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THE EXHIBITION OF NEW SOVIET FIGHTERS AND FIGHTER-BOMBERS

By

Colonel Zlatko Rendulic, Ph.D.

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By: Colonel Zlatko Rendulic, Ph. D.

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ABSTRACT

(U) This article deals with material which appeared in Flugwelt (No. 12, 1967) and Interavia (No. 9, 1967) and covers Soviet fighters and fighter-bombers from 1950 to 1965. Illustrated are the E-166 (experimental plane from the Mikoyan design group), a Sukhoy single-engine jet fighter (Mig 21), a Sukhoy twin-engine jet pursuit plane, a plane with variable wings based on the Su-7B, a later version of the same, and a long-range twin-jet pursuit plane flying at 2.8-3 times the speed of sound. These planes are compared in available detail with planes of Western manufacture. STOL and VTOL types are also mentioned. The author notes the unusually large number of planes projected in the USSR. He mentions the Hawker-Siddeley P-1127 as the most successful plane of its type and discusses the F-111, Mirage G, and YF-11. He concludes that the large number of new Soviet prototypes indicates that the USSR is again laying great stress on supporting aircraft. () Orig. art. has: 7 figures.

THE EXHIBITION OF NEW SOVIET FIGHTERS AND FIGHTER-BOMBERS

Colonel Zlatko Rendulic, Ph.d.
Graduate Engineer

The development of new types of Soviet aircraft takes place with much less advance publicity in the technical press than is the case in Western countries. For this reason, the big air shows are the principal source of information about new types of aircraft. Furthermore, it may be accepted as an unwritten rule that the new types of aircraft which are exhibited at these shows are acarcely in the first phase of prototype testing but are well along in their development – usually in the phase just before mass production.

The air show held in July 1967 was one of the largest post-war shows of this kind since it was in honor of the 50th anniversary of the Great October Socialist Revolution. At the Domodedovo airport a static exhibit of only a few military planes was on display and many more civil aircraft were shown. The new types were shown in flight at a large meeting.

At the last major air show, which was held in the summer of 1961, it was evident from the new types of aircraft exhibited that the USSR at that time was placing major emphasis in aviation development on strategic bombers capable of carrying long-range guided missiles. At last year's show a very large number of new planes of various types was displayed, but it is fair to say that the new types of fighters and fighter-bombers were the focal point of development. In this article, therefore, we shall describe the new fighters and fighter-bombers which are of the greatest interest to us. As certain specifications relating to these planes are not known, they will be referred to here as estimates.

Soviet fighters and fighter-bombers from 1950 to 1965 are distinguished by the similarity of the aerodynamic conception employed. Fighter planes operating at around the speed of sound, such as the MIG-15, the MIG-17 and others of that type, have a distinctive forward (Pitot) air inlet and sweptback wings with boundary layer controls. The MIG-19, which operates at slightly above the speed of sound, also has a forward inlet but a sweptback wing with a greater angle of sweep, which was in fashion at that time, and large boundary layer controls. The supersonic MIG-21 (in the Mach 2 category) again retains the forward supersonic inlet with a tapered shape, but it has an original aerodynamic conception which consists of a delta wing and a sweptback integral movable horizontal tail. This conception is aerodynamically simpler than that of the classic delta wing without a horizontal tail because it does not require an automatic stabilizing device and it is much more effective than the pure delta wing when account is taken of the magnitude of the wind shock factor, which is important in low altitude flight at high speeds in turbulent air. A typical example of this conception is the experimental plane E-166 (Figure 1), developed by a design team under the direction of chief designer Mikoyan.

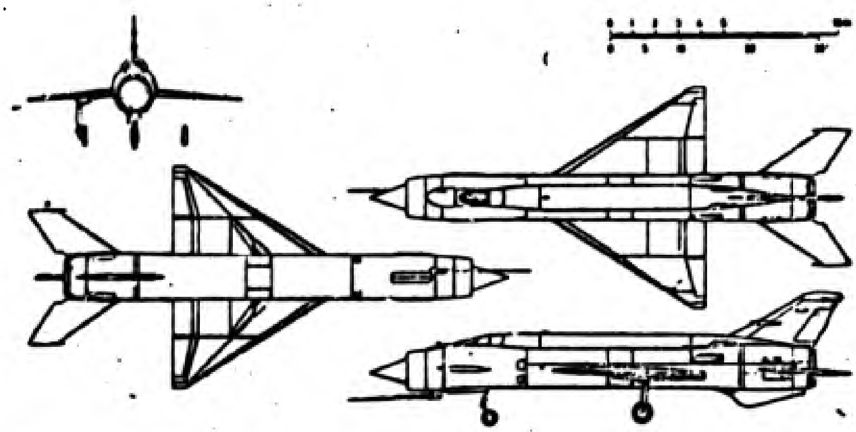

Fig. 1. The experimental plane E-166 designed by the Mikoyan team.

The E-166 plane in 1961 set a world speed record of 2401 km/ /hr. in a closed round flight of 100 km. The same plane in 1962 set the absolute world speed record of 2681 km/hr. at an altitude of 25 km. At lower altitudes, speeds of 3000 km/hr. have been attained. The plane's engine is of large size, especially the afterburner device. The engine develops a thrust of 10,000 kg, which is raised to approximately 15,000 kg when the afterburner is used. This is, therefore, one of the most powerful jet engines in the world. One of the largest American jet engines, the Pratt Whitney J58, develops a thrust of 13,800 kg using an afterburner. The Soviet engine is a classic turbojet without a forward or rear fan.

The MIG-21 is a smaller version of the E-166, employing a completely identical aerodynamic conception. A distinctive feature is the forward (Pitot) supersonic inlet with a movable cone that is the dominant type of inlet on all the Soviet supersonic aircraft so far produced.

The new types of aircraft characteristically employ virtually all the possible kinds of supersonic inlets, and they are based on various conceptions. This means that the USSR has carried out extensive aerodynamic tests to meet the requirements of all ranges of speed, experimenting with practically all the aerodynamic innovations presently known to the world. It should be pointed out that the whole development of modern supersonic aircraft is extremely costly and that many major powers (such as Great Britain) are not able to work on more than one or two such projects at a time. For many years Great Britain worked on the TSR-2 project, the total development of which cost around 240 million pounds; and in the end the project was abandoned as being too costly for mass production. Sweden, which also invests heavily in aeronautical development, for years has been working on only one new project involving a supersonic plane, the SAAB-37; and its development, before it reaches the stage of mass production, will cost around $260 million. France, which puts its greatest efforts into the construction of its own types of aircraft, has managed to work on, at best, three supersonic plane projects at the same time, all of which are from the same family-"Mirage." For this reason, it was rather surprising for the Western countries to learn that the Soviet Ministry of Aviation Production had succeeded in working simultaneously on the development of 12 new projects which cover nearly all the avenues of aviation research being explored by all the other countries of the world in the field of fighter and fighter-bomber aviation

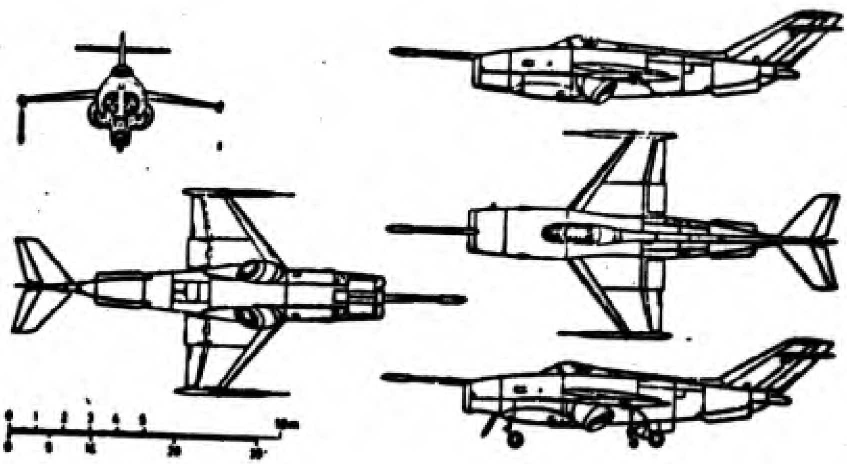

Fig. 2. Vertical takeoff and landing plane.

The first new type we shall consider is the vertical take and landing (VTOL) plane shown in Figure 2. It should be mentioned that VTOL projects have been around for about 10 years, but very few successful projects have been developed. Among the various VTOL systems, two have finally emerged as the most promising: one with combined lift and cruise engines and another with separate lift and cruise engines. So far the best known example of the combined lift and cruise engine type is the British Hawker Siddeley P.1127, which has four movable jet engines capable of varying the direction of the vectors of thrust by 90°. The best known example of a VTOL plane with separate lift and cruise engines is the French Mirage III-V, the "Balzac." Three prototypes of this plane were flown, but all three failed in testing and the project was finally abandoned. On the basis of the experience gained up to now, it appears that the system with combined lift and cruise engines is much safer and more promising. The Soviet project illustrated in Figure 2 falls into this category.

This plane is presumably the work of the design bureau headed by chief designer Yakovlev. The plane has two engines, which have two rotatable jets. The jets of both engines are interconnected so that the failure of one engine will not cause asymmetry in the motive force. The jets may be rotated within 90°, and they are slightly tilted outward. Accordingly, in vertical takeoff the intersection of both vectors of thrust is located above the center of gravity of the plane, with the result that the plane is stabilized during displacement from the moment of rolling (along the longitudinal axis). Stabilization of the plane in hovering is achieved by directing the four jets downward, two at the wing tips, one on the rear part of the fuselage and one on the tube which protrudes in front of the air inlet. Air for the jets comes from compressors. With the jets protruding in this fashion, the plane is readily controlled in hovering. The protruding forward jet imparts good stabilization to the plane along the transverse axis, which is very important for good maneuverability in transition situations.

The plane's landing gear is located centrally on the fuselage with two auxiliary legs which are retracted into aerodynamic compartments on the wing tips. The British P.1127 has the same arrangement as regards landing gear.

The remaining types of aircraft show that aeronautical engineers in the USSR are much more interested in short takeoff and landing (STOL) than in vertical takeoff and landing. It should be mentioned that the rest of the world also at the present time is giving priority to STOL projects. This is, moreover, confirmed by the fact that not a single combat plane of the VTOL type has been put into greater mass production. The Swedes, for example, feel there is not need to develop a combat plane of the VTOL type since it is inferior to the STOL plane when the overall performance of both types is considered. The Americans, too, have stopped working for the present on VTOL supersonic combat aircraft projects, and the Mirage III-V has shown that in the air after takeoff it is markedly inferior to the ordinary Mirage III, owing to excessive weight which affects the lift cruise engines and the automatic stabilizing devices.

It is therefore understandable that Soviet aeronautical engineers are now attaching priority to STOL projects. Among them, attention is drawn to the MIG-21 which has lift engines that assist it to shorten its takeoff. The use of lift engines in this plane is much less dangerous than in the case of VTOL aircraft, for there is no hovering mode. The takeoff procedure is the usual, but considerably shorter — about 500 meters. A new type of single-engine fighter with lift engines is shown in Figure 3.

The air inlet is located laterally on the plane with a movable half cone to control the shock wave at the entrance to the inlet. Radar systems of much greater bulk can be installed in the nose of the plane than is the case in the MIG-21 plane. Otherwise, the aerodynamic conception is standard with a delta wing and an integral movable sweptback tail. One or more lift engines are situated centrally on the fuselage behind the cockpit and near the center of gravity. It is estimated that the cruise engine develops a thrust of 12,000 kg when using an afterburner. The wing span is estimated to be approximately 9.5 m and the maximum weight of the plane is 17-18 tons. The airplane was presumably designed by the Mikoyan bureau. The plane's maximum speed is in the neighborhood of Mach 2.2. Very probably there is a version of the plane without lift engines. Additional fuel in place of the lift engines could considerably increase the tactical radius of the plane.

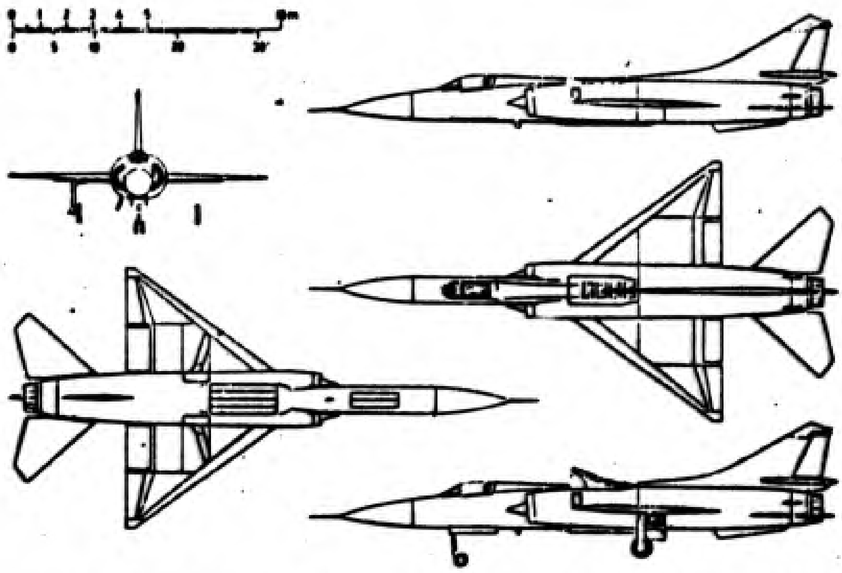

Fig. 3. Single-engine fighter with lift engines.

The next plane, also of the STOL type, is illustrated in Figure 4. It was probably designed by the design bureau headed by chief designer Sukhoy.

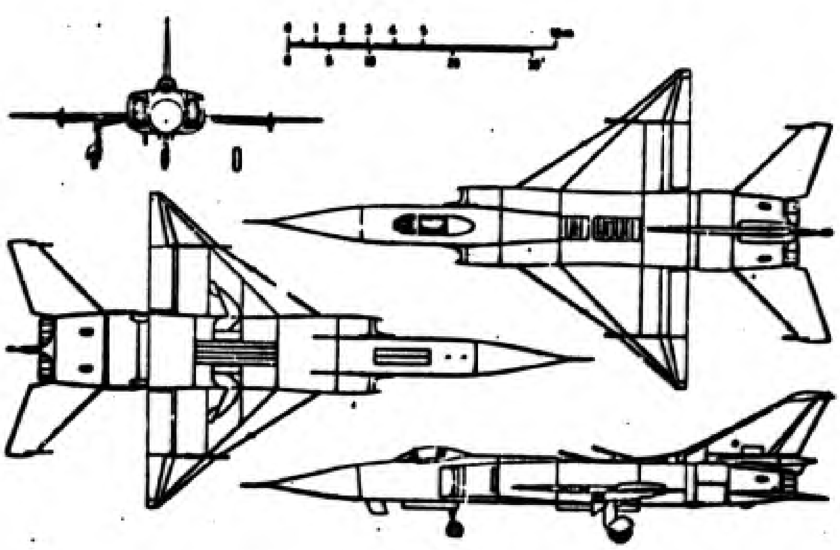

Fig. 4. Two-engine multipurpose plane with lift engines.

Two turbojet cruise engines with afterburner devices are located parallel to each other on the fuselage. A few lift engines are located centrally on the fuselage. The configuration of the wing is double-delta with boundary layer controls on the bend in the sweep of the wing. The entire movable tail is sweptback. The air inlets are nearly quadrangular in design in the front with a protruding plate to separate the boundary layer and to control the shock wave on the inlet. This type of inlet differs from the standard Soviet type with a cone or half-cone. Inlets of similar design are used on the SAAB-37 Vigen and the Phantom F-4 planes. In the nose there is room for search radar of considerable dimensions and for the installation of any other kind of modern electronic equipment. The wing span is estimated to be 11 m and the maximum weight is 20 tons. The maximum speed is approximately Mach 2.5 and perhaps even a bit higher. A version of the same plane without lift engines was also exhibited. This type, because of the large amount of fuel that can be carried in place of the lift engines, has a considerably greater tactical radius. The plane is capable of serving as a long-range bomber-interceptor, a fighter-bomber and a reconnaissance plane.

The airplanes with variable-sweep wings are of particular interest. Before July 1967, only one plane of this type was known to exist the American F-111 which had been flown and was far advanced in development; a large part of its prototype testing program had been completed. This multipurpose plane is quite complex and its unit cost in large-scale mass production will be more than $3 million. Another project of this type has been launched with the Franco-British interceptor with variable-sweep wings. The English rejected further development, and the plane was successfully completed by the French firm *Marcel Dassault*, as the Mirage G. This plane made its flight debut in November 1967, i.e., after the exhibition of the Soviet planes of this type.

There are two interesting types of planes with variable-sweep wings. The first we shall take up is the variable-sweep Su-7B (Figure 5).

When the wings are in the extreme rear position, i.e., when the sweep of the wings is greatest, the plane is a complete analog of the Su-7B. Approximately half-way along the wing is a turning point from which the outermost part of the wing is rotated and the sweep of the wing thereby varied. At this point also there are high boundary layer controls which serve the purpose of preventing a dislocation in the boundary layer owing to the dicontinuity in the sweep of the wing. When the wing is in the forward position, the leading edge of the wing is completely discontinuous. The usefulness of this arrangement, that only the outer part of the wing varies the sweep, is that the center of thrust is relatively little displaced to the front and when the wing is in the forward position, the center of gravity is also displaced so that the plane's handling characteristics are not perceptibly changed. For this reason, the horizontal tail of the Su-7B was found to be satisfactory without any enlargement. The further usefulness of this is that all the underwing store stations for armament and reserve tanks that are located in the central section of the wing do not impede the movement of the wing. In the case of the F-111, when the wing is moved, all the underwing store stations are moved so that they always remain parallel to the axis of the fuselage. This represents a special complication in design and perhaps also a source of possible failure in operation. The boundary layer controls on the Soviet plane serve the same purpose as the external ribs on the wing. There are several of them. In other words, since the console part has been retracted into the center plan, there is no place for internal ribs and the required rigidity of the wing dictated external ribs. On the movable part of the wing, there are slats and wing flaps so that it is possible to achieve a definite increase in the maximum rate of climb and thereby shorten the takeoff and landing, which are much shorter in this version than in the regular Su7B.

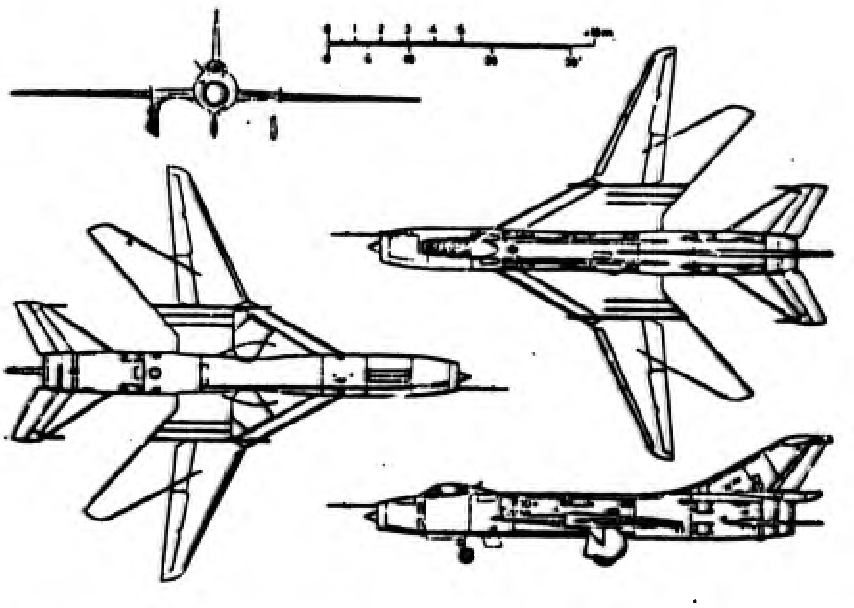

Fig. 5. Airplane with variable-sweep wings, based on the Su-7B.

The new type of interceptor with variable-sweep wings as shown in Figure 6 is much more interesting and original.

The airplane was presumably developed by the design bureau of chief designer Mikoyan. In terms of size, it is considerably smaller than the American F-111 and much closer to the French Mirage G. The axis of rotation of the wing is squarely centered on the fuselage so that in the fully extended position the wing span is increased nearly twofold. The maximum thrust of the engines with an afterburner device is estimated to be 12 tons, and the maximum weight of the plane is 17-18 tons. In the extreme rear position, the wings have a sweep of approximately 70°. This makes it possible to attain a maximum speed from approximately Mach 2.5 to perhaps Mach 2.8 for short periods. The air inlets are located laterally on the fuselage and, with the protruding boundary layer separator and the plate for controlling the shock wave, form an almost rectangular section. As previously noted, this type of inlet has never before been used on aircraft of Soviet design. A dis-

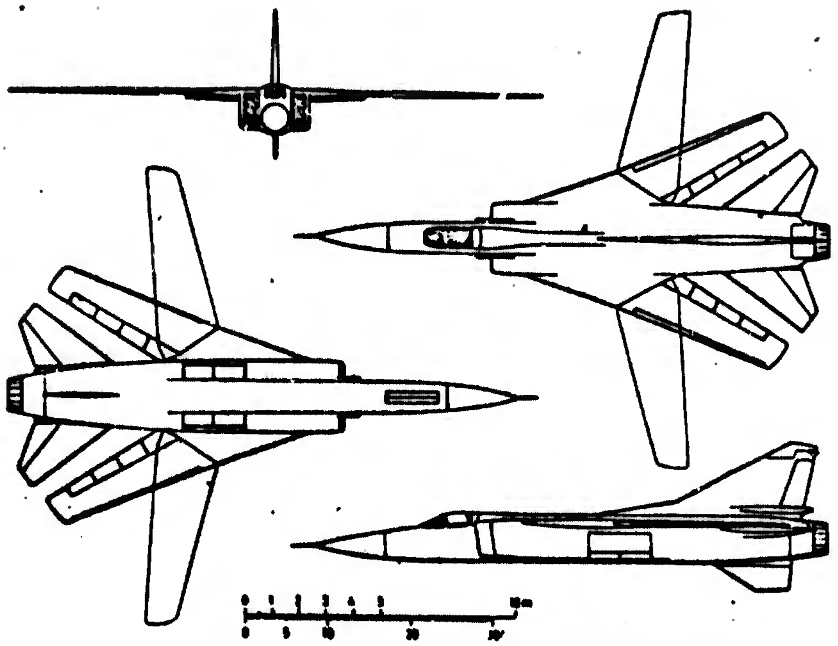

Fig. 6. Interceptor with variable-sweep wings.

tinctive feature is the large ventral fin, which is presumably angled to one side when the landing gear is extended. The plane has a very wide range of speeds with the wings in the extreme forward and extreme rear positions. Changing the angle of sweep between the extreme positions takes about 4 seconds, a fact which demonstrates that the plane is well along in flight tests.

One of the biggest surprises is the all-weather fighter with the broad action radius, whose maximum speed is estimated to be Mach 2.83. The plane has two jet engines which, using an afterburner, develop a thrust of approximately 12.5 tons apiece. The engines are located parallel to each other on the rear part of the fuselage (Figure 7).

The plane has an original aerodynamic conception. The rectangular air inlets have a sharply protruding upper lip for controlling the shock wave. Such a configuration of the air inlet has heretofore been very rarely used in any country. A similar principle as regards the inlet can be seen on the American A-5A Vigilante. The wing is trapezoidal in shape, designed to have a slight sweep but very little relative thickness. The horizontal shaft is located on the lower part of the fuselage so that it is completely beneath the plane of the wing, a design which is necessary if it is to be effective at such high speeds. Two vertical stabilizers and two sturdy ventral fins ensure directional stability. At speeds in the vicinity of Mach 3, it is very difficult to achieve satisfactory directional stability without an automatic stabilizing device. In the fore part of the fuselage, there is room for very powerful search radar. Titanium was used in the construction of this plane. The wing span is estimated to be 15 m, and the maximum weight is on the order of 35 tons. The plane's flight ceiling is around 31,000 m, and it is likely that in low altitude flight the plane attains supersonic speeds in the neighborhood of Mach. 1.2.

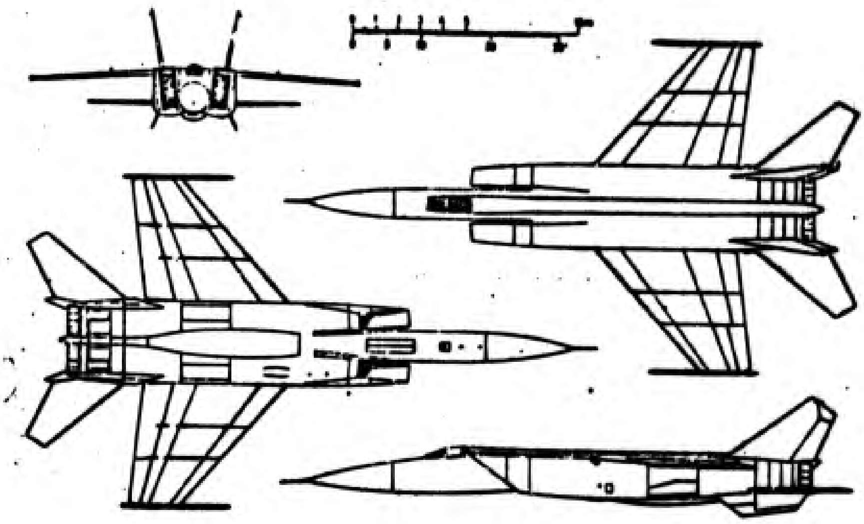

Fig. 7.

Clearly, this is a multipurpose plane. In addition to functioning as a long-range interceptor, it may be employed as an operative tactical and strategic reconnaissance aircraft, and it also has a nuclear strike capability from low or very high altitudes. Its flight altitude of 31,000 m together with its speed in the vicinity of Mach 2.8 enables the plane to attack with nuclear weapons and from so-called high flight profiles using V-Z missiles with nuclear warheads. In this regard, it performs a function similar to that of the American Lockheed YF-12 which is in the Mach 3 category with an operating altitude to 30,000 m, but it is quite a bit larger than the YF-12.

It is not positively known which design team developed this plane, but it is believed to be the work of the design bureau of chief designer Yakolev.

Even a very rough approximation of the cost of such an extensive program would show the great importance the USSR attaches to the development of this type of aircraft. If as a basis for comparison we take the cost of the Swedish project that developed the new fighter-bomber SAAB-37 Vigen, which can be regarded as the closest to certain of the less complex projects mentioned, the following figures can be obtained. The overall cost of developing the Vigen aircraft came to $260 million. Since the weight of the plane is on the order of 14 tons, it may be said roughly that the development cost per ton for such a plane will be approximately $19 million. In projects such as the one shown in Figure 7, this cost runs about 50% higher. If we refer only to the 7 projects we have considered, the cost of their development amounts to at least $2.8 billion. Taking into account also the sums spent on other types of aircraft, such as the gigantic transport craft and the supersonic missile-carrying bombers, it is not hard to imagine the sums which the USSR spends on aeronautical development. Even if we refer only to the fighters and fighter-bombers we have considered, it is easy to conclude that all the countries of Western Europe together are not developing so many projects of this type. Finally, we can summarize our review of the new Soviet fighters and fighter-combers as follows:

The extraordinarily large number of projects shows that the USSR is exploring all the new avenues of research in the field of aeronautics which are commonly explored by Western countries and the USA.

The most successful tactical plane of the Western countries with respect to vertical takeoff and landing is the British Hawker Siddeley P.1127. The Soviet plane is based on the same general principle of using s cluster of cruise engines, and it may be regarded in any event as being equivalent to the British project.

Most Western countries today, including the USA, attach primary importance to aircraft of the STOL type. In so far as one can judge from the projects exhibited, it appears that this is the preponderant view in the USSR as well. At present no country in the world has so many new projects relating to supersonic aircraft of the STOL type.

In America there is one example of a plane with variable-sweep wings – the F-111 – and in France also one example – the Mirage G, which made its debut in flight only at the end of 1967. The USSR possesses two types of aircraft with variable-sweep wings, of which one is a fighter-bomber and the other is an interceptor.

The relatively small number of conceptions of aircraft with the stereotype forward inlet has been replaced by various conceptions employing all the types of supersonic inlets which are currently known in any new projects. The air inlets are located laterally on the fuselage, thereby affording sufficient space to install larger search radar systems and other modern electronic equipment.

Before the air show, the only known airplane capable of Mach 3 with a flight ceiling in the vicinity of 30,000 m was the American YF-12. With this plane it once again becomes possible to attack from very high flight profiles because the majority of known Z-V missiles are not effective at such altitudes for the purposes of such speeds. The new Soviet airplane capable of operating at Mach 3 now enters this field.

The vertical takeoff, short takeoff and variable-sweep wing capabilities of the Soviet planes show that they are not merely perfected prototypes but aircraft which have passed the phase of aerodynamic prototype testing.

Considering the large number of new prototypes and the vast sums which are required for such development, one is led to conclude that the USSR is again attaching the highest priority to the development of support aviation.

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