UNITED STATES PATENT OFFICE.

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METHOD OF REGULATING THE QUALITY OF COKE.

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To all whom it may concern:

Be it known that I, WALTER L. GRAUL, a citizen of the United States, residing at Detroit, in the county of Wayne and State of Michigan, have invented a new and Improved Method of Regulating the Quality of Coke, of which the following is a specification.

As is well known, in the process of producing coke in ovens provided for the recovery of by-products the operation is carried on by subjecting bituminous coal to heat in the absence of air. By this means the volatile matter is driven off from the coal and a cellular structure is developed which gives to the coke its special quality as a fuel, by reason of the presentation of a very large surface for combustion with the oxygen of the air, thereby causing rapid combustion with the consequent production of a high temperature.

While the reason of the coking quality of coking bituminous coals, as distinguished from non-coking coals, is not well understood, it is supposed to be due to the presence in the coal of resinous bodies derived from the vegetable growths from which the coal was formed and that as these bodies melt during the coking process and the gases generated are driven off by the heat, bubbles are formed, the walls of which eventually harden when the volatile matter has been driven off, thus forming the cellular structure of the coke.

Bituminous coals are made up of a mixture of the coking substance mentioned in the foregoing paragraph and a mass of relatively inert matter, mainly fixed carbon and ash. In the coking process the volatile matter in the coal assumes a viscous condition, causing a swelling of the mass and later a shrinkage as the volatile matter leaves the mass, producing more or less violent distortion of the mass, probably thus causing the fissures and cracks which occur in the entire mass of coke and in the smaller individual pieces. The inert matter, on the other hand, changes comparatively little, tending to minimize the distorting influence of the volatilizing substance.

The quality of the coke produced will vary with variations in the relative proportions of the coking substance and the inert matter contained in the coal. Thus, if there is an excess of the coking substance in the coal, the coke will be hard, light and spongy with large cells but of little strength and will break into small pieces when discharged from the oven. With too great a proportion of inert matter, on the other hand, the coke will be weak and granular with an insufficient development of cell structure.

The commercial requirements as to the quality of coke vary with its different applications. Thus, while a good cell structure and some degree of both hardness and toughness are required in all cases, for some uses, as in iron blast furnaces, hardness is the more important in order that the coke may properly resist the action of the oxidizing atmosphere in the upper part of the furnace, whereas in other cases, as in foundry cupolas, for example, it is more important that the coke shall be in large pieces and shall have a high degree of toughness in order that it may not be broken by the heavy pieces of iron in the cupola and thus become compacted so as to resist the passage of air and gases.

It has heretofore been the practice, in order to produce coke adapted to specific uses, to mix together coals containing different proportions of the coking substance. While this is attended with a certain degree of success, the bringing together and mixing of different coals and the keeping on hand of different stocks is a source of difficulty and expense. It has been attempted also to compensate for a deficiency of the coking substance in the coal by adding pitch as a substitute therefor. But while this increases the hardness of the coke, it has the disadvantage of, at the same time, reducing its toughness. So also it has been attempted to remedy the opposite condition, *i. e.*, a deficiency in the inert matter in the coal, by adding coke breeze to the coal before coking. But while this increases the toughness of the coke it, at the same time, decreases its hardness. But in the development of the art up to the present time there has not been full recognition of the principle that certain coals, while otherwise suited for the production of coke, are deficient in the coking substance, or that the coking substance is of inferior quality to produce the best coke structure, or that there is a deficiency in the percentage of inert matter which is quite as necessary to the production of the proper coke structure as is the coking substance,

and that these deficiencies may be reinforced by the addition to the coal mixture, in the correct proportion, of other substances to make up the deficiency found in the coal mixture of either quality or amount of the coking substance, or in the amount of inert matter, as the case may be, or a combination of these additions as experiment shows them to be needed.

I have found by a study of many coals and in the light of a full recognition of these several deficiencies, and my invention is based on the discovery that while the addition of pitch to coal decreases the toughness of the coke produced, such decrease is less than the increase in hardness, and that while the addition of coke breeze decreases the hardness of the coke, such decrease is less than the resulting increase in toughness and that therefore by adding to a coking coal both pitch and coke breeze in proper proportions a coke having the desired qualities of hardness and toughness in such a degree as to best fit it for the use to which it is to be applied can be produced, the weakness incident to the introduction of each substance being corrected by the other, while the effects of both in increased hardness and toughness are retained.

To illustrate the foregoing there are given below figures showing results of tests to determine size and toughness of cokes made,—first, from a mixture of coals which experiment indicates has the coking substance slightly in excess of proper proportion; next, of the same mixture of coals with 3 per cent. of breeze added to compensate for the excess of coking substance; and last, with an additional 2½ per cent. of breeze and 2 per cent. of pitch added to increase the size and toughness of the pieces to the degree desired. The size is shown in percentage of weight of coke remaining on a screen with 4″ square openings; that of toughness in percentage of coke remaining on 3″ square screen in the standard "shatter test" method of determining the strength of coke.

	(1.) Coal alone.	(2.) Same coal with 3 per cent. breeze added.	(3.) Same as #2 with an additional 2½ per cent. breeze and 2 per cent. pitch added.
Size test: Per cent. on 4″	41	59	66
Shatter test: Per cent. on 3″	34	52	58

The results of these tests very clearly indicate that both the average size of the pieces and their toughness have been materially improved.

In carrying my invention into effect, I use preferably solid pitch which is pulverized to such an extent that 80 per cent. will pass through a screen having ⅛ inch openings and not less than 95 per cent. through a screen having ¼ inch openings. The breeze employed is of substantially the same size and both are thoroughly mixed with the coal before coking, in proper proportions. But I do not confine my invention to the use of these sizes, or to any degree of hardness of the pitch.

The proportion of pitch and breeze to be employed in any given case must be determined by experiment, having reference to the proportion of natural coking substance in the coal employed, the rate at which it is desired to coke the coal mixture, and the use to which the coke is to be applied *i. e.*, to the relative degrees of hardness and toughness desired. Such tests can be readily made in ways well understood by those skilled in the art.

Evidently to coals having an excess of the coking substance a greater percentage of coke breeze will be added and conversely to those deficient in the coking substance a greater proportion of pitch.

In general terms the formula of the mixture of pitch and breeze to be added to the coal may be defined as follows: first such proportion of either pitch or coke breeze as may be required with the coal employed to produce a coke having the qualities of toughness and hardness in equilibrium and such additional proportions of both pitch and coke breeze as may be required to produce a coke having the desired degree of toughness and hardness. Ordinarily such additional proportions of pitch and breeze will be about 3 per cent. of hard pitch and from 4 to 5 per cent. of fine breeze, although these proportions are subject to modification according to the quality of coke to be produced. The mixture when formed is subjected to a coking temperature in a closed retort or oven in the usual manner.

My invention besides enabling the production of coke of good cellular structure and of any practical degree of toughness and hardness, also presents certain other commercial advantages. Thus, in the manufacture of foundry coke in by-product ovens, it is ordinarily necessary to operate the ovens comparatively slowly in order to produce the tough blocky pieces required by the trade. I find, however, that when pitch and breeze have been added in accordance with the specified requirements, the coal can be coked much more rapidly and still produce coke having the desired characteristics; thus enabling the plant to be worked to better advantage.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The process of regulating the quality of coke which consists in adding to the coal to be coked such proportion of dry pitch or

coke breeze as will correct the excess or deficiency of the coking substance in the coal and such additional proportions of pitch and breeze as will give to the coke to be produced the desired degree of toughness and hardness and coking the mixture.

2. The process of regulating the quality of coke which consists in adding to the coal to be coked according to its quality such proportion of pitch or coke breeze as will cause the coke to be produced to have the qualities of toughness and hardness in equilibrium, and such additional proportions of both pitch and coke breeze as will give to the coke the desired degree of toughness and hardness and coking the mixture.

In testimony whereof I have affixed my signature, this 26th day of December, 1918.

WALTER L. GRAUL.