Civil and military aviation are continuing to develop in the USA. According to the data in [1], jet fuel consumption for military aviation amounted to approximately 28 million tons in 1969. Fuel consumption for civil aviation is expected to increase from 25 million tons in 1968 to 50 million tons by 1975 [2]. The commercial grades of jet aviation fuels have been standardized in the USA. In military aviation, the JP-4 grade has mostly been used for the past 15 years. Feed sources are more readily available for this grade than for others, since it is produced [3] from the benzene-ligroin fraction (a mixture of 65% benzene and 35% ligroin). In civil aviation, fuel with a higher flash point than JP-4, namely the Jet-AI and Jet-A grades, are used [4]. Although JP-4, Jet-AI, and Jet-A are intended for subsonic aviation, their thermal stability is laid down as a binding requirement in their specifications and is, consequently, checked. The quality of the jet fuels in use is most often much higher than the minimum laid down in the standards [5]. During the whole period in which jet fuels JP-4, Jet-AI, and Jet-A have been used, there have been no reports of serious complaints concerning their quality. The fuel specifications obviously reflect the actual requirements determined by operating conditions, and the aircraft fuel system operates well in contact with these fuels.

Jet fuel specifications in the USA do not stipulate or prescribe the feed and production technology for the fuels, nor their blend composition (blending methods). The specifications lay down only the obligatory minimum qualitative characteristics of the fuels, which must be ensured, regardless of their source and production technology. For this reason, any industrially feasible method of producing petroleum distillates can be used.

In the final production stage of jet fuels in the USA, various methods of improving oil fractions are used [6]. In order to eliminate mercaptans, the fractions are treated with a copper chloride solution. In order to remove impurities and water, the fuel is filtered through activated clay or a coalescent salt bed. To improve thermal stability and, consequently, to remove the tarry substances, the fuels are passed through bentonite clay or some other active earth. In some cases, the straight-run petroleum distillates used as reforming feed are also subjected to sulfuric acid refining, followed by neutralization with an aqueous alkali solution. According to experts, this procedure is twice as cheap as hydrofining. Improvement by hydrofining, hydrocracking, and even moderate hydrogenation, in which part of the aromatics are converted into naphthenes, is very common. The distillates thus obtained always have high thermal stability, a higher combustion value by weight, and improved combustion characteristics.

In the USA, a two-stage industrial apparatus is being used successfully for the hydrofining of straight-run distillates and for hydrocracking [7]. The first stage of the vapor-phase catalytic hydrogenation apparatus removes from the distillate unsaturated hydrocarbons and organic nonhydrocarbon impurities such as sulfur-, nitrogen-, and oxygen compounds. In the second stage, the aromatic hydrocarbons are partially converted into naphthenic hydrocarbons with a somewhat different catalyst. The process takes place at a temperature between 288 and 427°C and a pressure of 42-70 atm. The hydrogenation product used in the blending of the jet fuel contains 4.5-12.5 vol.% of aromatic hydrocarbons (instead of the initial 22-27 vol.%) and 87.5-95.5 vol.% of paraffinic and naphthenic hydrocarbons (instead of 57-78 vol.%); the fuel has a smoke point of 24-30 mm (instead of 15-17 mm).

For preparing jet fuel, the manufacturers use the hydrocracking component, in particular that obtained from the “isomax” process [2]. They thereby obtain a high yield of distillate (57-85 vol.% on feed) suitable for the preparation of jet fuels from the high-boiling vacuum gas-oil, often with a high sulfur content. The hydrocracking product does not contain sulfur-, nitrogen-, and oxygen compounds, and the residual amount of aromatic hydrocarbons is limited (10-11 vol.%).

It is clear from the above that the fuel obtained from subsonic aviation by blending the improved components does not require additives, although in case of necessity their use is admissible.
An intensive search is meanwhile being conducted for a military aviation fuel with a higher flash point than JP-4, since aircraft losses in Vietnam due to the inflammation of fuel and explosion of fuel tanks are high [3]. It appears that JP-4 will be replaced by the less volatile JP-8, which has higher boiling and flash point and lower vapor tension [8].

Throughout the world, investigators have long been discussing the problem of the quality and composition of supersonic aircraft fuels. The work in this field has taken a concrete turn in connection with the appearance of the first supersonic airliners such as the TU-144, Concorde, and Boeing-70.

In general, the fuels for supersonic aircraft, which must fly at altitudes of up to 20 km and more, will, in contrast to subsonic aircraft fuels, have improved antiwear properties (lubricity) and thermal stability, a higher flash point, lower vapor tensions, and higher heat capacity. It has now become extremely clear that it is meaningless to discuss the problem of supersonic aircraft fuels without taking into account operating conditions and flight speed. Quality requirements for fuel can be established only in the light of actual speed conditions and flying time of the aircraft, while the selection of feed and cost depend on those requirements.

Requirements with respect to the thermal stability of fuels (the temperature at which the fuel components should not undergo oxidative condensation) as a function of the flight speed of the aircraft are shown as a curve in Fig. 1 [9].

The first supersonic airliners will have a speed between 2 and 2.5 Mach (2-2.5 times the speed of sound), at an altitude of 20 km. The temperature of the fuel in the aircraft tanks at the end of 3 h of flight at that speed will not exceed 100-120°C [10]. This means that, as far as the thermal stability is concerned, commercial fuels produced for subsonic aircraft will be suitable for supersonic aircraft with speeds of 2-2.5 Mach [9]. At the same time, the use of JP-4 will be ruled out by its high vapor tension. JP-4 starts to boil at a height of 19 km; in order to prevent boiling, it must be in the fuel tank at an overpressure of 0.14 atm.

In the USA, it is considered that Jet-AI and Jet-A, and also JP-5, will be satisfactory hydrocarbon fuels for speeds up to 2.5 Mach. The characteristics of these fuels are similar. For a flight speed up to 3 Mach, it is planned that JP-6, which is distinguished from JP-5 by higher thermal stability, be used.

Investigators in the USA are working on a high-temperature hydrocarbon fuel, sometimes called JP-7, for aircraft with flight speeds up to 3.5 Mach. Its characteristics, and also those of JP-5 and JP-6, are given in Table 1. JP-7, which is thermally stable up to 345°C, is distinguished by high heat capacity, low vapor tension, and a higher flash point. Reportedly, it consists of isoparaffinic and naphthenic hydrocarbons but not aromatics. It is considered that, if the dissolved oxygen is removed from JP-7, it can be used for aircraft with speeds of up to 4.5 Mach.

Fuels intended for supersonic aircraft must have sufficient lubricating properties (antiwear properties). The pumpability of a hydrocarbon mixture having a viscosity range between 5 and 15 cS will decrease with heating.

At the same time, it must be borne in mind that the thermochemical stability of fuels composed of inadequately prepared components will have to be improved. An improvement of the operating properties, above all the thermochemical stability and antiwear properties, of fuels intended for supersonic aircraft may, in the opinion of experts, also require the use of effective additives [10].

The future solution of the fuel problem in the USA can be analyzed as follows. It is impossible for hydrocarbon fuels which are also used as cooling liquids in aircraft to remove more heat than 280 kcal/kg of fuel without additional operations. Therefore, to ensure both functions (those of coolant and fuel), at an aircraft speed of up to 5 Mach, the fuel must be prevaporized. The heat removal due to vaporization amounts to 550 kcal/kg. For this type of fuel, only individual hydrocarbons or mixtures of hydrocarbons suitable for vaporizing can be used [11].

For aircraft with speeds up to 5.5 Mach, the possibility of increasing heat removal through a chemical reaction (thermal or catalytic) with the fuel, taking place directly in the aircraft with heat absorption (endothermic fuels) is being discussed. The endothermic reaction removes the excess aerodynamic heat and the heat of overheated apparatus, and the reaction products are sent to the combustion chamber as fuel. There are many difficulties impeding realization of this project.