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LOW TEMPERATURE CARBONIZATION OF COAL

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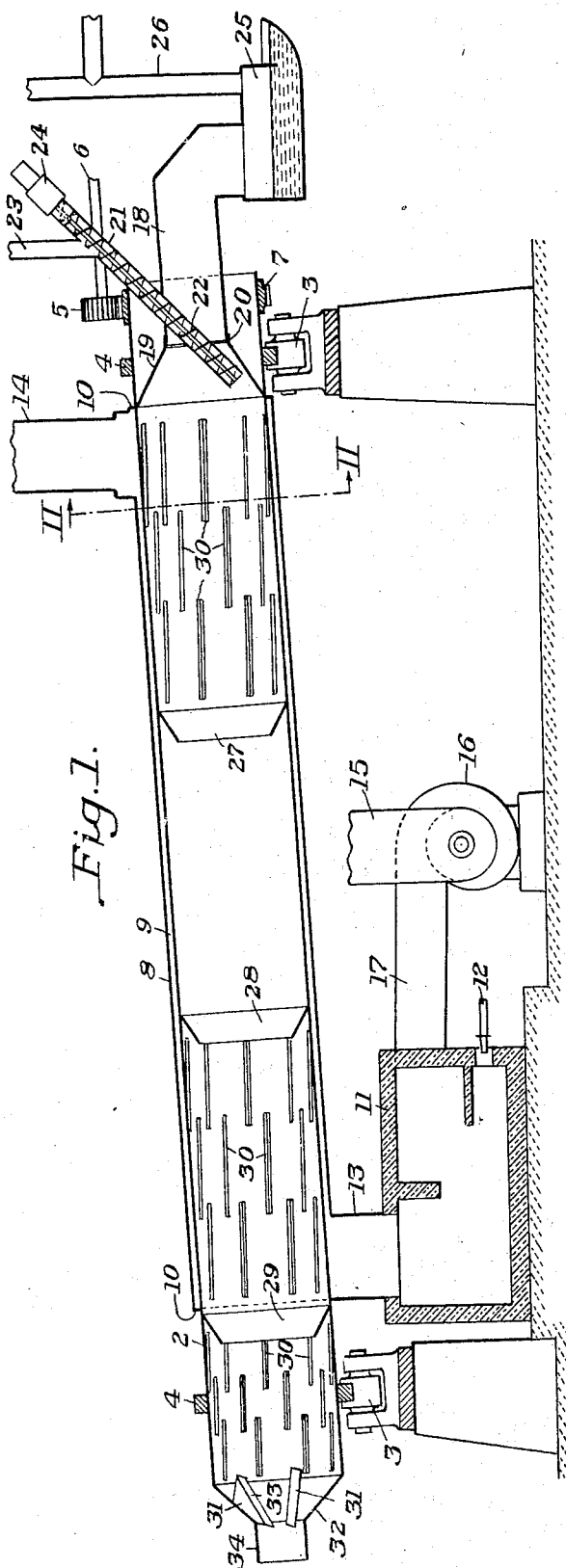


Fig. 1.

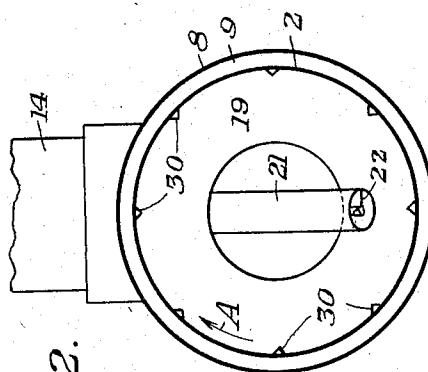


Fig. 2.

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LOW TEMPERATURE CARBONIZATION OF COAL

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10 Claims. (Cl. 202-9)

This invention relates to the low temperature carbonization of coal and particularly to certain improvements in the manufacture of coal balls by the low temperature carbonization process. This process is the subject of Wisner Patents Nos. 1,490,357, 1,748,815 and 1,756,896 and Leshner Patent No. 2,080,946. While the process disclosed in said patents has proved commercially satisfactory it has been found to have certain operating disadvantages which have greatly reduced the economy of the process and have in some instances adversely affected the quality of the product.

In the manufacture of coal balls by the low temperature carbonization process above referred to finely divided coal is ordinarily first "thermodized" or roasted in contact with air, which results in partially oxidizing the coal, and the roasted partially oxidized coal is then preferably maintained in a heated recirculating storage stream from which it is withdrawn, mixed with coke breeze and fed to the carbonizer. With certain coals the roasting step is omitted. The carbonizer may assume various forms and in one embodiment constitutes an inclined rotary retort. The coal heated to about 600° F. is introduced into the upper end of the retort and as the retort rotates the coal works its way downwardly therein. In the retort the coal is first preheated or raised to a temperature approaching its softening temperature or that at which it becomes plastic. Upon further heating the coal becomes plastic, after which it breaks up and forms into balls as described in the patents above mentioned. Such balls will be referred to herein as "coal balls", although they are of course constituted by partially carbonized coal or semi-coke.

The temperature at which the coal becomes plastic varies with different coals but is ordinarily between 700 and 800° F. In any event, the coal is plastic at a temperature not higher than about 850° F. and upon further heat treatment in the inclined rotary retort the coal balls are formed. The retort is externally heated, the heating gases ranging in temperature from about 1050° F. at the lower end of the retort to 850 to 950° F. at the upper end, such gases traversing the retort from the lower to the upper end thereof.

One of the principal disadvantages of the process as carried out heretofore has been the non-uniformity of the product, which at times has been of undesirably poor quality and has taken form either in balls which are too large

for commercial use or in finely divided particles which have no commercial value. This, as we believe, has been due to improper control of the movement of the coal through the carbonizer and lack of proper heat treatment thereof in the preheating, plastic and ball-conditioning zones.

It is difficult for us to assign definite reasons for the unsatisfactory results obtained by the prior process and we do not assume to understand or state fully all of such reasons. It is, however, the fact that such process has not given uniform results and has not at all times been fully satisfactory and this condition has existed over a considerable period prior to the present invention. The following explanation represents our present belief as to the reasons for the shortcomings of the prior process.

Certain observable facts in the prior process are that fine coal is heated to 600° F. in the presence of air and mixed with fine coke, also preheated to about the same temperature; the mixture is charged into the upper end of an inclined revolving steel retort, externally heated by gases ranging in temperature from 1050° F. at the lower end of the retort to 850° or 950° F. at the upper end; the slope of the retort and its revolving action convey this mixture of hot coal and coke breeze along its length; hydrocarbon gas is discharged at either the upper end or the lower end of the retort and low temperature coke in ball form is discharged at the lower end.

What takes place in the revolving retort in operation is, of course, impossible of direct observation. We have made observations of the interiors of retorts which have cooled off subsequent to operation over varying periods. From the character of the material found throughout the length of the retort and adhering to the interior of the steel shell as well as the markings on the shell we are able to reconstruct to some extent the reactions by which coal balls are made. The conclusions reached from these observations have been checked and confirmed by tests made in revolving retorts with intermittent operation.

The mixture of finely divided coal and breeze charged into the retort at about 600° F. is, as above mentioned, conveyed by the revolving action of the inclined retort toward the discharge end. At the point where the incoming material meets the steel shell of the retort the temperature of the shell is about 800° F. The tem-

perature of the coal mixture is increased as it progresses until it attains the temperature at which it becomes soft or plastic. Yellow tar vapor is first given off as it approaches the softening temperature. In the dry state the feed of coal and breeze does not stick to the steel shell of the retort. The hot, dry, fine coal and breeze flows almost as freely as a fluid. Its rate of flow is rapid and the cross section of material is thin and its arc of contact with the steel shell is small. Because there is thus little tendency for the material to be carried up by the revolving action of the retort, mixing and turning is at a minimum and segregation is promoted.

At a temperature above 700° F. the coal softens and gives off hydrocarbon vapors and distillation has begun. The exact temperature at which the coal softens is different for different coals, but the range is between 700° and 800° F. Distillation really begins at lower temperatures. Some hydrocarbon vapors are given off at temperatures below 600° F. These vapors are condensable light oils and the vapors are white, whereas the vapors given off at or about the softening point of the coal are yellow and condense to tar.

As the coal softens it becomes sticky. The whole mass does not melt into a fluid state, but some constituents of the coal soften, wet the surfaces of adjacent unsoftened or inert particles and bind the whole into a loosely coherent mass. In this condition its coefficient of friction on steel is greatly increased. Instead of a thin layer, loosely flowing, there is a thickening of the bed, because the increase in friction not only retards its flow down the retort but increases the length of climb up the arc of the revolving shell. The charge has changed from dry to wet. It is now in the plastic stage. The transition takes place quickly, probably in two or three minutes.

Revolving action of the retort raises the mass and as it falls over it is kneaded and disintegrated into smaller masses, quite irregular in shape and size. The segregation into small masses that later become hardened as coal balls is not dependent on "snow balling" action; that is, the larger masses are not the result of small pieces rolling down a surface of material and increasing in size as a snow ball gains in size as it rolls down a slope. The size of the masses that finally emerge as balls is determined by the agglutinating property of the coal at the time it reaches its softening temperature in the retort.

Transition from the dry state of the incoming feed, through the plastic stage, to the dry stage of semi-coke is rapid, of the order of 5 to 10 minutes, perhaps for some coals even less. The semi-fluid mixture is torn apart by the revolving action of the retort into soft masses that quickly attain sufficient consistency to be individual pieces. Only under most unusual conditions do two such pieces coalesce or do we find one ball rolled within another. Free to move along and out of the way of oncoming coal, these smaller masses of soft material soon become dry and solid with roughly spherical shape.

Size and structure of the coal balls are the most important objectives in control of the process. The desired size of product is a range between one and six to eight inches in diameter. The structure should be dense, homogeneous and resistant to shatter. Ash, sulphur and fusion point of ash are determined by the coal used. The content of volatile matter will depend on the treatment in the retort. It has been found that

a product with satisfactory structure will have a volatile matter content of between 14 and 18%.

Experience has shown that for any given coal

(1) The size of the pieces that emerge as low temperature coke balls is determined by the agglutinating property of the coal at the time it reaches its softening temperature in the retort, and

(2) The structure of the low temperature coke is determined (a) by the character and proportion of inerts mixed with the coal and (b) by the rate and maximum temperature of heating and the effective control of the rates and temperatures in preplastic, plastic and post-plastic ranges.

Proper application of heat to the coal is one of the problems encountered. Coal and low temperature coke are fair insulating materials. Heat transfer is slow under low temperature potential. In this process the heat for processing is applied both indirectly and directly. Indirect application is through the steel ducts of the roaster and the shell of the carbonizer. Heat transfer here is efficient because the coal is kept in motion over the steel and because by mixing fresh surfaces are constantly touching the metal. That is, the transfer of heat is efficient so long as the metal is clean. There is no difficulty in keeping the metal clean in roaster and storage apparatus but in the carbonizer, where the atmosphere contains condensable tar vapors, scale accumulates on the steel and retards heat transfer.

One factor determining the structure of the coal balls is the rate of application of heat and the maximum temperature in the carbonizing retort. Sufficient heat must be supplied to the coal and breeze mixture in the carbonizer to raise its temperature to about 850° F. Higher temperatures than this ordinarily simply serve to harden the surfaces of the balls and develop shrinkage cracks. Unless the material in process is heated to about 850° F. the product will be too high in volatile matter content and too soft to handle and its shatter index will be too low.

It is found that in the prior process coal fed into the upper end of the inclined rotary retort will traverse the length of the retort—some 100 feet—and be discharged at the lower end in 10 minutes. This movement is undesirably fast. The coal is not carbonized to the proper extent. While hot it is soft and can be pressed or changed in shape. The pieces do not assume the desired roughly spherical shape. The surfaces of the masses are wrinkled and folded.

The conical outlet of the retort retains a bed of material the length of which depends on the shape and slope of the retort. The bed consists of coke balls at the lower and deeper end and coal at the upper end where it thins out to the minimum depth. Coal flows down the shell from the charging end in a thin stream until it meets the tail of the bed. The bed may be too long and deep at the lower end and the balls destroy themselves by long continual grinding and in fact cut the steel of the retort.

We have discovered that by properly controlling the movement of the coal through the carbonizer the disadvantages of the prior process may be eliminated. The movement of the coal through the carbonizer may be regulated so that the coal is properly preheated and does not pile up against the coal in the plastic zone. Moreover, the depth of the coal in the ball-conditioning zone may be desirably reduced and the balls ejected at the proper time. The quality of the

product is superior and the production of the carbonizing unit is increased.

We restrain the movement of the coal along the retort. While this is particularly important in the preheating zone we find that advantages are also obtained by restraining the movement of the coal in the plastic and ball-conditioning zones. We also find that it is of advantage to at least partially temporarily segregate the coal which has not yet reached plastic state from that which has reached plastic state. Preferably the coal in each of the three zones—the first or preheating zone, the second or plastic zone and the third or ball-conditioning zone—is at least partially temporarily segregated during the process. This segregation may be effected by dams in the carbonizer. Such dams, in addition to performing their segregating function, also perform a restraining function to prevent the coal from piling up undesirably. The restraining function may also be performed by other means such as baffles or, as we have termed it, rifling, arranged in various ways in the carbonizer. At the lower or discharge end of the carbonizer the balls are preferably discharged through an opening at a higher level than the position of the balls in the carbonizer adjacent such opening and are elevated from such position to the level of the opening. This is preferably done by discharge lifters in the carbonizer. The combined result of the dams, baffles and discharge lifters is to bring about a nicety of control in the apparatus and thermal and economic advantages.

Other details, objects and advantages of the invention will become apparent as the following description of a present preferred embodiment thereof and a present preferred method of practicing the same proceeds.

In the accompanying drawing we have shown a present preferred embodiment of the invention and a present preferred method of practicing the same, in which

Figure 1 is a diagrammatic central longitudinal cross-sectional view through an inclined rotary carbonizing retort; and

Figure 2 is a transverse cross-sectional view taken on the line II—II of Figure 1.

Referring now more particularly to the drawing, reference numeral 2 designates an inclined rotary carbonizing retort which in its general shape and structure may be of standard design. The retort is designed for rotation in the direction of the arrow A in Figure 2, being supported for rotation upon rollers 3 cooperating with tires 4 carried by the retort. The retort is rotated by a gear 5 carried by a driving shaft 6 and meshing with a ring gear 7 carried by the retort adjacent its upper end. The means for supporting and rotating the retort are shown purely diagrammatically and without a showing of detail because the invention does not reside therein. Suitable thrust means are provided to prevent the retort from moving longitudinally during rotation.

The retort 2 is inclined as shown so that upon rotation the material therein will feed generally downwardly from right to left viewing Figure 1 due to gravity. The retort is surrounded throughout the major portion of its length by a stationary shell 8 the body of which is of generally cylindrical shape, as is the retort, and is spaced from the retort sufficiently to provide an annular passageway 9 between the retort and the shell. Both the retort and the shell are preferably made of steel. As the means for support-

ing the shell form no part of the present invention such means are not shown, but it will be understood that the shell is suitably supported to permit rotation therewithin of the retort 2. At its opposite ends the shell 8 has seals 10 which substantially seal the passageway 9.

There is provided a furnace 11 equipped with one or more gas burners 12 for supplying heat to the passageway 9. The heated gas from the furnace 11 passes through a header 13 into the passageway 9 and thence through such passageway about the retort 2 to a header 14 whence the gases are recirculated through a conduit 15 to a fan 16 which discharges the same through a conduit 17 back into the furnace 11. The fan 16 also creates the draft for forcing the heating gases from the furnace 11 into and through the passageway 9.

At the upper end of the retort 2 there is positioned and maintained by suitable supporting means (not shown) a stationary conduit 18. Integral with the retort 2 is an internal skirt portion 19 which at its left hand end, viewing Figure 1, is of the same diameter as the interior of the retort and welded thereto and at its right hand end is reduced to substantially effect a seal with the left hand end of the stationary conduit 18, such seal being designated 20. The stationary conduit 18 is perforated to admit a cylindrical casing 21 containing a feed screw 22 through which the charge of coal and breeze is fed into the retort. The charge passes into the casing 21 through a conduit 23. The screw 22 is rotated by a motor 24.

The lower or left hand end of the retort 2 may be either sealed or open to the atmosphere. The conduit 18 discharges the hydrocarbon gas issuing from the upper end of the retort through a water chamber 25 and a conduit 26 to a suitable gas reservoir. The movement of gas through the conduits 18 and 26 may be and preferably is facilitated by an exhaust fan (not shown).

Most of what has been described above is of more or less standard construction. The present invention has to do primarily with the control of the charge within the inclined rotary retort 2. Within the retort is a plurality of dams 27, 28, 29, three dams being shown, although the number thereof may be increased or decreased. The particular arrangement shown, however, affords particular operating advantages. Each of the dams is of generally frusto-conical shape and is welded at its periphery to the interior of the retort 2. The dams are inclined generally downwardly of the retort as shown. They serve to retard or restrain the movement of the charge along the retort whereby to insure proper carbonization thereof as above explained. The preheating zone above referred to extends substantially from the point at which the charge enters the retort to the dam 27. The plastic zone extends substantially from the dam 27 to the dam 28. The ball-conditioning zone extends substantially from the dam 28 to the dam 29. The portion of the retort to the left of the dam 29 may be considered as a portion of the ball-conditioning zone as the balls pass from the dam 29 and through the zone to the left of such dam before they are discharged.

The retort is also provided with baffles or rifling 30. Each of such baffles may conveniently comprise a metal angle having the ends of its legs welded to the interior of the retort as shown in Figure 2. The baffles 30 are disposed at an angle to the length of the retort so that upon rotation of the retort they exert a restraining force on the

charge tending to retard its downward movement in the retort. The baffles also serve to promote better mixing of the charge in the retort and to eliminate segregation, as upon rotation of the retort portions of the charge are carried up by the baffles and ultimately fall back into other portions thereof. The baffles also serve an important function in the portion of the retort to the left of the dam 28 in relieving the interior of the retort of the severe abrasive action of the balls. It has been found that without the protection of the baffles the retort adjacent its lower end has become worn substantially through in a short time.

Discharge lifters 31 are provided at the discharge end of the retort 2, such lifters being in the form of flanged metal plates having the edges of their webs welded to the interior of the inclined nose 32 of the retort as shown. The flanges 33 cooperate with the webs of the plates so that upon rotation of the retort the lifters in effect scoop up balls which rise above a predetermined level at the lower end of the retort and raise the same to discharge them through an outlet 34. The thickness of the bed of balls in the lower end of the retort may be controlled by the lifters 31, as those balls which lie below the lowest point which the lifters assume during rotation of the retort will not be lifted and ejected thereby. The lifters serve an important function in controlling the discharge of the balls and the depth of the bed at the lower end of the retort.

The dams, baffles and lifters cooperate to bring about controlled movement of the charge through the retort. The depth of the bed is maintained as desired at all points along the retort and proper carbonization of the charge is insured. Although baffles 30 are shown only in the zones before and after the plastic zone and not in the plastic zone, baffles may in some instances be provided in that zone or baffles may be omitted elsewhere in the carbonizer as the particular conditions may dictate. The character of the coal used is perhaps the major factor determining the particular arrangement of dams, baffles and lifters which may be most effective in any particular installation. The baffles are shown in overlapping groups of eight but they may be otherwise arranged. Also the baffles may assume various other forms while still accomplishing the desired functions.

While we have shown and described a present preferred embodiment of the invention and a present preferred method of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

We claim:

1. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating the coking coal mixed with breeze to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. to bring the coal to plastic state and thereafter continuing the heating and agitating said heated mixture of coal and breeze in an inclined rotary retort to form it into balls and retarding the movement of said mixture along the retort sufficiently to cause said mixture to move through the retort at an average speed substantially less than 10 feet per minute so that it forms into balls of reasonably uniform size for fuel by exerting at successive points along the retort extraneous pressure on surfaces of said

mixture other than those surfaces which face radially outwardly from the axis of the retort.

2. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. a mixture of coking coal and breeze and tumbling said heated mixture and advancing the same at an average speed of less than 10 feet per minute to reduce the coal to plastic state and continuing said heating, tumbling and advancing to form said mixture into balls and retarding the advancing movement of said mixture sufficiently to

cause said mixture to advance at an average speed substantially less than 10 feet per minute so that it forms into balls of reasonably uniform size for fuel by exerting at successive points along the advance of said mixture extraneous pressure on surfaces of said mixture facing generally in the direction of advance of said mixture.

3. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising feeding finely divided coking coal and breeze to a chamber wherein such coking coal and breeze are mixed and advanced, heating the mixture of coking coal and breeze to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. and tumbling and advancing said mixture and reducing the same to plastic state, thereafter continuing the heating, tumbling and advancing of said mixture in said chamber and retarding the advancing movement of said mixture before it becomes plastic sufficiently to cause said mixture to move through the retort at an average speed substantially less than 10 feet per minute so that it forms into balls of reasonably uniform size for fuel by exerting at successive points along the retort extraneous pressure on surfaces of said mixture facing generally in the direction of advance of said mixture.

4. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. a mixture of coking coal and breeze and tumbling said heated mixture and advancing the same at an average speed of less than 10 feet per minute to reduce the coal to plastic state and continuing said tumbling and heating to form the mixture into balls and at least partially temporarily segregating in the direction of movement the tumbling mixture which has not yet reached plastic state from that which has reached plastic state.

5. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. a mixture of coking coal and breeze and tumbling said heated mixture and advancing the same at an average speed of less than 10 feet per minute to preheat said mixture in a first zone and reduce the coal to plastic state and continuing said tumbling and heating to form the coal into balls in a second zone and at least partially temporarily segregating in the direction of movement the tumbling mixture in said respective zones.

6. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. a mixture of

coking coal and breeze and tumbling said heated mixture and advancing the same at an average speed of less than 10 feet per minute to preheat said mixture in a first zone and reduce the coal to plastic state in a second zone and continuing said tumbling and heating to form the coal into balls in a third zone and at least partially temporarily segregating in the direction of movement the tumbling mixture in said respective zones.

7. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising simultaneously advancing, heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. and tumbling a body of coking coal mixed with breeze to reduce the mixture of coking coal and breeze to plastic state and thereafter continuing the heating of said mixture and advancing and tumbling the same and exerting extraneous pressure at successive points along the retort on surfaces of said mixture facing generally in the direction of advance of said mixture sufficiently to cause said mixture to advance at an average speed substantially less than 10 feet per minute so that said mixture forms into balls of reasonably uniform size for fuel.

8. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating the coking coal mixed with breeze to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. to plastic state and thereafter forming it into balls by continuing the heating and tumbling in an inclined rotary retort while advancing the charge through the retort at an average speed of less than 10 feet per minute, maintaining a layer of substantial depth of balls at the lower end of the retort, elevating the balls

at the lower end of the retort to discharge the upper portion only of said layer through an opening at a higher level than the position of the balls in the retort adjacent such opening.

9. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating the coking coal mixed with breeze to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. to plastic state and forming it into balls by continuing the heating and tumbling in an inclined rotary retort while advancing the charge through the retort at an average speed of less than 10 feet per minute, maintaining a layer of substantial depth of balls at the lower end of the retort, elevating the balls at the lower end of the retort to discharge the upper portion only of said layer through an opening at a higher level than the position of the balls in the retort adjacent such opening and regulating the depth of the material in the retort adjacent the discharge opening by said elevation and discharge.

10. A process of low temperature carbonization of coking coal to form balls of semi-coke comprising heating to a temperature not substantially lower than about 600° F. and not substantially higher than about 800° F. a mixture of coking coal and breeze to bring the coal to plastic state and tumbling the mixture in a retort while advancing the same at an average speed substantially less than 10 feet per minute so that it forms into balls, maintaining a layer of substantial depth of balls at the lower end of the retort and regulating the depth of the charge at the portion thereof where balls are formed by elevating and discharging only balls rising above the desired level.

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