Chapter 3

EMERGENCE OF SCIENTIFIC RESEARCH, 1930–1941

During the 1930s, the Bartlesville station encountered and overcame a series of challenges to its jurisdiction, its funding, and its role in government. The Great Depression, in addition to an oil glut in the early years of the decade, imposed severe difficulties. The oil industry's drive to develop new methods of discovering and recovering oil slowed as prices plummeted. Crude oil sold in East Texas, for example, sank to ten cents a barrel. At such prices, only the large producers avoided the danger of economic disaster. Since the courts viewed limitations on production as illegal restraints of trade, industry was powerless to set production limits or even to set a price floor. Oil companies sought legal and technical means of limiting production. In this atmosphere, it appeared the Bartlesville station could have little role. Further, the declining federal and state revenues meant that the station's budget would be severely chopped. In 1931, the federal budget for the station was cut from $101,000 to $94,000, while the state appropriation was reduced from $62,500 to $57,500. Further cuts followed in 1932 and 1933. The oil industry, too, cut its expenditure for research, and fewer station technicians received offers of private employment. The Bureau of Mines faced the awkward dilemma of reduced budgets, lowered demand for research, and a tight job market that reduced staff attrition in response to job offers elsewhere.[1]

Assisted by friends in Washington and by the industrial network of Bartlesville alumni, Smith and Ludwig Schmidt—a petroleum engineer who was at the station from 1921 to 1947 and served increasingly as Smith's right-hand man—worked to find a continuing place for the Bartlesville station amid the swirling changes in the oil industry, the economy, and the emerging new institutional arrangements of the New Deal. In particular, they sought new sources of private funding and new justifications for state and federal government aid.

Not surprisingly, therefore, despite constant planning conferences and correspondence within the Bureau in Washington and Bartlesville over proposed work, the resulting publication list of the 1930s reflected not so much a pre-planned research agenda as the results of changing access to funding influenced by a host of difficult pressures. First, rivalry and disagreement between associations continued to put the station in a difficult position. Second, over a period of years, the oil glut made "conservation" and "more efficient utilization" of petroleum appeal as never before to the leaders of oil-producing corporations. If, in the name of conservation, states would establish rules and regulations leading to effective limitation on production, which the states themselves could enforce, then the legal deadlock over exactly how to put a stop to massive overproduction could be achieved. But this, of course, meant the threat of an increased federal role in regulatory activities, however, which aroused potential resentment among some oil industry leaders towards any federal role, even in research. Station technicians viewed such developments as endangering the close cooperation between government, station, and private industry which had been built up with such care during the 1920s.

"Conservation" now not only meant the avoidance of physical waste, but also the avoidance of inefficiency and waste that resulted from economic conditions—"economic waste." Although the oil glut rendered any research into improving recovery methods needless, industry did seek new devices which could measure and detect the rates of production and determine the size of underground reserves, in order to justify and enforce agreements and regulations to limit production. But measuring procedures imposed on resources or products entering a market were inherently controversial, since a refinement of measurement would usually reduce profits on one side of an exchange and raise those on the other. Measuring production or reserves in order to limit production appealed to the industry as a way to stabilize prices. The public, however, suspected that such measures might be contrary to consumer interests. Because of its concern with precise technical measurement, the station was in an excellent position to partici-

pate in the development of measuring devices. Yet station administrators approached participation in the commercial application of measuring devices with considerable trepidation because, like their predecessors in the early 1920s they sought to avoid controversy.

Thus, the period 1930–1941 was a dangerous one for the station. Bartlesville faced a tangle of conflicting pressures and threats to its funding that arose from the industrial disarray, the oil glut, and the Depression. Despite a constant fear of budget cuts and the difficult task of defining research work that would not endanger the station's standing in the conflict-ridden and volatile oil industry, the station not only survived but expanded its programs and physical facilities.

Support from New Deal programs and state relief projects, for example, enabled the station to engage in a major building program, adding laboratory space, a library, and administrative offices. And its good relations with Oklahoma continued, enabling the station to conduct field studies of Oklahoma oil fields, giving favorably disposed state legislators material which could be used to defend continued state appropriations. Research on a variety of projects also proceeded, including studies of liquid petroleum gas products, hydrogenation of liquid gases, studies of combination oil and gas wells, refining techniques, methods of casing and plugging wells, and safety techniques with hydrogen sulfide associated with oil field drilling.

Changing Relationships with State and Federal Government

During the 1930s, increased funding constraints forced the center to focus on its finances. A reduction in funding in 1931, for example, forced the cancellation of a biennial survey of the brands of motor fuel on the market even though it was of great use and much appreciated by the industry. Also, increasing attention was paid to which employees were on federal and which on state funds. The latter were regarded as less secure and were, therefore, used primarily to pay clerical, maintenance, mechanical, and some of the lower-paid technical staff.

Schmidt and Smith nurtured carefully the relationship with the State of Oklahoma in order to preserve what funding they could from that source, which never sank below $40,000 annually in the 1930s despite the cutbacks in the early years of the decade. Recognizing that oil men who were friends of the station would be able to influence the station's state appropriation, Schmidt sought in particular to promote *local* research in order to justify Oklahoma state funding. In March 1936, for example, he warned Cattell at the Bureau's Washington office of Petroleum and Natural Gas that the state legislature was considering appropriations when it met in January 1937 and that, unless the station got to work on a solid, local project, there would be no publication from the researchers bearing on Oklahoma matters. Schmidt linked the need for local research explicitly to funding, noting that the current biennial appropriation was $41,840. He recommended some kind of report be prepared on the newly flourishing Oklahoma City field: "Frankly, it seems to me that unless we have some recent work pertaining to Oklahoma fields or Oklahoma problems, our state funds are very likely to be jeopardized."[2]

The appropriation was further endangered when, during the election campaign later in 1936, the state Democratic Central Committee's Secretary-Treasurer, L. T. Cook, requested the help of Smith in raising funds from employees at the station. Very diplomatically, Schmidt (replying for Smith) informed Cook that, as a federal facility, the station was under civil service rules prohibiting solicitation for political funds by supervisory personnel. Schmidt thought it was better he reply rather than Smith (the Superintendent), as an official letter might embarrass the station when the appropriations came up in the state legislature.[3]

When the appropriations were under consideration the following January, Schmidt noted in a report to Cattell that the station's state funding was, indeed, endangered. Constitutional amendments and initiatives had created a local real estate tax exemption for homes valued under $1,000. The reduction in municipal and counties' revenues from this exclusion led to an increased demand for state funds for school districts. Governor Lew Marland, himself an oil man, passed on to the legislature increased school budget demands but made no recommendations as to revenue source. A bill was introduced in February 1937 to the lower house to cut the budget for the Bartlesville station. Schmidt's careful planning paid off however, as the station survived committee hearings and the budget held at the prior level.[4]

Men at the station sensed that a new kind of bureaucrat was coming out of the new federal agencies established by the New Deal—one who set the government and the agency against industry, and who would sacrifice cooperation and an advisory role for a regulatory and often more self-serving role. The contrast struck Schmidt particularly when he encountered some of the younger, new breed of bureaucrats from the Department of Agriculture at an interagency meeting in 1937, at which he reported to the interagency Basin Committee for the Southwest Mississippi River District (part of the New Deal planning effort for various river basin areas). In Schmidt's judgment, the Department of Agriculture representatives at the meeting appeared to stack the reports to emphasize their pet soil conservation projects, raising anger among both state and municipal officials.

In spite of this perceived trend, however, Schmidt and the other engineers at the station continued to view their agency as a focal point for intelligent intervention in business through cooperation and advice, following the philosophy of the Hoover-Coolidge New Economic Era well into the New Deal period. Such hints suggest that the delineation between the political philosophy of the two eras was never a sharp cleavage at the practical level of operations, but more an overlapping of slightly different emphases.[5]

In any case, despite the growth of federal agencies and bureaus perceived as building their own empires and neglecting service to the industry, New Deal funds provided an opportunity for the Bartlesville station to build a facility which incorporated a vast array of "dream features." Using Public Works Administration funds, the station constructed a permanent laboratory that went far beyond the earlier facilities in convenience, scientific equipment, and design. The new building contained laboratories with such features as tap distilled water, acid-proof and fireproof surfaces, and custom-designed desks and tables. A handsome, wood-paneled library with a fireplace in the reading room gave an element of quiet repose and stability. Completed in 1937, the new building brought the physical embodiment of permanence and modernity the station had sought for two decades.[6]

The dedication of the new laboratory provided an opportunity for the station to repay a whole range of political debts in both industry and government. Schmidt requested that personal letters of invitation to the most important guests come from the Director of the Bureau of Mines. The guest list was designed consciously to pay back debts, including some that had been neglected in recent years. Schmidt made particular mention of United States Senator Tom Anglin, who served as the Governor of Oklahoma's representative on the Interstate Oil Compact Commission. He also requested that a personal invitation go to Alf Landon, because he had initiated cooperative work between the station and the State of Kansas while Governor. The fact that he was the defeated Republican candidate for the Presidency, and therefore titular head of the Republican party, remained an unspoken additional reason for his inclusion.[7]

Among private oil men, Schmidt particularly wanted H. L. Doherty invited, since he had arranged for the largest contribution to the original Chamber of Commerce fund which had financed the construction of the station in 1917. In the mid-1920s, Doherty had advocated compulsory limitations on oil production through cooperative agreement—the process eventually called unitization. His plan had met general opposition in the oil industry, and Doherty had won many enemies. Despite the controversy surrounding his name, however, Schmidt wanted him invited, noting that old friends should not be forgotten. In all, the invitation list was constructed with a nice awareness of the political debts of the station, and the new building was officially opened in October 1937, with appropriate speeches, tours, and attendant publicity.[8]

The effort to develop acceptable projects and to lay down plans for future work that met government needs and priorities was sometimes hampered by the internal committee structures within the station. To identify ways to provide a better focus for the station, Cattell authored a comprehensive study of the organization and the technical or scientific problems being worked on in 1937. He noted that the problems studied at the station were selected from a much larger number being suggested by industry. The problems that the station chose to undertake were selected because of their usefulness, the staffing configuration of the station, and funding limitations. Cattell did not believe, he wrote, that industry dictated the choice of problems. He outlined a complex structure of committees at the station, with Schmidt and Smith either serving on, or co-chairing, three separate planning committees. Contemporary correspondence reveals, however, that although Smith remained nominal Superintendent of the station, Schmidt undertook increasingly most of the liaison with headquarters over policy matters such as external politics, the search for cooperative funding, and research choices. No evidence suggests that the elaborate committee structure outlined by Cattell ever really functioned as a research coordination effort. Instead, loose conversations, and hints from alumni and journal articles helped formulate research decisions. When these had been made and a tentative research agenda established, the heads of the various sections of the station tried to match personnel skills and funding with the potential research topics.[9]

By the mid-1930s, refinery practices and refinery chemistry financed by major oil companies in their own laboratories had moved beyond the station's capacity to make major contributions. The role to be played by the small facility at Bartlesville could no longer be central, Smith recognized. Further, the development of proprietary practices in refining and petroleum by-products made it difficult to define a role for the government-operated station. In contrast to the producers, which were usually small firms or individual operators lacking elaborate engineering research efforts, the refiners were typically large, vertically integrated companies with ample funds for their own research and development. As long as these major oil companies continued to purchase a large percentage of their crude oil from small producers, the opportunities would exist for government and cooperative research in production engineering problems but not in refining problems. Smith understood the increasing distance between the station's work and the state of refining technology, and

could only recommend that the station try to stay in touch with developments in the field.[10]

Smith also recommended maintaining better contact with refiners and with relevant professional associations, but did not think the station should pursue refining process research. He rightly recognized that this research would run the very real risk of involving the station in proprietary squabbles with industry.[11] In petroleum chemistry and refining, therefore, Smith basically pursued a holding action, being content to design some long-range analytical research efforts that would help justify staffing levels. Smith believed that his chemistry and refining group needed a good, solid, long-term project, and recommended that the station undertake an analysis of crude oils from each oil-producing area in the nation. Consequently, the station sharpened its methods for the analysis of crude oils and lubricating oils, which would later prove valuable under wartime pressure.

Cooperation with Industrial Associations

Through the 1930s, the Bureau of Mines continued to cooperate with industrial associations, a policy that had begun in the previous decade. Nongovernment funding could provide for travel to conferences, publication expenses, and research laboratory costs, but never to pay direct labor costs of government employees. In a time of stringent government budgets, however, association work could provide an attractive, even if partial, solution to the station's financial need for resources. In addition, it provided a valuable opportunity for station scientists and technicians to work closely with private industry on projects and problems that private industry held in high priority, in a way that avoided the risk of compromising impartiality by working on projects of clear benefit to particular companies. Particular oil companies were engaged in specific, profit-related research; the associations, in contrast, were interested in funding research into industry-wide problems. Thus, cooperation between the Bartlesville station and industry-wide or regional trade associations demonstrated a potential solution to the dilemma posed by public service to the privately operated and owned oil industry. Service and research for particular companies, as shown by the Lewis incident in 1918, could lead the government into a trap of performing work which carried no broad implications, which benefited but a single company, and which compromised the station's reputation for impartiality. However, work which an industrial association suggested, on a problem which the association decided to be of an industry-wide character, avoided such pitfalls while at the same time allowing the choice of direction of research to remain influenced by the private sector and avoiding the danger of becoming out of touch because of central planning by a government bureaucracy. The relationship between Bartlesville and the National Gas Association provides a good example. The Natural Gas Association sought answers to questions about the flow of natural gas through transmission lines, leakage from those lines, the specific physical properties of natural gas, and methods of measurement of gas well deliveries. The station contributed in each area in a close cooperative relationship with the gas industry that began as early as 1922, when R. A. Cattell prepared Technical Paper 325, "Natural Gas Manual for the Home," in cooperation with the Natural Gas Association. In 1928, Bureau of Mines Bulletin 265, using station work, covered "Leakage from High-Pressure Natural Gas Transmission Lines." And through the late 1920s, the Bureau studied the issue of the rate of flow of natural gas through pipelines under various conditions, both using published data and conducting experiments to determine the effects of various changing factors. Shortly thereafter, a 100-page document prepared by the station, "Factors Influencing Flow of Natural Gas through High-Pressure Transmission Lines," was issued both as an American Gas Association product and as a government report.

The question of measuring deliveries from gas wells could be treated as a classic issue in the effort to disseminate conservation methods that had characterized engineering approaches to economics through the 1920s. As E. A. Rawlins, gas engineer at the Bartlesville station, suggested in his report on gas well measurement, such research "will make it possible not only to prevent much actual gas wastage to the air, but will also make it possible for operating companies to plan definite depletion and gas-storage programs . . . with maximum recovery . . . and maximum efficiency."[12]

The measurement of gas well capacities in the early 1930s did, however, take the station into controversy despite their effort to avoid it by serving the industry as a whole. The occasion was the pursuit of what the Bureau believed to be one of their proper functions—"elimination from the lay mind" of "erroneous" views (in this case, erroneous views of gas reserves). State conservation laws required the measurement of gas well production rates at "open flow," in which gas flow would be measured in an open or uncapped well. This was because measuring pressure against a shut off or "closed-in" well gave very little indication of the volume of gas which might be present in the underground reserve. The publication of "open-flow" measurements by several states created the public impression of vast reserves and artificial price setting which station personnel believed was unjustified. Bureau men viewed as part of their function an effort to help the industry explain to the public that open-flow measurements, required under state law, did not

necessarily imply huge reserves, and station technicians pursued that objective by advocating a better understanding of the underground formations in order to judge accurately the size of reserves.

Through the 1920s, Bureau cooperation with the Gas association had consisted of working on projects of interest to the Association, with an occasional arrangement for co-publication. Between 1930 and 1934, the station continued work on two cooperative projects with the American Gas Association, including a study of mathematical formulas for gas pipeline flow and an investigation into methods of gauging and controlling natural gas wells. As it turned out, however, the Gas Association contributed only about 20 percent of the funds spent on these projects, as shown in Table 2.

TABLE 2

Relative Federal and AGA Cooperative Funding

Fiscal year	Federal funding	AGA cooperative funding	Total funding
1929–30	$12,000	$ 3,000	$15,000
1930–31	12,000	3,000	15,000
1931–32	12,000	2,500	14,500
1932–33	8,000	1,500	9,500
1933–34	6,000	1,500	7,500
Totals	$50,000	$11,500	$61,500

Source: RG 70, Box 224318/022.7, Natural Gas Section, AGA.

With the hope of preventing further decline and perhaps even improving the situation, Bureau officials began to lobby the association to increase their research funding. In May 1935, the Bureau outlined for the AGA all the work accomplished under the cooperative projects over the previous years, a record which an Association subcommittee presented at the annual meeting of the Association in Memphis. At that meeting, the American Gas Association proposed an industry code on gas well delivery measurement as part of the National Industrial Recovery Act establishment of industrial codes for each industry. Staff members at Bartlesville, on invitation by the Association, had reviewed the code and made minor suggestions for revision.[14]

The same year, the Association's Main Technical and Research Committee endorsed a proposed cooperative project with the Bartlesville station concentrating on methods of measurement of combination gas and oil well. The Association set aside $3,000 for this project for fiscal year 1936, at which time a separate agreement to work on the formation of hydrates (ices) in gas pipelines was funded for $1,500, to be conducted at the Bureau's helium plant in Amarillo. The total of $4,500 was the lion's share of a total of $6,000 which the AGA had budgeted for research in 1936. In short, the Bureau's lobbying paid off, and both the Bartlesville station and the Amarillo facility benefited.[15] At the same time it was decided that a Bureau man should serve as liaison on this main research committee. From 1934–1936, Eddie Rawlins from Bartlesville filled that role, which he left to work for the United Gas Public Service Company of Houston. W. B. Berwald, also from Bartlesville, replaced Rawlins on the committee in 1937–1938, when he, too, left government work for an industry job.[16]

From his position at United Gas, Rawlins, as was typical of the alumni, continued to provide help to the station, making suggestions for reports from the Bureau to the Association well into 1940. Even after he had moved on from Houston to the Union Producing Company in Shreveport, Louisiana, Rawlins kept in touch, supplying the station with suggestions and ideas.[17]

Through 1940, the station continued to work on gas problems, using additional funding from the Association. The problem of gauging and controlling combination oil and gas wells engaged M. A. Schellhart, natural gas engineer, assisted by R. J. Dewees and W. H. Barlow, associate petroleum engineers, and E. M. Tignor, junior natural gas engineer. These men produced a Report of Investigation, published March 1940, on work done between 1938 and 1939. They demonstrated that well test data could detect the level of a layer of sand which allowed loss of gas—called a "thief sand"—and recommended well recasing to eliminate the problem. The Association's monthly newsletter summarized the report and recommended it to Association members.[18]

Another project using Association funding, headed by Kenneth Eilerts as an associate physical chemist and assisted by R. V. Smith as a junior gas chemist, calculated optimum rates of recovery of a high pressure field. Using laboratory analysis, the chemists measured the physical properties of certain naturally occurring fluid hydrocarbon mixtures at pressures up to 5,000 pounds per square inch and at temperatures from 70°F to 270°F. In order to study the properties of a particular mixture of hydrocarbons at the naturally occurring pressure and temperature, Eilerts and Smith developed an "equilibrium cell" which could maintain the fluid at original temperature and pressure conditions for study. This work resulted in the publication of two papers. Such research proved extremely useful in promoting greater recovery of liquids from gas-oil mixtures extremely low in liquid content at surface temperatures.[19]

In 1937, Holley Poe became executive secretary of the American Gas Association. Poe was a native of Oklahoma and resident of Tulsa, who had worked in both gas and oil production in Oklahoma and for

Central States Power and Light Company in Tulsa. This was of great benefit to the station, because Poe's knowledge of the Bartlesville work and his commitment to Oklahoma institutions increased the support of the station by the Association. In early 1941, Poe recommended the highest Association support level up to that time for gas research—$5,000 to Bartlesville and another $1,500 to Amarillo.[20]

Hoping to make Poe's recommendations a reality, Cattel suggested that several nearly completed research papers from the station on gas topics be prepared for presentation at the 1941 convention of the Association. At the station, Smith reviewed the possible avenues of expenditure for the $5,000, either continuing work already underway or, alternately, beginning new defense-related surveys of all the gas reserves in the United States. Poe's recommendations were accepted by the AGA, at least in part.[21]

The Search for Technical Solutions to Nontechnical Problems

During the 1930s, several devices were developed by the Bartlesville station to meet industry's need for precise data for production limitation. This development can be viewed as a "technocratic" solution to an economic issue.

Hoover himself advocated the rationalization of industry through standardization, elimination of waste, and a variety of efforts to rationalize marketing, labor relations, and capital expenditures. A number of self-styled "liberal engineers" associated with him in the 1920s had hoped to solve a wide range of economic and social issues by rationalizing industry, hoping to go beyond the complex and unpredictable political process and solve problems through more rational, "technocratic" methods. By the 1930s, the support that Hoover had marshalled for this movement had largely dissolved, although some of his followers worked through the New Deal to implement their ideas. While such developments were proceeding in the form of major policy discussion at the national level, they also proceeded in a small way at Bartlesville. There, engineers consciously provided technical assistance to help resolve major economic problems well into the 1930s.[22]

The development of particular measuring devices which could accurately determine pressure, temperature, saturation, and porosity conditions in oil- and gas-producing strata, they thought, might provide the key to the problem of oil production control. Under the "law of capture," a first-come first-served philosophy favored rapid, or "flush," production and development of every field. Whoever got the oil out first and captured it was entitled to it. As long as demand exceeded supply, flush production would lead to flush sales and profits. But with the opening of East Texas in 1931 and the resulting overproduction, the fall in prices threatened the whole oil industry. In Oklahoma, Governor William H. Murray declared the taking of oil when there was no market demand an illegal act and prohibited it by force of arms, using the Oklahoma National Guard to declare principal oil fields "off limits." In Texas, Governor Ross Sterling used the Texas National Guard to close the East Texas field from August 1931 through mid-February 1932, until he was overruled by federal court. Neither governors nor producers could agree to limit production, however, since this would mean collusively agreeing to restrain competition in order to maintain prices.[23]

The logical way around the dilemma was to declare all producers drilling a single field as members of a producing cooperative or association—a solution that had been proposed in the 1920s by Doherty but not supported by industry at that time. Under this system, the "unitized field" limited production and paid those producers who held off drilling or producing on their leases from a pooled fund. Such limitation, instead of being a price-maintaining measure, could be presented to the courts as scientifically advisable in the interests of rational conservation techniques. Another method of controlling production was prorationing, in which production would be rationed on a daily basis. Prorationing could be established on a production-per-acre or well-by-well basis. When organized and enforced by state agencies such as the Texas Railroad Commission and the Oklahoma Corporation Commission, these kinds of limitations eventually withstood legal challenges. By 1936, the cooperation of the state commissions through the Interstate Oil Compact Commission, backed by federal legislation creating the Compact and outlawing interstate sale of hot oil (that is, oil produced outside the prorationing systems), finally put in place a workable national system of production limitation.

Yet such a rationale and system could only be enforced if producers could accurately determine such specifics as variations in well pressure. Clearly, a producer whose well tapped a high-pressure, richly saturated pocket would be entitled to a greater share of the prorated profits than a producer whose well tapped low-pressure, relatively unproductive strata. Such differences had to be accurately and consistently measured by standard, widely accepted devices.

Furthermore, the courts remained reluctant to endorse production limitation when the only purpose of the agreement was to hold up prices. To justify the limitations as "conservation," some technical determination of "optimum" production rates had to be made. Pressure-sensing devices were needed to show that flush production reduced natural pressure at a wasteful rate, while controlled production held the pressure in

reserve and resulted in greater production of the resource over time.

To further this objective, in 1934 Scott Turner, Director of the Bureau of Mines, told Congress about the research work at the Bureau and especially at Bartlesville, and hinted that research there could help resolve the problems of overproduction. He outlined the studies of energy reserves (in the form of pressure) in oil reserves, the behavior of fluids under different conditions, and the effects of moving fluids against resistance. "It is the belief of our engineers, after years of study, that an understanding of these fluid-energy relations is basic to the solution of many difficulties now confronting the industry, some of which are nontechnical in character." The phrase "nontechnical" was a massive understatement to describe what the oil industry appeared to be going through—ruinous overproduction in the midst of legal struggles to determine an acceptable system of controlling production.[24]

Even though Smith's years of work in establishing the station's scientific and technical reputation and the scrupulous concern for not showing favoritism in disputes could at last help the station, Cattell, Schmidt, and Fowler were all cautious. The first participation of station engineers in the process was tentative and exploratory. Through 1931 and 1932, station engineers engaged in field work to evaluate pressures in shut-in and flowing wells. In particular, Reistle worked in the East Texas field closed by order of the Texas Railroad Commission. Rather carefully, Bureau men tested their instruments, at first taking care to stay out of cases which might be tested in court or before the commission. As Reistle noted in 1931:

> In the East Texas area there seems to be a need for bottom hole pressure data covering the entire field in order to supply data from which engineers hope to obtain more accurate information on the ultimate production, potential production and the relationship of pressure decline to rates of oil and gas withdrawal. This information is desirable primarily because the field is subject to proration and it is the desire of at least a part of the operators to regulate the entire field so that each individual receives his equitable share of the oil.[25]

Reistle then explained that the test of the instrument was done on a north-south axis and an east-west axis, thereby producing a pressure and temperature survey of the field which provided a valuable and useful description of an underground formation as part of the test.

A similar tentative awareness that scientific work might bear on economic controversy showed up in 1932. In a report on the Oklahoma City Gas Reserve, Rawlins noted that the Lone Star Gas Company was having trouble with both the Texas Railroad Commission and the Oklahoma Corporation Commission:

> The result is that the Lone Star has undertaken a complete study from a gas reserve standpoint of all their properties in Texas and Oklahoma. Such instances are bringing the gas reserve problem to the forefront, and since the data and analyses have to withstand court procedure, the technical problems connected with such estimations are receiving considerable attention.[26]

The Bartlesville team established a field office in Oklahoma City to conduct studies of the gas reserves there. The study was not funded by cooperative agreement with the American Gas Association, but as a part of the Bureau's general investigation of reservoir conditions and of the operation of flowing wells. Once again, station engineers tried carefully to establish themselves as an independent and objective observing group in a highly controversial area. In a letter sent out to all the operators in the field, Superintendent Smith explained how the study would proceed. Ben Lindsly, as Senior Petroleum Engineer, would study bottom hole samples. The amount of dissolved gas that was liberated from the samples, the shrinkage of oil due to liberation of gas, and the potential energy of the liberated gas would all be obtained. Carl Reistle would study the mechanics of flowing wells using bottom hole temperature and pressure recording instruments. Smith explained to the producers that the object was to find a means of producing oil using minimum gas-pressure energy. Without stating it explicitly, an implied objective of the study was to develop a conservation justification—that of minimum use of gas-pressure energy—for holding down production.[27]

By 1934, the need for bottom hole sampling devices, both for pressure and temperature, was increasing as the movements to unitize fields voluntarily and to move in the direction of state-ordered prorationing caught on. The station received numerous requests from private operators for the instruments used by the engineers which, of course, brought up the question of patents.

The Bureau shifted from the Department of Commerce back to the Department of the Interior in 1934. This compounded the issue of patentability, leaving the Bureau with no recent precedents, since the Department of the Interior had had no scientific research responsibilities for the previous eight years. Cattell favored individual patents for the pressure recorder and the temperature gauge, allowing federal "shop-rights" in the devices to allow government use of the patented devices for the government's own purposes, without payment of a royalty, on the grounds that the devices had been developed within the government "shop."

Cattell advised Reistle and Lindsly that they might be able to patent their inventions as individuals, but left the matter of whether or not to seek patents up to the two individuals in question. Their original instructions had not included development of the instruments. But because the project they had worked on had been

assigned and the devices had related to that project, a court might find that the patents should be assigned to the government. At the same time, their personal claims would also be strong.

Lindsly subsequently filed for a patent, with the expectation that he would receive royalties from industry. This attempt failed due to other research that overtook him. Reistle moved more slowly on registering his pressure recorder, looking into the complexities of patent law. By late 1935, the issue had become moot for Reistle. In order to insure that no private concern would copy the pressure measuring device and patent it for private profit, the Bureau published a report on the pressure gauge (Report of Investigation No. 3291), making the details of the device public. Bureau staff members were not displeased to learn that the publication of the report upset plans by Gulf Oil to develop their own pressure gauge, since placing the details in the public domain through a report of investigations blocked the corporation from obtaining a patent.[28]

Reistle left the station to work in the Texas fields for the producers' association there and, later, for Humble Oil. He took his skills, abilities, ideas, and "know-how" to the field, transferring the principles of determining bottom hole pressure to a field where prorationing or limitation on production was crucial. In the 1920s, engineers and chemists had moved from the station into the producing companies to improve production; in the 1930s, Reistle moved on to help limit that production. The station, thus, still operated as a training ground for the industry.

Through both the 1920s and 1930s, this movement to the private sector was encouraged and contact continued with the alumni in the 1930s as it had in the 1920s. Through the 1930s, "alumni" working in industry continued to meet at annual conferences of the API at an "alumni breakfast" to discuss informally the research direction of the Bureau of Mines and the Bartlesville station in particular. In later years, some of the technicians who stayed on, perhaps with a touch of jealousy, began to look back at their departed colleagues as having "sold out" to industry. Others, however, were able to view the movement of technicians to industry more objectively as an extension of the government's cooperation with industry. As a training ground, the laboratory could develop a person's knowledge and experience. By working under the supervision of a senior specialist, junior staff could mature and hone their skills. Then, when they moved on, they not only made personal career moves but also moved a body of knowledge and experience from the government-funded laboratory to the private sector in a way which was far more complete and effective than publishing an article or report and hoping it would be read and digested by others already in industry. The alumni phenomenon through this period can be and was seen as a direct mechanism for technology transfer.[29]

In 1936, the producers' association in the Fitts pool in Oklahoma, worked out a cooperative agreement with the Bureau to devise a method of obtaining an accurate sample with bottom hole pressure intact. Bartlesville engineers first took a survey of the producers to get records of pressures and temperatures in both flowing tests and shut-in or capped tests. Pete Grandone and Berwald collected the data and conducted field tests. Through October and November 1936, the team varied between seven and nine men, both part time and full time, with the Bureau paying 77 percent of the cost and the Fitts Operators Committee 23 percent of the total $4,900 in salaries and expenses. As Grandone explained to Charles Richardson of Carter Oil, discrepancies in measurement of gas–oil ratios might stem from a loss of pressure on oil–gas mixtures brought to the surface in samplers. Station staff had calculated a method of extrapolating from the amount of gas dissolved in oil at surface temperatures what the saturation at the strata level would be using pressure and temperature gauges. However, Grandone believed that this method was quite unreliable, and that the possibilities for multiplying errors were considerable. The new research would solve the problem.[30]

The accuracy and independence of station work, established over the past decade, had the beneficial effect of drawing industry attention to Bureau publications and research. The Mid-Continent Committee on Production Technology provides one example. It appointed a subcommittee to investigate the different methods of determining oil-sand saturation of core specimens. T. W. Johnson, the station representative on the committee, passed on to Fowler some suggestions from the committee which could increase the station's role in these matters, precisely because industry men saw the station work as "independent" or "objective." Johnson noted that industry members of the committee did not want to share confidential information among themselves, especially since it would reveal where richer leases might be obtained in newly opening fields. The committee hoped "some uninterested body such as the Bureau of Mines" could resolve this dilemma by carrying on the work and developing an "absolute" or accurate method of determining oil-sand saturation. Various laboratories in the industry could then continue their own methods of testing but could adjust their results to the "absolute method" developed by the Bureau.[31]

The American Petroleum Institute provides another example. Fowler served on the Institute's Eastern Committee on Production Technology. When Morris Muskat of Gulf Oil, who chaired the committee, asked for material dealing with the accuracy of depth pressure measurements, Fowler referred Muskat to the

Bureau's report describing Reistle's pressure work and to a follow-up article in the *Oil and Gas Journal.* Since this work was continued by Berwald at Bartlesville, Fowler enjoyed suggesting to Muskat, at a large, Eastern-based refining company, that he should expect to find the experts on production in the Bartlesville station, in the heart of Mid-Continent producers' territory.[31] He was also careful to be delicate in handling the question of government technicians becoming involved in controversies with a financial and policy aspect, expressing the difficulty of serving both the industry and the Bureau thus:

> As a member of your [API] committee, I am in full agreement with the desirability of working toward the standardization of a method for determining the oil saturation of reservoir rocks, similar to the previous work on porosity and permeability . . . . Our men in the field have told me of several instances where disputes have arisen with reference to valuation of oil properties because different methods of determining saturation gave discordant results.[32]

Fowler indicated that Bureau staff would face the issues squarely, but since they were aware that industry viewed Bureau results as objective, they were determined to be cautious in publishing figures on disputed oil-sand saturation. To the "boys at Bartlesville," he put it a little differently. He was well aware that both bottom hole pressure readings and oil-sand saturation determinations were controversial in that they could play crucial roles in justifying and reinforcing limitation agreements. Consequently, he recommended that station staff keep working but remain sensitive to the "way of the wind" at the API.[33]

Through 1936 and 1937, at the urging of the Interstate Oil Compact Commission, the bureau received an appropriation from the federal budget to conduct a survey of crude oil storage. The commission needed statistics showing the total volume of crude oil held in storage and an analysis showing what percentage of the lighter fractions of the crude oil, suitable for refining into gasoline, had evaporated. The IOCC believed that, if long storage of crude oil resulted in the loss of lighter fractions, then an argument based on conservation could be made for limiting production to current needs. As Schmidt put it:

> A fundamental trend in the evolution of state oil conservation laws has been the recognition of the maintenance of a reasonable balance between the current production of crude oil and market demand, as a means of preventing physical waste, by avoiding unnecessary above-ground storage of either crude or refined products.[34]

The survey was difficult to conduct, since it required the cooperation of dozens of oil companies and the running of hundreds of tests on crude oil samples. The effort involved sampling and testing by Petroleum and Natural Gas Division personnel in San Francisco, Laramie, Amarillo, and Bartlesville, as well as at the Bureau headquarters in Washington. However, since Congress had increased the budget for this purpose, the Bureau enthusiastically backed the project and sought permanent additions to its staff as a result of the funding.

This survey for the IOCC led to a jurisdictional debate between the Bureau of Mines and the Petroleum Conservation Division (PCD) of the Department of the Interior. G. W. Holland, the Director of the PCD, expected to handle all liaison with the newly formed IOCC. At the urging of the IOCC, $55,000 was appropriated to allow the Bureau of Mines to conduct the survey of crude oil inventories in storage. Holland expected a full accounting of the appropriation and hoped to channel the reports to the IOCC. The Bureau ignored this interpretation of his authority and simply continued to report directly to the IOCC until 1938, when the IOCC established its own permanent staff and the Bureau's role in providing assistance declined.[35]

In 1937, the Cooperative Fuels Research group (CFR), a cooperative structure of the Society of Automotive Engineers representing the automotive industry, and the API representing the petroleum refining industry, sought to have the Bureau publish a gasoline survey similar to those conducted in the period 1921–1931. But unlike the earlier situation, the API now planned to use private industry members to collect the information for the survey. Bureau staff was hesitant to go along with the plan, because such a procedure would run the risk of giving Bureau endorsement to industry figures—something the Bureau had always scrupulously avoided. The CFR proposed a complex system of information safeguards in which one firm would report on three of its competitors. By comparing overlapping information from different refiners, some degree of verification could be developed on details such as octane rating, Btu content, and other characteristics of gasoline. Despite hesitations, however, Smith took on the coordination of the survey information collected by private firms and its publication for the CFR.

The gasoline survey turned out to be troublesome to administer under the company-gathering method, and eventually had to be discontinued. The firms in California were particularly difficult to work with. The intent was for the companies to provide the station with the information they collected, in the form both of coded comparisons among the individual companies and the coded sheets that allowed identification of individual companies. The latter was necessary to allow station analysts to resolve any apparent inconsistencies among overlapping reports. The California companies consistently failed to turn over the code sheets, making reconciliation of their data impossible.[36]

Both these surveys—the survey of crude oil in storage conducted by the Bureau with congressionally approved budget for the IOCC, and the motor fuel survey conducted for the Cooperative Fuel Research committee—demonstrated the orientation of the Bureau in the complex internal politics of the oil industry through this period.

The oil industry remained divided between integrated major oil companies and small producers and between Mid-Continent producers and East Coast refiners, with the West Coast firms operating independently of the other regions. Furthermore, the struggle over control among the federal government, state governments, and the courts all combined to create a fluid situation in which the station could easily become an innocent victim of a conflict between powerful foes. The Bureau retained its Oklahoma orientation and remained reluctant to accept figures and data from refiners, although it cooperated somewhat more gladly with the crude oil producers. More importantly, the Bureau, following the lead of Congress in its passage of the legislation allowing the Interstate Oil Compact, the Connally Hot Oil Act, and the appropriation to conduct staff work for the IOCC, cautiously adapted to the new legislative environment by seeking to play a supportive role in the newly emerging system of production control.

Cooperation with the American Petroleum Institute

Formal cooperation between the American Petroleum Institute, the largest oil industry group, and the Bureau of Mines did not come about until 1937, despite the growth of the API as the leading organization of major refiners through the 1920s and the 1930s. And when a cooperative agreement was worked out in 1937, political difficulties surrounded it.

The agreement between the API and the Bureau to cooperate was worked out at a conference of the API held in early June 1937 at Colorado Springs. Within the API, technical committees of experts from different companies were formed to work on common problems. During the oil oversupply of the 1930s, the "Well-Spacing Committee" had emerged as a crucial group. Its task was to work out one technical basis for limiting production through specifying the distances between wells for optimum production. If some objective or scientific optimum could be established, then state authorities could justify prorationing rules limiting drilling on a technical basis, thereby convincing courts that such limitations, while having the effect of controlling production and reducing the surplus, were in accord with scientific principles of conservation. In order to determine optimum spacing for different fields, however, it was necessary to gather technical information about the saturation, oil content, and porosity of the sands in specific fields. At the conference, the twelve-member Well-Spacing Committee had to vote on the proposed API-Bureau agreement. The committee consisted of ten oil men, a representative of the University of California, and H. C. Miller from the Bureau's Washington office. Some of the corporate members were sympathetic to the Bartlesville station, including D. R. Knowlton of Phillips Petroleum and Carl Reistle, formerly of the station and now representing Humble Oil. Nevertheless, a majority of the committee voted down a blanket proposal by Knowlton to finance a study of well spacing to be done by the Bureau at the Bartlesville station. Miller reported that the political atmosphere of the times outweighed the personal considerations and alumni contacts which he had hoped to use:

> I learned after the morning session that one of the reasons for the majority vote against making a blanket appropriation was that some of the companies were so suspicious of what Congress may do that they hesitated to vote for such an appropriation to a Government Bureau.[37]

Miller noted that Hardison of Standard of Texas and Copley of California Standard voted against every motion in support of the Bureau even though they were his own close personal friends. He suspected they acted on orders from superiors in their companies.

The resulting agreement on a specific project to be funded by the API and carried on by the Bureau came only after Miller, working with T. V. Moore of Humble and Edgar Kraus of Atlantic Refining Company, developed two specific, interrelated proposals. The first was to work out a method for determining the fluid content of reservoirs; the second was to study subsurface pressures and work out tables of relationships between pressure gradients and fluid recovery. Miller hoped to set the projects up as two separate sets of experiments, each to be supported by a $6,000 grant from the API, but he warned the station that the API would be unlikely to approve more than a single grant for $6,000 to cover both projects. This is, indeed, what happened.[38]

In an exchange of correspondence throughout July 1937, Carl Young, Secretary of the API, and R. A. Cattell, at Bureau headquarters, worked out the specifics of cooperation. Six thousand dollars would be provided by the API for the Bartlesville station to work on the problem of finding a reliable technique for sampling fluid content of oil-producing sands. When coupled with a plan for spacing wells, the research could provide a technical basis for plans to limit production. "With these accomplished, the industry will have made constructive progress in its search for a solution of this problem, not only well spacing alone, but in working out a rational system for producing oil fields consistent

with our present laws and regulations." In the parlance of the mid-1930s, "rational system" meant a legal means of holding down production to avoid the price-cutting that had led to the destruction of many companies.[39]

The API well-spacing committee sought to develop a method of obtaining a test sample of sand and rock from the bottom of wells that would allow the sample to be brought to the surface with its oil and gas content intact at strata pressure. Although existing core barrels allowed for the drilling of core material from the bottom of a well, the process of bringing it to the surface exposed it to water levels and to reduced pressures, during which the chance to obtain a precisely measurable sample of the oil and gas content would be lost. What was needed was a "pressure" core barrel which could hold a sample under the original pressure found at the bottom of the well. Miller, working with Berwald and D. B. Taliaferro from the Bartlesville station, met with Young and oil company representatives in Tulsa in September to discuss the precise work the station would undertake. Examining patent drawings of a core barrel designed by Granville A. Humason of the station, the API committee agreed that the barrel was a step in the right direction and reviewed the issue of how to dedicate to the public a patent for the proposed new invention. Miller explained that Bureau practice was for the individual inventor to apply for a patent on his device and to pay the patent fees; upon the granting of the patent, the inventor would then assign it to the public. Young suggested that the fees should come out of the API grant. The committee group doubted, however, that such a plan would lead to rapid development; rather, their view was that a monopoly on the pressure core barrel would be very difficult to establish, as several firms were already working on similar devices. In a memorandum to the committee, Miller noted, "I can see no other way out of this than to dedicate the patent to the government and let who will, manufacture the tool, giving all manufacturers an equal chance to bid on the construction of the trial models."[40]

The government sought to put on record the fact that any developments on the core barrel under the cooperative agreement would be *assigned*, not *voluntary*, work and therefore patentable for the government rather than by the individual researcher as his own project. In pursuit of this objective, John Finch, director of the Bureau of Mines, issued a formal order to Berwald to develop a device for the measurement of gas, oil, and water in a reservoir. "All employees engaged or assisting in this work," the order read, "are directed to exercise their inventive faculties towards the objectives of the study." This direct order would preclude someone later claiming the invention as an individual or personal by-product of his work at the station along the lines of the earlier patent opportunities opened to Reistle and Lindsly.[41]

Through the early months of 1938, Taliaferro and Berwald drafted a rough design of a core barrel, improving on Humason's design, to enable the core sample to retain its original pressure as it was brought to the surface. The rough plans were turned over to L. E. Garfield, a "core barrel engineer" at Hughes Tool Company, in May 1938 and, by July, Garfield had produced working drawings. Hughes Tool agreed to manufacture a model of the device for $1,500 and, by the end of 1938, the Bureau had approved the contract. Garfield told Taliaferro informally that the actual cost of developing the model was over $3,000. Hughes produced and field-tested a working model by May 1939. By November 1939, Berwald and Taliaferro learned that the Carter Oil Company was also working on a pressure core barrel, and a report on that device was made public at a Chicago meeting of the API. By May 1940, the API had purchased a Carter barrel and asked the Bureau to test it as well as the one developed by Hughes Tool.[42]

But, according to rumors that alumnus Reistle, who was serving on the Well-Spacing Committee of the API, picked up and passed on to the station concerning the Carter barrel, the Halliburton Company was actually slated to provide well-testing services using the Carter barrel, and this plan would supersede Bureau work on the device developed with Hughes' help.[43]

In any case, in the early months of 1942 war needs and concerns rendered the whole issue moot. The original need for the device had been to establish fluid content of wells and fields for the purpose of justifying *limits* on production; with the coming of the war and increased demand for petroleum, of course, the need for a pressure core barrel evaporated. Rumors from Reistle indicated that the Halliburton-Carter deal was "off for the duration of the war." With the increase in defense projects at the station, interest in the barrel declined, not to be revived until 1945 when its application to projects designed to increase, rather than limit, production made it once again a useful addition to the tool kit of the exploration companies.[44]

The aborted project demonstrated some limits on the station's ability to participate in the relatively fast-moving world of oil field technology and mechanical development. The time consumed in working out the politics of funding, getting the agreement signed, and issuing the proper orders to control the patent situation lasted from June 1937 through December 1937 and held back initial work. Then, in early 1938 it became clear that the rough design ideas of Berwald and Taliaferro could not be put together into a working model in the tool and machine shop at the station, and the project had to be farmed out to Hughes Tool,

where supplementary financial and design help perfected the device.

Several other issues were raised in the discussions within the bureau and not satisfactorily resolved before the Carter core barrel superseded the Bureau barrel. Exactly what aspects of the device would be regarded as innovative and therefore subject to patent? Could the device be adapted for use with hard rock bits as well as sand bits? How would service charges for field use of the pressure core barrel be handled to offset development costs? Since the Bureau would consume parts, supplies, and other expenses in using the barrel to run tests on oil fields, charges would have to be collected, yet no arrangement existed for government charge for such testing service, even to cover the cost of worn bits.

In addition to these unresolved issues, larger policy issues severely restricted the potential for Bureau activity in this area. The API, for clearly political reasons, hesitated to involve a government bureau too deeply in schemes to limit production. Further, the API funds covered mechanical costs and travel expenses, but not salaries. Estimates of government salaries expended on the project ran as high as $10,000. In addition, Young at the API limited even expenditures of government money rather strictly, with the result that about $3,480 of the original $6,000 was used to pay expenses incurred by Hughes Tool Company. An estimated $10,000 in field test experiments, design time, and other expenses by the Bureau was paid directly by the government, with only some $1,434 in travel expenses by government employees paid by the API grant. Thus, this experiment in private aid to government research certainly did not ease the government financial load to an appreciable degree.[45] Despite these difficulties, however, Cattell and others at the Bureau believed the precedent of cooperation with the API was a valuable one. A Bureau report submitted to the API in May 1940 compared the cooperation with API not unfavorably to other cooperative projects, including work with the states of Oklahoma, Kansas, Illinois, and Michigan, as well as earlier work with the American Gas Association.

There is no doubt that the API project represented a significant effort on the part of the station to adapt to the pressures of the decade. Private oil producers were concerned with developing some technical justification for limiting production, and such justification required improved knowledge of subsurface conditions. Although the cooperation with API from 1937 through 1940 did not produce any significant results, it did demonstrate that cooperation was possible despite the political atmosphere, and it did show the capacity of Bureau personnel to "invent" a measuring device on order. The war prevented a full follow-up immediately; but cooperation with the API proved a valuable precedent for later work.

Conservation and Production Limitation at the Station

As is clear from the foregoing, over the decade of the 1930s, in several distinct ways, the Bureau and the Bartlesville station became drawn into policy matters surrounding production limitation. Associations and agencies attempted to utilize the Bureau's reputation for scientific objectivity to produce results that would justify limitation in the name of conservation, and provide a technocratic solution to the economic crisis plaguing the oil industry in a variety of ways:

- Reistle's work in East Texas, using pressure determinations to describe fields as a unit, together with Lindsly's work on temperature, served as a basis for demonstrating that different wells to the same reservoir could be treated as potential cooperators, rather than as natural competitors.
- Rawlins' work on gas reserves led to explanations that open-flow measurement was deceptive and that reserves were lower than they might appear to the public.
- Scott Turner, Director of the Bureau of Mines, suggested that the Bureau's fundamental work on the mechanics of gas pressure driving crude oil to the surface would lead to basic knowledge allowing for the conservation of energy in the form of pressure, and that such knowledge would, in the end, lead to rational production (that is, limited production).
- Reistle's and Lindsly's devices became widely used to enforce production limitation, to measure pressure and production declines, and to provide a technical basis for claims of conservation in fields where unitizing agreements were tested in court.
- On the urging of the IOCC, the Bureau demonstrated that excessively long storage of crude oil led to its deterioration. The implication of the study was that production ought to be limited to current needs in order to avoid waste through evaporation.
- Working with the API, the Bureau worked toward developing the pressure core barrel, a device which could help determine optimum well-spacing, needed to justify state-imposed prorationing.

With respect to production limitation agreements, judges in the mid-continent area were faced with a major dilemma. Not only did overproduction produce an economic crisis of unmanageable proportions, but that crisis soon escalated into a major confrontation in

the political and judicial sphere. If the judges adhered to the old logic and treated all agreements to limit production as conspiracies in restraint of trade, then governors of the states would use force to close wells, presenting the courts with the difficulty of enforcing court orders against state-controlled troops and police forces. Thus, the courts were willing to listen to any sort of scientific justification for conservation to relieve the dilemma. It is precisely because the Bureau of Mines acted as an objective, independent, and scientific institution, with an unimpeachable record of concern for accuracy, that its devices and publications became so eagerly sought after in the period of the emergence of the state commissions and the IOCC.

By the period 1939–1941, the growing tempo of defense work not only reduced the Bureau's emphasis on the pressure core barrel, it changed the whole economic environment of the petroleum industry. Almost overnight, the industry moved from a demand to justify limiting production to a search for more, not less, oil. How to adapt the research at the station to the opportunities generated by defense and war priorities would itself be a difficult transition. Before the war clouds brought the conservation effort to an end, however, Cattell pondered the issues raised regarding patents by the contributions of Reistle, Lindsly, and Berwald.

Cattell wanted to avoid what he called patent "complexes," where an individual would unjustly try to get patents on his work; yet, at the same time, he saw a need for patents. If Bureau men developed something new, he believed, it should be made available to the public at minimal cost. The problem with simply publishing results, however, was that outside patent-scalpers would steal the idea and patent it. Some inventions should be patented—like orphans, Cattell argued, some would benefit from adoptive parents. Simple dedication to the public might prevent production by a manufacturer. There ought, in any case, to be some extra reward for invention. An expressed "shop-right" could be retained for the government use of any patented device. When conflict arose between the Bureau and the individual, however, the Bureau's interests ought to prevail.[46]

Despite the fact that Cattell explicitly examined the premises of the patent issue, he never questioned whether the government laboratory ought to be engaged in inventing devices to assist the industry. He took that as understood. Rather, the issue he raised and tried to solve was how best to encourage technical development and to get industry to adopt any devices that resulted.

The war would not only change the economics of the oil industry; it would also gradually foster entirely different bases for government-industry cooperation. Cattell's analysis of the patent issues in the years before the war can be seen as an effort to come to grips with some of the practical dilemmas arising out of the effort to serve industry. Entirely separate procedures could be adopted when the overriding priority of national defense provided for joint efforts.

NOTES

All box numbers cited are from the Bureau of Mines papers on deposit in the Fort Worth National Archives and Records Center, except where noted as retained at BETC.

1. Box 305242 (BETC)/101.1 History of the Bartlesville Station.
2. Schmidt to Cattell, March 12, 1936, Box 322232.
3. Schmidt to Cattell, Box 322345.
4. *Ibid.*
5. Schmidt to Cattell, December 3, 1937, Box 322235/Cattell File.
6. Box 224323/101.1 History of the Bartlesville Station.
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12. Rawlins, "Gas Reserve Report," in Box 223318.
13. *Ibid.*
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15. Cattell to Smith and Seibel, October 28, 1936, Box 224322/826, AGA.
16. Higgins to Berwald, March 15, 1937, Box 224320/0227, Natural Gas Section.
17. Rawlins to Heithecker, August 2, 1940, Box 224328/0227, AGA.
18. Report of Investigation #3493, May 1940.
19. Box 224328/022.7.
20. *American Gas Association Monthly,* June 1937.
21. Cattell to Smith, 1941, Box 224328/0227, AGA.
22. See Edwin T. Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Movement* (Cleveland, 1971).
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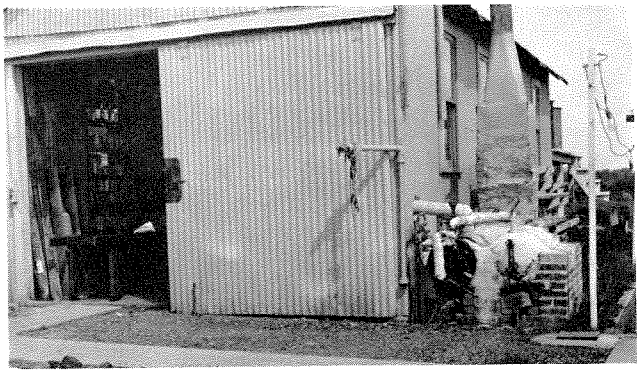
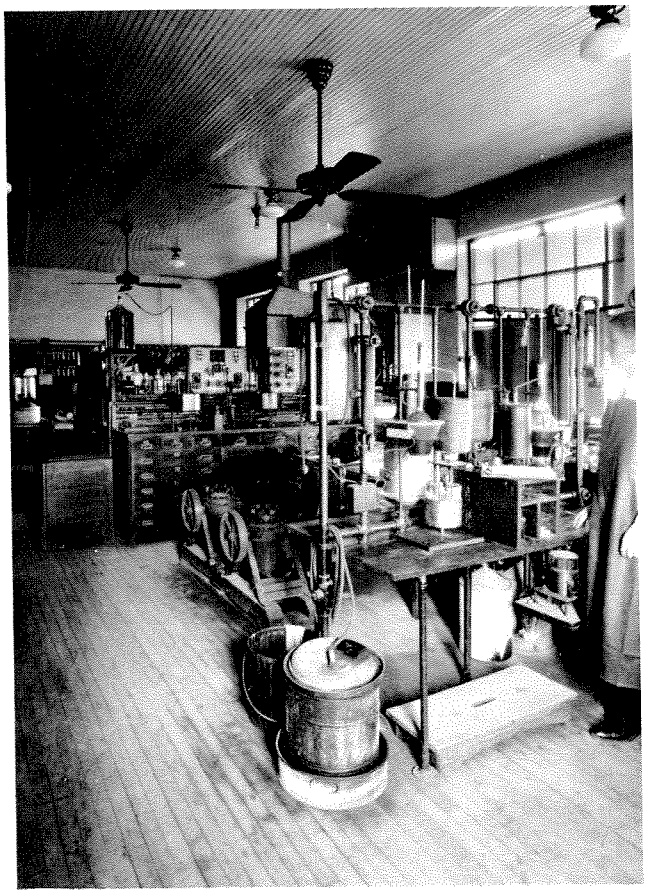
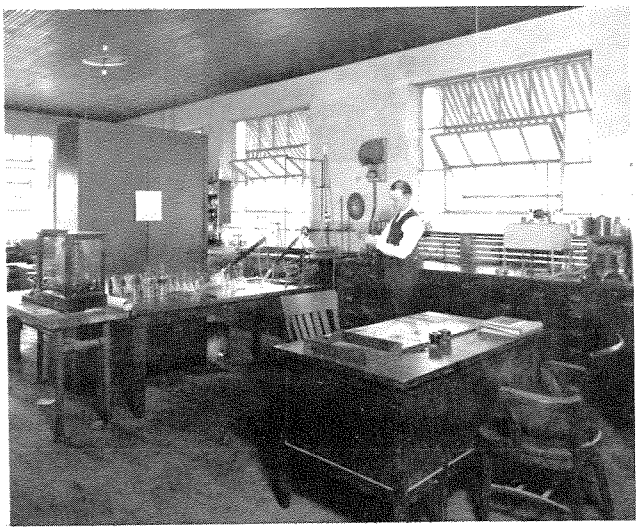
24. Turner to Cole, June 20, 1934, Box 224322 History of the Bartlesville Station.
25. Reistle to Fowler, October 31, 1931, Box 224316/017.41 Reistle.
26. Rawlins to Fowler, June 30, 1932, Box 224316/017.41 Rawlins.
27. Gas Reserve Report, Box 224318.
28. Cattell to Smith, March 24, 1934, Box 224316/019.22 Patents.
29. Miller to Smith, November 30, 1937, Box 224323/102 Organization of Petroleum Division, reporting on breakfast at which fifteen Bureau alumni, employees in private industry, met with four current Bureau employees at API Convention.
30. Grandone to Richardson, February 16, 1937, Box 224322/ Fitts Pool.
31. Box 224319/460 Porosity Determination.
32. Fowler to Muscat, March 4, 1936, Box 224319/466.0 Porosity.
33. *Ibid.*
34. Schmidt to Cattell, August 1, 1938, Box 322235/Cattell.
35. Box 224320/Fuel Oil and Crude Oil Survey.
36. Box 224319/Gasoline and Motor Fuel Tests–Gasoline Survey.
37. Miller to Cattell, June 8, 1937, Box 224320.
38. *Ibid.*
39. Young to Cattell, August 1937, Box 224320.
40. Box 224322/019.22 Patent Office.

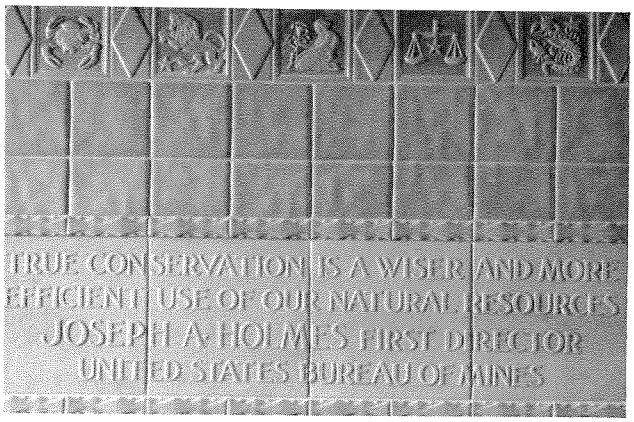
41. Finch to Berwald December 27, 1937, Box 224325/826, API.
42. Report of Investigation #3481; Memo to Committee Members, April 25, 1942, Box 224329/417 Spacing of Wells, API.
43. Taliaferro to Fowler, January 16, 1942, Box 224329/417 Spacing of Wells, API.
44. Heithecker to Fowler, May 18, 1942, Box 224329/417 Spacing of Wells, API.
45. Heithecker to Cattell, May 14, 1940, Box 224326/826 Contracts–API.
46. Cattell to Smith, 1941, Box 224329/Patents.

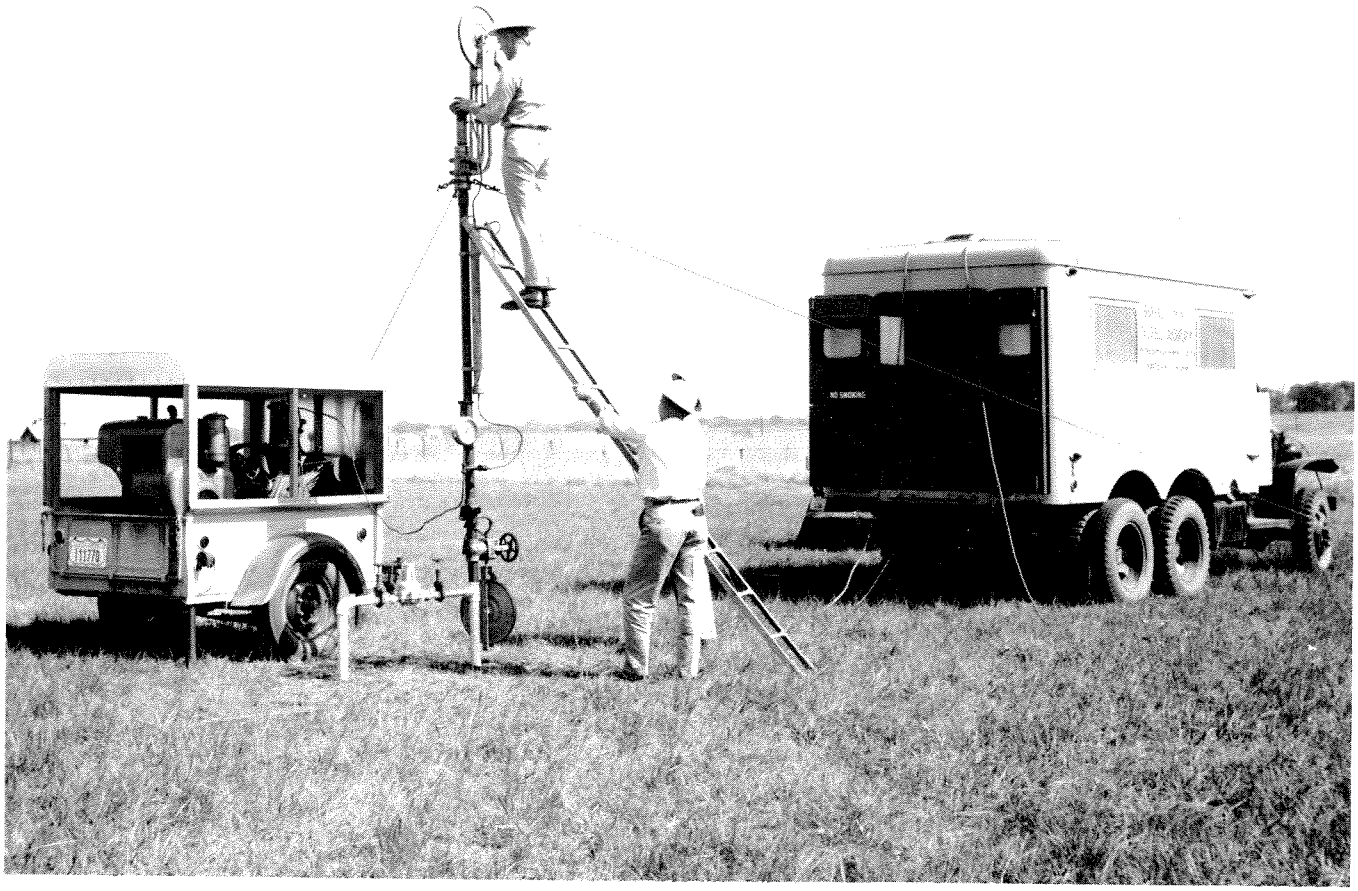






Work in the 1920s covered a range of subjects. Safety as exemplified by training in artificial respiration was important. A demonstration to a cable tool drilling crew in Osage County is shown (upper left). An experimental 10-gallon still (upper right) was used for assaying crude oil. The petroleum engineering laboratory in 1925 (lower left) was much different from present-day laboratories. The physical laboratory (lower right) was involved in development of a method to separate wax from crude oil.





Field Work

In accord with the motto over the fireplace in the library (upper left), research was taken to its place of application by mobile laboratories. A traveling water analysis laboratory is shown (upper right), and another laboratory truck is conducting experiments to determine the need for pressure maintenance by either gas or water injection. The more effective use of technology was the Bureau's way of promoting conservation.