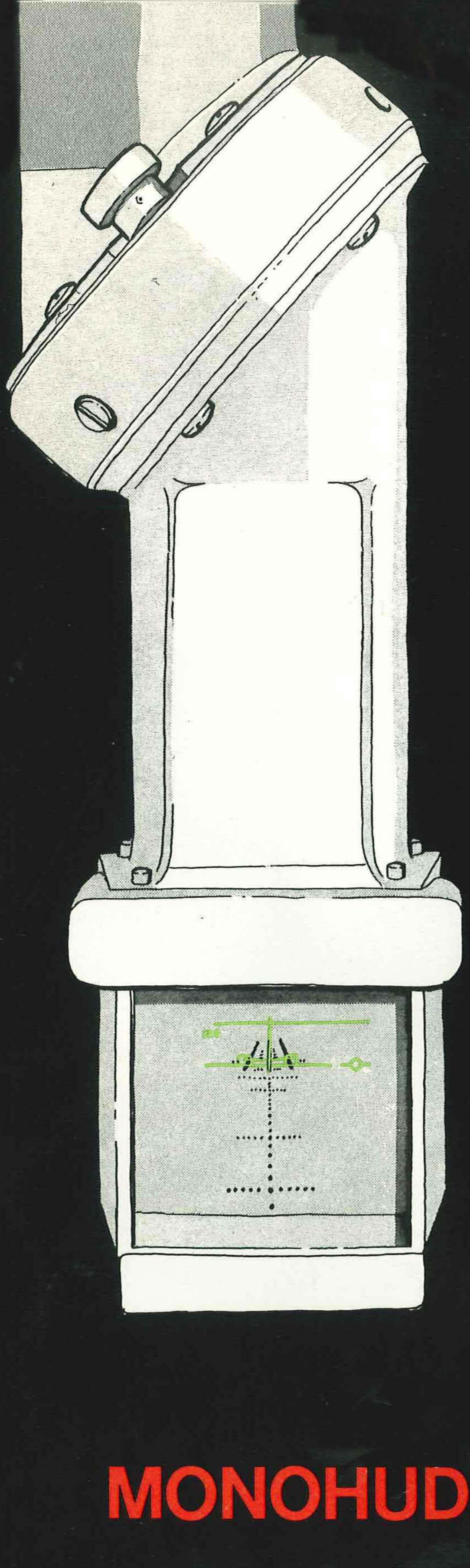
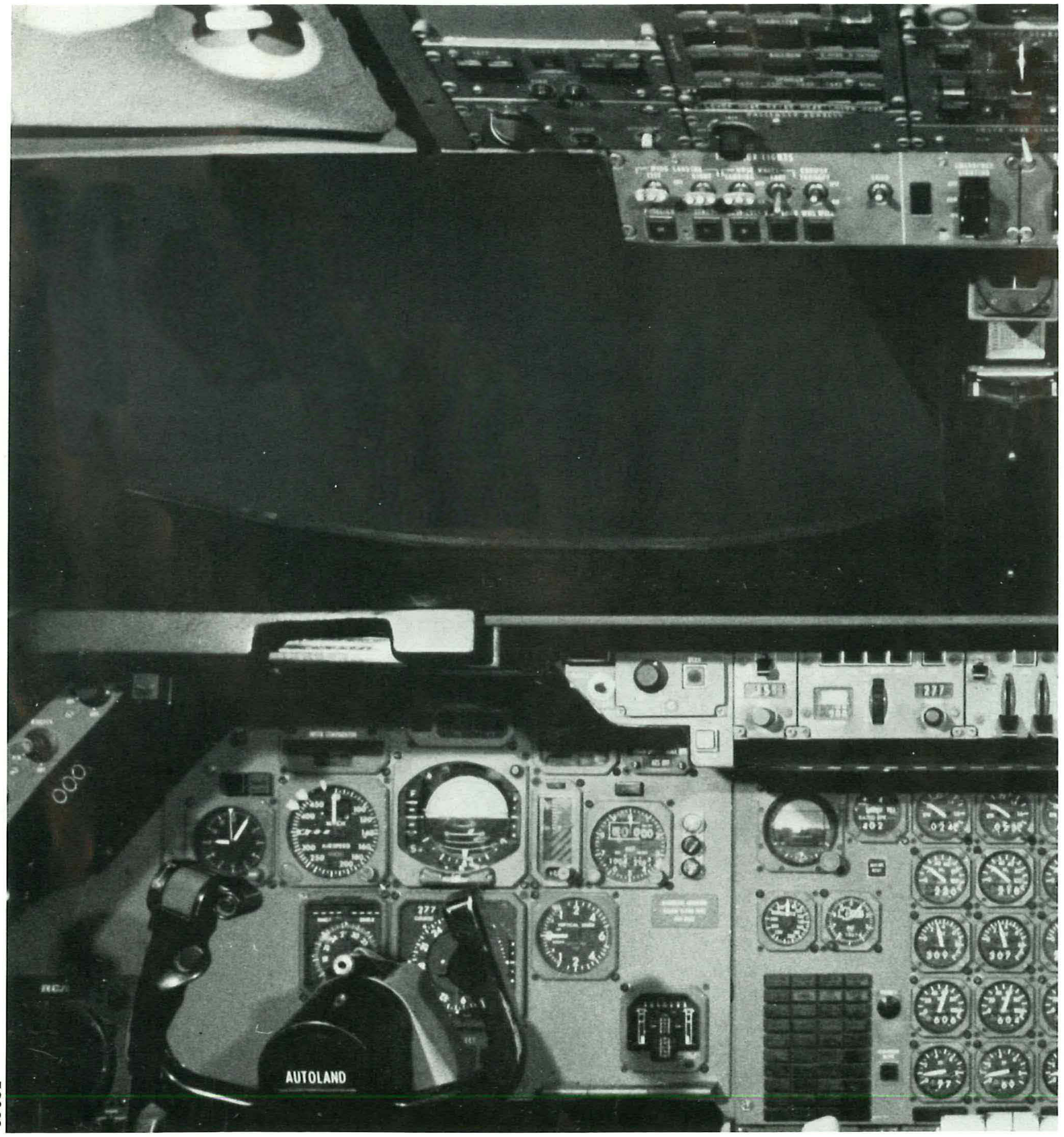
MARCONI AVIONICS



MONOHUD

A Miniature Head-Up Display

For the Pilot Who Has Everything



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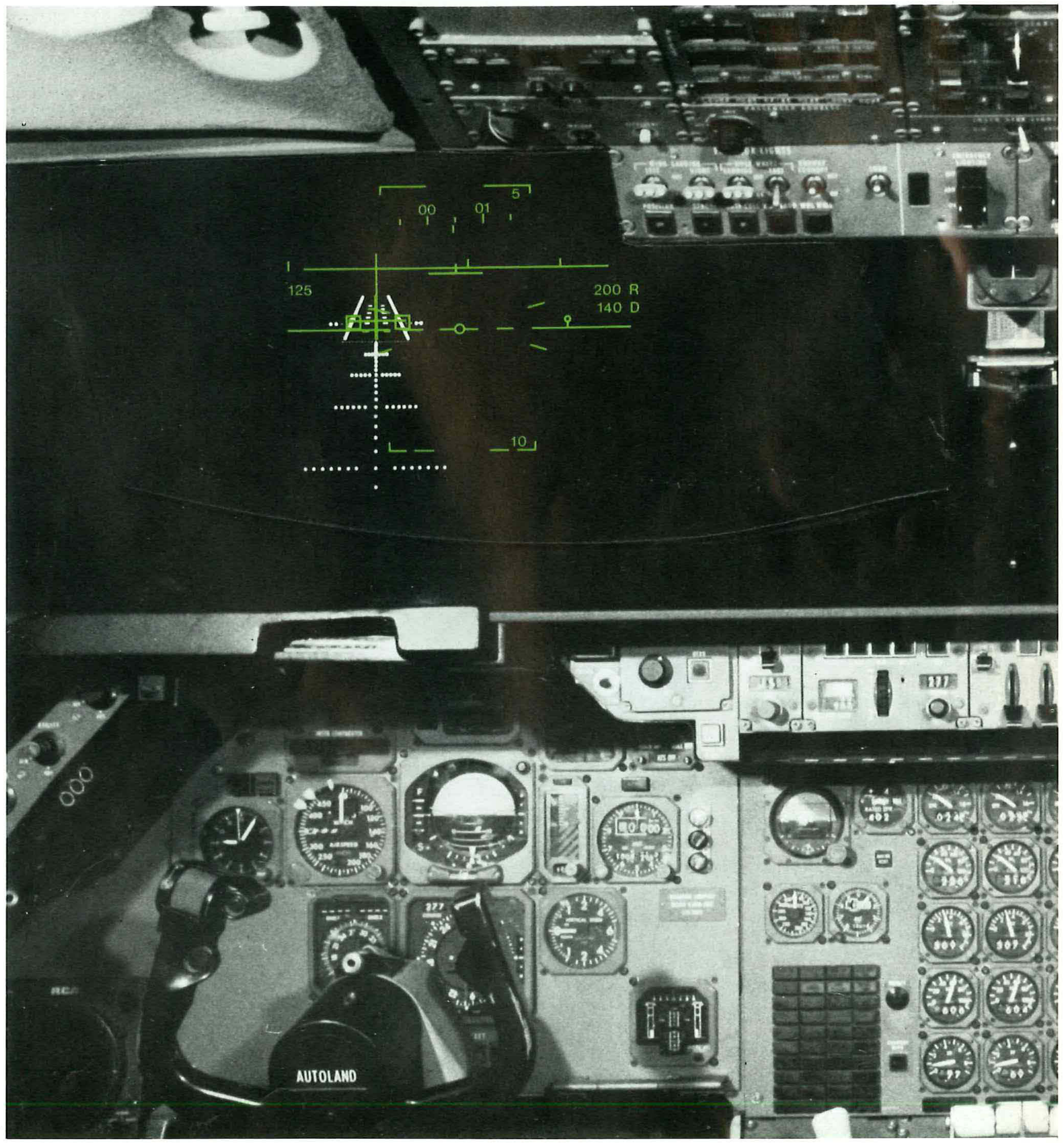
But Would Like to Know Where He's Going



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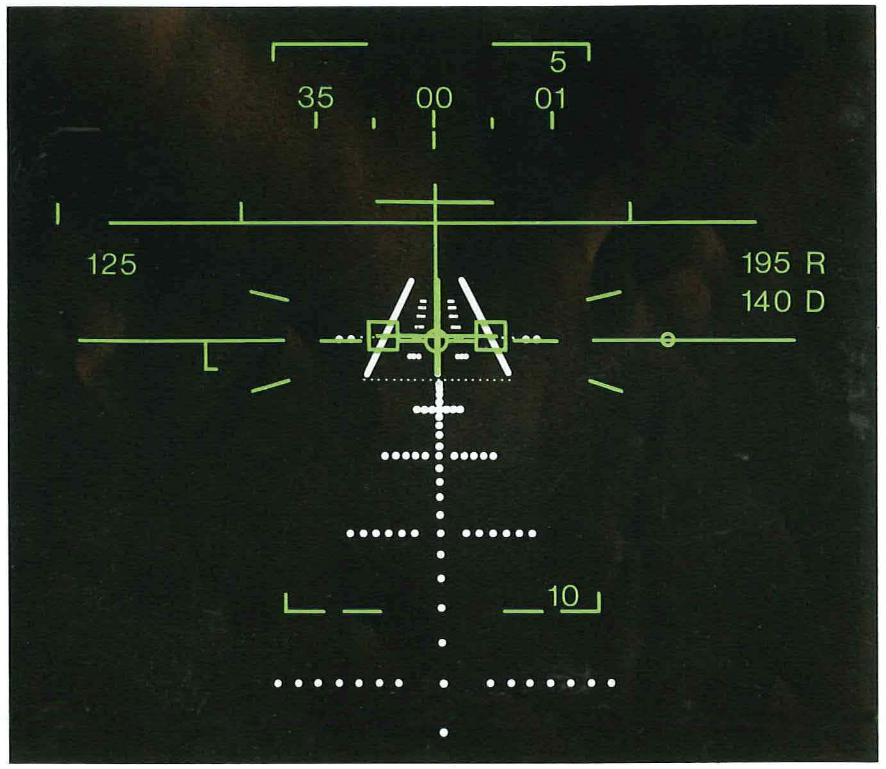
Why a Head Up Display ?

In recent years advances in landing aids have greatly enhanced the regularity of aircraft operations. Landings are safely and routinely carried out in conditions which in the 50s and early 60s would have resulted in annoying and expensive diversions or cancellations of scheduled service. These advances have tended to concentrate even more attention on the problem of approach and landing in adverse weather. Nevertheless the fact remains that the vast majority of landings (around 80%) are carried out in visual meteorological conditions. Of the remainder the majority once more are carried out in conditions requiring a final flight segment in which the pilot is in visual contact with the ground. The number of flights terminating in CAT III conditions (ceiling below 100 ft and/or visibility less than ¼ mile) is something of the order of one in thirty and even among these flights some visual reference is usually possible.

Since external visual reference plays a part in almost all landings it follows that a system which integrates the outside visual cues with internally generated aircraft performance data can be of considerable assistance to the pilot during the critical period when he is making the transition from instrument flight to visual touchdown. Such integration is exactly the task for which the head-up display (HUD) is most suited.

A system using a head-up display in conjunction with an ILS coupled auto-pilot can have very real advantages in almost any weather conditions.

- More precise approaches can be flown to non-ILS equipped air-fields. This is particularly important where conditions of terrain or neighbouring buildings can create optical illusions.
- The difficulty of pilot takeover after an autopilot disconnect with a fail-passive autoland system can be considerably eased. The HUD presentation provides a monitor of the approach and assistance for either continuing to land or initiating go-around action.
- With a dedicated ILS channel, the HUD can provide a completely independent monitor of a fail-operational autoland system.
- HUD provides unambiguous warning of deviation from the required flight path.
- HUD provides instantaneous warning of windshear.
- HUD assists take-offs and go-arounds by providing a display of flight parameters in a form that is instantly available to the pilot.
- HUD can improve overall landing performance by reducing touch-down dispersion and sink rate in manual landings.
- HUD can assist in fuel conservation by providing a guide to energy management in take-offs and landings.



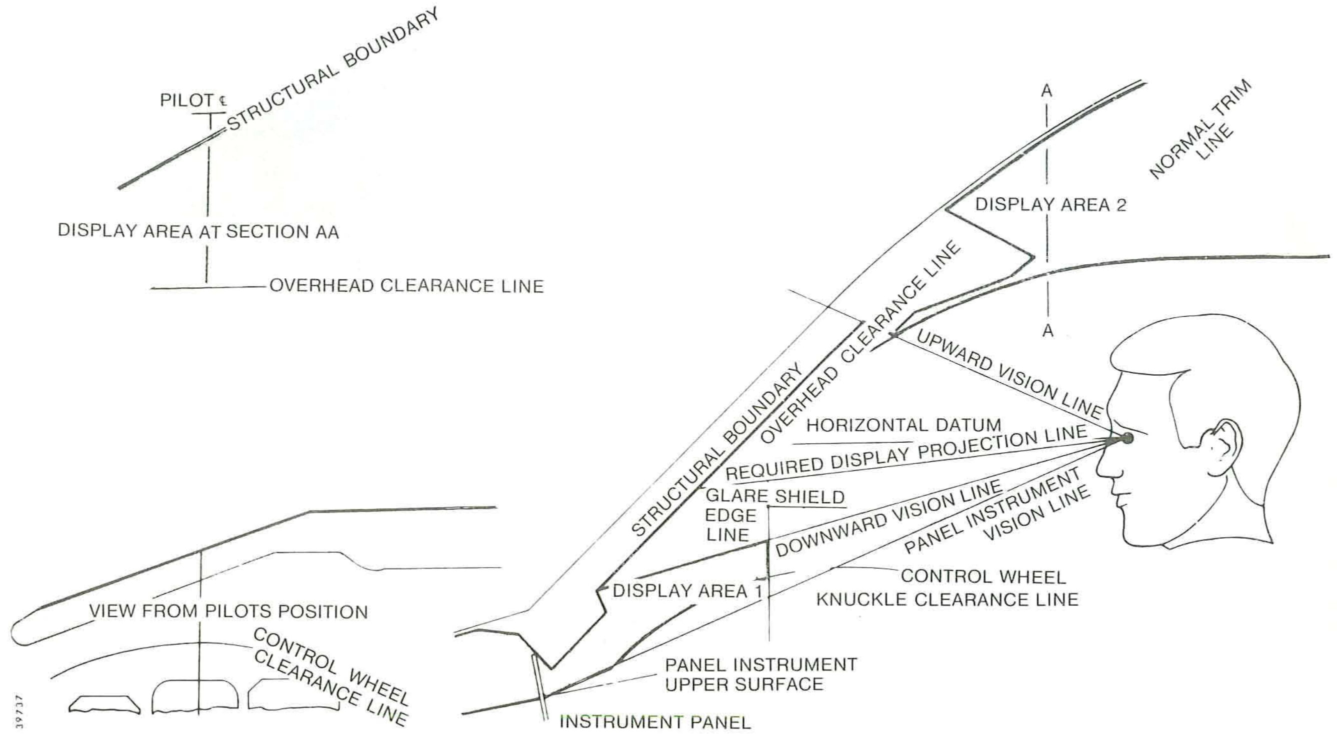
Why Didn't I Think of That ?

Finding a location in the crowded civil airplane cockpit for any new instrument can be a bit of a problem. For a head-up display system which must provide the pilot with a good field of view without obstructing his visual access to other instruments or in any way inhibiting cockpit mobility, it is a major engineering exercise.

Marconi Avionics have been involved in the problem of designing a satisfactory HUD system for civil aircraft since their pioneering efforts with the Blind Landing Experimental Unit of the Royal Aircraft Establishment in the mid 1960s. This work resulted in a series of trials in various civil transport aircraft in 1967-69.

These trials aroused considerable interest but also demonstrated the difficulties involved in fitting a HUD to the civil cockpit. If it were situated closely enough to the pilot's eyes to give an adequate field of view, it interfered with his view of other controls, and if it were moved forward out of the way, it provided a very restricted field of view. It became apparent from these trials that some form of retractable system would be required to match the civil cockpit.

Various solutions to the problem were investigated, all of which suffered from some shortcomings. Conventional HUD solutions tended to be massive and cumbersome and to require complicated stowage mechanisms whose continuing accuracy could not be guaranteed. Limited field of view systems proved operationally unsatisfactory. One promising system which was tried was a system similar to a pair of retractable binoculars which employed twin CRTs. This provided a fail-operational solution but required the most rigorous manufacturing and installation tolerances if visual perception problems were to be avoided. It was from these investigations and from considerations of how the human visual system works that the Monohud concept was evolved. It provided a simple and elegant solution to the problem.



Cockpit Constraints - or - Back To The Drawing Board

What is a Monohud ?

NASA Monohud

BAC 1-11 Monohud

The monohud is a small, inverted head-up display which projects symbology of vital flight parameters into the pilot's field of view monocularly. It is lighter and less bulky than conventional HUDs and can easily be folded away when not in use. Its retractable, monocular design enables it to be positioned much closer to the eye than conventional systems and thus provides a large field of view from an optic of minimal size.

It is a rugged system with the CRT and optics contained in one integral unit. This construction ensures that focusing and collimating difficulties, such as are encountered when the optical system must fold away from the CRT, are completely avoided and maintenance hours are correspondingly reduced.

The rugged construction and small size of Monohud considerably simplify the installation problem. The mounting can be more rigid than is possible for a heavier and bulkier system and as a result inaccuracies caused by wear and flexure of the mount are minimized. Accuracies tend to be one milliradian or more better than those of more complex systems.

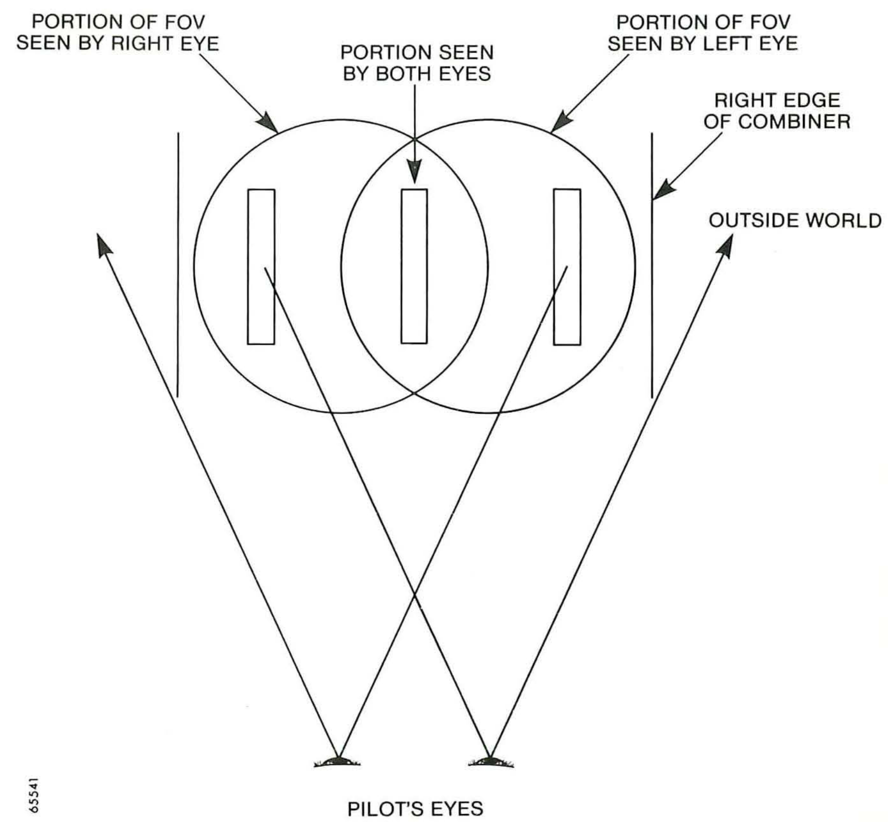
Current versions of the system provide a circular 30° field of view from eye motion of less than half an inch, although slightly larger versions with a 36° by 24° field of view are quite feasible.

How does it Work ?

At first thought, the concept of receiving symbology through one eye only may seem strange, since the other eye will be viewing the same scene without the symbology overlay. This, however, is identical to normal everyday experience. Each eye sees a slightly different aspect of the world around it and the brain correlates these images to create the composite picture of our normal human vision. This can be simply demonstrated by holding a blue filter over one eye and a yellow one over the other. With both eyes open a normal scene is perceived, closing one eye gives a blue or yellow tinted scene depending on which filter is in use.

The same principle is used, if not so obviously, in a normal binocular HUD. In such a system only the central part of the symbology is viewed with both eyes. As shown below the greater part of the display is viewed monocularly with the brain forming a composite picture of real world and symbology. Monohud is merely an extension of this principle in that all symbology is viewed with a single eye.

Proximity of the hardware to the operator has also proven to be far less of a problem than one might expect. The Monohud is located approximately 4 inches from the eye and initial subjective reaction has been that this was rather close. RAE trials, however, have shown that this is not the case. Because one looks through and not at the Monohud, it is not obtrusive when in operation and not noticed for the same reason that a normal pair of spectacles is not noticed. In the trials there were no instances of the pilot inadvertently touching the display with his head or visually losing the display. To quote the Project Test Pilot, "Proximity has been no problem although initially we thought it might be".



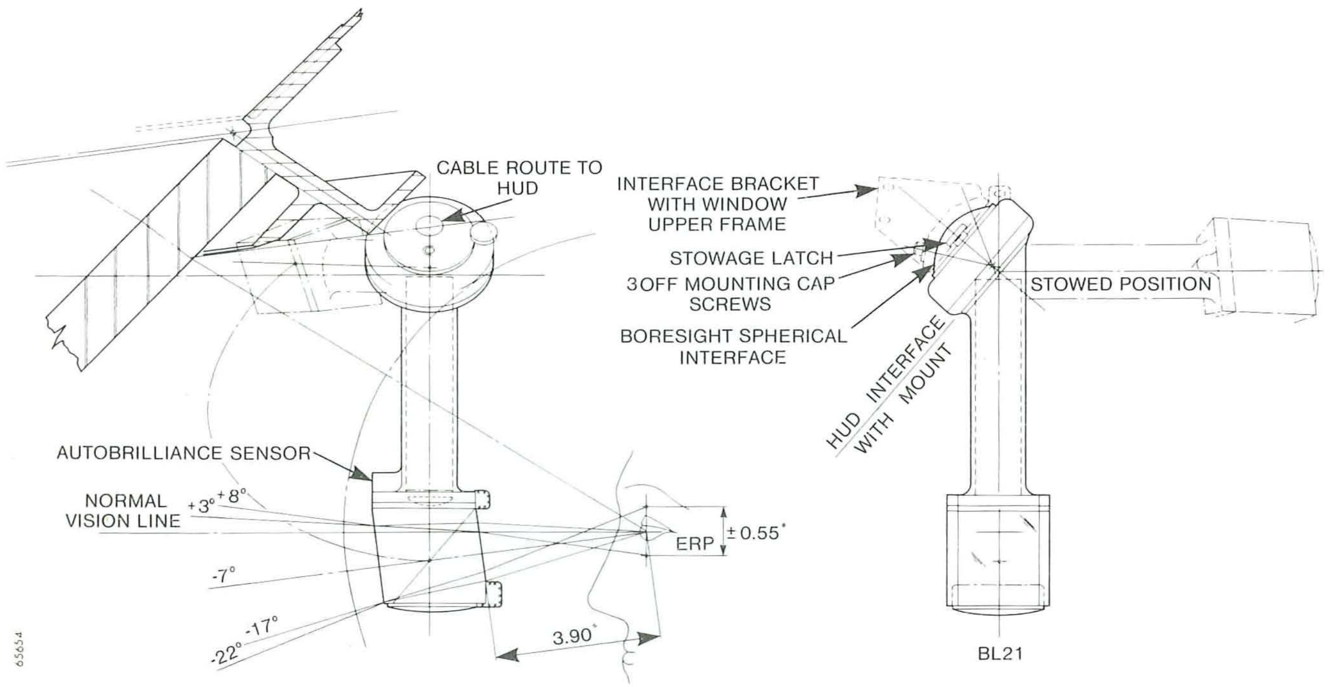
What Goes in the Cockpit ?

The total Monohud system consists of four line-replaceable units.

- Pilot's Display Unit (PDU) (1 or 2 depending on user requirements)
- Video Drive Unit (VDU) (1 or 2 as above)
- Symbol Generator (SG) (1 normally, 2 for complete redundancy)
- Control Panel (CP) (1 or 2)

Of these only the PDU and the control panel require cockpit space. The control panel is customised to user requirements and can be fitted in any convenient location. The PDU normally attaches to a fixed overhead mounting and folds away against the roof panel when not in use. Other mountings providing internal stowage in the cockpit roofspace are possible but require a slightly more complex stowage mechanism.

The PDU itself consists of the CRT assembly, the optical module, autobrilliance sensor and the mechanical mount, and weighs a total of 4.0 pounds. It features a break-away mechanism to protect the pilot's head in the event of sudden forward motion.



PDU Parameters

Total Field of View	- 30° circular (24° x 36° possible)
Instantaneous Field of View	- 20° circular (20° x 30° possible)
Line Width	- 1.5 milliradians
Writing Speed	- 37,500 deg/sec or 960 inches/sec.
Contrast Ratio	- >1.2 : 1 (against 10,000 ft lamberts background)
Brilliance Control	- Automatic after manual selection
Display Colour	- Green (P1 Phosphor)
Combiner Transmission	- 72%
Deviation of Line of Sight	- <0.3 milliradians
Collimation Accuracy	- <2.0 milliradians
Warm-up time	- 30 to 60 seconds

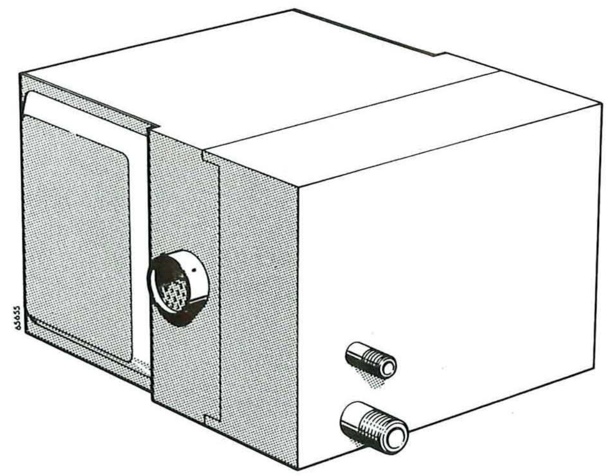
What Makes it Work ?

The electronic circuitry for Monohud is contained in two small units the Video Drive Unit weighing 8.5 lbs and the Symbol Generator weighing 14 pounds.

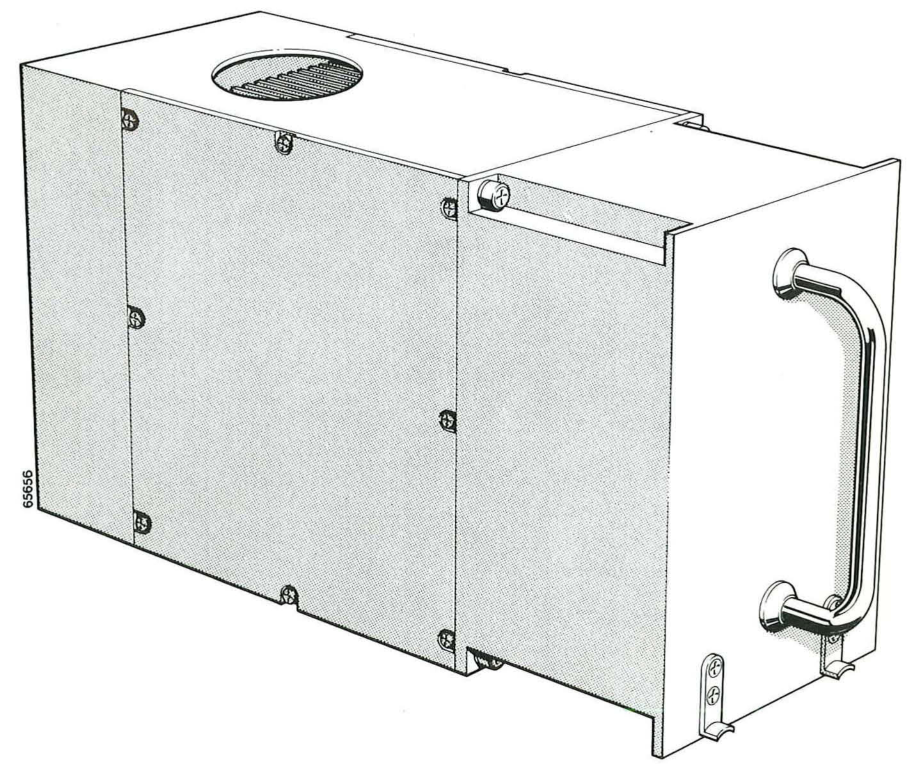
The Video Drive Unit is normally located in the cockpit roofspace and houses the circuitry usually found in the display unit of a conventional HUD system. These are the high voltage power supply,video drive, autobrilliance controls, CRT protection, self-test circuits and the deflection amplifiers: in short, all the electronics required to convert input signals into the CRT drive voltages which generate the display the pilot sees.

The Symbol Generator is a small digital computer which uses its own programmed logic to convert inputs from the aircraft sensors into the CRT drive instructions which provide inputs to the VDU. It consists of four sections.

- Input interface
- Microprocessor
- Waveform Generator
- Output interface



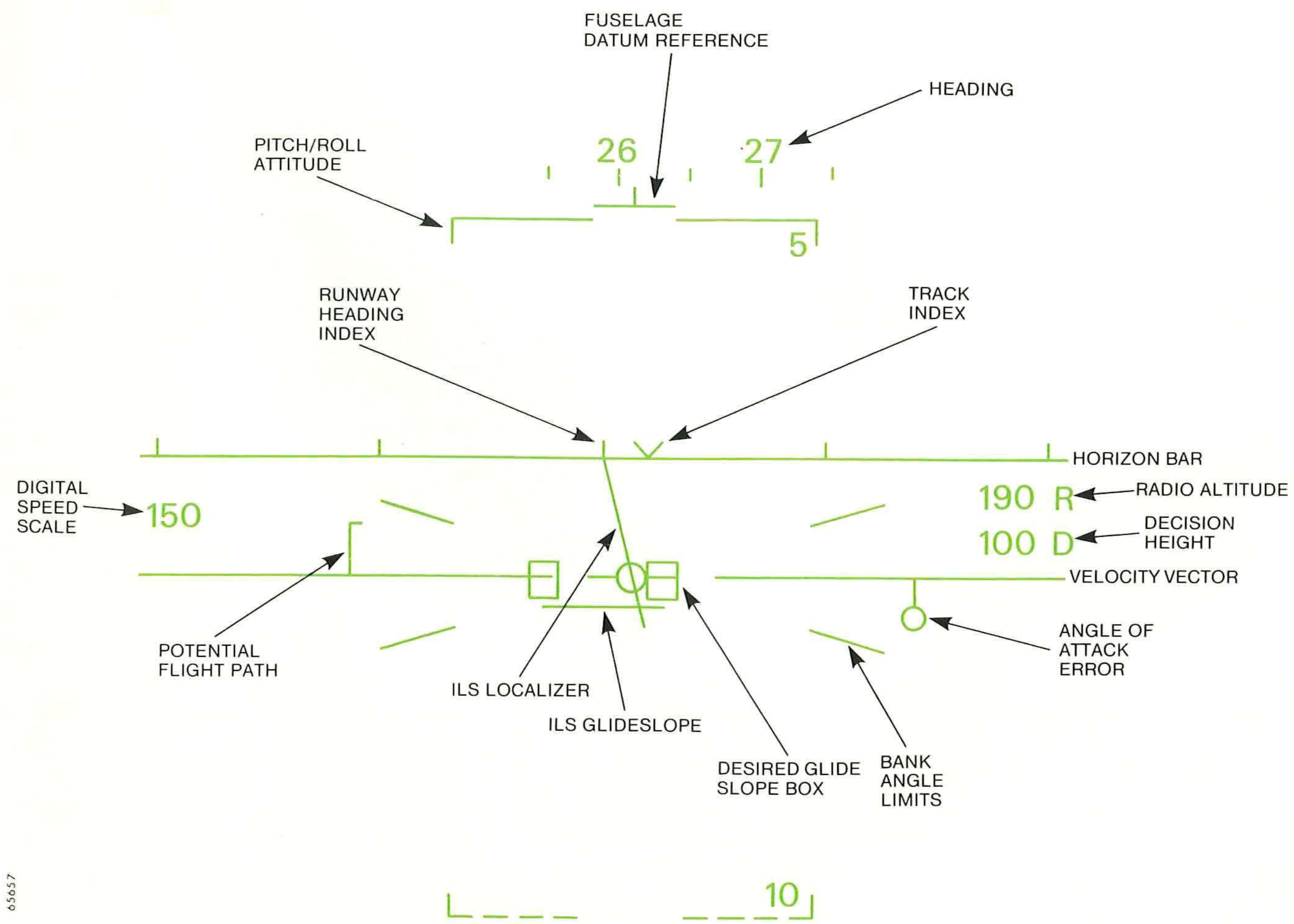
The input interface accepts analogue, digital and discrete inputs and converts them to a form acceptable to the microprocessor. The microprocessor, on instructions from its erasable, programmable (EPROM) memory, uses these inputs to generate demands on the waveform generator. The waveform generator uses these demands to produce digital representations of the required symbology which, after conversion to analogue signals in the output interface, are fed to the VDU. The use of EPROM memory devices enables changes in the display symbology to be made with no changes in system hardware, and since spare capacity is provided in the Symbol Generator the system is capable of considerable growth to meet future user requirements.



What Does it Show ?

The precise symbology displayed by the Monohud depends on customer requirements, but to provide the data the pilot needs to verify that he is in a safe condition to continue his approach, this should include presentations of:

- Pitch and Roll
- Heading
- Fuselage Datum Reference
- Desired Glide Slope
- Flight Path Angle
- Potential Flight Path
- Angle of Attack
- Indicated Air Speed or speed error
- Radio or Barometric Altitude
- Decision Height
- Bank Angle
- ILS Crosswires
- Flare Cue
- Drift



The symbology shown above is based on that used by Monohud during Royal Aeronautical Establishment trials. Various other presentations, including a synthetic runway symbol, have been tried using the erasable memory feature of the symbol generator to change symbology as required. The Monohud system caters fully for any changes in customer requirements which might occur after installation.

What Else Can it Do ?

With the inputs and symbology required for approach and landing, the Monohud system is also capable of assisting the pilot in roll-out, take-off and go-around situations.

Roll-Out

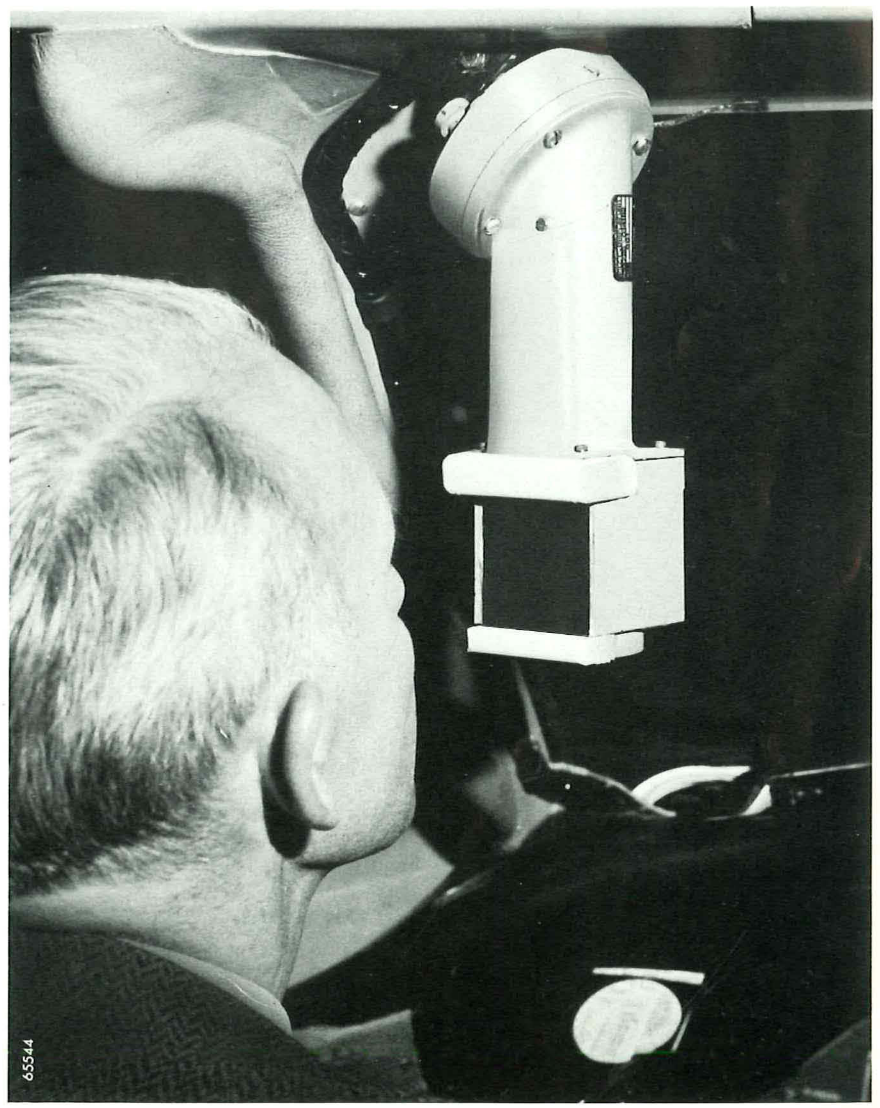
In roll-out, the presentation of ILS centre-line and heading information can be of considerable assistance to the pilot while he is decelerating to a safe taxi-ing speed in conditions of restricted visibility.

Take-Off

In take-off, the system provides compass heading and centre-line information while on the runway, and energy management information from the flight path angle and potential flight path symbols once airborne. This information can be of considerable assistance to the pilot in deciding on the correct course of action in any emergency that might arise in this critical flight segment.

Go-Around

In a go-around situation the flight path angle and potential flight path symbols can be of great assistance to the pilot in establishing an optimum climb-out.



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