# Human Engineering in Cockpit Design

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The Human Engineering Aspects of Aircraft cockpit design are considered. The specific requirements for control column hand grips and centralised warning systems are discussed. The fact that cockpit design has not yet attained a universally acceptable standard is analysed.

**Iuroduction**

During the last war, the vast strides in production and complexity of military equipment resulted in the 'human operator' not being able to utilise the equipment adequately and to the maximum efficiency. It was to this end that the science of Human Engineering came into being. Briefly, human engineering as applied to design of equipment, places major emphasis on efficiency as measured by the speed and accuracy of human performance in the use of the equipment. Allied with this efficiency are the safety and comfort of the human operator. Naturally this involves the application of information about human beings and their capabilities and limitations to the design of equipment.

Since the most significant man/machine combination in recent times has been the pilot/aircraft, human engineering has come to play an important part in the latter design.

As the pilot and aircraft relationship is almost entirely confined to the cockpit, recent thinking on the subject has been to 'human engineer' the cockpit and its equipment to fit the pilot. Not only must the cockpit fit the pilot physically by being tailored to his dimensions, but more important, that the cockpit and equipment be designed to fit his sensory capacities, his muscular co-ordinations, his mental thought processes and his already learnt habits and skills.

This paper discusses the cockpit in general with specific emphasis on 'Control Column Hand Grips' and 'Centralised Warning Systems'- perhaps the two most important items of cockpit equipment.

In the very early aircraft the cockpit was just a place for the pilot to sit in with a few essential controls around him which he was expected to operate. Over the years the cockpit controls have increased considerably and various kinds of displays are required for the pilot to be able to effectively use the machine. Sophistication in equipment has therefore been a logical change which has brought with it certain essential requirements in the design of a cockpit.

**Control Column Hand Grips**

With the experience gained over the years, it is now possible to clearly define these requirements both in quantitative and qualitative terms. Almost all of them concern the Human Engineering aspect of design–a subject which has been the focus of attention of many Research and Development organisations in the aviation

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field. Why is it that despite all this, a universally acceptable cockpit continues to elude us ? The point will perhaps be clear if we take a few specific examples. Let us first consider a very basic yet a very important cockpit control, namely, the control column hand grip. The basic requirements a control column grip should fulfil are to be both comfortable to the pilot and yet afford the maximum efficiency. These are now discussed in detail.

The basic shape of the grip whether it be a pistol type or spectacle type will be determined by the type of control system and the role of the aircraft. In most single seat aircraft the pistol grip is preferred, while in multi-engined aircraft, operating with two pilots, some form of a spectacle grip is desirable. It may be added here, that except for the physical and mechanical advantage gained by having a 'spectacle' type grip, tests have shown that efficiency in using both grips is the same. However, the advantages of spectacle type over pistol type grips is clear if large control forces are to be expected.

The basic grip must permit the full hand, to grasp and hold high out of trim forces in emergency conditions and yet be able to operate some essential controls provided on the grip. It therefore follows that the grip must be relatively slim and unencumbered.

The pilot should have maximum sensitivity at the hand when feeding in stick motions or feeding back airframe/stick responses to the brain. These mental signals are derived from the pressure sensations felt by the digits and palms. For efficient controllability the grip should therefore be moulded to fit the pilot's hand so that the maximum surface area of the digits and palms is involved in covering the grip controls. At the same time the fingers should be free to operate the various controls on the stick. A typical fighter stick usually have the following controls:

(i) Tailplane trimmer switch.
(ii) Gun firing trigger.
(iii) Bomb/Rocket release button.
(iv) Camera button.

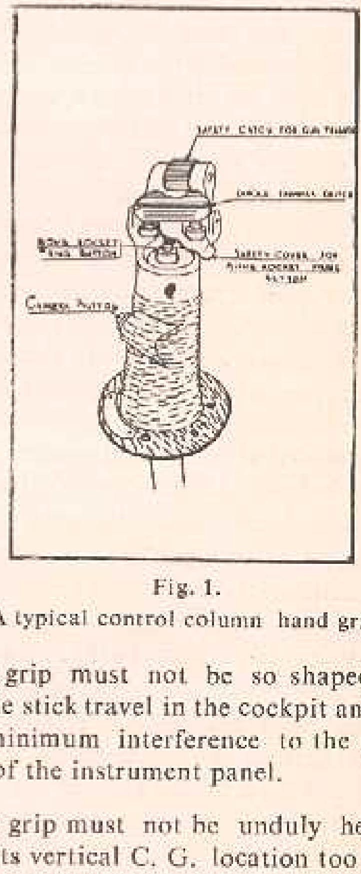

Fig. 1.
A typical control column hand grip

The grip must not be so shaped as to impede stick travel in the cockpit and must give minimum interference to the pilot's view of the instrument panel.

The grip must not be unduly heavy or have its vertical C. G. location too far up as these would tend to increase breakout forces at the grip, and yet the grip must be strong enough to withstand the highest possible hand and arm lever forces.

The grip should provide a rest position for the hand to permit flying with a relaxed grip, and yet permit operation of all the controls on the stick. This is normally catered for by providing a 'heel' at the base of the grip on which the base of the palm can be rested (Figure 1).

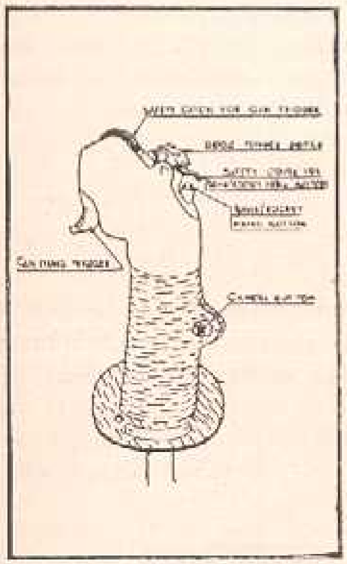

Fig. 2.
Another view of the control column hand grip

Finger operated services on the forward face of the grip which are not visible to the pilot should be instinctively identified.

The finish on the grip should be such that a certain amount of friction is provided to the pilot's gloved hand, and yet not be such that a strong grip will be uncomfortable.

The grip should be placed centrally to the pilot. An offset grip would result in a tendency for the pilot to pull the grip to a position lateral than desired.

The grip should be located close to elbow height for maximum comfort and accuracy in control movement and cause least fatigue.

It is a fact that today one frequently comes across a control column grip which leaves a lot to be desired. If the grip fulfills most of the requirements enumerated above, it obstructs the view of certain

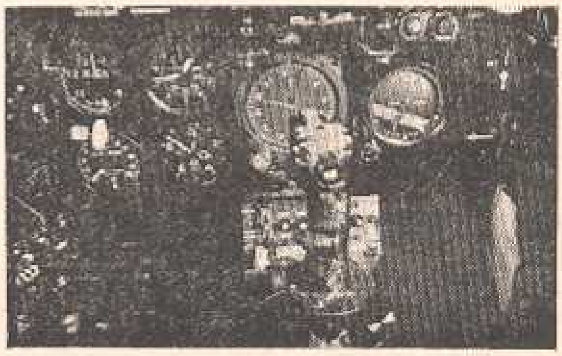

Fig. 3. Control column grip obstructing the view of instrument panel.

essential instruments/controls in the cockpit. The control column grip shown in Figure 3 is a convincing example. It obstructs pilot's view of the G 4 F compass even though it affords a comfortable grip and provides good accessibility of various buttons/controls mounted on it.

So far most design changes and improvements have mainly affected the shape and size of the grip without interfering with its location in relation to the pilot. The control column in its basic form has remained in front of the pilot ever since Wright Brothers flew in 1903. In the earlier days it was necessary to use the principle of a lever to obtain mechanical advantage. These days control surfaces are invariably operated hydraulically for which the original concept of obtaining a mechanical advantage no longer remains necessary. However, the stick still remains in front of pilot in almost the same shape and size as the early days. (Why has it not been relegated to one side in the cockpit so that the pilot is afforded an unobstructed view of his instrument displays? Why cannot it be replaced altogether by some other type of control which does not come in the way of the pilot and his primary instruments? Why with the present state of technology, it has not been so far possible to fly by wire other than for experimental purposes, by merely manipulating a small and inconspicuous control, perhaps no more than the size of a pencil, located at a convenient place in the cockpit? These are some of the questions which have remained unanswered and to which there seems to be no logical explanation, considering the phenomenal progress in science in the last two decades).

**Centralised Warning Systems**

Another very important aspect in the design of a modern cockpit is the display of failure warning to the pilot. A combination of visual and audio warning signals is generally used to attract pilot's attention in case of emergency. In view of the increasing number of signals, they are grouped together on a centralised warning panel and an attention getter is provided at a suitable location in front of the pilot. Any warning system, whether visual or audio or a combination of both, must meet the following criteria :

(i) easily detectable,
(ii) holding attention,
(iii) easily identifiable,
(iv) infinitely retainable.

It is interesting to note as to how many warning systems installed in present day aircraft, particularly combat aircraft, measure up to these seemingly clear and basic requirements. There is no doubt that there are some aircraft which have

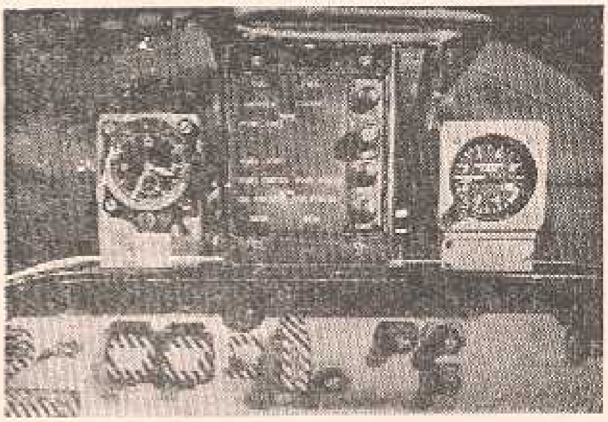

Fig. 4. Centralised Warning Panel

good warning system. The lay out as shown in Figure 4 is perhaps a good one.

The centralised warning panel is centrally mounted at pilot's eye level and directly in front of him. While the size of the lettering and the location and flashing frequency of the attention getter are adequate for the job for which they are intended, the location of the whole panel is a particularly good feature of this display. It must be realised that in a combat aircraft this place would normally be occupied by a Head Up Display or a Gun Sight. The size of the panel is quite large and usually so much of space will not be available in a modern fighter aircraft. The Centralised warning panel shown in Figure 4 seems to meet the criteria as indicated earlier. However, even with such a simple and clear presentation there would be a minimum response time before the pilot can start to react to the emergency after he has identified it. The requirement naturally is to keep the response time as low as possible and this depends on the effectiveness of the warning system and on the skill and training of the pilot to take necessary corrective action. Reaction time is taken as the time between the onset of a warning till the pilot takes corrective action.

The final outcome of a warning system installation in an aircraft is dictated by many factors. Till today we have not achieved any measure of standardisation in this respect and we therefore continue to be confronted by warning systems which leave more to be desired in some field or the other. The number of failure warnings to be indicated to the pilot is large. The lights and the writing on them are necessarily small, requiring comparatively more time to identify them and thus increase the reaction time in an emergency. The centralised warning panel in most fighter aircraft has to be located on the left or right side of the cockpit and not in front because of gunsight/Head Up Display. Therefore the pilot has to make a deliberate effort to identify a failure.

**Conclusions**

We should now try to analyse as to why this situation exists wherein such important aspects of cockpit design, have not reached a universally acceptable standard. It is because the human being can adapt himself to almost anything and can cope with considerable amount of discomfort and other shortcomings. Once he gets used to the environments in which he has to operate, his performance appears to be satisfactory. One can only say that it "appears to be satisfactory" because of the following indeterminables :

(i) No accurate quantitative measurements of a pilot's performance can be made except by indirect qualitative methods.

(ii) In the absence of a performance datum under ideal conditions, no performance comparison can be made to determine the deterioration in performance, if any, under existing environments.

These are just a few of the many important aspects of cockpit design which have large gaps in their development status. Obviously there are many others which fall in this category and can be improved to a universally acceptable standard. It is often argued that 'ideal' does not exist in practice. While accepting this statement, emphasis must be laid on developing a cockpit which will be acceptable to almost the entire pilot population within practical limits. It must be conceded that such a cockpit does not exist today. The basic idea of this paper has been to project a few problems from the test pilots' point of view connected with human engineering of a cockpit.

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