Nov. 15, 1938. G. A. VISSAC 2,136,870

METHOD FOR DRYING AND TREATING WET GRANULAR MATERIALS

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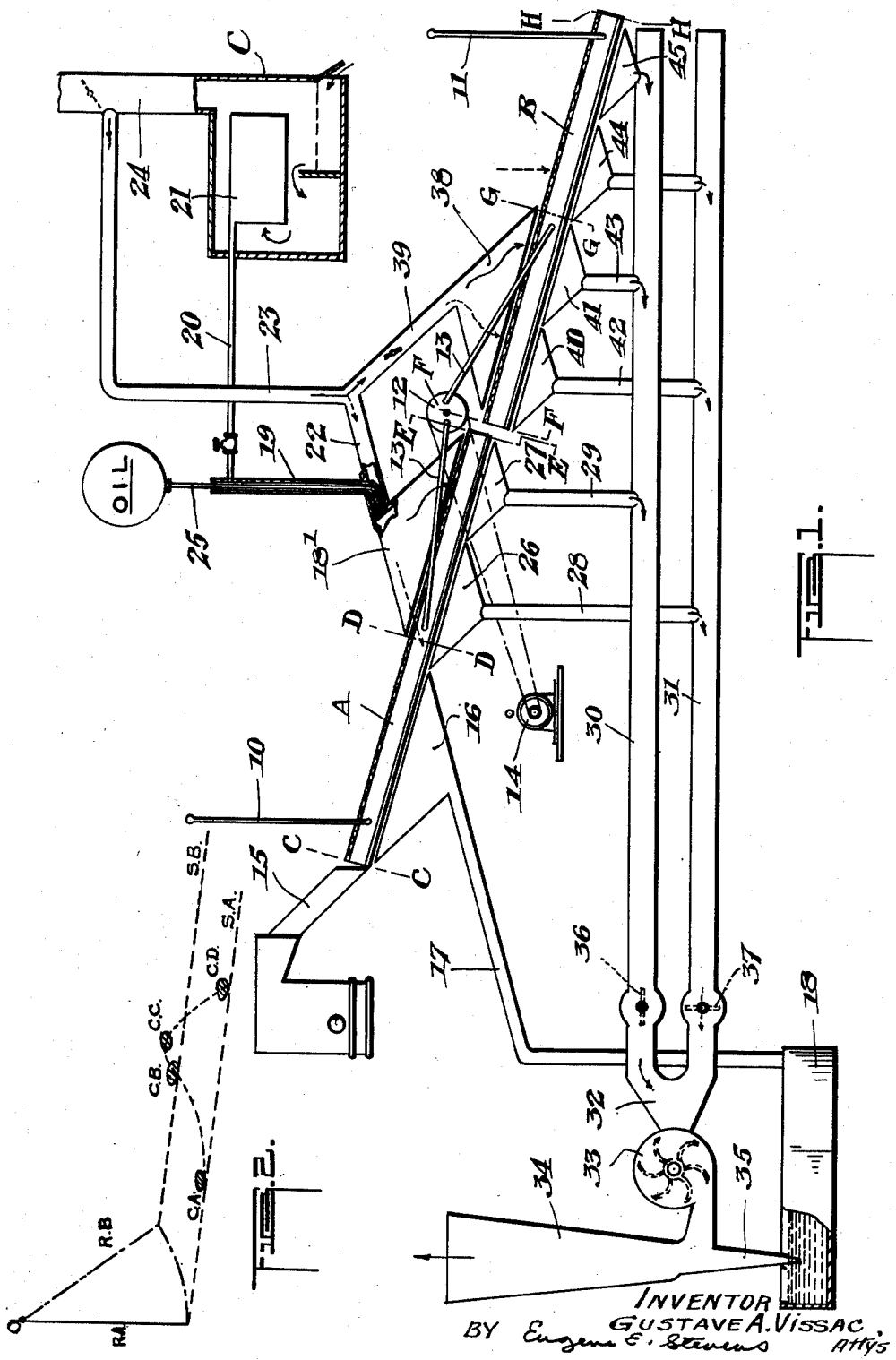

FIG. 1.

FIG. 2.

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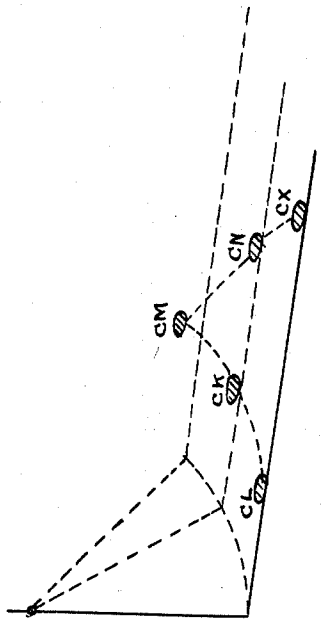

Fig. 4.

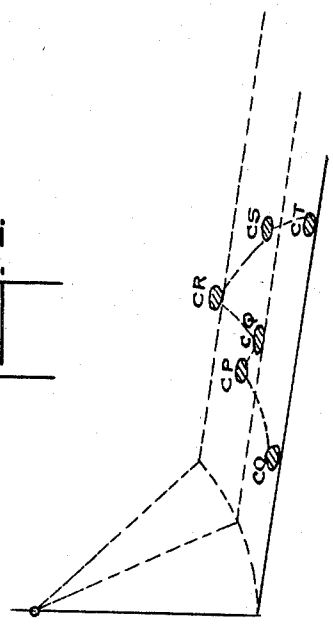

Fig. 5.

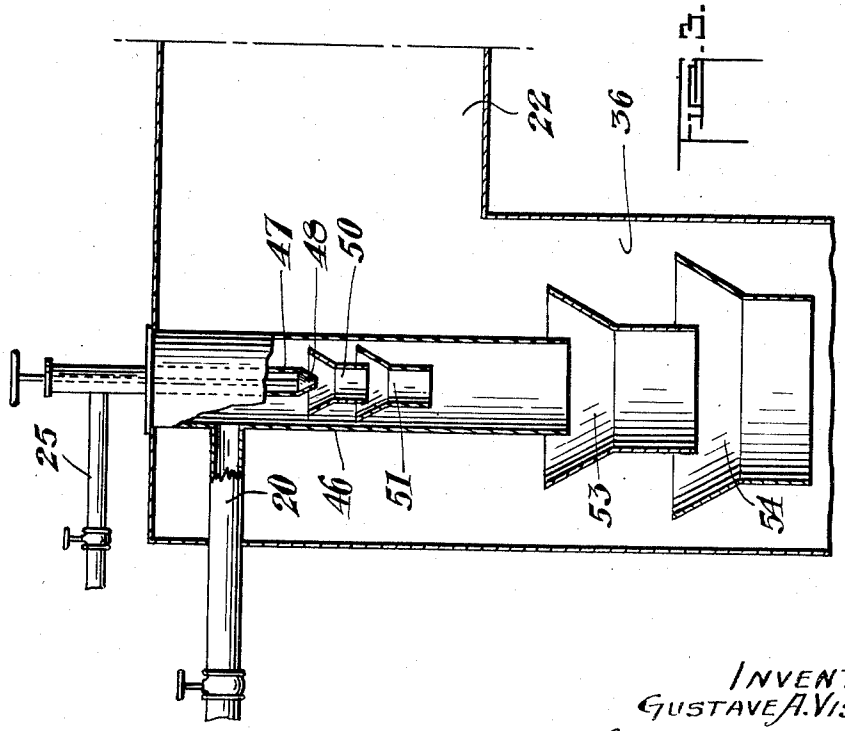

Fig. 3.

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Patented Nov. 15, 1938

2,136,870

UNITED STATES PATENT OFFICE

2,136,870

METHOD FOR DRYING AND TREATING WET GRANULAR MATERIALS

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Application August 11, 1936, Serial No. 95,419

6 Claims. (Cl. 34—24)

This invention relates to a method and apparatus for drying and treating wet granular materials, with particular reference to the drying of wet coal.

Different methods and apparatus for effecting the drying and preparation of wet granular materials have been suggested and used heretofore. However, the methods and apparatus previously employed have had serious disadvantages. Wet granular materials have been dried in vertical or rotary driers and on screens but degradation of coal, among other things is apparent in the use of rotary driers and, in other types of apparatus, there has been the difficulty of penetrating a bed of coal lying on top of a screen or conveyor with currents of air which generally tend to pack the bed and retard or prevent movement of the material. Furthermore, difficulty has been encountered in controlling the gas temperature while using ordinary types of furnaces. Lack of efficiency has, therefore, resulted.

For many years it has been the practice to treat materials to prevent deterioration and, in the case of coal, it has been well known to subject the product to an oil treatment in order to prevent deterioration and to control the dust. There has been experienced, however, difficulty in distributing the oil over the particles to render the coal dustless when properly dried.

It is an object of the present invention to provide a novel method and apparatus for drying and treating wet granular materials including coal so as to avoid apparent disadvantages in previously used apparatus and to provide in a simple manner means for the drying and treating of material quickly and efficiently.

A further object of the invention is to provide a method and apparatus which will use a minimum volume of air which may be caused readily to penetrate the bed of material being dried without materially affecting the movement of the material.

A further object of the invention is to provide for the use of heated gases for penetrating the bed of material to eliminate the moisture.

A still further object of the invention is to provide a practical way of coating the material with an agent such as oil in the case of coal treatment, by incorporating the agent with the heating gases to spray and contact all particles of the material in the bed undergoing drying.

A still further object of the invention is to provide a method and apparatus in which the various elements co-operating to effect drying and treatment are minutely controlled to such a degree as to provide for a final efficiently dried product and in a large volume comparative to the time of operation.

With these and other objects in view, the invention will be apparent upon a consideration of the following specification in conjunction with the accompanying drawings which form part of the application.

In the drawings:—

Figure 1 is a schematic side view of apparatus for drying and treating the material.

Figure 2 is a schematic view of one of the screens employed, to show the course taken by the material under normal conditions during the oscillation of the screen.

Figure 3 is a sectional view of a nozzle construction for mixing and ejecting the treating gases.

Figures 4 and 5 are schematic views to illustrate the course taken by material under conditions imposed by the proposed method of treatment during oscillation of the screen.

Referring more particularly to the drawings, A and B indicate two compensating shaker screens supported by suitable oscillatable hangers 10 and 11. The screens are preferably covered with a wire mesh, perforated plates or wedge wire screen surfaces of proper mesh and are connected to eccentrics 12 through connected rods 13 disposed preferably at an 180° angle, so that when the eccentric 12 is operated through any suitable source, such as the motor 14 the screens are subjected to opposed and continuous oscillation.

The wet granular material is delivered from the chute 15 on to screen A, which is divided into two sections CD and DE. The material, after passing over screen A, is transferred to screen B and this latter screen is likewise divided into two sections FG and GH, these sections being defined by the area between the transverse lines indicated by these various letters. On screen A the material is delivered first of all to section CD, below which is positioned a suitable hood 16 connected by a pipe 17 to a water sump 18. As the material passes over section CD, the excess moisture carried thereby is caused to pass through the screen by gravity and the momentum of the material owing to the shaking motion of the screen.

After passing over the area CD of the first screen, the partially dewatered material is moved over section DE above which is positioned a hood 18' which is connected by a pipe line 19 and 20 with the boiler 21 of a furnace C and is also connected in a suitable manner by pipe lines 22 and 23 with the flue 24 of the furnace C so that steam

and hot flue gases are discharged into the hood and pass downwardly through the bed of coal on the screen. The pipe lines connected with the hood may be arranged in any suitable manner and may take the form of pipe lines which commonly communicate with the hood as shown. Furthermore, in the case where the coal or other material being dred is also to be treated, other apparatus for treatment may be incorporated at this point. For instance, in the case of coal, if it is desired to treat it with oil, an oil line 25 may be incorporated with the pipes 19 and 22 and discharged with the gases through a suitable nozzle, as will hereinafter be described.

The steam and flue gases projected into the hood 18' serve to warm the coal and the condensed steam is shaken off and eliminated with the excess of condensed moisture of the coal. Below section DE are positioned hoods 26 and 27 communicating through pipes 28 and 29 with the conduits 30 and 31 respectively. These conduits preferably commonly communicate as at 32 with a suction fan 33 in turn communicating with an evase 34 which, through the drainage pipe 35, delivers the moisture to the water sump 18. In the conduits 30 and 31, in advance of the fan 33, are positioned pulsators 36 and 37 respectively which are disposed oppositely to one another alternately to establish connection between the fan and conduits 30 and 31 so that in a particular manner, by means of air currents, the coal is heated and the moisture is withdrawn when the coal is positioned in section DE of the screen A, as will be described more particularly hereafter.

The coal is then passed from screen A to screen B and is delivered to section FG over which is positioned a hood 38 connected by the pipe 39 with the pipe line 23 so that hot flue gases are passed to hood 38 and passed through the bed of coal lying on the section FG which was already heated in the previous section. The hot gases pass downwardly through the bed of coal and are discharged into hoods 40 and 41 which communicate by means of pipes 42 and 43 with conduits 30 and 31 respectively and are brought into communication with the fan as in the case of the prior two hoods. The hot gases pass through the bed of coal, subjecting the coal to an intense drying action, so that the moisture is largely eliminated when the coal passes from this section. As the coal moves on to section GH it is subjected to a final drying and cooling operation. In this instance it will be noted that the pair of hoods 44 and 45 are positioned beneath section GH and communicate respectively with the conduits 30 and 31. The upper side of the screen in section GH is completely open to the atmosphere so that through the action of the fan 33 cool air is drawn downwardly through the bed of coal so that a final effective drying operation takes place at this point in addition to the cooling of the coal before it is loaded into barges, etc., thus avoiding possible oxidization during transit due to a heated condition.

It will be realized from the foregoing general explanation of the apparatus illustrated that the method of drying generally consists in producing a flowing bed of the material and separating excess moisture by gravity, then preheating the partially dewatered material by steam and hot gases, subjecting the preheated material to hot drying gases and finally forcing cool air through the heated material finally to dry and cool it.

Having described the method and apparatus in a general way I will now deal with the development in a more specific sense in order that the advances made may be fully appreciated. In order efficiently to dry all the material it is essential that the steam, air or gases, penetrate the entire depth of the bed, otherwise the surface only of the bed, which comes into contact with the steam, air, or gases is dried. It has been found that if these are forced upwards through the bed, in the case of materials such as coal emerging from a wet washery, which contain a high percentage of moisture, the moisture forms into a heavy fog over the bed which the gases are unable to disperse and which later condenses and falls back onto the coal, thus nullifying to an extent the drying action of the gases. I overcome this disadvantage by subjecting the bed to downward currents of steam, gases and air, and I ensure thorough penetration of the bed by the provision of regulated air pulsations. For coal is discharged onto a shaker screen and subjected to continuous downward current of air, it packs and becomes difficult to move and the air currents cannot penetrate the bed efficiently in intimate contact with all particles of the coal. However, under the present development by the use of proper pulsations of air properly combined with the shaking motion of the screen, having regard to periods of compression and depression of the mass of coal on the screen, a free motion of the coal on the screen is obtained and the air thoroughly penetrates and intimately contacts with the coal particles throughout the bed. The same is true of the gases and steam and a treating agent such as oil, in the case of coal, if used.

On referring particularly to Figure 2, wherein the motion of the coal on the screen is illustrated, CA represents a coal particle on the surface SA. The particle CA being inert, follows the motion of the screen and reaches the position CB. After the screen has reached the position SB, it stops and then returns to SA but the coal from its momentum continues to position CC and then under the action of gravity falls to the position CD on the screen SA. Consequently for each complete oscillation of the screen the coal advances a distance equal to CA—CD. However, if during this complete oscillation of the screen, a downward current of air or gases is continuously maintained over the surface of the screen, the coal instead of leaving the screen at CB will be continuously pressed on the screen and return with it to CA. To avoid this I employ pulsating currents, which, on the contrary, are established and disestablished in such a way as not to blow down in at least part of the forward and return motion of the screen. Thus the coal will not be held on the screen but will be permitted to move to an extent such as referred to above, although the relative displacement of the coal will be slightly decreased. Therefore, according to the present development, the air and gases are intimately contacted with the particles of coal making up the bed since the air and gas can readily penetrate the bed as it is agitated and the coal continuously passes along in an efficient manner through the various stages of treatment on the screen.

As an illustration, assume the screen to be oscillating at 240 periods per minute and air pulsating at the rate of 480 pulsations per minute, this results in one quarter of a second for complete oscillation of the screen whose displacements are positive for the upstroke of the screen (compression of the coal) and negative for the downstroke (compression of the coal). Air and

gas pulsations are positive when a connection is established with the fan 33 through the pulsators 36 and 37, causing a strong current of air to be established downwards over a portion of the screen. Pulsations are negative when the pulsator is closed on the pipe line to which the particular hood considered is connected. During the closure of the pulsator there is no downward current of air on the coal in the area overlying the hood whose pipe line is closed. On the contrary, with the closure of a pulsator, a slight upward current of air is produced due to a returning wave of the air pulsation.

To illustrate the action, reference is made to Figure 1 and Figures 4 and 5, which illustrate the action of a piece of coal lying upon the screen above the hood 26, a similar action occurring above the hoods 27, 40 and 41. Upon referring to Figure 1, it will be seen that hood 26 is illustrated as connected to pipe line 31 which is closed off from the fan by the pulsator 37. Consequently, assuming that the screen is moving forwardly at this point, it will be realized that there is a negative pressure on the coal, thus when the screen moves one-half the distance of its forward movement, the piece of coal CO will reach the position CP (see Figure 5). At this point the pulsator 37 is reversed to establish a positive downward pressure of air, whereupon the piece of coal will be moved back towards the screen, reaching substantially the position CQ and, moving upward with the screen, will reach the position CR. At this point the pulsator again changes, establishing a negative or slightly upwardly directed current of air, and as the screen moves back in downstroke through one-half its movement in this direction, the piece of coal will be free and reach substantially the position CS. At this point the pulsator again changes, establishing a downward pressure of air which will cause the coal to move downwardly to reach substantially the position CT, so that during one complete oscillation of the screen under the conditions referred to the coal will move along the screen a distance substantially equal to CO—CT. The coal moves this distance in one-quarter of a second, having regard to the ratio as between the air pulsations and screen oscillations, so that during the period of one second the coal will be caused to move substantially four times this distance during which time it will be subjected to four periods of active forward motion, four periods of aeration, four periods of slightly assisting motion, four periods of slightly assisting aeration. A similar action takes place on the other half of the screen section underlying the hood 18' and overlying the hood 27, although the action of the air current is substantially reversed for the reason that the hood 27 is, as illustrated in Figure 1, in direct connection with the fan 30 due to the fact that the pulsator 36 is in the open position. Therefore, assuming that the screen is moving forwardly at this point, the coal will be subjected to a downwardly directed current during the first part of this movement.

On referring to Figure 4, it will be seen that as the screen moves forwardly a distance equal to one-half its travel the coal CL is subjected to a positive downward pressure so that it will be held on the screen and reach the position CK at the half-way mark. At this point the pulsator 36 reverses and a negative pressure is established so that, as the screen travels forwardly the last half of the distance, the coal will reach substantially the position CM. At this point downward pressure is again established so that the coal is impelled downwardly and slightly forwardly till it reaches the position CN, at the half-way mark in the downward movement of the screen, whereupon a negative pressure is again established so that it is loose on the screen and when the screen reaches the extreme lower position in its downward movement the coal will reach substantially the position CX. Consequently the coal moves a distance equal to CL—CX in a similar manner to the operation above referred to. It is apparent, therefore, that there is a constant forward movement of the coal while subjected to varying air currents and thus, in addition to securing proper motion of the coal, there is provided the most efficient conditions for heating and drying the coal as well as oiling when it is proposed to give the coal an oil treatment.

The eccentrics 12 have an adjustable stroke which provides for regulation of the total displacement of the coal, due consideration being given to losses due to compression periods to obtain the desired output compatible with the total duration of the treatment periods necessary to obtain the desired results.

An important feature of the invention resides in the fact that all the hoods under the screen are of exactly the same shape and size, so that they all can be resonators to the same notes of music or to the same air pulsations of certain periods; in other words, all harmonics.

The driving motor 14 is designed to provide a very sensitive variable speed drive and, when the system is put into operation, resonance is obtained by tuning to the ear. The adjustment of the speed of the motor permits one to catch the desired period of air pulsation for which all the air boxes or hoods are resonators. This results, therefore, in a considerable increase in efficiency; instead of air currents counteracting against each other and waste of energy, there is a considerable amplification of these air currents. Consequently maximum volumes of air are circulated for minimum of energy supplied which results in maximum efficiency in heating, drying and oil spraying when this is carried out.

The efficiency of the method and apparatus is readily illustrated by referring to operation with screens of a size to provide a width of 4 feet and lengths of 6 to 7 feet for sections CD, DE, FG and GH, which provide for a tonnage of 50 tons per hour of coals over one-eighth of an inch in size. During passage of this volume of material over the screens the moisture content was reduced on section CD down to 12 to 14% and at the end of section GH down to a moisture content of 2 or 3%.

As a result of the drying process described the coal as it is discharged is just suitable for shipment. It will not freeze in the winter time and not oxidize to any extent. However, during its transportation in barges or railway cars it is liable to deteriorate. Fines will therefore be made, thus producing an objectionable dust when the coal is delivered to the consumer. To control the dust, oil has been used for many years and may be particularly and suitably applied for the present method of treatment. Through its addition with the hot gases in the drying operation the oil, as previously referred to, is introduced through the pipe line 25 to the hood 18'. To be efficient the oiling must disseminate the oil and throw it in contact with the whole mass of the coal

equally and regularly. This is readily brought about with the introduction of the oil along with the gas during the agitation of the coal as previously described. In other words, the gases through the pulsating arrangement project through the loose mass of coal so that a large volume travels through the coal and comes into intimate contact with the whole mass. The oil is heated to a fluid and thrown under pressure by a pump as usual, but when ejected in the present process it is carried by a strong and large volume of hot gasses and by steam through the coal as the latter, when loose, is aerated and dried. In this way all particles of coal have a chance to receive a thin film of oil, and as the oiling is regular it is accompanied with a minimum consumption of oil. A relatively cheap oil can be used when it is applied to the coal as described in view of the efficient heating and spraying action which takes place.

To spray the oil in the present process a special construction may be employed, for instance, in the gas conduit **22** there will be arranged an oil ejecting construction composed of the pipe line **46**, corresponding to pipe **19** illustrated in Fig. 1, into which the oil jet **47**, controlled by needle valve **48**, is projected. Also communicating with this pipe is the steam conduit **20**. Within the pipe **46**, below the oil ejector, are positioned the mixing cones **50** and **51** through which the oil is directly ejected, the wide ends of the cones permitting the steam to intermingle with the oil. At the lower end of the pipe **36** is provided further mixing cones **53** and **54** which permit the hot gases in the conduit **22** to pass into intimate contact with the intermixed steam and oil, so that, as the mixture is projected into the hood **18'**, there is a very fine composite mixture of hot gas, steam and oil which readily penetrates the loose bed as described and contacts with the whole mass of coal equally and regularly.

Moreover, due to the fact that the oil is piped to the hood within the pipe **46**, which acts to carry the steam, the oil is readily heated to a proper degree and the construction, in addition to ensuring a good mixing, acts as a blower injector. There is no danger of the oil evaporating as an oil of high boiling point may be selected.

As an example of the air and oil consumption for conditions, sizes and tonnages as above referred to, a volume of around 25,000 cubic feet of air and gases passes constantly through the apparatus and the amount of oil used is two to three pounds per ton.

The heating system provides a marked advance and contributes to the success and efficiency of the method and apparatus disclosed. Most driers use hot gases from a furnace in coal drying as accomplished at the coal mine, and plenty of low grade and cheap coals are available and used. However, in such furnaces as the gases produced by such coal can run as high as several thousand degrees, there use introduces many problems. For instance, most coals begin to oxidize at 200° C. and this oxidization is likely to alter their coking and burning qualities and if carried further will cause ignitions or explosions. According to the present process, however, by employing steam, the heating of the combustion gases is first used to produce the steam and when the gases leave the boiler they are always at a temperature under the danger point so that they can be passed through the coal mixed with air, if necessary to obtain the desired volume, without any possibility of disadvantageous results. In view of this, quick and efficient drying is accomplished in a relatively simple type of apparatus.

As a further illustration of this in an apparatus of the dimensions above referred to, the coal advances one inch for a screen oscillation of two inches, and therefore when operating at 240 oscillations of the screen per minute, this results in the coal advancing four inches per second. Thus for a bed of a thickness packed to four inches, an output of 50 tons per hour is achieved.

It is apparent from a consideration of the various steps involved that in addition to the method of drying generally set forth, wherein a percentage of moisture is removed by gravity and the remainder successively eliminated by heating and preheating with steam and gases, drying with gas and drying with air, the method includes the subjection of material to controlled pulsations of the air which when combined with the heating provides for quick drying, as well as a steady movement of the material. On the other hand, the heating by way of steam and gases in a controlled manner constitutes an important factor. It is apparent therefore that by a combination of mechanical drying through agitation, heat exchange by steam and hot gas, and evaporation by intense gas circulation in a loose mass, as provided for in the apparatus and method described, that a very efficient operation is provided for with relatively small apparatus and small consumption of coal and power. With this, there is provided the most efficient conditions for treatment of the material, such as by oil in the case of coal, inasmuch as the oil may be readily dispersed and brought into intimate contact with the coal particles.

However, it will be realized that while coal has been used as a general illustration of the material treated, the apparatus is generally applicable to the drying of wet granular materials and that where materials are subjected to treatment by special agents, such agents might be brought into contact with the material in a similar manner to the dispersion of the oil as above referred to.

Various modifications may be made in this invention without departing from the spirit thereof or the scope of the claims, and therefore the exact forms shown are to be taken as illustrative only and not in a limiting sense, and it is desired that only such limitations shall be placed thereon as are disclosed in the prior art or are set forth in the accompanying claims.

What I claim as my invention is:—

1. The method of drying wet granular material, which comprises producing a flowing agitated bed of material, subjecting the bed to a series of controlled air pulsations applied substantially throughout the length of the bed, preliminarily separating excess moisture by gravity, preheating the partially dewatered material by forcing steam downwardly therethrough, subjecting the preheated material to downwardly forced hot drying gases, forcing air downwardly through the heated material as a cooling and final drying step, and discharging the dried cool material from the bed, said air pulsations inducing the passage of the steam, hot gases and air through the bed.

2. The method of drying wet granular material, which comprises producing a flowing agitated bed of the material and subjecting the moving bed to a series of air pulsations alternately directed to different portions of the bed and applied substantially throughout the length of the bed.

3. The method according to claim 2, in which the alternate air pulsations are applied from opposite surfaces of the bed.

4. The method of drying wet granular material, which comprises producing a flowing agitated bed of the material, subjecting the moving bed to a series of air pulsations alternately directed to different portions of the bed and applied substantially throughout the length of the bed, and forcing hot gases and steam downwardly into the bed for drying purposes and carrying the hot gases and steam through the bed into intimate contact with the particles therein by means of said air pulsations.

5. The method of drying wet granular material, which comprises producing a flowing agitated bed of material, subjecting the moving bed to a series of controlled air pulsations directed to different areas of the bed and applied substantially throughout the length of the bed, and correlating the air pulsations with the movement of the bed to amplify the air currents.

6. The method of drying wet granular material, which comprises producing a flowing agitated bed of material, producing steam by means of hot combustion gases, directing the steam downwardly to an area of the bed to preheat the material, directing the combustion gases to the bed dividing said gases, applying a portion of said gases downwardly to the bed together with the steam in the preheating operation, applying the other portion of the gases downwardly to another area of the bed as a drying operation, and finally drawing cool air downwardly through the bed as a final drying and cooling step.

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