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The World War II German Synfuels Program

Dr. Kurt J. Irgolic
Center for Energy and Mineral Resources
Texas A&M University

THE WORLD WAR II GERMAN SYNFUELS PROGRAM

Kurt J. Irgolic*, R. A. Calvert†, D. L. Chapman**,
W. E. Clark, W. D. Gill, A. P. Krammer†,
A. M. Stranges† and T. H. Tooley†

Department of Chemistry* and History†, University Libraries**
and
The Center for Energy and Mineral Resources

Texas A&M University
College Station, Texas 77843

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INTRODUCTION

The technology to produce synthetic liquid fuels goes back to the pioneering research by Friedrich Bergius, a German chemist, whose work on the conversion of coal to liquid products earned him the Nobel Prize in 1931. The development of an additional technique, the Fischer-Tropsch Synthesis, provided Germany with the tools required to achieve self-sufficiency in petroleum fuels. This effort at self-sufficiency became one of the chief national goals of the German government. The scientific community joined hands with private industry and government to perfect the coal conversion processes. By the end of World War II the Germans had constructed more than 22 synthetic fuel plants, which accounted for 90% of Germany's required aviation gasoline, and approximately 68% of the regular fuel consumed by other military and civilian usage. After the war, these synthetic fuel plants were either dismantled or allowed to convert to the production of ammonia, or the processing of heavy petroleum fractions. West Germany today has no synthetic fuel production.

THE DEVELOPMENT OF SYNTHETIC FUEL PROCESSES IN GERMANY

In 1933, three synthetic fuel plants were in operation in Germany. By 1945, their number had increased to twenty-two. From January 1938 to March 1945, the German synthetic fuel industry produced 127,357,000 barrels of gasoline, diesel fuel, aviation fuel and "Treibgas", a mixture of hydrocarbons such as propane and butane, which can be liquefied at room temperature by compression. The production of synthetic fuels rose from 570,000 barrels per month in 1938 to 2,900,000 barrels per month by April 1944. During the first four months of 1944, the twenty-two German synthetic fuel plants produced approximately 11 million barrels of fuel, an amount exceeding the entire production of 10.6 million barrels for the year 1939. The production data retrieved from German reports[1] are summarized in Fig. 1, which provides irrefutable testimony to the success of the German efforts in converting coal to liquid fuels.

These spectacular successes of the German chemical industry have their roots in the German tradition of replacing natural products by synthetic materials. This tradition dates back to the 1860's. In the field of dye manufacture, the compound alizarin, which was known since 1826 as the active component in the natural dye, madder, was synthesized successfully by the chemists Carl Graebe and Carl Liebermann. The Badische Company began the large scale manufacture of synthetic alizarin in 1880.[2] Later, in 1883, Adolf von Baeyer established the structure of indigo, and by 1900, indigo was produced synthetically in annual quantities equal to those obtained naturally from 250,000 acres of farmland in India.[3]

Nitrogen compounds, needed as fertilizer components and for the manufacture of explosives, were imported from Chile during the 19th and early 20th century. Obvious advantages would accrue to a nation, which could make itself independent of imported nitrogen compounds by utilizing the elemental nitrogen present in large quantities in the air. Fritz Haber's experiments established by 1908 that nitrogen from the air can be combined with hydrogen employing appropriate catalysts at elevated temperatures and high pressures to form ammonia. Ammonia is well suited to serve as the feedstock for the preparation of other nitrogen compounds such as nitric acid, nitroglycerin, TNT and nitrogen-containing organic compounds required by the dye industry. The chemist and engineer, Carl Bosch, transformed Haber's laboratory demonstration of nitrogen fixation into a large industrial operation. The

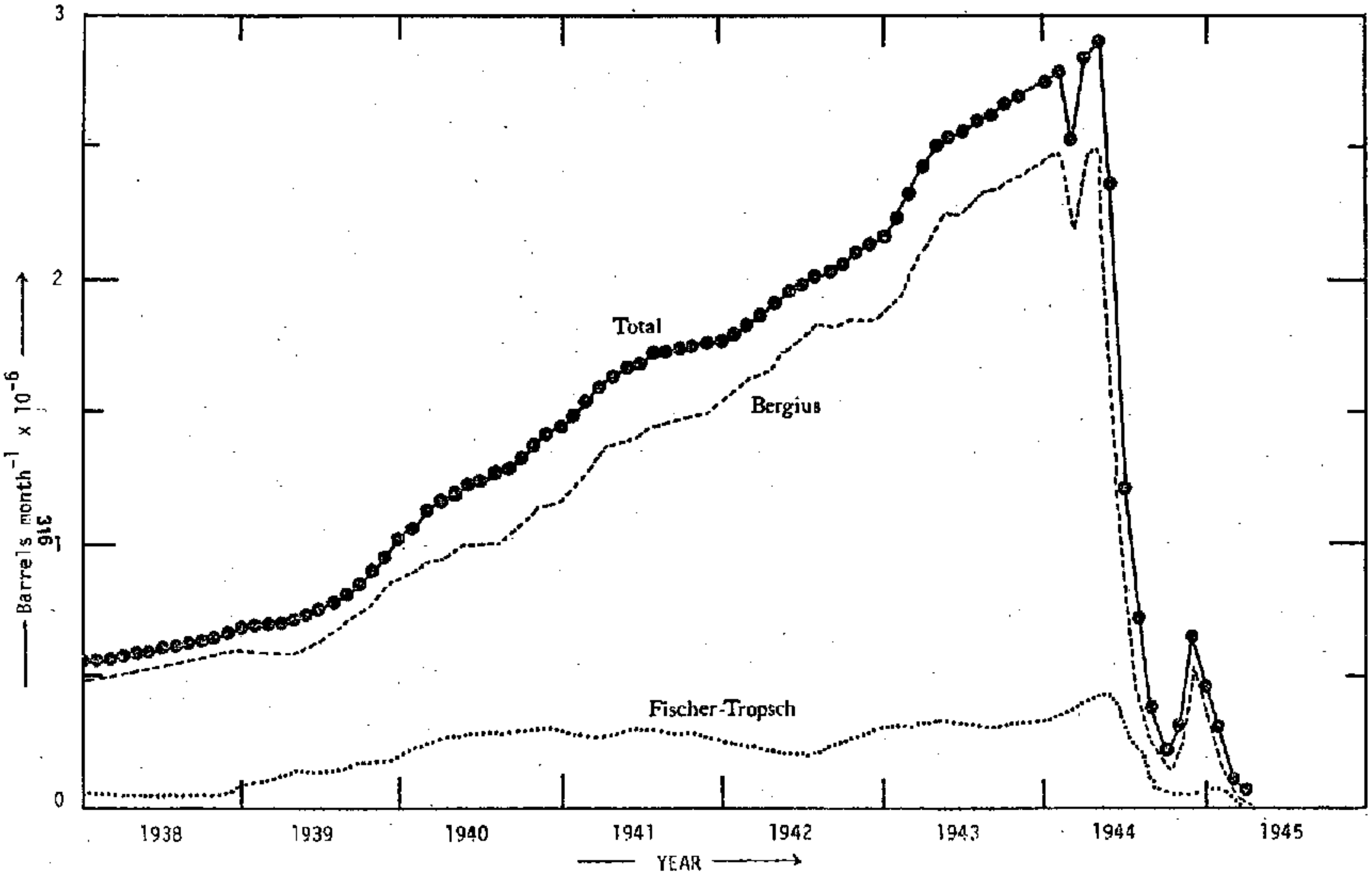


Fig. 1: The German Synthetic Fuel Production During the Period January 1938 through March 1945

Haber-Bosch synthetic ammonia process kept the German World War I machinery running for at least two years longer than expected after the British navy had cut off Germany's nitrate imports from Chile. The work on the ammonia synthesis produced valuable experience in performing reactions at high temperatures and pressures and led to the development of materials and reaction vessels which were able to function under these drastic conditions.

Friedrich Bergius, who had studied with Fritz Haber, began to investigate the reaction of coal powder, suspended in heavy oil, with hydrogen at high pressures and temperatures with the goal to produce hydrocarbons suitable for use as a motor fuel. The experiences accumulated during the development of the ammonia synthesis proved to be of great value to this ambitious endeavor. Success came in 1912, but it took another twelve years before the gasoline synthesis from coal now known as the Berguis process became a practical industrial process. In 1938 four plants produced 12,450,000 barrels of motor fuel from coal and coal tar.[4]

During the decade between 1920 and 1930 an alternate way of producing hydrocarbons was developed. Fischer, Tropsch and other investigators were successful in forcing mixtures of carbon monoxide and hydrogen, obtained from coal and water, to react in the presence of transition metal catalysts. Under appropriate conditions only saturated and unsaturated hydrocarbons were formed. In 1932, a pilot plant was built, and in 1933 Ruhrchemie A. G. constructed a plant of 8,300 barrels per year capacity. In 1936, five additional plants were in operation or under construction. It has been reported that over 8,300,000 barrels of Fischer liquid were produced during 1940.[5]

The direct liquefaction of coal (Bergius process) and the indirect liquefaction of coal (Fischer-Tropsch process) are clearly a continuation of the long German tradition of replacing natural products of vital importance to the nation by synthetic materials of at least equal quality. These developments made it possible for Germany to take the road toward independence from imported oil in 1936. By 1944 Germany had almost reached her goal.

THE GERMAN ENERGY PLAN AND ITS RESULTS

During the early 1930s, private industry was mobilized by financial incentives to develop a synthetic fuel industry. The government erected stiff tariff barriers against the importation of foreign fuel. It harnessed various segments of the fuel industry to work together as a combine and provided increased profit and legislative incentives to cooperating corporations.

The Fuel Agreement (Benzinvertrag) of December 14, 1933, between I. G. Farbenindustrie and the Reichswirtschaftsministerium (Office of the Secretary for Economy) may serve as an example. I. G. Farben agreed to produce at least 2,490,000 barrels per year of synthetic gasoline by the end of 1935 and to maintain this rate of production until 1944. The production cost, which included depreciation, five percent interest and a small profit, was set at 18.5 Pfennig per liter (1.1 quarts). The government agreed to support this price. It would pay to I. G. Farben the difference between the production cost and any lower price at which the gasoline might have to be sold. The government would also buy the gasoline if no other market were to be found. However, I. G. Farben would have to pay to the government the difference between the production cost of 18.5 Pfennig per liter, which at that time was more than three times the world market price, and any higher price realized on the market. By 1944 I. G. Farben had paid 85 million Reichsmark to the government.[6]

In September 1936, Adolf Hitler announced his Four Year Plan to make the German military ready for war in four years, and the German economy independent and strong to maintain a major war effort.[7] Since all phases of the war preparation required fuel, the development of independence in petroleum arose as the major thrust of the Four Year Plan. In fact, in 1936 Hitler urged the oil and rubber industries to become independent of foreign production in eighteen months.

Although the synthetic oil industry did not reach these goals, synthetic oil production increased dramatically (Fig. 1) under the Four Year Plan, especially in light of the difficulties under which the Plan was carried out. In 1933, only three small synthetic fuel plants (Ludwigshafen-Oppau, Leuna, Ruhrchemie-Sterkrade-Holten) were operating in Germany. During the same period, Germany's oil consumption was about one half that of Great Britain, one fourth that of Russia, and one twentieth that of the United States.[8] Yet, even at such low consumption, domestic resources were inadequate; eighty-five percent of Germany's oil was imported.

Financial conditions also looked grim as Germany embarked on the Four Year Plan. The raw material industry was only just recovering from the depression. In the chemical industry, by 1936, capital outlays were just comparable with the pre-depression level. In spite of these handicaps, the accomplishments of the plan in the area of synthetic fuel production were substantial.

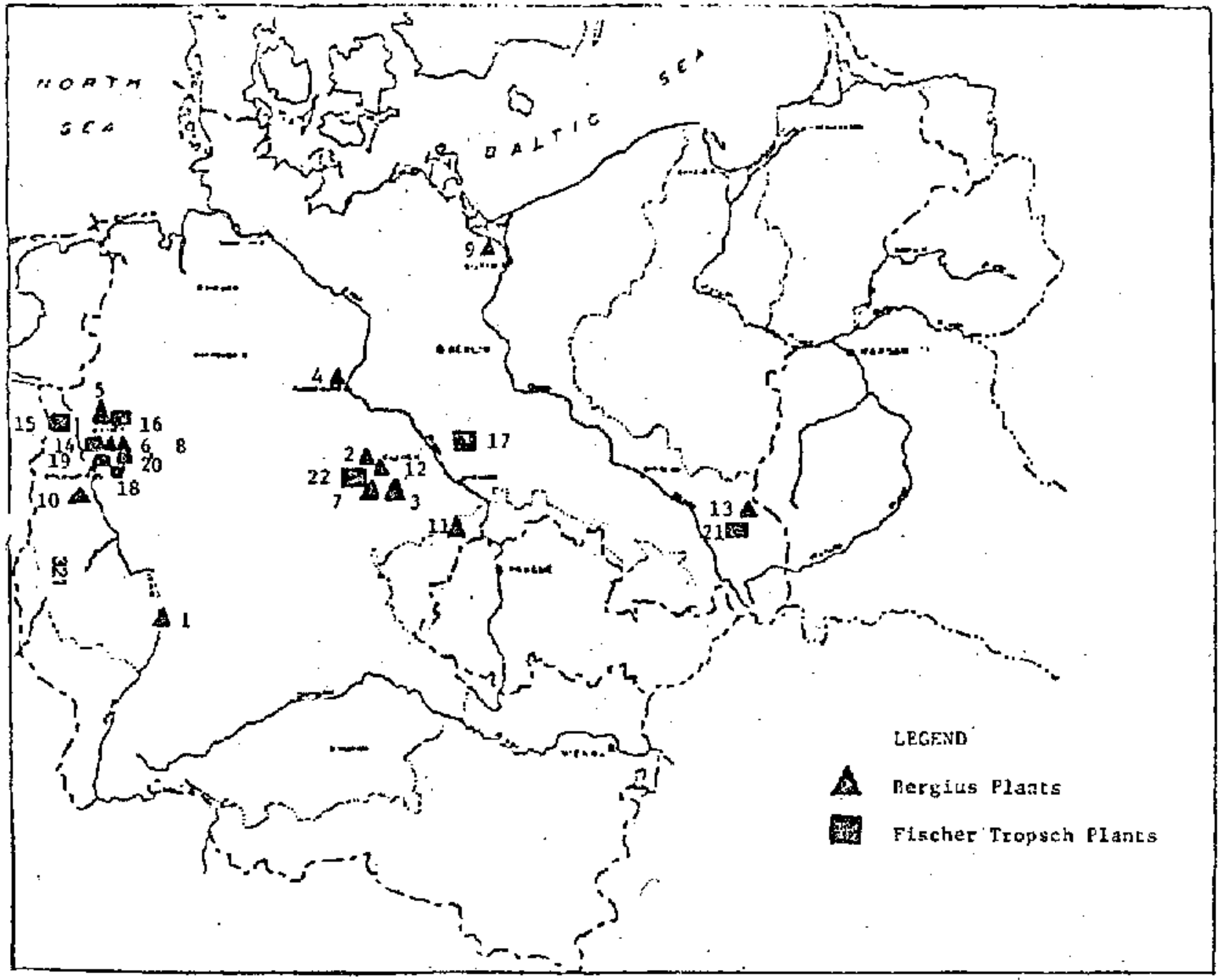
In order to understand the successive stages of the Four Year Plan, a broad look at its organizational stucture is necessary. In October 1936, Hitler appointed Hermann Goering to be head of the Four Year Plan administration. Goering was, of course, no expert in either economic or technical matters. Therefore, the planning took place almost entirely at lower levels of the administration. Three units operated under Goering: (1) the Small Council of Ministers, a group of Reich ministers, who ostensibly oversaw Four Year Plan operations; since they met only a few times, they did very little planning or advising; (2) the General Economic Council, which was made up of the heads of special committes operating under the Four Year Plan; and (3) the Bureau of Raw Materials and Synthetics, which actually carried out the technical planning.

Although the Bureau of Raw Materials and Synthetics was headed by General Loeb, a political appointee, the planning divisions under the Bureau appear to have been integrated to a great degree with German private industry. For example, the Research and Development Division was headed by Dr. Carl Krauch, who was also a director of I. G. Farben, the German chemical cartel.

During the winter of 1937-38, Goering oversaw a general reorganization of the Four Year Plan administration, which placed it into the organizational framework of the Ministry of Economics. Over a period of months, a Four Year Plan agency headed by Krauch took the lead as the predominant planning body.

The development of a workable synthetic fuel plan coincided with the increasing involvement of the chemical industry in the Four Year Plan. The major planning elements were supplied by the chemical industry. In July 1938, Krauch submitted the New Economic Production Plan (also known as the Karinhall Plan), which was developed by I. G. Farben scientists and technicians.

The synthetic fuel program made substantial progress. By 1939 fifteen synthetic fuel plants were in operation. In 1944, twenty-two plants (Fig. 2) converted coal into gasoline and other products. The annual production peaked in 1943 with more than twenty-five million barrels.



1. Ludwigshafen/Oppau
2. Leuna
3. Böhlen
4. Magdeburg
5. Scholven
6. Welheim
7. Zeitz
8. Gelsenberg
9. Pölitz
10. Wesseling
11. Brüx
12. Lützkendorf
13. Blechhammer
14. Ruhrchemie
15. Rheinpreussen
16. Viktor
17. Schwarzheide
18. Hoesch
19. Krupp
20. Essener Steinkohle
21. Schaffgotsch
22. Lützkendorf

FIG. 2: Location of Bergius and Fischer-Tropsch Plants in Greater Germany

Adapted by Texas A&M German Documents Retrieval Project from USSBS #109, Oil Division Final Report, 25 August, 1945, inter pp. 74 - 75

THE BERGIUS PROCESS

Most of the synthetic fuel was produced in Germany by the Bergius process. The hydrogenation of coal was carried out in two phases, the liquid phase and the vapor phase. The ground coal was suspended in a heavy oil and a catalyst added. This paste was heated to 300°C and then pressed into reactors, where it combined with hydrogen at pressures between 300 and 700 atm. The exothermic hydrogenation reaction raised the temperature of the mixture to 450°. Cold hydrogen gas or cold pasting oil was introduced into the reactor at various points to keep the temperature from rising above 500°C. After leaving the reactor the mixture passed through heat exchangers, hot separators, distillation units, coolers and cold separators. The product of the liquid phase hydrogenation consisted of 10 to 20% gases, 5 to 10% solids, 50 to 55% heavy oil and 20 to 30% middle oils. Generally, a pressure of approximately 230 atm. was adequate for the hydrogenation of lignite. Higher ranked coals required pressures up to 700 atm. Reactions at higher pressures increased the yield of middle oils, promoted the cracking of heavy asphalts and oils and minimized the production of gases. Molybdenum catalysts performed well during hydrogenation of coal. The limited molybdenum supply, however, necessitated the use of low cost iron compounds as catalysts.[8a]

The middle oils produced in the liquid phase reactors were further treated in the vapor phase with hydrogen over fixed bed catalysts at pressures of 200-300 atm. at 400°C. The second stage hydrogenation yielded 50-70% gasoline with a boiling range up to 165°C. The catalysts for the vapor phase hydrogenation most frequently consisted of tungsten sulfide carried on Terrana earth or activated alumina. The gasolines emerging from the vapor phase hydrogenation process were further subjected to various treatments to produce concentrations of aromatics or branched-chain paraffins in the gasoline to give the octane numbers desired for the particular application of the fuel.

Germany's preference for the high pressure, direct liquefaction of coal as developed by Bergius over the Fischer-Tropsch synthesis of hydrocarbons from carbon monoxide-hydrogen mixtures can be traced to Carl Bosch, I. G. Farben's chief executive, who had successfully transformed Fritz Haber's ammonia synthesis from a laboratory process to a commercial industry. Bosch had made it his personal crusade to do the same for the Bergius coal hydrogenation process. An additional factor in favor of the Bergius process was its ability to operate with many carbonaceous starting materials such as anthracite, bituminous coal, brown coal, lignite, various coal extracts, pitches, tars, shale oil and petroleum residues.

THE TECHNICAL OIL MISSION AND SIMILAR INVESTIGATIVE GROUPS

While Germany was producing synthetic fuels, The administration of President Roosevelt recognizing the real possiblilty of American involvement in World War II, showed concern over the petroleum reserves of the United States as early as May 1941. At that time, the President established the Office of the Petroleum Coordinator for National Defense, which was to gather information on military and petroleum products and to make recommendations to appropriate agencies for action to insure an adequate supply of petroleum. By June 1941, private industry was involved in this program, lending technical advice on government policies. In December 1942, an executive order created the Petroleum Administration for War (PAW), using the Office of Petroleum Coordinator for National Defense as its basis. It was within PAW in late 1942, that the idea of searching out technical information from Germany arose. In the summer of

1943, PAW Administrator Harold Ickes recommended such an enterprise to the Joint Chiefs of Staff. By December 11, 1944, advisors from private industry were nominating petroleum scientists and engineers to go on a mission to Germany to collect data on German petroleum technology. Their group consisting of twenty-six experts from private companies and the Bureau of Mines was called the Technical Oil Mission (TOM). Several other investigative groups including the United States Strategic Bombing Survey, a Navy team, and an Air Force team also were eventually sent into Germany for collection of industrial data. Little, if any coordination existed among these teams.

In mid-December 1944, TOM was placed under the direction of Dr. William C. Schroeder. TOM was interested in eight areas: (1) petroleum products and test methods; (2) gasification and carbonization of solid fuels; (3) hydrogenation of coal, tar, and oil; (4) synthesis of oil from water gas; (5) recovery and separation methods for gases, liquids, and solids; (6) oil shale processes; (7) materials of construction, including metallurgy and (8) by-products from the synthetic oil processes.

The first TOM team arrived in Germany in late February 1945. In their investigations, TOM personnel cooperated with the British teams, who worked under the auspices of the Combined Intelligence Objectives Subcommittee (CIOS).

TOM teams entered the German plants as soon as possible after the plants fell into Allied hands. The TOM teams found that although the inspection of the plants was useful, the most valuable information came from plant records, research records, and interviews with German scientists and engineers. As the TOM personnel siphoned off the technical documents, they sent them to England by the ton. The amount of documents was staggering to the investigators of 1945. When the Americans entered the I. G. Farben building in Frankfurt, they found papers knee-deep on the floors of the gigantic building and waist-deep in the stairwells. In London, CIOS personnel at first attempted to translate and abstract the received documents; however, as the flow of documents inundated the CIOS offices, the reports were microfilmed at random. One hundred and forty-one reels were thus produced. Later the entire program was moved to the United States where an additional 164 microfilm reels were filled. Many documents which had been shipped across the Atlantic were placed into depositories, loosely so defined, because the documents were stored in America wherever there was space to house them.

CIOS, BIOS (British Intelligence Objectives Subcommittee) and FIAT (Field Intelligence Agency, Technical) issued more than 1400 reports which are subjective analyses of factories or interviews of German scientists and engineers, written at the plant sites or in Paris or London. Many of these reports are part of the TOM reels.

By the end of 1945, most of the personnel from the Technical Oil Mission had returned to their former positions among them the Bureau of Mines' Synthetic Liquid Fuels Division. The Bureau of Mines had done limited research on synthetic fuel processes since 1916. The passage of the Synthetic Liquid Fuels Act of 1944 led to an attempt to organize for full scale pilot and demonstration plant operations for production of synthetic fuels.

In 1947, the Bureau of Mines acquired a Haber ammonia plant at Louisiana, Missouri, for conversion to a synthetic fuel demonstration plant. In May 1947, construction was begun on a modified Bergius plant based on German data and equipment. In March 1948, the decision was made to build a second synthetic fuel plant using the Fischer-Tropsch process. In 1949, the Bergius plant was completed and by 1951, both plants designed to produce from 200 to 400 barrels of fuel per day, were in operation. As part of the research and development of the technology for the plants at Louisiana, Missouri, the Bureau of Mines consulted some of the German documents and utilized the advice of German scientists to a limited extent.

THE GERMAN DOCUMENT RETRIEVAL PROJECT

In 1945, the United States salvaged from the chaos of war the largely unknown, yet entirely workable, technology of coal to oil conversion. The records describing this technology became very attractive after the oil embargo of 1973 as a source of information for the further development of a synthetic fuels industry. It did not seem to be in the best interest of the nation to ignore this opportunity unique in modern history to investigate the synthetic fuel records of a country whose scientific and industrial expertise on this subject was unsurpassed, and to make the knowledge contained in these records available at a time when it is so urgently needed.

In 1975, the Center for Energy and Mineral Resources at Texas A&M University initiated the German Document Retrieval Project to find out where the German synthetic fuels records are stored; whether copies of the documents can be obtained; whether these records had been investigated either cursorily or in depth; whether abstracts, and subject author indices exist for these records; whether potential users have access to the original records and whether the data contained in these records are still useful.

German synthetic fuels records were found to have been deposited in many places, among them the National Archives, the Library of Congress, military installations, private collections, the Imperial War Museum in London and depositories in Germany. Thus far, a list of locations at which German documents had been stored has not been found. The existence of such a list is doubtful.

Although many of these documents were classified, they are as war booty now public property. Copies of these documents when found are, therefore, available.

The German documents captured by the Allied teams have not been catalogued adequately. A very large fraction of the documents have not been catalogued at all. Many times boxes full of reports were found which had not been opened since their arrival in the United States. It is difficult under these circumstances to estimate with any accuracy the number of pages of records pertaining to coal conversion processes. Presently, the best estimate is one million pages.

When the German Document Retrieval Project was initiated many claims came to our attention stating that these records had been thoroughly investigated. All of these claims were checked out. Our inquiries showed, that only a fraction of the records have been abstracted or translated. Thirteen of the 305 TOM reels consist largely of translations of German documents, another four reels contain reports of groups which studied some of the documents, and an additional thirteen reels comprise abstracts of documents gathered by FIAT. The reports by the TOM study groups formed within various companies range from simple lists of the titles to abstracts or translations of the documents. A reasonable estimate seems to be that about 15,000 of the 300,000 frames on the TOM reels contain titles, abstracts and translations. However, to the best of our knowledge, these abstracts and translations are not available in any other document collection but the TOM reels. The majority of the TOM material consists of original German reports. The copied set of the TOM reels at Texas A&M University is one of the two usable sets existing in the United States.

An index to the titles of the document collection on the TOM reels does exist. A copy of it is in our possession. This index is not detailed enough for easy retrieval of data. The collection in the Imperial War Museum in London is only sketchily catalogued. The material held in storage at the German Archives in Koblenz has been described by the archivist as "uncatalogable."

Therefore, the conclusion that the German coal coversion records are practically inaccessible to the potential user at the present time is unavoidable.

After it had been ascertained that the documents are available but practically inaccessible, the question of the usefulness of the information contained in the documents had to be answered.

There is no doubt that Germany had the first successful synthetic fuels industry with a production of 128 million barrels during the period 1938 through 1945. Germany did not continue work on coal liquefaction after the end of World War II since the conference held in Potsdam in 1945 forbade Germany to produce fuels from coal. The Washington Agreement of April 13, 1949 ordered the coal conversion plants to be dismantled. The Petersberg Agreement of November 1949, halted the dismantling process and in 1951 the ban on coal hydrogenation was lifted. The plants now located in West Germany, however, were converted to process natural petroleum.[9] No development work on coal hydrogenation seems to have been performed in these plants after 1945.

The hydrogenation plants at Pölitz, Magdeburg, Blechhammer, and Auschwitz which were located in the Russian occupied zone, were dismantled and reassembled in Siberia for the production of aviation fuel from coal.[9] The plants at Leuna, Böhlen, Zeitz and Brüx continued the coal hydrogenation process for some time, but seem to have now also been converted to the processing of natural petroleum.[9] Thus, none of the German World War II coal hydrogenation plants - at least none of those in the western zone - continued the development work in coal hydrogenation.

The Bureau of Mines successfully operated two coal hydrogenation plants, which by 1951 produced from 200 to 400 barrels of fuel per day by the Bergius and Fischer-Tropsch processes. The monthly reports, describing the operation of these plants and the modifications to the German processes instituted by

Bureau of Mines personnel, are said to have been destroyed several years ago. Only annual reports exist, which have not been entered into the Technical Information Center computer data bank. The Louisiana, Missouri plants were closed in 1953.

In South Africa, the SASOL Company was formed in 1950 to produce synthetic fuels from coal. The plant in Sasolburg, built with a capital investment of $450 million, has a current output of 2,470,700 metric tons of petrochemicals per year including 1,683,000 tons of gasoline.[10] Fixed-bed Lurgi gasifiers provide the synthesis gas for the Fischer-Tropsch plant, in which the carbon monoxide-hydrogen mixture is contacted with appropriate catalysts in a modified German fixed-bed or an entrained circulating-bed arrangement.[11] Twenty-five percent of South Africa's consumption of 300,000 barrels per day of petroleum products in 1975[12] are supplied by the synthetic fuel plant.[13] An expansion to ten times the present synthetic fuel production capacity is in progress.[10,13]

During the past three decades, companies, goverment laboratories and universities, among them Union Carbide, Shell Oil, Sun Oil, Gulf Oil, Bureau of Mines, Energy Research Centers of the Energy Research and Development Administration (ERDA), Institute of Gas Technology, Consolidation Coal Company, and Hydrocarbon Research, Inc., have investigated coal gasification and liquefaction processes.[14] ERDA supported previously and the Department of Energy funds now many research and development projects in coal conversion. Examples of such projects are H-Coal, Synthoil, Multistage Liquefaction, Donor-Solvent, CO-Steam, Flash-Liquefaction and many coal gasification projects.[15] Several pilot plants are in operation or in the planning stage.

Some of these projects may have benefitted from a limited access to the German coal conversion documents. The extent to which the Bureau of

Mines' Louisiana, Missouri operation used German data is known. Although it is difficult to ascertain exactly how extensively and intensively the documents were perused by researchers and engineers of private companies, all indications point toward a very minor use of this information.

The difficulties which were and still are encountered in locating and retrieving the German documents give unequivocal proof that the information in these documents is and has been practically inaccessible. A considerable part of the German technology of coal conversion is probably out-dated. However, the description of experiments; catalyst preparation, use and effects; details of plant components; problems of reactor design, function and performance; proper operating pressures, and temperatures; distillation procedures; temperature control, corrosion control, precipitation problems in reactors and pipes and procedures of product processing should still be valuable as the foundation for further development in the area of coal conversion. It would be very surprising, if the German experience as recorded in the documents were not to make a major contribution toward the United States' development of efficient and economically viable processes of coal liquefaction and perhaps gasification provided there exists an easy access to the data.

On the basis of the above preliminary investigations about the location, accessibility and value of the documents the decision was made in July 1976, to expand the project. Approximately forty petroleum, gas and chemical companies were invited to join the project, provide financial support and experts for the Technical Advisory Council. Diamond Shamrock, Dow Chemical and Union Carbide are now participating.

The abstracting and indexing of the documents began in June 1977 following the procedures of DOE's Technical Information Center (TIC). Eight thousand of the 600,000 copied pages of documents which have thus far been brought to Texas A&M University have now been abstracted and indexed. The abstracts and indices are now being published in Fossil Energy Update and incorporated into the TIC energy computer data bank.

The German documents, which were brought to Texas A&M University and those yet to be located, contain the information on the development of coal conversion technology from bench scale to commercial plants, which resulted in the production of 128 million barrels of synthetic fuels during a seven year period employing the Bergius and the Fischer-Tropsch processes.

Reports abstracted thus far gave general descriptions of the processes as operated in various plants including coal preparation, liquid-phase and vapor-phase hydrogenation, and various product-refining steps. Many other items provide specific details on individual steps in these processes. There are analyses and comparisons of properties of starting materials (bituminous coals, lignites, extracts, pitches, tars, petroleum residues), products (aviation fuel, gasoline, diesel fuels, fuel oils, gaseous fuels), catalysts (molybdenum, iron, tungsten, tin compounds), and steels for the high-pressure, high-temperature reaction chambers. There are experiments and discussions of gas equilibria in the coal conversion reactors, medium- and high-pressure reactors, preventive measures against coking-up of separators, catalytic action of ash and unreacted coal, thermal control of reactions, and recovery of catalysts. There are discussions of improved apparatus design and construction. There are very detailed and comprehensive material balances and heat flow balances. There are discussions of methods used to overcome difficulties such as precipitation of by-products and stopping-up of pipes, corrosion of interiors of vessels, bursting of pipes and pressure drops through the system. Finally, there are blueprints for apparatus, flowsheets for processes and layouts for plants.

The failures and successes detailed in the documents can provide both the basis and the guidelines for basic and applied research, and for process development to the pilot and commercial plant. If just one costly failure in the development of coal conversion processes is avoided by consulting the German technology - an occurrence of great likelihood - the total cost of organizing and making available the German synthetic fuel records will easily be recovered. There does not seem to be any doubt, that the data in the German documents must be made available to those who work in the area of coal conversion.

There is another important benefit which can be realized from a study of the German documents. The technical details of the processes and their development together with the German Energy Plan, a copy of which is in our possession could serve as the basis for an understanding of the political, economic, social and technical events, which made it possible for Germany to dramatically increase synthetic fuel production (Fig. 1) under less than ideal conditions. The book, "Der synthetische Treibstoff" by Wolfgang Birkenfeld, which was published in 1964, discusses some of the political aspects of this development. The document collection available to the German Document Retrieval Project, potentially holds the information required for a thorough study of the technology transfer so successfully achieved by the German scientific, technical and industrial establishment.

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