April 7, 1931. L. CHAVANNE 1,799,885

PROCESS OF GENERATING PRODUCER GAS

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Fig.1

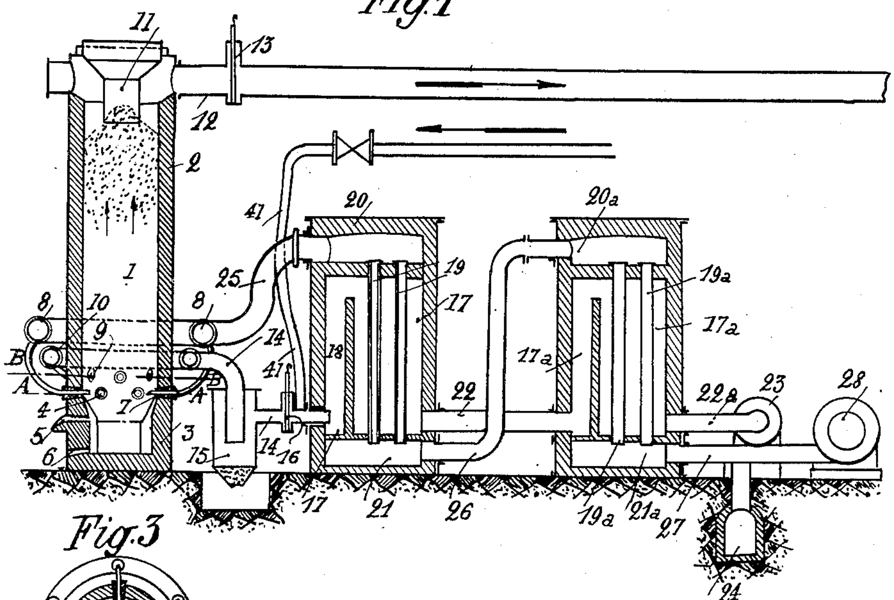
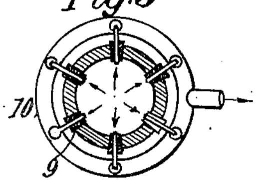


Fig.3



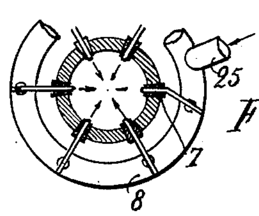


Fig.2

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Fig. 4

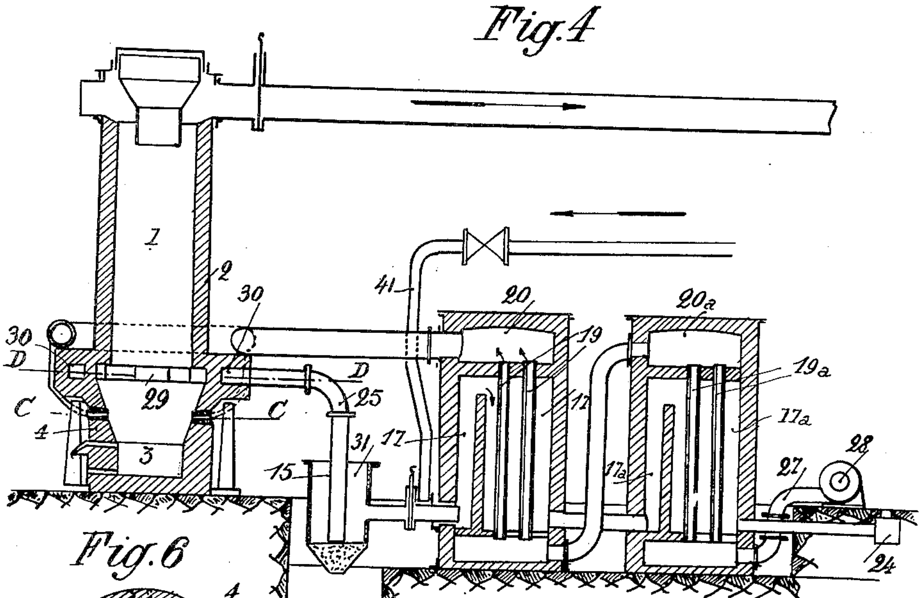


Fig. 6

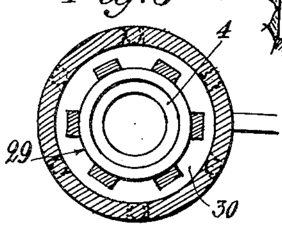
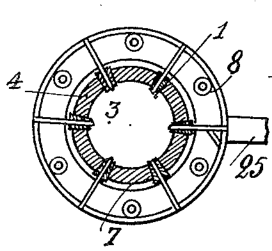


Fig. 5



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PROCESS OF GENERATING PRODUCER GAS

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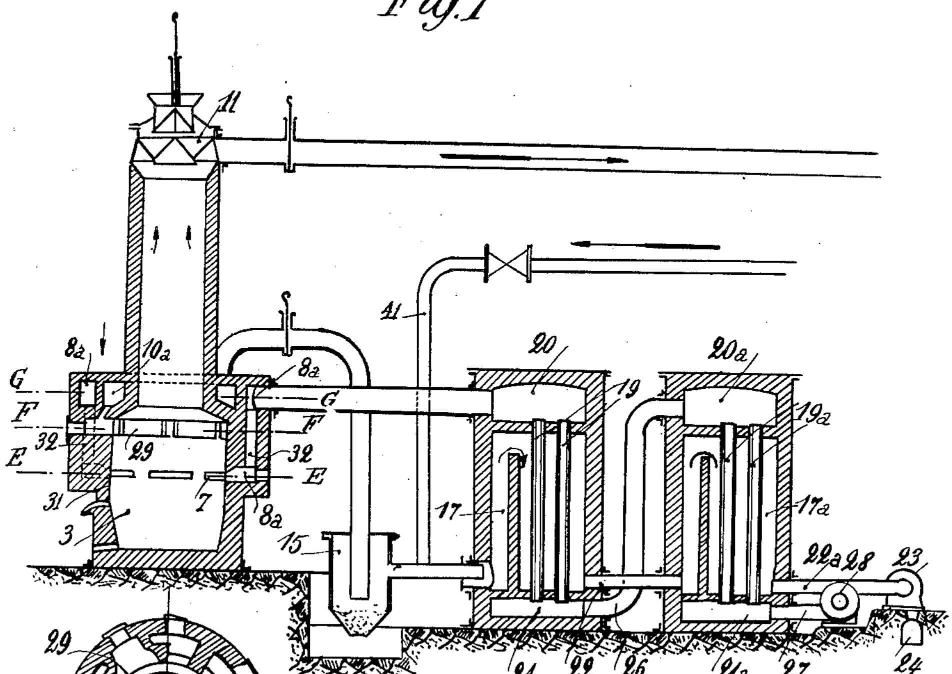
Fig.7



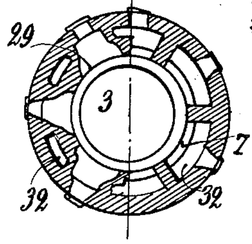


Fig.8

Fig.9

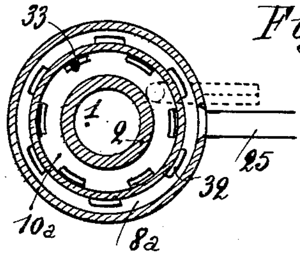


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Fig.10

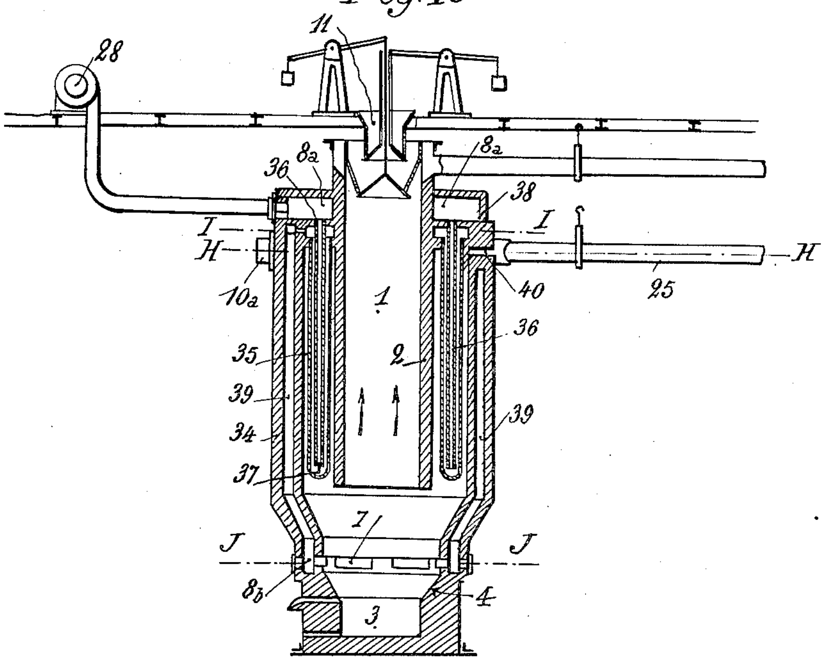


Fig. 11

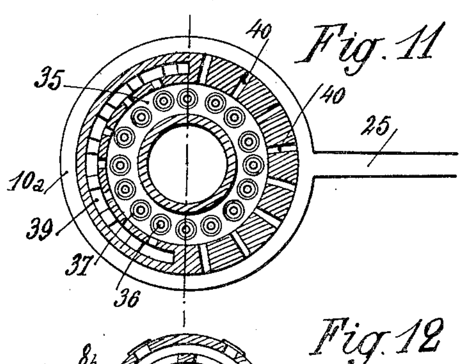
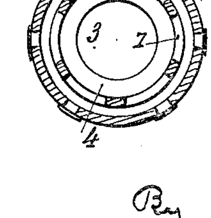


Fig. 12



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UNITED STATES PATENT OFFICE

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PROCESS OF GENERATING PRODUCER GAS

Application filed February 12, 1925, Serial No. 8,810, and in France February 13, 1924.

Processes of gasification by means of fusing ashes, as well as the greater part of the gas producers in which these processes are carried out, have been up to the present, designed to treat special fuels, by reason of the great difficulty of assuring the gasification and simultaneously the fusion of the ashes of any fuel continuously.

The interrupted progress of the operations occurs generally as follows:

When the heat generated in the fusion zone is insufficient the unmelted ashes agglomerate, and forming a solid mass, rapidly block up the apparatus;

When the heat is excessive and if it is not partially absorbed the fusion zone extends in height, and "the fire rises". This extension causes stoppage—by cohesion—of the elements of the charge which form an arch which does fall in under the weight of the materials; this results therefore in another cause of choking of the apparatus.

Between these two conditions there is "the normal condition" corresponding to continuous gasification and fusion.

The present invention remedies the causes of stoppage indicated. It comprises processes and methods of operation which permit of the gasification, by means of fusion of the ashes, of any mixture of solid fuel with other materials.

These processes consist of injecting at the base of the column of fuel or combustible mixture a blast of fluids capable of supporting combustion of suitable composition, heated or otherwise, the free oxygen and nitrogen contents being adjusted in order to produce and maintain a narrow zone of fusion surmounted by a greatly extended zone where distillation is effected at low temperature; these characteristics of the condition of the column and the operations of which it is the basis, are permanently assured by means of an appropriate temperature gradient obtained by varying the proportions and temperature of the blast fluid mixtures supplied to the column, by varying the composition of the charges and the extent to which they are heated by the partial withdrawal of the heating gases, and by external cooling action.

The temperature of the blast depends principally on its free oxygen content and on the nature of the combustible mixture to be treated. It is possible, according to circumstances, to inject pure oxygen or added endothermic material.

It is necessary that the gasification of fixed carbon liberate sufficient heat and that the temperature should be high enough to melt completely the ashes and additions so that the molten residue should be homogeneous and fluid. Such results are obtained:

a. When the blast is composed of fluids like: heated air; air enriched with oxygen, heated or not; air mixed with steam or with carbon dioxide, or both, heated or not; air enriched with oxygen, or oxygen mixed with steam, carbon dioxide, burnt gases, etc., said gases reacting endothermically upon the carbon of the fuel; such mixed fluids containing together a proportion of free oxygen regulated according to their temperatures, the constituents of the charges to be gasified, and the results to be obtained.

b. And when these blasted fluids, reacting together exothermically upon the carbon of the fuel, generate gases (in the combustion zone) at a temperature approximately equal to or exceeding the temperature developed when a blast of air alone, heated at 200° C., is blown.

By way of example, in a twenty-foot high mass of fuel having a low percentage of ash (under 4%), the temperature of the gases generated at the twyers lever with a blast of air alone, heated at 200° C., is approximately 1,750° C., but can be reduced with a lower blast pressure and conveniently sized constituents of the charge. It may also be stated that for a mixture of fuels having a content of 45% in ashes and an average of 25% of fixed carbon, a blast containing about 40% of oxygen and heated to about 375° C. will develop in these gases a temperature ranging around 2,250° C.

Under these conditions, the temperature of the fusion zone may vary but it is always such that the transformation of carbon into carbon monoxide is practically instantaneous and complete. The heat liberated in the fusion zone is fixed essentially by the materials melted and the gaseous products of gasification which in ascending are cooled by heating the materials of the charge proceeding in the opposite direction.

When the blast is oxygen-enriched (that is to say containing more free oxygen and less free nitrogen than atmospheric air) for the same quantity of carbon gasified the same quantity of calories liberated is fixed on a smaller quantity of gas and the appropriate temperature of the fusion zone is more rapidly attained at a level nearer to the level of the twyers, than is the case where atmospheric air is used. When the oxygen-enriched blast is heated the maximum temperature of the fusion zone is attained still more rapidly.

The narrow zone of fusion assures, by the regular descent of the charges, stability of operation; the narrower it is the more easily the weight of the materials which it supports assists in the breaking down of the scarfing scaffolds in the regions concerned. It is thus possible to arrange the height of the fusion zone, dependent upon the size of the materials of the charge, to be less than a quarter of the total height of the fuel column; this height can even be reduced to a few inches whilst the height of the column may be more than 20 feet. It is also obvious that the differences in temperatures between the descending column of fuel mixture and ascending column of the gases will be greater with large size lumps than with pea size lumps, all other conditions being the same, because, in the latter case, of the tightening of the isothermal surfaces. Therefore adjustments in the heights of zones and the temperatures of the gases ought to be made accordingly. It may be stated, by way of example, that with a fuel column varying in height from about 8 to 15 feet, and a charge comprising a mixture of coal and other materials of pea size with a certain percentage of lumps and in which the content of ash and inert matter ranges from about 20% to 35%, the fusion zone can be limited to from 4 to 10 inches in height provided a suitable gaseous mixture is used for the blast.

One effect of injecting an oxygen-enriched blast is to increase the speed of gasification. It is thus possible to gasify 400 to 1000 pounds of fuel mixture per square foot (2000 to 5000 kgs. per M.^{2}). Moreover by judiciously combining the other means set forth hereafter it is possible to vary rapidly the rate of gasification, for example, from 50% to 100% without substantially modifying the composition of the gas.

Another effect of injecting an oxygen-enriched blast is to give a richer gas, inasmuch as it contains less nitrogen; and further to increase the yield of condensable by-products of the distilled gas.

There is no need to go to the practical limits of heating of the blast since the latter is oxygen-enriched, and according to the degree of oxygen-enriched it is possible to dispense with the heating of the blast.

For the stable operation of gasification, whatever the fuel treated, necessitating a narrow zone of fusion and a large zone of low temperature distillation, it is sometimes necessary to localize at different levels in the column certain endothermic effects of desired intensity. For this purpose there is injected into the fuel column material which supports combustion, heated or otherwise, chosen from those which like CO_2, H_2O (liquid or vapor), products of combustion, etc., assist, by reaction, to improve the calorific value and the quantity of the gas produced.

In order to lower the temperature of the fusion zone and to limit its height, the temperature of the materials entering this zone may be modified, and as these materials are heated by the ascending gases, the action of the latter can be reduced by partially withdrawing the gas at certain levels in the fuel columns. The gas thus withdrawn from the fusion zone may have a temperature more or less approaching the temperature of the said zone. It is thus desirable to utilize the high temperature of this gas and the sensible heat thereof, for the needs of the installation itself for example, heating the blast, raising of steam, etc.

The gases obtained at different levels of the heating and distillation zone carry off condensable by-products derived from the volatile materials in the fuel. The quality of these condensable products depends on the nature of the fuel, on the temperature gradient of the column and on the position of the points of extraction. These temperatures according to the present process are relatively low (below 662° F. or 350° C.). In regulating the delivery of the gas obtained the regulation of the temperatures of the fuel column is modified in the required manner to modify the quality and quantity of condensable by-products carried off by the gases.

The gases derived from the distillation zone, of high calorific values (more than 450 B. t. u. per cubic foot)—(4000 calories per M.^{3})—free or otherwise from by-products—according to the use to which they are put—can be mixed together or with the gases obtained from other zones of the fuel column.

When the composition of the ash of the solid fuels is such that their temperature of softening may be sufficiently below their temperature of fusion stoppages occur. This inconvenience is obviated by limiting the extent of the sticky zone, bringing it nearer the plane of the twyers, and reducing the thickness of the fusion zone which is consistent with the result arrived at. For this purpose materials are added such that the softening temperatures and fusing temperatures of the fuel mixture are as nearly as possible the same. The additions with the fuel ash, giving a slag which is homogenous and fluid, are not limited to the usual fluxes, that is to say to ordinary limestone; other materials suitable for this purpose enable an aluminous slag to be obtained suitable for the manufacture of various cements, the slag remaining sufficiently basic to combine with the sulphur of the charges. Among other results a gas free from sulphur is produced.

The additions may also comprise substances, the heating, reduction, fusion and volatilization of which correspond to absorptions of heat in a definite region of the column. They are such that the vapors and dusts carried off by the gases and the melted products collected in the fusion zone can be advantageously utilized. Also they are chosen from materials such a scrap iron, refuse waste from mines, ores of poor quality, etc., which by transmutation yield purified metals, cast iron enriched in silicon (from 5% to 8% Si.) and free from sulphur (less than 0.04% S.), ores of increased value, etc.

It is possible to produce endothermic effects in the fuel column externally by means of suitably arranged water coolers, and the heat carried off by the cooling water may be utilized for the requirements of the installation itself, for example, for raising steam.

In order to illustrate the invention I mention hereafter certain essential features of its application to gas producers, it being understood that the description thereof and the method of procedure described in no way limit the scope of the invention.

Among the different forms of construction of gas producers suitable for carrying out the present invention into practice the example illustrated in the accompanying drawings may be selected in which Fig. 1 is a side elevation in section of a gas producer plant in accordance with the invention. Figure 2 is an under-side view on the line A—A Fig. 1 of the gas producer properly so called. Figure 3 is a similar section on the line B—B. Figure 4 is a section similar to Figure 1 showing a modification. Figure 5 is an underside view on the line C—C of Figure 4. Figure 6 is a similar view on the line D—D of Figure 4. Figure 7 is a section similar to Figure 1 on a second modification. Figure 8 is a view in which the right hand portion is a half section on the line E—E of Figure 7, and the left hand portion is a half section on the line F—F of Figure 7. Figure 9 is a section on the line G—G of Figure 7. Figure 10 is a section similar to Figure 1 of a third modification. Figure 11 is a view in which the right hand portion is a half section on the line H—H of Figure 10 and the left hand portion a half section on the line I—I of Figure 10. Figure 12 is a section on the line J—J of Figure 10.

Referring to Figure 1, the gas generating apparatus is composed of a gas producer 1 having a cylindrical shaft and a cylindrical crucible 3 which are connected together by a conical portion 4; crucible 3 may be of larger or smaller size and may take the shape shown in dotted lines in the figure and is provided with tap holes 5 and 6. 7 are blast tuyères arranged above the crucible and in connection with a collector 8. Nozzles of tuyères 7 are cooled by a water circulation in a known manner. Above them are a series of tubes 9 having the general shape of blast nozzles and are also cooled by a water circulation. Tubes 9 lead both inside of shaft 1 and to a collector 10. At the upper portion of shaft 1 is a suitable charging apparatus or hopper 11 preferably of the continuous distribution type; 12 are pipes provided with a valve 13 leading from the upper portion of the casing which surrounds hopper 11.

From collector 10 leads a tube 14 for the passage of gas to a dust separator 15, and 16 is a valve controlling the inlet into a chamber 17 through a burner arrangement 18 which may be regulated as desired. Chamber 17 is provided with tubes 19 which form a communication between a chamber 20 and a chamber 21, one situated above and the other below 17. From chamber 17 leads a tube 22 communicating with a chamber 17*a* similar in all respects to the chamber 17 and also comprising tubes 19*a*, an upper chamber 20*a* and a lower chamber 21*a*. From the chamber 17*a* starts a tube 22*a* which leads to a suction fan 23 drawing products of combustion from chamber 17*a* and delivering into a flue 24. In some cases fan 23 may be omitted; pipe 22 then leads directly to flue 24.

Collector 8 communicates through tubes 25, chamber 20, tubes 19, chamber 21, tube 26, chamber 20*a*, tubes 19*a*, chamber 21*a* and tube 27, with a delivery fan 28 which draws from a source of supply not shown a blasting mixture such as air and oxygen and delivers it into the gas producer through the heating circuit. This source of supply when a mixture of air and oxygen is employed may be of any suitable known type and preferably comprises an apparatus of a known type which allows the content in oxygen of the mixtures of air and oxygen blown by the fan to be maintained constant or be made variable as required.

The installation operates as follows:

The apparatus is assumed to be in normal operation, the gas producer being full of fuel. Any of the common solid fuels may be used such as lignite, peat, bituminous, semibituminous or anthracite coal, coke, and even garbage, to which may be added various low-grade ores, ore residuals, or wastes containing metals and metalloids such as zinc, copper, tin, lead, silver, etc., or potassium, sodium, etc., or their compounds. The valve 13 is conveniently open, fan 28 blows mixtures of air and oxygen into the base of the column through the tuyères 7. The high temperature developed by the combustion of fuel under action of the hot air and oxygen creates as above explained a thin zone of combustion of very high temperature which ensures both the combustion of the fuel and the fusion of the residues.

The fuel situated above this zone is subjected to the action of radiating heat, and to the sensible heat of the ascending gases escaping from the top layer of the fuel; the upper part of the fusion scorification zone contains fixed carbon and inert matters only. The combustion of the carbon brought in the high temperature zone of combustion takes place almost instantly and the descent of fuel is consequently very rapid; the heat developed in this zone is absorbed partly by the production of slag and other residues and carried out partly by the production of slags and through the gas outlets 9 and pipe 10 and may be advantageously employed as will be seen later, for heating the blast mixture, whilst the remaining heat led off by the portion of gases passing through the fuel column and which are evacuated through the pipe 12, is just sufficient to cause the free escape in the distillation zone of the light hydrocarbons which remains intact and which are collected out of the producer by condensation under form of very fluid tars of little density from which light products having low boiling points, as well as oils and lubricating oils can also be recovered either directly or by further fractional distillation. Gas passing out of tube 12 will be the richer in carbon monoxide as the blast contains more oxygen, i. e. within certain limits of temperature defined by the oxygen content of the blown mixture.

When the fuel treated has a normal amount of ashes it may be necessary and economical to employ the whole sensible heat of the combustion gas produced or only part of it for heating the blasting mixture blown into the gas producer.

For this purpose the arrangement shown in Figure 1 and already described in a general manner may be adopted. The very hot gases may be removed partly through the outlet nozzles 9 suitably arranged in or above the zone of fusion scorification and these gas outlets are preferably of large size as shown in Figures 4 and 7 (designated 29 in these figures). If necessary gas is sucked off by fan 23 through chambers 17 and 17*a* and passes around tubes 19 and 19*a* through which is blown the mixture of air and oxygen and thence to the tuyères 7. By this means the sensible heat of the gases withdrawn is transmitted to the blasting mixture and is returned with little loss to the gas producer.

According to the circumstances or conditions the gases withdrawn by outlets 9 may be burnt in the chamber 17, the burner arrangement 18 being employed for this purpose. Gases derived from the upper portion of the gas generator may after cleaning be delivered to the burner through the pipe 41.

The slags normally pass out through tap holes 5.

Tap hole 6 serves to empty completely the crucible but more particularly for running off the liquefied dense matters derived from the fuel or which have been added such as ferrous metals, for instance, introduced into the charge with a view to their desulphurization and enrichment in silicon, etc., as above described.

It is to be remarked that although Figs. 1, 4, 7 and 10, do not show special arrangements for blowing steam, carbon dioxide, etc., nor do they show several gas outlets in the upper part of the distillation zone, for allowing the fractional separate removal of unaltered by-products, the gas producer must be fitted with these devices.

The arrangement shown in Figure 4 contains the essential parts similar to those shown in Figures 1 to 3.

In this case however crucible 3 is connected to stack 2 by a conical portion 4 whose upper diameter is larger than the shaft so as to form a sort of recess for openings 29 which communicate with a collecting chamber 30 from which leads the gas outlet tube 25, the gas passing through the dust chamber 15 to the apparatus heating the blasting mixture blown into the gas producer.

Apart from this particular arrangement the working of the apparatus is identical to what is described for Figs. 1 to 3.

The installation shown in Figures 7 to 9 with relation to those shown in the preceding figures is modified in shape as regards the crucible. In the embodiment shown the crucible is of larger size and comprises a cylindrical portion 31 at the bottom of which are situated the tuyères 7. These are formed of channels leading into the interior of the crucible and start from the collector 8*a* formed in the masonry of the gas producer and communicating with the tuyères by vertical passages 32.

The means for removing the gases is similar to what is shown in Figure 4 but the openings 29 are situated below the collector 10*a* for the withdrawn gases and are connected to it by passages 33. The reduced diameter of the shaft increases the speed of the fuel descent. Thus, the height of shaft can be increased and this facilitates the location of openings at various levels near the top of the producer, through which recovery of the by-products may be effected by separate stages.

In the gas producer arrangement properly so called shown in Figures 10 to 12, crucible 3 is completely separated from shaft 2. The crucible 3 is prolonged by a wall 34 constituting a sort of casing which forms between it and the gas producer a cylindrical chamber 35 containing tubes, which comprise each an inner tube 36 and an outer tube 37 with one closed end. The top of tubes 36 leads to collectors 8*a* which receive from the fan 28 a mixture of air and oxygen as required for the blast.

The bottom of tubes 36 lead into the closed end of tubes 37 which in their turn lead to an annular chamber 38 communicating through descending chambers 39 into an intermediate collector 8*b* from which start the flattened tuyères.

The bottom of cylindrical chamber 35 opens at above the fusion zone. It communicates through passages 40 with collector 10*a* and leads off gas by main pipe 25.

In these figures a preheating arrangement for the blasting mixture blown by fan 28 is formed by the chamber 35 and the tubes 36 and 37 which are surrounded with hot gases passing through chamber 35, and withdrawn by collector 25. This novel and characteristical arrangement by which a single apparatus embodies the molten slag gas producer itself and the fluid heating system is particularly efficient for fuel mixtures having very little contents of volatile matters.

As already explained it is obvious that, instead of burning the withdrawn gases in a burner as above, and providing the volume of these gases is sufficient and their point of withdrawal sufficiently close to the tuyères, they could be made to circulate simply through the chamber 17 and 17*a* which would act as recuperators and transmit the sensible heat of the gases to the blast. The gases thus cooled down by passage through the stoves would then be collected beyond them for utilization.

It is also obvious that the device provided for withdrawing part of the generated gases from the intermediate zone of the gas producer may not be used if the various duties it performs are not deemed necessary in certain conditions of operation.

It is also evident that the stoves shown could be replaced by any other apparatus suitable to heat the blasting mixture to a proper temperature in the above limits and that this apparatus could use any supply of heat, outside of the gas produced in the gas producer, to heat the blasting mixture. Such stoves or similar heating apparatus could even be entirely omitted if the installation was to continuously use a blasting mixture sufficiently enriched with oxygen.

I employ means included in the present process to assure the formation and maintenance of graduated zones of appropriate temperatures in the fuel column extending from the thin zone of fusion to the large zone of low temperature distillation; it promotes continuous gasification by means of fusion of the ashes of any fuel whatever its nature.

What I claim is:

1. A process of generating producer gases, which comprises blasting at the base of a fuel column a gaseous mixture preheated to above 200° C. containing a higher percentage of oxygen than air and regulated to develop a temperature of about 1750° C. or more in the gases rising from the lower portion of the fuel bed, maintaining near the blasting level a fusion zone, and thereabove an extended zone of distillation at a low temperature, and collecting gases and entrained by-products from the top of the distillation zone, and removing molten products from the base of the fuel column.

2. A process for utilizing solid fuels in a slagging gas producer, which comprises generating gases by blasting at the lower portion of the fuel bed a gaseous mixture, its temperature and content of free oxygen being regulated for melting the fuel ashes in a fusion zone extending above the blasting level and maintained to a thickness not exceeding one-fourth of the total height of the fuel column, and thereabove an extended zone of distillation at a low temperature, adding an aqueous fluid at a level near the top of the fusion zone, withdrawing gases and entrained by-products, and removing molten products from the base of the fuel column.

3. A process of generating producer gases, which comprises blasting at the base of a fuel column a gaseous mixture preheated to above 200° C. containing a higher percentage of oxygen than air and regulated to develop a temperature of about 1750° C. or more in the gases rising from the lower portion of the fuel bed, maintaining near the blasting level a fusion zone, and thereabove an extended zone of distillation at a low temperature, adding gases containing carbon dioxide at a level near the top of the fusion zone, withdrawing gases and entrained by-products, and removing molten products from the base of the fuel column.

4. A process of generating producer gases, which comprises blasting at the base of a fuel column a gaseous mixture preheated to above 200° C. containing a higher percentage of oxygen than air and regulated to develop a temperature of about 1750° C. or more in the gases rising from the lower portion of the fuel bed, maintaining near the blasting level a fusion zone, and thereabove an extended zone of distillation at a low temperature, mixing with the fuels materials to absorb heat at various levels of said column, withdrawing gases and entrained by-prod-

ucts, and removing molten products from the base of the fuel column.

5. A process of generating producer gases, which comprises blasting at the base of a fuel column a gaseous mixture preheated to above 200° C. containing a higher percentage of oxygen than air and regulated to develop a temperature of about 1750° C. or more in the gases rising from the lower portion of the fuel bed, maintaining near the blasting level a fusion zone, and thereabove an extended zone of distillation at a low temperature, diverting outside the producer at selected levels of said column portions of the ascending gases, withdrawing the remainder of the gases and entrained by-products, and removing the molten products from the base of the fuel column.

6. A process of generating producer gases, which comprises blasting at the base of a fuel column a gaseous mixture preheated to above 200° C. containing a higher percentage of oxygen than air and regulated to develop a temperature of about 1750° C. or more in the gases rising from the lower portion of the fuel bed, maintaining near the blasting level a fusion zone, and thereabove an extended zone of distillation at a low temperature, cooling the lower portion of the fuel column, withdrawing gases and entrained by-products, and removing molten products from the base of the fuel column.

7. A process for utilizing charges of solid fuels mixed with other materials in a slagging gas producer, which comprises generating gases by blasting at the lower portion of the fuel bed a gaseous mixture, its temperature and content of free oxygen being regulated for melting the fuel ashes in a fusion zone extending above the blasting level and maintained to a thickness ranging from a few inches when the pieces of the charge are of pea size to one-fourth of the total height of the fuel column when they are of lump size, withdrawing gases and entrained by-products, and removing molten products from the base of the fuel column.

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