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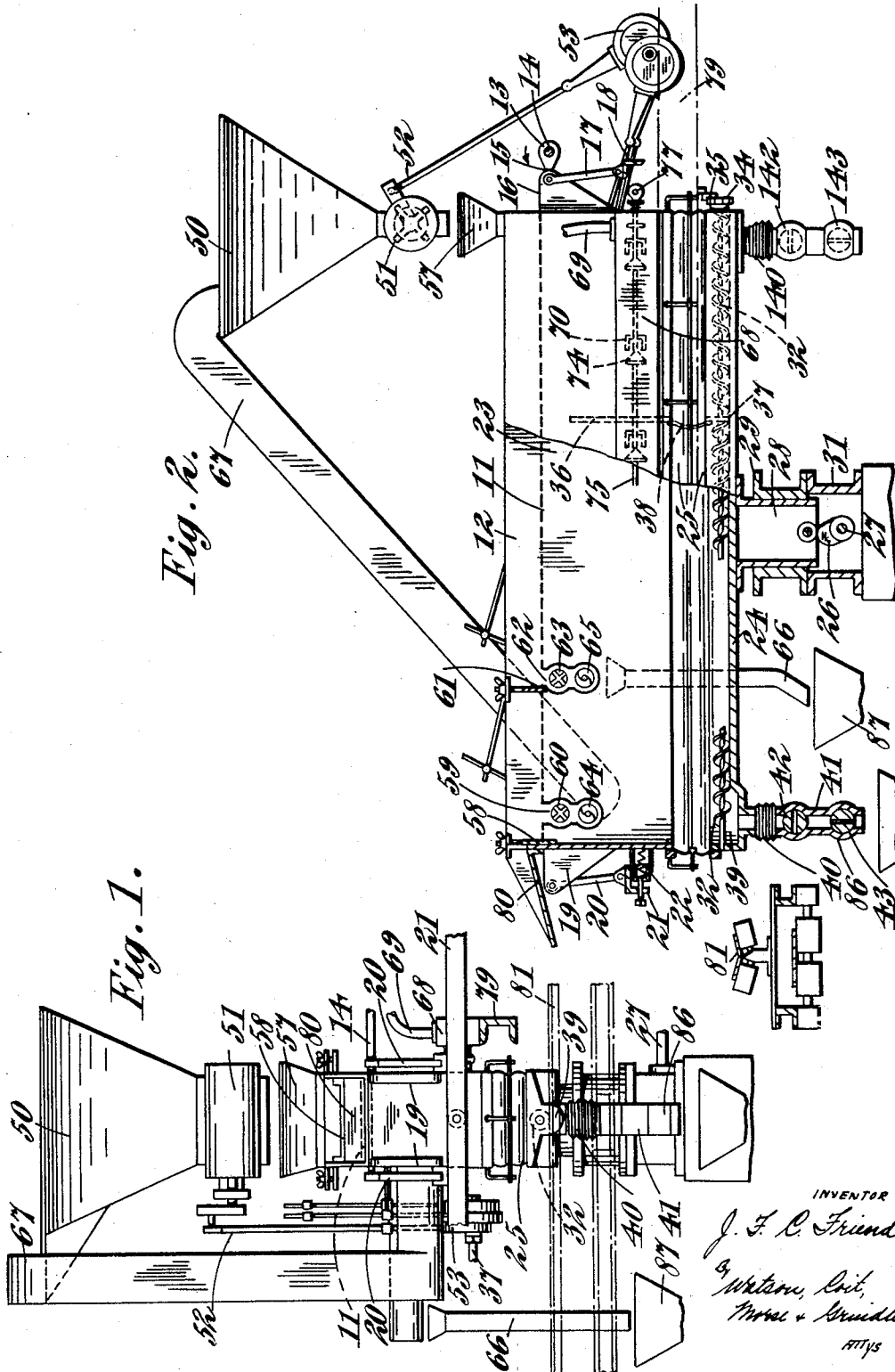
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CONCENTRATION OF MINERALS INCLUDING COAL

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2 Sheets-Sheet 1



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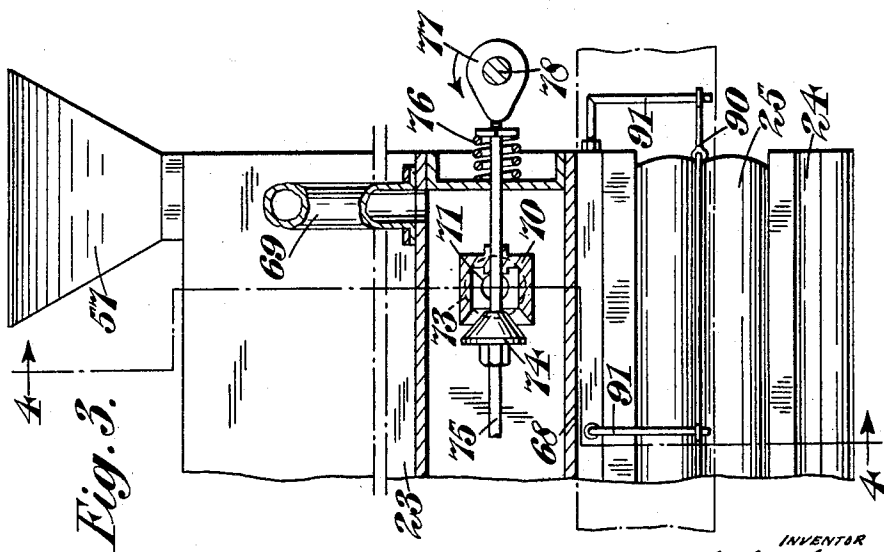
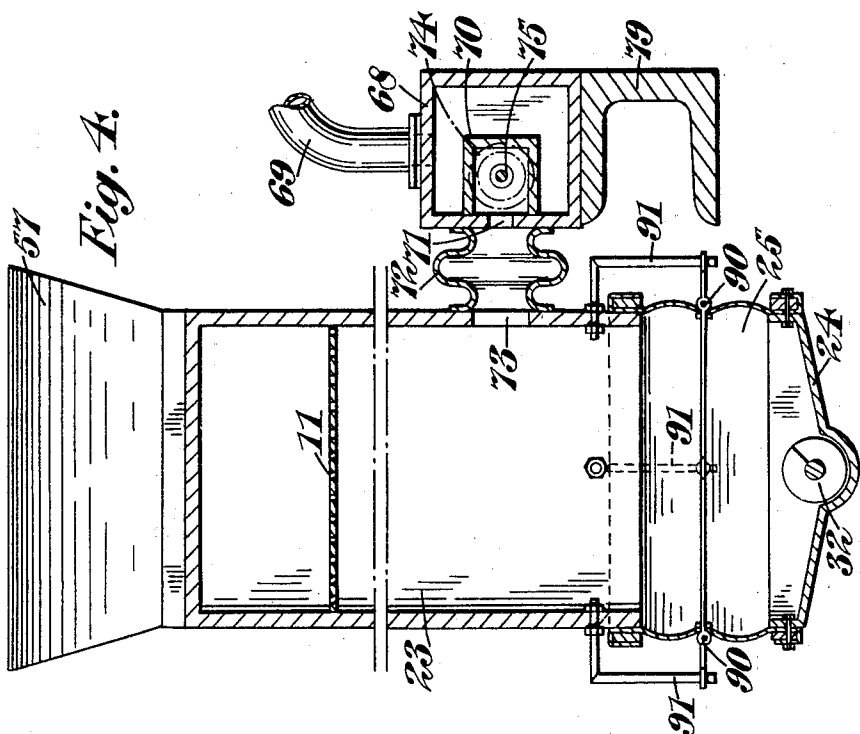
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CONCENTRATION OF MINERALS INCLUDING COAL

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2 Sheets-Sheet 2



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CONCENTRATION OF MINERALS INCLUDING COAL

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This invention comprises improvements in or relating to the concentration of minerals including coal.

It is an object of the invention to provide a process for the dry concentration of minerals and particularly coal in cases where a wet process of concentration is not desirable or possible. The process according to the present invention permits of the treatment of a wide range of sizes at one operation. It is especially advantageous in the treatment of small coal containing fines or dust.

Processes are known in which a layer of coal lying upon a perforated screen is subjected to air pressure from below such that the coal is slightly lifted or loosened by the upward passage of the air and stratification of the material into layers of different specific gravity is facilitated. It has also been suggested that the upward passage of air should be effected under a pulsating pressure. Such processes, however, suffer from a serious disadvantage as the air carries away with it fine material or dust which is difficult to recover and if left unrecovered makes the plant a nuisance to the neighbourhood. Moreover, stratification of fine material or of material of widely differing sizes is not satisfactory.

According to the present invention a process of concentration of minerals (for example coal) comprises the steps of causing a layer of mineral in subdivided form to travel horizontally in a series of intermittent advance movements, alternately distending the layer by upward movement of gas into it from below and contracting it by downward movement of gas out of it, so as to cause stratification of the mineral into layers of different components, said distension of the layer being timed to occur between said advance movements, and separating said layers from one another. (The term "horizontally" as applied to the travel of the mineral is intended to mean that the principal com-

ponent of the movement of the layer is in a horizontal direction but not that such movement may not have also a vertical component. The term "gas" is intended to include atmospheric air and it will be understood that the movement of gas referred to is relative to the coal—i. e. if desired the bed of coal may be moved so that the gas moves relatively to it.)

Not only does the downward movement of gas (relatively to the coal) assist in the stratification of the material but it tends to carry back into the material any fine mineral which might otherwise be carried away as dust. Preferably the mean upward pressure of gas acting on the mineral is less than that necessary to support the mineral in distended condition.

The mineral treated may be coal of a size less than one half-inch in linear dimensions (for example has maximum linear dimensions of one-eighth of an inch).

The invention further comprises apparatus for concentrating minerals (for example coal) having in combination a horizontally extending screen, means for causing a layer of mineral to move over the screen horizontally so as to cause material thereon to advance intermittently relatively thereto, an air chamber below the screen and a reciprocating piston in communication with the air chamber for causing alternations of positive and negative pressure therein, the positive pressure being timed to occur between the advance movements of material over the screen. Preferably the air chamber or a part communicating therewith is provided with valves for the admission of additional air, and means for operating them at predetermined points of the cycle.

In either form of apparatus the preferred method of ensuring feed of a layer of mineral such as coal across the screen consists of means for reciprocating the screen longitudinally, which means are operatively con-

connected to the means for causing alternate positive and negative air pressure below the screen so as to be properly synchronized therewith.

The following description sets forth one example of an apparatus in accordance with the invention and of the process as carried out therein. In the example reference is made to the accompanying drawings in which:

Figure 1 is an end elevation of the apparatus.

Figure 2 is a side elevation of the same, parts being broken away to show the internal construction.

Figure 3 is a detail of valve mechanism, and

Figure 4 is a further detail.

The apparatus comprises a horizontal screen or deck like a concentrator deck having upstanding side walls 12 and a perforated bottom or screen portion 11, the openings in which are small enough to maintain the layer of material upon the screen as it passes over the same. Suitable driving means is provided for oscillating the screen longitudinally in such a manner as to cause the material to be concentrated to be propelled over the screen surface. The driving means comprises a cam 13 upon a shaft 14 which engages a cam roller 15 on a bracket 16 mounted upon the end of the apparatus. The bracket 16 serves also to form a point of attachment for a swinging link 17 pivoted to a fixed frame element at 18. At the other end of the apparatus is a similar bracket 19 mounted on a swinging link 20 which is supported on a frame member 21. Between the frame member 21 and the end of the apparatus is a spring or springs 22 which serve to return the concentrator against the movement of the cam 13. Reciprocation of the concentrator by the cam 13 is therefore effected upon rotating the latter, and the shape of the cam must be made such as to impart a suitable well known jerking movement to the screen whereby the mineral is propelled forwardly in jerks over its surface.

Below the screen 11 is an inner chamber 23 which is closely fitted to the underside of the screen 11 and arranged to oscillate with the screen. The bottom of the chamber is a piston 24 of approximately the shape and size of the screen above and connected to the walls of chamber 23 by canvas 25.

Suitable cam driving mechanism 26 with shaft 27 for the piston is provided and this is so interconnected with the driving shaft 14 for the propulsive action for the screen 11 that the latter will operate to propel the material at a time when the piston 24 is moving downwards and the material is reaching a collapsed condition.

The piston 24 is mounted for vertical sliding movement upon a vertical slide 28 which

moves in a guide 29. The guide 29 is mounted on a pedestal 31 which houses the cam 26. The longitudinal movement of the screen 11 is allowed for by making the canvas 25 sufficiently loose to permit relative lateral movement between the bottom of piston 24 and the wall of the chamber 23.

The piston 24 as best seen in Figure 4 which shows it in cross-section, is of channel-shaped form with a central longitudinal trough to receive a screw conveyor 32. The screw conveyor is rotated while partaking of the vertical movement of the piston 24 by a ratchet 34 operated by a fixed pawl 35. The function of the conveyor is to discharge from the air-chamber 23 any fine material which passes through the screen 11 and to this end it delivers the fine material to a pocket 39, whence it falls through a bellows 40 into a fixed trap 41 provided with automatically operated air locks 42, 43 in series, which are opened alternately by drive chains from the shaft 27. Thus, the fine material is discharged through the valves 42, 43 without permitting passage of air through the discharge pocket 39.

As will be seen, the conveyor 32 is in two sections having threads of opposite hand so that one portion of the conveyor worm delivers towards one end of the piston 24, while the other portion of the conveyor delivers towards the other end. The latter portion delivers through bellows 140 and air locks 142, 143 similar to the bellows 40 and air locks 42, 43. The air chamber 23 is subdivided by a partition 36 at the junction between the two portions of the worm conveyor 32 and a section 37 of the partition is fixed to the piston 24 and joined to the partition 36 by a piece of canvas 38 sewn to the bellows 25.

The air locks 42, 43 and 142, 143 are suitably operated by means not shown in the drawings, for example by drive chains from the shaft 27. The operation of such devices is well understood and forms no part of the present invention.

A hopper 50 is provided for feeding subdivided material, such as fine coal to be cleaned or concentrated, on to the screen 11 at the entry end thereof in a layer of uniform thickness. The hopper 50 is provided with a measuring valve 51 at the bottom thereof operated by a variable speed drive 52 of the Humphrey-Sandberg or other type. Below the measuring valve is a subsidiary hopper 57 which delivers the material on to the screen 11.

At the exit end of the screen 11 is a weir 58 adjustable in height and lower than the thickness of material which it is contemplated the screen shall handle. Moreover, the screen stops short before the end of the air-chamber is reached by a sufficient distance to provide an exit slot 59 for refuse or heavy material. Below the exit slot 59 is a rotat-

able roller provided with a number of radial vanes 60, and rotation of the roller serves to provide means to discharge such material at a predetermined rate. The roller is provided with driving means, not shown in the drawings, suitable for rotating it at this speed. A second weir 61 is provided with a discharge slot 62 in front of it at an intermediate position on the screen 11 between the inlet end and the final discharge and this also has a rotatable vaned discharged member 63. Below the rotatable members 60 and 63 are disposed screw conveyors 64, 65. The screw conveyor from the intermediate slots 62 delivers into a reject chute 66 while the screw conveyor 64 and the final slot 59 delivers into a middlings-return elevator 67 which returns material to the hopper 50.

Alongside one of the walls of the air-chamber 23, but somewhat spaced therefrom is an air-supply duct 68 having an air-inlet pipe 69 to which air may be supplied if desired under pressure. Within the duct are a plurality of valve boxes 70 which overlie air passages 71 through the walls of the duct 68. The air passages 71 are connected through flexible leather or rubber connectors 72 to air inlets 73 in the walls of the chamber 23. Admission of air to the chamber 23 through the valve boxes 70 is controlled by valves 74 mounted upon a valve operating spindle 75 which extends in series through all valve boxes. The valve operating spindle is provided with a return spring 76 and is actuated by a cam 77 which bears upon the end of the spindle 75. The cam 77 is mounted upon a cam shaft 78 and the cam shaft 78 is connected by suitable operating means to the other actuating mechanisms of the apparatus in such a way as to maintain its proper time relation therewith. As best seen in Figure 4, the air duct 68 is mounted on a fixed channel iron 79 which forms part of the framework supporting the apparatus.

At the discharge end of the apparatus is a discharge chute 80. Below the chute 80 is a transversely running belt conveyor 81 for carrying away concentrated material.

In operation of the above apparatus material to be concentrated, say coal, is continuously fed in a condition finer than say $\frac{1}{8}$ " to $\frac{5}{8}$ " in linear dimensions into the hopper 50.

From the hopper 50 the fine coal is delivered through the valve 51 on to the screen 11 of the first portion of the apparatus. Here it forms a layer the thickness of which is determined by the rate of feed and the rate of feed is regulated to keep the thickness constant. Upward movement of the piston 24 compresses air in the chamber 23 below the screen 11 and forces air into the layer of coal above the screen so that the layer is caused to be swollen and the particles of coal become separated from one another by films

of air. During the upward movement of piston 24 the material of greater specific gravity becomes free to move in relation to that of lesser specific gravity and sinks downwardly, readily displacing particles of lesser specific gravity in its passage. At the top of the piston stroke the piston 24 is caused to pause for a time, by suitably shaping the cam 26, and this pause allows a further very beneficial differential movement of the coal particles to take place in accordance with their specific gravity, particularly in the finer sizes of particle. Thereafter the piston 24 moves downwardly causing a suction stroke which collapses the mass of coal together and at the same time carries the material of greater specific gravity in the mass of coal downwardly.

It will be seen that while the layer is distended the air moves upwardly through it and delays the falling movement of the particles and thereafter, while still distended, the air moves downwardly through it, accelerating the falling movement under gravity. This action of the air emphasizes the natural tendency of the particles of less specific gravity to sort themselves out from those of greater specific gravity without (as could an air current of constant direction) imparting a net upward or downward movement beyond that due to gravity.

The continuation of this action leads to the coal stratifying in layers of varying densities, the most dense material being at the bottom. At the weir 61 a proportion of the densest material is removed and the lighter material and middlings passes over the weir. At the weir 58 only good coal is allowed to pass over and the middlings are returned to the hopper 50 for retreatment.

Fine material, including coal dust, is stratified along with the coarser particles, and owing to the suction it is not allowed to escape from the apparatus. Some of the finer valuable material will become concentrated and pass over the chute 80 with the coarser good material. Of the rest a mixed material will pass through the first part of the screen (to the right of partition 38 in Figure 2) and is best returned to the hopper 50 for retreatment. The fine material passing through the screen to the left of partition 38 is waste or reject material.

Owing to the porosity of the coal there may be a slight leakage of air during the upward stroke of the piston 24. A small quantity of fresh air is, therefore, admitted under pressure through the valves 74 by opening them at the time when the piston is at or near the top of its stroke and more or less at rest. This small quantity of fresh air, admitted under pressure, has a useful effect in enabling the distension of the mass of coal to be maintained while the piston is brought to rest and assisting the pause, dur-

ing which distension is maintained before suction begins. The effect may be varied by suitably timing the opening of the air ports and the movement of the piston and details of the timing are best determined by practical tests in accordance with the nature of the material under treatment. The rate of feed of the material may also be varied by modifying the phase relationship of the feeding movement to the piston stroke. By these means and by carefully correlating the piston speed, piston stroke, stroke of screen, and depth of bed of material various grades of material may be concentrated with success. Clearly it will be desirable that materials to be separated, the constituents of which differ from one another in their specific gravity but little, should rest upon the screen for a longer time than in cases where the differences in specific gravity are sharp and stratification rapid. In the case of coal, a suitable depth of bed has been found to be about four inches and a suitable movement for the piston, 160 double strokes per minute, with a length of stroke of three inches.

There is, then, a combination of depth of bed, duration and intensity of suction, acceleration of upward pressure, and timing of fresh air valve, which will give the best results in each case. The apparatus will, however, give a certain valuable result within a wide range of settings.

The air passing through the mass is so small in quantity and so low in velocity that only a small quantity of the finest particles can remain suspended in it. These can be removed by passing the air through a filter or by mixing it with water in the form of mist. This operation need only be on a small scale and of low cost.

It will be understood that the accompanying drawings are largely diagrammatic, and it is possible to vary the design of the various parts and the mechanical construction of the guides, bellows, and other working elements all of which falls within the province of a skilled engineer. It would be within the scope of the invention to eliminate the bellows and piston mechanism producing alternating pulsating air pressure below the screen 11 and to substitute therefor any equivalent means of producing alternating pressure.

To prevent undue flapping of the canvas bellows 25 which tends to alter the form of the pressure-wave in the chamber 23, the canvas may be surrounded by one or more bands 90 attached to guides 91.

I claim:—

1. A process of concentration of minerals which comprises the steps of causing a layer of mineral in subdivided form to travel horizontally in a series of intermittent advance movements, alternately distending the layer by upward movement of gas into it from

below and contracting it by downward movement of gas out of it, so as to cause stratification of the mineral into layers of different components, said distension of the layer being timed to occur only between said advance movements, and separating said layers from one another.

2. A process of concentration of minerals as claimed in claim 1, wherein the mean upward pressure of gas acting on the mineral is less than that necessary to support the mineral in distended condition.

3. Apparatus for concentrating minerals having in combination a horizontally extending screen, means for reciprocating the screen horizontally so as to cause material thereon to advance intermittently relatively thereto, an air-chamber below the screen and means in communication with the air-chamber for causing alternations of positive and negative pressure therein, the positive pressure being timed to occur between the advance movements of material over the screen.

4. Apparatus for concentrating minerals as claimed in claim 3, wherein the air-chamber or a part communicating therewith is provided with valves for the admission of additional air, and means for operating them at predetermined points of the cycle.

In testimony whereof I affix my signature.
JOHN FREDERICK COOP FRIEND.