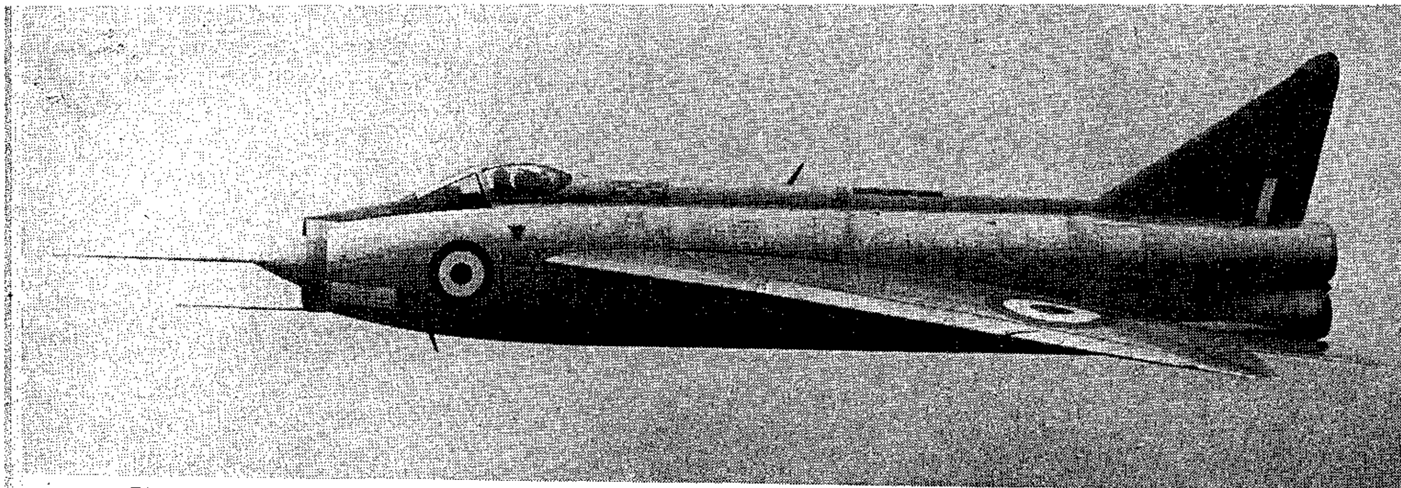

BRITAIN'S LAST? The English Electric P1B, once described as Britain's last manned fighter likely to become operational.

Fighters With a Future (Part 1)

Air defense evolution retains the manned interceptor as a vital vehicle

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For a time it appeared that the long history of the fighter plane would come to an end soon after defensive guided weapons had been developed.

Further reflection suggested that the fighter will have an important part to play so long as there are bombers or reconnaissance aircraft to intercept. But the manned aircraft must be properly combined with the guided weapon for this purpose.

It is difficult to imagine defensive guided missiles undertaking a semi-offensive tactical role, which has also been the task of the fighter in all situations up to and including Korea, Suez and Oman. Offensive missiles can threaten only well-established targets and then mainly by resort to warheads that would also destroy civilization.

The ability of the manned aircraft to fly in and intercept, or to reconnoitre and strike at small targets, has underlined its value in situations other than in any ultimate conflict. The design of fighters must change radically however. A change is already apparent in such aircraft as the English Electric P1B, with its Ferranti fire control system and radar.

The Weapon System

An illustration of a modern fighter is given in Figure 1. The fighter is now considered as a complete weapon system, which is a change in tradition as much as in technical detail. It was usual at one time for the fighter designer to concern himself only with airframe design. It is true that he kept after the engine designer to ensure that maximum performance was being extracted, but his primary concern with equipment and armament was whether it could be installed inside the airframe.

This was in an era when the superiority of a fighter was measured largely in terms of miles per hour or ceiling. Performance in this sense is still important, although it has much more complex definitions in terms of the ability to climb, accelerate and turn into position to launch small missiles.

Rocket - propelled missiles are the main reason for this change in philosophy. Small air-borne missiles have much more speed and manoeuvrability than the fighter, and this enables them to complete the last part of the interception with greater economy. Although this is true only up to the limits of guidance and reliability, these factors can now be made to meet almost anything a bomber can do.

Moreover, a rocket-propelled weapon can climb so steeply that it can be launched ten or twenty thousand feet below the bomber at the expense of a small increase in the size of missile. This allows a very large reduction in the size of the fighter and the over-all cost. This cost is still the lowest for many tasks since the most expensive component (i.e. the fighter) can destroy a number of targets in successive sorties.

Air-borne radar is another reason

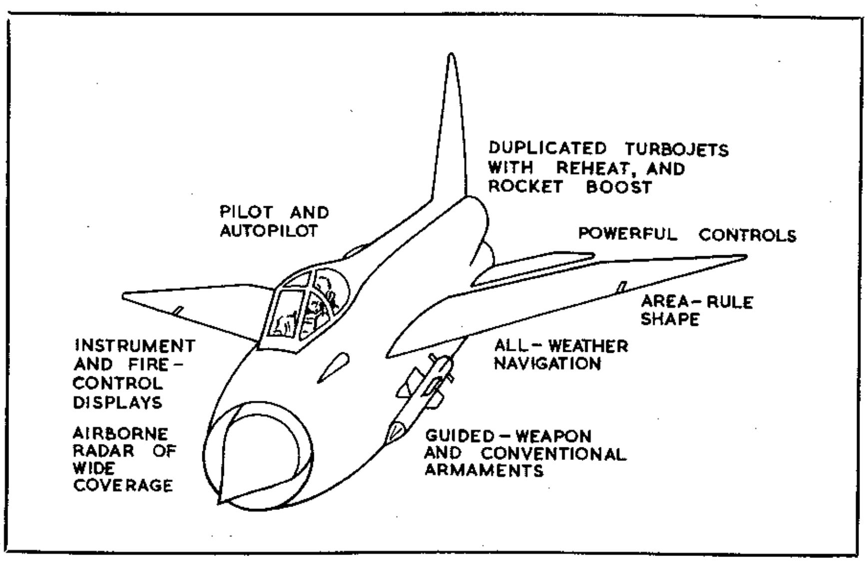

FIGURE 1. Elements of a modern fighter weapon system.

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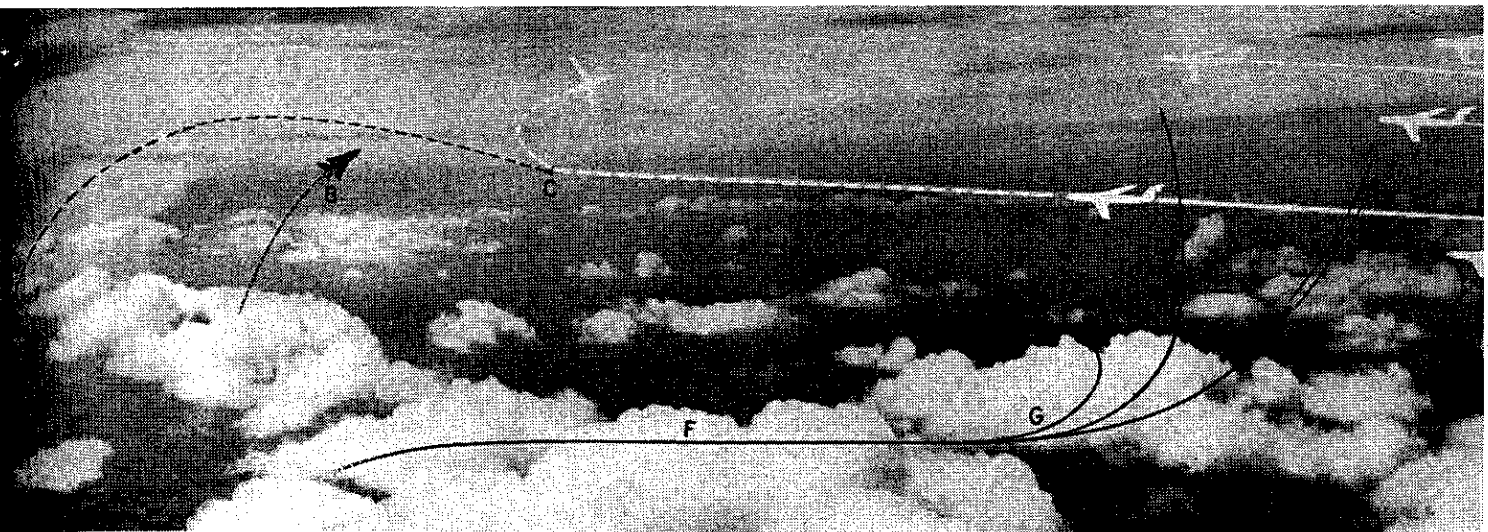


INTERCEPTION PATTERN. (Figure 2) The enemy bombers (D) are detected by ground radar as they move to attack point A by guided weapon or powered bomb to be released at point C. The path of the defending fighters directed by ground radar is shown at F, and their turn to attack after detection on airborne radar at G. A rocket boosted fighter is climbing at point B.

for a change in design philosophy. This is due to the fact that high altitude combat involves distances to accelerate or turn which are often too great for manoeuvring up to the final interception point with human eyes alone. Ground based radar has neither the accuracy nor capacity for this purpose, particularly in the presence of enemy "jamming."

Air-borne radar is now a well-developed method for augmenting the pilot's vision and may itself be augmented by infra-red techniques. But unless the equipment is designed in parallel with a high performance aircraft, one is liable to end up either with equipment which itself is outclassed by the enemy, or with no equipment ready at all.

All-weather fighters used to be much larger than day fighters of equal performance due to the extra equipment required to operate at night or in bad weather. But the major item of equipment is now required in daylight, if we accept radar as a necessary adjunct at high altitude. Since the enemy is likely to use modern navigational aids to attack by night or in bad weather it seems useless to spend much of our future effort or exchequer on the day fighter.

Accurate navigation and blind approach aids are other items required for all-weather operation. Development of these has now reached the stage where they can be made small and semi-automatic for the use of the pilot.

These are not the only ways in which the advances in electronics and servo systems required for the guided missile industry can be utilized to improve the fighter itself. There is no reason why a large part of the all-weather fighter force should not be single-seaters. An auto-pilot is fitted to fly the aircraft whilst the pilot is concentrating on his radar screen.

Man himself seems essential for the latter task and any setback in electronic warfare could well restore the case for a second man in the crew. A balanced solution would seem to rely on electronics and other automatic aids only to the point where each man can carry out his functions with sufficient time to cope with emergencies brought on by malfunctioning of some part of his equipment. The reliability of much of this equipment seems to be approaching the stage where it can be developed to work 90 per cent of the time. But the remaining 10 per cent must not be allowed to abort the interception!

Ground launched guided missiles already have more than sufficient range to replace the heavy anti-aircraft gun. These can provide protection to key targets as a supplement to the broader cover offered by the fighter. Weapons like the English Electric Thunderbird are inevitably much larger than air-borne missiles but are much smaller than fighters. Development of such weapons provides some hope for intercepting high performance missiles.

Destroy The Launcher

If offensive missiles are launched from a bomber however it would be more satisfactory to shoot down the bomber itself before it has come in close enough to release its powered missiles. This still seems to be the task of the fighter. Guided weapons with an interception range of some hundreds of miles rely on so many components to complete their interception that the various percentages of unreliability soon add up to make the interception more a matter of chance than anything else.

Furthermore the size of the weapon grows to the point where it becomes too expensive to be thrown away on every test flight or to be destroyed completely after each interception. It will then pay economically as well as in reliability to make it large enough to carry a crew to ensure its recovery after each flight and to carry a number of smaller but more manoeuvrable missiles to destroy a variety of targets.

The presence of the crew to interpret the airborne radar also provides accurate guidance at much greater distances from the ground radar. Presence of a crew throughout the flight test development and operational use of the system also reduces the time taken to develop or adapt the system to meet technical advances which the enemy might make. This is most important now that it takes so many years to develop any new system.

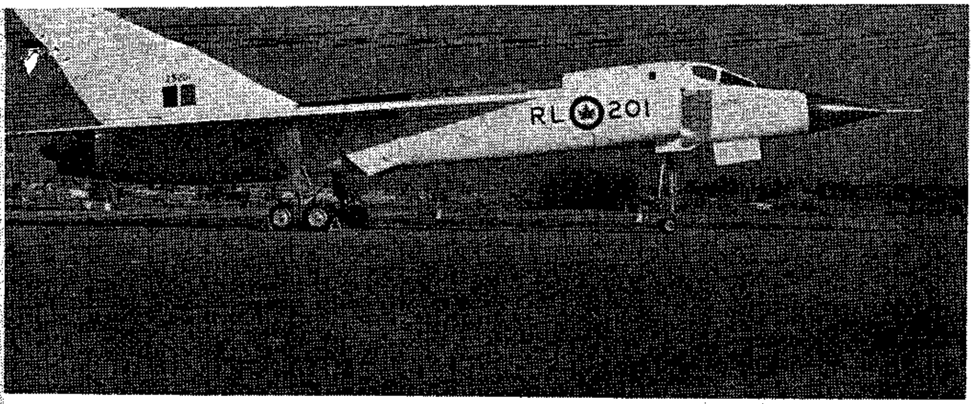
In guided missile jargon this long-range interceptor might be described as a two-stage weapon. The man in the first stage is provided with approximate mid-course guidance from ground radar and airborne navigation but with accurate terminal guidance from airborne radar. The smaller second-stage weapons can have guidance provided either from the first stage (beam-riding) or partly from the first stage (semi-active radar) or completely self-contained (fully active radar or passive homing with infra-red). Simplest of all, the weapons need have no guidance except that provided at launch by the air-borne radar, or by visual sighting.

This first stage can still be recognized as a modern form of fighter. At the present time, it must still have sufficient performance and manoeuvrability to get into position to use unguided armaments, such as guns and small rockets, or simple guided armaments like those now entering service.

As soon as we can rely on more advanced missiles for the second stage, the fighter will degenerate into a missile-launching platform, carrying its own precision airborne radar.

Typical Interceptions

Broad statements of philosophy are best illustrated by examples. Let us assume that modern fighters are sta-



THE ULTIMATE in interceptors from Canada's viewpoint is the Arrow.

tioned ready to intercept an attack by day or night. It should be possible to base these fighters on widely spaced airfields in countries where cities and other targets are well scattered. The ability of the fighter to move from one airfield to another enables the defenses to be switched or reinforced in accordance with the tactical situation.

This flexibility avoids the danger of a Maginot Line-type of defense which can be punctured, turned or even avoided altogether. The value of more static defenses is to defend key targets, and this is where ground-launched guided weapons play a vital role. A simple diagrammatic picture of the situation is given in Figure 2.

Early warning radar is required with any defensive system to give the maximum warning of attack while the bombers are still at a sufficient distance from their targets. Unlike present forms of ground-launched weapons, fighters have sufficient endurance and long-range guidance to be dispatched as soon as the threat has been confirmed.

In a confused battle with many attacks and even with jammed ground radar as well, the fighter can deal with the situation from the air. It is possible for the enemy to jam a number of ground radar stations, but virtually impossible for him to deal with a whole series of fighters each carrying its own radar "station."

The fighter can take off and climb up to its cruising altitude in two or three minutes. Directions from the ground radar may be in the form of an elaborate radio link with the controls of the aircraft. But the fighter pilot always retains the ability to fall back on simple voice communication as he did so effectively in the last war.

While the fighter is many miles from its target, its own radar scanner is searching. Information is presented on the pilot's screen and this increases his effective vision by many times. Even with chance encounters, a proper airborne radar should enable the pilot to locate a target whilst he still has sufficient distance to manoeuvre into position to use his weapons.

The turn to attack can begin as soon as the pilot identifies a target on his radar screen. Radar instrumentation is arranged to supply information on the course to steer so as to reach the best position for launching the weapons against the target. There are a number of ways of doing this. The most sophisticated is to stop the radar scanner from wagging and leave it pointing directly at the target.

A servo system is then used to "lock" the scanner so as to follow the direction of the target. The angular positions of the scanner, and possibly range information from the radar, are then fed into a computer which provides the course to steer either through the pilot's instruments or through the autopilot as well.

Aiming The Weapon

Weapon aiming must obviously be accurate with unguided shells or rockets, pointing ahead of the target with just sufficient "lead" angle to collide with it. This computing is at present carried out in the highly ingenious but simple mechanism of the gyro-gunsight. Less accurate aim should be required with guided missiles, because they can manoeuvre and guide themselves.

With a beam-riding weapon, it is necessary for the fighter to aim accurately at the target right up to detonation of the warhead. With semi-active weapons (some versions of Falcon and Sparrow) in which the larger airborne radar transmits the signal and the weapon receives the echo from the target, it is only necessary for the fighter not to turn away so rapidly after firing its weapon that its airborne radar loses effective sight of the target.

But with unguided weapons (guns or rockets), homing weapons (infrared weapons like the de Havilland Firestreak), or fully active weapons which carry their own radar transmitter (Vickers Red Dean), the fighter can turn away as sharply as it likes. Unguided weapons follow an approximately straight path only for a very short distance as they follow a ballistic path with appreciable aerodynamic dispersion.

To ensure vital hits on the target, it is usually necessary to aim a large number of missiles in a rapid burst at short range, but this situation can be improved considerably by using more powerful rockets and warheads.

Weapon guidance should reduce the number of missiles required to destroy a target. The navigation systems of these guided weapons are usually such that, after launching, the missile turns rapidly on to the collision course which should strike the target. This latter course is almost straight, unless the target manoeuvres rapidly.

The missile should pass very close to the target if a number of conditions are satisfied:

- The guidance system is properly designed and aims continuously near the vital area of the target.
- The missile is able to respond rapidly so as to reduce the terminal errors. This can be obtained with a small missile and a properly designed control system.
- The missile has sufficient manoeuvrability to turn on the path dictated by initial aiming errors or by evasive manoeuvres of the target. The wing size required to satisfy this is a small fraction of that required to bring the complete fighter or ground launched missile up to the same altitude.
- The missile has sufficient performance to reach the target. Even if the target is at very high altitude, the size of the rocket motor required to satisfy this is again a small fraction of that required to bring the complete fighter or ground-launched missile up to the same altitude.
- All components of the missile should function reliably throughout its flight. Due to the shorter flight under its own power and other simpler conditions, this is much easier to obtain than on ground-launched weapons.

Reliability Factor

The last one is still a difficult condition to satisfy. There is always a chance that the proximity or contact fuse will not set off the warhead sufficiently close to destroy the target.

An additional safeguard is to supplement the guided weapons by other weapons, which would be adequate to finish off a crippled target or to allow attacks on different targets. Until the practical service reliability of guided weapons has been thoroughly assessed, the safest policy is to carry as many different armaments as possible or to make them quickly interchangeable on the ground.

(To be continued)