April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963 6 Sheets-Sheet 1

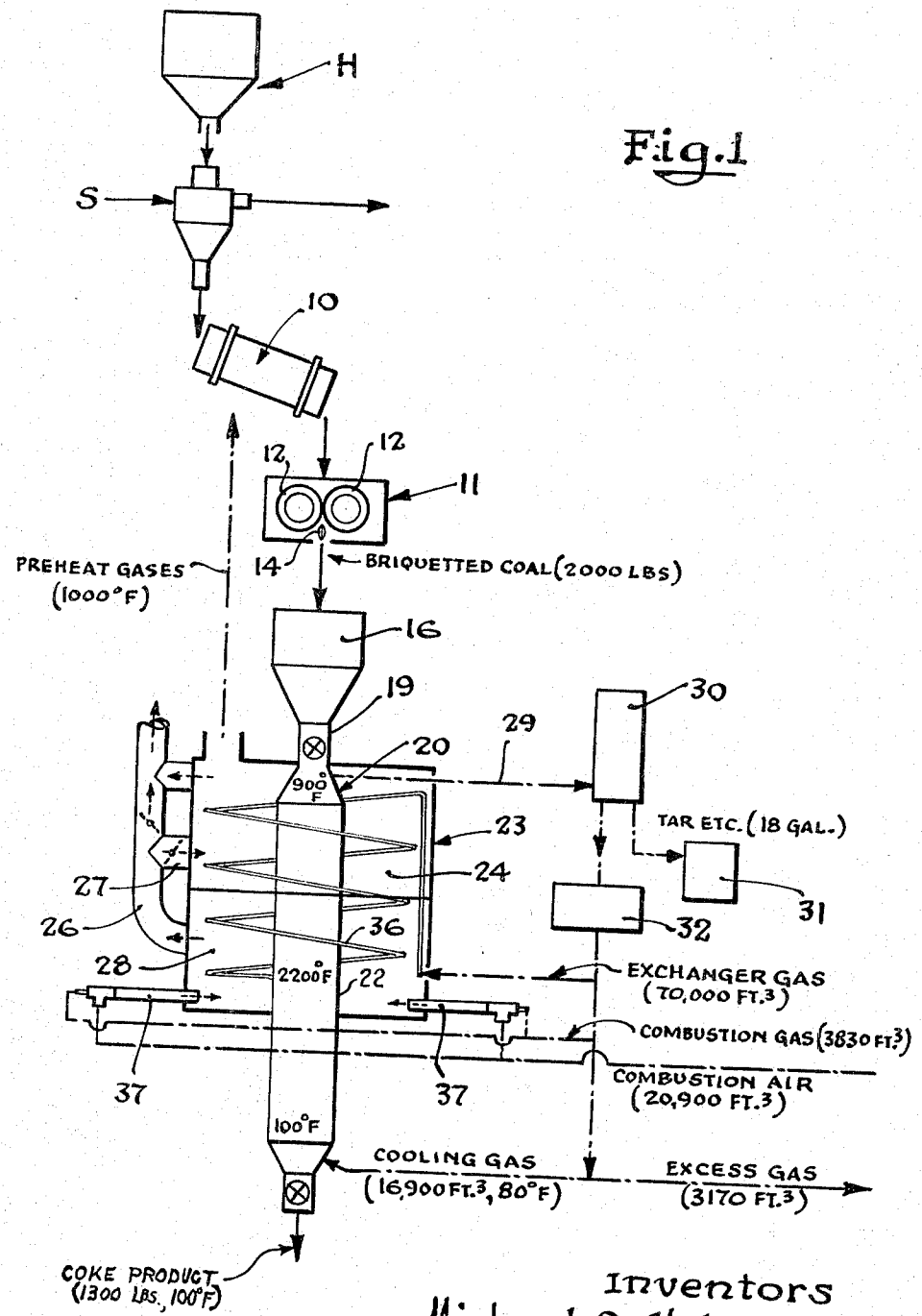


Fig. 1

Inventors
Michael O. Holowaty
Charles R. Jackson
By Hibben, Noyes & Bicknell
Attorneys

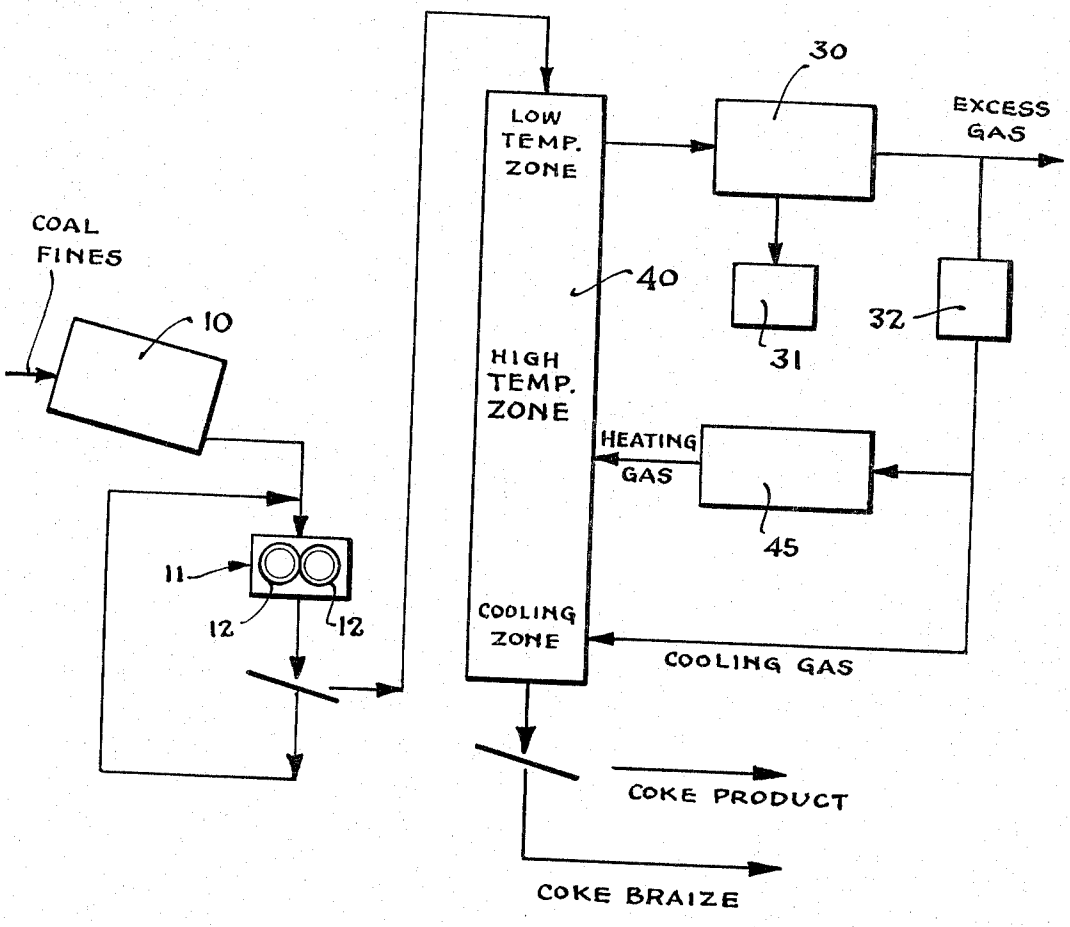
April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963

6 Sheets-Sheet 2

Fig. 2



Inventors
Michael O. Holowaty
Charles R. Jackson
By Hibben, Noyes & Bicknell
Attorneys

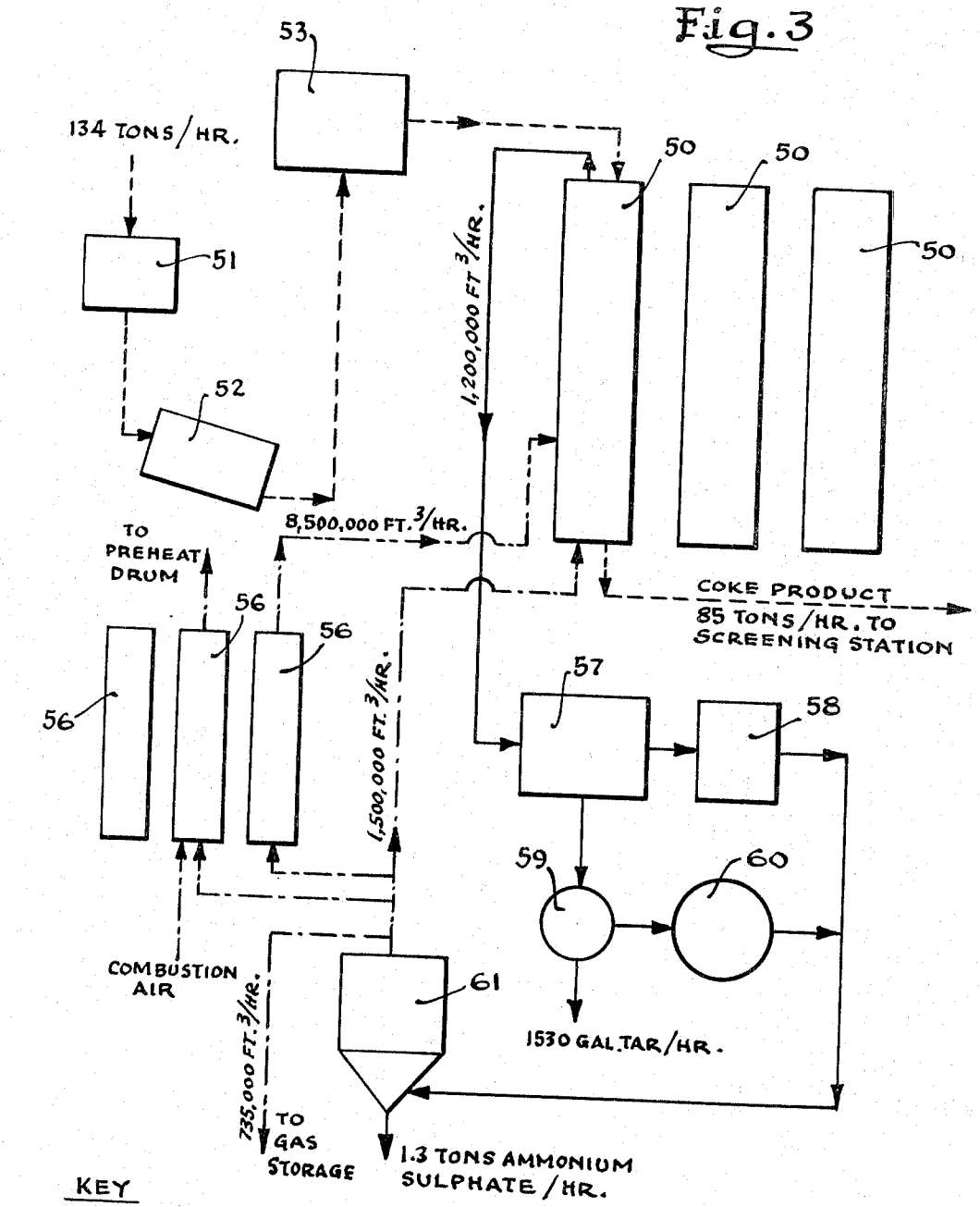
April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963

6 Sheets-Sheet 3

Fig. 3



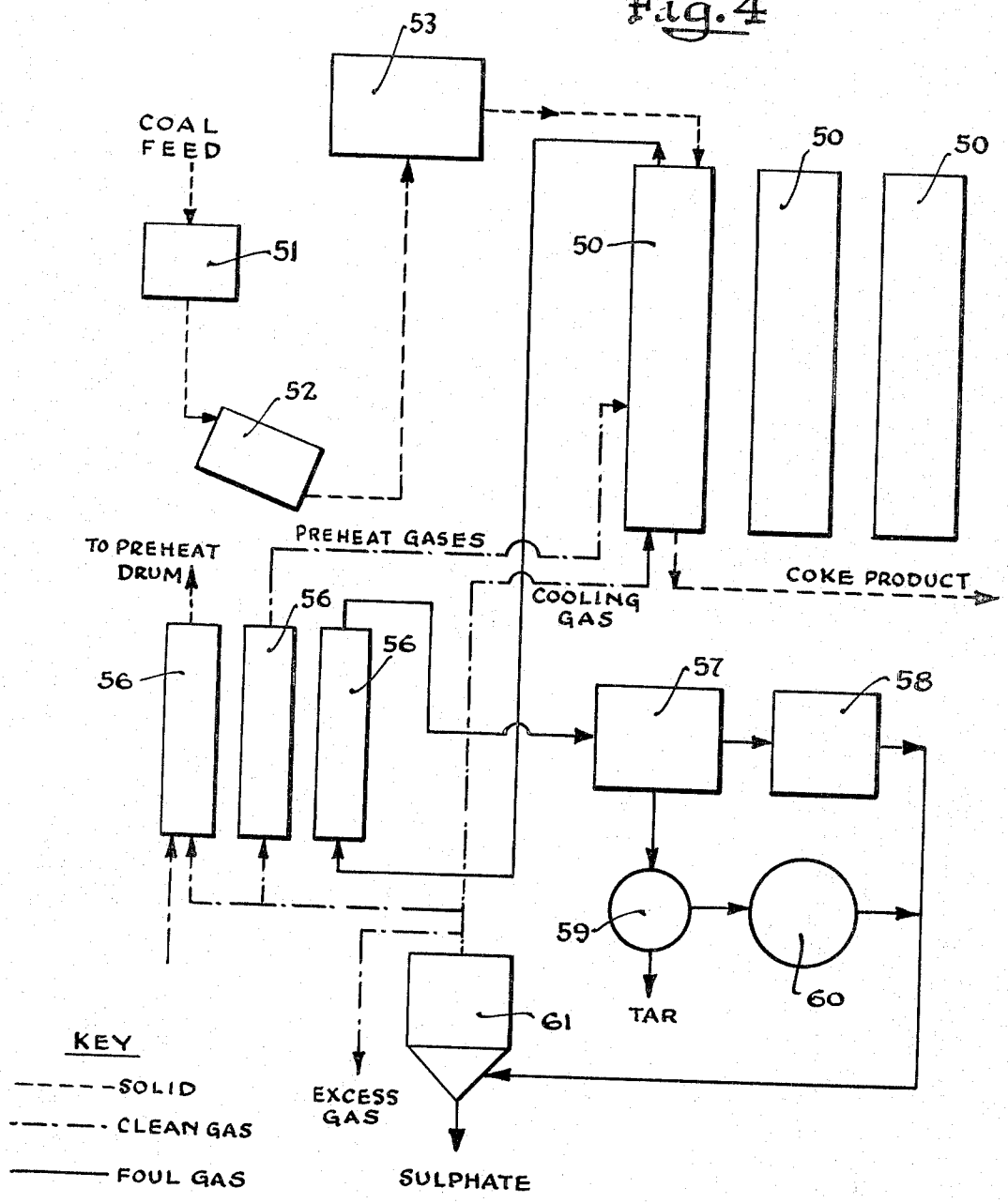
Inventors
Michael O. Holowaty
Charles R. Jackson
By Hibben, Noyes & Bicknell
Attorneys

April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963 6 Sheets-Sheet 4

Fig. 4



Inventors
Michael O. Holowaty
Charles R. Jackson
By Hibben, Noyes & Bicknell
Attorneys

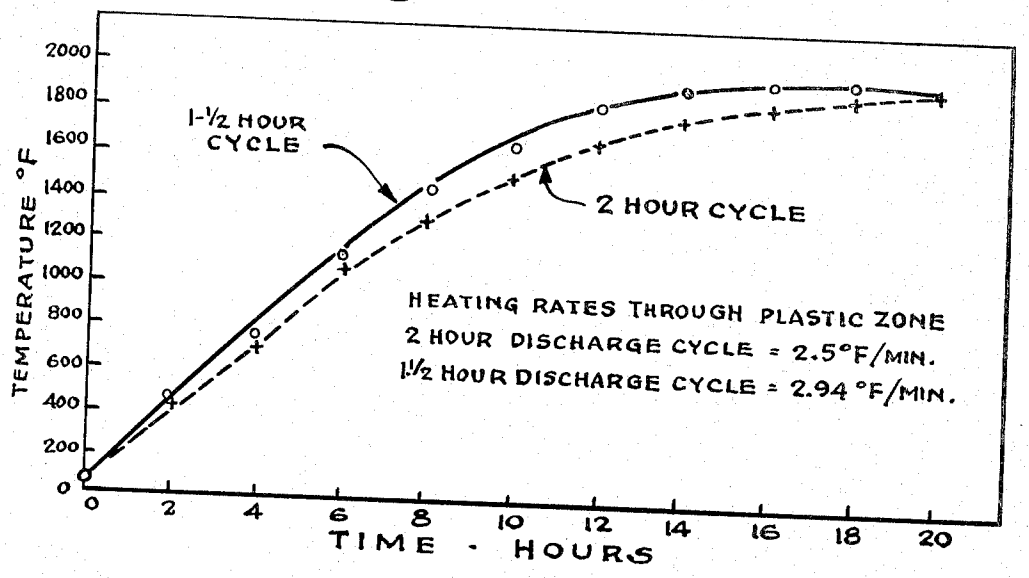
April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963

6 Sheets-Sheet 5

Fig.5



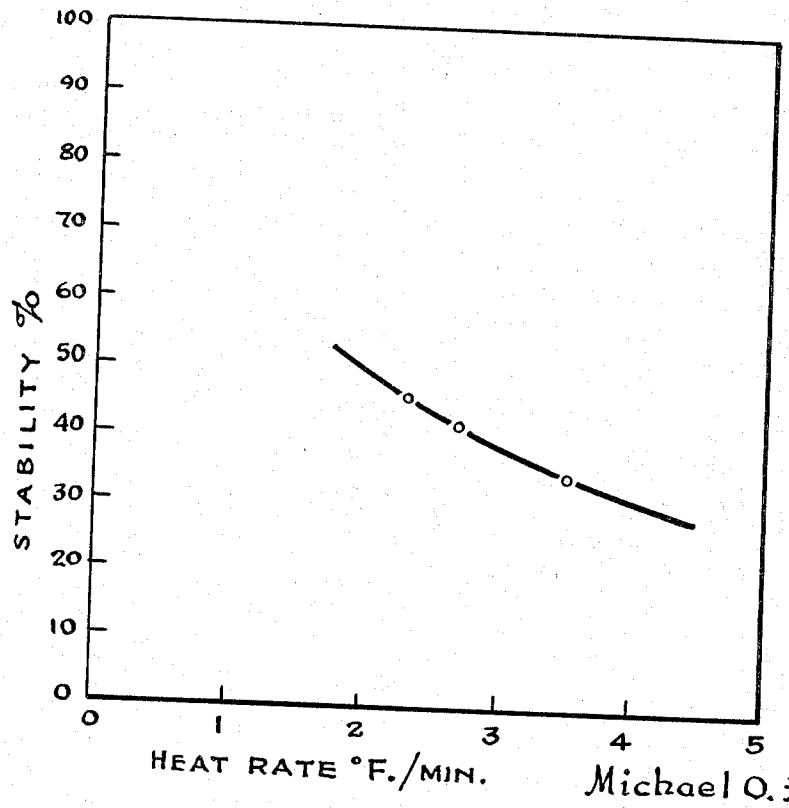


Fig.6

Inventors
Michael O. Holowaty
Charles R. Jackson
By Hibben, Noyes & Bicknell
Attorneys

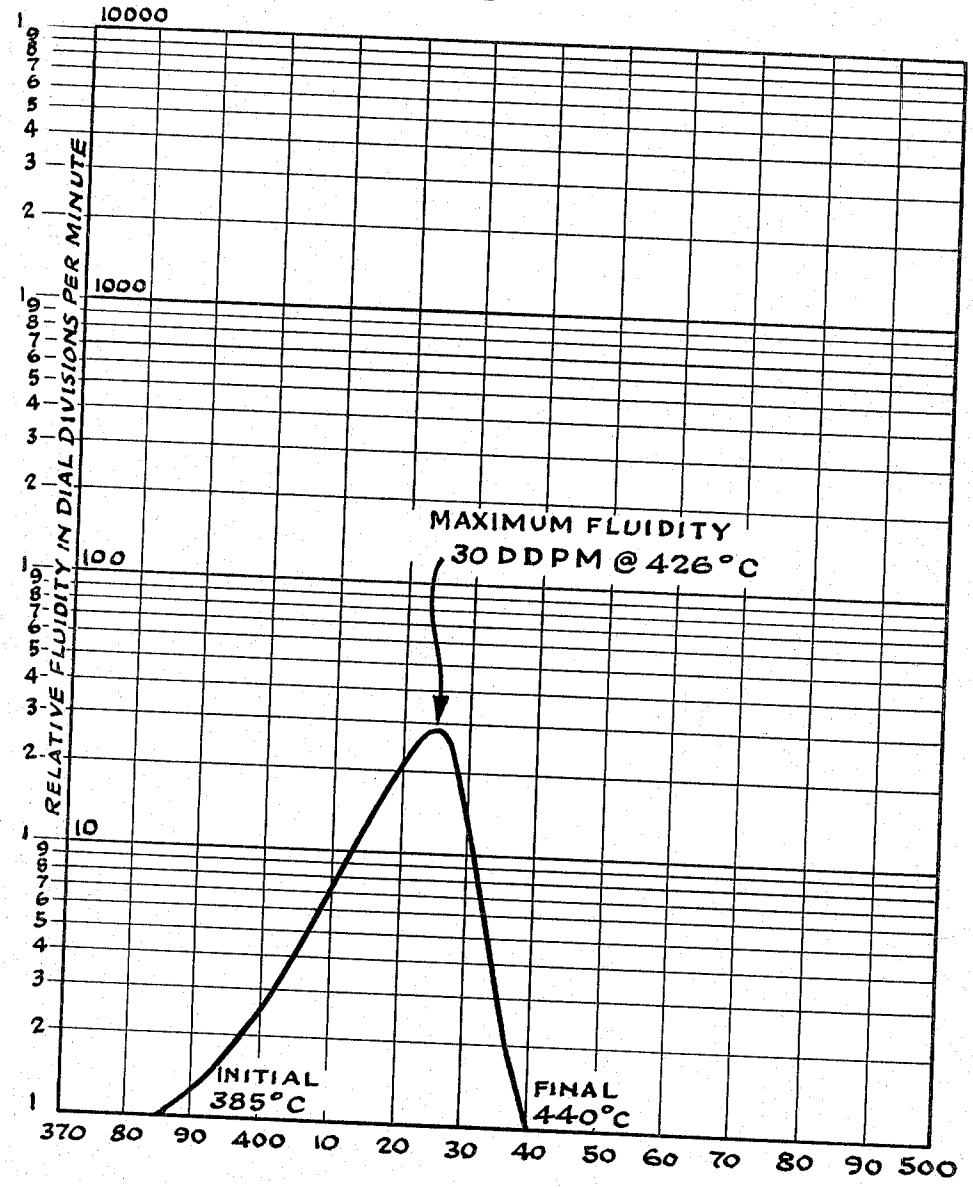
April 25, 1967 M. O. HOLOWATY ET AL 3,316,155

COKING PROCESS

Filed Jan. 25, 1963

6 Sheets-Sheet 6

Fig. 7



Inventors
Michael O. Holowaty
Charles R. Jackson
By Hitbon, Noyes & Bicknell
Attorneys

United States Patent Office 3,316,155 Patented Apr. 25, 1967

3,316,155

COKING PROCESS

Michael O. Holowaty, Gary, and Charles R. Jackson, Hammond, Ind., assignors to Inland Steel Company, Chicago, Ill., a corporation of Delaware

Filed Jan. 25, 1963, Ser. No. 253,856
6 Claims. (Cl. 201—6)

The present invention relates generally to a process of producing metallurgical coke from carbonaceous material normally considered unsuitable for producing metallurgical coke, and more particularly to an improved process of producing satisfactory metallurgical coke from 100% Illinois type coals, including fines of Illinois type coals which heretofore have not been used for producing satisfactory metallurgical coke.

The availability of substantial amounts of Illinois coals makes it highly desirable to use these less expensive coals, particularly the fines having a particle size smaller than —10 mesh, for the production of metallurgical coke. Earlier it was found possible to use run-of-the-mine Illinois coal for producing metallurgical coke by employing a two stage coking operation in which Illinois type coal is subjected to a first low temperature coking heat treatment at a temperature between about 1200° F. and 1500° F. followed by a second stage heating at a temperature of between about 2000° F. and 2400° F. In order to produce metallurgical coke from Illinois type coal fines having a particle size less than about —10 mesh, however, it has been found necessary to employ a special combination of steps over and above the foregoing two stage coking treatment.

It is therefore an object of the present invention to provide a process of producing satisfactory metallurgical coke from Illinois type coal fines having a particle size less than about —10 mesh.

It is a further object of the present invention to provide a process of continuously producing a satisfactory metallurgical coke from 100% Illinois coal having a particle size less than about —10 mesh without admixing a binding agent therewith.

Other objects of the present invention will be apparent to those skilled in the art from the following detailed description and claims when read in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic block diagram of one embodiment of the present invention showing the approximate flow rates of the major process streams;

FIG. 2 is a schematic block diagram of a modified form of the process of FIG. 1;

FIG. 3 is a schematic block diagram of a further embodiment of the present invention showing approximate flow rates of the major process streams;

FIG. 4 is a schematic block diagram of a modified form of the process of FIG. 3;

FIG. 5 is a graph showing the time-temperature relationship of briquettes heated in accordance with the present invention at two different rates of heating;

FIG. 6 is a graph showing the relationship between the tumble strength and rate of heating of briquettes produced according to the present invention; and

FIG. 7 is a Gieseler plastometer data curve of Illinois No. 6 coal.

It has been found possible to produce a strong uniformly sized metallurgical coke from 100% Illinois coal in particulate form and to achieve the other objects of the present invention by employing a three stage process which comprises (1) preheating 100% Illinois type coal in a finely divided form to incipient fluidity, (2) briquetting the heated coal particles by means of briquetting apparatus which is heated to a sufficient temperature to

form a thin shell of coke on each of the said briquettes during briquetting without significantly reducing the volatile matter content of the briquettes, and (3) gradually and continuously heating the hot briquettes to completely carbonize the briquettes and thereby form satisfactory metallurgical coke briquettes.

In general, to produce satisfactory metallurgical coke in the form of briquettes from particulate 100% Illinois type coal it is essential that the particulate Illinois type coal having a particle size of less than —10 mesh and preferably at least 90% less than —20 mesh be preheated to the point of incipient fluidity, just below the point where the coal softens and becomes plastic and before actual decomposition or volatilization of the components of the coal. Generally, Illinois type coals must be heated to a temperature of between about 500° and 750° F. and preferably between about 600° and 700° F. in order to bring the particles to incipient fluidity. In FIG. 7 of the drawing the Gieseler plastometer data curve of Illinois No. 6 coal shows that Illinois No. 6 coal has a softening temperature of about 385° C. (725° F.). When the coal particles are heated to just below the softening temperature, they can be readily and rapidly transformed into dense briquettes by further heating through the plastic stage in a heated briquetting apparatus. When the briquetting apparatus is maintained at an elevated temperature above the solidification temperature of the particular coal, the coal is readily compressed into briquettes and a surface layer of coke formed thereon during passage through the briquetting apparatus. The temperature at which the coal becomes plastic or solidifies, of course, varies somewhat on the oxidation level of the coal. The presence of a surface layer or outer shell of coke on the briquettes substantially decreases the tendency of the briquettes to fuse during the subsequent carbonaceous step when the briquettes are subsequently heated to coking temperatures.

It has also been further observed that because of the greater heterogeneity of the composition of Illinois type coals as compared with eastern coals, there is a distinct advantage in employing very small diameter particles of Illinois coal in the present process. Thus, it is advantageous in the present invention to employ the coal in a very finely divided form, including substantial amounts of —100 mesh fines of Illinois type coals, to form the briquettes. It is also preferred to have the Illinois coal of a particle size such that about 90% is less than —20 mesh, since a large percentage of very finely divided coal improves the handling strength of the coke briquettes, as evidenced by very high tumble test values of the resulting metallurgical coke briquettes.

In order to form satisfactory coal briquettes of finely divided 100% Illinois coal after the coal is heated to incipient fusion, the hot coal particles are compressed between heated mold surfaces, such as a roll-type briquetting press comprising a pair of oppositely disposed briquetting rolls, which exert a sufficiently great pressure to form dense briquettes of the desired size and which can be heated to a sufficiently high temperature to provide a surface skin or shell of coke thereon so that the briquettes can be handled and transferred to the coking furnace without substantial fragmentation and without having the briquettes fuse together during coking. It is preferred that the briquetting apparatus form briquettes in the shape of ellipsoids or egg-shaped briquettes having a major diameter of about two inches. The briquetting apparatus is also preferably adjusted to exert a pressure above about 12,000 pounds per square inch to form a very dense briquette structure. Since great pressure during the briquetting operation causes the density of the briquettes to increase, making it more difficult for volatile

ases to be released during carbonization, it is necessary to employ a low rate of heating the briquettes during the carbonization or coking operation, particularly during the period the coal passes through the plastic temperature range while volatile components are released. The latter is important in order to avoid building up internal gas pressure within the briquettes which could result in excess cracking of the briquettes. Also, the larger the briquettes, the slower must be the heating range in order to avoid having a sharp temperature gradient within the briquette which might result in stress points forming within the briquette and causing cracking and eventual breaking of the briquette. It is therefore advisable to use the smallest possible briquette size which provides the necessary gas permeability in the blast furnace.

The surfaces of the briquetting apparatus which contacts the coal particles during the formation of the briquettes are heated to a temperature above the carbonization or solidification temperature of the coal so that during the brief period of a few seconds required by the briquetting apparatus to compress the coal into dense briquettes a thin skin of coke will be formed about the briquette, but without decomposing a substantial portion of the coal comprising the complete briquette. It is necessary therefore that the briquetting mold surfaces have a temperature of between about 850° and 1200° F., and preferably between about 900° and 1000° F.

During the treatment of the coal particles from the time they are heated to incipient fluidity to the time the hot briquettes are discharged from the briquetting apparatus, the coal particles and briquettes are preferably protected against oxidation by means of a protective, non-oxidizing atmosphere, such as flue gas or an inert gas.

From the briquetting apparatus, the hot briquettes having a temperature of about 600°–700° F. are immediately and directly discharged while protected against oxidation into a feed hopper having associated therewith a charging means which periodically or continuously feeds the hot briquettes into a suitable coking furnace, preferably a vertical shaft furnace, wherein the hot briquettes are gradually and continuously heated to form metallurgical coke briquettes containing less than about 1% volatile matter.

The carbonization or coking apparatus employed in the present invention consists preferably of a vertical shaft or column having three major zones in direct uninterrupted communication. The uppermost section is the low temperature zone into which the hot briquettes are fed and in which the briquettes are heated directly and gradually by gas heat transfer from their initial briquette temperature of about 600°–700° F. to a temperature of about 1500° F., during which time the briquettes move slowly downwardly through the upper section of the vertical shaft furnace. The second or central section of the furnace is the high temperature zone in which the briquettes are heated by gas heat transfer and wherein the briquettes can also be heated by conduction heat transfer through the walls of the shaft furnace, if desired. During the passage of the briquettes through the second or high temperature zone, the briquettes are heated from a temperature of about 1500° F. to a temperature of at least 1800° F. and preferably to about 2000° F. so that the briquettes are transformed into metallurgical coke having not more than about 1% volatile matter remaining therein. At no time is there a sharp temperature gradient between the first and second zones of the vertical shaft furnace, nor are the briquettes contacted with gas or a wall surface having a temperature more than about 300° F. higher than the temperature of the briquettes. The third section of the furnace is the cooling zone at the lower end of the vertical shaft furnace in which the hot briquettes are cooled from a temperature of about 2000° F. down to a temperature of between 100° F. and 250° F. by countercurrent passage of a cool non-oxidizing gas injected into the column at the lower end thereof. The heated cooling gas, after absorbing heat from the

briquettes, passes upwardly through the column and assists in heating the briquettes in the upper section of the column. The necessity of using a water quench to cool the coke briquettes is eliminated.

It has been found that one of the important variables in the instant carbonization or metallurgical coking step and the variable which to a significant degree determines the strength of the briquettes is the rate of carbonization or heating of the briquettes in the vertical coking furnace, and that this variable is more critical in the production of metallurgical coke briquettes from 100% Illinois type coal than from conventional coking coals. Thus, in the present metallurgical coking process the rate of heating the coal during the plastic stage must be carefully controlled and limited so that the volatile matter is evolved so slightly that a significant portion of the tar and heated by-products remain within the briquette and supply the briquette with its own binder. In FIG. 6 of the drawing a graph is shown correlating the stability (tumble strength) of the coke briquettes with the rate of heating, and it was found that the briquetes formed by heaing at the lowest rate (2.3° F./min.) had the highest stability and hardness values with the smallest amount of dust. Thus, in the present invention it has been found preferable to maintain the rate of heating of the low fluidity 100% Illinois type coal briquettes at a rate of between about 1.5° F. per minute to about 3.5° F. per minute, particularly during the plastic heating stage.

In the immediately following paragraphs the present invention is described in detail as applied to the production of metallurgical coke briquettes from 100% Illinois No. 6 coal fines obtained from −10 mesh screening of run-of-the-mine Illinois No. 6 coal comprising about 28% of the raw coal, and beneficiated to the extent of removing a portion of the high ash refuse comprising about 7% thereof. The larger particles of the fines were crushed so that at least about 90% have a particle size less than −20 mesh. The Illinois No. 6 coal used had the following analyses:

	Percent
Volatile matter (dry basis)	38.2
Ash (dry basis)	6.5
Sulphur	1.0
Moisture	9.0
Fixed carbon	55.3

As illustrated in FIG. 1 of the drawing, a 2000 pound quantity of the above Illinois No. 6 coal is fed from a hopper H and a separator S into a coal preheater **10**, such as an inclined rotary kiln or retort and heated to a temperature sufficient to raise the temperature of the coal fines passing therethrough to about 700° F., the temperature at which the Illinois No. 6 coal fines are at incipient fluidity or just below the softening point. The preheated coal preferably protected by a non-oxidizing atmosphere and while at a temperature of about 700° F. is discharged directly into a briquetting apparatus **11** comprised of a pair of oppositely disposed briquetting rolls **12** having the surface thereof provided with briquette mold cavities and heated to a temperature of about 1000° F. The heated rolls **12** compress the coal fines into compact briquettes **14** having a generally ellipsoid shape with the major axis thereof being about two inches long. The rolls **12** exert a compression force on the coal fines of about 12,000 pounds per square inch, and are rotated at such a speed that the briquettes have a surface layer thereof carbonized during the time the briquettes remain in contact with the rolls **12**. The hot briquettes **14** having a temperature of between about 600° F. and 700° F. are discharged into a feed hopper **16** wherein they remain protected by a non-oxidizing atmosphere, such as flue gas. Periodically, a charge of briquettes **14** having a temperature of about 600° F. are fed into the top of a vertical coking furnace **20** through a conventional double valve charging system **19** which prevents gases escaping into the atmosphere from the coking furnace **20**.

The coking furnace **20** in the present instance is comprised of a vertically disposed cylindrical column **22** about one foot in diameter and about fifteen feet high.

The hot briquettes **14** on entering the upper or low temperature zone of the furnace **20** are contacted by heated non-oxidizing gases rising upwardly through the column **22**. The gases which initially contact the briquettes have a temperature of about 900°–1000° F. so that the briquettes are not subjected to a great thermal shock. It is also desirable to have the gases leave the top of the furnace **20** at a temperature of about 900° F., since considerable precipitation of tars would result if the off-gases were at a much lower temperature and excess heat losses would result if the off-gases were to have a temperature substantially greater than 900° F.

The temperature and rate of heating of the briquettes in the upper or low temperature zone is preferably determined by the temperature and volume of gas passing upwardly through the vertical coking furnace **20**. Only in the extreme case is it necessary or desirable to heat the exterior of the column **22** opposite the low temperature zone of the furnace **20**. When such is necessary a portion of the hot gases from the jacket **23** surrounding the column **22** are directed into the jacket section **24** through flues **26** and **27** conveying the combustion gases from the heat exchange section **28**. The off-gases are removed from the top of the column **22** through conduit **29** which carries the off-gases into a spray column **30** which washes and collects the heavy liquid by-products from the off-gases, conveys the tars to a tar skimmer **31** and discharges the remaining gases to a by-product processing system **32**.

During the passage of the briquettes downwardly through the low temperature zone comprising the upper five foot section of the column **22**, the briquettes **14** are slowly and uniformly heated preferably entirely by the hot gases from their initial temperature of about 600° F. to a temperature of about 1500° F. During this heating in the low temperature zone, the coal gradually releases the major portion of the volatile matter. A portion of the released volatile matter is retained within each briquette to serve as a binding agent.

Without encountering any sharp temperature gradient or obstruction within the column **22**, the briquettes move from the low temperature zone into the second or high temperature heating zone of the furnace **20** comprising about a seven foot middle section of the column **22**. In the apparatus used the heat exchange section **28** is formed about the lower portion of the high temperature zone. The heat exchange section **28** having a heat exchange coil **36** passing therethrough is heated by four concentric gas-air tube burners **37** which supply heat to the annular combustion space surrounding the coil **36** and the lower portion of the high temperature zone of the furnace **20**. The flue gas passing through the heat exchange coil **36** is heated and injected at a controlled rate into the lower portion of the high temperature zone from which is passes upwardly countercurrently to the downwardly moving briquettes **14**. The heated gas has a temperature between about 2000° F. and 2500° F. and preferably a temperature of about 2200° F. when the gas enters the column **22** and effects heating of the briquettes **14** to a temperature of about 2000° F. which is sufficient to produce satisfactory metallurgical coke briquettes.

The third section of the coking furnace **20** is the cooling zone in which the hot briquettes are cooled by the countercurrent passage of a cool inert gas, such as flue gas or clean coke-oven gas which is injected into the lower end of the column **22**. The cooling gas reduces the temperature of the coke briquettes from a temperature of about 2000° F. to a temperature of between about 100° and 250° F. The cooling gases are, of course, gradually heated as they pass upwardly through the column and conserve thereby a substantial amount of heat which is used to heat the briquettes entering the column **22**. In this way a substantial amount of heat ordinarily lost in water quenching the briquettes is recovered. In addition, the gradual cooling of the coke briquettes **14** increases the strength and abrasion resistance of the product and no objectionable oxidation of the briquettes takes place between discharging and quenching. Certain of the operating characteristics of the apparatus and the product characteristics of briquettes produced in accordance with the foregoing specific application of the present invention are shown in FIGS. 5 and 6 of the drawing.

The modified process illustrated in FIG. 2 of the drawing is substantially similar to the process above described and illustrated in FIG. 1, but differs therefrom in having all of the heat supplied to the vertical coking furnace **40** corresponding to furnace **20** by introducing into the lower end of the high temperature heating zone an inert gas which is preheated to the desired temperature (about 2200° F.) by passing the gas through a gas preheater **45** spaced from the coking furnace **40**. The latter modification is used when a vertical coking furnace unit has a diameter substantially in excess of about one foot, since the efficiency of wall heat transfer is low with large diameter column and it becomes advisable to supply all of the heat required for coking by means of hot gases passing upwardly through the column in the above described manner.

A further modified process for producing large volumes (2000 tons per day) of metallurgical coke briquettes from 100% Illinois type coal in accordance with the present invention and wherein the coking furnaces **50** have a diameter of about 30 feet and a height of about 50 feet is illustrated in FIG. 3 of the drawing. In order to practice the process illustrated in FIG. 3, 100% Illinois No. 6 coal of the foregoing size and composition must be crushed by passing through a crusher **51** having a capacity of about 100 tons per hour to effect reducing about 90% of the coal to about −20 mesh and thereafter heating the crushed coal by passing through a preheating drum **52** having a sufficient capacity to heat the coal to about 700° F. Two hot briquetting roll presses **53** of sufficient capacity to produce 100 tons per hour of briquettes are required. The hot briquettes having a shell of coke formed entirely thereabout are fed directly into the top of three vertical coking furnaces **50**, as required. The heat for carbonization of the briquettes is supplied entirely by hot gases preheated to approximately 2100° F. in three pebble-type stoves **56**. Two of the pebble-type stoves are operated on alternating combustion and preheat cycles. The third pebble stove is used as a spare. The off-gas containing tar by-products and ammonia are sent to the by-product recovery system which includes two primary coolers **57** and two tar precipitators **58**, a decanter **59**, an ammonia still **60**, and a saturator **61** for recovering tar and amonia from the off-gases.

A still further modified form of the process of the present invention is illustrated in FIG. 4 of the drawing. The process of FIG. 4, while basically similar to the process of FIG. 3, differs therefrom primarily by having means which can either recover by-products (as in FIG. 3) or burn the byproducts to supply heat for the coking furnace, depending on the market value of the by-products. Thus, in the process of FIG. 4, the off-gases from the top of the furnace are not sent directly to the by-product recovery area. Rather, these gases containing tar by-products are fed to one of the three pebble-type stoves or other heat transfer surface. The pebbles of the pebble-type stove have a sufficiently low temperature to condense the tar products and cool the gases, thereby effecting deposition of a substantial proportion of the tar on the surface of the pebbles. Also, a significant portion of the heat ordinarily lost in the primary cooler is recoverd by the pebble stove. The gas is then fed from the stove to the by-product recovery area where

ıe remaining tar and ammonia products are stripped 'om the gas.

In the latter process three stoves are required and are perated in a three-stage alternating cycle. The first .age described above is the tar deposition stage. When he pebbles are heated by the off-gases to a temperature uch that the tar recovery is no longer efficient, the stove s switched to the combustion stage and the off-gases are ent to another stove which is at a cooler tar deposition emperature. Coke oven gas and air are fired into the irst stove and the tar deposits are burned from the sur- ace of the pebbles. In this way the temperature of the ebbles is brought to approximately 2500° F. at which ime air is shut off, the stove purged, and clean coke-oven gas is fed to the hot stove. The latter gas is thus pre- heated to about 2200° F. and sent to the coking units to supply the necessary heat for carbonization of the bri- quettes. In order to complete the cycle the coke-oven gas is passed through the pebbles until the pebbles are cooled to the tar deposition temperature. The preheating stage is considerably longer than the combustion stage, thereby requiring using two of the stoves in series for preheating the transfer gases while the remaining stove is in com- bustion stage.

Metallurgical coke briquettes produced by any of the foregoing specific processes results in a substantial eco- nomic saving due to the coal used to form the briquettes having a much lower initial cost and because of the more economical use of equipment and the conservation of heat in the coking process.

The term "Illinois type coal" as used herein designates "banded" bituminous coals having in excess of 12 percent volatile matter and comprised of distinct layers or isolated sections of carbon-bearing material, such as vitrain, clarain, fusain, and durain.

We claim:

1. A process of producing metallurgical coke bri- quettes from 100% Illinois type coal which comprises; preheating 100% Illinois type coal in a finely divided form to incipient fluidity without effecting volatilization of the coal having a particle size less than —10 mesh size with at least 90% being less than —20 mesh, forming briquettes of said coal by applying simultaneously pres- sure and heat to said coal while the coal remains at said incipient fluidity, said heat applied during briquetting being sufficient to form a thin shell of coke about the entire surface of said briquettes without significantly re- ducing the volatile matter content of said briquettes at a rate of between about 1.5° F and 3.5° F. per minute, and gradually heating said briquettes through the plastic stage such that at least a portion of the volatile matter released by said coal is retained within the said briquettes and supplies the entire binding agent required for said bri- quettes, and continuing said heating above the carboniza- tion temperature of said coal to form metallurgical coke briquettes having a maximum of about 1% residual vola- tile matter.

2. A process of producing metallurgical coke bri- quettes from 100% Illinois type coal which comprises; preheating 100% Illinois type coal in a finely divided form having a particle size less than —10 mesh size with at least 90% being less than —20 mesh to incipient fluidity without effecting volatilization of the coal, form- ing briquettes of said coal by applying simultaneously pressure and heat to said coal while the coal remains at said incipient fluidity, said heat applied during briquetting being sufficient to form a thin shell of coke about the entire surface of said briquettes without significantly re- ducing the volatile matter content of said briquettes, charging said briquettes into the upper end of a vertical shaft-type coking unit through which said briquettes are moved slowly by gravity and gradually heating said bri- quettes through the plastic stage at a rate of heating of between about 1.5° F. and 3.5° F. per minute such that at least a portion of the volatile matter released by said coal is retained within the said briquettes and supplies the entire binding agent required for said briquettes, con- tinuing said heating above the carbonization temperature of said coal to form metallurgical coke briquettes having a maximum of about 1% residual volatile matter, and cooling said briquettes below their combustion tem- perature.

3. A process of producing metallurgical coke bri- quettes from 100% Illinois type coal which comprises; preheating 100% Illinois type coal in a finely divided form having a particle size less than —10 mesh size with at least 90% being less than —20 mesh to incipient fluidity without effecting volatilization of the coal, form- ing briquettes of said coal by applying simultaneously, pressure and heat to said coal while said coal remains at said incipient fluidity, said heat applied during briquetting being sufficient to form a thin shell of coke about the entire surface of said briquettes without significantly re- ducing the volatile matter content of said briquettes, charging said briquettes into the upper end of a vertical shaft-type coking unit through which said briquettes are moved slowly by gravity and gradually heating said bri- quettes through the plastic stage in a low temperature zone of said unit at a rate of heating between about 1.5° F. and 3.5° F. per minute such that at least a portion of the volatile matter released by said coal is retained within the said briquettes and supplies the entire binding agent required for said briquettes, continuing heating said bri- quettes above the carbonization temperature of said coal in a high temperature zone of said unit to form metallurgi- cal coke briquettes having a maximum of about 1% residual volatile matter, the heat required for said heating of said briquettes in said coking unit being supplied pri- marily by hot inert gas which is introduced into the coking unit at the lower end of the said high temperature zone, and cooling said briquettes below their combustion temperature before discharging from said unit by intro- ducing cool inert gas into the lower end of said coking unit.

4. A process of producing metallurgical coke bri- quettes from 100% Illinois type coal which comprises; preheating 100% Illinois type coal in a finely divided form having a particle size less than —10 mesh size with at least about 90% being less than —20 mesh to a tem- perature between about 500° and 750° F. to effect in- cipient fluidity of said coal without effecting volatilization of the coal, forming briquettes of said coal by applying simultaneously pressure of at least 12,000 pounds per square inch and heat between a temperature of about 850° and 1200° F. to said coal while said coal remains at incipient fluidity, said heat applied during briquetting being sufficient to form a thin shell of coke about the entire surface of said briquettes without significantly re- ducing the volatile matter content of said briquettes, charging said briquettes having a temperature of between about 500° and 750° F. into the upper end of a vertical shaft-type coking unit through which said briquettes are moved slowly by gravity, gradually heating said bri- quettes through the plastic stage to a temperature of about 1500° F. in a low temperature zone of said unit at a rate of between about 1.5° and 3.5° F. per minute such that at least a portion of the volatile matter released by said coal is retained within the said briquettes and supplies the entire binding agent required for said briquettes, con- tinuing heating said briquettes to a temperature of be- tween about 1800° F. and 2200° F. in a high temperature zone of said unit to form metallurgical coke briquettes having a maximum of about 1% residual volatile matter, the heat required for said heating of said briquettes in said coking unit being supplied primarily by coke-oven gas having a temperature of between about 2000° and 2500° F. which is introduced into the coking unit at the lower end of the said high temperature zone, and cooling said briquettes to a temperature below about 250° F.

before discharging from said coking unit by introducing cool coke-oven gas into the lower end of said coking unit.

5. A process of producing metallurgical coke briquettes from 100% Illinois type coal which comprises; preheating 100% Illinois type coal in a finely divided form having a particle size less than −10 mesh size with at least about 90% being less than −20 mesh to a temperature of about 700° F. to effect incipient fluidity of said coal without effecting volatilization of the coal, forming briquettes of said coal by applying simultaneously pressure of at least 12,000 pounds per square inch and heat of about 1000° F. to said coal while said coal remains at incipient fluidity, said heat of about 1000° F. applied during briquetting being sufficient to form a thin shell of coke about the entire surface of said briquettes without significantly reducing the volatile matter content of said briquettes, charging said briquettes at a temperature of about 600°–700° F. into the upper end of a vertical shaft-type coking unit through which said briquettes are moved slowly by gravity and gradually heating said briquettes through the plastic stage to a temperature of about 1500° F. in a low temperature zone of said unit at a rate of between about 1.5° and 3.5° F. per minute such that at least a portion of the volatile matter released by said coal is retained within the said briquettes and supplies the entire binding agent required for said briquettes, continuing heating said briquettes to a temperature of about 2000° F. in a high temperature zone of said unit to

form metallurgical coke briquettes having a maximum of about 1% residual volatile matter, the heat required for said heating of said briquettes in said coking unit being supplied primarily by coke-oven gas having a temperature of about 2200° F. which is injected into the coking unit at the lower end of the said high temperature zone, and cooling said briquettes to a temperature below about 250° F. before discharging from said coking unit by injecting cool coke-oven gas into the lower end of said coking unit.

6. A process as in claim 5, wherein said coal is Illinois No. 6 coal.

References Cited by the Examiner

UNITED STATES PATENTS

1,496,053	6/1924	Illingworth	201—6
2,131,702	9/1938	Berry	201—6
2,594,226	4/1952	Shea	201—7 X
2,706,706	4/1955	Pettyjohn	201—7 X
2,937,080	5/1960	Komarek et al.	44—10
3,093,463	6/1963	Madley et al.	44—10
3,232,845	2/1966	Komarek et al.	201—7

MORRIS O. WOLK, *Primary Examiner.*

JOSEPH SCOVRONEK, *Examiner.*