CHAPTER IX

Wartime Production Solutions

HF Alkylation

A number of processes for producing components of aviation gasoline came into use during or slightly before the war and made important contributions. The most important of these was HF (anhydrous hydrofluoric acid) alkylation developed by Universal Oil Products Company (hereafter UOP) and by Phillips Petroleum. HF was used as a catalyst in place of sulfuric acid in the older alkylation process. Both alkylation processes had their peculiar advantages depending upon locality and the raw materials available.

Isomerization

The next most important was isomerization developed by Shell, UOP, and Standard Oil Company (Indiana), referred to hereafter as Indiana. The most important use of these processes consisted of converting normal butane to isobutane and normal pentane to isopentane. Isobutane thus produced was an important factor in alkylate production since insufficient isobutane was available from natural and other sources. Isopentane was an important constituent of Grade 100/130 and isomerization of the normal pentane of 40 PN, which could not be used in Grade 100/130, resulted in isopentane of 76 PN. The Indiana Isomate process isomerized normal butane, normal pentane, and normal hexane. Isomerization of normal hexane produced neohexane of about 80 PN but this was done on a very limited scale.

Hydroforming

The hydroforming process of the Kellogg Company was in limited use before World War II for the production of high octane motor gasoline. During the war hydroforming (otherwise catalytic reforming) was installed on a much larger scale for the production of toluene used for TNT. Xylenes were produced as by-products of toluene and these were used in Grade 100/130 and for the production of xylidine. Toluene is the ideal aromatic as regards use in aviation fuel but was not available for such use except for occasions when produced in excess of TNT requirements.

Triptane

After the supercharged engine tests of triptane referred to above, considerable interest was aroused in further exploration of this material. This interest resulted in agreement to have some 300 gallons produced at a cost of $30 per gallon and of this Wright Field agreed to buy 125 gallons for test in an aircraft engine. The 300 gallons were produced by the Dow Chemical Company using a synthesis method evolved by the Ethyl Corporation and requiring about 2 lb of magnesium metal for each gallon of triptane produced. The Army in 1941 tested triptane in a Pratt & Whitney 1830 engine developing about 1,400 hp and found that without lead it had 100 lean PN and about 165 rich PN. This test showed that triptane was equal to the octane of the octane scale under severe (lean) engine conditions and much better under mild (rich) conditions, and these findings supported the view that triptane was the best hydrocarbon for an aviation fuel that had been seen to that date. Even at this late date the Army test of triptane in a 1,400 hp engine seemed a very courageous effort even though only $3,000 worth of fuel was involved and the engine test must have involved less than $3,000 even if allowances were made for a possible engine wreck. This general view of experimental fuel costs appears distorted when the results of the explorations of 100 PN fuel are considered. However, the view was still widely held at the time of the Army tests. The Army findings were confirmed by Wright Aero at a somewhat later date. Wright used a single-cylinder engine equipped with a Cyclone R-1820 cylinder.

General Motors Triptane Plant

After these tests Kettering decided that triptane needed testing on a much larger scale and that it could not be properly evaluated as a potential aviation fuel until it was available in tank car (about 10,000 gallons) quantities. Consequently, the Research Laboratories Division of General Motors explored new methods of triptane manufacture and evolved one which was more economical than the one used by Dow and which did not involve the use of metallic magnesium. General Motors, with priorities sponsored by the Army but without government financial support, built a plant at a cost of about half a million dollars which produced around 150 gallons per day of triptane from about the end of 1943 to the end of 1945 and the material was supplied without cost to the agencies which were testing it. The Army sponsored the triptane program but requested NACA to evaluate the material either as a constituent of an aviation fuel or as a whole fuel. As a whole fuel, triptane with 4 cc lead was explored in single cylinders of various aircraft engines but none had sufficient mechanical strength to produce knock on this fuel blend without wrecking the cylinder. In fact, very few laboratory engines used for fuel evaluation with supercharging were strong enough to permit triptane +4 cc lead to be appraised. NACA, however, carried out a very complete evaluation of triptane in blends with Grade 100/130. Tests were carried out in the laboratory on single-cylinder engines and on complete aircraft engines and also with Pratt & Whitney 1830 engines in flight. The NACA tests showed triptane to have the highest effective PN of any then known possible hydrocarbon component of aviation fuels.

Allison tested a blend of triptane with Grade 100/130 and developed 2,800 hp in a V-1710 engine for a short period.

Triptane the Best Potential *Aviation Fuel*

The entire engine test program of triptane has confirmed the view that it is the ideal aviation fuel. There are only two objections to triptane; one is its relatively high freezing point, but this difficulty can be overcome by blending with about

15% isopentane, such blending being necessary in any case to obtain the volatility necessary for service use. The important objection to triptane is the fact that it cannot currently be produced at a cost of less than several dollars per gallon, the high cost being associated with equally large manpower requirements.[1]

Triptane's Contribution to Knowledge of Fuel Behavior

While triptane has shown no sign of becoming available as an aviation fuel, the engine tests of it have greatly enlarged the knowledge of engine performance of fuels. This knowledge was further extended by the General Motors triptane plant which produced a number of pure compounds as by-products of triptane production. Some of these by-products and notably some branched chain paraffins were, for the first time, produced in sufficient quantity to permit complete engine evaluation.

[1]See above, pp. 655-656.