tube will cut down the conductivity several hundred per cent, so that a much higher temperature is required to bring the temperature within the tube up to the desired point.

CONCLUSIONS REGARDING CARBON FORMATION.

It is evident from the development of the process that the formation of carbon in the cracking tube is not an obstacle to the operation of the process when control conditions are in proper relationship. Too low a rate of feed at a moderately high temperature will cause higher percentages of carbon to form. Excessive temperatures and pressures will likewise promote excessive carbon formation, but when these factors are in their proper relationship the character of the carbon is such that little or no difficulty is encountered in its removal.

MATERIAL USED IN TUBES.

Double extra-heavy lap-welded tubes with walls five-eighths inch in thickness have been used for the cracking chambers. These tubes come in stock lengths of from 20 to 23 feet, so that a single length may be cut into two cracking tubes. The initial cost of these tubes in the stock sizes is approximately $85 so that a cracking tube will cost approximately $42.50.

BULGING OF TUBES FROM OVERHEATING.

Lap-welded tubes have not proved entirely satisfactory. Defects developed from time to time in the seams, under the high furnace heats, so that the tubes would fail during a run. In spite of this tendency, however, there has never been a case of outright bursting in all the eight months of operation. The tubes contain only gaseous hydrocarbons, and the expansion incident to their combustion on exposure to air has not been sufficient to prove dangerous. In general, the only indication given of a break in a tube is the falling off in pressure which results. During the first few months of operation the tubes frequently did not average more than 10 days' heating before they started to bulge. A typical case of this sort of tube trouble is shown by the photograph of a longitudinal section of a displaced tube (see Plate VI, *B*).

Most of the tubes which were displaced manifested the effect of overheating. Some oxidation had occurred, but in few if any tubes had it progressed to such an extent as to indicate that it was the cause of the tube yielding. The local superheating for the most part ranged over that part of the tube which was incased in the fire-brick casement or chimney previously described, although in some instances the bulge had started at a point above the top of the checkerwork. It seemed that as soon as excessive heating had caused a tube to soften in some

place, bulging resulted immediately through the effect of internal pressure. This bulging or flow once started continued until the walls had become so thin that they ruptured under the pressure. In a number of cases the metal in the tubes at the point of rupture had been thinned down to a knife-like edge.

LIFE OF TUBES.

The short life of the tubes in the multiple-tube furnaces during the earlier stages of development is in striking contrast to their life in the single-tube furnaces, where individual tubes were used for months without removal. This fact indicates the much better temperature regulation attained. Since the large furnaces have been operated at a temperature ranging from 625° to 650° C. and a pressure of 150 pounds per square inch, as compared with a temperature of 700° C. and a pressure of 250 pounds per square inch in previous runs, the life of the tubes has been greatly prolonged and tube trouble has practically disappeared, even with the lap-welded tubes.

A small number of lap-welded tubes that were calorized (coated with aluminum) by the General Electric Co. have been in operation for several weeks. The results to date of writing have been entirely satisfactory, especially as less carbon trouble has been experienced with these tubes than with like tubes not calorized.

Mr. A. J. Moxham, the president of the Aetna company, who has had extensive experience in the manufacture of steel, has given the problem of prolonging the life of the tubes his close personal attention. It is his opinion that the solution is to be found in the use of thick-walled cast tubes of high-carbon steels, the walls of which should be 1¼ to 1½ inches thick. The rate of heat transmission through walls of such thickness will be less than with the lap-welded tubes, which will tend to bring about a more uniform heat in the interior of the tubes. At the same time the thick walls should not present any difficulties in the way of maintaining satisfactory cracking temperatures. The great advantage expected to be gained results from the fact that cast steel of this character will not deteriorate under the influence of heat until the temperature becomes excessive. This means prolonged service and decreased cost of operation. The objection to the use of a cast-steel tube is the difficulty in making satisfactory castings. This is overcome in a large measure by having the walls of the thickness indicated. Several cast-steel tubes with walls three-fourths inch thick were tried out but did not give satisfactory results. The tubes were pitted after several days heating in the furnace. It is probable that cast-steel tubes of greater thickness would have given better satisfaction, as a better casting could be more easily obtained. Rolled-steel tubes have also been experimented with, and satisfactory results obtained up to the present