minimum of danger. The actual nature of the reaction was given less consideration than the commercially important questions of initial materials and final products and the regulation of conditions necessary to produce desired ends.

NECESSITY FOR COOPERATION OF CHEMISTS, ENGINEERS, AND PRACTICAL REFINERS.

There are few industrial operations coming under the field of physical chemistry that are more complex in character than that involved in the treatment by heat of hydrocarbons for transformation into various products. Practically all the variables of chemical phenomena are involved, and the complexity of the reactions is such that little, if anything, is known about a great many of them. Although the problem is thus complicated, both as regards theory and practice, the possibilities are great.

Chemical development has lagged behind both mechanical and operative improvements in the petroleum industry. The explanation can be found in the fact that the solution of too many problems of theoretical chemistry has been left to the mechanical engineer or practical operator, who can not be expected to be as efficient in chemical research as a man who has devoted himself to the study of chemical and physical phenomena and their industrial applications.

Only the combination of the skill of the mechanical engineer with the detailed knowledge of the chemist can yield the best results. It is obvious that maximum efficiency can no more be obtained by a mechanically perfect machine designed on wrong principles than by one that is mechanically weak though theoretically correct.

PLACE AT WHICH BUREAU'S EXPERIMENTS WERE CONDUCTED.

The experimental work described in Part I of this report was done in the department of chemical engineering of Columbia University, New York, which extended the facilities of the laboratories, libraries, and other equipment for use in experiments.

CHARACTER OF EXPERIMENTS.

The work consisted essentially in the subjection of five typical petroleum oils to a wide range of conditions of temperature and pressure. The oils used were as follows:

1. A water-white Pennsylvania kerosene or burning-oil distillate, representing the paraffin-base oils of the Appalachian oil fields.
2. An Oklahoma residuum, typifying the mixed-base oils of the Mid-Continent field.
3. A California (Kern River) crude, representing the asphaltic-base oils of the Pacific Coast fields.

4. A Mexican crude.
5. A Russian residuum.

The general course of procedure in the experiments was as follows:

The oil was subjected to treatment at various temperatures ranging from the initial boiling point of the material to as high as 1,000° C., the increase being in stages of 150° C. In like manner the effect of pressure was studied over a range varying from about one-thirtieth of an atmosphere to a pressure higher than 30 atmospheres (500 pounds per square inch). Various combinations of temperature and pressure were applied systematically to each oil.

It is to be understood that work was carried on with the idea of obtaining comprehensive results rather than for the purpose of discovering optimum conditions for the production of any desired hydrocarbons. Unfavorable and favorable conditions were studied with equal care. Attention is especially called to this feature, because many unfavorable data are necessarily recorded, and these might be considered as militating against the commercial practicability of the results.

GENERAL DISCUSSION OF GASOLINE AND BENZENE-TOLUENE PROCESSES.

The processes more particularly described herein have been commonly termed a gasoline process and a benzene-toluene process. In both the general method of operation is similar, but the conditions of control differ materially and the end products vary widely. The gasoline process is operated at lower temperatures and high pressures; for example, at a temperature of 500° to 550° C. and at a pressure up to 300 pounds, whereas the benzene-toluene process is operated at a temperature of 625° to 675° C. and at a pressure up to 250 pounds. However, the reader will understand that if the rate of oil feed is properly varied, it is not necessary to work within the ranges of temperature and pressure specified.

The processes are to be distinguished from the ordinary cracking processes in that the hydrocarbon material is kept in a gaseous state throughout the entire course of operation. In processes involving the subjection of large masses of liquid to high temperatures and the pressures necessary to prevent volatilization, degrees of heat exceeding 400° to 450° C. are dangerous because the corresponding pressures are excessive.

ADVANTAGES OF GASEOUS-PHASE CRACKING PROCESSES.

The advantages of having the reaction occur entirely in the gaseous state are fourfold, as follows:

First. The hydrocarbon material is fully expanded, so that if there is a leakage of joints or a giving way of the retainer no danger results.