Tar has received much attention as being a possible factor in the development of cancer. The experimental work in the production of tar cancers in laboratory animals, as reviewed by Dr. W. H. Woglom (1) in his extensive monograph citing 290 references, indicates that certain animals are susceptible, others are not, to certain tars applied over long periods of time. Mice and rabbits are susceptible, rats and fowls unaffected. Confusion has resulted from lack of accurate determination of what constitutes a cancer, keratinized papillomas being regarded as, or as not, precancerous, or as cancers. Some writers state that what will produce a wart will produce a cancer while others are more modest in their assertions. The choice of tar in the experimental work has been variable, the descriptions ambiguous, although it is evident that tar from some form of distillation of coal has been employed in the successful work. Also European synonyms do not correspond with American names. The inexplicable spontaneous development of cancer in untreated animals offsets the reports of successful experiments and may suggest other lines of investigation.

Tar is one of the terminal products in the distillation of carbonaceous substances. One tar differs from another tar according to its source. In the United States there are three principal makes and sources of tar, from the distillation of coal, of petroleum and of wood. The last probably comes principally from the Wisconsin area and the southern turpentine section. In Pennsylvania the manufactured tars are usually called coal tar and gas tar, the latter name coming from the product rather than the source.

Coal tar is derived from the distillation of coal, either in the production of producer-gas or of coke and its by-products. It
varies in composition according to the coal from which it is derived and the temperature of distillation. Blast-furnace tar is quite similar in production and composition to producer-gas tar, which is made at low temperatures, whereas coke by-products are produced at high temperatures. The differences in temperature of distillation determine the by-products evolved.

What is termed gashouse-tar is producer-gas tar, a low temperature distillate of coal. The distillation at low temperatures produces paraffin oil tar which is used chiefly as fuel.

The destructive distillation of coal is carried on in vertical or in horizontal retorts. Horizontal retorts are used at low temperatures for producer-gas or at higher temperatures for recovering coke by-products. Deelman found that the horizontal retort tar was more carcinogenic, experimentally, than the vertical, which with low-temperature blast furnace tar is reported as being harmless. Block and Widmer (2) found the higher the temperature of the distillation the stronger was the carcinogenic activity, with a maximum between 275° and 284° C. Kingzett (3) stated that the vertical retort produces more creosote, more pyridine and more tar acids; but the horizontal retort yields more benzol, toluol and xylol. Tar acids are a mixture of phenol with cresols. The temperature of the vertical retorts is low, of the horizontal usually high (terminating at 900° to 1100° C. or more). Leitch (quoted by Woglom) experimentally found benzene, xylol and "numerous tar products" devoid of carcinogenic principles. Kennaway (4) found that the carcinogenic substance distills over between 250° C. (creosote fractioning) to above 500° C. (the pitch distillation temperature). Bloch and Dreifuss said the active principle was produced between the 370° and 440° C. temperatures of distillation. These are the temperatures above the creosote distillation and include the green oil of anthracene, which begins at about 270° C. After the anthracene oil has distilled over, pitch is left. Subjecting it to too much greater temperatures renders it into coke or ash. The heavy oils, with or without the addition of zinc sulphate, are used in creosoting railroad ties and wooden paving blocks. The creosoting liquid
is usually 20 to 30 per cent gas tar. About twenty men in this work whom I examined complained of burns from the splashings and handlings but showed no other effects.

High-temperature coal distillates evidently contain therefore the carcinogenic substances. The evidence does not point so much to a physical irritation as to a chemical one, but, as Kennaway states it may be an aromatic not yet isolated or it may result from a catalytic reaction as yet unrecognized. A chemical synthesis from an unknown aromatic, or anthracene, or a lesser abundant fraction of coal tar acting against susceptible tissue may be the carcinogenic factor.

Anthracene oil is the principal high-temperature content of coal tar. In experimental work Mertens found it inactive when applied to guinea-pigs, but as numerous other investigators all failed to produce tar cancers in these rodents, this experiment proved nothing. Others report it very toxic to mice. Kennaway, also quoted by Woglom, failed of success with anthracene, but stated anthracene can incite the development of cancer. A papilloma was produced by an ethereal extract of it. Grandhomme reported upon two workmen handling anthracene and showing no effects from it. Leyman, without giving particulars, mentioned three workers in anthracene who developed tumors of the scrotum.

Anthracene, C_{14}H_{10}, yellowish, crystalline, with blue fluorescence, is obtained from anthracene oil which forms between 12 and 24 per cent of coke tar, and coming over at temperatures between 275° and 350° C. when “green grease” or “green oil” appears in the distillate. It comprises about 40 per cent of the greenish anthracene oil which also contains phenanthracene, carbazole, acridine, etc.

Acridine, C_{13}H_{9}N, and chemically close to anthracene, is a constituent of heavy tar oils produced in high temperature carbonization of coal. It has been supposed to be responsible for tar cancer, but in 200 mice it failed to produce cancer in nine months.

The direct effect of tar upon workmen handling it was investigated by visiting six municipal gas works, the six coke by-
products plants in Pennsylvania, five plants making briquettes and the largest plant handling tars and similar substances. Eighty-eight tar handlers were examined in 18 plants. The only men showing any effect from the tar were those handling coke tar, nearly all of whom showed warts, and none epitheliomatous changes. The tar-warts varied from a sessile papilloma to varucca, none of which was as tall as venereal warts. No keratosis was found. The papillomas varied in size, up to an eighth of an inch in diameter; some exuded a drop of pus on pressure; none contained hairs. Removal of the warts did not leave ulcers. There was no loss of hair. No man had any adenitis.

Coke tar handlers get the tar principally upon the hands. The tarred roofing-paper men have their hands constantly in contact with tar and frequently get it upon the forearms and to an extent upon the thighs from tar-splashed clothing. Sixteen coke tar handlers were examined and all except one were found to have tar-warts, but none had epitheliomatous or other cancerous conditions. The men declared tar-warts were more plentiful in the springtime. Dr. Block, of the Barrett Co., reported a few warty effects among five hundred handlers of their tar products, but no cancers. The sixteen men I examined had worked up to thirteen years in tar, several five years or longer. Nine of the men were making tar-paper from coke tar. In the manufacture of felted roofing papers asphalt is replacing coke tar. Fourteen men making this felted paper or coating roofing shingles by immersion in natural asphalt showed no warts or other skin lesions of any character.

Water-gas tar is petroleum tar, a complex substance resulting from the distillation of petroleum, by a method called cracking, which consists in spraying coal-oil over red hot fire bricks. Steam is sprayed into the retort and explains the name of the gas. The water-gas tar is not an acid tar, as is coal tar, and it was the universal statement by gas works operators that it has never been suspected of producing skin cancer. The gas works, producing water-gas from petroleum and the resultant gas tar, employed 44 men who handled tar. None of these men
have ever had tar-warts, nor developed cancer. One man had been working constantly in gas tar for 43 years, another 16, others 10 years. One company produces 10,000 gallons of tar per month and none of the 21 handlers showed any effects whatever. To this list may be added 20 roofers who daily handle gas tar and showed no cutaneous effects from it, other than occasional burns. The Philadelphia Gas Works manufactures both producer gas and petroleum water-gas. Among 750 employees they reported no cases of cancer. Some years ago a man died with epithelioma of the temple, but he had not handled tar. One man who was examined had been handling all kinds of tars constantly for seven years and without any effect upon his health.

Coal briquettes are made by incorporating culm with gas tar, hydrolene oil, sulphite liquor emulsion or other binders. Five briquette plants were found to be using gas tar as a binder. Three employed 73 men about the plants, but only 11 men in all five plants came in contact with the tar, and none had warts or any other effects from the occupation, except occasional burns. The gas tar was delivered to the plants in tanks and then heated by steam and piped where needed. The only contact by the men with the tar was in making couplings. These men had worked at this job two or three years.

Tar-warts are produced by coal tar from high temperature distillates, and not by low temperatures, and not by petroleum tar. The phenolic and anthracene oils are produced by high temperatures. Coal tar contains a large proportion of phenolic and anthracene oils, which petroleum tar does not; gas tar, however, contains a considerable amount of paraffin oil. The phenols are known to cause dermatitis on susceptible skins but there is no present reason to regard them as capable of producing papillomas. The heavy oils, which are yielded by the high temperatures in coke making, are known to be more concerned with the development of pustular skin conditions, than are the lower-temperature light oils, but the writer has not read that any investigator of oil dermatoses has stated that the heavy oils produce elevated warts. I have seen numerous instances of
pustulation in men exposed to heavy oils, but no papillomas of any kind. These pustules are regarded by some persons as due to a blocking of ducts in the skin, by others as a result of an opening of the sebaceous ducts to infection. I agree to the latter view. If coal tar directly produces skin lesions the effect must, therefore, be either a mechanical response to a complex irritation or to a chemical activity of one of its component parts.

CONCLUSIONS

Tar obtained from the distillation of coal at high temperatures contains a substance carcinogenic to certain laboratory animals. Workmen handling coal tar showed tar warts as a result, but no other effect. No irritant action on the human skin was found from low temperature distillate tar or from petroleum tar.

REFERENCES