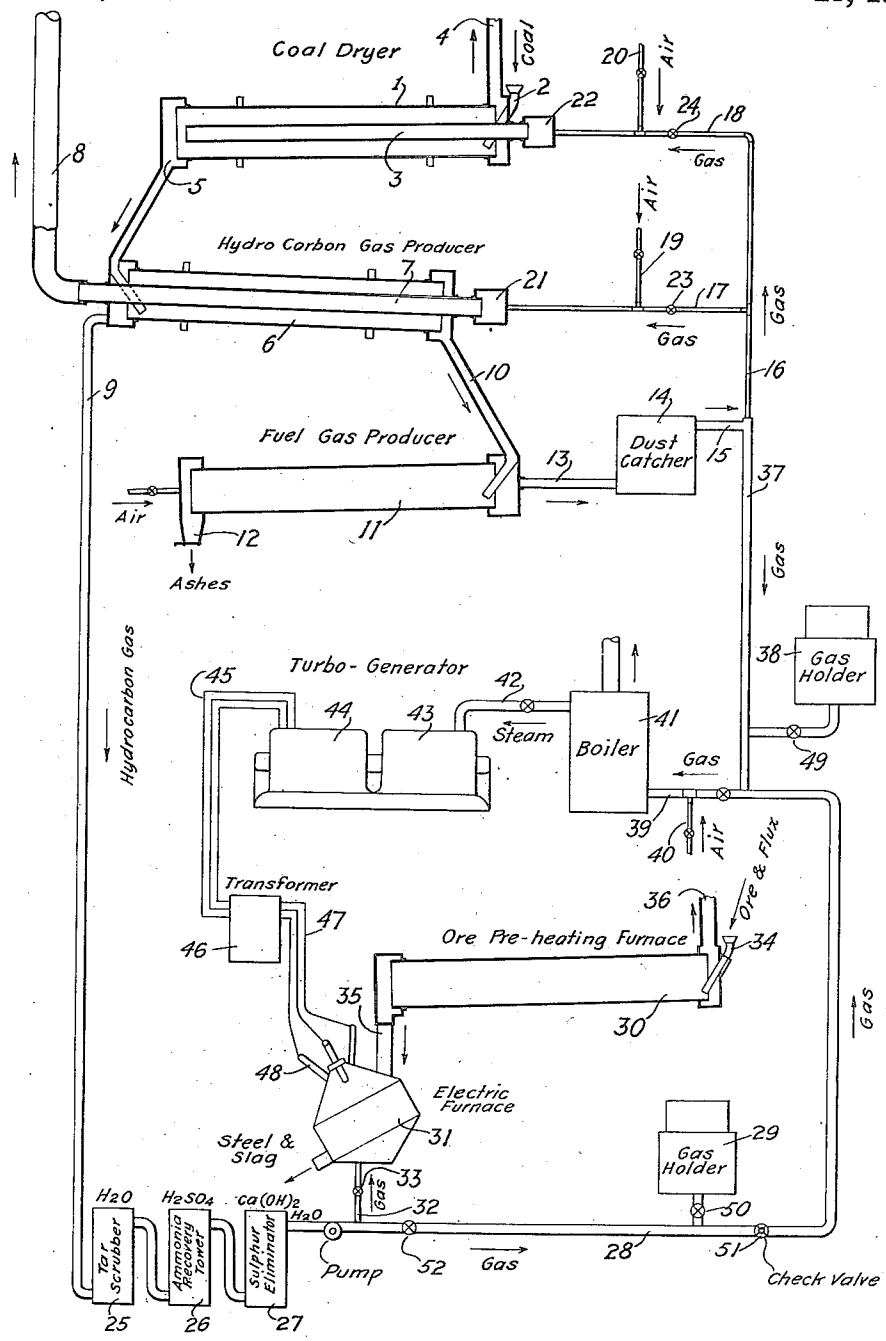
W. E. F. BRADLEY.

REDUCTION OF ORES.

APPLICATION FILED AUG. 10, 1918.

1,407,372. Patented Feb. 21, 1922.



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REDUCTION OF ORES.

1,407,372. Specification of Letters Patent. Patented Feb. 21, 1922.

Application filed August 10, 1918. Serial No. 249,352.

To all whom it may concern:

Be it known that I, WALTER E. F. BRADLEY, a citizen of the United States, residing in New York, county and State of New York, have invented certain new and useful Improvements in the Reduction of Ores, of which the following is a specification.

In my prior application, filed July 17th, 1918, Serial Number 245,368, entitled Method of producing iron and steel, I have described a method in which the hydrocarbon gas is employed as the reducing agent. While, according to that application, the hydrocarbon gas may be derived from any source, the specific example therein referred to suggests the employment of natural gas, which is mainly a hydrocarbon in the form of methane. Other hydrocarbons are capable of performing the reducing action and as natural gas is not available in all localities, the present invention seeks to provide a method following the general principles of that disclosed in said prior application, but in which the hydrocarbon gas is artificially produced from materials such as lignite, bituminous or semi-bituminous coal or other material which has a gaseous constituent that can be driven off by suitable treatment, as for example, by means of heat.

The invention is applicable in general to the production of iron and steel from material containing iron chemically united with oxygen such, as for example, hematite or other oxide or carbonate ores of iron, magnetite sands, iron concentrates and the like. Such materials are herein designated "ores."

In order that the process may be economically carried out, it is desirable that the raw materials and the energy or source of energy employed, should be utilized economically and with conservation. The reduction of ores requires that a suitable operative temperature be maintained and that a sufficient number of heat units be developed to maintain this necessary temperature, while at the same time supplying the heat units of chemical action, as the reduction of these ores is an endothermic process. At the same time, in order to obtain a product of high purity, it is important to avoid introduction of contaminating materials into the charge which is being reduced, as the subsequent removal of such impurities involves additional expense and practical difficulty.

With these various conditions in view, the method according to the present invention, utilizes the raw materials in such a manner as to provide the desired hydrocarbon reducing gas which is introduced into the charge to be reduced, while excluding from the charge all contaminating impurities so far as possible. Furthermore, the material from which the gas has been produced is then utilized in an economical manner for generating heat, a part of which may be consumed in the operation by which the hydrocarbon gas is produced and other portions of which may be employed for maintaining the temperature of the charge and supplying the chemical heat units of the reducing action. This utilization of heat is carried out in a regenerative manner so far as practicable.

The method will be more clearly understood with reference to a specific example illustrated in the accompanying drawing. Said drawing is a diagram of an ore reduction system embodying the principles of the invention.

It will be apparent that any coal having a gaseous constituent, such as lignite, bituminuous or semi-bituminous coal, as distinguish from anthracite, may be employed as the source of the hydrocarbon gas. As the principle of operation is essentially the same in any case, no matter which material is employed, I may refer to the raw material by the generic term "coal," it being understood that this word is employed to designate any suitable raw material from which the hydrocarbon gas can be produced by principles similar to those herein disclosed.

Referring specifically to the drawing, 1 indicates a rotary drier into which the coal is introduced through the hopper 2. The heating flame passes longitudinally through a flue 3 concentrically disposed within the main drum 1 and the gases therefrom pass in the opposite direction through the drum 1 and are discharged through the stack 4. The coal in passing through drum 1 moves from right to left and having been freed from moisture so far as possible, is then delivered in dried condition through the chute 5 into the hydrocarbon gas producer, comprising a rotary drum 6 within which a heating tube 7 is concentrically arranged. The heating tube 7 extends axially through

the rotary drum 6 from one end to the other and is maintained at such temperature as to distill off the hydrocarbon gas from the dried and preheated coal, leaving the latter in the form of coke. The products of combustion from heating tube 7 are discharged through the stack 8. The hydrocarbon gas distilled off from the coal is delivered through pipe 9 at the higher end of the rotary drum 6, whereas the coke is delivered into the chute 10 at the lower end thereof. The coke delivered through chute 10 passes into a fuel gas producer 11 where it is burned with limited supply of air to produce carbonic oxide, the resulting ash being discharged periodically or otherwise through the chute 12, whereas the producer gas passes through pipe 13 into a dust catcher 14 and is delivered for use through pipe 15 in condition for use in developing heat where required. A portion of this producer gas is shown diagrammatically as being led through pipe 16 into branch pipes 17, 18, for use in the heating flues or tubes 7 and 3 respectively, it being understood that the air for supporting the combustion is admitted to each branch by way of suitably controlled air inlets 19 or 20, the combustion taking place within the combustion chamber 21 or 22 respectively. Control valves 23 and 24 may be employed to regulate the supply of gas in each of the branches 17 and 18 respectively.

The hydrocarbon gas delivered into pipe 9 from the rotary drum 6, will, in most instances, contain in addition to the hydrocarbon gas, other material such as tar, ammonia and sulphur. Some of these materials would be detrimental to the product, if introduced into the charge which is being reduced by the hydrocarbon gas and furthermore, may represent valuable by-products. Therefore, I lead the hydrocarbon gas from pipe 9 through the scrubbers 25, 26 and 27, in the first of which tar may be removed by a spray of water, in the second of which ammonia may be removed and recovered by reaction with sulphuric acid and in the third of which sulphur may be eliminated by milk of lime or lime water. The hydrocarbon gas thus purified is then delivered to pipe 28 which leads to a gas reservoir 29 where excess quantities may be stored.

As diagrammatically indicated, the reduction of the ore is occurring in a preheating rotary drum furnace 30, and an electric furnace 31. The reduction of iron ore with hydrocarbon gas involves a negative heat balance of chemical reaction, necessitating the supply of heat from an outside source to make up the deficiency and to maintain the temperature. It will be understood that the gas may be introduced into the electric furnace 31 through a pipe 32 under the control of valve 33, while the finely divided ore and flux is introduced into the preheating drum furnace 30 by way of the feed hopper 34. The rotation of drum 30 carries the charge toward the lower end of the drum 30, from which it is discharged through the chute 35 into the electric furnace 31. The hydrocarbon gas passing through pipe 32 is introduced into the charge where reduction is taking place and the resulting gaseous mixture passes upwardly through the flue 35 and over the charge of ore and flux passing through drum 30, and is finally discharged through stack 36 from which point it may be discharged into the atmosphere or utilized for heating at some portion of the system.

The supply of electrical energy, however, constitutes an important element of the present invention, as it is dependent in large measure upon the material from which the hydro-carbon gas has been derived. According to the present invention, this material may be employed directly in the form of coke as a fuel for developing electric power or it may be first converted into a combustible gas and supplied to the power-developing apparatus of any suitable type, for example, a turbo-generator set, as illustrated. In this embodiment, the producer gas obtained by incomplete combustion of the coke, as already described, may be utilized in part for developing heat in the coal drier and hydrocarbon gas producer. Additional quantities of this producer gas, as shown in the accompanying drawing, may be led through pipe 37 into a gas reservoir 38 and into a pipe 39 for combustion with air admitted through suitably controlled pipe 40, the combustion being utilized in a boiler 41 for producing steam which is delivered through pipe 42 into a steam turbine 43 operating electric generator 44. The power developed in generator 44 is delivered through the primary conductors 45 to a transformer 46 and the secondary current may be taken off through conductors 47 and delivered to the electrodes 48 of the electric furnace 31.

The gas holder 38 may be connected or disconnected from pipe 37 at will, by means of valve 49. A similar valve 50 controls the communication of gas holder 29 with pipe 28. It may be desired to deliver hydrocarbon gas from pipe 28 to supplement the producer gas from pipe 37 in the firing of boiler 41. For this reason, pipe 28 is extended beyond the gas holder 29 and brought up into communication with pipe 37 at a point where the air inlet pipe 40 enters. A check valve 51 prevents producer gas from passing downward into pipe 28 whereas a control valve 52 is arranged in pipe 28 to prevent the delivering of hydrocarbon gas into the pipe 37 when it is desired to do so.

While I have shown and described only so much of the system as relates directly to

the utilization of the raw materials from which the hydrocarbon gas is produced, it is not to be understood that the invention precludes the supply of additional power, heat or reducing agent, from other sources, if for any reason they should seem desirable in a particular locality.

In general, the operation may be summarized as follows. The coal is first subjected to a drying and preheating operation, and then to a distillation stage from which a hydrocarbon gas is derived. The ore and flux are fed through a preheating furnace into an electric furnace, and the hydrocarbon gas after purification is passed through the charge in the electric furnace and out by way of the preheating furnace. The iron or steel thereby produced may be discharged in any desired manner. The coke remaining from the coal after the hydrocarbon gas has been set free is utilized as fuel either directly or indirectly, a portion of the heat being applied to the drying of the coal and distillation of the hydrocarbon gas, while another portion is used in firing the boilers for the production of electric power employed in the electric furnace. The tar, ammonia and sulphur products may be recovered from the raw hydrocarbon gas and handled in any well known manner where their recovery may represent marketable byproducts. By driving off moisture from the coal, and avoiding the introduction of air into the gas which is to be used as a reducing agent, the reduction of the ore is more advantageously accomplished.

While I have described the invention more particularly with relation to the treatment of iron ores, I wish to include within the scope of the invention, the treatment of ores in general, whether of iron or of other material, wherein the same principles may find useful application.

I claim:

1. The method of reducing ores, which comprises distilling a hydrocarbon gas from coal, utilizing the hydrocarbon gas as a reducing agent for the ore, and utilizing the resulting coke, out of contact with the ore, as a source of heat for maintaining the temperature of the ore during reduction.

2. The method of reducing ores which comprises heating coal to derive a hydrocarbon gas, utilizing the resulting coke, out of contact with the ore, as a source of heat for developing electric power, utilizing the electric power to supply heat to the ore, and bringing the hydrocarbon gas into contact with the ore to reduce the same.

3. The method of reducing ores which comprises heating coal to derive a hydrocarbon gas, burning the resulting coke, out of contact with the ore, with limited air supply to produce a combustible gas, burning the said combustible gas to develop electric power, supplying heat to the ore by means of the electric power developed, and subjecting the ore to the reducing action of the hydrocarbon gas.

4. The method of reducing ores, which comprises heating coal, while excluding air therefrom to derive a hydrocarbon gas, utilizing the hydrocarbon gas with the exclusion of air, as a reducing agent for the ore, and utilizing the resulting coke, out of contact with the ore, as a source of heat for maintaining the temperature of the ore during reduction, while at the same time, excluding oxidation products thereof from the ore.

WALTER E. F. BRADLEY.