

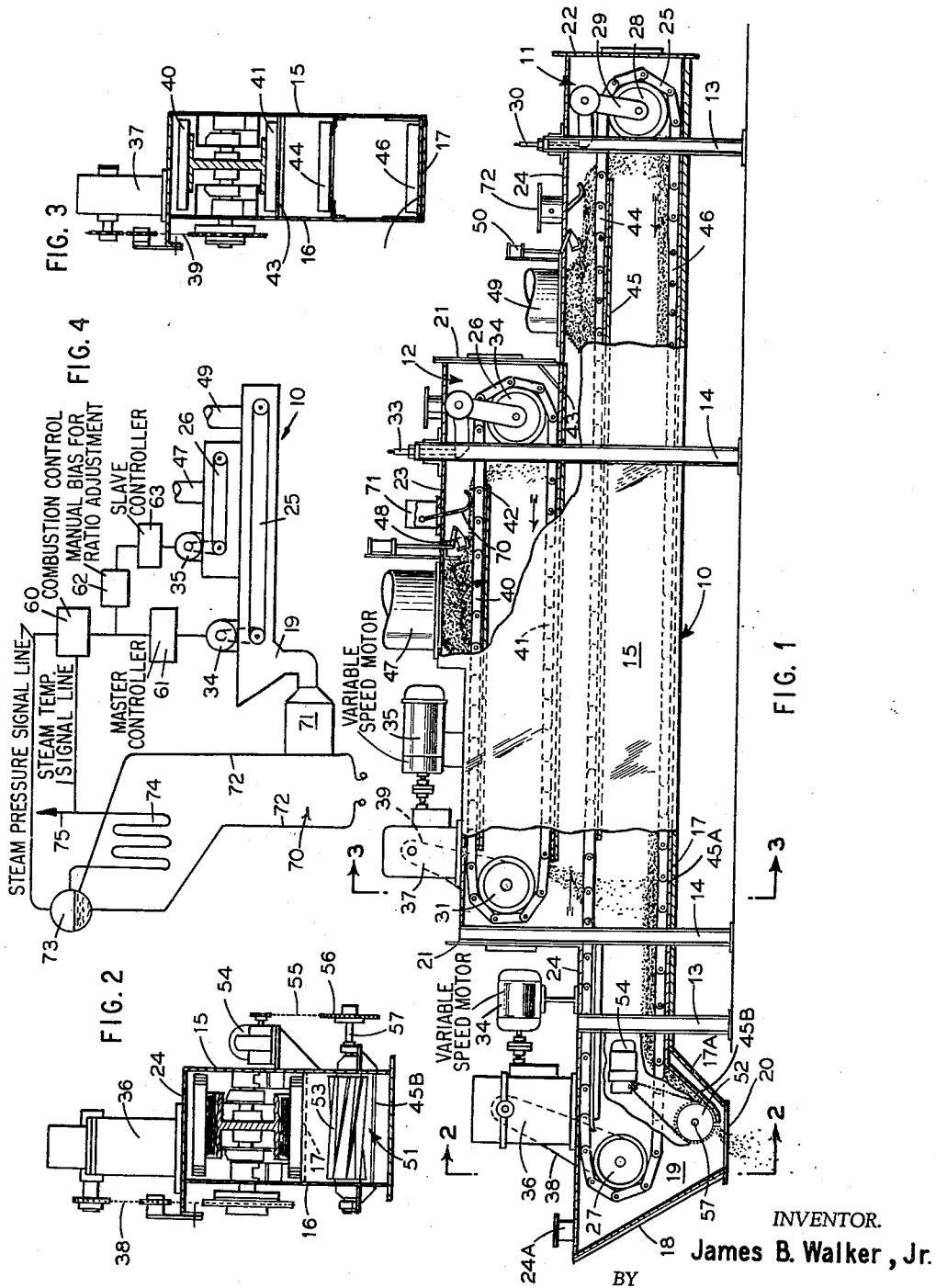
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FUEL FEEDING METHOD AND APPARATUS

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FUEL FEEDING METHOD AND APPARATUS

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This invention relates to a fuel feeding method and apparatus for mixing at least two fuels in a predetermined ratio and more specifically to a method and means adapted to form an optimum fuel charge of at least two uniformly blended or combined solid fuels having different characteristics in which the constituent fuels are apportioned in accordance to their respective characteristics and the ratio of the apportioned fuels being maintained substantially constant or at an optimum predetermined variable ratio throughout a load range of a fuel burning means receiving the charge.

In the operation of a steam generating unit or the like in which large quantities of fuel are required to be continuously burned under widely variable operating and load conditions, it is oftentimes necessary and/or highly desirable to simultaneously burn at least two fuels having different physical and/or chemical characteristics or properties. Whenever more than one kind of fuel is to be simultaneously burned it is essential, in order to achieve optimum combustion and therefore maximum heat output or utilization of the fuels, that the different fuels be uniformly blended or mixed in predetermined ratios in accordance to their respective characteristics. In feeding any such predetermined mixed fuel charge to a combustion zone of a steam generator, as for example a cyclone furnace, it is further essential that the relative proportionate amount of the constituent fuels be maintained in a predetermined optimum ratio throughout the load range of the furnace and that the feeding of the blended mixture thereto be accomplished at predetermined regulable rate. Heretofore, it had not been customary to blend or mix two fuels, such as char and coal, having different physical and/or chemical characteristics in predetermined proportional amounts to obtain an optimum fuel charge for any load condition within a load range of a combustion zone. As a result it has been difficult, if not impossible, to achieve optimum, controllable combustion conditions in a combustion zone subjected to varying load conditions when such fuels are to be simultaneously burned therein.

An object of this invention is to provide a method and apparatus for continuously forming an optimum fuel charge composed of at least two fuels having different burning characteristics in which the constituent fuels are uniformly mixed in predetermined amounts.

Another object of this invention is to control the relative apportioned amounts of the constituent fuels comprising an optimum fuel charge at a predetermined optimum ratio throughout a load range of a fuel burning means receiving the fuel charge in accordance to the demand thereof.

Still another object resides in a means and method of handling char in preparation for feeding the same to a combustion zone as a primary fuel.

The instant method by which the above objects and the advantages of the present invention are attained comprises essentially of maintaining a separate source of supply for each of the constituent fuels which are to be blended and withdrawing of a predetermined quantity of each fuel, depending upon the respective characteristics thereof, from each of the supply sources; varying the rates of withdrawal of each of the different fuels from its respective supply in accordance with the changing load requirements of a combustion zone adapted to receive the fuel, maintaining or controlling the rates of fuel with-

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drawal in a predetermined optimum ratio over the load range of the combustion zone, blending or mixing the amounts of respective fuels withdrawn to form an optimum homogeneous fuel charge and feeding the blended charge to the combustion zone at a regulable rate.

The foregoing method, according to this invention, is preferably mechanically performed with a minimum of manual attention by an apparatus in which a preferred embodiment thereof comprises generally of a separate supply means for each of the differently characterized fuels. Each of the supply means includes a fuel pipe having an unobstructed discharge opening through which its respective fuel is supplied by gravity to a withdrawal means operatively associated with each supply means.

The withdrawal means comprise suitable conveyor means that are connected in parallel in a master-slave relationship for conveying regulable predetermined proportionate amounts of fuel from each of the respective supply means to a point removed therefrom where the fuels are subsequently combined and mixed to form an optimum fuel charge. Control means responsive to a combustion control regulate the relative linear movement of the conveyor means which determines the amount of each fuel withdrawn and further insures that the ratio of the apportioned fuel amounts, which is varied in accordance to the loading conditions of the combustion zone, is maintained in an optimum mixture throughout the load range of the combustion zone or fuel burning means. Prior to delivery of the fuel charge to a fuel burning means, the two proportioned fuels are simultaneously passed through a distributing means and the different fuels are discharged therefrom in a substantially homogeneous state. Thereafter the blended mixture is combined with a carrier or combustion air and subsequently delivered to a burner means or furnace.

A feature of this invention resides in the provision of a free, unobstructed flow of fuel from its respective supply means to its respective conveyor means whereby flooding or clogging of the respective fuels is eliminated.

Other features and advantages will be readily apparent when considered in view of the specification and drawings in which:

FIG. 1 is a side elevation view of a preferred embodiment of the present fuel feeding means, having portions thereof broken away.

FIG. 2 is a sectional end view taken along line 2—2 of FIG. 1.

FIG. 3 is a sectional end view taken along line 3—3 of FIG. 1.

FIG. 4 is a schematic block diagram of the control arrangement therefor.

The method and means for feeding or handling fuel in accordance with the present invention is particularly suitable for feeding at least two different types of solid fuels, as for example low volatile char and coal in any proportioned combination thereof to form an optimum fuel charge. Char is herein defined as that residue which results from the destructive distillation of 30 to 40% volatile, coal by various carbonization processes whereby valuable tars and volatile gases are skimmed off the raw coal. This char residue is characterized in that it is a fairly uniform granular product approximately $\frac{1}{16}$ " in size; having a density of about 19.4 lbs. per cu. ft. and a volatile content ranging from 8 to 25% depending on the particular carbonization process producing the char.

With an increasing trend toward the destructive distillations of coal, as by low temperature carbonization for obtaining the valuable coal tars and volatile derivatives therefrom, there has been available an ever increasing supply of the residue char. Since this char is generally rich in B.t.u. content (9000 to 14,000 B.t.u. lb.), interest in the use of such char as a low cost boiler fuel has

increased in recent years. However, as the more ignitable volatile matter has been drawn off in the carbonization process, difficulty has been encountered in maintaining combustion of the residue char. For this reason the acceptance of char as a valuable, useful, and low cost fuel for generating steam has not achieved wide popularity.

According to this invention, an apparatus and method are set forth whereby char is successfully handled so as to render it a suitable fuel for use in a combustion zone of a steam generating unit, as for example a cyclone furnace which is particularly suitable for the combustion of a low grade fuel. However, to maintain ignition and depending on the percentage of volatile content of a particular char, more or less crushed or granulated bituminous coal having a density of approximately 48.6 lbs. per cu. ft. is combined therewith to form an optimum fuel charge.

Referring to FIGS. 1 to 3 there is shown a preferred embodiment of a fuel feeding or handling apparatus for practicing the present invention whereby coal and char are predeterminedly proportioned with a minimum of manual attention in accordance to the demand of a cyclone furnace throughout the load range thereof. The instant apparatus comprises generally a housing 10 enclosing suitable conveying means for transporting the required proportionate amounts of the respective fuels to be mixed. The arrangement of the housing is such that it includes a lower section 11 having intermediate the ends thereof a stepped, or upwardly extended section 12. Spaced standards 13 and 14 constitute the supporting structure for the apparatus and form the frame to which the side walls 15 and 16 are connected. A bottom plate 17 is disposed between the side walls 15 and 16 and extends substantially the length of the housing, the forward end 17A of the bottom plate 17 being inclined downwardly and forms with an inclined front end plate 18 and side walls 15 and 16 a hopper-like chamber 19 terminating in an opening 20 through which the optimum fuel mixture is discharged as will be hereinafter described. Removable end cover plates 21 and 22 close both ends of the upper section 12 and right end of the lower section 11, respectively. Top wall members 23 and 24 close the top of the upper housing section and lateral extending top portion of the lower housing section, respectively. A vent means 24A is provided for venting the housing.

Arranged within the housing are a pair of suitable conveying means 25 and 26, one being disposed in the lower section 11 and the other superposed thereabove in the upper section 12. As shown, each conveyor is of the endless drag chain type in which the runs of the upper conveyor means 26 are relatively shorter than those of the bottom conveyor 25.

According to this invention the lower drag chain 25 is threaded over a suitably driven sprocket 27 at one end thereof and over an idling sprocket 28 at the other end thereof. If desired the idling sprocket 28 may be pivotally mounted as by means of a bell crank arrangement 29 whereby the amount slack in the drag chain 25 can be readily adjusted by screw 30 which regulates the position of the idling sprocket 28. The upper drag chain 26 is similarly threaded over a driven sprocket 31 and adjustable idler sprocket 32, the adjustment of the latter for regulating the amount of chain tension being accomplished by adjusting screw 33.

The drive means for each of the driven sprockets 27 and 31 comprise respectively a variable speed motor means 34 and 35 connected to a suitable speed reducer 36 and 37. A belt or chain 38, 39 connects the respective sprockets 27, 31 in driving relationship to its respective motor drive means and speed reducer, the arrangement being such that the direction of travel of the upper run of each conveyor is to the right as indicated by the arrows in FIG. 1. The drive motors are elec-

trically connected by a suitable circuit in a master-slave relationship whereby the speed of one regulates the speed of the other.

Disposed immediately below the spaced flights or pockets of both the upper and lower runs 40, 41 of conveyor 26 are wear plates 42 and 43 respectively, for supporting the layer of fuel which is dragged by chain 26. The upper run 44 of the lower conveyor 25 is likewise provided with a wear plate 45 immediately therebelow in the vicinity of the supply pipe 49 and plate 45A supported on the bottom plate 17 constitutes the wear plate of the lower run 46, the forward end 45B of the wear plate 45A being inclined downwardly in the hopper chamber 19.

In accordance with this invention the arrangement is such that a separate kind of flowable solid fuel is supplied to the upper runs of each conveyor 25, 26. In the illustrated form of the invention, coal from a suitable supply source is fed by gravity through a coal delivery pipe 47 having a relatively large, unobstructed opening in communication with the upper run 40 of the conveyor 26. As shown, the free flow of coal through the pipe 47 causes the coal to spread on the wear plate 42 in a pile having a substantially 30° slope or angle of repose. Thus the linear movement of the pockets of the upper run 40 through the coal pile causes a portion of the coal to be withdrawn. As long as the coal is continuously supplied, it will be noted that the linear speed of the upper run 40 relative to the fixed coal opening regulates the amount of coal withdrawn from the coal pile, the height or thickness of the coal layer withdrawn being determined by a pneumatically, piston operated gate means 48 placed downstream of the coal supply. If desired the gate means 48 is rendered readily adjustable so that the fixed height of the layer of coal conveyed from the coal pile can be varied. In the illustrated embodiment the gate 48 regulates the depth of the coal bed, at either 3 or 6 inches, depending on the speed of the coal conveyor 26. In the event that the supply of coal becomes exhausted the feeler or sensing rod 70 of a telltale means 71 actuates a suitable alarm to draw attention to the exhaustion of the coal supply. As seen in FIG. 1 the layer of coal is dragged to the end of wear plate 42 and is then cascaded onto the lower wear plate 43 and dragged therealong in the opposite direction by the lower run 41 to the end thereof, the coal being then cascaded through the upper run 44 of the lower chain conveyor 25 and deposited upon a layer of char conveyed by the lower run 46 of conveyor 26 as will be hereinafter described.

A second fuel, which in the instant case is the primary fuel, char, is supplied from a suitable source to the upper run 44 of the lower conveyor through pipe 49. This supply pipe is likewise provided with an unobstructed discharge end through which the char gravitates toward conveyor 25 and comes to rest on wear plate 45 at a suitable angle of repose as shown. The movement of the upper run 44 of conveyor 26 through the char pile conveys an amount of char away from the char supply, the relative linear speed of the run 44 through the char pile controlling the amount of char withdrawn therefrom and the height of the char layer being determined by a gate means 50, which may be either a fixed gate or an adjustable gate to determine the thickness of the char. Telltale means 72, similar to that of 70 actuates a suitable signal in the event the char becomes exhausted.

In order to insure a uniformly regulable feed rate, i.e. to prevent the feeding of the mixed fuel charge in lumps or slugs which may be formed due to moisture or the like, a distributor 51 is provided for breaking up any such slugs of fuel. In addition the distributor aids to intermingle the two fuels to form a more or less homogeneous fuel charge.

As shown the distributing means 51 is in the form of a roller 52 having helical blades 53 and is rotatably mounted adjacent the incline wear plate 45B. If desired a spiked roller may be substituted for a helical blade

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roller. Means for rotating the roller 52 includes a motor 54 which is connected into driving relationship therewith by means of a chain or belt 55 driving a sprocket or pulley 56 connected to the roller shaft 57. With this arrangement the combined fuel sliding down wear plate 45B passes between the inclined plate 45B and the roller 52, whereby the blades of the latter cause intermingling of the solid fuels while at the same time insuring a break up of any slugs or packed masses of the fuel passing therebetween.

According to this invention conveyors 25 and 26 are connected by suitable means, preferably by an electrical circuit into parallel, master-slave relationship wherein the relative speeds therebetween can be selectably varied over a considerable range whereby the fuel delivery rate thereof may vary from 1 to 1 to 20 to 1 B.t.u.-wise, and which for any selectable fuel ratio within the above range are interlocked to maintain their relative speeds for maintaining an optimum fuel ratio throughout the load range of a combustion zone or furnace. In the instant case the char conveyor 25 constitutes the master and coal conveyor 26, the slave. Thus depending on the particular analysis of the fuels to be handled, the present fuel handling apparatus can handle either 100% char or 100% coal, or a combination of the two in any proportions thereof within the above range.

In FIG. 4, there is shown a schematic diagram illustrating the disclosed feeder apparatus 10 in conjunction with a steam boiler 70. As shown the boiler 70 is fired by a cyclone furnace 71 of the type disclosed in U.S. Patent 2,594,312. The fuel for firing the cyclone furnace 71 is supplied by the feeder 10, as hereinbefore described; the blended mixture being supplied to the cyclone furnace 71 through fuel pipe 71A.

Steam generated in the wall tubes 72 of the boiler is discharged into the steam drum 73, and the steam separated therein is passed through a superheater 74 where it is finally heated to a given superheat temperature, the highly heated steam then being delivered through conduit 75 to a steam turbine for generating electricity.

In accordance with this invention the operation of the feeder apparatus is rendered responsive to fuel demand. This is attained by a suitable controller 60 which is responsive to an appropriate impulse signaled by certain measurable vapor generator variables which are indicative of fuel demand, as for example steam temperature, steam pressure, steam flow, and/or combinations of the same as evidenced by United States Patents 2,079,165, and 2,623,698. It is to be noted that the particular variable or variables indicative of fuel demand employed for signaling a particular impulse to controller 60 is not intended to form any part of this invention. It is only significant that a suitable impulse signaled by a given variable or variables indicative of fuel demand, be sent to combustion controller 60 in a suitable manner, e.g. as disclosed by the above patents. The controller 60 in turn sends the signal of the received impulse to the master conveyor control 61, which in turn activates the master conveyor variable speed motor 34, accordingly. The controller 60 sends the same impulse signal through the manual bias control, and then to the slave conveyor control 63, which furnishes the impulse to activate the slave motor 35.

In operation the linear speed of the respective conveyors with respect to the fixed fuel pipes 47 and 49 control the amount of fuel withdrawn therefrom. Since the char conveyor 25 is considered to be the master and as it is to withdraw the major portion of the fuel comprising the optimum fuel charge, it will generally have a greater linear rate of speed than that of the slave conveyor 26. Regulation of the relative chain speeds as by the manual bias ratio adjustor 62 is determined by the respective fuel analysis of the coal and char to be combined. Thus with the known fuel analysis and ratio set, the rate at which each fuel is withdrawn by its respective

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conveyor is controlled by the load requirements of the combustion zone receiving the fuel charge. As the combustion zone is subjected to variable load conditions, the linear speed of the two chain conveyors are varied in accordance therewith for withdrawing more or less of each of the different fuels, but always in the proportion to maintain an optimum fuel mixture.

For example the following tables are illustrative of the respective chain speed for each of the conveyors and depth of fuel layer thereon when operating at half boiler load and full load and utilizing as an optimum fuel charge composed of either all coal, all char and a combination of the two, as for example in the ratio of 95% char to 5% coal based on the B.t.u. input.

Half boiler load

Char conveyor:

Char only, 10.35 ft./min., 10" char bed depth.

95% char; 5% coal, 9.82 ft./min., 10" char bed depth.

Coal only, 6.7 ft./min., 0" char bed depth.

Coal conveyor:

Coal only, 6.7 ft./min., 6" coal bed depth.

95% char, 5% coal, .65 ft./min., 3" coal bed depth.

Char only, off.

Full boiler load

Char conveyor:

Char only, 20.7 ft./min., 10" char bed depth.

95% char, 5% coal, 19.65 ft./min., 10" char bed depth.

Coal only, 13.4 ft./min., 0" char bed depth.

Coal conveyor:

Coal only, 13.4 ft./min., 6" coal bed depth.

95% char, 5% coal, 1.31 ft./min., 3" coal bed depth.

Char only, off.

The arrangement of the conveyors is such that the fuel is cascaded from the upper to lower run of each of the conveyors, with the combining of the two fuels occurring on the lower run of the master conveyor chain 25. With the coal of the upper conveyor cascading on the char layer below, each flight or pocket of the char chain receives an amount of coal sufficient to maintain the ignition of the char. Subsequently the stratified coal and char fuel layer is delivered in a more or less predetermined ratio through a mixing and blending step which also breaks up any slugs or packed masses of the fuel. Thereafter the mixed fuel is ultimately combined with combustion air and delivered to a point of use.

While the present invention is illustrated and described as a fuel feeder, it will be understood that the method and apparatus thereof may be utilized in the handling of any two flowable solid materials which are desirous of being mixed together in definite ratios under a varying operational environment. It is to be further appreciated that the invention is not to be taken as limited to all of the details thereof as modifications and variations thereof may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. A fuel feeder, adapted to supply a burner means with different kinds of fuels in the form of an optimum fuel charge, comprising a pair of feeder means having spaced overlying portions, each of said feeder means including an endless drag chain having an upper and lower strand of flights, means forming a fuel supporting surface disposed immediately below an intermediate portion of each of said upper and lower flight strands, a separate fuel supply means for each kind of fuel, each of said supply means having an unobstructed opening associated with the upper strand of its respective feeder whereby said fuel supply openings are disposed opposite the fuel supporting surface underlying the upper strand of each of said feeders, means for moving said drag feeders at relative speeds to vary the amount of fuel supplied to the respective feeders whereby each drag feeder conveys a quantity of fuel

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away from said fuel supply openings and cascades said quantity of fuel from the upper supporting surface to the lower supporting surface thereof and the lower strand of one of said drag feeders cascading its charge onto the fuel charge dragged by said lower strand of said other feeder so as to form a predetermined optimum fuel charge, said feeders traveling at an optimum speed ratio therebetween thereby insuring the formation of an optimum fuel charge having a given fuel ratio.

2. A fuel feeder, adapted to feed an optimum fuel charge composed of a predetermined proportional amount of different types of fuels to a fuel burning means, comprising an upper and lower traveling feeder means, each of said feeder means including an endless conveyor having an upper and lower run of spaced flights, the runs of said upper feeder means being relatively shorter than the runs of said lower feeder means, a fuel supply means operatively associated with the upper run of each of said feeder means, said supply means each supplying a different kind of fuel and having an unobstructed opening through which said respective fuel gravitates toward its associated feeder means, means forming a fuel supporting surface opposite each of said openings and disposed immediately below an intermediate portion of the upper run of its respective feeder forming a receptacle for said fuel, means forming a second fuel supporting surface disposed immediately below the lower run of each of said feeders, and means for moving said feeder means at relative speeds so that each of said upper runs cascades a measured charge of its respective fuel from said first fuel supporting surface to said second supporting surface and said lower run of the upper feeder means cascading its measure charge onto the charge carried by the lower run of said lower feeder means, said feeder means being adapted to maintain either a constant or variable speed ratio therebetween over a given load range in accordance to a given fuel demand.

3. A fuel feeder, adapted to feed an optimum fuel charge composed of predetermined proportional amounts of different types of fuel to a fuel burning means comprising a housing, an upper and lower traveling feeder means disposed within said housing, each of said feeder means including an endless conveyor having an upper and lower run of spaced flights, the runs of said upper feeder means being relatively shorter than the runs of said lower feeder means, a separate fuel supply means for each of said fuels operatively associated with the upper run of each of said feeder means, each of said supply means forming a supply source of said different types of fuel, said supply means each having an unobstructed opening through which fuel gravitates toward its respective feeder means, means forming a fuel supporting surface opposite each of said openings and disposed immediately below an intermediate portion of the upper run of its respective feeder forming a support for said fuel, means forming a second fuel supporting surface disposed immediately below the lower run of each of said feeders, means for moving said feeder means at relative speeds for withdrawing a proportionate amount of fuel from each of said supply means and each of said upper runs cascading intermediate the ends thereof the measured amount of its respective fuel from said first fuel supporting surface to said second supporting surface and said lower run of the upper feeder means cascading its measured amount onto the lower run of said lower feeder means intermediate the ends thereof, the relative speed of said feeder means being adapted to maintain the ratio of said fuel rates over a 1 to 1 to 20 to 1 range B.t.u.-wise throughout a burner range, and a gate means disposed downstream each of said supply openings for controlling the depth of the fuel layer carried by the upper run of each feeder means.

4. A fuel feeder, adapted to feed an optimum fuel charge composed of predetermined proportional amounts of different types of fuel for burning comprising a hous-

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ing, an upper and lower traveling feeder means disposed within said housing, each of said feeder means including an endless conveyor having an upper and lower run of spaced flights, the runs of said upper feeder means being relatively shorter than the runs of said lower feeder means, separate fuel hoppers operatively associated with the upper run of each of said conveyors, each of said hoppers forming a source of supply for said different kinds of fuel, said hoppers each having an unobstructed opening through which fuel gravitates toward its respective feeder means, a fuel supporting plate opposite each of said openings and disposed immediately below an intermediate portion of the upper run of its respective conveyor forming a support for said fuel, a second fuel supporting plate disposed immediately below the lower run of each of said feeders, means for moving said conveyors at relative speeds so that each of said upper runs conveys a proportionate amount of fuel away from the respective supply opening and cascades intermediate the end portions thereof the fuel carried thereby from said first fuel supporting plate to said second supporting plate and said lower run of the upper feeder means cascading the fuel carried by it onto the lower run of said lower feeder means, the relative speed of said feeder means being adapted to establish a range of fuel withdrawal ratio varying from 1 to 1 to 20 to 1 throughout an operating range in accordance with a given fuel demand and a distributing means adjacent the discharge end of said lower conveyor for blending the combined charge carried by the lower run of said lower conveyor.

5. A method of combining different kinds of fuels to form an optimum fuel charge and feeding the same for burning comprising the steps of, disposing a supply of different kinds of fuel into separate hoppers, unobstructedly feeding the fuel from its respective hopper by gravity directly onto separate conveyors, operating said conveyors in parallel to regulate the amount of fuel fed to each of the conveyors by controlling the linear speed of the respective conveyors past its respective hopper, controlling the speed of one conveyor with respect to the other so as to establish a speed ratio therebetween, maintaining said speed ratio of said conveyors throughout a predetermined range of fuel consumption to insure that the relative proportionate amount of each of said fuels required to form an optimum fuel charge is supplied to its respective conveyor, transferring the proportionate amount of fuel carried by one conveyor onto the other to form on the latter a combined fuel charge, blending said combined fuel charge to form a homogeneous mixture, and regularly delivering said blended fuel mixture to a point of combustion.

6. A method of combining different kinds of fuel to form an optimum fuel charge and feeding the same for burning comprising the steps of disposing a supply of different kinds of fuel into separate hoppers, feeding the fuel from its respective hopper onto separate conveyors moving linearly therebeneath, operating said conveyors in parallel to regulate the amount of fuel fed to each of the conveyors by controlling the linear speed of the respective conveyors past their respective hopper, controlling the speed of one conveyor with respect to the other so as to establish a speed ratio therebetween, maintaining said speed ratio of said conveyors throughout a predetermined range of fuel consumption to insure that the relative proportionate amount of each of said fuels required to form the optimum fuel charge is supplied to the respective conveyor, and combining the respective amounts of fuel withdrawn from each of said supplies to form an optimum fuel charge.

7. A fuel feeding device adapted to form an optimum fuel charge composed of at least two fuels having different characteristics and adapted to supply the same to a fuel burner means comprising a separate supply means for each of said fuels, conveyor means operatively associated with each of said supply means for withdrawing

a quantity of fuel in a given proportion depending upon their respective characteristics, each of said supply means having an unobstructed opening through which its respective fuel is discharged onto its associated conveying means, means responsive to fuel demand for varying the speeds of said conveyor means, means whereby the speed of one conveyor means regulates the speed of the other conveyor means to establish a predetermined speed ratio therebetween for maintaining the ratio of the said proportionate amount of the different fuels discharged onto the respective conveyor means, and means for blending the fuel discharged from both of said conveyor means, thereby insuring the formation of an optimum fuel charge.

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