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# TRANSLATION

FLYING APPARATUSES TODAY AND TOMORROW

By

V. Myasishchev

## FOREIGN TECHNOLOGY DIVISION

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BY: V. Myasishchev

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## FLYING APPARATUSES TODAY AND TOMORROW

by

V. Myasishchev

With each discovery in the field of aviation science and technology and the implementation of new kinds of energy the possibility grows greater for the creation of newer and newer kinds of flying apparatuses. Fifty years ago there were two types of aircraft--for "passive" flight balloons, and for "active" flight airplanes. The first kind did not find much application. The second kind, however, is developed very intensively as a means of transportation and as a powerful military medium in armed conflict.

The flight characteristics of airplanes constantly increase. Only in the last 17 years the maximum speed increased, as an example, by a factor of 4, the altitude by a factor of 3, and the range by a factor of 2.

During this time there appeared new types of piloted and pilotless flying craft: helicopters, rockets for many purposes and of many sizes, and orbiting and space craft.

The program of the Communist Party of the Soviet Union with the maximum simplicity and precision determines the basic direction of the development of aviation:

"The newest reactive technology will receive further rapid development, above all in the field of aerial transportation and also for making use of outer space."

### Peculiarities of Modern Supersonic Airplanes

Airplanes of the new, supersonic "generation" distinguish themselves by the way their speed and altitude are increasing. The outlook is promising for efforts to improve the takeoff and ascent characteristics, in particular for shortening the takeoff run and landing runs to vertical flight, and for

full automation of the takeoff and landing under bad meteorological conditions.

The basic factors which assure the obtaining of the highest flight characteristics, as before, remain: systematic improvement in the aerodynamic quality of flying craft of all kinds and improvement in their takeoff and landing characteristics, increase in the weight-load efficiency, i. e., reducing the weight of the design and equipment, improvement in the characteristics of the power plant in the direction of decreasing the specific consumption of fuel and specific weight of the engine, and finally improving the dependability of the operation and resources of all the systems and designs.

(See page 2a for Fig. 1)

- (1)  
Speed up to 1,600—1,800 km/hr
- (2)  
Speed up to 2,100—2,500 km/hr
- (3)  
Speed up to 2,500—3,000 km/hr

Fig. 1. Designs of super-sonic aircraft

Let us consider, for example, some possibilities in the development of passenger aircraft of the near future in the light scientific and production strides in modern aircraft building.

In the next twenty years civil aviation will become a massive form of transportation. Even now the high-speed airplanes, particularly over the long routes, successfully compete with the railroads. This was eloquently brought out by the figures of Comrade N. S. Khrushchev at the 22nd meeting of the CPSU, "Civil aviation ... lifts into the air up to 100,000 passengers."

Further development of passenger aircraft will go along the line of cruising speed of flight; judging by the data from the foreign press, it will go from 950—1,000 km/hr at the present time to 2,000—2,300 km/hr in the 1966—1970 period, and up to 3,000 km/hr in the 1975—1980 period. With the increase in speed there will be a reduction in the time of the flight, and this will make it possible to decrease the number of operational aircraft required.

It is very important to take the latter circumstance into consideration

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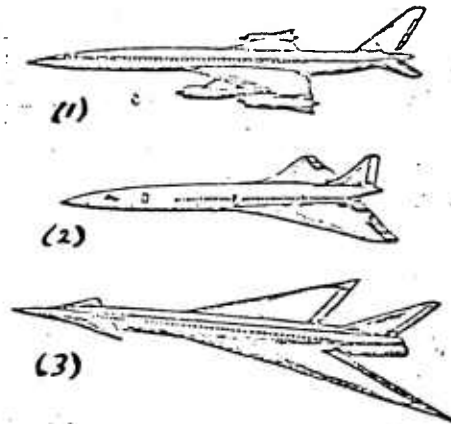


Fig. 1

in the technology of production. The fact is, on the one hand it is necessary to overcome many difficulties connected with the designing of minimum weight, and on the other hand lessening the cost of production with a relative small number of registered aircraft.

In Fig. 1 there are shown sketches of possible supersonic airplanes of the future. At the top there is shown an airplane with a speed of 1,600—1,800 km/hr. Its power plants can still be on pylons. The horizontal stabilizing is on the tail. The wing with a special set of profiles has very little thickness—up to 4%. The construction is of dural. Of course, this is not the only possible design. A tailless design, for example, will provide certain advantages with relation to aerodynamic qualities, and principally in reducing the weight of the construction, i. e., in increase in weight efficiency.

One of the possible schemes for speed is shown in the middle sketch. In its make-up it is very similar to the Franco-Anglican project the "Concord," for a cruising speed of 2,300 km/hr. The construction can be of dural with improved heat resistance.

At the bottom there is an airplane for a speed of 2,500—3,000 km/hr. Its power plants have intakes of great length under the wing. The horizontal stabilizing is flowing on the design of the "utka" [duck]. The wing is curled; its maximum thickness is 3—3.5%. The construction is of steel sheets with welding and power soldering.

The question of the speed of flight is often discussed at length in the foreign press, but its selection is determined by some simple considerations. With a cruising speed up to 2,000 km/hr the construction is very close to the limit of heat resistance for aluminum alloys about which there has been accumulated a great deal of experience in industry and operation.

For the supersonic passenger airplane the choice of cruising speed of 3,000 km/hr in the U. S. A. is explained by the desire to assure certain "reserves"



in the competition struggle. This choice is based on the experience of the North American Company in the creation of the RB-70, the Valkyrie, and the Navajo distance rockets.

#### Some Basic Parameters of the Aircraft of the Near Future

Since the basic parameters in the designing which determine the optimum flight data for the aircraft are provided by the high values for the aerodynamic quality of the aircraft and its weight efficiency let us acquaint ourselves with a few concepts of their possible characteristics.

The figure for the aerodynamic quality, i. e., the ratio of the lifting force to the resistance to the motion of the flying apparatus is the basic index of the make-up of the aircraft. It depends basically on a number of geometric factors: dimensions, form, and quality of the surface of the wing, the tail unit, and the fuselage.

The aerodynamic make-up takes in the possibility of changing the geometric dimensions in flight, both as a result of different air loads which vary in amount and in connection with the kinetic heating of the construction. The temperature of the surface with a speed of 2,000 km/hr goes up to 75--110°C, and at a speed of 4,000 km/hr 380 to 550°C.

By putting together in realistic make-ups the effect of the compressibility of the air and the different forms and dimensions of an aircraft on the basis of modern aerodynamic researches it is possible to get a concept of the possible values for the aerodynamic quality  $K$  at different supersonic speeds of flight. In Fig. 2 there is shown the range for the possible values of  $K$ . At Mach 2.0 the value for  $K$  can be from 6.0 to 8.0 and at Mach 3.0 from 5.5 to 8.0.

Such a broad range of values of aerodynamic quality is explained basically by the possible range of geometric ratios. First of all this is the figure for the area of the wing. The quality increases with decreasing load per square meter of wing, which now approaches the realistic optimum of 350 to

375 kg/m<sup>2</sup>, of course, with great difficulties arising in the assuring of high weight efficiency, thereupon the relative thickness of the wing, determined as 3.5—4% for Mach 2 and as 3.0—3.5% for M 3.0 and higher. Further, there is

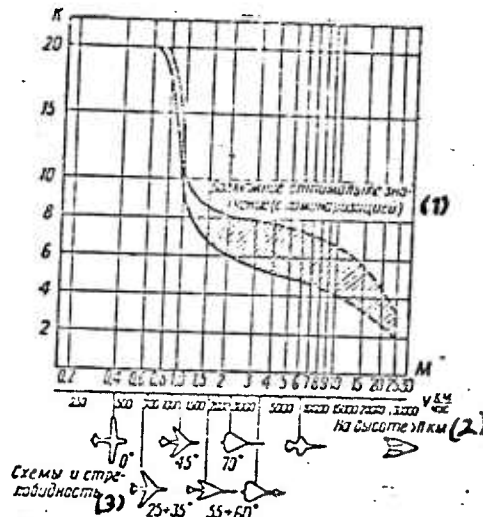


Fig. 2. Aerodynamic quality of flying apparatuses.

Key: (1) possible optimum value (with lamination); (2) at altitude > 11 km; (3) sweepback scheme.

there is the form and quality of the surface of the wing, the tail unit, and fuselage from the point of view of the effect on the lamination of the flow around these surfaces, and the artificial lamination of the flow around as a means of controlling the boundary layer of air.

Individual foreign scientists consider that it is possible to plan the scientific and research work and from computation attain by 1975 for the optimum supersonic aircraft the maximum quality, equal to 10.

Constantly more research and experimental work is being done now in the field of the wing's make-up with changeable geometry in flight.

Such a wing with a variable sweepback quality and relative span would assure the optimum figure for the aerodynamic quality under different modes

the general resistance of the power plant as a consequence of the dimensions of the engine, and, particularly the ratio of the inside diameter to the outside one, which should be the very greatest. Here is also an interference of the power plant with the wing or fuselage on which it is located. The make-up of the power plant of a supersonic airplane, perhaps, is the most difficult area. There are examples where the power plant reaches 35—40% of the resistance of the aircraft. Finally,

of flight from subsonic speed with take-off, landing, and run to supersonic speed in cruising-speed operation. In Fig. 3 there are shown some possible schemes of aircraft with changeable geometry in flight.

The creation of realistic designs with such a wing will make it possible to shorten the take-off run and the landing run and bring us closer to the solution of the problems connected with the creation of vertical flying aircraft.

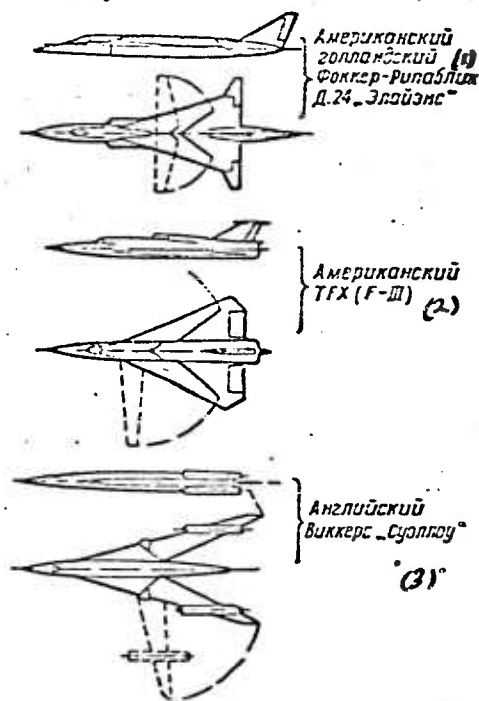


Fig. 3. Designs of airplanes with changeable geometry of the wing

Key: (1) American Dutch Fokker-Republic D-24 Alliance; (2) American TFX (F-III); (3) English Vickers Swallow

load and the weight of the fuel will be, and, consequently the distance of the flight.

The weight efficiency of the aircraft built at the present time is de-

A great deal of attention has been given to the lessening of the action of the sonic boom on ground objects, this being the shock wave that is produced when an airplane, especially a large one passes through the sound barrier. It is considered that the pressure caused in this way should not go above  $5-6 \text{ kg/m}^2$ .

The weight efficiency which characterizes the ratio of the fully load to the full flying weight of the aircraft serves as a basis for an index of the perfection of the design and the equipment of the aircraft. The less the weight of the construction and the equipment of the aircraft the greater with the same flight weight the useful

terminated by the static ratios shown on the scale of the graph (Fig. 4). From it there is seen the possibility of further increasing the weight efficiency of aircraft of recent years.

We have already said that the efforts to obtain the greatest aerodynamic quality lead to a diminution of the specific load on the surface of the wing, but this in turn decreases the weight-ratio efficiency of the aircraft. Therefore unremitting work is going on in the rationalization of the design by means of the use of new high-quality materials which enable one to lower the weight of the construction and the equipment.

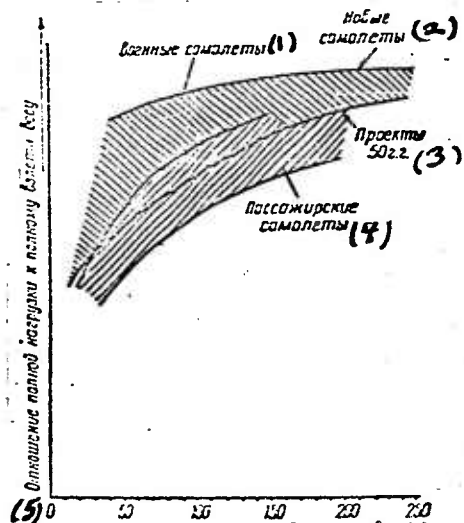


Fig. 4. Weight ratio (by static data)

Key: (1) military aircraft; (2) new aircraft; (3) projects of the fifties; (4) passenger aircraft; (5) ratio of useful load to take-off weight.

In Fig. 5 there is shown the diminution in the relative weight of the construction of aircraft during the last thirty years with simultaneous increase in the speed of flight. We see that the average values for the relative weight is improving in recent years very noticeably, being reduced by about 40%. The fact is that meanwhile the flying weight itself of aircraft of all types is increasing, and this is brought about by the pursuit of distance in flight.

The increase in the weight of the useful load and distance of the flight with the greatest possibility for the speed of the whole trip has the effect of reducing the cost of the transportation and therefore serves as the basic economic index for civil aviation, besides also for all kinds of transportation.

Progress in the development of all the basic characteristics of the air-

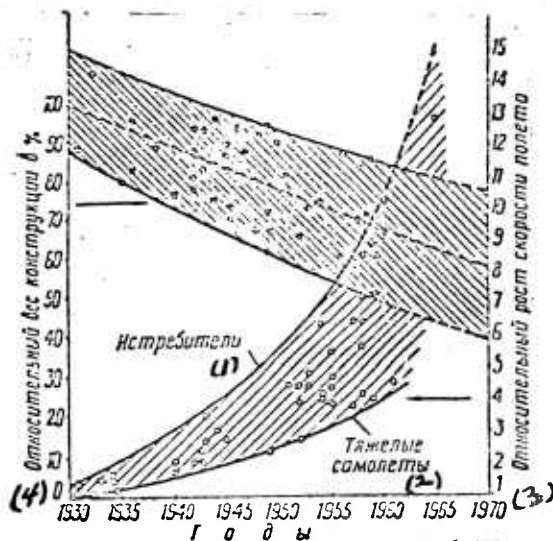


Fig. 5. Change in the relative weight of the design.

Key: (1) fighters; (2) heavy aircraft;  
 (3)  $\text{relative speed in flight speed} = \frac{\text{current wt. fraction}}{\text{1930 wt. fraction}}$   
 (4)  $\text{relative structural weight in \%} = \frac{\text{current Wt. fraction}}{\text{1930 Wt. fraction}}$

plane was assured in the first place by the very great amount of work not only on the aerodynamic design, but on the construction, which we have already noted, and on the creation of new highly resistant materials and new technological processes.

The high figures for the weight-ratation efficiency at high speeds require the best use of the construction materials. There is very rational construction of honeycomb panels of dural glued and of steel soldered. They enable one to obtain very strong,

thin-walled casing everywhere supported by honeycomb filler, especially under conditions of the heating of these constructions during high speed of flight.

#### Problems of Hypersonic and Outer-space Craft

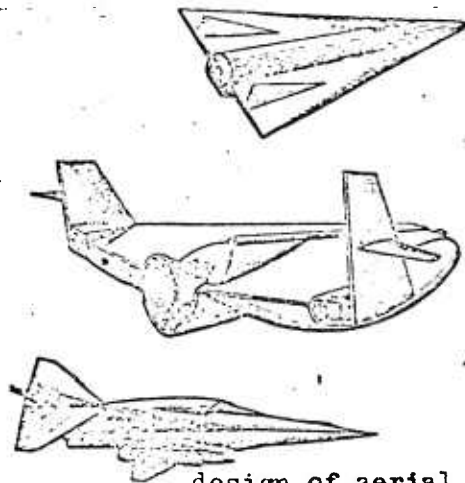
The decisive transition from earth aircraft transportation to outer-space transportation will be by the use of rockets and rocket planes on the basis of using rocket carriers created for research purposes. In the beginning they will be used probably for the carrying of mail and freight and afterwards also passengers, both to different points on the earth and on space flights.

In connection with the great progress in the investigation of outer space, particularly in our country, and the development of hypersonic dynamics, one may assume that not far distant is the conducting of systematic research flights, and then passenger transportation in outer space.

Scientists and designers in many / countries / of the world are working on the solution of a number of basic problems which arise in the creation of such space apparatuses, in particular, of the space aircraft, i. e., an aircraft capable of autonomously changing the trajectory of its flight in the upper reaches of the atmosphere and in landing.

First of all it is essential to assure safe conditions for the life of people in flying at altitudes of 100 km and higher and under the heating of the casing of such a space vehicle up to 800—1,000° (in the optimum version) and up to 2,000°C at separate places in the construction. In this respect Soviet scientists, constructors, and astronauts have made brilliant achievements well known from the literature.

An important position is occupied by questions of aerodynamics in take-off and landing, stability, and dirigibility in flight. The constructors of hyper-



design of aerial  
and orbital aircraft  
Fig. 6. Projects of air-space and orbital flying apparatuses.

sonic flying apparatuses at first were able to ignore some problems of classic aerodynamics by taking as a basis symmetrical geometric forms. However, after deeper research of the hypersonic aerodynamics of bodies in the passing from an orbit to the ground the specialists find constantly more use for the influence of aerodynamic design on the speed and dirigibility, on the local speed of the flow around,

and on the temperature of the heating, which is considered one of the basic problems of flight from an orbit.

In Fig. 6 there are shown different projects for air-space and orbital flying apparatuses developed by scientific institutes and design bureaus

of many countries. Characteristic of these projects is the use of different hypersonic forms, positive interference, and increased pressures, as well as the obtaining of step-shocks for improving the hypersonic aerodynamic quality. All this is indispensable for assuring that the accelerations and overloads are not great in maneuvering in the atmosphere for choosing the landing zone and lessening the surface temperature.

By following this course it is possible to get temperatures that are withstandable by modern construction steels and titanium alloys.

Individual foreign investigators are now considering a new direction in this matter--the use for braking on reentry into the atmosphere of the principles of magnetogas dynamics. One has in mind the substitution of a hard aerodynamic surface by an invisible magnetic field. The entrance of a body into the atmosphere at an extremely high speed (20,000 km/hr and more) is accompanied by heating and ionization of the surrounding gas to such a degree that it becomes a relatively good conductor of electricity. This can assure the necessary interaction of the gas with the magnetic field and with a body without hard aerodynamic surfaces. For the construction of such apparatuses there are pressing motives because of the great heating of the surface (up to 2,000°C) and the need for preserving definite strength and rigidity. Meanwhile there should be provided heat-insulation of the cabin and the instrument sections, especially when descending from orbits with greater coefficients of lifting force than in a ballistic descent and longer ones in order to assure control in landing the apparatus. All this should be accomplished with a minimum of weight.

The basic design directions in the development of orbital and space vehicles are being formulated around the main problem--the creation of a heat-resistant design with minimum weight. It is considered that such designs can be of two types: "hot" and "cold."

The "hot" designs are such as get hot and are capable of operating the necessary time at high temperatures. The radiation of heat is accomplished by carrying or noncarrying heat insulation, and the absorption of heat by the carrying away of masses of low or high temperature. Ballistic descent will give examples of the solution of such "hot" designs for the briefest time of return from orbit.

"Cold" designs with passive or active cooling are indispensable for flying apparatuses spending a longer time in the atmosphere than the "hot" ones, especially where their use is repeated. Here it is possible to use designs with heat absorbers, metals, their oxides, and graphites, and also with convective methods of cooling by water, gases, or liquids. The elastic properties of ceramic heat shields are considerably improved by the chemistry of silicates.

The methods of solving the problem of the creation of heat-resistant designs are listed here in the order in which the degree of difficulty in their accomplishment increases. However, the weight advantages of the more difficult methods of heat protection are so great that their development is very attractive.

\* \* \*

As we see the development of scientific and project researches of many promising flying apparatuses finds itself on a high level. This offers a possibility for hoping for the successful solution of a number of concrete design problems, which leads to still more rapid progress in aviation.



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