Chapter 4

WORLD WAR II AND THE RESPONSE OF OIL TECHNOLOGY, 1941–1946

With the coming of war, the pendulum had begun to swing for both the American petroleum industry and the Bartlesville station. No longer faced with the problems of overproduction that had redefined conservation in the 1930s as an attack on "economic" as well as physical waste, oil men in both the private and public sectors now geared up to meet the unprecedented military demands for petroleum and its products. For the major integrated oil companies represented by the American Petroleum Institute (API), the war brought a reaffirmation of the benefits to be achieved through the associative state. Wartime cooperation with the Office of Petroleum Coordinator for National Defense, later the Petroleum Administration for War (PAW), resulted in tremendous growth and profits for the industry. Suspicious of Interior Secretary Harold Ickes' threats to make oil a public utility during the difficult years of the 1930s, oil executives now found the wartime petroleum czar and his many lieutenants who had come from industry to be helpful partners. Since there was business enough for all, and since economic prosperity was cloaked in a fervent patriotism, industry leaders resolved many of the existing divisions between independent and major, producer and refiner, Easterner and Westerner, as petroleum went to war.

This new environment also signaled a governmental policy change which had significant impact on the Bartlesville station. On the brink of war and facing all the uncertainties that entailed, the nation once again became concerned with the availability of petroleum supplies in both the near and longer term. On November 5, 1941, Interior Secretary Harold Ickes captured this mood in an address to the twenty-second annual meeting of the API in San Francisco. After first reviewing the problems of oil tanker shortages and voluntary conservation as part of the war preparedness program, the Secretary turned his attention to larger policy issues:

> Do not forget that petroleum is an exhaustible and irreplaceable natural resource. Not only does our commerce and our industry and our husbandry and our pleasure depend upon it, this war demonstrates that the possession of an abundance of petroleum and its products is a matter of life and death to a nation. And our own nation would be negligent of its duty, recreant to its trust, if it permitted any industry to waste such a valuable natural resource.[1]

This was most encouraging to Bureau of Mines technicians who had spent their entire careers working toward conservation practices in the oil fields. For over two decades, Bartlesville had led the way in many areas of conservation research, including the study and analysis of new fields, research into stimulative and secondary recovery technologies, rehabilitation of old wells, basic theoretical behavior of oil reserves, experimentation with drilling fluids, pressure core barrel testing, testing of high pressure gas wells, and a host of other related activities. Most of these "bread and butter" projects had been maintained throughout the 1930s and were in place when the war broke out. As Deputy Division Director Harry Fowler would later comment, the Bureau "not only was staffed with a key group of engineers and chemists capable of undertaking almost any work connected with the production, transportation, and refining of petroleum and natural gas, but one that during the preceding twenty-five years had accumulated a storehouse of information."[2]

Thus, one major theme of the World War II experience at Bartlesville was continuity. When America needed engineering expertise to insure the maximum utilization of oil and gas reserves, station personnel were there to take up the challenge, thereby justifying their role in keeping alive the light of conservation during a period of petroleum glut in the 1930s. But World War II also brought with it enormous change for a host of American institutions, and Bartlesville was no exception. Much of this change resulted from research projects undertaken with regard to two of the most important technological achievements of the war—the production of huge amounts of high octane aviation gasoline and the creation almost overnight of a vast synthetic rubber industry.

Bartlesville's initial war work centered on the aviation gasoline problem; station engineers assumed the tasks of identifying sources of crude oil, laboratory analysis of aviation fuel blends, and exploration of gas-condensate fields as sources of aviation fuel base stock. As these projects expanded, they became a major part of station work and highlighted the role of the petroleum chemistry and refining section. After the adoption of the Bernard Baruch committee report on synthetic rubber in 1942, the Bureau established a thermodynamics research section at Bartlesville to develop basic data on the conversion of butane and butene gases to butadiene, the basic component of general purpose synthetic rubber. Although by war's end this thermodynamics group had barely gotten underway, it symbolized a new direction for the station in the post-war era. By the mid-1950s, the Bartlesville thermodynamics laboratory had become a major center for the generation of basic data on hydrocarbons and sulfur and nitrogen compounds, and was known throughout the world. Coupled with the chemistry and refining work related to the aviation fuel program, this petroleum thermodynamics activity helped to move Bartlesville in the direction of a research center rather than an experiment station. Bartlesville did not abandon its traditional roles of fostering conservation practices in the oil and gas industries and providing practical engineering expertise to the Mid-Continent producer; but it did find that its functions had been expanded in important and far-reaching ways as a result of the World War II experience.

Mobilization for War

As soon as President Roosevelt declared a limited national emergency on September 8, 1939, after the Nazi invasion of Poland, Bureau of Mines engineers began to look for their place in war service. Yet despite high hopes, the early months of the preparedness program would prove frustrating, as many staff members felt that their expertise was going unrecognized and unused. They realized fully that much of their ongoing work had a direct bearing on the national goal of increased petroleum production and sought direction from Washington. Finally, in June 1940, Interior Secretary Ickes requested the director of the Bureau of Mines to provide specific information on a number of technical questions—including United States refining capacity, the overall aviation gasoline and fuel oil situation, and prospects for increased crude oil production. Cattell, who was Petroleum and Natural Gas Division chief—this was the same basic position he had held for the last two decades, although the name changed somewhat—outlined a national defense program for his unit in a memorandum to the director on July 5, 1940, and sent copies to the supervising engineers at each of the Division field headquarters. Cattell stressed that none of these projects were to be substituted for regular work, but that information should be gathered for Ickes on an informal basis.[3]

In September 1940, Cattell directed all Division engineers to review their ongoing projects and make recommendations as to changes in direction for the war effort. At a meeting of the Division subcommittee for production held in Bartlesville in October 1940, there was discussion of the overall situation. The committee decided to continue studies of oil-field water disposal related to waterflooding and research with drilling muds which would potentially save much steel for the war effort (primarily a San Francisco office assignment), and to reemphasize studies of fire hazards, evaporation losses, and corrosive effects of water as they impacted on petroleum transportation and storage. The committee decided that studies of natural gas hydrates, undertaken at Amarillo as a cooperative project with the American Gas Association (AGA) in the 1930s, should probably be deemphasized until the war was over.[4]

The first specifically defined war assignment for the Division grew out of a meeting between representatives of the Bureau of Mines and the Advisory Council of National Defense in September 1940. They agreed to conduct a survey of crude oil suitable for manufacturing aviation gasoline, a project which began a major Bartlesville effort in aviation gasoline work during the war. The study commenced in the fall of 1940 and, by early summer 1941, Bureau engineers had collected 250 individual crude samples which were forwarded to Bartlesville for analysis.[5]

More formal arrangements coincided with Roosevelt's appointment of Harold Ickes to the post of director of the new Office of Petroleum Coordinator on May 28, 1941. Bartlesville and other Division field offices had been functioning on an almost *ad hoc* basis with the Secretary, primarily providing statistics on numerous questions that had been asked on short notice. In August, a meeting between Cattell and Ralph J. Schilthius, representing Ickes, resulted in the drafting of an agenda of war problems that the Bureau production section could undertake. These included a study of the effects on production of the withdrawal of salt water from the East Texas field, an analysis of "distillate" (condensate) fields, and basic research into the rate of production and oil field drilling techniques as they affected the efficiency of oil field operations. The second of these projects, the study of condensate fields, would become a major Bartlesville wartime project.[6]

Further discussions in August with Wright Gary of the Petroleum Coordinator's office defined other Division assignments. Gary maintained that the number one national defense problem should be an extension of the crude oil survey for the manufacture of aviation gasoline to include a study of alkylate blends. These are high octane substances produced through specialized refinery processes, which, when blended with high quality base stocks and tetraethyl lead, produced 100-octane aviation gasoline. At this time, Bartlesville research was divided into three sections: a special technologic section, an oil and gas engineering section, and a chemistry and refining section. By the summer of 1941, the aviation gasoline blending studies had begun to take up virtually all the time of the expanded chemistry and refining section headed by senior chemist Harold Smith.[7]

These two research areas—the aviation gasoline study and investigation of the composition and reserves of reservoir fluids in gas condensate fields (which could become the source of aviation fuel components)—were designated by the Office of Petroleum Coordinator in 1941 as the two major war problems, and became the major focus of Bartlesville's early war research. Still, many on staff believed that the Petroleum Coordinator was not utilizing their talents sufficiently. Despite their long experience and the demonstrated relevance of their ongoing work in efficient oil and gas field management, they felt that Ickes' office and other defense agencies had failed to grasp the importance of this work in insuring a continuous, uninterrupted supply of oil for national defense.[8]

Even after Pearl Harbor, Cattell reported to his field engineers in February 1942 that "conditions in Washington remained uncertain."[9] Requested supplemental funds for the aviation gasoline study, gas condensate investigation, and already committed secondary recovery studies were still pending congressional action, and the Washington Division office as well as the field offices were becoming increasingly frustrated. In an effort to boost morale, Cattell wrote to the field:

> In spite of the uncertainties we have two very definite jobs in the petroleum field on which we can place emphasis. These are the two jobs requested by the Deputy Petroleum Coordinator, one relating to aviation gasoline blends and the other to condensate fields. We are held back because we lack equipment and funds for travel, supplies, and additional personnel. About all we can do to prevent this is to keep our plans with what we have available and throw as much as we can of our present facilities in the direction of these studies without putting ourselves in a position where we cannot supply information on other phases of our work if and when information concerning them is needed.[10]

Cattell also noted that "many of the boys feel that they could have contributed more to the war," but he reminded them that "having men on the job available for contingencies and emergencies is part of war."[11] In a larger sense, this had been the history of the Bartlesville station—being available with the proper technical expertise when the nation called.

Much of this frustration ended shortly thereafter, in an increased flurry of activity. Only ten days later, the Division received its first emergency funding authorization, and it embarked on a number of important research projects that called for exactly the expertise Bartlesville could provide. For several years, the regular annual appropriation for the Division's oil and gas research had remained constant at $260,000. These monies maintained and operated the main experiment station in Bartlesville; a second smaller station in Laramie, Wyoming; field offices in San Francisco and Dallas; supporting research at the Amarillo, Texas, helium plant; and a small headquarters staff in Washington. This appropriation had been augmented in 1941 by an additional grant from the Army Air Corps to fund the aviation gasoline survey. But if the Division was to make a major contribution to the war effort in 1942, increased funding was necessary.[12]

The Division's budget for fiscal year 1942 had originally been held at $260,000 but, after Pearl Harbor, an additional $66,000 came through for aviation fuel research. Annual appropriations then increased steadily in fiscal year 1943 ($368,000), 1944 ($553,380), and 1945 ($657,640). In addition, other special project funds flowed to the Division from various congressional deficiency appropriations acts. The Division hired new personnel and acquired needed equipment as it expanded to envelop war-related projects. At the height of its expansion in 1945, however, the total technical personnel of the Petroleum and Natural Gas Division amounted to only 147 individuals. Of this total, the largest concentration of technical staff was in Bartlesville, approximately seventy-five researchers. Because the station was spread relatively thin, many of the "bread and butter" projects carried on before the war, though continued in some form, had to be cut back.[13]

Aviation Gasoline Studies: The First Major War Problem

Knowledge of the technology of combustion in engines remained rather primitive in the early years of the twentieth century, and it was only during World War I that researchers discovered that high performance aircraft required special fuels. One of the first important Bureau of Mines projects in the area of petroleum refining had been research undertaken into the production of a synthetic aviation fuel for the military. Because of the cost of its manufacture, however, this approach died out after the war, and refiners primarily relied on the addition of benzol, natural (casing-head) gasoline, or cracked gasoline to straight-run product in order to obtain sufficient quality.[14]

Catalytic cracking, a technology developed in the 1930s, was also to have a major impact on the production of aviation base stock during World War II. First developed by French inventor Eugene Houdry, this process yielded a gasoline of much higher octane than that produced in conventional thermal cracking stills. Higher octane base stocks meant that smaller amounts of expensive additives were needed to obtain 100-octane quality. During the war, Houdry's fixed-bed catalytic units and the later-developed Jersey Standard fluid catalyst process played a vital role in Uncle Sam's aviation fuel program.[15]

In order to obtain the "fighting grade" 100-octane fuel demanded by the military, it was necessary to utilize all of the above processes and additives, many of them in conjunction with one another, and all enhanced with tetraethyl lead. Bartlesville engineers and chemists conducted a series of tests throughout 1941 on the various chemical properties of selected fuel samples, their relative merits as blended fuels, and the most efficient ways to produce them.[16] The goal of these studies was indicated in an October 1941 memorandum from Ralph Davies, Ickes' deputy. He defined the purpose as making "a series of tests to determine the effectiveness of various blends of alkylate, base stocks, isopentane and other materials. This will be of great assistance in immediate plans to utilize most efficiently the various components of 100 octane aviation gasoline."[17] This research represented a substantial expansion of work begun earlier by simply surveying and identifying crude oil fields and reserves which would yield the best base stocks.

This more sophisticated study of alkylate blends necessitated the addition of new equipment at Bartlesville. In addition to general equipment and personnel costs, the station required a supercharged test engine to test aviation blends. Bartlesville already possessed two variable, one-cylinder "bouncing pin" test engines which were perfectly adequate for evaluating the octane of automobile gasolines. These engines were used in conjunction with the national gasoline surveys begun in the 1930s as a cooperative project with the Cooperative Fuel Research (CFR) Committee. For evaluating aviation fuels, however, the anti-knock index alone was insufficient. Because they were used at high altitude in very high compression engines, vapor pressure, volatility, and other characteristics were crucial in assessing the quality of aviation fuels.[18]

As the alkylate blend program got underway in early 1942, there remained a fundamental question as to which source of base stocks should be given priority. The Coordinator's Office decided that those base stocks available to small refiners or used primarily by small refiners with alkylate would be first on the list. By serving the needs of the independent, Bartlesville was following its historical pattern of primary service to those smaller firms who had no research capability of their own.[19]

Since catalytic cracking units were not yet readily available to most refiners, another promising avenue of research was "superfractionation," to isolate the higher octane from the lower octane fractions in selected crudes, thereby obtaining a desirable base stock gasoline for 100-octane aviation. To conduct tests of this procedure, Bartlesville purchased a high temperature fractionating unit. By the fall of 1942, the lab had conducted preliminary studies of 17 samples, but a serious shortage of steel needed for the construction of commercial superfractionation facilities prompted the Petroleum Coordinator's Office to suspend this particular program.[20]

Two of Bartlesville's research sections—petroleum chemistry and refining, and efficient petroleum utilization—devoted their energies to the aviation fuel project. From 1942 through the end of the war, between thirty-five and forty professional chemists and engineers worked on refining problems. At the beginning of the war, station research centered on the quantitative side—how to obtain more aviation fuel; toward the end of the war, however, the qualitative issue of improving these fuels was prominent. The petroleum chemistry and refining section divided into five subprojects: (1) the processing of crudes and naphthas to provide test materials; (2) analysis of hydrocarbon mixtures and blending of high octane agents; (3) evaluation of samples by engine test; (4) testing for sulfur content, lead susceptibility, vapor pressure, and other relevant investigations; and (5) a technical reporting group responsible for making the results of all tests available to industry and government organizations. The efficient petroleum utilization section divided into four subprojects: (1) evaluation of crude oil to determine the content of aviation base stock; (2) evaluation of base stocks in blends with high octane agents; (3) upgrading of base stocks; and (4) analyses of base stocks for hydrocarbon content. A related aviation fuel project, which began in 1941 and continued for quite some time during the war, studied evaporation losses in the storage of high octane gasolines. Under the direction of Bartlesville engineer Grandone, this unit took careful measurement of the evaporation rates of different blends. These data proved valuable during the war in designing adequate storage and transportation facilities for such a volatile product.[21]

Bartlesville and Laramie teams evaluated an additional 65 samples of crude oils and condensates for aviation fuel in 1942, and continued to update this work with studies in 1943 and 1944. Related research released in 1942 and 1943 was critical for industry's use of desulfurization to increase the lead susceptibility of marginal base stocks in the manufacture of aviation gasoline.

An extremely important project related closely to the aviation fuel work was the survey of crude oils and refinery distillates as a source of toluene for the manufacture of TNT for military explosive devices. The Office of Petroleum Coordinator first requested the Bureau to conduct these surveys on May 9, 1942, and a report on them was submitted to the office on July 31 of that year. As toluene requirements became increasingly critical, additional requests came from Washington, and the Bureau supplied confidential data on toluene up through 1944. Both the Bartlesville and Laramie stations worked on the identification of sources of toluene and methylcyclohexane (which could be converted to toluene), issuing a report in April 1944 on 107 samples which they had analyzed. By the spring of 1944, there was sufficient toluene available for the munitions industry, and the Bureau of Mines redirected the toluene program to a study of the qualitative aspects of aviation fuel. Much of this work focused on superfractionation, and a total of three reports came out of these redirected studies in 1944 and 1945.[22]

The massive production of high octane aviation fuel for the military in World War II was one of the more important technological achievements of the conflict. British Foreign Secretary Lord Curzon's statement that the Allies had "floated to victory on a sea of oil" in World War I is often cited as an important measure of petroleum's growing importance in the twentieth century. Yet, if the Allied Powers had floated to victory in 1918, they had surely flown there in 1945 on the wings of 100-octane aviation fuel—an achievement that the United States Joint Chiefs of Staff termed "one of the great industrial accomplishments in warfare." In 1945, the Army Air Force alone consumed daily fourteen times the total volume of gasoline shipped to Europe for all purposes between 1914 and 1918.[23]

Bartlesville's contributions to aviation gasoline research were part of a much larger cooperative effort by business and government under PAW leadership. Industry, the Bureau of Mines, the National Bureau of Standards, the Cooperative Fuel Research Committee, and other organizations cooperated in the exchange of technical information, and private firms shared patent and licensing agreements under PAW auspices. At war's end, over 400 individual refineries were turning out the 87-, 91-, and "fighting grade" 100-octane aviation gasoline needed for the military forces.[24] Because of the need for hard data on the chemistry of base stocks and blends, there was a subtle but important change of focus in the personnel hired and the research agenda at Bartlesville. The aviation gasoline work pointed the station toward the direction of a research center involved with the basic chemistry of hydrocarbon compounds rather than its more traditional role of oil field production technology.

Gas-Condensate Studies: The Second Major War Problem

Because the liquids obtained in gas-condensate fields were of potential use as blends in aviation gasoline, the gas-condensate research complemented other Bartlesville research into aviation gasoline crude sources and high octane blends. With the deeper drilling of natural gas wells in the 1930s, producers frequently discovered a water-white or straw-colored liquid (then referred to as distillate) along with dry gas. Although similar to natural or casinghead gasoline that had been obtained from natural gas for a number of years, these condensates possessed chemical properties which made them even more valuable.[25]

Bartlesville engineers had pioneered in the study of these condensates in the 1930s through cooperative studies funded partly by the American Gas Association, and had conducted detailed studies of the flow characteristics, composition, and properties of fluids obtained from one of the wells in the East Texas field. Gas wells containing high ratios of liquid to gas received the designation of "combination wells."[26]

A preliminary war study in the fall of 1941 indicated that as many as 100 individual reservoirs of the condensate type might require investigation. To carry forward this work, however, additional funds would be required to supplement the Bartlesville operating budget. The only test equipment owned by the Bureau of Mines at the time was a cell for determining the phase relations of reservoir fluids (gas to liquid) developed at the Bartlesville station in the 1930s. The station submitted a proposal for a field study program under the direction of R. E. Heithecker and Ken Eilerts in December 1941. Targeted for immediate action in 1942, these field studies were planned to entail three separate stages. First, each reservoir designated by the Petroleum Coordinator would have an engineering study to provide a concise overall description of field conditions in order to estimate liquid and gas quantities. Second, Bartlesville engineers, with consent of the field operators, would conduct stabilization tests of the behavior, pressure, and temperature conditions in a given well at varying rates of flow. Finally they would analyze all hydrocarbon fluids coming from the well to generate data on the construction of cycling plants to produce liquids from wet gas.[27]

In February 1942, Heithecker made an exploratory trip to Texas and Louisiana. He met with many combination well operators, the Texas Railroad Commission, and the Conservation Department of the Louisiana Minerals Division, compiling a list of gas-condensate fields. In Bartlesville, Eilerts was preoccupied with assembling the intricate field-testing apparatus that would be needed to carry out the tests. Before Eilerts had completed the critical materials preparation, however, the Petroleum Coordinator's Office, on April 16, 1942, requested an immediate study of the Logansport-Joaquin combination field in Louisiana and Texas—a request prompted by growing shortages of critical materials for manufacturing aviation fuel. Heithecker's and Eilert's team submitted their report in July and quickly undertook studies of two additional Louisiana fields. Although these studies proved valuable, the Bartlesville group found themselves unable to meet the six-to-eight week time schedule that the Petroleum Coordinator had designated for each field. To expedite the work, Eilerts assembled a mobile field laboratory, and in January 1943, Cattell assigned the entire staff of the Dallas field office to condensate studies.[28]

Between June 1942 and April 1944, the Petroleum Coordinator's office received detailed reports on thirteen condensate fields, nine compiled by Bartlesville staff and four by the Dallas office.[29] In commenting on the value of these studies, Deputy PAW Director Davies wrote:

> Not only this office, but the entire natural gas and natural gasoline industry has benefited to a substantial degree by the availability of the Bureau's technical knowledge and skill at a time when the industry itself finds it extremely difficult to maintain adequate technical personnel.[30]

Davies, himself a former oil company executive, was referring primarily to the importance of condensate liquids for the aviation program; the sum total of Bureau research into combination wells, however, yielded data of much broader significance.

By 1944, approximately forty cycling plants existed to obtain condensate liquids found in these wells. The Bureau had also established the important conservation principle that the cycled dry gas reintroduced back into the well would not only provide future reserves of natural gas but, ultimately, by maintaining maximum well pressure, insure an increased long-term yield. Eilert's work, in particular, also confirmed that the best way to influence efficient exploitation of these fields was to unitize them—that is, to operate each as a cooperative pool—because keeping the number of actual drilled wells to a minimum through unitization would give the field a longer life. These conclusions, not particularly relevant to the original purpose of the condensate studies, nevertheless conformed to Bartlesville's previous experiences in conservation and well-spacing and were to have significant importance in the post-war era.[31]

In the midst of the war-emergency condensate studies, a related problem cropped up that soon commanded a great deal of the Bartlesville group's time. On September 4, 1942, Davies had requested that a complete engineering study be made of the Chickasha-Cement high pressure gas area in Oklahoma. Because of unprecedented demand for industrial use of natural gas, there was an alarming drop in closed-in pressure in the field and concern that it might soon become depleted. From December 1942 to June 1943, a Bartlesville team headed by Heithecker devoted its time exclusively to this project.[32]

The study became complicated when evidence appeared that oil migrating into the adjacent Medrano gas reserve threatened a great underground waste of gas. The Bartlesville engineering report resulted in a prorationing order by the Oklahoma Corporation Commission limiting production in the Medrano Sand of the West Cement field, issued on January 4, 1943, and amended on March 27, 1943. On July 9, 1943, Cattell directed that the West Cement study be terminated and Bartlesville's energies redirected to the gas-condensate studies. Tests of the West Cement field could reach no definitive conclusion as to the relationship between the oil and gas present. However, the importance of the knowledge gained in the West Cement study became appreciated in the post-war era as Bartlesville emerged as an important center for information on the determination of flow in high pressure gas wells and the development of allocation formulas for unitized gas operations.[33]

Thermodynamics Research

In August 1942, Harold Smith and Heithecker traveled from Bartlesville to Washington to review war work already undertaken and to discuss with both the Washington Division office and the Office of Petroleum Coordinator the focus of future projects. The two primary war problems at this point remained the same as before: the aviation blending project and the study of condensate fields, each under their respective direction. While in Washington, Smith, along with Cecil Ward and Harry Fowler of the Division office, met with Paul M. Raigordsky from the Office of Petroleum Coordinator. The purpose of the meeting was to discuss the establishment, within the Bureau of Mines, of a research team to investigate the direct conversion of butane to butadiene, the major component of general purpose synthetic rubber. This meeting turned out to be the genesis of the thermodynamics section at Bartlesville.[34]

At the outbreak of the war, there existed several processes for making synthetic rubber. DuPont's neoprene, for example, was an excellent product for certain specialized uses, but remained unsuitable for heavy-duty uses, such as in automobile tires. A more satisfactory product for heavy-duty use was Buna-S, a rubber manufactured from two organic ingredients, butadiene and styrene. The giant German chemical combine, I. G. Farbenindustrie, held the patents for the basic process, which it had developed in the 1930s. The United States rights were held by Standard Oil of New Jersey, a partner to Farben in several international cartel and licensing agreements. On June 28, 1940, after the fall of France to Hitler, President Roosevelt designated rubber as a strategic and critical material. Concerned about future rubber supplies as part of the war emergency, the federal government established a special subsidiary of the Reconstruction Finance Corporation, the Rubber Reserve Corporation, to address the rubber situation. Industry concluded the first agreements relating to technical information and patent rights with the Rubber Reserve Corporation on December 19, 1941, soon after Pearl Harbor. With the loss of critical natural rubber supplies after the Japanese conquest of Malaysia in early 1942, the situation became even more serious.[35]

A crucial technical question that faced policymakers was to determine the best and most efficient way to manufacture butadiene, the primary material needed for Buna-S. There were several ways to obtain butadiene from alcohol, most of which involved the dehydrogenation of ethanol. These processes had been developed in Europe, but in this country the Carbide and Carbon Chemicals Corporation owned patent rights to one of them. Additionally, there were three basic processes to manufacture butadiene from petroleum. The first of these relied on the original I. G. Farben patents and involved the dehydrogenation of butylene (butene) gas captured as a by-product of petroleum refining. The second was a similar dehydrogenation of butane and butene patented by the Houdry Process Corporation, the industry leader at that time in catalytic cracking technology. The third approach was a process developed by the Phillips Petroleum Company involving the dehydrogenation of butane obtained directly from natural gas.[36]

In February 1942, the Rubber Reserve Corporation issued a report recommending that 705,000 tons of Buna-S be produced with butadiene obtained from the Standard Oil (I. G. Farben) process. This sparked a great controversy which continued throughout 1942. Houdry, Phillips, and the alcohol lobby campaigned publicly and lobbied in Washington to change this decision—neither the first nor the last time that business competition and wartime cooperation came into conflict. Moreover, the debate was colored by the Standard Oil/I. G. Farben connections, and the Truman Senate Committee investigation in the spring of 1942 had given Standard a black eye for collaborating with the enemy in time of war. Congress passed the Rubber Supply Act in 1942, but FDR vetoed it on August 6 because of the continuing controversy among the advocates of different processes. He then appointed a special Blue Ribbon Committee, chaired by financier Bernard Baruch, to study the problem and make appropriate recommendations. The other committee members were Harvard president James B. Conant and MIT president Karl T. Compton.[37]

In its meeting with the Office of Petroleum Coordinator in August 1942, Bureau of Mines technologists described their proposed thermodynamics project as operating on a "fundamental" basis and "not a part of the so-called growth program of supplying immediate needs for rubber." As the Bureau began to stake out the groundwork for this research, the Baruch Committee submitted its report on September 16, 1942. Its conclusion basically endorsed the earlier Rubber Reserve Report with one exception. The largest amount of butadiene (283,000 tons per year) would be produced from the Standard Oil process, but smaller allotments were given to the alcohol, Phillips, and Houdry processes.[38]

Meanwhile, the Bureau of Mines had been assembling a formal proposal for supplemental funding to accomplish the thermodynamics work. On September 14, 1942, only two days prior to the formal announcement of the Baruch Report, they received a "green light" to go forward with a supplemental appropriations request of $50,000 to establish a laboratory at Bartlesville to pursue studies in petroleum thermodynamics.[39]

The literal meaning of the term "thermodynamics" is heat power or power developed from heat. The science of thermodynamics provides laws that govern the passage of energy from one system to another, the transformation of energy from one form to another, and the utilization of energy for useful work. Proper application of the first and second laws of thermodynamics allows one to analyze closely all transformations of energy and matter. For the chemist, thermodynamics data can provide, without costly experimentation, the amounts of given material that will be in both the initial and final stages of all chemical reactions. These scientific data, obtained in a research laboratory, are one of the necessary tools of the chemical engineer. In the 1920s and 1930s, researchers had only begun to apply the tool of thermodynamics, long used by the physical chemist, to organic chemistry. The Department of Chemistry at the University of California, Berkeley, became a major center for this research, and Professor G. N. Lewis of that department one of its foremost pioneers.[40]

There is nothing magic about the science of chemical thermodynamics. Indeed, the success of any thermodynamics analysis is critically dependent on the data underlying it. The numerical results of an analysis can only be accurate to the extent that the basic data are accurate. The central motivation of the Office of Petroleum Coordinator was to provide accurate data on the conversion of butane to butadiene. The Bartlesville laboratory was, therefore, to perform fundamental measurement tasks. The butane conversion process was one of those endorsed by the Baruch Report (Phillips process), and Bartlesville chemists had a long history of working on natural gas analysis. Once obtained, these fundamental data could then be utilized to make all butadiene conversions more efficient.[41]

In May 1943, the Bureau took a major step forward when it hired Dr. Hugh Martin Huffman from the California Institute of Technology to head the new thermodynamics section at Bartlesville. Huffman was a Ph.D. chemist, a former student of G. N. Lewis, and a respected researcher in the field of chemical thermodynamics. After coming to Bartlesville, he would pioneer in the development of instrumentation to measure the precise equilibrium of chemical reactions, and he later founded the prestigious annual Calorimetry Conference, which still continues today. Huffman visited Washington in early May, where he met not only with Bureau of Mines personnel but with chemists at the National Bureau of Standards. The main purpose of the meeting was to define a research agenda for Bartlesville that would avoid duplication with other ongoing projects. Among those with whom Huffman conferred was Dr. Frederick Rossini of the National Bureau of Standards, director of the American Petroleum Institute's Project 6 (an industry-funded basic research program on the fractionation, analysis, isolation, purification, and properties of petroleum hydrocarbons). Rossini was one of the leading chemical thermodynamicists in the country. Begun in 1927, this first cooperatively funded API research generated a mass of basic data which remains today a fundamental tool of the petroleum chemist and engineer. Included in these data are tables of the thermodynamics properties of various hydrocarbons. After discussing the Bartlesville program with the National Bureau of Standards people, Huffman then met with Dr. E. R. Gilliland of the Office of the Rubber Director to identify those areas of the rubber program where the Bartlesville work would be most helpful.[42]

The Division office had begun to make plans for staffing the new laboratory as early as February 1943. Now, with Huffman on board and funding approved, plans went forward in earnest. While in Washington, Huffman had also met with the Civil Service Commission, seeking qualified technical personnel, and had looked into ways to obtain the intricate instruments that he would require given the difficulties of the war priority situation.[43]

From the beginning of Huffman's arrival in Bartlesville, he signaled a new approach to research. He hired new men from the outside with the necessary degrees and experience in chemistry, and made clear his intention of publishing in leading national journals rather than Bureau of Mines publications—a fact that apparently irked some of the older staff, particularly Superintendent Smith, who had made the maintenance of Bureau scholarly standards his personal crusade for years. Huffman himself was only the second Ph.D. ever employed at the station and the only one on the staff at the time he was hired. One of the first men that Huffman himself hired was Donald R. Douslin, holder of an M.S. degree in chemistry from the University of Iowa, who came to the station from its Bartlesville neighbor, Phillips Petroleum. At Phillips, Douslin had worked on the firm's butadiene process, particularly the vapor-liquid equilibrium of related hydrocarbon systems. Other key men in Huffman's group included chemists J. W. Knowlton and Guy Waddington.[44]

Huffman's section concerned itself chiefly with the determination of specific heats—the heat necessary for phase changes, heats of combustion, and pressure-volume-temperature (PVT) data for many hydrocarbon compounds. Industry was heavily involved by this time in the crash program for synthetic rubber; but the Bartlesville team was only beginning to conduct basic research related to the equilibrium reactions involved in the butane-butadiene conversion. As had frequently happened in the past, the technology was in part preceding the science.[45]

The first several months of the thermodynamics work at Bartlesville were absorbed with obtaining and constructing new equipment, particularly apparatus for low temperature and combustion calorimetry, and progress was slow. Knowlton's job was to erect the combustion calorimeter and, by October 1943, he had tested it with calibrated samples from the National Bureau of Standards. Further experiments with sample hydrocarbons supplied by the American Petroleum Institute, however, indicated nagging flaws in the equipment and poor test results. The group finally decided that it had to operate the calorimeter at night so as to be immune from the vibrations caused by machinery and slamming doors. The first new experiments and data collection on two compounds, thus, did not occur until April 1944.[46]

In fact, thermodynamics data on butadiene reaction equilibrium turned out to be a very minor part of the synthetic rubber program during World War II. During 1943 and 1944, most of the butadiene produced in the United States was derived from alcohol (77 percent in 1943; 64 percent in 1944). This occurred because butylene gas, the refinery source for butene in the Standard Oil dehydrogenation process, was more critically needed to manufacture alkylates for aviation fuel. In 1945, however, butylene gas became available in sufficient quantity for petroleum-derived butadiene to constitute 61 percent of the total production figure.

The basic data developed by Huffman's thermodynamics laboratory, therefore, ultimately proved valuable.[47]

In late 1944 and early 1945, the laboratory turned out its first data on hydrocarbons. Aware that the immediacy had passed for the butane-butadiene work, Huffman began preliminary work to determine the heat of combustion of tetraethyl lead, a study with relevance at the time to the aviation gasoline program and all later studies of fuel technology. In 1945 his group broadened its inquiries to include thermodynamic studies of other basic hydrocarbon compounds, work very much in line with what other similar laboratories were doing.[48]

This group of well-trained researchers, possessing highly sophisticated equipment, was now ready to apply its skills to a range of related problems. They began a broad study of the specific heats of gases and explored other projects in discussions with the National Bureau of Standards and university laboratories conducting parts of the API basic studies. One forward-thinking project begun in 1945 centered on the study of the heats of combustion of jet-propulsion fuels. Although American technology was far behind the Germans in this field, there was great research interest in jet engines, and it was clear that they would be of post-war importance. One specific post-war outgrowth of the thermodynamics work was an 18-year Bartlesville station research program, cofounded by the American Petroleum Institute and beginning in 1948, on the sulfur compounds of petroleum. Later, an American Petroleum Institute project beginning in 1952 extended this effort to nitrogen compounds, a project which continued for twelve years.[49]

Although the actual thermodynamics research conducted at Bartlesville during the war had little impact on the synthetic rubber program, had it not been for the war emergency and the perceived need for these data, the section never would have been started—a fact of fundamental importance, because the establishment of this specialized research section had a profound effect on the future direction of the station. Combined with the sophisticated studies of aviation gasoline blends conducted by the refining and chemistry section during the war, this basic research thrust was significant in moving the station closer to the mode of the petroleum research center it later became.

Conservation and Secondary Recovery

The flurry of optimism that had appeared in 1941 following Ickes' references to the need for oil field conservation practice faded as the work at the station became almost exclusively dominated by the aviation fuel and gas-condensate studies early in the war. Commiserating with Schmidt, who had been lobbying for funding for a major Bartlesville study of secondary recovery in the Mid-Continent fields, Fowler wrote him in September 1942 that "we are now in the position of consultant to the OPC and in taking up any piece of work we must keep in mind that first things come first and the OPC, as far as we are concerned, is the organization to tell us what comes first."[50] Virtually all the Bartlesville supply and travel money remaining from fiscal year 1942 was earmarked for the aviation gasoline and condensate studies.

Fowler soon was able to provide some "happier" news, however. A supplemental appropriation for 1942 of $115,000 did contain a small amount for secondary recovery work—to Fowler this was an important, if belated, recognition of its importance. Of the total supplemental funds, $34,000 was designated for aviation fuels, $50,000 for the new thermodynamics lab, and $23,000 for condensate work. That left a mere $7,500 for a survey of Mid-Continent oil fields to recommend the application of practical secondary recovery operations and repair of wells, which Governors Armstrong of Oklahoma and Ratner of Kansas and Senator Capper of Kansas had requested in the spring of 1942.[51]

This dearth of secondary recovery work had troubled Schmidt and Superintendent Smith, who had been preparing their proposal to the new Oklahoma legislature and Governor-elect Robert S. Kerr for an increase in state appropriations for the 1943–1944 biennium. Much of the interest in secondary recovery emanated from an Interstate Oil Compact Commission (IOCC) report released in December 1942 showing that Oklahoma ranked second only to Pennsylvania in the total number of stripper wells. Schmidt also pointed out that the Bureau had last published something on marginal wells in 1937 and that "problems relating to marginal well operations and secondary recovery have been gradually shoved to the background so that within the past few years they were merely mentioned."[52]

To complicate matters further, the Bureau had provided substantial funds to investigate secondary recovery in Pennsylvania at the instigation of the Office of Petroleum Coordinator which, prompted by a shortage of Pennsylvania paraffinic oils valuable for high-grade lubricants, designated this as a war problem. In March 1942, the Bureau also opened a new Franklin, Pennsylvania, field office with staff spun off from Bartlesville, engineers C. J. Wilhelm and Sam S. Taylor. Cattell had assured Smith that, once war assignments had been covered, he would support a study of secondary recovery in Oklahoma and Kansas which he hoped would lead to future work in Oklahoma. "In this way," Cattell maintained, "we will be able to meet some of our obligations in Oklahoma along the lines of Armstrong's request, and, at the same time, will be able to do what the Bureau should do in assisting independent operators."[53]

Coinciding with the opening of the Franklin field office, Schmidt, then head of the secondary recovery section at Bartlesville, was promoted to the title of Assistant Supervising Engineer at Superintendent Smith's suggestion. This was apparently in part to provide recognition to Schmidt, who had been passed over as head of the Franklin office by Wilhelm, and to increase his salary. Records also indicate that Schmidt had been assuming more administrative responsibility from the aging Smith, particularly in negotiating a research agenda with Washington.[54]

Writing to Schmidt in December 1942, Fowler also sought to assure him that the Washington office would continue to push for support of secondary recovery projects. The 1944 fiscal year budget request contained a sum of $33,000 for such work, and the small supplemental appropriation of $7,500 mentioned above would be available soon after the convening of the 78th Congress in January. Fowler strongly supported secondary recovery, but conceded that "one of the difficulties is to be able to find the right people and tell the story in the right way to show that our work is a definite contribution to winning the war."[55]

Throughout the war, only a small group at Bartlesville worked on secondary recovery and related problems such as the disposal of oil field brines associated with waterflooding technology. Ben Taliaferro and David Logan published a history of Oklahoma waterflooding in 1942, and smaller studies of air and gas injection projects in Oklahoma were also written. One engineer conducted a preliminary study of stripper wells in Michigan, western Kansas, Arkansas, New Mexico, and Kentucky, and a group undertook a more detailed study of secondary recovery in the limestone formations of Illinois and Indiana. The focus of wartime secondary recovery work, however, was in the Franklin field office.[56]

Cooperative Research Projects

The emergence of cooperatively funded research in the 1930s represented one of the more significant institutional developments having a bearing on the future development of the Bartlesville station. In a general sense, of course, Bartlesville had always been engaged in cooperative funding, given the joint sponsorship with the Bartlesville Chamber of Commerce, private industry, the State of Oklahoma, and the federal government that had made the whole idea possible in 1918. Specific research projects funded jointly by outside groups from the private sector, however, represented an important new departure. As Bartlesville evolved into a more broadly defined research center in the post-war era, the cooperative model provided not only external funds to carry on research, but also an entree into the mainstream of state-of-the-art petroleum technology as perceived by industry.

To a great degree, World War II represented a hiatus from privately funded cooperative research as the pressing demands of PAW work forced many already contracted projects to the back burner. The most significant efforts brought together in the 1930s and extending into the war were: (1) API-sponsored pressure core barrel work; (2) AGA-sponsored studies of gas flow measurement, gas hydrates in transmission lines, and gas-condensate wells; and (3) the biennial motor gasoline surveys conducted in conjunction with the Cooperative Fuel Research (CFR) Committee, jointly funded by the API and the Society of Automotive Engineers (SAE) which came together during World War II to form the Coordinating Research Council. All three survived to a limited degree during the war and served as models for important cooperatively funded projects of the late 1940s and 1950s.

In 1937, as discussed in Chapter 3, the API had begun funding a joint project with Bartlesville to develop a pressure core barrel. This device could not only cut a core sample from a drilling formation but seal it at the same time, thus allowing detailed laboratory analysis of the core at its original rock pressure. The motivation for the project was to provide data for technically informed well-spacing regulations, and Bartlesville worked directly with the Institute's Well-Spacing Committee. The Hughes Tool Company constructed the barrel according to Bartlesville design, and it made its debut in 1939. Ultimately, its inventors, H. C. Miller, Taliaferro, and Berwald, received a patent (Serial No. 2,348,736, December 8, 1942).[57]

A conflict over priority, however, also previously discussed in Chapter 3, had developed between the API-Bureau design and a similar device patented by B. W. Sewall of the Carter Oil Company (Serial No. 2,216,912, October 8, 1940). This situation was complicated further when Sewall received a patent for a modified version of his core barrel on April 15, 1941 (Serial No. 2,238,609). Miller *et al.* raised a claim at this time that the new Sewall patent contained features found in their device, and filed a protest in 1942 on behalf of the public (i.e., the Bureau of Mines) and the API. In the interest of wartime cooperation, the Attorney General's office settled the controversy, and the official API history of petroleum engineering credits Carter and the Bureau of Mines jointly as having invented the pressure core barrel. This conflict, however, further clouded efforts to maintain testing programs with the pressure core barrel during the war.[58]

By 1942, the Carter barrel, which was commercially available, had become the one most commonly used by industry. In fact, Bartlesville engineers were testing the device for the API as part of their funding agreement. But in June 1942, the API had decided not to renew its annual $6,000 contribution for fiscal year 1943. A major factor in this decision was that the prorationing regulation needs demonstrated in the 1930s were no longer of immediate concern in the wartime petroleum economy. Schmidt wrote to Cattell in November 1942 requesting permission to use the core barrel in his secondary recovery studies of Oklahoma fields. Cattell, expressing both his own conservatism and an awareness of the sensitivities aroused by the patent disagreement, replied: "Personally, I do not feel that the Bureau has any right to go off on a new line of attack in the secondary recovery studies using the pressure core barrel without approval of the API committee." API approval did come (if not funding), and the barrel found some limited use in both secondary recovery and deep-well condensate studies during the war.[59]

One of the more fruitful associations that developed in the 1930s was a series of cooperative funding arrangements with the AGA to investigate a series of technical problems. The AGA made available a sum of $5,000 for fiscal year 1942 to carry forward ongoing work on the causes of freezing in natural gas pipelines in the form of hydrates, and studies of combination wells. Because of the wartime demands of the OPC, gas hydrate studies came under the rubric of special war problems. In October 1945, however, negotiations opened up again with the AGA to continue cooperative work into the post-war period. An agreement to study the storage of the natural gas in hydrate form was entered into on May 24, 1945, whereby the AGA Natural Gas Section would provide $15,900. This arrangement enabled the Bartlesville station to resume this amicable association and continue it into the post-war years.[60]

The National Motor Gasoline Surveys coordinated by Bartlesville commenced in the winter of 1935–1936 under a cooperative agreement between the Bureau of Mines and the CFR Committee. Further reports on the quality of gasoline marketed regionally appeared in subsequent summers and winters up to 1941. The Bureau suspended the survey during the winter of 1941–1942 and summer of 1942 because it was felt that the published data might possibly be of value to the enemy. It resumed in the winter of 1942–1943 and continued throughout the duration of the war. Chemist E. C. Lane authored the surveys until 1941, when they were taken over by chemist Oscar Blade, who continued this work until 1970.[61]

The survey took on particular importance in 1946, when the Civilian Production Administration needed estimates of tetraethyl lead for an anticipated peacetime boom. Although it required limited resources at Bartlesville, the National Motor Gasoline Survey was another important link between pre-war and post-war peacetime economies. As a neutral research organization, Bartlesville was the ideal clearinghouse for handling sensitive proprietary data provided by the major oil companies.[62]

Post-War Planning

In January 1945, the chief of the Bureau of Mines Fuels and Explosives Branch, Dr. A. C. Fieldner, requested the Petroleum and Natural Gas Division to formulate a post-war program of research. Cattell corresponded with his field offices and conducted discussions in Washington to determine a general program and tentative budget. With the end of the war now in sight, it would require a major administrative effort to coordinate the completion of Bartlesville's wartime work and begin to implement a program of future research.[63]

Superintendent Smith had by far outlasted his six predecessors, but was now in the twilight of his career. Cattell decided that Harry Fowler should move to Bartlesville to replace Smith as of February 13, 1945. Smith remained on staff at the station as a sort of "super editor," a task which he had really pioneered for himself over the years with his insistence on high writing and publishing standards. Smith retained his sense of humor in what must have been a delicate situation when he wrote Cattell on February 28: "This is only 16/28 of a monthly letter as during the first 12 days of February I was still Supervising Engineer." Demonstrating also that he was taking his new job very seriously indeed, Smith informed Cattell that he had already written a memorandum to Fowler outlining a "Program for Technical Writing" to be implemented at the station.[64]

As early as September 1944, a report by H. C. Miller and Fowler, entitled "War Work of the Production Section of the Petroleum and Natural Gas Division," had raised the theme of continuity to emphasize the importance of conservation studies in the post-war era. Although maintaining that the Bureau's traditional role had endured despite the disruptions of special war problems, they wrote that "there should be even less disruption in the adjustments from war to peace because the basic problems of the division always have pertained to the efficiency of oil recovery and better methods for making petroleum and its products easily available at reasonable cost—a desirable post-war objective."[65] The authors also compiled an agenda of research projects, many of which had been continued throughout the war on a limited scale.

Among the projects identified which had particular relevance for Bartlesville in the post-war era were several which related to the station's traditional role of oil field conservation practice. The wartime demand had added scores of wells to the stripper category, and it was clear that ongoing secondary recovery studies would be needed; but research in primary oil development was also relevant as new wells would most probably require deeper drilling and new methods of managing deep reservoirs. The exploitation of deep, high pressure reservoirs also opened up a broad field of research pertaining to the cycled dry gases that remained in reservoirs after removal of liquid fractions. This was already a Bartlesville speciality. The station could also fruitfully resume its pre-war work on the basic function of water in the production of oil by studying water-driven as opposed to gas-driven wells and the relationship of this basic research to secondary recovery. Experience had shown that further work was required on the measurement of the open-flow capacities of natural gas wells and methods of estimating both oil and gas reserves in order to achieve maximum efficiencies. There would be post-war need for pressure core barrel tests in determining well-spacing regulations and a demand for reactivating work on the formation of gas hydrates in gas transmission lines. Furthermore, World War II studies of high pressure, condensate-type reservoirs had highlighted the need for studies of corrosion in well-head fittings and other equipment.[66]

The 1944 report concluded with a restatement of the overall philosophy that had been hammered out over the years as the Bureau technicians walked the narrow line between basic and applied research, between the furthering of knowledge and proprietary interest:

> Individual companies and operators cannot be expected to prosecute extensive research of the kinds which the Bureau through long experience is best qualified to do with impartial benefit and without prejudice of property lines or viewpoint engendered by company application. In fact, the general problems on which the bureau will follow its course of coordinated research in the post-war period are of such types that usually company research organizations and commercial groups, as well as schools and colleges, are not in a position to undertake.[67]

Cattell visited Bartlesville in September 1945 for a three-day series of conferences with Superintendent Fowler and the members of each of the four technical sections: secondary recovery, petroleum production, petroleum chemistry and refining, and petroleum thermodynamics. Adjustment to peacetime conditions and evaluations of the assets represented in the research of the four groups headed the agenda. At Huffman's suggestion, there was a series of seminars presented by each section for the entire staff in order to encourage the exchange of ideas among different groups who might be working on related problems. For example, a chalk talk given by Harold Smith on the significance of studying pure compounds for finding better uses for petroleum meshed well with Don Douslin's seminar on PVT research into the thermodynamics of hydrocarbons and related compounds. Similarly, all engineers working on production-related projects were brought together to discuss such topics as the use of helium as a tracer gas and cycling and gas injection projects in primary fields.[68]

In addition to addressing its technical research agenda at the end of the war, Bartlesville also had to plan for the inevitable bureaucratic and political changes that were in the wind. With the formalization of the Petroleum Administration for War in December 1942, Harold Ickes had given assurances to oil company executives that regulation would come to an end with peace. Within a month of V-J day, the PAW had revoked almost three-quarters of the total of sixty recommendations, orders, and directives in place at war's end. Its staff, which had peaked at 1,438 employees, was down to 161 by December 31, 1945, and fifty-eight by April 1. A regulatory vacuum existed which, for the most part, pleased the private oil industry, but which also contained the potential for confusion and confrontation during the transition to peace.[69]

Fowler attended the winter meeting of the IOCC at Wichita in December 1945 and reported on some of these problems. There was generally favorable comment concerning Bureau technical reports, but Fowler was concerned about an IOCC move to create its own economics branch and make its own demand forecasts. There appeared to be a consensus within the IOCC that it should now take over the demand forecasts and other statistical work that the PAW had handled during the war. Fowler cautioned that "It is quite evident that a number of organizations have their eyes on the data files of the PAW, and apparently the Bureau may have to fight if it gets the material it wants. Or maybe I should say that the Bureau had better get 'high behind' before there is an act of Congress turning it over to somebody else."[70] These fears were not realized, but they indicated that another level of post-war planning was also necessary.

Also in December, Fowler met with officials of the Mid-Continent Oil and Gas Association, Independent Petroleum Association, and the refining editor of the *Oil and Gas Journal* to discuss post-war federal petroleum research, "a subject of primary interest to industry at that time."[71]

A central activity at Bartlesville during the first six months of 1946 was the compilation, revision, and editing of manuscripts and reports. Because of the extensive field work and testing that had been required during the war, and the quick turnaround demanded by the PAW for reports, station personnel had not had the time to produce the permanent Bureau publications that Smith had fostered during his long tenure. In his monthly letter of May 1946, Smith raised this issue directly with Cattell. Working from a list of Bureau publications from 1940 to 1946, Smith said he was shocked to note that "Not one bulletin or monograph was published in this period, and only three technical papers." He argued that, except for two important field reports, the other seventy-six listed represented "plenty of 'PUBLICITY' but little 'REPUTATION.'" Cattell responded with a general memorandum to all Supervising Engineers which echoed Smith's concerns but toned down the rhetoric.[72]

The immediate post-war years remained ones of consolidation. Part of this involved the completion of manuscripts and publication of data, but it also meant carving out a research agenda that could deal adequately with both the backlog problems that remained from the pre-war era and new sets of challenges presented in the future. Now that the wartime emergency had come to an end, could Bartlesville and the Bureau sustain the view that government-sponsored research had a continuing role to play in the modern American petroleum and natural gas industries?

NOTES

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58. H. C. Fowler to H. C. Miller, January 29, 1943, Box 224331, folder 019.22; Fowler to C. A. Young, API, February 24, 1943, Box 224331, folder 019.22; Leonardon, "Logging," p. 501.
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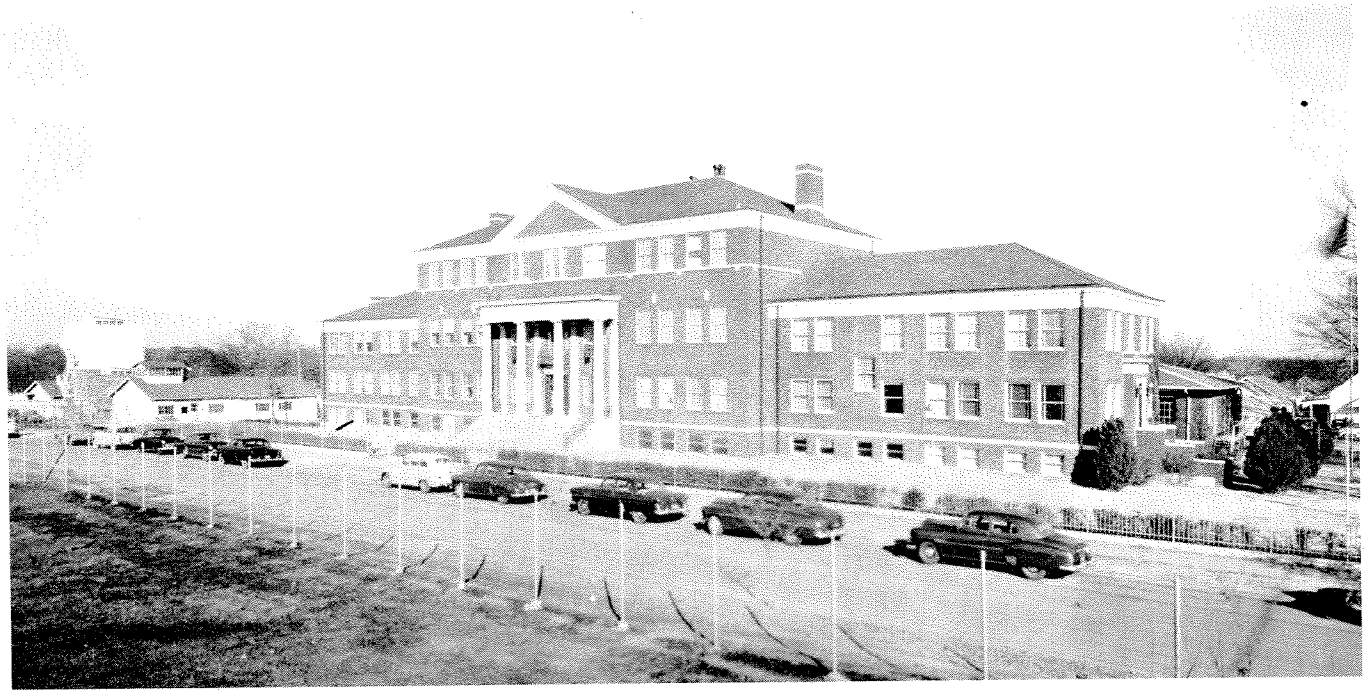
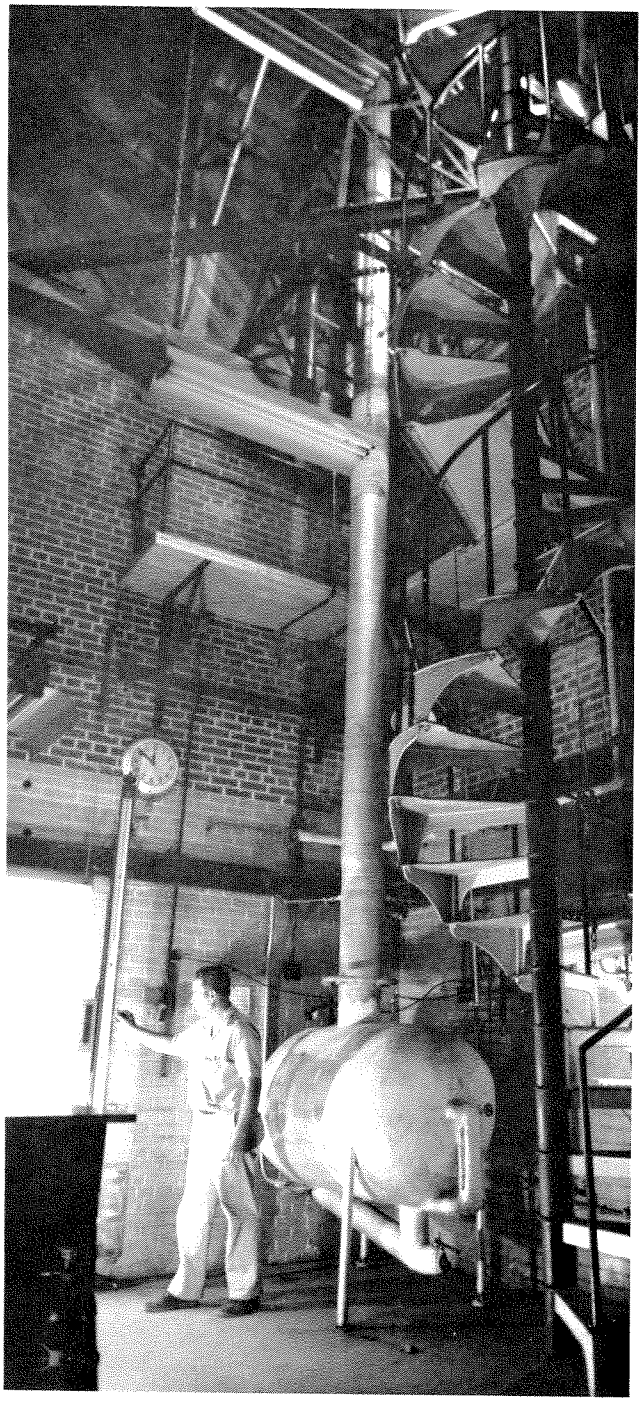
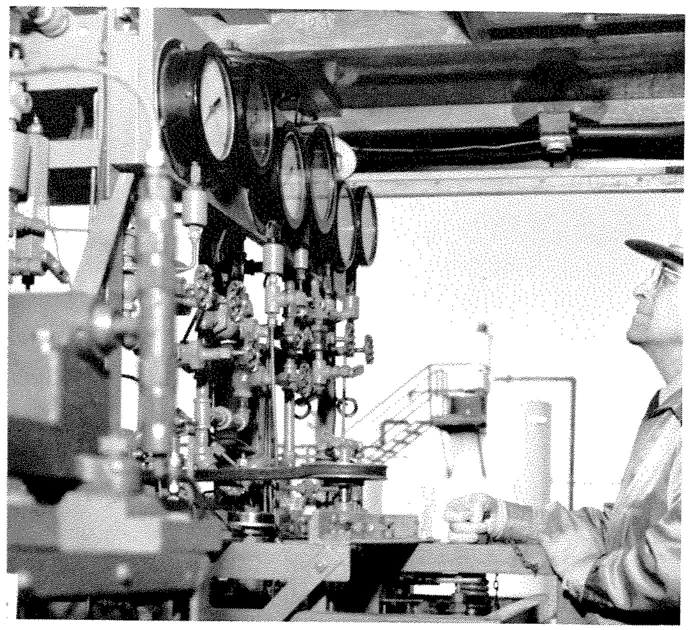
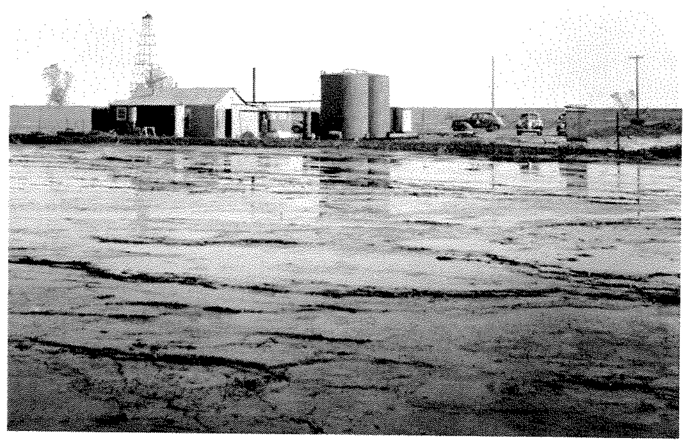
60. R. R. Sayers to E. A. Poe, AGA, July 14, 1941, Copy of Cooperative Agreement, July 1, 1941, Box 224330, folder 826AGA; H. D. Hancock, AGA, to Members of the Technical Research Committee, July 5, 1945, Box 224333, folder 022.7; Biennial Report, Petroleum and Natural Gas Division, 1942–43, Box 224332, folder 050, pp. 106-107.
61. O. C. Blade, "National Motor Gasoline Survey, Summer 1945," Box 224334, folder 632.1.
62. R. A. Cattell to Nielsen B. O'Rear, June 17, 1946, Box 224334, folder 632.1.
63. Monthly Report, Petroleum and Natural Gas Division, January 1945, Box 224332, folder 017-41.
64. N. A. C. Smith to H. C. Fowler, January 26, 1945, Box 224332, folder 017.41; Monthly Letter, N. A. C. Smith, February 28, 1945, Box 224332, folder 017.41.
65. Miller and Fowler, "War Work," p. 111.
66. *Ibid.*, pp. 111-129.
67. *Ibid.*, p. 129.
68. Monthly Report, Bartlesville Station, September 1945, Box 224333, folder 017.41.
69. "Somebody's Sweetheart Now," *Time* (December 14, 1942), p. 29; Frey and Ide, *PAW*, pp. 289-90.
70. H. C. Fowler to R. A. Cattell, December 18, 1945, Box 224333, folder 022.97.
71. Monthly Report, Bartlesville Station, December 1945, Box 224333, folder 017.41.
72. Monthly Report, Bartlesville Station, February, March, April, May, June, 1946, Box 224333, folder 017.41; Monthly Letter, N. A. C. Smith, May 29, 1946, Box 224333, folder 017.41; R. A. Cattell to Supervising Engineers, June 11, 1946, Box 224333, folder 017.41.



The office building, constructed in 1918, was enlarged to an administrative-laboratory building (upper picture) in 1937. This enlargement reflected the growth of the Station from 3 to the 58 people listed in the dedicatory booklet. A mobile laboratory is shown (lower) which was used to promote secondary recovery in the late 1940s and 1950s.







Three of the War programs at BETC involved analysis of aviation gasoline basestock, testing of condensate wells for production of basestock, and reclamation of old waste ponds for usable paraffin wax. The picture on the left shows a high-efficiency distillation column constructed for separation of crude oils analyzed for aviation base stock, and toluene for explosive manufacture. The top right picture shows C. K. Eilerts in a mobile laboratory checking the production of a field. The lower right picture shows the plant at El Dorado, Kansas for reclaiming wax from waste ponds.