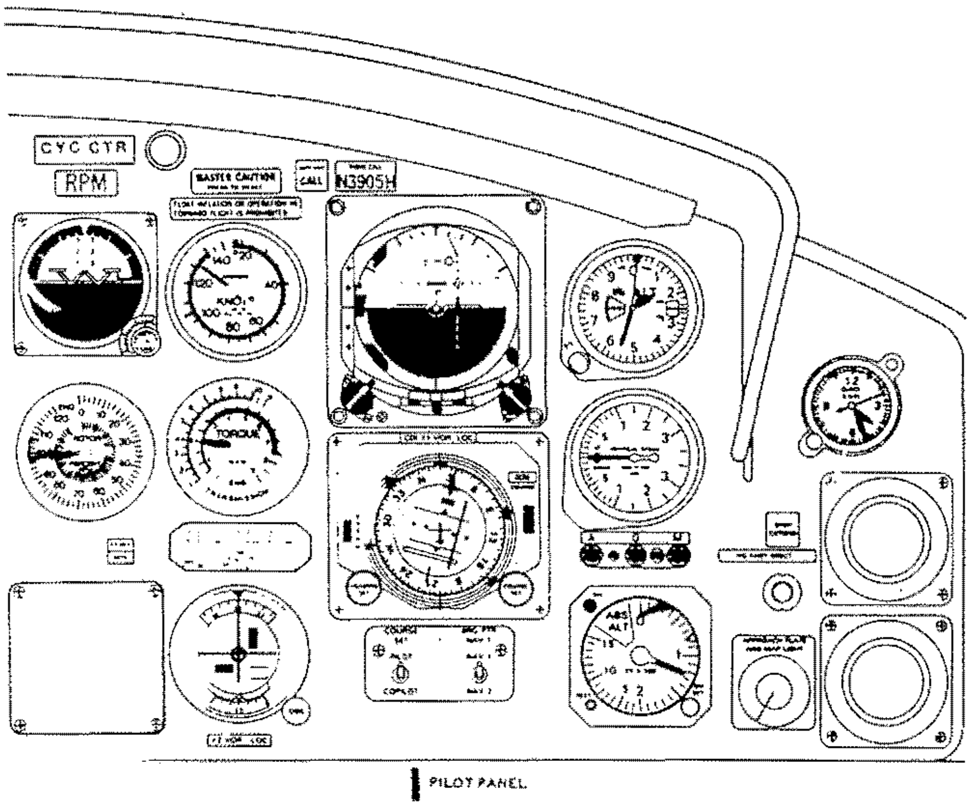


FIGURE 19. SIKORSKY S-61N INSTRUMENT PANEL.

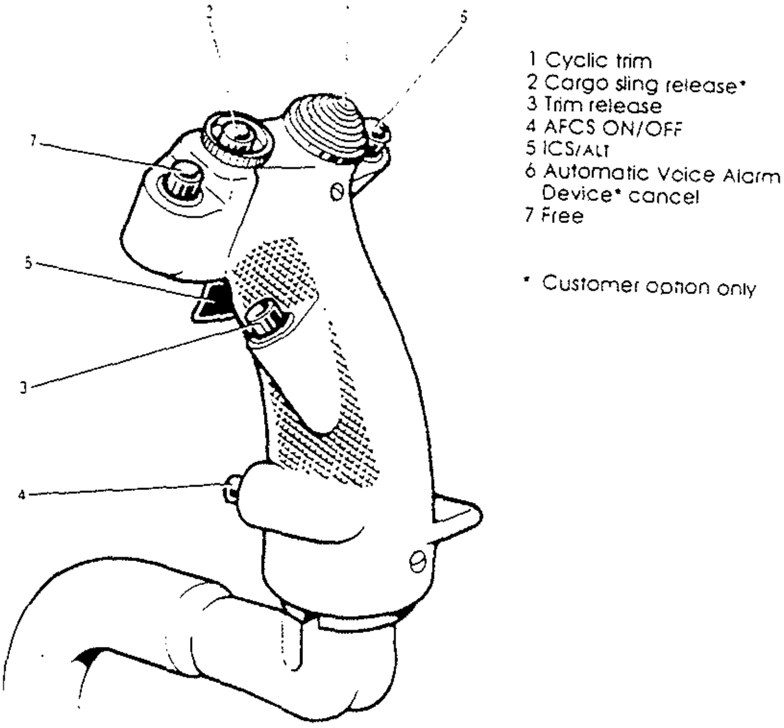


Bell 412 SP (1988)

FIGURE 20. BELL 412 INSTRUMENT PANEL.

Control Grips

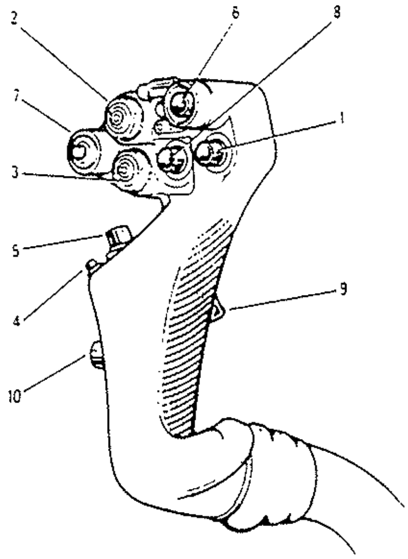
FIGURE 21. CONTROL STICK GRIPS.



Eurocopter AS 332L2 (1993)

CYCLIC PITCH CONTROL STICK HAND GRIP

FIGURE 22. EUROCOPTER AS 332L2 STICK GRIP.



1 - Autopilot disengagement

2 - 4-way A/S beep trim control (Active only if the optional FDC 155 coupler is fitted)

3 - 4-way (pitch and roll) beep trim control

4 - AP upper modes release (or coupler cyclic channel release if a coupler is fitted)

5 - Artificial feel release

6 - External load normal release control (when applicable).

7 - Engagement and disengagement of the autopilot air speed hold (or ground speed hold if the optional FDC 155 coupler is fitted)

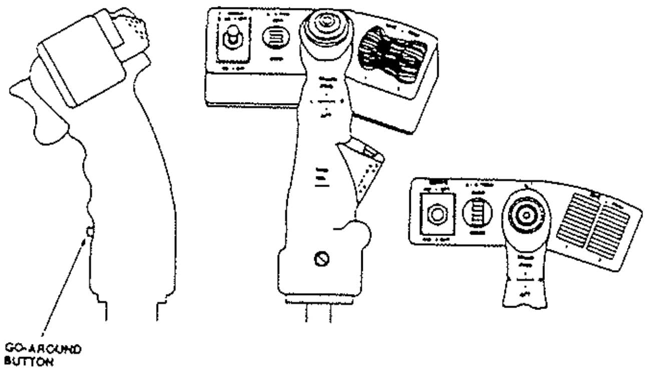
8 - Guarded push-button (Reserved)

9 - Radio-press-to-talk switch

10 - (Reserved)

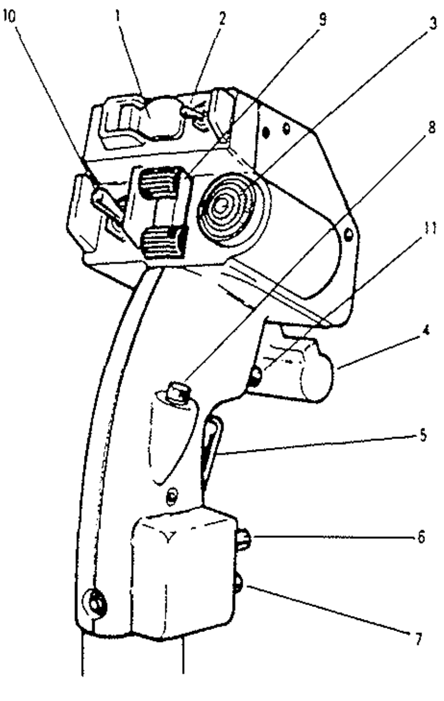
AS 365N2 Stick Grip (1993)

FIGURE 23. EUROCOPTER AS 332L1 STICK GRIP.



COLLECTIVE STICK GRIP

Sikorsky S-76C



1 Hoist cable cutter*
2 Landing light on/off and automatic retraction
3 Landing light elevation and azimuth control*
4 Emergency floatation gear inflation control*
5 Collective trim
6 OEI mode
7 Windshield wiper control
8 AP go around engage/disengage button*
9 Collective beep trim
10 AP hydraulic unit cut-off
11 Public address*

* Customer option only

AS 332L2

Collective Grips (1993)

FIGURE 24. COLLECTIVE STICK GRIPS.

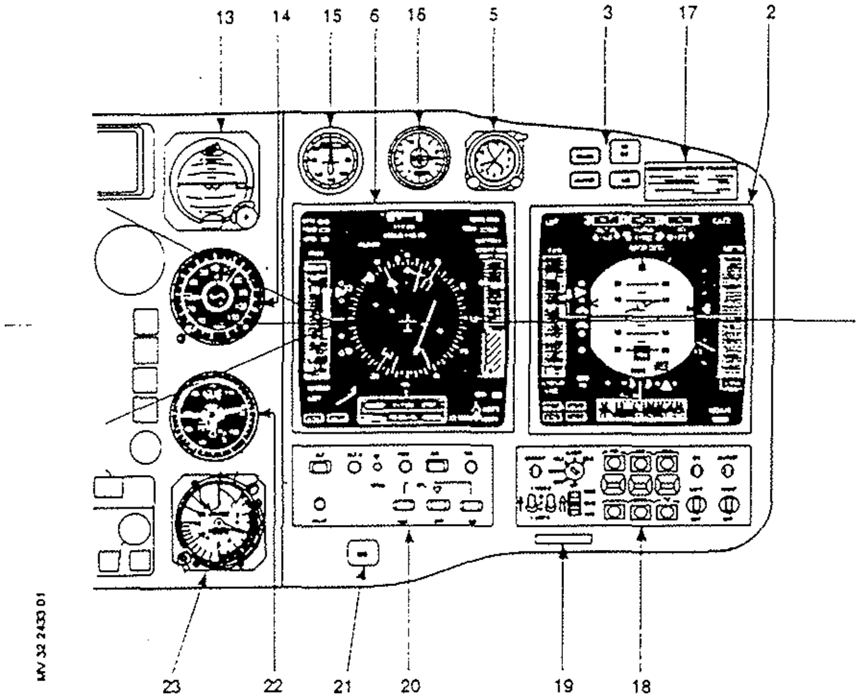


Fig. 3

KEY (Cont'd)

15. Airspeed indicator
16. Altimeter
17. Emergency static pressure indicator placard
18. Display Control Unit (DCU)
19. Maximum takeoff weight placard
20. Automatic Flight Control Panel (AFCP)
21. ICE warning light
22. Triple indicator : NR, NF1 & NF2
23. Radio-altimeter indicator
24. Engine 1 and 2 fuel pressure indicators
25. MGB, IGB and TGB indicators and lights
26. Engine monitoring lights
27. Hydraulic system monitoring light and indicators
28. Outside air temperature (OAT) indicator

Helikopter Service AS 332L2 Instrument Panel (1993)

FIGURE 25. HELIKOPTER SERVICE AS 332L2 INSTRUMENT PANEL.