STEALTH AIRCRAFT: Master of the skies

"Stealth" is one of the most unusual combat aircraft which is almost invisible even to the most sophisticated radar. It will continue to roam freely in the skies undetected and undeterred till it meets its match in future. ■ **by Dharam Pal**

The first target selected to be hit on the opening day of the Gulf war was Iraq's main communications building in Baghdad. The building housed the command and control system, the network of telephone lines and microwave communications that connected Baghdad to the outlying army headquarters and to the country's air defence centres.

Considering the importance of this building, it was adequately protected by surface-to-air missiles and anti-aircraft guns to thwart attacks by allied aircraft. Yet the opening shot was fired in the form of a one-tonne laser-guided bomb, dropped into the building with absolute accuracy from an aircraft.

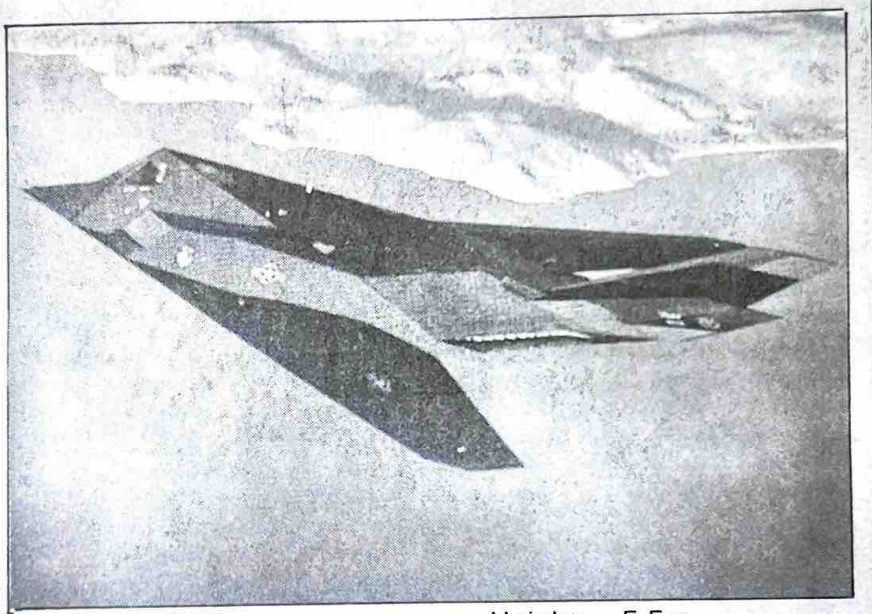
The aircraft that sneaked into the Iraqi airspace almost undetected and returned unscathed was an F-117, commonly known as Stealth aircraft. Subsequently many more missions were flown by this wonder aircraft without being detected by the Iraqi defence radar system. Even when Iraqi radars detected the aircraft, the air-defence weapons (missiles and guns) could not track it long enough to fire at it successfully.

Thus the flights of such aircraft came to be described as "leisurely drive through Baghdad." Literally speaking, even in the early days of the war, when other aircraft of allied forces were being hit and destroyed by the Iraqi surface-to-air missiles and anti-aircraft guns, Stealth aircraft roamed freely. In fact, they "owned the skies."

No doubt, Stealth is one of the most unusual combat aircraft in aviation history because it is virtually invisible to the radar eye. That is the reason why, till date, it has been shrouded in mystery and hidden behind the curtain of secrecy.

Although the decision to build Stealth fighter F-117A was taken in 1978, and the first flight was undertaken in June 1981, it was in November 1988 that the Pentagon acknowledged the existence of this aircraft. And it was only in April 1990 that a selected public saw, for the first time, this wonder aircraft.

F—117A: STEALTH FIGHTER



Wing Span 13.3m
Length 21.1m
Height 5.5m
Overall Weight 23,500 Kg

To know more about this aircraft, which is almost invisible even to the most sophisticated radar, we must go back into history to trace requirement and subsequent development of weapons as well as their aerial delivery platform, namely the aircraft.

Wars are as old as civilisation itself. Though never stated in as many words, the underlying principle of any warring community or nation has been to achieve its aim whatever it may be, "with the maximum enemy losses and a minimum of self-loss."

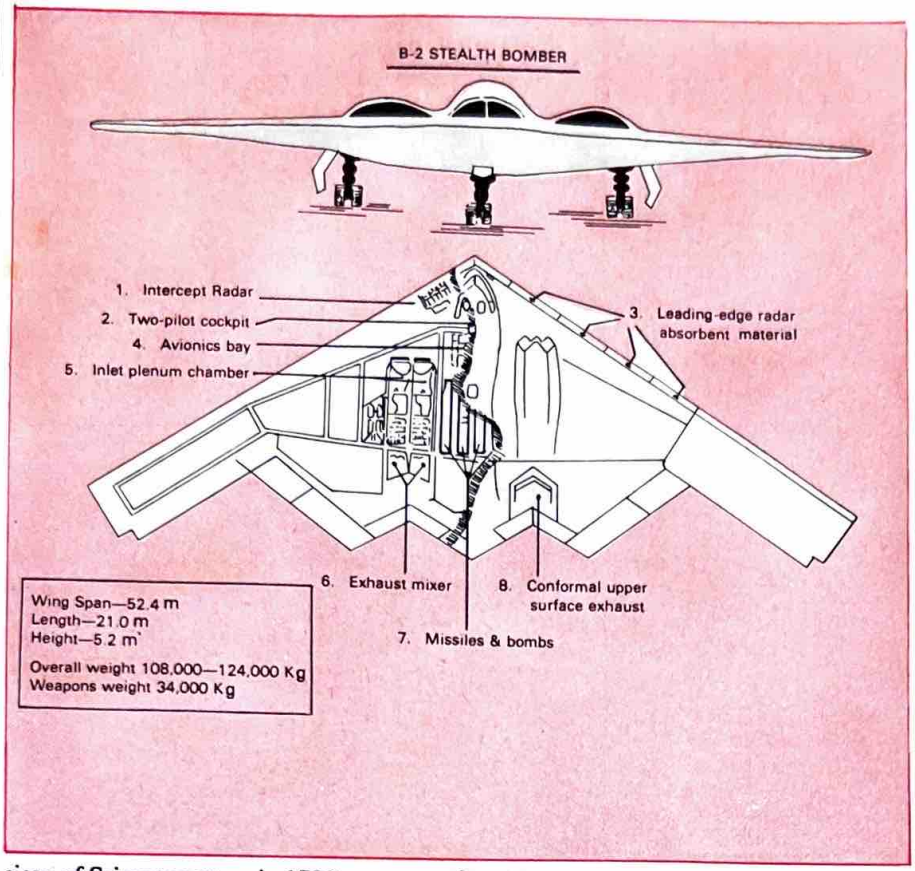
This fact can be established by going through the chronology of development of weapons and their launching techniques.

Arrows, catapults, trebuchets and ballistae constituted the earlier crude weapons which eliminated fist-to-fist and sword fighting. To increase enemy casualties, cannon was then developed and used.

Advent of rockets

Next came rockets. Their first application was in 1232, when townsfolk of K'aifung-fu, north of the Yellow River, directed "fire-arrows" which made a thunder-like noise and travelled a great distance against the besieging Mongol hordes.

However, rockets as real potent weapons were used effectively in the 19th century, though, as per recorded evidence, Tipu Sultan's forces subjected the British troops to effective rocket fire during the



siege of Srirangapattam in 1799.

Though by 1930 many potent and effective rockets had been built, these could only be used against an enemy which was literally face to face. Their applicability, however, was enhanced manifold by another great invention of this century—the aircraft.

The arrival of the aircraft in the sky during the second decade of this century heralded a new era in warfare. It virtually took the war to the enemy's doorstep. Through it the enemy began to be subjected to attacks by various types of weapons like bombs, rockets, and missiles.

A potent force

With the passage of time, these weapons have become more lethal and more accurate. What is more, the combination of high performance aircraft that can operate in any type of weather with the highly advanced weapon system represents a potent and menacing force.

However, no single invention or discovery has ever held the throne for long. More so when it threatens human life. Ever since the aircraft began to be used for military purposes, it never had the sky for itself.

During World War I, flight of an aircraft over the enemy territory was subjected to small arms fire from pistols, revolvers and guns. As the years flew by and aircraft became faster, more effective and more deadly, projectiles like sten-fire, anti-aircraft shells and rockets were aimed and fired at it. Today's sophisticated, faster-than-sound aircraft are threatened by deadly and highly accurate ground-fired missiles.

The threat to the aircraft would not have been so effective but for the radar, the magic invention of the 1930s. Radar, an acronym for Radio Detection And Ranging, is basically a sensor. It operates by transmitting electromagnetic energy into the atmosphere and by detecting the same energy reflected by the objects.

Let us say a narrow beam of this energy is transmitted continuously by the antenna in the direction from which an enemy aircraft is likely to approach. When this beam strikes the aircraft, it is reflected back to the radar. This indicates the presence of an aircraft in the sky.

Now, by measuring the time period between the transmission of the pulse and the reception of the reflected signal, the distance of the aircraft from the radar system can be known very accurately. And the rate at which this time-interval (transmission and reception of probe signal) is changing will indicate the speed of the approaching aircraft.

Once the aircraft position and speed is known, a missile can be fired to destroy the aircraft. Thus a combination of radar and missile poses a serious threat to the combination of aircraft and its weapons. This was demonstrated for the first time in 1960 when a US reconnaissance aircraft U-2 was shot down by the Soviets while it was flying over their territory.

The aircraft flying at a height of over 1,00,000 feet (more than 30 km above the earth's surface) was, at that time, considered to be safe and above the range of any missile.

There are many more examples of superiority of the radar-missile combination over aircraft. Heavy losses of US aircraft over North Vietnam during the 1960s and of Israeli aircraft over Sinai desert in Arab-Israeli wars during the 1970's were mainly due to effective combination of radars and surface-to-air missiles.

Evading radar

At present, an aircraft costs anything between Rs 50 crore and Rs 250 crore. The highly accurate and sophisticated weapons it carries cost no less. Thus, it is of paramount importance that the aircraft penetrates into enemy territory, carries out its mission effectively and returns to the base safely.

Now, so long as the radar is there, it is not possible to achieve this task. This, however, can be achieved either by fooling or jamming the radar missiles or by being invisible to them.

The technique of fooling, and/or jamming the radar has been thought of, developed and perfected over the last 2 decades to such an extent that even a brief mention of it would require another full-length article. However, it has not been really effective and foolproof because of 2 basic factors.

First, advances in radar technology have been phenomenal and highly sophisticated radars with all-weather capability and high resolution have been developed. Secondly, various techniques have been developed to overcome the deception methods employed by an aircraft. Thus, the only way left to ensure that an aircraft survives an attack is to make it invisible.

To destroy an aircraft, one needs to detect, identify and track it by the physical signs of its presence. Its reflections on the radar screen, heat generated by its engines, airframe and components; emissions from its own electronic system and its visual image are some of these signs.

These signs are called "signatures." The technology aimed at reducing these signatures is called "Stealth technology."

The main objective of Stealth is to allow the aircraft to penetrate enemy defences with the lowest possibility of detection. This means countering or defeating not only ground-based search-and-

track radars but also space-based sensors and Airborne Early Warning (AEW) and Airborne Warning and Control System (AWACS) aircraft.

As mentioned earlier, a radar comes to know about the presence of an aircraft due to the reflection of radio waves from its surface. Thus to avoid detection, aircraft material should not reflect radio waves. It should deflect, scatter or absorb them. Plastic materials, which absorb radio waves and composite materials which are poor reflectors of radio waves, are being considered aircraft material. Special points are being developed to diffuse small amounts of radio energy. All these methods can reduce "signature" to such an extent that an aircraft might appear on the radar screen as if it were a vulture.

The amount of energy reflected depends upon the size as well as shape of the target. Most of the reflected signals are from vertical surfaces and sharp corners. To overcome this drawback, future generation aircraft would have smaller vertical surfaces and no sharp corners. Both these features are incorporated in the Stealth aircraft as can be seen from the accompanying pictures.

Carrying the weapons within the aircraft's body is another method of reducing signatures as it permits a clean, edge-free configuration. All the Stealth aircraft thus carry weapons internally.

"Infra-red signatures"

An object located or moving in the atmosphere or on the surface of the earth having a different temperature than its surroundings can be detected easily. It is called "infra-red signatures." In an aircraft, the engine is the main source of infra-red signatures. Its combustion chamber and exhaust gas nozzle are high temperature areas.

The methods adopted to reduce these signatures are: installing the engines inside the aircraft's body, providing by-pass air contours around the combustion chamber and modifying the shape of the exhaust nozzle. Installing the engines in long curved tunnels lined with absorbent walls is another idea under consideration.

Avionic equipment, air-crew and many other aircraft services also generate heat. During a supersonic flight, leading edges of the aircraft surfaces attain high temperatures due to kinetic heating effects. On striking the edges, high velocity air comes to rest, thereby converting kinetic energy into thermal (heat) energy.

Therefore, to reduce "signatures," the generated heat has to be removed. An effective method makes use of aircraft fuel to take away this heat. However, the system will require special fuels that can withstand high temperatures without decomposing.

The reconnaissance aircraft SR-71A, also called Black-Bird, which holds many world records and flies at mach 3.35 (mach one equals approximately 1,200 kmph at sea level) burns a special fuel JP-7. This liquid hydrocarbon fuel is not far removed from conventional kerosene, but is designed to absorb surplus heat without performance deterioration.

Aircraft speed, no doubt, cuts down the time available for an enemy's interception. However, high-speed flight creates higher fuselage and engine temperatures that are easier to detect. Similarly an engine with after-burner will have higher infra-red signatures. Stealth aircraft are thus designed to fly at subsonic speed with engines having no after-burners.

To reach enemy targets with an element of surprise, an aircraft generally flies low, at high speed, under cover of darkness and at times in bad weather. To avoid detection and enemy fire, it often follows a circuitous route.

The radar located within the aircraft enables the pilot to reach the target. However, emissions from the aircraft radar can be picked up, thus giving away its position. New systems are being developed to reduce these "signatures."

Inertial navigation is one. In another terrain under development, data-base navigation system, a picture of a large area of the real terrain would be stored in an onboard computer. The aircraft's forward-looking sensor would provide a thermal image of the terrain ahead of the computer.

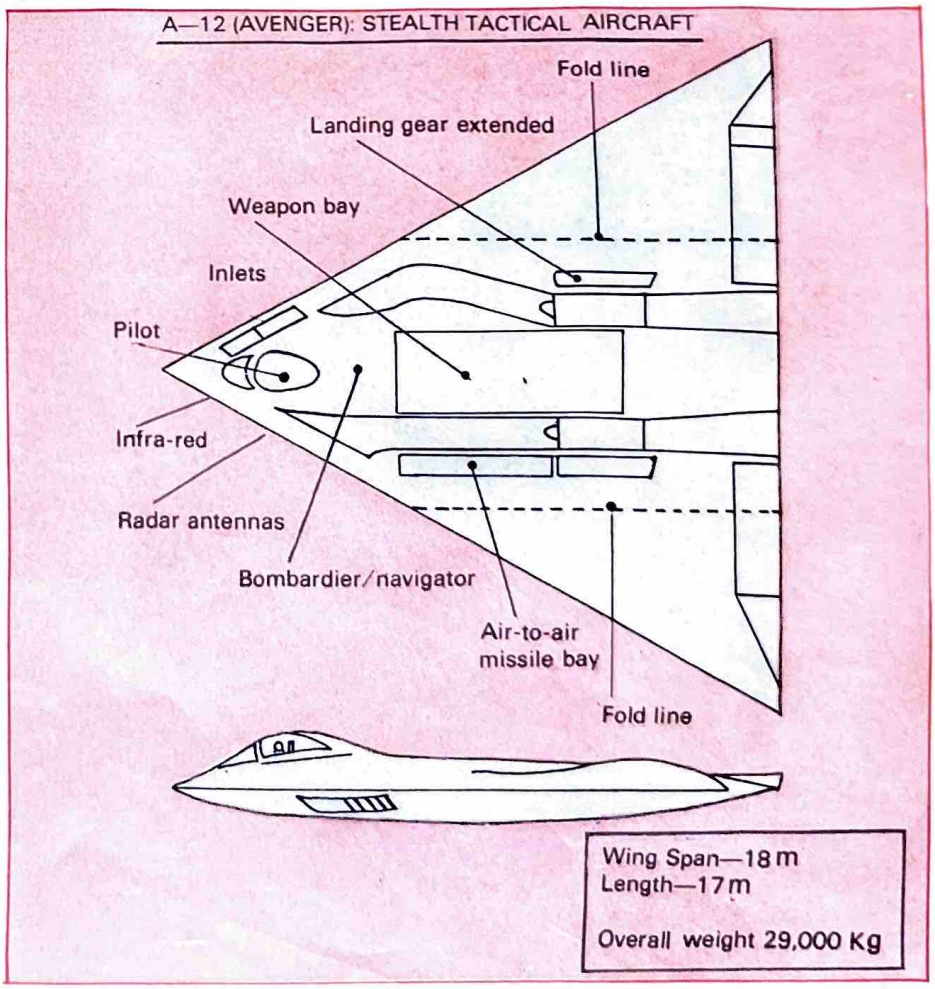
After matching the 2 terrains, the computer will print out navigational errors, using which the pilot can correct his flight path. A laser-radar is likely to be used to detect unmapped obstacles.

Future aircraft

Reduction of acoustic signatures is also on the cards. Future aircraft would incorporate noise-absorbent materials. In addition, the aircraft's visibility to electro-optical systems would also be reduced through the active camouflage technique.

In this system, there would be lights on the underside of the aircraft, which would be coupled to sensors on its upper surface. These lights will illuminate the wings and the belly to match exactly the illumination of the sky. Using this technique the aircraft, though visible to the naked eye, is likely to fool the electro-optical system.

Advanced technology bomber B-2,



popularly known as the Stealth bomber, has been developed to meet the specific requirements of the US Air Force as a low-observable aircraft. It meets almost all the requirements of a Stealth aircraft.

The wings have zig-zag edges that presumably is a compromise between the conflicting requirements of Stealth and aerodynamics. There is no vertical tail. Aircraft construction is of graphite exopy (carbonfibre) and other composite materials, much of it possibly of a honeycomb nature to absorb radar emissions.

All weapons are carried within the aircraft. Engines are non-after-burning. There are no sharp curves. This factor causes the radiation to be reflected equally over a wide sector. All this gives a very important advantage in non-detection of the aircraft by enemy radar. However, most of the data on visual, acoustic and thermal signatures still remain securely classified.

Black Jet

Only 15 B-2 bombers are reported to have been manufactured till date. Each bomber can carry about 16 medium-range cruise missiles or a certain number of B-83 nuclear bombs up to a maximum load of 34,000 kg. The aircraft flight is a high subsonic, it has a range of about 12,000 km and can go up to an altitude of 15-16 km.

The US Air Force's Stealth fighter F-117A has no official nickname, but it is already known as the "Black Jet," though air crew and maintenance personnel prefer to call it "Nighthawk."

The F-117 has an unusual look due to its facted design. The planer surfaces have been set at unusual angles to scatter incoming radar beams instead of reflecting them. This dramatically reduces the aircraft's radar cross-section. To achieve the same effect, the B-2 Stealth bomber uses compound curves.

The F-117's primary structures, thought to be made mostly of aluminium, are covered by radar-absorbent material. This soaks up radar beams, yielding minimal reflection. Other major structures are made of radar-resistant composites.

Both visual and acoustic signatures have also been reduced. Radar-absorbent material on the exterior offers a dull black finish (thus the name Black Jet) that reflects little light. The engines produce almost no smoke.

Buried engines and absence of afterburners make the F-117 extremely quiet. Besides high temperature, highly reflective turbine blades have been properly shielded.

Though its weapon-carrying capacity is not known, the aircraft appears to have a laser-designator for directing the bombs.

A total of 27 Stealth fighters, quoted at $ 106 million a piece, are reported to have been operating in the Gulf war.

Due to fly by the end of 1991, A-12 Avenger is the first Stealth aircraft designed for tactical deep strike missions. Referred to as Advanced Tactical Aircraft, it is being developed to meet the requirements of both the US Navy and the Air Force.

The plan-form shape is dictated by Stealth. Radar reflections from the leading and trailing edges have been minimised by a pure delta configuration. The engines are of high by-pass ratio, non-afterburning type. To minimise thermal and acoustic signatures, engines are concealed behind serpentine ducts.

All weapons will be carried internally. The large weapons bay can accommodate 3,000-3,500 kg load. There are likely to be separate bays for air-to-air missiles.

This Stealth aircraft, as per current estimates, is likely to cost $ 85-90 million (Rs 153-162 crore).

Stealth aircraft are being designed to frustrate anti-aircraft guns, surface-to-air missiles and interceptor aircraft. No development, till date, however, has ever taken place in isolation. Thus, while the above-mentioned Stealth projects are being developed and perfected, counter-Stealth technology is already under way.

The UK and the Soviet Union too have started developing these technologies along with the requisite counters for aircraft having Stealth capability. The USA also has a counter-Stealth programme.

The possibility of using space-borne radar and infra-red sensors to detect aircraft with low radar cross-section appears to be highly probable. The rationale is that aircraft with low radar cross-section are likely to have very large plan-form as viewed from space, a fact which is borne by all the 3 Stealth aircraft mentioned earlier.

In addition, it will be very difficult to achieve low infra-red signatures from both below (for ground-based sensors) and above (for space-based sensors).

Warning and action time

Notwithstanding quantum jumps, no technological advancement will ever make an aircraft completely invisible. All programmes contemplate only one thing: Reducing the ability of enemy radar and infra-red sensor to detect and track an aircraft.

This, in turn, will reduce the warning and action time available to the defender. This apparently minor gain might ultimately prove to be the clincher between destruction and survivability of an aircraft.

No doubt, today the Stealth aircraft roam freely in the skies over Iraq, undetected and undeterred. But this scenario is not likely to remain unchanged in future. Judging by past developments in aviation, sooner or later the stealth will meet its match.

However, till that happens, Stealth aircraft will continue to own and rule the skies. □□

WHO'S WHO IN INDIAN POLITICS

• **One who can boomerang like lightning.**
Om Prakash Chautala. (Keeps coming back.)

• **One who is a soft operator.**
Mulayam Singh Yadav.

• **One who is law-bound.**
Hukam Singh Yadav.

• **One who can wax and wane.**
Chandra Shekhar.

• **One who created a fur-roar.**
V. P. Singh.

• **The one between the Devil and the deep sea.**
Devil-al(l).

• **One who plays a red flute.**
Bansi Lal.

• **One whose 'rath' was his Ad van?**
Ad-van-i.

• **One whose victory went away too soon.**
Yash-went Sinha.

• **One who is a Richie Rich sage.**
Subra-money-am Swamy.

• **One who is the father of political war.**
Pa-war.

• **One who directs children's dances.**
Bal-tha-kar-ray.

—Hema Gandhi

• *The best advice you'll get is from someone who made the same mistake himself.*