

Dec. 9, 1952

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2,621,083

APPARATUS FOR PREPARING A SUSPENSION OF FINELY-DIVIDED
SOLID IN A GASEOUS MEDIUM
Filed Dec. 22, 1948

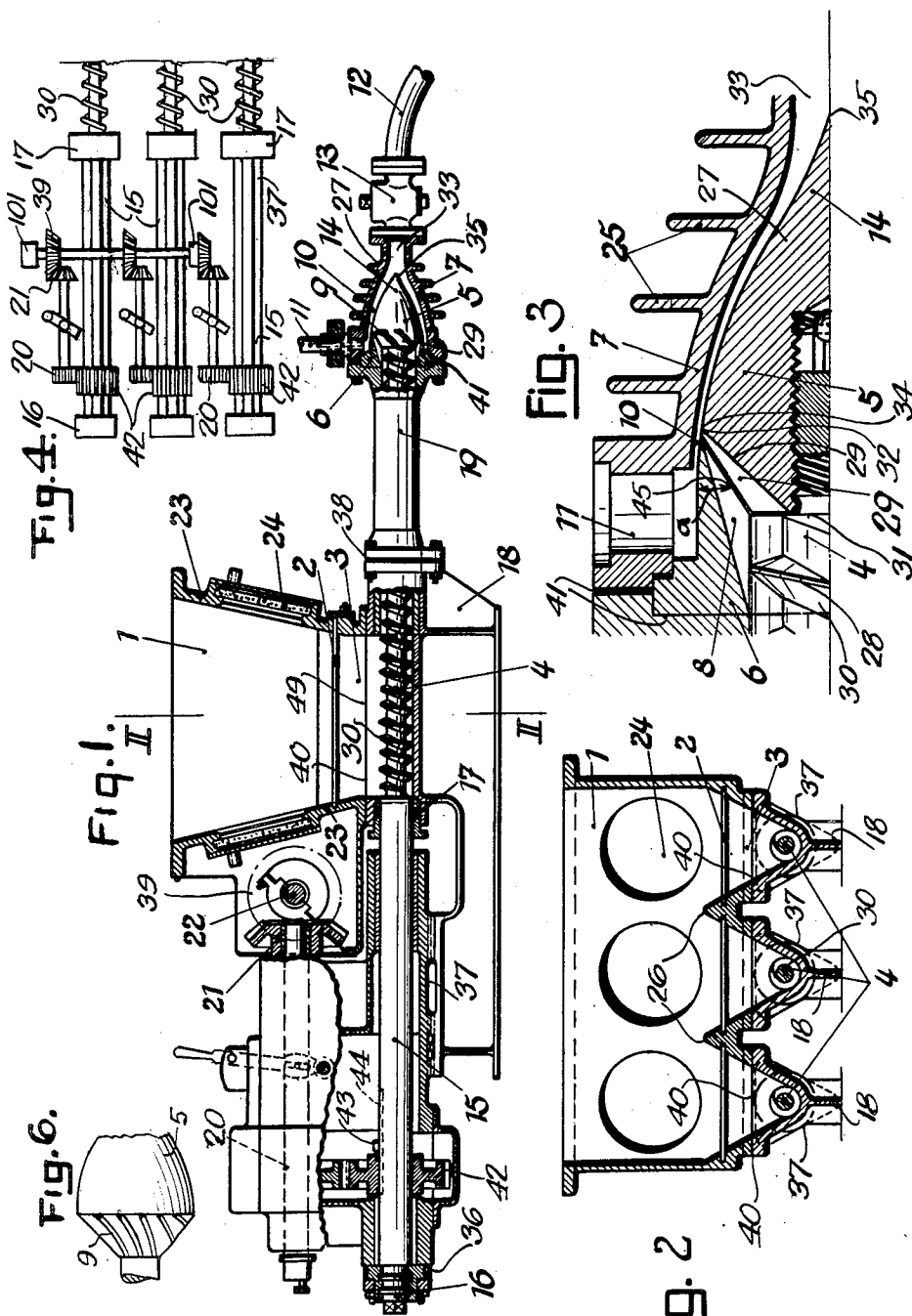


FIG. 2

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UNITED STATES PATENT OFFICE

2,621,083

APPARATUS FOR PREPARING A SUSPENSION
OF FINELY DIVIDED SOLID IN A GASEOUS
MEDIUMJoseph Daniels, Essen-Ruhr, Germany, assignor
to Koppers Company, Inc., Pittsburgh, Pa., a
corporation of DelawareApplication December 22, 1948, Serial No. 66,813
In Switzerland December 29, 1947

10 Claims. (Cl. 302—50)

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The present invention relates broadly to apparatus for preparing a homogeneous suspension of finely-divided solid in a gaseous medium and is more particularly directed to the provision of novel apparatus especially adapted for preparing homogeneous suspension of finely-divided solid combustible matter in such suspension in a therewith reactive gaseous medium that the former can be gasified by the latter to yield a gaseous product of substantially uniform composition. For example, the present invention is especially useful in a process for the continuous production, from a suspension of finely-divided solid carbonaceous fuel in free oxygen, or in oxygen-enriched air, or even in air itself, of combustible gas having substantially uniform composition and calorific value.

One of the difficulties presented by the use of known apparatus for preparing suspensions of finely-divided solid fuel in a therewith reactive gaseous medium for their subsequent employment in gasification processes to produce combustible gas has been the problem of producing homogeneous suspensions having constant and fixed proportions both of the suspended solid fuel and of the gasifying medium so that there could result from the gasification a gaseous product of constant and predictable composition.

An object of the present invention is therefore to provide improved species of apparatus adapted to furnish a thorough and intimate mixing between the finely-divided solid fuel and the gaseous medium in which it is to be suspended and thereby to form a practically homogeneous mixture of said components that has a uniform composition.

A further object of invention is to provide practical apparatus whereby the formed homogeneous suspensions can be delivered to a point of use while retaining their homogeneous composition.

The invention has for further objects such other improvements and such other operative advantages or results as may be found to obtain in the apparatus hereinafter described or claimed.

The problem of preparing an intimate mixture of a finely-divided combustible in a therewith reactive gas is not new; it arises, for example, both in the technology of the gasification of finely-divided solid fuel to produce combustible gas and also in the technology of heating with powdered fuel where complete combustion of the fuel is the desired purpose.

For the latter said application, various systems of preparing a mixture of pulverized solid fuel

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and, for example, air and of feeding the so-formed mixture to a combustion zone have been designed and successfully operated. For example, it has been proposed to employ a screw-feeder to deliver powdered coal from a storage therefor to a mixing device in which the powdered coal is dropped by gravity from the end of the screw-feeder into an opening in the top of a mixing apparatus wherein it is mixed with air at low pressure.

In another known arrangement, the powdered fuel descends by gravity from a hopper into a screw-conveyor which is driven by a variable speed motor; at its discharge-end, the housing of the conveyor-screw is surrounded by an annulus into which air is blown and this air and the powdered coal, delivered by the conveyor-screw, are mixed by paddles arranged on the discharge-end of the shaft of the conveyor-screw before the suspension is delivered to its point of use. The afore-described and similar apparatus may be adequate for the special requirements for powdered-fuel underfiring or combustion, but it is obvious that a continued and positive homogeneous mixing of the finely-divided solid with the gaseous medium cannot be achieved because no means are provided for loosening-up and re-dispersing coal particles that can be agglomerated into a relatively lumpy condition as they travel under some pressure through the housing of the screw-conveyor. In order to correct this condition, it has also been suggested to arrange at the outlet of the conveyor-screw a friction arrangement that breaks-up any lumps of the agglomerated powdered fuel without reducing the size of the coal particles before they pass into contact with a blast of transporting air. However, such transporting current of air is brought into contact with the deagglomerated coal particles by means of a current of air that flows at right angles to the axis of the conveyor-screw. In result, despite the action of said friction arrangement in breaking-up agglomerated lumps of the powdered fuel, formed during its traversing of the screw-conveyor, a satisfactorily homogeneous suspension of powdered solid fuel in the stream of air does not result because the fuel particles are not moved away from each other but rather into contact with each other under the influence of the flowing air stream.

According to the present invention in apparatus for the above-stated purpose, an important feature comprises providing, for the introduction of finely-divided solid fuel into a stream of a transporting gas, thereby to form a suspension of

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the former in the latter, of a screw-conveyor that at its discharge end is equipped with a sort of triturating or rubbing apparatus that comprises a rotor and a stationary annular co-acting member. The latter is affixed to the housing for the conveyor-screw whereas the former (the rotor) is attached to the conveyor-screw itself at its discharge end, the two said features co-acting as a sort of grinding mechanism. Around the periphery of the said stationary annular member there is disposed an annular nozzle for emitting a stream of a gas, such as free oxygen, or oxygen-enriched air, that not only picks up the finely-divided solid fuel at the periphery of the triturating apparatus but also carries it along in suspension while continuously flowing in a direction that is substantially parallel with the axis of the conveyor-screw; the formed suspension thereafter flows into an extension of the housing of the conveyor that encases said triturating apparatus; the said housing extension is itself also connected with a conduit leading to reactor apparatus wherein the suspension is further treated or reacted.

In the accompanying single sheet of drawings forming a part of this specification and showing for purposes of exemplification a preferred apparatus in which the invention may be embodied and practised but without limiting the claimed invention specifically to such illustrative instance or instances:

Fig. 1 is a longitudinal view in elevation with parts in section;

Fig. 2 is a section taken along the line II—II of Fig. 1; and

Fig. 3 is an enlarged section of a portion of Fig. 1.

Figure 4 is a diagrammatic top view of the left hand side of the apparatus of Figure 1 illustrating the independent feeds.

Figure 5 is a vertical cross-section of stationary annulus 6 of Figure 1, illustrating ribs or teeth 8.

Figure 6 is a front view of a portion of rotor 5 of Figure 1, illustrating the ribs or teeth 9.

Referring now to the drawings; the finely-divided solid fuel, or the like, from which is to be made a suspension in a gaseous medium, flows from a storage therefor (not shown) by gravity into a collecting hopper, 1, which is subdivided at its lower part by suitable partitions 26 into three outlet compartments, 3, of which each is provided with an individual sliding valve 2 that controls the descent of the finely-divided solid fuel into its associated outlet compartment. Each of the compartments, 3, is provided with a thereto individual conveyor-screw, 4, which transports the finely-divided solid fuel to a mixing device 27 disposed at the outer end of each conveyor-screw. Each of the conveyor-screws 4 is arranged to be driven independently as hereinafter illustrated.

The mixing device 27 arranged at the end of each conveyor-screw 4 comprises a triturating apparatus that itself comprises a rotor, 5, and a stationary annulus, 6, that coact to break-up agglomerations of the finely-divided fuel formed during its traversing of the conveyor-screw housing. The rotor, 5, is somewhat pear-shaped and at its widest part has a greater cross-section than that of conveyor-screw, 4, to which it is affixed at its outer end and with which it integrally rotates; the stationary annulus 6 is fixedly supported in the housing 19 for the conveyor-screw. Both the rotor 5 and the annulus member 6 are furnished at their adjacent surfaces with simi-

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lar projecting helical ribs, respectively 9, 8, as is clearly evident in Fig. 1. The helical ribs on one of said members are right-handed whereas those on the other member are left-handed, as shown in Fig. 5, so that rotation of the one member in respect of the other moves finely-divided material passing therebetween toward their circumferences in the manner common in milling practice.

The function of this triturating apparatus of the mixing device is, as aforementioned, to redisperse or break-up agglomerations of the finely-divided material, that may result from its compacting during passage through the transporting conveyor and before it comes into contact with the transporting current of gas in which it is to be suspended. This elimination of compacted clumps or agglomerates is preferably effected without further reduction in grain size of the finely-divided material, such as solid fuel.

The outer periphery of the stationary annulus 6, in combination with casing member 7 of the mixing device forms an annular orifice 10, as is clearly shown especially in Fig. 3, of which the free cross-section or clearance is dependent upon the external diameter of the employed stationary annulus 6. This annular orifice 10 is another feature of the mixing device and it communicates with conduit 11 whereby the employed gaseous medium is delivered thereto under pressure by means of a control-valve (not shown).

In operation of the apparatus of invention, as will be understood by reference to Fig. 3, the finely-divided solid material that is transported by rotation of the conveyor-screw 4 is delivered to the above-described triturating unit wherein it is finely dispersed, preferably without any additional reduction in grain size, by passage between the helically curved ribs 8, 9, of the members respectively 6, 5, which decrease in depth toward the orifice 10. At the moment it is discharged into the annular orifice 10, the finely-divided and dispersed solid material is moving along flow paths lengthwise of the axis of screw 4, and is picked-up and carried along in the stream of employed gaseous medium that is delivered from conduit 11 under pressure along flow path lines in substantial parallelism with the axis of the screw conveyor 4 into the annular orifice 10 and from which orifice the solid and gaseous medium is discharged in substantial parallelism with the axis of the conveyor-screw 4; a practically homogeneous suspension of the finely-divided solid material in the gaseous medium is thus produced that flows along into the widening interspace between the rotor 5 and the casing 7. In its preferred embodiment, the shape of the triturating apparatus is such that the discharge of the gaseous medium from the annular orifice 10 creates an injector or aspirator effect whereby the passage of the finely-divided material through the triturating apparatus is facilitated as the material discharged therefrom is picked up by the gaseous stream and carried along therewith. To effect this end, as is clearly apparent in Fig. 3, the working surfaces of the triturating apparatus are cone-like, so that they meet the annular orifice 10 at an acute angle (designated by α in said drawing) i. e., the inner conical contour 29 of the rotor 5 is just beyond the terminus 28 of the vanes 30 of screw 4 with the apex 31 of the conical contour 29 intermediate the base 32 of the inner conical contour 29 and the end 28 of the screw vanes 30.

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The interior of the casing 7 of the mixing device tapers increasingly from annular orifice 10 towards the outlet in front of the control valve 13 that regulates the flow of the formed suspension through delivery-pipe 12 whereby it flows to further treatment. In order to avoid within the casing 7 any dead space where solid of the formed suspension might be deposited, the rotor 5 at its outer end has a pear-shaped or outer conical contour extension 14, so formed that the aggregate of the free cross-sectional area between said extension 14 and the casing 7 is at any cross-section substantially equal in diameter to the diameter of said casing or suspension outlet duct 33 at its tapered end, and the base 34 of the outer conical contour 14 is intermediate the base 32 of the inner conical contour 23 and the apex 35 of the outer conical contour 14.

The conveyor screw 4 is mounted freely to rotate in its cylindrical housing 19; for this purpose, its unthreaded portion 15 has a shaft-like form that is supported at its outer and inner ends in bearings, respectively, 16, 17; the bearing 16 is adapted to take up any axial thrust arising from operation of the conveyor-screw and can be adjusted from outside the apparatus as conventional, as by insertion of washers or rings, as at 36. By means of this arrangement, no bearing or stuffing-box is required either at the discharge-end of the conveyor-screw 4 or adjacent the aforescribed rotor member 5 located at its discharge-end. This construction is of special advantage in those instances where finely-divided combustible material is being mixed with pure oxygen or with air highly-enriched in its content of oxygen.

The bearings 16, 17 for each of the conveyor-screws 4 are mounted in a thereto individual housing 37 and support 18 upon which is attached by flanges 38 the cylindrical housing 19 for the end portion of the conveyor-screw beyond the hopper 1. The housing 37 and support 18 also support a coupling device or clutch 20 as well as the bearing for bevelled gear wheel 21 that is driven by means of a gear 39 on the drive-shaft 22 from any appropriate source of power; for example, a variable speed motor. Drive shaft 22 rotates in bearings 101 by means of this construction, when for example, three conveyor-screws are disposed closely adjacent and deliver from a single hopper 1, as shown in Fig. 2, and when a common driving-means 22 is employed for them, it is possible to detach any one of the three conveyor-screws and dismantle it without disturbing operation of the remaining conveyor-screws. To accomplish this purpose, for example, the slide-valve 2 for the concerned conveyor-screw 4 is closed and thereafter the housing 37 and its support 18 and the body 23 are disconnected from each other on parting line 40 as well as the connection between the casing 7 of the mixing apparatus and the conveyor-screw cylinder 19 on parting line 41. Thereafter, the housing 37 and its support 18 and the conveyor-screw mounted therein can be removed from the rest of the apparatus, i. e., from under hopper body 23, leaving the other screws in place. At the same time bevelled gear 21 is disengaged from connection with drive-shaft 22 and the bevelled wheel 39 attached thereto, shaft 22 being fixed to hopper structure 23, while 20, 21, etc. are fixed to and move with housing 37 and support 18. This accomplished, the connection between the cylindrical housing 19, and the housing 37 and its support 18, can be broken on parting line 41 by removal of their

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joining bolts, shown in Fig. 1, and after removal of the bearing 16 and removal of the rotatable head 5 by unscrewing it from screw 4, the associated conveyor-screw and its shaft-like portion 15 can be removed from the housing 37 and its support 18 by removing the same to the left.

It will be understood of course that mechanics skilled in the art of machinery would first release gear 42 by removing the key 43 from the key slot 44, and as conventional with machinery, the parts are put together with a slight clearance for removal and adjustment.

Alternatively, the screw 4 can be removed without removing the housing 37, by detaching casing 7 on parting line 41, removing the head from screw shaft 4, then removing bearing 16 and key 43, whereupon the screw shaft 4 can be withdrawn from housing 37 through the end where the bearing 16 was attached, thus leaving housing 37 and support 18 in position on the apparatus as a whole.

Also adjustment of the screw shaft 4, to the right or to the left of Figs. 1 and 3, can be made without detaching casing 7, and without removing head 5, by merely removing key 43 and bearing 16, then adjusting shaft 15 to the right or left, to adjust the size of the space 45 between teeth 8 and 9, whereupon key 43 is replaced and bearing 16 is restored with insertion or removal of washers, or the like, at 36 to maintain the adjusted setting.

To facilitate free movement of the finely-divided material downward in the hopper 1, porous ceramic plates 24 are provided in its walls and through these plates a suitable inert gas is blown, thereby maintaining the contents of the hopper in an agitated or fluffy condition that avoids material bridging in the hopper.

In order to dissipate heat of friction that may develop inside the casing 7, it is advantageous to arrange heat radiating ribs 25 or other suitable cooling means on its outer surface.

The term oxygen as employed in this specification is employed to designate not only pure oxygen or air of enriched oxygen content, or even air itself, but also other gaseous media whether or not they are capable of reacting with the finely-divided solid material with which they are to be admixed.

The above described apparatus is of special utility for preparing homogeneous suspensions in gaseous media from such finely-divided carbonaceous materials as, coal, brown-coal, lignite, peat, or the like, and also from such non-carbonaceous materials as, for example, finely-divided sulphur.

The invention as hereinabove set forth is embodied in particular form and manner but may be variously embodied within the scope of the claims hereinafter made.

I claim:

1 Apparatus for suspending finely-divided solid material in a gaseous medium comprising, in combination: a conveyor having a housing and a mechanically operative conveyor screw therein for transporting finely-divided solid from a storage therefor; and a mixing device disposed at the discharge end of said conveyor screw comprising, a rotor head fixed to the conveyor screw for coaxial rotation therewith, said rotor head being disposed beyond the terminus of the flights of the conveyor screw and having an inner conical contour and an outer conical contour, the apex of the inner conical contour being located between the terminus of the screw conveyor

flights and the base of the inner conical contour, and the base of the outer conical contour being located between the base of the inner conical contour and the apex of the outer conical contour, an annular member in fixed relation coaxially of the screw and of the inner conical contour of the rotary head, said annular member surrounding the terminal flights of the screw and the inner conical contour of the rotor head with a clearance and said annular member extending from the outer circumference of the terminal flights of the conveyor screw toward the inner conical contour of the rotor head and terminating at the region of greatest diameter of the inner conical contour to form an annular outlet with the latter at the region of greatest diameter of the inner conical contour for flow of finely-divided material from the screw, up over the inner conical contour and annularly out through the outlet in the form of a continuous annulus of dispersed solids about the circumference of the inner conical contour in a direction outwardly crosswise of the plane of the outer conical contour of the rotary head, an annular casing enclosing the annular member and the rotary head with the annular outlet therebetween, said casing being spaced from the annular member and the outer conical contour and terminating in a suspension outlet duct beyond the apex of the outer conical contour, the aggregate of the free cross sectional area between the outer conical contour and said casing being, at any cross-section, substantially equal in diameter to the diameter of the suspension outlet duct, an annular channel surrounding said annular member at a region in advance of said annular outlet for inflow of gaseous medium, and restricted orifice means of less cross sectional area than the annular channel and the cross sectional area of the space between the outer casing and the outer conical contour for flow of gaseous medium from the annular channel into said space, said restricted orifice means being arranged circumferentially around the annular member between the annular channel and the annular outlet and disposed to discharge the gaseous medium from the annular channel linearly into the space between the outer casing and the outer conical contour in a direction crosswise of the annular outlet between the annular member and the inner conical contour for flow of finely-divided solid from the annular outlet down along the space between the outer casing and the outer conical contour to the suspension outlet duct.

2. Apparatus as claimed in claim 1, and wherein the co-acting space between the fixed annular member and the rotary head of the mixing device is decreasingly inclined in the direction toward the annular outlet, so as to create an aspirator injector effect in said space.

3. Apparatus as claimed in claim 1, and wherein the housing of the mixing device is provided with cooling ribs.

4. Apparatus as claimed in claim 1 and wherein the co-acting contiguous surfaces of the fixed annular member and the inner conical contour of the rotor head of the mixing device are each provided with helical ribs.

5. Apparatus as claimed in claim 1, and wherein the fixed member of the mixing device forms the terminus of the housing for the con-

veyor-screw and is detachable relative to the remainder of the housing.

6. Apparatus as claimed in claim 1 and wherein a plurality of said conveyor-screw and mixing device units communicate with a common supply-hopper for the finely-divided solid material, each unit being sealable off from and removable from the common supply hopper independently of the other units.

7. Apparatus as claimed in claim 1 and wherein a plurality of said conveyor-screw and mixing device units communicate with a common supply-hopper for the finely-divided solid and each conveyor-screw can be dismantled independently of another of the plurality thereof, thereby affording continuance of operation of the hopper and the rest of the others of the conveyor screws and mixing devices during removal, repair, or stoppage of any one of them.

8. Apparatus as claimed in claim 1 and wherein a plurality of said conveyor-screw and mixing device units communicate with a common supply-hopper for the finely-divided material and the drive for each of the plurality of conveyor-screw and mixing device units comprise a common drive shaft with an independently disengageable clutch-coupling for the respective conveyor screws.

9. Apparatus as claimed in claim 1 and wherein the rotary member of the mixing device is mounted at the discharge-end of the conveyor-screw and both the discharge end part of the conveyor-screw and the rotary member are supported in cantilever fashion and the opposite end of the conveyor-screw is supported in an externally accessible bearing for adjusting its axial thrust.

10. Apparatus as claimed in claim 1, and in which the hopper outlet is subdivided into a plurality of outlet compartments, and in which each outlet compartment is provided with an individual valve for shutting off flow of material from the hopper to the respective compartments and are also individually provided with a screw-conveyor and mixing device as aforesaid, the latter comprising an axially adjustable shaft having a free floating screw flight portion with part of the flight portion within the outlet compartment, and a part of the flight portion extending beyond the outlet compartment between the same and the mixing device, a plain shaft portion extending beyond the outlet compartment in the opposite direction from the mixing device, and bearings for the plain portion of the shaft forming a cantilever support for the same with the screw portions out of contact with their housings.

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