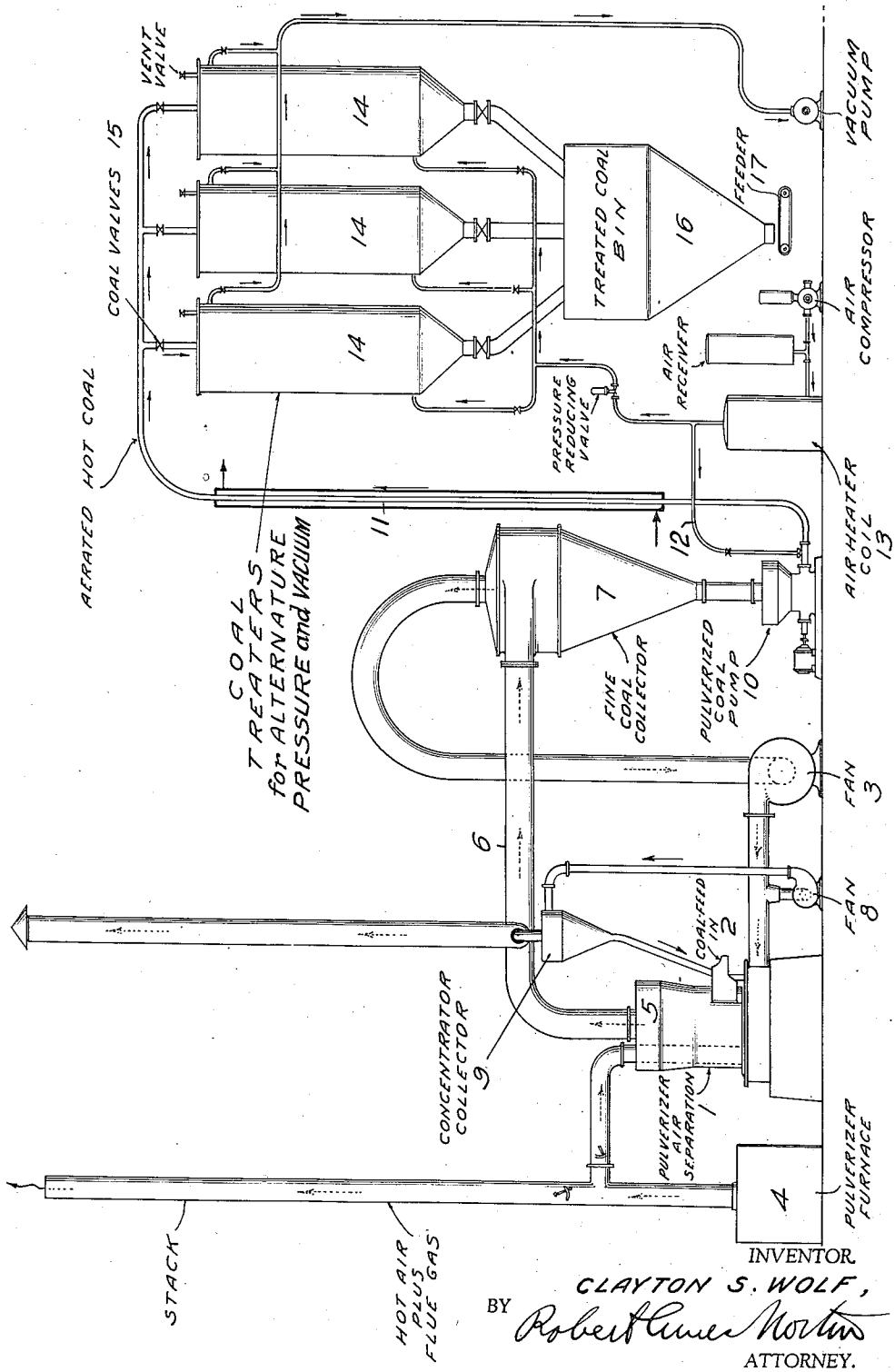
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VACUUM TREATMENT OF COKING COALS

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VACUUM TREATMENT OF COKING COALS

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5 Claims. (Cl. 202—10)

The present invention relates to the treatment of coking coals and more particularly it relates to a method of treating badly swelling and caking coals to alter the coking characteristics thereof.

Many bituminous coals, such as high volatile bituminous coals, cake and swell badly when it is attempted to carbonize them in the production of coke. The swelling and caking characteristics of such coals are particularly troublesome when it is attempted to crush the coal, compress into briquettes and then carbonize the briquettes.

It has been proposed in the past that badly swelling and caking bituminous coals be treated prior to briquetting and carbonization to reduce the swelling and caking characteristics so that the coal can be successfully briquetted and carbonized. The pre-treating processes employed heretofore are oxidation processes. One such proposed oxidation process involves subjecting the coal to a treatment at an elevated temperature and maintaining the temperature under atmospheric conditions for varying lengths of time. In general, the process involves heating the coal to a temperature of about 150° C. and maintaining that temperature for a period of 24 to 120 hours depending upon the type of coal being treated. An improved oxidation process is described and claimed in the co-pending application Serial No. 343,518 filed June 2, 1940, which comprises grinding the coal, raising the temperature of the coal to about 150° C. and then subjecting the heated coal to elevated air pressures of from about 20 to 150 lbs. per square inch while maintaining a temperature of about 150° C. for a period of from 3 to 6 hours depending on the type of coal. While the above-described pretreating processes are useful in altering the coking characteristics of bituminous coals, they are somewhat cumbersome in that relatively long periods of time are consumed in the treating process which materially slows down plant production in coking operations.

In accordance with the present invention I have discovered an improved pre-treating process for altering the coking characteristics of bituminous coal and which process produces results equivalent to the prior pre-treating processes and yet can be carried out in a very much shorter period of time.

The pre-treating process of the present invention involves crushing the coal, raising the temperature of the crushed coal to about 150° C. and maintaining at this temperature until all of the surface moisture and that of constitution which may be created at this temperature of 150° C. has been removed. This can usually be accomplished in about one hour. Some coals, however, are sufficiently dry in their natural state and the drying is not necessary. The dry crushed coal is then subjected to a vacuum equivalent to about 28 inches of mercury for about 15 to 30 minutes and then allowed to come to atmospheric pressure for a period of 30 minutes to one hour. After which the coal is again subjected to a vacuum equivalent to about 28 inches of mercury for another 15 to 30 minutes. These alternative vacuum atmospheric treatments may be repeated a number of times in some cases. During the above vacuum and atmospheric treatments of the coal the temperature is maintained at about 150° C. When badly swelling and caking bituminous coals, such as those of the Pittsburgh seam type and which normally cannot successfully be briquetted and carbonized, are subjected to my pretreating process the coal is altered to such an extent that it can successfully be formed into briquettes and carbonized at a temperature rise of at least 2° C. per minute during the plastic temperature range.

I do not desire to limit the present invention by any particular theory or explanation as to why my pre-treating process alters the coking characteristics of swelling and caking coals. One possible theory is that the effect is achieved by oxidation since it is known that oxidation processes produced similar changes. If the change is due to oxidation, it may be that the vacuum treatment breaks down and removes with the aid of 150° C. temperature the occluded liquid or gaseous films which surround each coal particle and thereby permits the oxygen of the air to react quickly with the coal at normal atmospheric pressures and that the second or successive evacuations may be necessary to remove such liquid or gaseous films again when they may have been formed by the oxidation of the coal when air was permitted to enter it again after the first evacuation. I know of no other satisfactory explanation of why the alternate vacuum atmospheric treatment produces the effect. It may well be, however, that the changes are not caused by oxidation at all but are merely due to a change in or the removal of certain volatile constituents from the coal itself.

It is well known that some coking bituminous coals can be ground to a fineness of say about 28 screen mesh and compressed into briquettes without the use of any binder and that the briquettes can be carbonized in any conventional

manner and the rate of temperature rise can be regulated to prevent excessive swelling while going through the plastic temperature range. For each and every type of coking bituminous coal there can be determined a maximum rate of temperature rise (degrees per minute) through the plastic temperature range above which the briquettes will swell. These rates vary tremendously for different coals, being in the order of a fraction of one degree C. a minute for some coals and as high as 5° to 10° a minute for others. It is an advantage of the present invention that my pre-treatment of the coal permits an appreciable increase in the rate of carbonization of briquettes without swelling, and particularly coals that swell at a very low rate temperature rise.

Suitable plants for carrying out the vacuum treatment process of this invention include broadly any type of tank or treater in which coal can be charged and maintained at a substantially uniform temperature of about 150° C. and which will permit the formation of a vacuum in the treater surrounding the coal equivalent to about 28 inches of mercury and also having means for releasing the vacuum and permitting the coal to come in contact with air at atmospheric pressure while still being maintained at 150° C.

The vacuum coal treaters may be used as individual units or they may form a series of such vacuum treaters so arranged that while one tank is being subjected to vacuum treatment another tank can be subjected to atmospheric treatment in which way it is possible to continuously provide treated coal to subsequent briquetting operations. The treaters may likewise form a unit in a complete coal treating plant which can be comprised of pulverizing equipment, drying and preheating equipment, conveying means for introduction of the coal into the vacuum treaters followed by briquetting and carbonization equipment if desired. In some instances the vacuum treaters may also be designed so that the coal can be subjected to alternate elevated pressures.

The invention will be more fully described in connection with the drawing which is a semi-diagrammatic elevation of a suitable plant for carrying out the process. It should be understood, however, that in its broader aspects the present invention is not concerned with any particular plant for carrying out the process, and the drawing represents only one such suitable plant arrangement.

In describing the method of carrying out the present invention in connection with the drawing, the description relates specifically to the treatment of a badly swelling and caking Pittsburgh seam coal, containing about 35% volatile matter, and is to be oxidized to such an extent that the treated coal can be made into coal tar pitch briquettes and carbonized at a rate of about 2½° C. per minute temperature rise through the plastic temperature range without swelling. The coal as delivered to the plant is of low surface moisture content.

The coal is fed into a pulverizer 1 by means of a suitable feeder 2 as illustrated in the drawing. The coal in the pulverizer is ground so that the material finer than 20 mesh is picked up by the stream of air entering the pulverizer from the larger fan 3. The temperature in the mill is controlled by an admixture of more or less of hot flue gases produced in the adjoining pulverizer furnace 4 by a combustion of coal, oil or gas. The air sweeps through the upper portion 5 of the pulverizer which contains suitable separation equipment as an integral part of the mill, the oversize dropping out of the air stream and returning to the grinding elements of the pulverizer. The air stream leaving the mill is conducted by means of the conduits 6 to the cyclone type dust collector 7 where about 90 to 95% of the coal is separated from the hot air, the remainder returning to the larger fan and thus to the mill for recirculation.

The smaller fan 8 removes air from the system and blows it through the concentrator collectors 9 where the remaining coal is substantially all removed and the waste air is then passed to the atmosphere. The fine coal collected in these concentrator collectors is returned to the mill as shown. The amount of air passing through the concentrator collectors 9 is the same as the amount drawn into the system from the pulverizer furnace 4, plus the water evaporated from the coal, plus the water formed by decomposition of some of the coal.

The coal in the cyclone collector 7 is dry and at a temperature equal to or somewhat lower than that desired in the treaters. The temperature is controlled by the amount and temperature of flue gas drawn into the pulverizer 1 from the pulverizer furnace 4. A screen analysis of this coal shows it to range in particle size from about 88% less than 28 mesh to about 10% less than 200 mesh.

This hot coal is then fed out of the bottom of the cyclone collector 7 by means of a pulverized coal pump 10. In order to pump the pulverized coal and cause it to travel through the conveyor pipe 11, the coal is aerated by the introduction of air through the air line 12 into the coal conduit as shown. The amount of air required for proper aeration is on the order of 5% by weight of the coal conveyed. This air required for aeration is first heated to any desired temperature in the air heater coil 13 and provides one method of producing accurate temperature control of the coal before its introduction into the coal treaters.

The coal is conveyed through the conduit 11 to the coal treaters 14. The conduit is preferably jacketed and steam or oil at temperatures of 150° C. or more is introduced into the jacket to further raise or control the coal temperature desired. The length of this conduit and the temperature of steam or oil used in its jacket is sufficient to assure the delivery of coal at exactly the proper temperature, in this example 150° C. to the coal treaters 14.

The treaters 14 are simple insulated tanks capable of withstanding an external pressure of at least 14 lbs. per square inch. In a large plant there would be a number of treaters as shown and in a smaller plant perhaps only two or even one. When the first treater is filled, the coal valve 15 in the coal conduit is closed and the valve to the next treater is opened. The first treater is subjected to a vacuum equivalent to 28 inches of mercury by means of the vacuum pump and allowed to stand for about 15 minutes at the reduced pressure. The vacuum is then broken by opening the vent valve to the treater and the coal is allowed to remain in the presence of air at atmospheric pressure for about 30 minutes, after which it is again subjected to a vacuum equivalent to about 28 inches of mercury for a second period of about 15 minutes, after which the coal is discharged from the treater into the treated coal bin 16 from whence a suitable feeder 17 conveys the treated coal to the fluxing and

briquetting equipment. The process is repeated for each of the treaters in order and which results in continuous operation of the plant.

The air introduced into the treaters during the atmospheric pressure treatment may be preheated if desired in order that the coal in the treater may be more easily maintained at a temperature of about 150° C.

The alternate vacuum atmospheric treatment may, of course, be repeated a plurality of times if desired. In some cases the vacuum treaters may also be adaptable for applying elevated air pressure to the coal instead of the air treatment at atmospheric pressures.

The invention will be described more in detail in connection with the following specific example, in which different types of coking bituminous coals are treated in accordance with the present invention, briquetted and compared to the same type of coal without the pre-treatment.

Emerald coal of the Pittsburgh seam type was ground and screened on a 28 mesh screen. The ground coal was then dried under atmospheric conditions at a temperature of 150° C. for a period of 1 hour. The heated ground coal was then placed in a vacuum coal treater which treater was then sealed and evacuated to the equivalent of 28 inches of mercury and held there for 15 minutes. The vacuum was then disconnected and air allowed to enter the treater until it reached atmospheric pressure. The coal was allowed to remain at atmospheric pressure for 30 minutes and was then evacuated again to 28 inches of mercury and held there for 30 minutes. The vacuum was again disconnected and the treater allowed to come to atmospheric pressure and the coal immediately removed for briquetting. Briquettes were made from the coal using no binders and at the same time briquettes were made from the coal which had not been treated in any way other than grinding. Briquettes were also made from treated coal and untreated coal in which 5% sulfite liquor dry substance was used as a binder. The briquettes were then subjected to carbonization under the same conditions, the conditions being such that the rise in temperature during the plastic range was at a rate of 3.3° C. per minute. The briquettes which were made from the untreated coal using no binder were very badly swollen and diametrical measurements could not be made as the briquettes assumed the proportions of unmeasurable puff balls of strong, hard, very porous coke. The briquettes made from the treated coal with no binder permitted diametrical measurements and showed a swelling of about 25%. These briquettes were well bonded and had smooth glazed surfaces.

The sulfite liquor bound briquettes were also carbonized under identical conditions, the conditions being such that the temperature rise through the plastic range was at a rate of 3.3° C. per minute. The sulfite liquor bound briquettes from the untreated coal showed substantially no diametrical swelling or shrinkage, the bonding was good, and the surface of the briquettes was only fair, being somewhat rough. The sulfite liquor bound briquettes made from the treated coal showed a very great improvement over those from the untreated coal. The diametrical shrinkage was approximately 7%, the bonding was excellent, and they had smooth glazed surfaces. The density of these briquettes was, likewise, very good.

An analysis of the above results clearly shows that the coals pre-treated in accordance with the present invention result in the production of not only higher grade briquettes but also under conditions which are commercially practical. The untreated coal of the above type could not be briquetted, using no binder, and carbonized without swelling or diametrical increases in volume except at a very low rate of temperature rise during the carbonization, such carbonization being limited to between .3 and .8° C. per minute through the plastic range. Whereas the treated coal briquettes with no binder were successfully carbonized at a temperature rise of 3.3° C. per minute through the plastic range with only a slight swelling. When the temperature rise is reduced to between 2 and 2½° C. per minute, then this small diametrical increase or swelling can be eliminated. In briquetting operations, if the temperature rise through the plastic range is somewhat less than 1° C. per minute, they are not commercially practical processes. It is readily seen, therefore, that such coals when pretreated in accordance with the present invention are altered to such an extent that they can be briquetted and carbonized at a temperature of at least 2° C. rise per minute and which is sufficient to permit the carbonization to be carried out with commercial success.

It is also known that certain coking bituminous coals, which cannot be successfully briquetted and carbonized using no binders because of swelling, can be successfully briquetted and carbonized with 4 or 5% sulfite liquor dry substance as a binder in the preparation of briquettes. In the above example it is clearly shown that when briquettes made from the untreated and treated coal, using sulfite liquor as a binder, are compared the treated coal briquettes are much better and present a better range of operating conditions than those produced from the untreated coal.

The present invention is not to be limited to the Pittsburgh seam type of coal employed in the example and the process is applicable to all coking bituminous coals having swelling and caking properties which made them unsuited for briquetting and coking. For example, the process can be used to improve the conditions under which coal, such as the Beckley seam coals, can be briquetted successfully without pre-treatment when sulfite liquor is used as a binder but cannot be successfully briquetted and carbonized when binders such as molasses, pitch, or coal tar are used. The Beckley coals, therefore, may be pre-treated in accordance with the present invention to very greatly improve conditions under which the coal can be briquetted and carbonized. The improved conditions resulting from the pretreatment are an increase in the rate of temperature rise through the plastic range over that normally employed without an increase in swelling or caking, and the coking characteristics of the coal are changed to such an extent that a wider choice of binders may be used.

The process may also be used in pre-treatment of certain British coals such as "Pease and Partner's coals" "C," "E," and "F," which coals are badly swelling and caking and not suitable for briquetting and carbonizing at a temperature rise of more than about ½° C. per minute through the plastic temperature range. Coal "C" is described as "Thrislington washed nuts" containing about 33.2% volatiles, 63.8% fixed carbon, 3.00% ash and is strongly coking. "E" is described as "Waterhouse's unwashed coal" con-

taining about 26.4% volatiles, 69.6% fixed carbon, 4.00% ash and is strongly coking. "F" is a strongly coking, low ash coal containing about 28.3% volatiles, 69.9% fixed carbon, and 2.80% ash. These coals, however, when treated in accordance with the present invention can be briquetted with suitable binders at a temperature rise of about 2½° C. per minute to produce well bonded, unswollen, dense briquettes.

In the particular type of coal described, it was only necessary to apply the vacuum treatment twice for a period of about 15 minutes each separated by a period of about 30 minutes in which the coal was allowed to come in contact with air at atmospheric pressure. With some coals, such as those coals that are very highly volatile and have very great swelling and caking properties and coals in which binders such as pitch or coal tar are to be used, it may be desirable to subject the coal to a plurality of alternate vacuum and atmospheric treatments for varying lengths of time in order to alter the coking characteristics of a particular coal to render it best suited for a particular briquetting operation. The atmospheric treatment may also be replaced by a pressure treatment in the presence of air. The temperature may in some cases be lower than 150° C., and in some cases it may be necessary to use a higher temperature.

What I claim is:

1. A method of altering the coking characteristics of swelling and caking coals which comprises pulverizing the coal and subjecting to alternate vacuum and atmospheric treatments at an elevated temperature, said coal after such treatments being altered to such an extent that it can be carbonized at a faster rate without undue swelling than it could have been preceding such treatment.

2. A method of altering the coking characteristics of swelling and caking coals which comprises pulverizing the coal, drying at a temperature of about 150° C., subjecting the dry coal to a vacuum equivalent to about 28 inches of mercury for a period of time, releasing the vacuum and allowing the coal to come in contact with air at atmospheric pressure for a period of time, followed by a second vacuum treatment equivalent to about 28 inches of mercury for a short period of time while maintaining the coal at a temperature of about 150° C. during the alternate vacuum and atmospheric treatment, said vacuum and atmospheric treatments being for a period of time sufficient to alter the caking characteristics of the coal to such an extent that the coal can be carbonized at a faster rate without undue swelling than it could have been preceding the treatments.

3. The method of altering the coking characteristics of Pittsburgh seam coals which comprises pulverizing the coal, drying at a temperature of about 150° C., subjecting the dry coal to a vacuum equivalent to about 28 inches of mercury for about 15 minutes, releasing the vacuum and allowing the coal to come in contact with air at atmospheric pressure for about 30 minutes followed by a second vacuum treatment equivalent to about 28 inches of mercury for about 15 minutes while maintaining the coal at a temperature of about 150° C. during the alternate vacuum atmospheric treatment, said coal after such treatments being altered to such an extent that it can be carbonized at a faster rate without undue swelling than it could have been preceding such treatment.

4. A method of making briquettes from caking coals which coals cannot normally be compressed into briquettes and carbonized at a temperature rise of more than about ½° C. per minute without badly swelling and caking which comprises pulverizing the coal and subjecting to alternate vacuum and atmospheric treatments at an elevated temperature to reduce the swelling and caking properties thereof so that when compressed into briquettes and subjected to carbonization, the carbonization can be carried out at a temperature rise of at least 2½° C. per minute through the plastic temperature range.

5. A method of making briquettes from coking coals which coals cannot normally be compressed into briquettes and carbonized at a temperature rise of more than about ½° C. per minute without badly swelling and caking which comprises pulverizing the coal, drying at a temperature of about 150° C., subjecting the dry coal to a vacuum equivalent to about 28 inches of mercury for about 15 minutes, releasing the vacuum and allowing the coal to come in contact with air at atmospheric pressure for about 30 minutes followed by a second vacuum treatment equivalent to about 28 inches of mercury for about 15 minutes while maintaining the coal at a temperature of about 150° C. during the alternate vacuum and atmospheric treatment to reduce the swelling and caking properties thereof so that when compressed into briquettes and subjected to carbonization the carbonization can be carried out at a temperature rise of at least 2½° C. per minute through the plastic temperature range.

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