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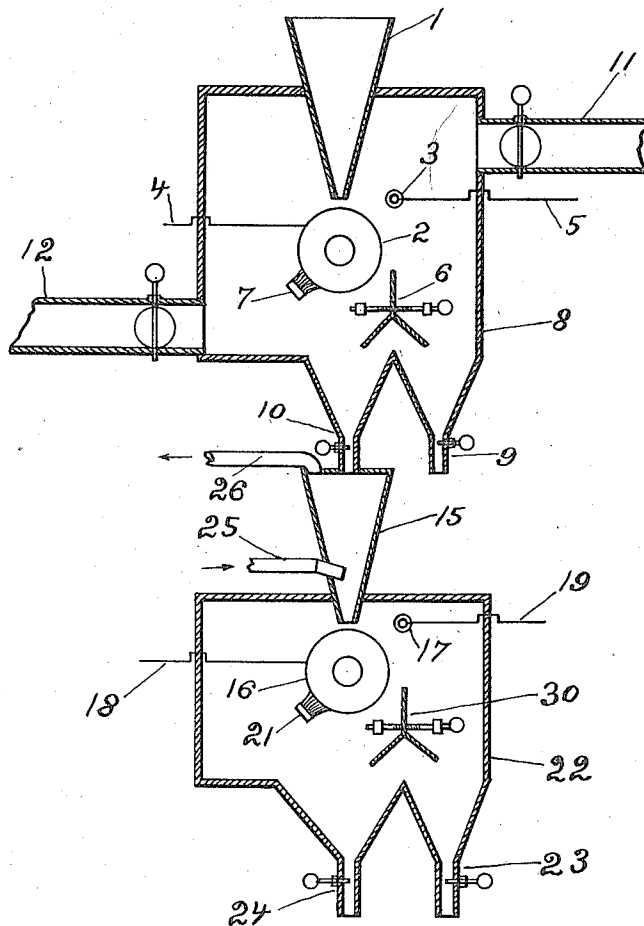
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SEPARATION OF COAL.

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1,152,442.

Patented Sept. 7, 1915.



Witnesses

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# UNITED STATES PATENT OFFICE.

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## SEPARATION OF COAL.

1,152,442.

Specification of Letters Patent.

Patented Sept. 7, 1915.

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*To all whom it may concern:*

Be it known that I, FREDERIC W. C. SCHNIEWIND, a citizen of the United States, residing at Englewood, in the county of Bergen and State of New Jersey, have invented certain new and useful Improvements in the Separation of Coal, of which the following is a specification.

This invention relates to the separation or purification of coal; and it comprises a process of purifying coal from gangue and other impurities, or of separating different kinds of coal from each other, wherein the coal is so treated as to bring out or develop the difference in hygroscopicities of the different constituents of the coal, and thereafter subjected to electrostatic separation.

It also comprises such a process of purification or separation wherein coal, and particularly bituminous coal, in a pulverulent condition is first purified and separated from inorganic impurities, and particularly those of a conductive nature such as pyrites and pyritical gangue or slate, by electrostatic means and the purified or partially purified coal thereafter moistened to develop the difference in hygroscopicities of the various ingredients of the coal, and the moistened coal is then separated by electrostatic means.

It further comprises such a process of purification or separation wherein pulverulent coal containing undesirable constituents, such as mineral charcoal, of a relatively more friable nature, is first purified from the finer particles of the more friable constituents by screening or pneumatic means, or otherwise, before the development of the hygroscopicities and the electrostatic separation.

It further comprises such a process of purification or separation wherein coal is first dried to remove any excess moisture and to increase the hygroscopic properties of the coal before the subsequent moistening and development of such hygroscopicities; and it further comprises certain modifications of such a process, and combinations thereof with other coal treating and purification processes; all as more fully herein-after set forth and as claimed.

Coal, as it occurs in nature, and as mined, contains varying amounts of inorganic material such as slate or gangue and pyrites more or less intimately distributed throughout its mass. Many coal veins also consist of strata of different kinds of coal intermixed

or interlaminated so that the mined coal is not homogeneous, even when obtained from the same mine and vein, but is made up of different coal constituents too intimately intermixed to be readily separated. Many bituminous coals, in particular, are of this nature, being made up of layers or mixtures of harder and of softer coal, or of lustrous and dull coal, or of coking and non-coking coal, or of purer and less pure (bone coal or slate) coal, etc.

For coking purposes the coal should be as pure as possible and relatively free from ash and sulfur (pyrites) and also from coal which is non-coking in its nature. The non-coking constituents, if present, make the coke resulting of inferior value. Among the different constituents of bituminous coal may be mentioned the shiny lustrous coal (called in German *glanzkohle*) which is generally the purest coal and has the best coking quality; the dull coal (called in German *mattkohle*) which possesses generally a higher percentage both of ash and of volatile matter but which is generally of poor coking quality; the cannel and pseudo-cannel coals; and mineral charcoal (*faserkohle*). The mineral charcoal in particular is of a friable nature and has no coking quality whatever.

During the mining operation the larger lumps and pieces of slate are removed, but the finer particles of impurities and those intimately distributed throughout the coal still remain. The mining operation, on the other hand, serves to mix the various lumps and layers of coal found in proximity to each other so that they are even more extensively intermixed than before mining. Such run-of-mine coal, if too high in ash cannot be used economically for industrial purposes where a low-ash coal or coke is necessary. Also, as indicated above, coal containing too large an amount of non-coking coal, is of inferior value for coking purposes.

In my application Serial No. 737,689, filed December 19, 1912, I have described and claimed a process of purifying or separating coal from such impurities as are of an electrostatically conductive nature or as are united to particles of an electrostatically conductive nature by disintegrating the coal sufficiently to separate the particles of conductive pyrites or gangue as much as possible from the coal particles and subjecting

the thus disintegrated coal to electrostatic separation whereby the conductive particles are repelled and separately collected from the coal particles. This process is of value particularly for removing pyrites and pyritical gangue from pulverulent coal and thus reducing its sulfur and ash content.

The present invention relates to a process of purification or separation based on the difference in hygroscopicities of the different constituents of coal intermixed with each other. Some of these different constituents have been enumerated above, particularly the different kinds of coal found in bituminous coal mixtures. Many of these different kinds of coal and of the constituents of the same kind of coal vary materially in their physical character and in their hygroscopicity. Thus where lustrous and dull coal occur in the same vein, the lustrous coal may in one case show the greater hygroscopicity while in another case the reverse may be true. In general lustrous coal is more hygroscopic than dull coal; but to this generalization there appear to be many exceptions. It is also in general true that the younger and softer coals are more hygroscopic than the older and harder coals, and hence it follows that anthracite usually contains less water and is less hygroscopic than the softer coals richer in hydrogen and oxygen. Thus in lignite and some of the brown coals the naturally occurring water, or the water which may be absorbed from moist air, may amount to more than 20%. Again in bituminous coals the absorption of water or hygroscopicity may vary, for example, between 2 and 7.5%, although it is usually nearer the lower figure than the higher. Different constituents of the same vein such as lustrous and dull coals may show differences of as much as 1 to 1.5%, or even more in their hygroscopicity under the same conditions. Mineral charcoal which may also be present mixed with other kinds of coal is a very undesirable constituent, particularly of coking coals. Its hygroscopicity is generally very low *e. g.* 1.2%. These percentages of water content or hygroscopicity for convenience of reference have been given as those possessed by the coals at 15° C. It will of course vary somewhat with the temperature of the coal and the humidity of the atmosphere to which the coal has been exposed, as well as vary with different coals and the above descriptions are given merely as specific illustrations of the varying hygroscopicities of different kinds of coal.

The property of greatest value for purposes of the present invention is the property of condensing moisture upon the surface of the coal particles or of mechanically holding moisture thereon. Different kinds of coal possessing different hygroscopicities are capable of condensing varying amounts

of water upon their surfaces. The amount and speed of adsorption or condensation will of course depend on the moisture content and temperature of the surrounding air or gas in cases where the coal is exposed to such air or gas, but it nevertheless varies to a greater or less extent in different kinds of coal under the same conditions, due apparently other things being equal, to the varying surface attraction inherent in the different kinds of coal.

According to the present invention coals containing in intermixture different constituents possessing different hygroscopicities are treated to develop such differences, and then subjected to electrostatic separation whereby the coal possessing the greater hygroscopicity and particularly the greater amount of condensed or mechanically retained water on its surface is repelled to a greater extent than the less hygroscopic coal other things being equal, and separation thus effected. If the coals already possess such differences of moisture content that the selective action of the electrostatic separation is able to effect their separation, they may be separated without further treatment after suitable disintegration. Such a condition, however, seldom arises. Usually the coal must be first reduced in size and then moistened immediately before the separation takes place, or if the coal is already too moist it may be partly dried to develop the difference in electrostatic susceptibilities and then separated electrostatically.

Coal from wet mines, or coal which is not sufficiently dry, may require to be first dried, and with other coals it is sometimes more advantageous to give the coal a preliminary drying before moistening since by drying the moisture contained in the interior of the particles may be removed, the exterior or surface moisture being most effective for electrostatic separation.

In cases where the coal also contains a large amount of pyrites and gangue it can be with advantage first subjected to electrostatic separation to reduce or remove such conductive impurities. By such a preliminary purification not only is the content of sulfur (pyrites) and pyritical gangue decreased, but complications which might otherwise arise subsequently are minimized. For such particles if present would be repelled along with the more strongly repelled hygroscopic coal and effective separation might be thus rendered more difficult; while by first removing the pyrites and gangue the subsequent separation of the greater and less hygroscopic coal proceeds more smoothly.

Previous to the electrostatic separation and to the development of the hygroscopicity the coal must be suitably reduced in size. The crushing may be of the run-of-

mine coal, in one or more stages, to particles of a size suitable for electrostatic separation. Crushing to pass an 8-mesh sieve is usually necessary, and crushing to pass a 10 or 12 mesh screen may give even better results. Instead of crushing directly to this fineness, the coal can be screened to remove large lumps and only smaller sizes further crushed. Usually the different layers of coal are so arranged that crushing to the extent indicated, viz., about 8-mesh, will separate the particles of the different kinds of coal from each other. The crushing should, however, be carried to such an extent that no appreciable cracks or crevices remain in the particles since such cracks might hold moisture mechanically or by capillary attraction, particularly if the coal were subjected to the action of liquid water, and the separation might be thereby injuriously affected. The particles should be as uniform in size as possible and to this end may be graded by screening or by other methods of volumetric classification, or may be separated from the fine particles and dust by pneumatic means, etc. The more friable constituents such as mineral charcoal which is one of the softest of the bituminous coal constituents, and also one of the least desirable in coking coals, will tend to be crushed more readily and more finely than the harder and more valuable coal so that more of such constituents may be found in the fine coal dust and in the finer coal particles. In such cases the crushed coal can be advantageously screened to remove this fine powder or dust, or it can be subjected to pneumatic separation whereby the finer and lighter particles are removed with the blast of air or other gas and separately collected, the coal being at the same time dried if a blast of warm or dry gas is used. Again screening for the purpose of removing the larger particles, and pneumatic treatment to remove the fine dust can both be used, the intermediate fraction or fractions only in such cases being subjected to electrostatic separation. These fractions can be varied with different coals and only such fractions obtained by screening, washing, or pneumatic or other processes treated according to the present invention as the nature of the coal or the relation of coking and non-coking components may render advantageous. With coals containing mineral charcoal it may be advantageous to remove this constituent before the first electrostatic treatment. This can in many cases be readily effected by pneumatic means or by screening or separating as above described, the fine dust being thus also removed, including that of explosive fineness.

After the coal has been crushed, and after it has been subjected to such preliminary drying, screening, separating or puri-

fying processes as already described, in case such preliminary processes are necessary or advantageous, it is treated to develop the difference in the hygroscopicity of the different constituents. It is now in a granulated condition, and may also be free from fine dust, as already described, and it is advantageous that it should be so free, since the presence of fine dust in excess may seriously interfere with the moistening of the coal. It is also advantageous that the pyrites and pyritical gangue should have been previously removed as already indicated, and the process will be described as applied to such a previously purified product, although it will be evident that other products can be similarly treated.

The moistening or development of the differences in hygroscopicities should advantageously immediately precede the electrostatic separation. This moistening may be effected in different ways. It is necessary that a small amount of moisture only be added. This may be added by passing a current of moist air or gas through the granulated coal. The variety of coal having the higher hygroscopicity or the greater capacity for surface condensation will adsorb the water more readily and to a greater extent. The adsorption can be increased by increasing the water vapor content of the air to saturation or to the dew point, or by using coal at a temperature below the dew point of the air current used. Since some coals tend to oxidize readily even on exposure to moist air it is in some cases more advantageous to use a moist current of an inert gas such as flue gas, or better the products of combustion of coke oven gas or coal gas. Such waste gas contains a large percentage of hydrogen which burns to water and is present as water vapor in its products of combustion. Oxidation during the moistening of the coal is thus prevented or minimized.

The water content of the waste gas can be increased by further addition of steam or water. Steam itself may in some cases be used, preferably diluted with air or an inert gas. The amount of moisture can be determined by the volume, temperature and moisture content of the gas passed over a given quantity of coal; also by the temperature of the coal. After the difference in hygroscopicity has been brought out in the coal mixture it is ready for electrostatic separation.

Instead of using moist air or gas liquid water may in some cases be used, the more porous coal absorbing and retaining more than the harder and greasy lustrous coal. Also when a current of dry air or gas is passed through the wet coal, or when it is slightly heated to remove the excess of water, the lustrous greasy coal will be more readily dried,

and thereby differentiated. This moisture may be only mechanically retained and visible or it may be that more properly called hygroscopic moisture which is invisible. The more porous coals thus more readily absorb and hold water mechanically and through capillarity than do the harder smooth coals. Some grades of anthracite and their admixed slate show such differences. Also certain grades of bituminous coals contain intermixed impurities of a relatively more porous nature.

Particularly when the coal resulting from the present process is to be used for coking it is advantageous that the coal be protected from oxidation during its preliminary treatment, since even atmosphere oxidation tends to lessen the coking qualities of the coal. The further addition of oxygen to the coal which readily takes place with many coals when exposed to the air causes a decrease in the heat value of the coal in much the same manner as do ash and moisture since oxygen itself is also incombustible. Viewed from another standpoint the prevention of oxidation serves to protect the oxidizable constituents of the coal and to preserve these constituents in an unoxidized condition in which they appear to be most valuable, particularly for coking purposes. In order that this protection from oxidation may be as complete as possible it is advantageous not only that the coal be protected from atmospheric oxidation during its moistening but that it also be protected during the subsequent electrostatic separation as well as during the previous crushing, drying, screening, pneumatic treatment and other preliminary processes which may be carried out. Such protection can be readily effected by the use of an inert atmosphere such as flue gas or nitrogen. A preliminary pneumatic separation using a current of inert gas can also be effected. With other steps of the process either a relatively stationary surrounding atmosphere or a current of the non-oxidizing gas can be used. After the coal mixture containing constituents possessing different hygroscopicities has been moistened to bring out or develop such differences it is subjected to electrostatic separation.

When a mixture of coal particles of different degrees of wetness or possessing different hygroscopicities and moistened as already described, are brought in contact with an electrostatically charged electrode or surface the wetter particles or the particles containing a larger amount of condensed water on their surface are more strongly repelled than the drier particles and can thus be separated to a greater or less extent from each other. It will be understood, however, that this separation is not a sharply defined one; since there is no

sharp line of distinction between the different particles as respects their conductivity and their non-conductivity. The separation is rather of two materials of like nature between which, however, selective electrostatic differentiation can take place.

In effecting the separation the coal particles can be charged electrostatically and then passed through an electrostatic or combined electrostatic and electromagnetic field; or brought in contact with an electrostatically charged surface. Coal thus previously charged is repelled by an electrode similarly charged and attracted by one oppositely charged while coal which is not thus charged remains unaffected. In the case of coal particles with different moisture contents and hence different electrostatic capacities the more moist will tend to be more and the less moist less, affected by the electrostatic treatment. The terms "conductors" and "non-conductors" as applied to such a moistened coal mixture can be used only with their relative and not with their absolute significance.

If the coal particles are not previously charged they may be subjected directly to an electrostatically charged electrode or surface charged *e. g.* to 15,000 to 50,000 volts, and the particles which because of their greater water content are capable of being more readily charged will be more readily repelled and can be thus separately collected.

The electrostatic separation of the present invention can be carried out in an explosion preventing atmosphere, or under explosion preventing conditions, but owing to the presence of added moisture, there is less danger of explosion with this process. The danger from explosion is further minimized by the previous removal of the fine dust and fine mineral charcoal.

It will be evident that the process of the present invention can be repeated in part or in whole with the same coal. Thus fractions resulting from a first treatment can be subjected to a second or third treatment, or they can be subsequently again treated to develop their difference in hygroscopicity and again subjected to electrostatic separation. Such subsequent treatment may include only moistening, or moistening preceded by drying to remove previously added moisture and increase the hygroscopicity of the coal.

Coal to be used for coking purposes should advantageously be as dry as possible. Water present in coal charged into a coke oven must be vaporized before coking takes place thus lowering the temperature of the oven and requiring heat energy for its removal. Where coal has been moistened in the manner above described it is accordingly sometimes advantageous to dry the coal be-

fore utilizing it for coking purposes, an ordinary rotary drier being suitable for this purpose. Where the coal as originally mined is high in moisture and this moisture is removed by drying previous to the development of the hygroscopicities a similar economy and advantage is effected since the added moisture is mainly only on the surface of the coal particles.

The process of the present invention can be used as supplemental to or in combination with other purification processes. Some of these combinations have been already indicated. Thus the development of the hygroscopicities and the subsequent electrostatic separation can be preceded by drying, pneumatic purification, screening, and other processes of volumetric separation, etc. The electrostatic treatment for the elimination of the pyrites is particularly advantageous as a preliminary process in combination with the hygroscopic treatment and separation. The removal of fine particles of dust or of mineral charcoal or other more friable constituents *e. g.* by screening or pneumatically is also advantageous previous to the hygroscopic treatment and even previous to the first electrostatic treatment for the separation of pyritical gangue, etc. Other combinations than those herein described can also be effected both supplemental to and in combination with the separation based upon hygroscopicity.

In the accompanying drawings is shown, diagrammatically, an arrangement wherein can be carried out the process of the present invention including the preliminary treatment of the coal to remove the conductive constituents (pyrites) and the subsequent moistening or development of the differences of hygroscopicities of the different coal constituents followed by electrostatic separation of the moistened coal. It will be understood, however, that the process is not dependent upon this particular type or arrangement of apparatus which is given merely for purposes of illustration.

The apparatus shown comprises a hopper 1, which in practice is provided with feeding means (not shown) for insuring an even and regular feed of the coal therefrom, a revolving roll or electrode 2 below the hopper outlet, a small wire electrode 3, incased in glass or wood, etc., connections 4 and 5 leading from the electrodes 2 and 3 respectively to a suitable source of electrostatic energy, an adjustable partition or division plate 6 below the roll 2 and slightly in front of the same, a brush 7 contacting with the roll for removing adhering particles therefrom, and an inclosing casing 8 provided with valved discharge outlets 9 and 10 and with valved air or gas inlet and outlet connections 11 and 12. Below the outlet 10 and communicating with the same

is a second hopper 15 similar to 1 but provided with inlet and outlet connections 25 and 26, the lower of which leads from a suitable source (not shown) of moist gas or air, and the upper of which is connected with an eduction fan or other eduction means (not shown). Below the hopper 15 are roll 16 and electrode 17 provided with wire connections 18 and 19 respectively, partition 20 and brush 21, all similar in their structure and arrangement to the corresponding elements of the upper casing. A lower surrounding casing 22, is also provided, having valved discharge outlets 23 and 24.

In this apparatus the present process can be carried out as follows, the description being rather by way of illustration than of limitation. The coal in a crushed and granulated condition and freed from the fine mineral charcoal and the fine coal dust, and also if necessary from any excess moisture, is charged into the hopper 1. Generally the coal is screened and only a particular size treated at once, *e. g.* between 4 and 8 mesh, 8 and 16 mesh, 16 and 60 mesh, etc. The coal is fed from the hopper 1 in a thin stream on to the roll 2 where the more conductive particles are charged and repelled and thus separated from the less conductive coal, the conductive particles (pyritical gangue, etc.) falling to the outside of the partition 6 and being discharged through the outlet 9 while the less conductive coal falls inside the partition 6 and into the outlet 10 from which it falls into the hopper 15. The casing 8 surrounding the upper electrostatic apparatus is provided with inlet and outlet connections 11 and 12 by means of which a current of a drying, or explosion-preventing, or non-oxidizing gas can be passed through the casing, and the coal undergoing separation maintained under drying, explosion-preventing, or non-oxidizing, or all three, conditions, as desired and as more fully described in my prior application Ser. No. 737,689. The hopper 15 is connected by means of the inlet pipe 25 with a source of moist gas which may advantageously be the products of combustion of coke oven gas, which contain a large amount of water vapor resulting from the combustion of the hydrogen of the coke oven gas burned. The outlet 26 from the hopper 15 is provided with a fan or other means not shown of securing circulation of the gas through the hopper. By regulating the velocity of the moist gas relative to the flow of coal through the hopper, a greater or less amount of moisture can be condensed upon the coal particles and the difference in hygroscopicities of the coal constituents can thus be developed, the time required depending both on the rate of flow of the gas and on the difference in temperature of the gas and coal; also upon the degree of saturation of

the gas which can be decreased by diluting with a dry gas. This action of the moist gas upon the coal has been already described in detail, and it is not deemed necessary to do so again in connection with the specific form of apparatus illustrated. From the hopper 15 the moist coal is fed on to the roll 16 and separation of the more moist and more conductive coal constituents from the less conductive effected in a manner similar to that already described in connection with the upper apparatus, the more and less conductive portions being separately collected and removed through the outlets 23 and 24. There results from this specific process described four different fractions or portions of the coal, viz,—the fine coal dust and mineral charcoal removed before the coal reached the hopper 1; the rejected fraction, usually small in amount and high in ash and sulfur discharged from the casing 8 through the outlet 9; and the two coal fractions obtained in the lower casing 22 and discharged through the outlets 23 and 24, and varying in amount depending upon the differences in hygroscopicities of the different coal constituents. The rejected portion obtained at 9 may be further treated to separate impurities from the coal and the fractions obtained at 23 and 24 can be used directly or further treated, as already described more in detail.

The foregoing description of the apparatus illustrated and of the process as carried out in it is intended to be illustrative of a specific application of the invention. Variations in this apparatus and specific process, and modifications of the same and combinations with other processes can be made, as more fully hereinbefore indicated, and such modifications and combinations are included within the limits of the accompanying claims.

I claim:

1. The process of separating coal from granulated coal mixtures which comprises moistening the coal to develop the differences in hygroscopicities of the different constituents of the mixture, and subjecting the moistened coal to electrostatic separation.

2. The process of separating coal from coal mixtures which comprises crushing the mixture to such an extent that particles of different constituents of the mixture possessing different hygroscopicities are separated from each other, developing the difference in hygroscopicities of such coal particles by moistening the same while still in a freshly crushed condition and subjecting the moistened coal mixture to electrostatic separation.

3. The process of separating coal from coal mixtures which comprises crushing the coal, subjecting the crushed coal to electrostatic separation to separate therefrom con-

ductive pyritical impurities, developing in the resulting coal the difference in hygroscopicities of the different constituents by moistening the same and subjecting the moistened coal mixture to electrostatic separation.

4. The process of separating coal from coal mixtures which comprises crushing the coal, separating from the crushed coal the finer particles, moistening the resulting coal to develop the difference in hygroscopicities of the different constituents of the mixture, and subjecting the moistened coal to electrostatic separation.

5. The process of separating coal from coal mixtures which comprises crushing the coal, separating from the crushed coal the finer particles, subjecting the resulting coal to electrostatic separation to separate therefrom conductive pyritical impurities, developing in the resulting coal the difference in hygroscopicities of the different constituents by moistening the same, and subjecting the moistened coal to electrostatic separation.

6. The process of separating coal from granulated coal mixtures which comprises drying the coal, moistening the dry coal to develop the difference in hygroscopicities of the different coal constituents, and subjecting the moistened coal to electrostatic separation.

7. The process of separating coal from granulated coal mixtures which comprises moistening the coal to develop the difference in hygroscopicities of the different constituents of the mixture by passing there-through a current of moist gas, and subjecting the moistened coal to electrostatic separation.

8. The process of separating coal from granulated coal mixtures which comprises moistening the coal to develop the difference in hygroscopicities of the different constituents of the mixture by passing there-through a current of a moist non-oxidizing gas, and subjecting the moistened coal to electrostatic separation.

9. The process of separating coal from granulated coal mixtures which comprises condensing moisture upon the surfaces of the coal particles to develop the difference in hygroscopicity of the different constituents of the mixture, and subjecting the thus moistened coal to electrostatic separation.

10. The process of separating coal from granulated coal mixtures which comprises condensing moisture upon the surfaces of the coal particles to develop the difference in hygroscopicity of the different constituents of the mixture by passing there-through current of moist gas, and subjecting the thus moistened coal to electrostatic separation.

11. The process of separating coal from granulated coal mixtures which comprises

moistening the coal to develop the difference in hygroscopicities of the different constituents of the mixture, subjecting the moistened coal to electrostatic separation, and maintaining the coal during such treatment under substantially non-oxidizing conditions.

12. The process of separating coal from coal mixtures which comprises crushing the mixture to such an extent that particles of different constituents of the mixture possessing different hygroscopicities are separated from each other, developing the difference in hygroscopicities of freshly crushed coal particles by moistening the same, subjecting the moistened coal mixtures to electrostatic separation and maintaining the coal during such treatment under substantially non-oxidizing conditions.

13. The process of separating coal from granulated mixtures of bituminous coal which comprises moistening such mixtures of bituminous coal to develop the difference in hygroscopicities of the different kinds of coal contained in the mixture, and subjecting the moisture mixture to electrostatic separation.

14. The process of separating the various constituents of bituminous coal mixtures and of removing therefrom mineral charcoal which comprises crushing the coal, separating from the crushed coal the finer particles including the finer particles of the mineral charcoal, moistening the mixture to develop therein the difference in hygroscopicities of the different constituents of the mixture and subjecting the moistened coal to electrostatic separation.

15. The process of separating the various constituents of bituminous coal mixtures and of removing pyritical impurities therefrom which comprises crushing such coal to form a granulated mixture, subjecting such mixture to electrostatic separation to remove con-

ductive pyritical impurities, developing in the thus purified coal the difference in hygroscopicities of the coal constituents by moistening the same, and subjecting the moistened mixture to electrostatic separation.

16. The process of separating the various constituents of bituminous coal mixtures and of removing mineral charcoal and pyritical impurities therefrom which comprises crushing such coal to form a granulated mixture, separating from the crushed coal the finer particles including the finer particles of the mineral charcoal, subjecting the mixture to electrostatic separation to remove the conductive pyritical impurities, developing in the thus purified coal the difference in hygroscopicities of the coal constituents by moistening the same, and subjecting the moistened mixture to electrostatic separation.

17. The process of treating coal containing coal constituents of the same or substantially the same density but of different coking qualities which comprises crushing the coal to pass a 4-mesh screen, sizing the coal into fractions of the same or substantially the same size, and treating each fraction electrostatically to separate said coal constituents from each other.

18. The process of treating moist coal containing coal constituents possessing different hygroscopicities which comprises partially drying the moist coal until different hygroscopic conditions are developed in the different constituents, and subjecting the resulting coal in a granulated condition to electrostatic separation.

In testimony whereof I affix my signature in the presence of two witnesses.

FREDERIC W. C. SCHNIEWIND.

Witnesses:

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