ACTIVITIES OF THE DEPARTMENT OF CHEMICAL ENGINEERING RELATING TO THE PETROLEUM INDUSTRY

B. H. SAGE, PH.D., '34
Associate Professor of Chemical Engineering

In recent years the petroleum industry has increased the relative proportion of its technical personnel and it became desirable to include in the Institute's chemical engineering curriculum additional work of an engineering nature in order that graduates might cope more effectively with the technological problems associated with the advances of the industry. With this objective in view a fifth-year course leading to the degree of Bachelor of Science in Chemical Engineering was initiated for the school year 1939-40. This fifth-year work includes training in the fundamentals of chemical engineering from both an analytical and experimental viewpoint and is open to a limited number of men who have completed a four-year course in the applied chemistry option. Business economics and administration is studied throughout the year and time is available for the student to pursue advanced academic work of a more specialized nature than was possible during the basic training period of the four-year course.

A sixth year of academic work is available for a small number of men. This leads to the degree of Master of Science in Chemical Engineering and affords the student special opportunity for engineering research experience, since at least half of the student's effort is devoted to research activities. This work is apparently being well received by the students since during the present year the maximum number of eight men that can be adequately handled with existing laboratory space is filled entirely with high quality men from the Institute, leaving no room for outside applicants. Further increases in the number of either fifth- or sixth-year students cannot be made without additional space for both research and course work.

A.P.I. PRODUCTION PROJECT

The laboratory has been fortunate in retaining since 1928 a research project sponsored by the Production Division of the American Petroleum Institute. The initial objective of this project was the investigation of the "solubility of natural gas in crude oil" under the conditions encountered in underground reservoirs. This limited objective has since been expanded to include a general study of the volumetric, phase and thermodynamic behavior of pure hydrocarbons and their simple mixtures, as well as the behavior of samples of oil and gas mixtures obtained from a number of oil fields throughout the country. In order to cover the range of conditions of industrial interest the experimental work initially included pressures up to 2,000 pounds per square inch in the temperature interval between 100° and 220°F. At the present time most of the measurements of the laboratory are made with pressures up to 10,000 pounds per square inch and at temperatures from 100° to 460°F. This increase in the ranges of both pressure and temperature has been made necessary by the rapid increase in the depth of active producing formations. The primary objective of this work for the American Petroleum Institute is the prediction of the properties of hydrocarbon mixtures under the conditions that are found in nature from a minimum amount of factual information concerning the nature and condition of the system in question. A lengthy series of articles presenting the data obtained has appeared in *Industrial & Engineering Chemistry* during the past several years, in addition to publication by the A.P.I.

Experimentally, the measurements include specific volume, heat capacity, JouleThomson coefficients, composition of coexisting phases, and the viscosity of homogeneous systems These properties are determined as a function of pressure, temperature and composition. Owing to the high pressures involved it has been necessary to develop special equipment for the purpose. From these measurements the thermodynamic properties of both simple and complex hydrocarbon mixtures have been evaluated as a function of state. These data then form the basis of more generalized predictions which may permit the estimation of the properties of naturally occuring hydrocarbon mixtures as a function of state. At the present time the experimental background is not sufficiently complete to permit such predictions to be made with accuracy at the higher pressures and temperatures currently encountered in practice, but it is believed that the same methods now successfully applied at the lower pressures may be extended in scope as soon as the necessary background of experimental data is available.

Information of this nature may be applied to many of the problems relating to the behavior of fluids in underground petroleum reservoirs and in the processing of hydrocarbon fluids, if it is assumed that equilibrium obtains. Volumetric measurements are of interest in petroleum production in connection with the estimation of reserves, proration of production, and the flow of homogeneous and heterogeneous mixtures in both porous media and in conduits. Phase equilibrium data in the same division of the industry find their primary use in the estimation of the state of fluids under subsurface conditions and in predicting the influence of trapping and other surface operations upon the separation of the desirable constituents from the well production. Thermal data permit the evaluation of the heat and work associated with the changes in state of fluids during production and in subsequent surface operations. The design of certain processing equipment and the estimation of optimum operating conditions both in refining and natural gasoline plant installations finds use for volumetric, phase equilibrium and thermodynamic data. The measurements of the viscosity of homogeneous fluids are of interest primarily in connection with the study of the movement of such fluids in the production and processing of petroleum.

OTHER RESEARCH PROJECTS

In addition to the work for the American Petroleum Institute the laboratory has been favored by research projects sponsored by a number of the major oil companies such as the Union Oil Company, Standard Oil Company of California, Texaco Development Corporation, General Petroleum Corporation, Shell Oil Company, and the Polymerization Process Corporation. Experimental work relating to the volumetric and

(Continued on page 21)

AN ENGINEER LOOKS AT THE ORIENT

(Continued from page 14)

general ease and luxury. To this effect, witness the goodly number of Americans who live happily in these parts for indefinite years. But for an engineer the glamour wears thin when the realization comes sharply one day that here there is no chance to keep really abreast of new developments and that a few more years will see him cut off forever from the possibility of earning his way in technical pursuits "at home." And for all the Americans I met in my travels even thirty years of residence abroad didn't change the fact that "home" was still the U.S.A.

THE RISE OF NATIONALISM

With war conditions spreading slowly but surely over most of the area there is little chance that many American engineers will be going out to the Orient in the next few years but there will undoubtedly be openings for white engineers after the war is over. It must be remembered that in China and Thailand particularly, the spirit of nationalism is newly risen to great heights. Young China is especially keen on the necessity of providing its own "working" engineers. As an instance, I cite the case of the young Chinese girl, a fellow passenger on the ship on which I returned. She was coming to study engineering—at a California university. She came under protest, at the insistence of her family. She wished to study in one of the Chinese universities near Chungking and when I inquired whether she would teach when she returned, she said, "No, China needs less intellectuals and teachers and more of her own engineers actually on the job. I hope to fit myself to go out and work in the construction of New China."

Although this trend probably means the end of the white man's domination of business and industrial enterprise in the Far East, it may well afford increased opportunity for white engineers to serve as training supervisors during the coming expansion of industrial enterprise. From my own experience this would be an ideal opportunity for American engineers since it would offer a chance to see these foreign countries and yet would not offer the enticement of too permanent employment.

---

caibo beer isn't bad. The Caracas beer, however, from the capital city, is terrible. Apparently they don't believe in aging it.

Bourbon whiskey is unknown. The much-touted "cheap imported Scotch," of which I heard in the States, was also non-existent. It costs as much as $12.00 per fifth last December. The only cheap drink is native white rum, plenty powerful, and aged perhaps a couple of weeks. $1.50 per quart.

White Owl cigars are 50c each. Native cigars, not bad, are 2c each and up. Native cigarettes ("firecrackers" to us) are 15c for 15. U. S. cigarettes are 75c per pack tax-stamped and 50c from bootleggers. There is no Venezuelan-made pipe tobacco. I tired of paying 80c per small tin of P. A., much of it mildewed, and had a pound of my favorite smoking mailed from the States. The import duty was almost $9.00, and thenceforth P. A. was good enough. No trouble is experienced with tobacco drying out, but quite the opposite. One can tie a knot in a cigar any time.

ACTIVITIES OF CHEMICAL ENGINEERING DIVISION

(Continued from page 9)

phase behavior of naturally occuring hydrocarbon mixtures from specific oil fields has been the objective of two of these projects. This experimental work supplements and expands the program sponsored by the American Petroleum Institute and permits the latter work to be directed toward a study of the more fundamental aspects of the problem.

The direct measurement of the composition of coexisting phases is one approach to the evaluation of the phase behavior of both simple and complex hydrocarbon systems. One Fellowship of the Department has been directed toward the investigation of the composition of the phases of ternary hydrocarbon system throughout the heterogeneous region at temperatures of industrial interest. Furthermore, the refining division of the petroleum industry is becoming increasingly interested in the phase behavior of mixtures of paraffinic and olefinic hydrocarbons and a study of the phase behavior of a binary mixture nof n-butane and i-butane is in progress.

Equilibrium is aproached only as a limit in many operations encountered in the production and processing of petroleum. A study of the non-equilibrium behavior of these systems, including the formation and growth of bubbles from supersaturated solutions, and material transfer between the phases of heterogeneous systems under a variety of conditions has constituted a part of the objectives of one of these industrial research projects for a number of years. The migration of sand into oil wells has been a source of difficulty in connection with petroleum production operations and the effectiveness of the subsurface placement of gravels to inhibit such movements has been studied in detail.

The personnel of the Department may be divided into two general categories, one embodying students and the other full-time investigators and technicians. The fifth-year students are occupied primarily with laboratory course work relating to the fundamentals of chemical engineering operations while the sixth-year men are associated directly with the industrial research activities of the laboratory. The greater part of the experimental work of the research projects results from the activities of nine full-time research assistants and technicians. It is believed that the close contact between the investigators and fifth- and sixth-year students is a desirable one in that the student is placed in an environment more similar to that encountered industrially than is usually the case in academic laboratories.