UNITED STATES PATENT OFFICE.

THOMAS BOVERTON REDWOOD, OF FAIRLAWN, FINCHLEY, ENGLAND.

IMPROVEMENT IN PROCESSES FOR THE MANUFACTURE OF GAS.

Specification forming part of Letters Patent No. **191,883**, dated June 12, 1877; application filed August 28, 1876; patented in England, June 23, 1876, for 14 years.

To all whom it may concern:

Be it known that I, THOMAS BOVERTON REDWOOD, of Fairlawn, Finchley, in the county of Middlesex, England, have invented new and useful Improvements in the Manufacture of Gas for Burning, which improvements are fully set forth in the following specification.

This invention has for its object to improve the quality and increase the quantity of gas obtained by distilling coal in retorts, as now usual. For this purpose I cause the gas, as it issues from a retort, or while it contains a portion, at least, of the condensible vapor which is generated, together with the gas, to come into contact with heated copper or alloy of copper, so arranged as to expose a large extent of surface to the gas. I prefer to pass the gas immediately, as it issues from the hydraulic main, through a heated retort packed full of copper tubes—say of an inch diameter—so that an extended heated surface may be exposed to the gas without materially obstructing its passage. I prefer that the tubes should be short lengths—say one foot—and in packing them in the retort I take care that the different lengths do not butt truly together, but are arranged so as to subdivide the current of gas as far as practicable.

By this means the volume of the gas is increased, and its quality, both as regards illuminating power and also freedom from an undue quantity of sulphur in other form than that of sulphureted hydrogen, is at the same time improved, as will hereinafter fully be explained.

The converting-retort should be heated externally by a fire, by which it can be kept at a cherry-red heat, and the gas, after passing through the converter, should be conveyed to the condensers and purifiers through a pipe of ample size, so that it may pass off freely without back pressure.

In cases where it may be desired to get a larger quantity of tar than would be produced by operating in the foregoing way, the gas may be carried not only through the hydraulic main, but also through the condensers, before it passes to the converter; but in this or any case in which most of the aqueous vapor as well as tar would be separated from the gas before it reaches the converter, it will be desirable to introduce water, or the vapor of water, with the gas into the converter, which may be done in any convenient way, to the extent of about a pint of water, or an equivalent quantity of steam, for every thousand cubic feet of gas.

When the coal employed in the process yields a gas of very high illuminating power, such as cannel-coal, I cause a stream of water-gas to pass through the retort in which the coal is distilled, and then lead the combined products through the converter, arranged and heated as already described.

In order that my invention may be thoroughly understood, and to clearly point out what the advantage is that copper possesses over other metals or materials which might be used in heating crude coal-gas for the purpose of increasing its volume, the following well-known facts must be borne in mind:

First, crude coal-gas contains, among other things, certain hydrocarbons in the state of permanent gases, including olefiant gas, (C_2H_4,) butylene, (C_4H,) and acetylene, (C_2H_2,) marsh-gas, (CH_4.) It also contains other hydrocarbons which, at common temperatures, exist as liquids, but the vapors of which remain in a state of diffusion in the gas to a slight extent at common temperatures, and to a greater extent when hot. Among these liquid hydrocarbons is amylene, (C_5H,) and other homologous bodies, as well as benzole (C_6H_6) and its homologies.

Second, the light-giving properties of these hydrocarbons, and of the coal-gas containing them, depend mainly upon the proportion of carbon contained in a given volume of the gas or vapor when burned as a source of light. Thus, among the permanent gases, marsh-gas, which contains the smallest proportion of carbon, gives, in burning, the smallest amount of light, while butylene and acetylene burn with a highly-luminous flame. The presence of too much carbon, however, is objectionable in a gas to be used for burning as a source of light, because it gives a smoky flame, and on this account olefiant gas, butylene, and acetylene could not be burned alone, and are valuable only for the purpose of enriching or increasing the light-giving properties of poor gases, such as marsh-gas, hydrogen, and carbonic oxide.

Third, the chemical formulæ appending to the foregoing hydrocarbons represent in each case a molecule of the substances, such molecules consisting, in most cases, of several atoms of each of the elements present—namely, carbon (C) and hydrogen (H)—the figures attached to the letters in the formulæ indicating the numbers of the atoms of those elements.

Fourth, the volumes of all molecules in the gaseous or vaporous state are the same—that is to say, the quantities of matter represented by the formulæ CH_4, C_2H_4, C_4H_8, C_2H_2, C_5H_{10}, C_6H_6, which are the formulæ, respectively, of marsh-gas, olefiant gas, butylene, acetylene, amylene, and benzole, when existing in the state of gas or vapor, occupy the same space; and as the carbon and hydrogen are present in the same proportion in olefiant gas and butylene, the only difference being that the molecule of butylene contains twice as many atoms or twice as much matter as the molecule of olefiant gas, it follows, as a necessary consequence, that if, by any means, the molecules of butylene could be split in two, one volume of the butylene would thus make two volumes of olefiant gas. So, also, if a molecule of benzole could be split into three, it might be converted into three times its volume of the valuable light-giving gas, acetylene, a minute quantity of which is usually present in coal-gas.

Fifth, by the application of heat to hydrocarbon gases and vapors a splitting up of the molecules in various ways may be effected, and the vapors of liquid hydrocarbon may thus be converted into permanent gases. The permanent hydrocarbon gases may also be broken up in the same way, and usually are broken up when subjected to a high temperature. It is thus, as is well-known, that ordinary coal gas may be increased in volume by exposing it to a strong heat; but, so far as my knowledge extends, in all attempts heretofore made to increase the volume of coal-gas in this way, the light-giving properties of the gas have been destroyed or greatly injured, so as to render the method valueless to gas-makers. This has arisen from the fact that the two principal hydrocarbon gases contained in coal-gas—namely, marsh-gas and olefiant gas—when heated by bringing them into contact with most solid substances, at a red heat, are decomposed, olefiant gas being split into marsh-gas and solid carbon, which latter is deposited, and marsh-gas being split up into hydrogen and solid carbon, this latter change being attended by a doubling of the volume of gas.

No method of which I am aware has heretofore been proposed by which a splitting up of the more complex hydrocarbon molecules, and consequent augmentation of volume, can be effected without more than counterbalancing the value of such effect by the destruction of other light-giving hydrocarbons and the deposition of solid carbon from the gas. Hitherto attempts in this direction have been made by heating the gas in contact with iron, clay, or coke; and it is known that, in contact with these substances at a red heat, marsh-gas and olefiant gas are decomposed; hence the failures of such attempts.

Now, the advantage gained by the use of copper as the heated surface to which crude coal-gas may be exposed, and by which the volume of the gas may be increased without diminishing its illuminating power, arises principally from this, that the gas can be exposed to red-hot copper without any carbon being separated from it, whereas, in contact with iron or other metal, although the volume of the gas would be increased, its illuminating power would be diminished, carbon being deposited in the solid form. The advantage arising from the use of copper, therefore, does not consist, merely or principally, in its being a good conductor of heat, and thus affording the means of conveying the requisite heat to the crude gas to convert the hydrocarbon vapors into fixed or permanent gases; but it consists in a peculiar catalytic action which the heated copper exerts in causing some of the liquids or other hydrocarbons contained in crude coal-gas to split up into gaseous hydrocarbons, the molecules of which contain a smaller number of atoms than do those from which they are produced, so that the volume of the gas is increased, while at the same time the copper, at the temperature required to produce the foregoing effect, causes no material deposition of carbon from any of the hydrocarbons present. It therefore causes an increase of volume without any diminution of illuminating power.

The advantage gained by the use of copper applied in the manner specified for effecting the separation of sulphur from coal-gas is due to the fact that by heating crude coal-gas which contains bisulphide of carbon, as well as the vapor of water, the former is converted into sulphureted hydrogen and carbonic acid—thus $CS_2+2H_2O=2H_2S+CO_2$.

That this reaction takes place is well known; but it has not hitherto been made available for facilitating the separation of bisulphide of carbon from coal-gas, because no method has been known by which the gas could be heated to the required extent without causing a deposition of carbon, and by that means injuring the illuminating power of the gas. In contact with red-hot copper, this change, as well as the other changes referred to, may be easily effected, and the sulphureted hydrogen produced, together with that originally present in the gas, is easily removed by means of an oxide-of-iron purifier.

What I claim is—

1. The hereinbefore-described process of manufacturing coal-gas, which consists in distilling coal and leading the gas so obtained, with vapors generated with it, into contact

with copper or an alloy of copper, kept in a highly-heated state, and arranged so as to expose a large extent of surface, substantially as set forth.

2. The hereinbefore-described process of manufacturing gas, which consists in distilling coal, passing a stream of water-gas through the retorts during the distillation of the coal therein, and leading the combined products into contact with copper or an alloy of copper, kept in a highly-heated state, and arranged so as to expose a large extent of surface, substantially as described.

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