a higher temperature in the large tube than in the cracking tubes, so that an additional superheating of the vapors and cracking takes place. The carbon is collected at the bottom of the expansion tube upon a metal screen.

Kittle,[a] by means of a compression air pump, forces liquid oil under a pressure of 100 pounds per square inch through a coil of pipe three-sixteenths of an inch in diameter and at least 20 feet long. The coil is immersed in a molten-lead bath, the temperature of the bath being at least 700° C., so that the temperature of the oil in the tubes will be approximately 500° C.

Another process, in which a catalyzer is used to promote cracking, is that of Ellis,[b] in which the oil, after having been preheated, is atomized into the top of a vertical tube or chamber completely filled with catalytic material. A pressure of 30 to 60 pounds per square inch is maintained by controlling the discharge of the gases produced. A volume of air is admitted into the chamber sufficient to effect combustion of 3 to 10 per cent of the oil in order to crack or convert a part of the remaining hydrocarbon material.

In the process patented by Turner[c] a mixture of steam and liquid oil is carried through a series of coiled pipes, 2 inches in diameter, the coils being so arranged that any desired amount of superheating of the mixture of steam and oil vapor can be obtained. The products then pass through a series of fractional condensers. A temperature of 1,000° F. (538° C.) to 1,400° F. (760° C.) and a pressure of about 60 pounds per square inch are specified.

Von Groeling's[d] process also involves the use of steam. Oil from a series of tubes externally heated in a furnace is fed into a still into which steam is introduced. The mixed vapors of steam and oil pass to the top of the still and then repass through the same tubes, so that the vapors from the still are forced to travel through the current of oil proceeding to the still. In this manner the oil is preheated before it reaches the still. A temperature of 350° to 500° C. is maintained both in the still and in the cracking tubes. The vapors, after passing from the cracking tubes, enter a dephlegmator and finally a condenser, where they are liquefied without pressure.

In Zerning's[e] process water and liquid oil are forced by means of a pump through tubes heated to 300° to 400° C., the resulting vapors being rapidly passed through pipes heated to a "dark red" heat, whence they are passed through a cooling device, where the water and tarry substances are condensed. The uncondensed vapors and fixed gases are collected in a gas reservoir and then driven by means

[a] Kittle, H. A., English Patent 8336, Apr. 6, 1909.
[b] Ellis, Carleton, English Patent 25631, Nov. 8, 1912.
[c] Turner, C. W., U. S. Patent 1046683, Dec. 10, 1912. See also U. S. Patent 726379, Apr. 28, 1903.
[d] Von Groeling, A. F., English Patent 10213, Apr. 30, 1913.
[e] Zerning, Hermann, English Patent 731, Jan. 9, 1913.

of force pumps through the hydrocarbons that are to be treated. The pressure used is not specified, but it is claimed that too high pressures should be avoided.

Clark[a] has patented a process somewhat similar to that involved in the Zerning[b] patent except that water is not introduced. The liquid oil to be treated is charged into a large tank or receiver, from which the oil is withdrawn by means of a pump and circulated in a fine stream through a coil inclosed in a combustion chamber. The heated liquid oil is then returned to the receiver. By continued circulation, the oil in the receiver is raised to a temperature of 343° to 454° C., and a pressure of 3 to 7 atmospheres (45 to 105 pounds) is built up by controlling the escape of the vapors by a pressure-release valve placed beyond the condenser.

Bacon and others[c] have worked out an improvement on their earlier process[d] in which liquid oil is fed by a force pump into the top of a vertical pipe or retort 19 inches in diameter and 20 or more feet in length, inclosed in a furnace chamber. The liquid oil is maintained at a level above the top of the furnace combustion chamber, the retort or tube projecting some 5 feet above the top of the furnace. The liquid oil is heated to a temperature of 350° to 500° C., under a pressure of 60 to 300 pounds per square inch. A settling chamber is provided at the bottom of the retort into which the tar and coke formed in the cracking zone of the retort can be deposited and be withdrawn from time to time.

A more recent and novel process is that of Dubbs[e] in which oil and water are heated in coils, under a pressure of 50 to 600 pounds per square inch, to a temperature of 66° to 316° C., and the mingled vapors are then discharged through a suitable jet into an expansion chamber and the pressure released. Additional heat is admitted into the expansion chamber when necessary.

HYDROGENATION OF PRODUCTS OF CRACKING.

It will be noted that many of these inventors have attempted to combine with the cracking process that of hydrogenation, in order to minimize the formation of the unsaturated hydrocarbons characteristic of low-pressure cracking reactions. This they propose to accomplish either by the decomposition of steam, which is mingled with the oil vapors so as to produce free hydrogen, the liberated oxygen combining with free carbon to form carbon monoxide, or else by the employment of a catalyzer to break down sufficient of the hydro-

[a] Clark, E. M., U. S. Patent 1119496, Dec. 1, 1914.
[b] Zerning, Hermann, English Patent 731, Jan. 9, 1913.
[c] Bacon, R. F., Brooks, B. T., and Clark, C. W., U. S. Patent 1131309, Mar. 9, 1915.
[d] Bacon, R. F., and Clark, C. W., U. S. Patent 1101482, June 23, 1914.
[e] Dubbs, J. A., U. S. Patent 1135506, Apr. 13, 1915. See also U. S. Patent 1100717, June 23, 1914.