AVIATION WEEK ARTIST'S conception of Soviet nuclear-powered bomber shows large nuclear powerplants suspended from pods midway under delta wing, conventional turbojets with short takeoff afterburners on wingtips, and 195-ft. fuselage to aid in radiation protection.
Soviets Flight Testing Nuclear Bomber

Atomic powerplants producing 70,000 lb. thrust are combined with turbojets for initial operations.

Washington—A nuclear-powered bomber is being flight tested in the Soviet Union.

Completed about six months ago, this aircraft has been flying in the Moscow area for at least two months. It has been observed both in flight and on the ground by a wide variety of foreign observers from Communist and non-Communist countries.

In its initial flight testing, the new aircraft is powered by a combination of nuclear and conventional turbojet engines. Two direct air cycle nuclear powerplants are housed in 36-ft.-long nacelles slung on short pylons about midway out on each wing. These nuclear powerplants, with 6-ft.-diameter air intakes and using small but high-power reactors to replace the combustion chambers in the turbojet cycle, produce about 70,000 lb. thrust each.

They are supplemented by two conventional turbojets installed in wingtip pods fitted with short afterburners to provide about 35,000 lb. thrust each for takeoff performance. The conventional, chemically fueled turbojets are used primarily for safety purposes during the early flight test program of the nuclear powerplants. In later versions of the aircraft, they may be retained for high-speed dash performance or replaced by two more nuclear powerplants after their reliability has been proved in flight.

The Russian nuclear-powered bomber is not a flying test bed in the sense that earlier U. S. Air Force and Navy programs had called for installing a nuclear powerplant in a conventional airframe such as the B-36 or Saunders-Roe Princess Flying boat solely for test purposes. The Soviet aircraft is prototype of a design to perform a military mission as a continuous airborne alert warning system and missile-launching platform similar to the USAF CANAL project for which Convair and Lockheed are now making design studies (AW Nov. 10, p. 37). The CANAL mission was recently described in detail by Maj. Gen. Donald Keim (see box page 28).

In its present configuration with both nuclear and conventional turbojets, the Soviet aircraft has a performance capability in the high subsonic and low supersonic speed ranges with its range limited only by engine component life and crew endurance.

The Soviet nuclear-powered plane has a fuselage about 193 ft. long and a 78 ft. wing span. The delta-type wing is sweptback on both leading and trailing edges. From an initial angle of 60 deg. sweepback at the wing root, the leading edge changes to about 55 deg. sweep at the inboard engine pylon mounts and beyond to the wingtips to produce a "cranked" effect familiar on British bombers such as the Handley Page Victor and Ayrvo Vulcain. Trailing edge of the wing is swept about 15 deg. This delta-type wing uses a relatively thin, high-speed airfoil confirming eventual performance goals for this design in the Mach 2 speed area.

Vertical tail rises about 22 ft. above the fuselage. It is a typical "tail" type fin used by Soviet designers to ensure good directional stability. Horizontal tail surfaces have a span of 30 ft. and are swept back at about the same angle as the outboard wing panels. They apparently are kept well clear of the nuclear powerplant efflux both by placement high on the fuselage and by span length.

Aircraft has a gross weight of about 300,000 lb., and a wing loading of about 118 lb. per sq. ft.

The direct air cycle nuclear powerplant has been described in some detail in Soviet technical publications (see diagram on page 28). In a test published last year by the Military Press of the Soviet Defense Ministry entitled "Application of Atomic Engines in Aviation," the direct air cycle powerplant is described as follows:

"The simplest is a design that differs from the ordinary turbojet engine only in that the combustion chamber is replaced by a reactor...

"This simplest design permits obtaining the highest specific performance parameters. In this case, the air duct..."
SCHEMATIC DIAGRAMS from Soviet technical source on a direct air cycle atomic turboshaft.

Nuclear reactor is used in place of internal chemical fuel combination chamber with air and compressor shaft passing directly through reactor.

becomes a airflow duct where the airflow through the engine is at all times parallel and in a straight line so that hydraulic resistance is at a minimum. The air is heated directly in the reactor without an intermediate heat transfer agent. This simplifies the design and eliminates excessive heat loss. However, this design which is simple in principle, is exceedingly difficult to realize. The shaft connecting the turbine with the compressor has to pass through the reactor. Cooling the shaft under these conditions becomes a difficult and actual problem.

The point is that the shaft not only becomes heated as a result of heat transfer from the hot reactor parts but considerable liberation of heat occurs within the shaft itself due to scattering and absorption of neutrons and gamma rays by the shaft material. So much heat is liberated in the shaft that cooling of the shaft changes from a simple engineering matter to a complex problem whose solution will govern the very possibility of developing an atomic turboshaft engine on the basis of this 'simplest' design. This direct air cycle nuclear power plant represents the same approach pursued by the Aircraft Nuclear Propulsion Department of General Electric Co. under USAF and Atomic Energy Commission sponsorship since 1951 at facilities in Evendale, Ohio, and Arco, Idaho.

Dr. R. Shoultz, general manager of the GE nuclear propulsion program, reported that actual operational tests at the ARCO facility hod "proved the feasibility of a direct air cycle aircraft propulsion system and demonstrated its performance." The Shoultz report was made in a paper prepared for the Second United Nations International Conference on Peaceful Uses of Atomic Energy held last September in Geneva, Switzerland (AW Sept. 25, p. 55).

He described the results of operating heat transfer reactor experiment No. 1 (HTRE-1) during more than 100 hr. of turboshaft running on nuclear power without "any failures of any sort."

Shoultz also reported that HTRE-I determined the following:

- Integrated performance of the reactor and turboshaft engine in the powerplant system.
- That overheating in portions of the reactor would not lead to local flow starvation and progressive overheating.
- Integrity and life of key components of the system.
- Ability to carry out extensive detailed handling of radioactive components.
- Control response of the reactor and its relationship to turboshaft engine control.
- Unanticipated problems and their possible solutions.

The approach to flight testing nuclear-powered aircraft both in this country and in the Soviet Union calls for initial operations on conventional chemical fuels to prove out aircraft systems and familiarize the crew with operational techniques. However, even in operational use of a nuclear-powered military aircraft, nuclear powerplants may be operated initially on chemical fuel until the reactor temperatures are sufficiently high for full power operation. Then chemical fuel combustion can be phased out and the turboshaft permitted to operate on nuclear power alone. Similarly, on return from a mission the reactors would be shut down some distance from destination, with the return to base and landing again made on chemical fuels. For this type of operation, a chemical powerplant system also must be incorporated in the nuclear powerplant package.

Powerplants Flight Tested

Although much of the early flight testing of the Soviet nuclear aircraft has been conducted on conventional fuel the nuclear powerplants have definitely been tested in the air. Fission of one pound of uranium 235—most frequently mentioned in Soviet technical literature along with plutonium 239 as an airborne reactor fuel—will liberate about the same amount of energy as the burning of 1,700,000 lb. of gasoline.

There is no specific information available on the types of shielding employed on the new nuclear-powered aircraft but recent Soviet technical literature has been studied with brief but positive references to a "major breakthrough" in shielding techniques. Soviet technical literature emphasizes the concept of divided shielding with heavy use of stainless steel in the engine and aircraft structure to provide identical core shield for neutron radiation and another type of shielding protecting the crew quarters from gamma radiation. The extreme length of the aircraft fuselage also would be aimed at maximum separation of crew from the radioactive engines. The podded installation is best suited

Nuclear Plane's Military Mission

Washington—"Imagine a fleet of 'enemy' high speed aircraft continuously positioning the airspace just outside our early warning net capable of air launching a devastating missile attack against our hardened installations. Through a consideration of these capabilities, combined with those possessed by the intercontinental range ballistic missile, the degree of possible future threat of surprise attack becomes apparent."...

"An ideal airborne alert manned aircraft system must carry a large payload and remain on nomadic patrol for extended periods of time in various areas of the world. It must maintain continuous communication with appropriate headquarters, and be capable of instantaneous reaction with air launched missiles. When required, the system should be capable of following the up the missile launching phase with a low-level high-speed penetration of the enemy's homeland in order to seek out and destroy hardened targets or targets whose locations are not sufficiently well known to permit attack by long-range missiles.

The combination of these features can be achieved through the application of nuclear propulsion. . . . Such a system may be similar in weight and size to the B-32 and be capable of carrying a heavy payload on extended endurance missions. Because of its endurance, varying amount load and high speed capability at minimum altitudes, its operational versatility would be outstanding. . . . But perhaps even more important is its inherent operational flexibility for meeting various limited war and peacetime situations."— Maj. Gen. Donald J. Keen USAF deputy chief of staff for development for nuclear weapons.

AVIATION WEEK, December 1, 1958
U.S. Nuclear Powered Aircraft Program

- 1946—Nuclear Energy Propulsion for Aircraft program (NEPA) organized under Air Force contract with Fairchild Engine & Aircraft Co. project manager at AEC. Purpose is to study feasibility of applying nuclear power to aircraft and to develop components for such a system. Consultants from aircraft engine manufacturers and universities participate.

- 1948—Lexington committee, primarily Massachusetts Institute of Technology professors, called in by AEC to study NEPA program. Recommends continuation of project.

- 1949—Oak Ridge AEC laboratory establishes nuclear propulsion research program.

- 1949—Technical Advisory Board reviews NEPA program, recommends continued.

- 1950—Fairchild top management change and company is relieved of NEPA project.

- 1950—Divided shielding concept developed and NEPA program is given new direction by a new technical committee.

- 1951—USAF concludes NEPA had demonstrated feasibility of nuclear propulsion of aircraft.

- 1951—May, General Electric organizes aircraft nuclear propulsion program as part of its Aircraft Gas Turbine Division under USAF and AEC contract.

- 1951—May, Pratt & Whitney gets USAF contract to explore closed cycle nuclear reactor.

- 1951—Fall, GE gets approval for development of direct air cycle type nuclear powerplant.

- 1952—Spring, GE begins work to develop experimental nuclear powerplant to be tested in B-36 with flight date projected for 1956. GE aircraft nuclear propulsion project becomes a separate department and begins work on six-day week.

- 1953—Spring, Convair builds first aircraft equipment in radiation environment.

- 1953—May, Pratt & Whitney Aircraft gets EAC backup contract on USAF closed cycle work.

- 1953—Spring, Charles E. Wilson, Secretary of Defense, decides to cancel Convair-GE aircraft nuclear propulsion program. GE program retained by USAF Secretary Harold Talbott's decision of unfunded accounts to project.

- 1954—Fall, ground test reactor, first of its type outside AEC, designed and built by Convair, put into operation.

- 1954—USAF cancels B-36 nuclear powerplant. GE continues support of GE program on limited scale. GE program with HTA 1.4 system development with X-39 engine aimed at high-performance nuclear powerplant system to be operational in 1956.

- 1954—Fall, aircraft shielding test reactor, first flying reactor built and designed by Convair, put into operation.


The development of the nuclear aircraft program was aimed at high subsonic cruise bomber with supersonic dash capability. Pratt & Whitney and General Electric are engine contractors and Convair and Lockheed are airframe contractors.

- 1955—May, Pratt & Whitney and General Electric share engine development contracts with Convair and Lockheed.

- 1955—October, engine-airframe company teams for system WS-125A selected by Air Force. GE and Convair as one team. Pratt & Whitney and Lockheed the other.

- 1956—January, GE successfully rates X-39 turboprop engine with nuclear reactor in HTRE-1 for successful operation on nuclear power.

- 1956—Spring, USAF plants construction of 10 kilowatt test reactor for aircraft materials testing at Wright Field, Ohio.

- 1956—September, National Advisory Committee for Aeronautics begins construction of nuclear test reactor at Lewis Flight Propulsion Laboratory, Cleveland.

- 1956—September, GE operates HTRE-1 with turboprop engine running 100 hr. on nuclear power without failure of any kind.

- 1956—Fall, USAF cancels WS-125A program. Powerplant development continued with no specific aircraft goals.

- 1957—July, Pratt & Whitney completes Connecticut Aircraft Nuclear Engineering Laboratory (CANEL) at Middletown, Conn., under AEC contract.

- 1957—June, Soviet Union ground tests nuclear aircraft powerplant.

- 1957—August, USAF cancels Pratt & Whitney closed cycle engine development contract. CANEL cuts operations. Development of reduced scale. AEC continues support of P&WA program on small scale.

- 1957—Fall, General Electric proposes accelerated program aimed at getting flying test bed with nuclear powerplant into air as soon as possible.

- 1958—March, President Eisenhowe informs Congress there is no urgency in nuclear aircraft propulsion program, rejects accelerated program and authorizes continued low budget development program.

- 1958—June, USAF proposes CAMAL nuclear-powered aircraft program to develop continuous airborne alert, missile launching and low-level penetration mission.

- 1958—July, Navy gets funds to conduct feasibility study of a nuclear-powered aircraft using Pratt & Whitney engines.

- 1958—August, Flight of Soviet nuclear-powered bomber prototype are observed in Moscow region.

- 1958—December, Air Research and Development Command scheduled to analyze Lockheed and Convair CAMAL design studies preliminary to possible award of prototype construction contract.

To the direct air cycle type nuclear powerplant since its operation makes the entire turbojet engine radioactive. The pod would facilitate engine removal by remote control for ground radiological safety and make replacement of the powerplants relatively simple.

Taking a nuclear-powered military aircraft from the early flight test stage, through which the Soviet aircraft is now passing, to a fully operational capability for both, airborne early warning and missile launching capability probably will require at least 18 to 24 months. A nuclear powered aircraft requires extensive testing for other flight operational subsystems other than the powerplants and their operation under varying degrees and different types of radioactivity.

The current Soviet milestone in testing nuclear powerplants in flight is a military prototype is the result of a high-priority and financially well-supported program stretching back through nearly eight years of research and development.

High priority for the nuclear aircraft program was assigned during the current Ninth five-year program which began in 1956 and will end in 1960. During the past few years, Soviet technical and popular publications began a steady crescendo in their coverage of atomic aircraft powerplant developments in addition to marine atomic powerplants for icebreakers, submarines and surface vessels. This similar type of publication build-up has preceded every new major Soviet technical achievement, including the intercontinental ballistic missile and the Spetsnaks.

As long as a year ago, there were brief but specific mentions in the Soviet technical press of successful ground testing of atomic aircraft powerplants. Recent speculative stories in the Soviet popular press suggest conditioning the Russian people to an announcement of a spectacular achievement by an atomic-powered aircraft in the near future, probably a nonstop, non-refueled flight around the world.