A mass spectral method (fig. 42) has been developed for analyzing paraffin-naphthene fractions of gasoline obtained from coal hydrogenation. By this technique, cyclopentanes and cyclohexanes with single and with multiple alkyl side chains can be distinguished from each other and from paraffins. As yet, the method is not easily extended to C_9 and higher hydrocarbons because of the scarcity of reference compounds. However, appreciable concentrations of a C_9 (hydrindane) and a C_{10} dicyclic compound (methylhydrindane, decalin, or a terpane) have been identified in vapor-phase gasoline. The results of this analysis are incorporated in tables 18 and 19 (see Composition of Gasoline Obtained from Coal).

Gasification of Coal in the Vortex Reactor

Gasification of pulverized coal with oxygen and steam may be used for the production of synthesis gas (carbon monoxide plus hydrogen) for the Fischer-Tropsch process or of hydrogen for the hydrogenation of coal. This process has been studied in a vortex reactor to gain an insight into the operating variables and the performance characteristics of such a system and as a means of predicting the optimum conditions for adiabatic gasification of coal. The construction of the reactor and the flow diagram of the unit have been shown in the 1949 Annual Report (Bureau of Mines Report of Investigations 4651); a diagrammatic sketch of the coal feeder (fig. 43) shows the path of the coal into the reactor, as well as the oxygen outlet that permitted introduction into the reaction zone of part of the oxygen with the coal. The vortex reactor had a diameter of 2 feet, and its depth was varied from 2 to 36 inches. The unit was preheated to 2,000° F. with a mixture of natural gas, air, steam, and oxygen. After the reaction temperature was reached, the gas and air were shut off, and coal was admitted at the rate of 100 pounds per hour. Oxygen and steam were preheated to 1,300° F. and added in such amounts that the oxygen:coal ratio ranged from 7 to 11 cubic feet per pound, while the ratio of steam to coal was maintained at 0.55 pound per pound.

By introducing some of the oxygen with the coal (instead of introducing all of it through the tangential slots of the reactor), the production of synthesis gas was increased considerably under otherwise equal conditions. Increasing the oxygen:coal ratio resulted in higher reaction temperatures. Because the unit was not an adiabatic reactor, more heat was lost at the higher temperatures by radiation and convection; such losses can be reduced substantially in larger installations. The gasification reaction,

$$C + H_2O \longrightarrow CO + H_2$$

$$C + CO_2 \longrightarrow 2CO$$

did not begin until most of the oxygen had been consumed. Steam and oxygen also reacted with the volatile matter distilled from the coal; but the amount of carbon monoxide and hydrogen produced in this manner was small, so that residual char (after devolatilization of the coal) was the principal source of synthesis gas. The rate of gasification of coal was approximately of first order with respect to the amount of carbon available, at least up to space velocities of 33 pounds of coal per cubic foot of reactor space per hour. By changing the depth of the vortex reactor, the space velocity of the coal was in effect varied without changing its rate of flow. Evaluation of the data, obtained over a range of radial and space velocities as well as reaction temperatures, showed that the rate of gasification was diffusion-controlled above about 2,200° F.

As the radial velocity at a given space velocity increases with the diameter of the vortex, higher conversion is attainable with reactors of larger diameter when diffusion is rate-controlling. For example, complete gasification of the available carbon appears to be possible at sufficiently high temperatures in an adiabatic vortex reactor of 8-foot diameter over a wide range of space velocities of coal. Using empirical rate data, methods were developed for predicting the performance of such adiabatic reactors, and a ratio of 7 to 7.5 cubic feet of oxygen per pound of coal appeared to be most economical for the production of synthesis gas. For this optimum ratio, 34.1 pounds of coal and 247 cubic feet (S.T.P.) of oxygen are needed to produce 1,000 cubic feet (S.T.P.) of carbon monoxide plus hydrogen.

Technical Publications

A book by Storch, Golumbic, and Anderson on the Fischer-Tropsch and Related Syntheses has been published by John Wiley & Sons, Inc., and contains an exhaustive and critical review of the large number of reports and documents pertaining to this subject. In addition, much information on thermodynamics and on heterogeneous catalysis is included.

A Bibliography of Pressure Hydrogenation (of coal) has been completed. Parts I and II, covering literature and patents, respectively, have appeared as Bureau of Mines Bulletin 485; part III, comprising the indexes, will be published in the near future. A two-part Bibliography of Fischer-Tropsch and Related Processes, containing about 6,000 annotated references, is being completed; the literature section is to be printed soon, and the patent review is being assembled and typed.

Reviews on the current status of fluid dynamics, of the oxo synthesis, and of Bureau of Mines work on synthetic liquid fuels have been presented in various journals, and translations of foreign documents concerning the Fischer-Tropsch synthesis have been made available as information circulars of the Bureau of Mines. About 1,000 copies of each issue of Synthetic Liquid Fuels Abstracts, a bimonthly publication, were sent to the mailing list. However, curtailed appropriations have compelled at least temporary suspension of this service.

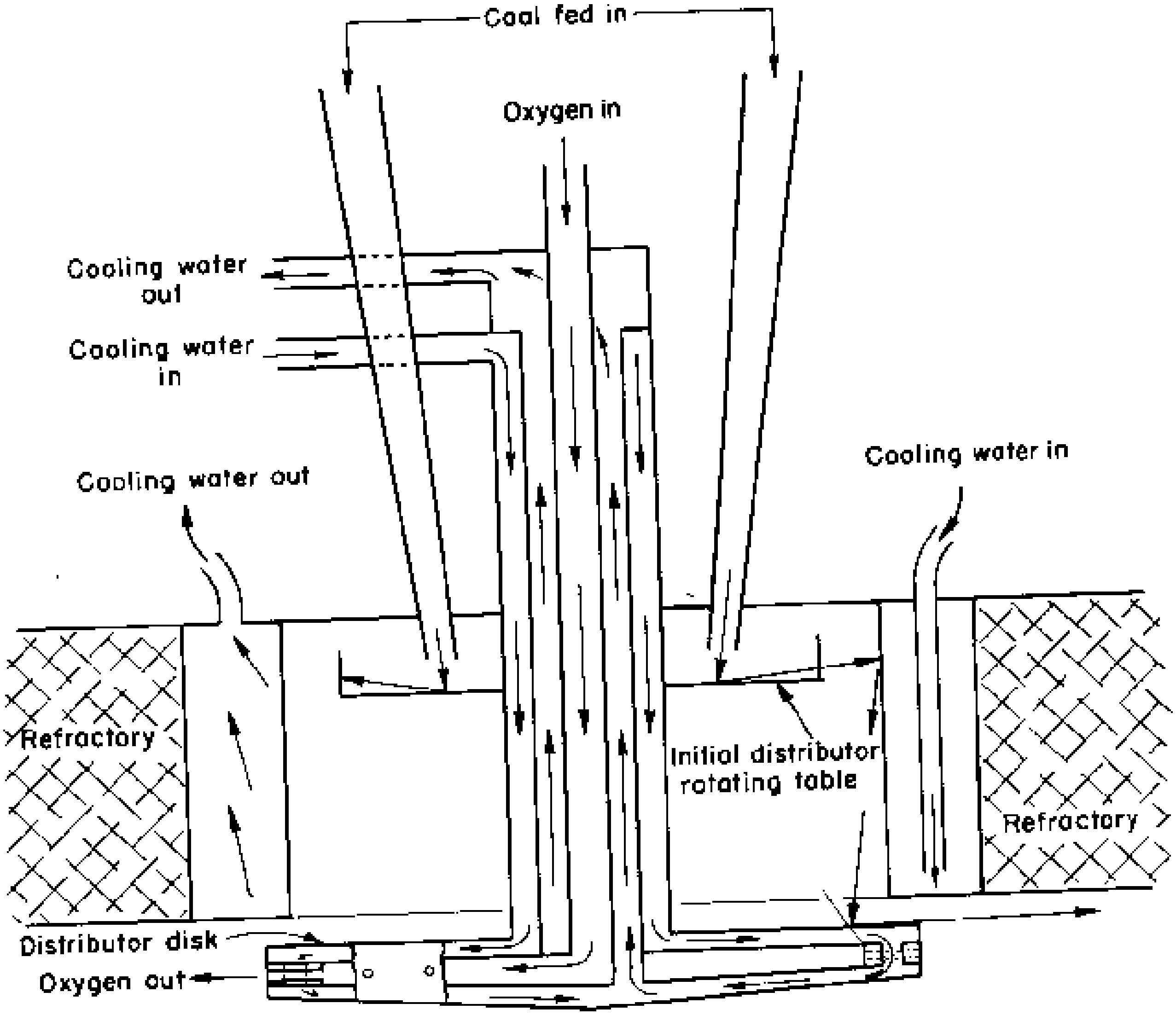

Figure 43. - Coal feeder for vortex gasifier.