

## CHAPTER 1. - INTRODUCTION

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For 11 years the Bureau of Mines, U. S. Department of the Interior, carried on extensive investigations under authorization of the Synthetic Liquid Fuels Act of April 5, 1944 (30 U. S. C. 321-325 and amendments). This program was authorized by the 78th Congress to establish methods for producing oil from coal, oil shale, and other substances. Although research and development on producing oil from coal and oil shale had been carried on before and continue now as part of the regular Bureau of Mines program, it is the purpose of this report (Part 1. - Oil From Coal - of the two-part series) to summarize contributions made under the act from 1944 to 1955 and to furnish references to publications in which more detailed descriptions of results may be found. Part 2. - Oil From Shale - will be published later.

## Reasons for the Synthetic Liquid Fuels Program

Despite recurrent predictions of shortages of petroleum and actual shortages during periods of national emergency, American demands for gasoline and fuel and lubricating oils have continued to be satisfied from petroleum since the first oil well was drilled near Titusville, Pa. Yet it has long been recognized that petroleum reserves, though large, are not inexhaustible. Gradual dwindling of American petroleum production has been predicted variously as due to begin within one or two generations. In fact, increasing American production has not kept pace with the still more rapidly growing demand during and since World War II. Development of large oilfields in the Near East augmented the known world supply and led to increasing importation of oil into the United States. But such imports, although a quick and inexpensive way of balancing demand with production, are subject to foreign control, and shipments might be interrupted in time of war.

Meanwhile, it had been recognized also that the much larger reserves of coal and of oil shale provide a sure supply of fuel (within the borders of the United States) sufficient to last many hundred years. Abroad, notably in Germany where petroleum was scarce and had to be imported, conversion of the relatively abundant coal to liquid fuels had been studied extensively and eventually scaled up to industrial size. During World War II, fuel for the Nazi war machine was supplied to a considerable extent from synthetic liquid fuel plants, and these plants became prime targets for Allied bombing attacks.

These considerations, which were discussed in congressional hearings (9, 11, 12, 13)<sup>3/</sup> by technical experts and scientists from industry and Government, led to the decision by the Congress that every effort should be made to develop new domestic sources of fuel oil, lubricants, and gasoline. One approach to this problem was to support a research program that could revive and expand oil-shale research, apply the proven German processes to the coals of the United States, develop and improve the technology and materials, and develop new methods for converting oil shale and coal to synthetic liquid fuels.

The Bureau of Mines had already reported on research on synthetic liquid fuels - during 1925-29 on oil from oil shale and in 1928-30 and 1937-44 on oil from coal. A much enlarged program was now begun under the legislation enacted in 1944.

### The Synthetic Liquid Fuels Act of 1944 and Its Amendments

#### Basic Synthetic Liquid Fuels Act of April 5, 1944 (58 Stat. 190)

Public Law 290 of the 78th Congress, as approved April 5, 1944, contains the following pertinent portions:

AN ACT Authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances, in order to aid the

<sup>3/</sup> Underlined numbers in parentheses refer to items in the list of references cited at the end of each chapter of this report.

prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior, acting through the Bureau of Mines, within the limits of critical materials available, is authorized for not more than five years to construct, maintain, and operate one or more demonstration plants to produce synthetic liquid fuels from coal, oil shale, and other substances, and one or more demonstration plants to produce liquid fuels from agricultural and forestry products, with all facilities and accessories for the manufacture, purification, storage, and distribution of the products. The plants shall be of the minimum size which will allow the Government to furnish industry the necessary cost and engineering data for the development of a synthetic liquid-fuel industry and of such size that the combined product of all the plants constructed in accordance with this Act will not constitute a commercially significant amount of the total national commercial sale and distribution of petroleum and petroleum products. Any activities under this Act relating to the production of liquid fuels from agricultural and forestry products shall be carried out in cooperation with the Secretary of Agriculture and subject to the direction of the Secretary of Agriculture.

SEC. 2. In order to carry out the purpose of this Act, the Secretary of the Interior is authorized -

(a) to conduct laboratory research and development work, and with pilot plants and semiworks plants to make careful process engineering studies along with structural engineering studies in order to ascertain lowest investment and operating costs, necessary to determine the best demonstration plant designs and conditions of operation;.....

SEC. 6. There is authorized to be appropriated not to exceed the sum of \$30,000,000 to carry out the provisions of this Act.

Amendment of March 15, 1948 (62 Stat. 79)

This amendment extended the work from 5 years to 8, increased the authorization from \$30,000,000 to \$60,000,000, and broadened section 1 of the act as follows:

....and that not to exceed \$1,000,000 of the amount authorized by this Act may be applied to a program of production research on secondary recovery from stripper oil fields and in refining processes.

Amendment of September 22, 1950 (64 Stat. 905)

The second amendment further extended the work from 8 years to 11 years, increased the authorization from \$60,000,000 to \$87,600,000, and provided:

SEC. 2. Of the sum authorized in section 1 of this Act, not to exceed \$2,600,000 shall be used for the construction and equipment of an experiment station in or near Morgantown, West Virginia, for research and investigation in the mining, preparation, and utilization of coal, petroleum, natural gas, peat, and other minerals.

### Appropriations for Research and Development Under the Act

Of the \$87,600,000 authorized, \$85,179,730 was appropriated. After expenditure for producing excess power at the demonstration plant at Louisiana, Mo., and unexpended amounts were subtracted, the net expenditures on the program during the 11-year period were about \$82,000,000.

Allocations to the various phases of research and development are summarized in table 1. Table 2 gives estimates, which were made from the information available, on the construction and major equipment cost of the special experiment stations and demonstration plants.

### Location of the Work

Experimental work under the act was aided by the activity of the Technical Oil Mission to Germany and the Technical Industrial Intelligence Committee, in which senior Bureau of Mines personnel was involved during 1945 and later (1 - 6). Survey teams visited German synthetic liquid fuels plants and laboratories and oil-shale installations in Europe, Australia, and South Africa, interrogated scientific and engineering personnel, and collected documents describing plants and processes. This information was used in research, development, and demonstration-plant work.

All investigations under the act were carried on in the various experiment stations and demonstration plants as described below. Only the coal-to-oil research, however, is discussed in further detail in the body of this report.

### Coal Research

Central Experiment Station, Pittsburgh and Bruceton. - The Central Experiment Station of the Bureau of Mines in Pittsburgh, adjoining the campus of Carnegie Institute of Technology, had already carried on laboratory and pilot-plant investigations on coal hydrogenation and on the Fischer-Tropsch synthesis.<sup>4/</sup> With passage of the act in 1944, these studies were expanded. The work was later transferred to new buildings (fig. 1), erected between 1945 and 1948 on the grounds of the Bureau's Experimental Coal Mine at Bruceton, Pa., about 13 miles south of Pittsburgh.

<sup>4/</sup> Many of the technical terms used in this report, such as coal hydrogenation and Fischer-Tropsch synthesis, are explained in the Glossary, Appendix I.

TABLE 1. - Allocation of appropriations under synthetic liquid fuels program for fiscal years 1945-55

| Fiscal year | Coal research and development |                           |                                   | Coal demonstration       |               |                           | Oil shale                |           | Total for construction/ | Total appropriations/ |                     |
|-------------|-------------------------------|---------------------------|-----------------------------------|--------------------------|---------------|---------------------------|--------------------------|-----------|-------------------------|-----------------------|---------------------|
|             | Hydrogenation                 | Fischer-Tropsch synthesis | Gasification and gas purification | Underground gasification | Hydrogenation | Fischer-Tropsch synthesis | Research and development | Mining    |                         |                       | Demonstration plant |
| 1945.....   | \$2,000,000                   | \$325,000                 | \$425,000                         | \$ -                     | \$260,000     | \$80,000                  | \$585,000                | \$215,000 | \$700,000               | \$2,403,399           | \$5,000,000         |
| 1946.....   | 1,212,885                     | 1,212,885                 | 172,000                           | -                        | 2,196,660     | 542,000                   | 224,680                  | 348,760   | 1,090,130               | 3,937,398             | 7,000,000           |
| 1947.....   | 560,720                       | 560,720                   | 250,000                           | -                        | 1,078,046     | 1,042,000                 | 428,514                  | 187,189   | 1,142,811               | 2,124,000             | 5,250,000           |
| 1948.....   | 750,000                       | 750,000                   | 275,000                           | -                        | 3,000,000     | 500,000                   | 375,000                  | 350,000   | 1,000,000               | 2,378,524             | 7,000,000           |
| 1949.....   | 962,500                       | 962,500                   | 346,285                           | 500,000                  | 3,453,715     | 4,925,000                 | 500,000                  | 400,000   | 1,700,000               | 7,680,000             | 14,385,000          |
| 1950.....   | 878,781                       | 878,781                   | 385,295                           | 385,295                  | 1,997,113     | 2,628,360                 | 597,978                  | 436,668   | 1,561,729               | 1,671,079             | 9,750,000           |
| 1951.....   | 829,780                       | 829,780                   | 474,000                           | 201,260                  | 2,026,370     | 1,728,000                 | 510,154                  | 148,266   | 1,651,890               | 718,100               | 8,999,500           |
| 1952.....   | 708,490                       | 701,410                   | 683,890                           | 119,510                  | 1,768,200     | 1,557,700                 | 480,406                  | 148,166   | 1,466,500               | 718,802               | 8,116,822           |
| 1953.....   | 684,400                       | 684,400                   | 3,375,000                         | 141,700                  | 1,704,300     | 1,488,500                 | 482,300                  | 151,500   | 1,323,204               | 2,850,000             | 10,450,304          |
| 1954.....   | 772,600                       | 672,600                   | 857,100                           | 56,300                   | 148,500       | 148,500                   | 482,300                  | 218,000   | 1,323,204               | 200,000               | 4,679,104           |
| 1955.....   | 767,600                       | 667,600                   | 850,000                           | -                        | -             | -                         | 476,800                  | 218,000   | 1,039,000               | -                     | 4,019,000           |
| Total....   | 10,127,756                    | 8,245,676                 | 8,093,570                         | 1,404,065                | 17,632,904    | 14,640,060                | 5,143,132                | 2,821,549 | 13,998,468              | 24,681,302            | 85,179,730          |

1/ Construction figures are included also in the separate allocations to the several lines of work.

2/ Total appropriations include the following special allocations, not included in regular allocations shown above:

excess power production (1949, 1951, 1952, 1953)..... \$2,262,550  
research on agricultural residues (1945, 1949)..... 510,000  
research on secondary recovery and refining of petroleum (1949)..... 300,000

TABLE 2. - Estimated total cost for construction and major equipment in synthetic liquid fuel research establishments

| Establishment   | Cost        |
|---|-------------|
| Experiment Station, Bruceton, Pa.....                     | \$3,500,000 |
| Experiment Station, Laramie, Wyo.....                     | 750,000     |
| Experiment Station, Morgantown, W. Va.....                | 3,000,000   |
| Coal-Hydrogenation Demonstration Plant, Louisiana, Mo.... | 10,000,000  |
| Fischer-Tropsch Demonstration Plant, Louisiana, Mo.....   | 5,000,000   |
| Oil-Shale Demonstration Plant, Rifle, Colo.....           | 8,000,000   |

Appalachian Experiment Station, Morgantown, W. Va. - Gasification of coal and purification of the gas produced have been studied at Morgantown, W. Va., at first in space made available in West Virginia University buildings. The new Appalachian Experiment Station (fig. 3), 5 miles north of Morgantown, was erected between 1952 and 1954.

Demonstration Plants, Louisiana, Mo. - Demonstration plants for converting coal to liquid fuels were erected on the site of a former synthetic ammonia plant at Louisiana, Mo., which was made available by the War Department in December 1945. Construction of a demonstration plant for coal hydrogenation (see fig. 2) was started in May 1947, and the plant began operating in 1949. A plant for the Fischer-Tropsch process (fig. 2) was contracted for in March 1948, completed in 1950, and in full operation in 1951.

Work at Louisiana was discontinued May 29, 1953. The plants were put in standby condition and returned to the Department of Defense in September 1953.

Underground-Gasification Project, Gorgas, Ala. - In 1946 the Alabama Power Co. made available a tract of coal land at Gorgas, Ala., for studying underground gasification of coal. The aim of this field-scale work has been to find methods for economically converting unmined coal into gas.

### Oil-Shale Research

Petroleum and Oil-Shale Experiment Station, Laramie, Wyo. - Laboratory and pilot-plant studies on producing oil from oil shale were started in 1944 in laboratories set up in University of Wyoming buildings. A new Bureau of Mines experiment station was begun in 1945 on a site adjoining the University of Wyoming campus and completed in 1947 (fig. 4).

Experimental Mine, Rifle, Colo. - Large-scale work on oil shale was located on Naval Oil-Shale Reserve land near Rifle, Colo. The site was selected, and preparations for mining were started in 1945. The mine was operated both to provide oil shale for the demonstration plant and to develop and improve mining techniques.

Demonstration Plant, Rifle, Colo. - The site for the oil-shale demonstration plant was selected in 1944, and construction of the plant was begun in 1945. The plant was completed in 1949. Operation of gas-combustion retorts and of refining equipment was aimed at developing methods for separating and upgrading oil from oil shale. The plant was placed in standby condition in 1955.



FIGURE 1. - Air View of Synthetic Liquid Fuels Experiment Station at Bruceeton, Pa.