Aug. 5, 1958 D. V. SHERBAN 2,845,883

CLASSIFICATION OF GAS ENTRAINED FUEL PARTICLES

Filed June 10, 1950 3 Sheets-Sheet 1

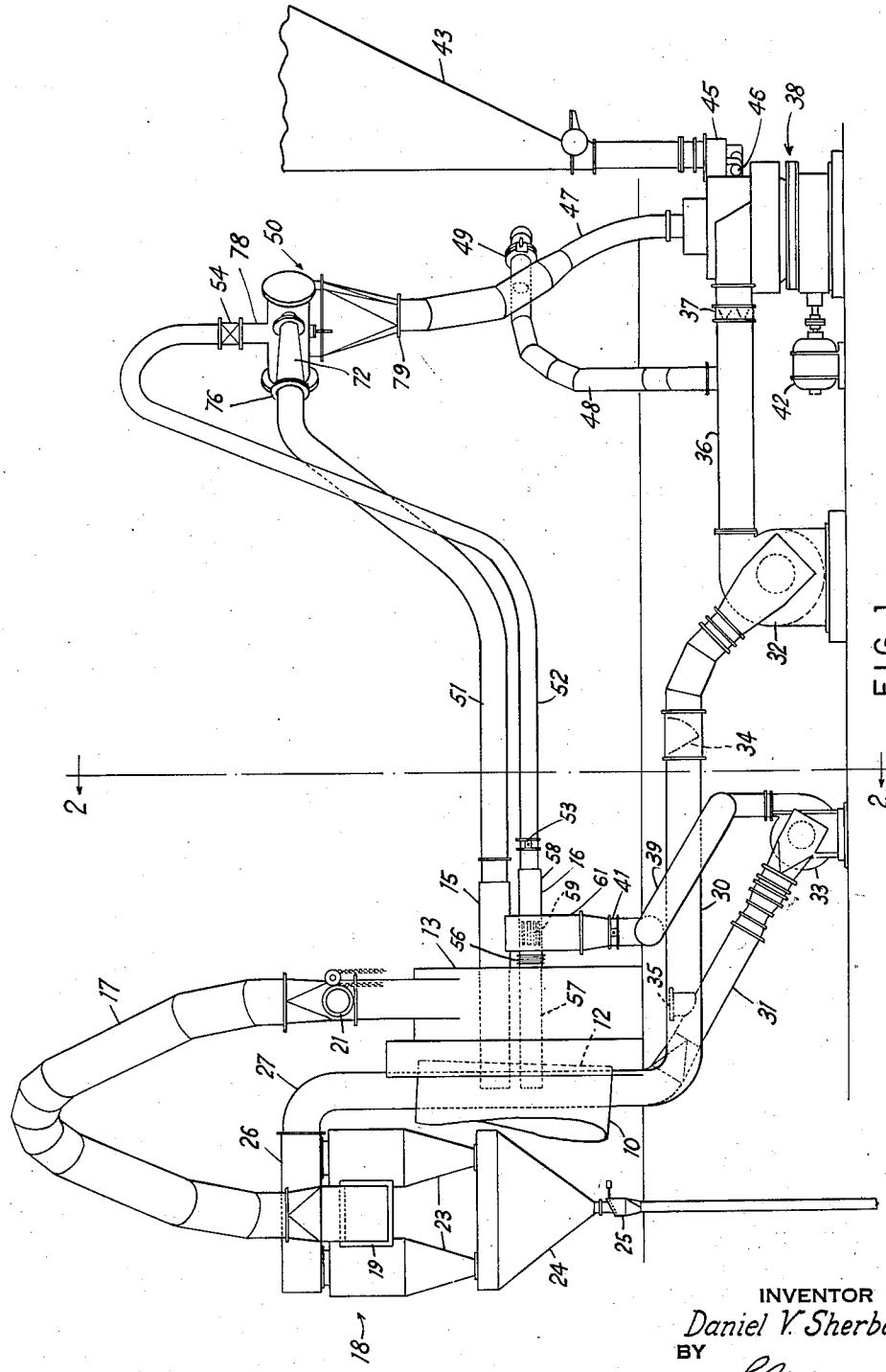


FIG. 1

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CLASSIFICATION OF GAS ENTRAINED FUEL PARTICLES

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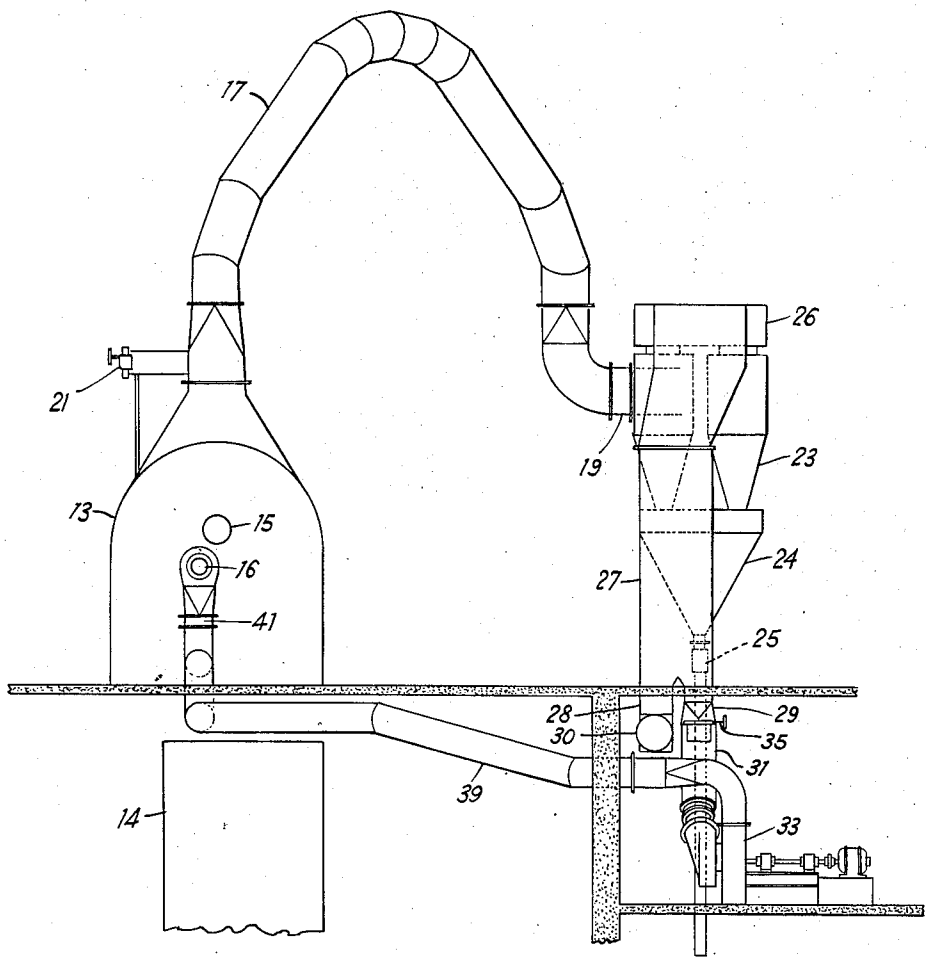


FIG. 2

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CLASSIFICATION OF GAS ENTRAINED FUEL PARTICLES

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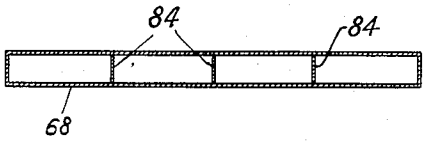


FIG. 6

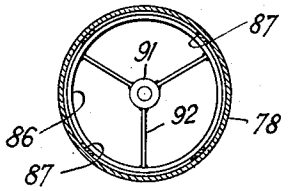


FIG. 5

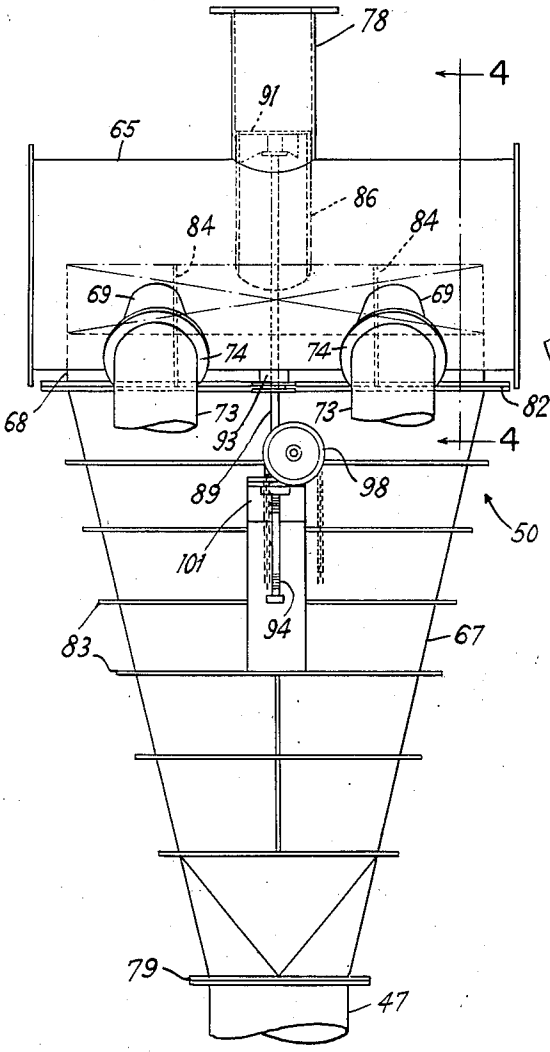


FIG. 3

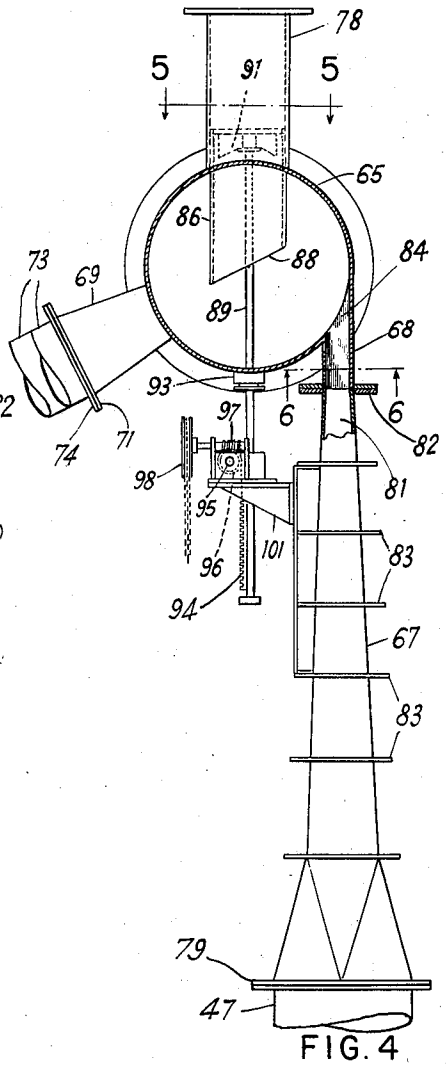


FIG. 4

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CLASSIFICATION OF GAS ENTRAINED FUEL PARTICLES

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Application June 10, 1950, Serial No. 167,349

6 Claims. (Cl. 110—106)

The present invention relates in general to the classification of gas entrained fuel particles and more particularly to the construction and operation of a combined classifying and distributing apparatus associated with, or adapted for use in, a pulverized fuel firing system. As herein disclosed, the invention is suitably embodied in a direct firing system wherein a stream of pulverized fuel and air from an air swept pulverizer is divided into separate streams of different classification with respect to the density and/or fineness of the fuel particles entrained therein, and the separate streams are discharged through separate burners into a common combustion chamber for developing dissimilar combustion zones therein. The invention is specifically applicable to a process for heat treating high grade iron are fines which formerly have been lost in the process of making steel, the purpose of the heat treatment being to effect a sintering or semi-fusion of the undersized ore particles so as to form round, hard nodules which may be transported and later used in blast furnaces in the manufacture of steel. The nodulizing process is carried out in a horizontally extending rotary kiln into which the iron ore fines are fed at one end and the nodules are discharged from the opposite end. The fuel is directed into the kiln from the material discharge end, and thus in countercurrent relationship to the movement of material therethrough.

In the firing of a rotary kiln for the heat treatment of materials, it is frequently desirable to regulate combustion conditions within the kiln so as to develop zones of different temperatures and thereby provide different rates at which the material is heated in the different zones. In the present instance wherein a rotary kiln is used for progressive heat treatment of mineral particles so as to cause them to be discharged in modified, nodular form, it is desirable to maintain a very high temperature zone adjacent the material discharge end and a relatively lower temperature zone at locations spaced from the discharge end. Such different temperature zones can be established and maintained by burning fuel which will develop the necessary different flame characteristics at the respective spaced locations, by the difference in the ignitibility of the fuel-air mixture discharged by different burners.

In accordance with the present disclosure, pulverized fuel is supplied to two separate burners from a common pulverizing source, namely, an air swept pulverizer. One burner is arranged to develop a high temperature zone at or directly adjacent the material outlet end of the kiln and is supplied with a fuel-air mixture having a relatively high flame propagation characteristic due to the relative fineness of the entrained fuel particles. The second and larger capacity burner is arranged to develop a lower temperature zone and is supplied with a fuel-air mixture having a relatively low flame propagation characteristic due to the relative coarseness of the entrained fuel particles. Both burners extend into the kiln at approximately equal distances. The second burner however discharges into the kiln at a location above the axis of rotation whereas the first burner discharges at a location below the rotational axis, and closer to the layer of material along a lower wall portion of the kiln.

The lower burner which is supplied with the stream of fuel having the higher rate of flame propagation, due to the relative fineness of the entrained fuel particles, is also supplied with the amount of additional air necessary to effect complete combustion so as to result in a relatively short flame and the maintenance of a high temperature heating zone confined to a region adjacent the material discharge end. The upper burner which is supplied with the stream of fuel having the lower rate of flame propogation, due to the relative coarseness of the entrained fuel particles, provides a relatively long flame of somewhat lower temperature which extends into the kiln a much greater distance than the more intense flame from the lower burner. The lower burner, or both burners if necessary, may be water cooled for protection from the heat of combustion.

The combination classifier and distributor which is interposed between the source of air-borne fuel and the conduits leading to the respective burners, is of a particularly advantageous form since it enables the relative fineness of the material flowing in the two burner streams to be differentiated and adjusted; the apparatus also being of simple construction and operable with a low pressure drop.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is an elevational view of a pulverized fuel firing system embodying my invention;

Fig. 2 is a sectional view of the illustrated system taken along line **2—2** of Fig. 1;

Fig. 3 is an elevational view of fuel classifying apparatus included in Fig. 1;

Fig. 4 is a side view of the apparatus shown in Fig. 3, partly in section along line **4—4**; and

Figs. 5 and 6 are plan sections of different parts of Fig. 4, taken along lines **5—5** and **6—6**, respectively.

In more detail, Figs. 1 and 2 illustrate a pulverized fuel firing system associated with a rotary kiln **10** for the purpose of providing the heat necessary for nodulizing undersized iron ore particles as they move through the kiln. High grade ore fines are fed into the kiln through its upper, material inlet end, not shown, and the nodules are discharged through the lower, material outlet end **12**. Suitably, the kiln measures about 11½ feet in diameter and about 350 feet in length. The discharge end **12** extends into a hood **13** which is rotatably sealed in known manner to the wall of the kiln, the hood being open at its bottom to a cooler **14** into which the hot nodules fall as discharged from the kiln. Two pulverized fuel burners **15** and **16** extend through the hood **13** and into the discharge end of the kiln, for a short distance, as generally indicated in Fig. 1. The upper burner **15** enters the kiln horizontally at a distance of about one foot above the center of the kiln discharge opening, while the lower burner **16** enters horizontally at a distance of about one foot below the center, and to one side thereof, as indicated in Fig. 2. It will be assumed that the direction of kiln rotation is counterclockwise as viewed from the discharge end.

The waste gases of combustion are exhausted from the material inlet end of the kiln to a stack, suitably by means of induced draft fan means, none of which equipment is shown. Air from combustion enters the hood 13 from the cooler 14 in which the air is heated by contact with the hot nodules discharged from the kiln, the heated air in hood 13 thus being available for the combustion of fuel discharging from burners 15 and 16, in combination with additional air which is supplied, as hereinafter described.

A controlled proportion of the heated air delivered to hood 13, over and above the total amount required for combustion, and including a small proportion of gases from the kiln, is conducted by means of conduit 17 to a multiple unit cyclone separator 18 through inlet 19. Tempering air, from atmosphere, is admitted to conduit 17 under control of valve 21. The separated dust particles are discharged through lower dust outlets 23 into a suitable collector 24 and thence periodically under control of valve 25 to a point of disposal. The cleaned air is discharged from the cyclone outlet compartment 26 through a duct 27 having lower branches 28 and 29 which are connected respectively by conduits 30 and 31 to separately driven fans 32 and 33. A valve 34 in conduit 30 serves to proportion the air admitted through conduits 30 and 31 to the respective fans. Tempering air is admitted to conduit 31 under control of damper 35. Air from fan 32 is delivered through conduit 36, under control of valve 37, to pulverizer 38 from which pulverized fuel and primary air are supplied to both burners 15 and 16. Fan 33 delivers tertiary air to burner 16 through conduit 39, under control of valve 41.

Pulverizer 38 is suitably of known construction having for example one or more circular series of rollable grinding elements disposed between upper and lower rings of which at least one ring is driven from an electric motor 42. Raw fuel, such as coal, of suitable size is fed to the pulverizer from an overhead bin 43 by means of a mechanical feeder 45 having a regulable electric motor drive 46, independent of the pulverizer drive 42, for controlling the input of coal in accordance with the desired output requirements. Primary air introduced through duct 36 constitutes a gaseous carrier medium for the pulverized fuel particles so as to result in a fluent output mixture of pulverized coal and air being discharged through the pulverizer outlet conduit 47. An air bypass conduit 48 having a valve 49 therein connects the primary air duct 36 to the pulverizer outlet conduit 47.

In order to effect the required distribution of pulverized coal and primary air to burners 15 and 16, a classifier 50 is interposed between the pulverizer outlet conduit 47 and the burner lines 51, 52 which lead to the respective burners. The classifier 50 serves to separate the incoming pulverized fuel and air mixture into separate streams containing the relatively fine and coarse fuel particles. The classifier 50 also serves as a distributor since, as hereinafter explained, separate outlets of a particular arrangement are provided whereby the respective fuel-air streams are discharged and distributed to selected points of use. A control valve 53 is included in line 52 adjacent the lower burner 16, and a shut off valve 54 in the same line adjacent the distributor 50. The lower burner 16 includes a bellows connection 56 between its discharge tip 57 and body portion 58 so as to enable the discharge tip to be tilted through an appreciable angle in any direction during operation. Tertiary air is admitted to burner 16 through circumferentially spaced slots 59 in the wall of the body portion 58, the air entering from a bustle pipe connection 61 in which the air supply conduit 39 terminates.

The distributor 50, as detailed in Figs. 3–6, includes a cylindrical header 65, of circular cross section throughout, to which the pulverizer discharge conduit 47 is connected through a transition piece 67 and inlet nozzle 68. The pulverized coal and air mixture is thereby directed tangentially of the inner wall of the header and distributed uniformly along the entire length of the header. Distributor outlet nozzles 69, having terminal flanges 71, extend radially and downwardly from adjacent opposite closed ends of the header at a centerline inclination of about 27° to the horizontal when in the installed operating position. A Y-pipe 72, having inlet branches 73, is connected by flanges 74 to the flanged outlet nozzles 69, the common outlet pipe length being connected by a flanged joint 76 to the upper burner line 51. An upper outlet nozzle 78 extends radially and vertically from the uppermost part of the header, midway between the ends thereof and between the symmetrically arranged outlet nozzles 69. Nozzle 78 is connected through shut-off valve 54 to the lower burner line 52.

The transition piece 67 is formed as a conduit element having an inlet of circular cross section at its flanged connection 79 to the pulverizer outlet conduit 47, and having an outlet 81 in the form of a narrow rectangular opening corresponding to the rectangular cross section at the entrance to nozzle 68; the nozzle suitably being formed as an integral part of header 65 and being connected to the transition piece 67 by means of a flanged joint 82. Intermediate flanges 83 constitute reinforcing members. The internal cross sectional area of the transition piece 67 is practically the same at both ends, although the piece is of gradually flaring formation in a horizontal direction so that its outlet 81 extends substantially throughout the length of header 65; the internal diameter of the distributing header 65 being about one-and-one-half to two times the diameter of the transition piece inlet opening at the flanged joint 79. The nozzle 68, of the same internal cross section throughout as the transition piece outlet 81, is arranged tangentially of the header 65 to cause the entering fuel and air to sweep the inner wall of the header along its entire length, thereby providing uniform distribution of the entering mixture throughout the length of the header. Nozzle 68 is divided longitudinally by partitions 84 to provide four equal flow channels so as to assist in maintaining substantially uniform distribution of flow into header 65.

The length of the transition piece from its inlet at joint 79 to its outlet at nozzle joint 82 is sufficient to provide a relatively small angle of divergence to approximate the recovery portion of a venturi throat passage to minimize drop at relatively high flow velocities. Tests on apparatus proportioned substantially as above described and constructed for commercial service have shown that with an entrance velocity through the transition piece inlet of 4000 feet per minute, the pressure drop through the entire distributor from inlet 79 to the entrances to offtakes, such as nozzles 69, is only two-and-one-half inches water, including entrance loss.

The discharge of the fuel-air mixture through nozzle 78 is under the control of an adjustable sleeve 86, axially slidable within the nozzle. Angularly spaced guide or runner strips 87, of thin metal, welded to the interior wall of the nozzle, serve to reduce friction during movement. The inner end of the sleeve is cut at an oblique angle as at 88 so as to lie in a plane parallel to the plane containing the centerlines of nozzles 69. The sleeve 86 is supported and operated by means of a shaft 89 having its upper end secured to a spider 91 of which the radially extending webs 92 are welded to sleeve 86 adjacent the upper, outer end thereof. The shaft 89 extends to the exterior of header 65 through a packing gland 93 and is formed with a rack 94 toward its outermost end for engagement by a worm-driven spur gear, not shown; the spur gear being mounted on a common shaft 95 with worm gear 96, and being operated through worm 97 and chain wheel 98. The gearing assembly is supported on a bracket 101 which is rigidly attached to the transition piece 67. In the construction illustrated, the range of adjustment of sleeve 86 is equal to the inside

radius of header **65**; the innermost position being indicated in Fig. 4 wherein the center of the oblique inner end **88** coincides with the centerline of the header. Thus, in the outermost position of sleeve **86**, the center of the oblique inner end **88** coincides with the inner circumference of the header.

In the operation of the structure described, it is to be noted that provision is made for controlling fuel burning conditions to conform to the requirements of the nodulizing process. The upper burner **15** provides a long flame to precondition the material under treatment as it progresses toward the discharge end of the kiln. The material then moves into an intensive heating zone zone which is served by a second 100 percent-air turbulent type burner **16**. These conditions call for a coal distributing apparatus whereby the upper burner **15** is supplied with a very rich mix of primary air and coal, whereas the lower burner **16** is supplied with a variable relatively lean mix.

The distributor **50** is particularly suited for the above described conditions since it enables separate burners to be simultaneously supplied with fuel-air mixtures of different densities, with provision for varying the density of the mixture supplied to at least one of the burners. The distributor includes two longitudinally spaced outlets located adjacent opposite ends of the distributor cylinder for supplying fuel to the larger capacity long flame burner **15**. The purpose of this arrangement is to insure continuous turbulence within the distributor header at all times regardless of the load.

Due to the nature of centrifugal distributor performance, the coal, or other entrained solid material, tends to concentrate on the internal periphery of the distributor header, whereas the center portion constitutes a very lean inactive zone. By adjusting the sleeve **86** from its outermost position to the center of the header, it is possible to vary the density in the outlets to both burners at the same time without changing the total incoming solids in the distributor. Since the total air through the system is not changed for any given load, the pulverizer feeder controller normally associated with feeder **45** tends to maintain constant fuel-air ratio through the pulverizer.

Certain features disclosed and claimed herein are also disclosed in my copending prior application Serial No. 526,612, filed March 15, 1944 and now Patent No. 2,511,017.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. Apparatus for classifying and distributing pneumatically transported pulverized fuel comprising an elongated header of circular cross-section, means forming an inlet extending longitudinally of and tangentially arranged relative to the circumferential wall of said header whereby a mixture of air and pulverized fuel entering said header inlet will have a whirling movement in said header, a plurality of spaced discharge outlets opening through the circumferential wall of said header, and means associated with one of said discharge outlets and adjustable transversely of the whirling stream of air and fuel for varying the fineness of fuel and the ratio of fuel to air entering said one discharge outlet.

2. Apparatus for classifying and distributing pneumatically transported pulverized fuel comprising a horizontally disposed elongated header of circular cross-section, means forming a longitudinally elongated inlet tangentially arranged relative to the circumferential wall

of said header whereby a mixture of air and pulverized fuel entering said header inlet will have a whirling movement in said header, a plurality of spaced discharge outlets opening through the circumferential wall of said header, and means associated with one of said discharge outlets and adjustable radially of said header for varying the fineness of fuel and the ratio of fuel to air entering said one discharge outlet.

3. In a pulverized fuel firing system comprising an air swept pulverizer from which a pulverized fuel and air mixture is directed through separate burners, a combined classifying and distributing means comprising a horizontally disposed cylindrical header having an inlet nozzle arranged to receive said mixture from said pulverizer and direct said mixture tangentially into said header, and outlet conduits connected to said header and arranged to direct separate portions of said mixture to the respective burners, said outlet conduits having inlet openings circumferentially spaced from one another and from said inlet nozzle and respectively radially arranged relative to said header to receive said separate mixture portions from radially separate regions internally of said header.

4. A distributor comprising a horizontally disposed cylindrical header having an inlet nozzle arranged to discharge a fuel and air mixture into said header tangentially along the inner wall thereof, said inlet nozzle having a narrow rectangular discharge opening extending throughout the major portion of the total length of said header, an outlet nozzle connected to said header at a location circumferentially spaced from said inlet nozzle opening, a second outlet nozzle connected to said header at a location circumferentially spaced from said inlet nozzle and from said first outlet nozzle, and means associated with the inner end of said second outlet nozzle for varying the density of the mixture conducted into said second outlet nozzle directly from an interior header region inwardly spaced from said header wall.

5. A distributor as claimed in claim 4 wherein the mixture density varying means associated with the second outlet nozzle is of tubular formation and is adjustable radially of said header.

6. A distributor as claimed in claim 5 wherein the tubular mixture density varying means terminates in an inner oblique end inclined inwardly toward the position of said first outlet nozzle.

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