April 20, 1965 J. G. CONNELL 3,179,391

METHOD AND APPARATUS FOR MAKING AGGREGATE

Filed June 22, 1962 5 Sheets-Sheet 1

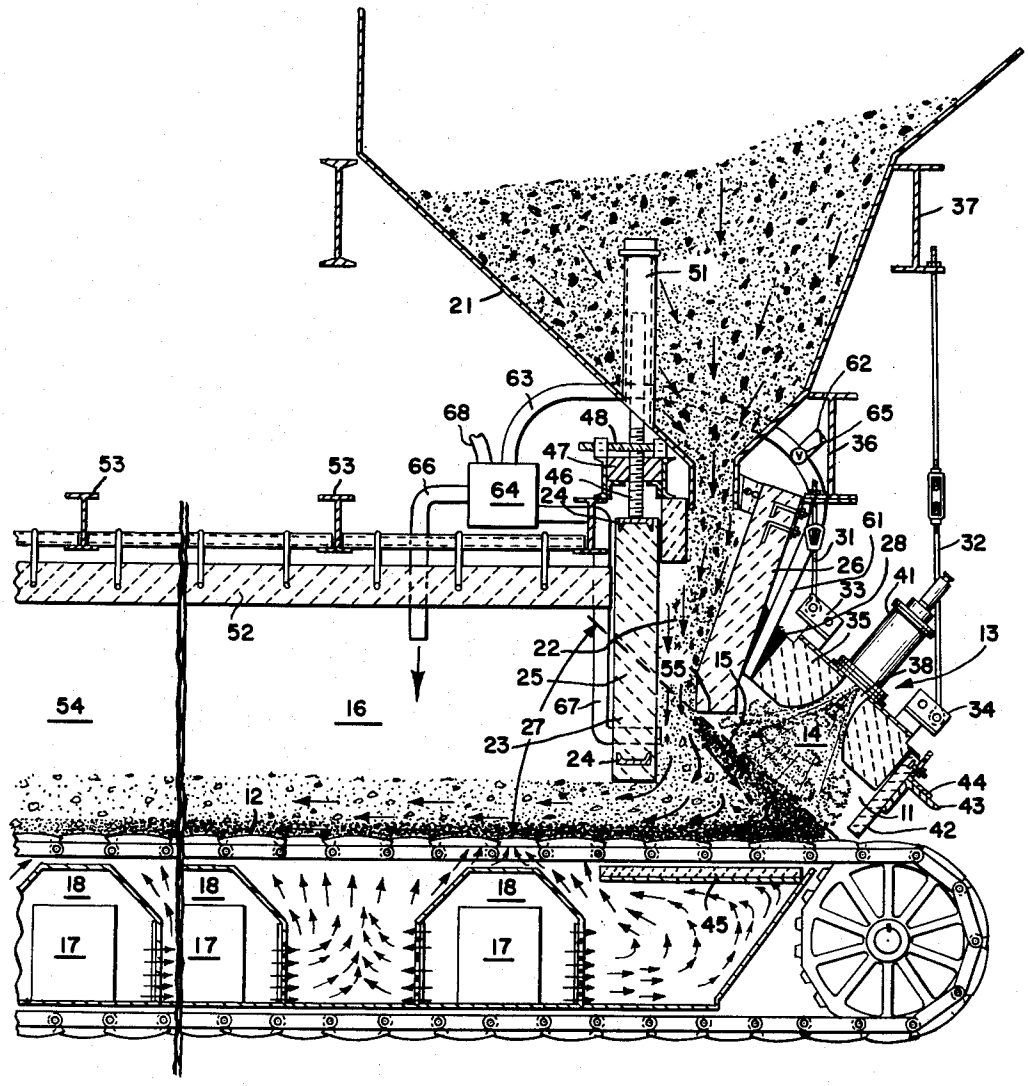


FIG. 1.

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5 Sheets-Sheet 2

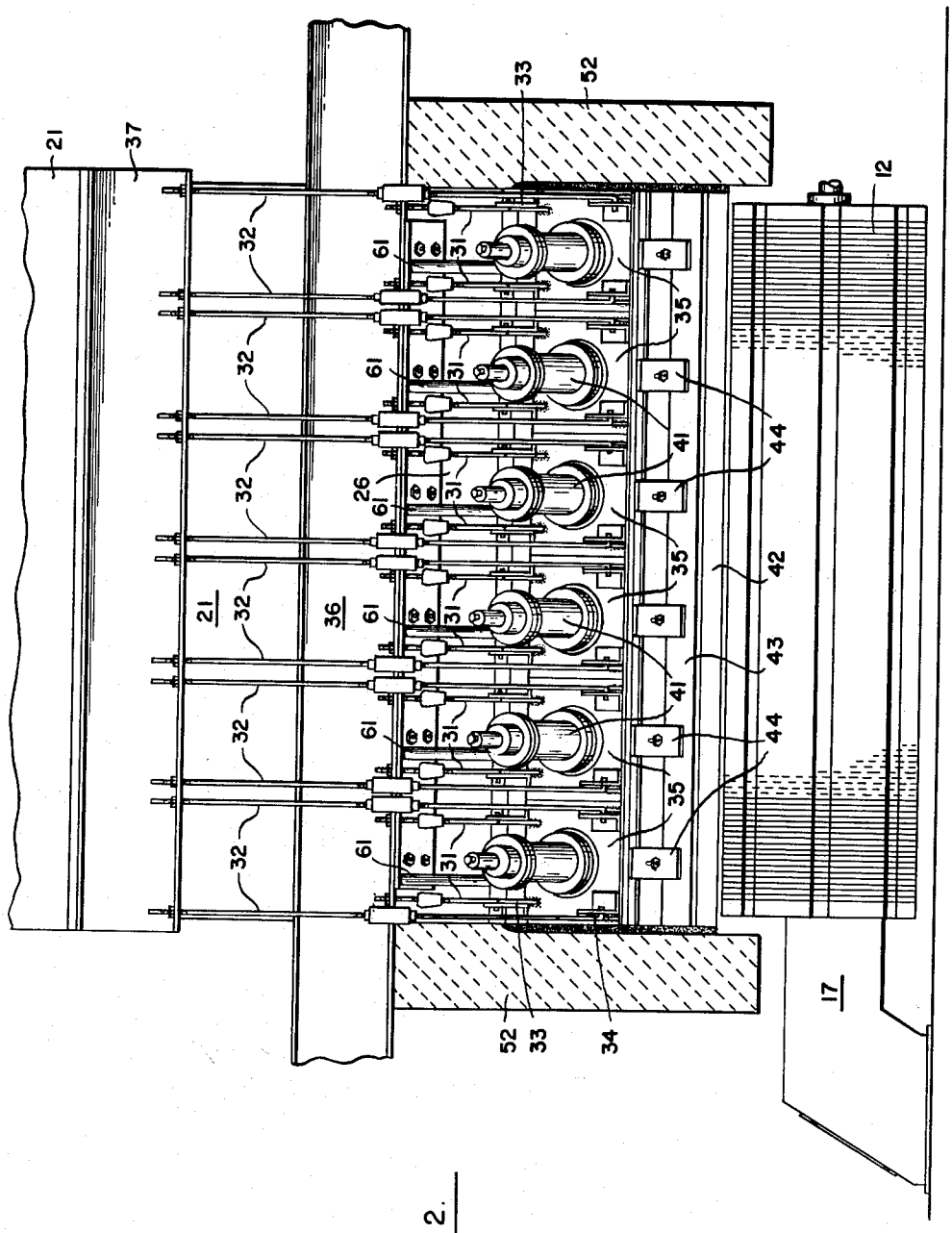


FIG. 2.

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FIG. 3.

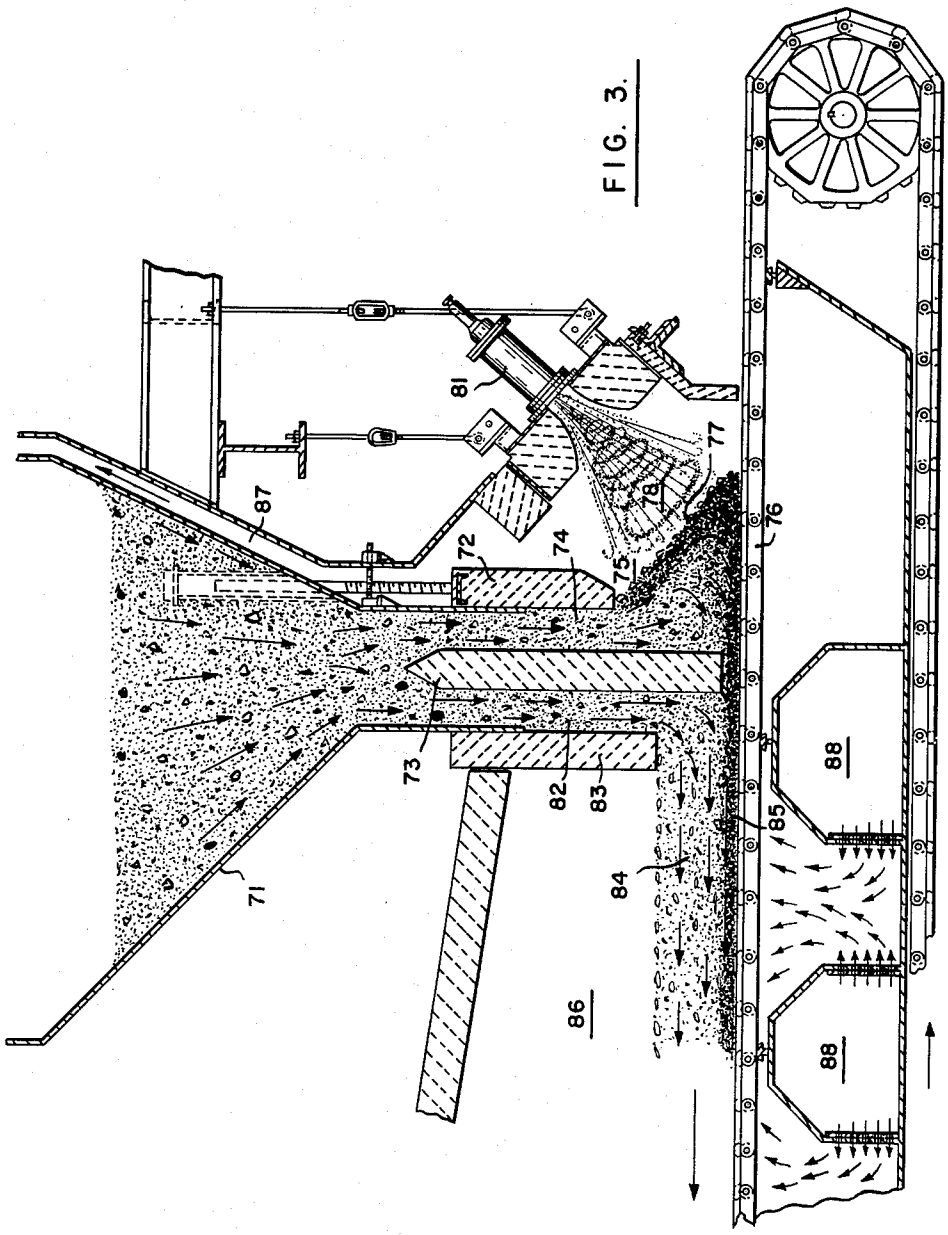


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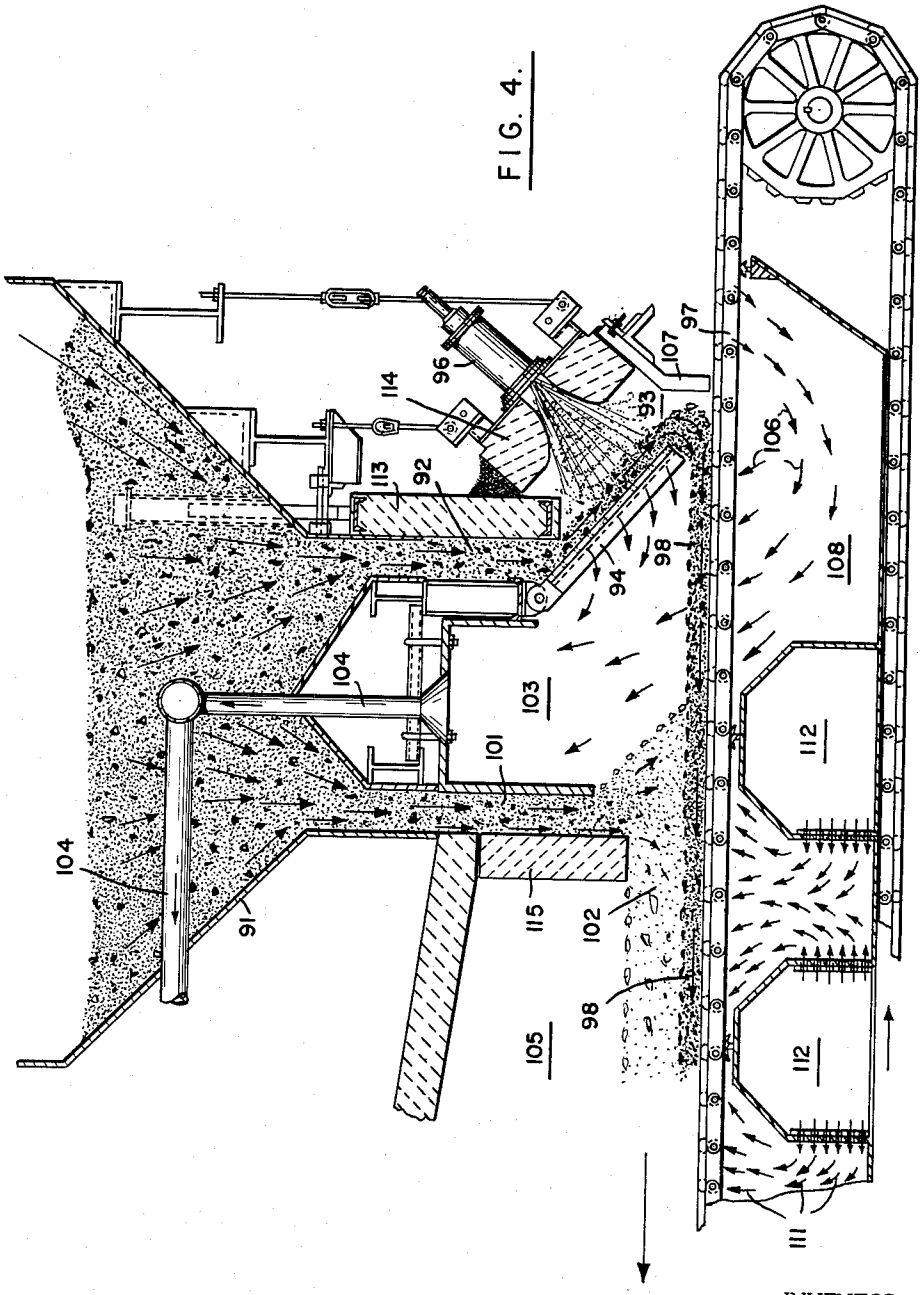
FIG. 4.

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METHOD AND APPARATUS FOR MAKING AGGREGATE

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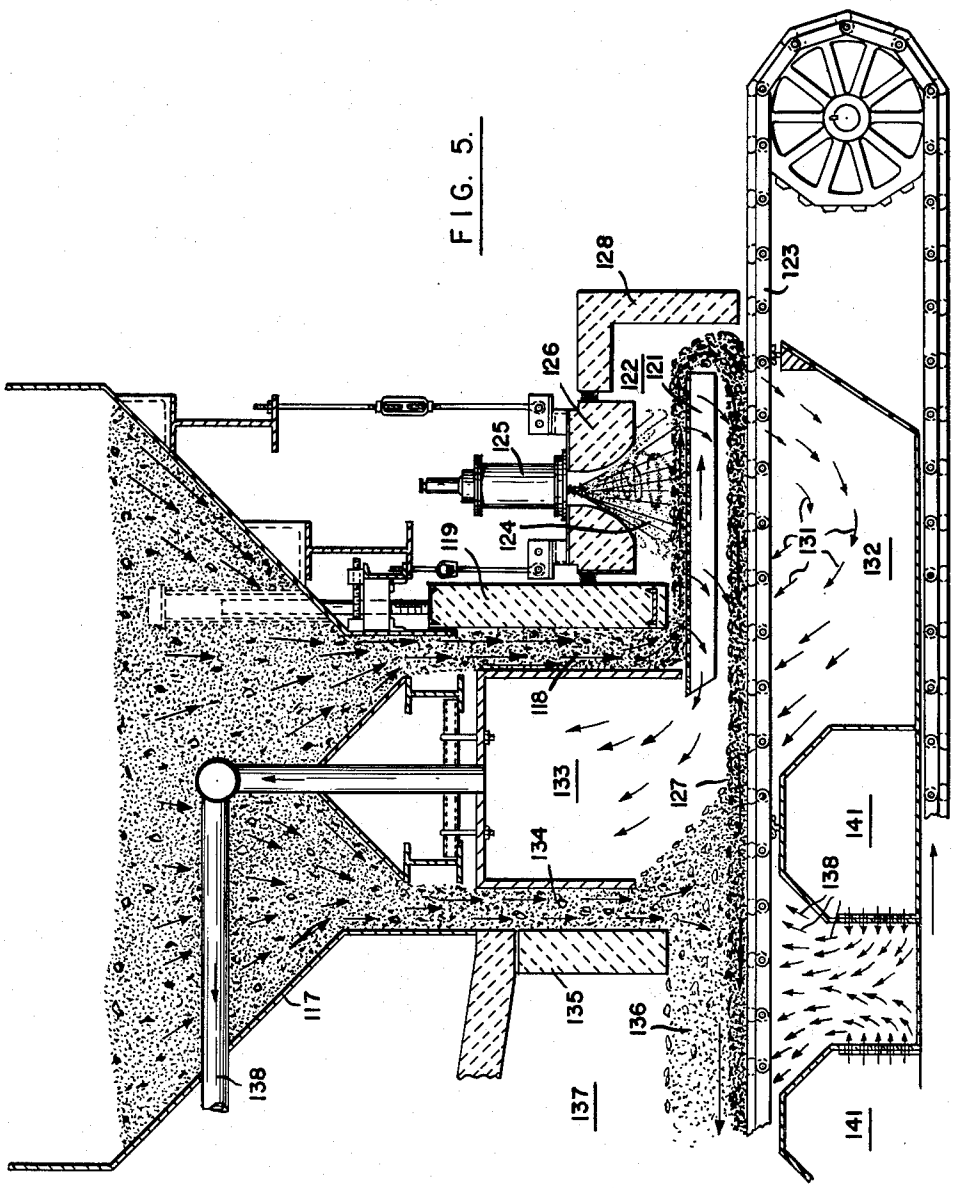
FIG. 5.

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United States Patent Office 3,179,391 Patented Apr. 20, 1965



# 3,179,391
# METHOD AND APPARATUS FOR MAKING AGGREGATE

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Filed June 22, 1962, Ser. No. 204,448
18 Claims. (Cl. 263—28)

This invention relates to improvements in a method and apparatus for making lightweight aggregate such as used in building construction and for insulating materials, and more particularly concerns a method and apparatus for making such aggregate from semi-combustible or non-combustible carbonaceous shale (coal refuse), petro coke, low grade or semi-bituminous coal, or the like.

It is an object of this invention to provide an improved method and apparatus for making aggregate which is more efficient and satisfactory than those heretofore employed.

It is another object of the invention to provide an improved and efficient method for producing aggregate from a semi-combustible material (i.e., containing a sufficient amount of carbon to achieve and sustain combustion) which includes, in a continuous operation, the steps of quickly pre-igniting a pilot layer of the material in an ignition zone, positioning an upper layer of non-ignited material upon the pilot layer after it has been pre-ignited, and moving both layers together into and through a combustion zone wherein the upper layer of material is ignited from the bottom up by the pre-ignited pilot layer and the entire mass of the material is completely burned.

It is also an object to obtain a low operating cost by utilizing natural or manufactured gas, oil, powdered solid fuel or the like which can be used in a burner nozzle, or an electric arc or the like, for producing the desired pre-ignition of the pilot layer of the material.

It is another object of the invention to provide a method which may be employed for producing aggregate from non-combustible materials (which alone have insufficient combustible content to maintain combustion) by blending therewith combustion supporting supplements (in the form of solid or liquid additives).

It is another object of the invention to provide improved apparatus for carrying out the present method for making aggregate that is adjustable to efficiently handle different types and sizes of material.

Other objects and advantages of this invention, including its simplicity and economy, as well as the ease with which it may be adapted to existing equipment, will further become apparent hereinafter and in the drawings in which:

FIG. 1 is a vertical longitudinal sectional view of one form of apparatus for making aggregate in accordance with this invention;

FIG. 2 is a view in elevation of the front end of the apparatus shown in FIG. 1; and

FIGS. 3 to 5 are vertical longitudinal sectional views showing other embodiments of the apparatus of this invention.

Although specific terms are used in the following description for clarity, these terms are intended to refer only to the structures shown in the drawings and are not intended to define or limit the scope of the invention.

Turning now to the specific embodiments of the invention selected for illustration in the drawings, there is shown in FIGS. 1 and 2 apparatus for continuously making aggregate from carbonaceous shale or the like, comprising an ignition chamber 11, an endless traveling grate 12 located at the bottom of and extending entirely across the ignition chamber 11 and adapted to receive a pile of carbonaceous shale, a burner block assembly 13 positioned in and extending transversely entirely across ignition chamber 11 for directing flames 14 against the



carbonaceous shale in the ignition chamber 11 substantially perpendicularly to the sloping side 15 of the pile to quickly pre-ignite a pilot layer of the shale thereon, and a combustion chamber 16 which is located adjacent to and rearwardly of ignition chamber 11 and beneath which the grate 12 travels on leaving the ignition chamber, whereby the traveling grate 12 in moving toward the combustion chamber acts to gently tumble the pre-ignited pilot layer of the shale and roll it under a layer of the non-ignited shale so as to thereafter completely burn the entire mass of shale in combustion chamber 16 as blowers 17 force air upwardly from air chambers 18 against the pre-ignited shale forming the bottom layer of the mass.

Positioned above ignition chamber 11 is a surge or storage bin 21 which is of steel plate construction and is used to store carbonaceous shale to insure a constant gravity feed of material to a feed chamber 22 located immediately therebelow.

Feed chamber 22 supplies material by gravity feed to the ignition chamber 11, and includes a leveling gate 23 which is constructed of structural steel channels 24 encased in cast refractory material 25. The lower portion of gate 23 separates the ignition chamber 11 from the combustion chamber 16. Leveling gate 23 may be raised or lowered to control the depth of the bed of material carried by grate 12 from the ignition chamber into combustion chamber 16.

Feed chamber 22 also includes a front gate 26 which is made of cast refractory material and extends in an inclined fashion from the bottom of storage bin 21 to the ignition chamber 11. The lower portion of the front gate 26 is positioned rearwardly of burner block assembly 13, and the position of front gate 26 is adjustable.

The angle that sloping side 15 makes with the upper level of traveling grate 12 is the angle of repose, indicated in FIG. 1 as the angle 27. The angle of repose as herein referred to is the angle which a particular material takes when poured into a pile. This angle will vary with variations in the material, as each material has its own characteristic angle of repose.

The angle of repose is important from the point of view of maximum efficiency and use of the flames 14 from burner block assembly 13, which flames should preferably be directed substantially perpendicularly to the sloping side 15 of the pile to insure pre-igniting the shale in an even, uniform manner.

The position of front gate 26 determines the height of the pile of material in the ignition chamber and thereby determines the area of sloping side 15 thereof exposed to the flames 14.

Burner block assembly 13 comprises a plurality of transversely aligned burner blocks 35, and is mounted adjacent front gate 26, and is connected thereto by a mortar seal 28 after the front gate and the burner block assembly have been set in the desired adjusted positions. Blocks 35 are suspended from steel rods 31, 32, which are adjustable lengthwise by turnbuckles and extend between brackets 33, 34 mounted on the back of burner blocks 35 and stationary I-beams 36, 37. It should be noted that steel rods 31, 32 support burner blocks 35 in a position which is approximately parallel to the sloping side 15 of the pile of carbonaceous shale in ignition chamber 11. Burner blocks 35 are made of cast refractory material, and each is provided with a hole 38 in the center, through which passes the flame 14 from a burner, such as burner 41.

A drop plate 42 made of a cast refractory material is mounted on the front of the burner block assembly 13 and extends the full width thereof and projects downwardly from the same substantially to close the space at the front of the ignition chamber 11 between the burner block assembly and the traveling grate 12. Drop plate

42 is adjustable toward and away from the traveling grate so that it may be set in the desired space relation thereto both to regulate the entrance of air into the ignition chamber 11 to support combustion and to prevent the escape of the shale or other material. Drop plate 42 is supported by a drop plate support angle 43 to which are welded the drop plate clip angles 44. There is a slot in the upper leg of each clip angle 44, and drop plate 42 is adjustably bolted to clip angles 44 through these slots.

Positioned below the upper run of the traveling grate 12, beneath ignition chamber 11, is an adjustable baffle plate 45 which prevents any forced air from the adjacent air chamber 18 from entering ignition chamber 11 and interfering with the pre-ignition of the material.

The mechanism for raising and lowering leveling gate 23 includes a threaded rod 46 which is connected to the gate, is threaded into a fixed support 47, and is driven by a worm 48. The upper end of rod 46 is received into a housing 51 which projects into storage bin 21.

The upper run of the grate 12 passes rearwardly from the combustion chamber 16 into and through the lower portion of a cooling chamber 54 which is located behind and in open communication with the combustion chamber. A roof 52 preferably extends over both chambers 16 and 54 and is supported by cross I-beams 53. There are one or more air chambers 18 below the combustion chamber 16 and below the cooling chamber 54 for directing air upwardly through the upper run of the grate 12 to the material thereon in the respective chambers. Air is supplied to the air chambers from any suitable source, as by motorized blowers 17 therein.

Considerable pressure is built up within ignition chamber 11 by the hot gases generated therein. To relieve this pressure, there may be provided a series of vent pipes 61 which are positioned in the mortar seal 28 between burner block assembly 13 and front gate 26. The hot gases in vent pipes 61 may exhaust to the atmosphere through openings 62, or may be directed by means of valves 65 through pipes 63 to an exhaust fan 64, and from there discharged into combustion chamber 16 through pipes 66.

Exhaust fan 64 may also draw hot gases from ignition chamber 11 through a series of pipes 67 which pull the hot gases through the pile of non-ignited feed material and thereby aid pre-ignition of the pilot layer thereof. Pipes 67 pass through gate 23 and then extend upwardly through furnace roof 52 to exhaust fan 64.

Instead of directing the hot gases from fan 64 through pipes 66 into the combustion chamber 16, where the hot gases assist and maintain combustion, the hot gases may be passed through pipes 68 to the atmosphere or to apparatus for making steam, or used for other purposes.

In operation, the carbonaceous shale or the like is fed into storage bin 21 by means of a conveyor belt, pay-loader, clam shell bucket, truck, or other mechanical device. The shale is gravity fed from storage bin 21 to the feed chamber and thence into the ignition chamber 11 as a result of traveling grate 12 conveying the material away from the ignition chamber. As the shale moves through feed chamber 22 and passes the bottom 55 of front gate 26, it forms a pile the side 15 of which assumes its natural angle of repose 27 in the ignition chamber 11 where pre-ignition of the pilot layer is effected by the flames 14 from the burner block assembly 13. The ignited pilot layer of the material continues to move in the ignition chamber along the sloping side 15 of the pile of shale and is deposited on the traveling grate 12 which is moving in the opposite direction. By the movement of the traveling grate 12 the ignited pilot layer is gently tumbled and rolled to turn it upside down under a non-ignited layer of the material, the two layers moving together under the leveling gate 23 and into and through the combustion chamber 16. Turning the pilot layer upside down causes the surface thereof which has been directly exposed to the frames 14 and hence is the most intensely ignited portion of such layer, to be brought to the bottom and in contact with the grate. This promotes thorough combustion which proceeds upwardly throughout the pilot layer and the non-ignited layer superposed thereon.



Air from blowers 17 is forced from air chambers 18 through the bottom of the upper run of traveling grate 12 and through the pilot layer of ignited material and the layer of non-ignited material superposed thereon in sufficient amounts to support complete combustion of the entire mass of material in combustion chamber 16.

From the combustion chamber the traveling grate 12 carries the material to the cooling chamber 54 where air is forced upwardly from one or more air chambers 18 through the upper run of the grate to cause the burned-out material to cool, expand, and solidify sufficiently to form a substantially homogeneous bed across the complete width of the traveling grate 12. The clinker cake thus formed is delivered to the exit end of the apparatus and is cut to size for delivery.

Turning now to the embodiment of the invention illustrated in FIG. 3, there is shown a storage bin 71 containing shale or other semi-combustible material. A front gate 72 and a middle gate 73 extend downwardly from storage bin 71 to form a front feed passage 74 through which some of the shale passes to an ignition chamber 75. A traveling grate 76 is positioned beneath ignition chamber 75 and receives the shale from front feed passage 74.

The shale in ignition chamber 75 forms a pile having a sloping side 77 which is pre-ignited by a plurality of flames 78 from ignition means such as burners 81.

A rear feed passage 82 is formed by middle gate 73 and a rear or leveling gate 83. Rear feed passage 82 extends downwardly from storage chamber 71 and some of the shale passes therethrough to deposit an upper layer 84 of non-ignited shale on top of a layer 85 of pre-ignited material.

The traveling grate 76 rolls the ignited shale after it has moved along the sloping side 77 of the pile of shale in the ignition chamber 75 and turns it upside down under the non-ignited shale therein to form a pilot layer 85 of pre-ignited shale particles and carries the pilot layer 85 beneath middle gate 73 to receive the upper layer 84 of non-ignited shale from rear feed passage 82. The continued travel of the grate 76 moves the layers 85 and 84 together under the leveling gate 83 and into and through combustion chamber 86 (located immediately behind the leveling gate) where pilot layer 85 ignites upper layer 84 from the bottom up.

An exhaust conduit 87 extends from ignition chamber 75 and aids in dissipating the pressure built up in ignition chamber 75. Forced air (indicated by the arrows) from intake air chambers 88 aids in maintaining combustion in chamber 86.

The embodiment of the invention disclosed in FIG. 4 includes a storage bin 91 which contains the shale to be treated, a front feed passageway 92 extending downwardly from the forward portion of storage bin 91, an ignition chamber 93 positioned in front of the lower end of the feed passageway 92, ignition means in the ignition chamber 93, such as burners 96 of a burner block assembly 114, and a traveling grate 97 positioned beneath the ignition chamber 93.

In this form of the invention the shale discharged from the front feed passageway 92 does not form a pile on the traveling grate 97 but moves downwardly from such passageway in a relatively thin layer along a stationary inclined grate 94 in the ignition chamber 93. This grate extends downwardly and forwardly below the lower end of a front gate 113, above the traveling grate 97, in spaced and preferably parallel relation to the burner block assembly 114, so that the shale traveling along such grate is exposed to and pre-ignited by the flames from the burners to form a pilot layer 98 which falls

freely from the lower end of the grate **94** and is deposited on the traveling grate **97**, whereby it is rolled and turned upside down. The grate **94** is adjustably mounted as by being pivoted at its upper end to a fixed part of the apparatus to permit its angle of inclination to be set relative to the angle of repose of the shale or otherwise varied to suit different operating conditions.

The traveling grate **97** carries the pilot layer **98** across the bottom of an exhaust chamber **103** located behind the front feed passageway **92** and the grate **94** in the ignition chamber and between the same and a rear feed passageway **101** which extends downwardly from the rear portion of the storage bin **91**. To relieve pressure built up in the ignition chamber **93** and in the exhaust chamber **103** the latter is shown as provided with an upwardly extending gas exhaust conduit **104** to which suction means may be connected if desired.

As it passes rearwardly with the traveling grate **97** the pilot layer **98** is carried below the lower end of the feed passageway **101** from which a layer **102** of non-ignited shale is deposited on the pre-ignited pilot layer. The two layers of shale are then carried together under the leveling gate **115** and into and through the combustion chamber **105**.

Free air (indicated by the arrows **106**) is drawn down through the traveling grate **97** from in front of a drop plate **107** into air chamber **108** and then upwardly through the pilot layer **98** into the exhaust chamber **103** and thereby aids in maintaining combustion of such pilot layer of shale as it passes through exhaust chamber **103**. Forced air (indicated by arrows **111**) from air chambers **112** passes upwardly through the shale layers **98** and **102** in combustion chamber **105** to aid in securing complete combustion of the shale therein.

A front gate **113** forms the front of front feed passageway **92** and is adjustable vertically to regulate the thickness of the pilot layer **98** flowing over the inclined grate **94**. The burner block assembly **114** is connected to the front gate and extends forwardly therefrom.

The leveling gate **115** forms the rear portion of rear passageway **101** and determines the height or thickness of upper layer **102** of shale.

The embodiment of the invention shown in FIG. 5 includes a storage bin **117** which has extending from the front portion thereof a front feed passageway **118** through which some of the shale passes to be deposited upon a horizontally disposed vibrating grate **121** that moves the shale forwardly in a relatively thin layer under the lower end of a front gate **119** and into and through a forwardly extending ignition chamber **122** in a direction opposite to the direction of movement of traveling grate **123**. The height or thickness of the pilot layer is determined by the vertically adjustable front gate which forms the front wall of the passageway **118**.

Flame **124** from burners **125** mounted in horizontally positioned burner blocks **126** in the ignition chamber **122** impinge upon and pre-ignite the shale on the vibrating grate **121** to form a pilot layer **127**.

The pilot layer is tumbled off the front end of the vibrating grate **121** and deposited upon the surface of the traveling grate **123** which is located below the grate **121** and on which the pilot layer is rolled and turned upside down. A drop plate **128** is supported on the front of burner blocks **126** and defines the front of ignition chamber **122**.

Free air is drawn downwardly through the pilot layer **127**, the vibrating grate **121** and the traveling grate **123**, as indicated by the arrows **131**, into air chamber **132** (located below the traveling grate) and then upwardly therefrom through the traveling grate and the pilot layer **127** into exhaust chamber **133**. This chamber **133** is disposed immediately behind the front feed passageway **118** and is provided with an exhaust conduit **138**.

Behind the exhaust chamber **133** is a rear feed passageway **134** through which shale feeds by gravity from the rear portion of the storage bin **117**. The traveling grate **123** conveys the pilot layer **127** rearwardly beneath the exhaust chamber and the lower end of the rear feed passageway, from the latter of which a layer **136** of non-ignited shale is deposited upon the pilot layer. The two layers travel together with the grate **123** under a leveling gate **135** (which determines the height or thickness of the layer **136**) and into and through a combustion chamber **137**. Beneath the traveling grate **123** are air chambers **141** from which air is forced upwardly through such grate and the bed of shale thereon to support combustion of the entire bed in the combustion chamber.

In summary, each of the various forms of the apparatus of the present invention for making aggregate from carbonaceous shale or the like comprises an ignition chamber, means for feeding a pilot layer of the material to the ignition chamber, ignition means positioned in the ignition chamber for quickly pre-igniting the pilot layer, means for positioning an upper layer of non-ignited material upon the pilot layer after it has been pre-ignited, a combustion chamber adjacent to the ignition chamber, and a traveling grate adapted to receive both layers and carry them together into and through the combustion chamber wherein the entire mass is completely burned.

The lightweight aggregate obtained from this invention is used in making cinder blocks for building construction, among other things.

The present invention may be used not only on carbonaceous shale, but, as pointed out above, may also be used on very low grade shale alone which does not have sufficient carbon to burn. In this case, sufficient combustible material is added to allow pre-ignition, and to cause subsequent combustion to occur in the combustion chamber. Accordingly, the invention is not limited to carbonaceous shale but may be used with petro coke, low grade or semi-bituminous coal, and mixtures of non-combustible and combustible materials.

Another advantage of the apparatus of this invention is that it is readily adjustable to suit different kinds of material.

In practice, satisfactory results have been obtained from apparatus wherein the ignition chamber, the combustion chamber and the traveling grate are about 12 feet wide and the burner block assembly includes a series of six burner blocks which cover the full width of the ignition chamber, thereby assuring quick and complete pre-ignition therein of the pilot layer of shale.

The present invention has resulted in considerable savings in initial cost, maintenance, and space, and in the time required to ignite and completely burn the shale. Under the present system, satisfactory results have been obtained by increasing the travel of the grate to 90 feet an hour, with corresponding increase in output.

Carbonaceous shale has a B.t.u. value of perhaps 6000 compared to the B.t.u. value of anthracite coal of from 1200 to 1400, and so it has not been conventionally used as a fuel because of the difficulty in igniting it. The present invention provides an inexpensive and easy method of igniting carbonaceous shale, and the 6000 B.t.u.'s from the carbonaceous shale may be utilized for various purposes, as, for example, to produce steam in boilers of improved design.

It is to be understood that the form of the invention herewith shown and described is to be taken as a presently preferred embodiment. Various changes may be made in the shape, size and arrangement of parts. For example, the bars or keys on the traveling grate are shown in FIG. 1 as having a curved surface, but they may be formed with a flat surface, if desired. Equivalent elements may be substituted for those illustrated and described herein and certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention as defined in the subjoined claims.

I claim:

1. A method for making aggregate from carbonaceous shale or the like comprising directing at least a substantial portion of said shale rearwardly to form a pilot layer, directing flame perpendicular to the surface of said pilot layer in an ignition zone to pre-ignite said pilot layer, rolling the pre-ignited pilot layer to turn the pilot layer upside down, and positioning an upper layer of non-ignited material upon the pilot layer after it has been so turned.

2. A method for making aggregate from carbonaceous shale or the like comprising feeding material to an ignition zone, directing at least a substantial portion of said material rearwardly to form a pilot layer, directing a flame perpendicular to the upper surface of said material in the ignition zone to form a pre-ignited pilot layer, rolling said pre-ignited pilot layer to turn the pilot layer upside down, positioning upon the pilot layer after it has been so turned a non-ignited upper layer of the material, conveying the pilot layer and the upper layer superposed thereon into and through a combustion zone, and forcing air upwardly against the pre-ignited pilot layer in its travel through the combustion zone, the upper layer of material being ignited from the bottom up by the pre-ignited pilot layer and the entire mass being burned in the combustion zone.

3. A method for making aggregate from carbonaceous shale or the like comprising directing at least a substantial portion of said shale rearwardly to form a pilot layer, directing flame perpendicular to the surface of said pilot layer in an ignition zone to pre-ignite said pilot layer, rolling the pre-ignited pilot layer to turn the pilot layer upside down, positioning an upper layer of non-ignited material upon the pilot layer after it has been so turned, and moving both layers together into and through a combustion zone, the upper layer of material being ignited from the bottom up by the pre-ignited pilot layer and the entire mass being completely burned in the combustion zone.

4. A method for making aggregate from carbonaceous shale or the like comprising feeding said shale to an ignition zone to form a pile therein having a sloping side, directing a flame against the sloping side of said pile of shale to form a pre-ignited pilot layer, and rolling the pre-ignited pilot layer beneath said sloping side to turn said pilot layer upside down under the non-ignited shale in said pile.

5. A method for making aggregate from carbonaceous shale or the like comprising feeding said shale to an ignition chamber to form a pile therein having a sloping side, directing a flame against the sloping side of said pile of shale to form a pre-ignited pilot layer, rolling the pre-ignited pilot layer beneath said sloping side to turn said pilot layer upside down, positioning a layer of non-ignited shale upon the pilot layer after it has been so turned, and forcing air against the pre-ignited pilot layer to ignite the non-ignited layer and burn the entire mass.

6. A method for making aggregate from carbonaceous shale or the like comprising feeding said shale to an ignition chamber to form a pile therein with a sloping side of said pile forming an angle of repose, directing a flame against said shale substantially perpendicularly to said slope to ignite the shale on said slope to form a pre-ignited pilot layer, rolling the pre-ignited pilot layer beneath said sloping side to turn said pilot layer upside down, positioning a layer of non-ignited shale upon the pilot layer after it has been so turned, and forcing air against the pre-ignited pilot layer to ignite the non-ignited layer and burn the entire mass.

7. A method for making aggregate from carbonaceous shale or the like comprising feeding said shale to a feed chamber, passing said shale from the feed chamber to an ignition chamber to form a pile therein with a sloping side of said pile forming an angle of repose, directing a flame against said shale substantially perpendicularly to said slope to ignite the shale on said slope to form a pre-ignited pilot layer, rolling said pre-ignited pilot layer beneath said sloping side to turn said pilot layer upside down, positioning a layer of non-ignited shale upon the pilot layer after its has been so turned, forcing air against the pre-ignited pilot layer to ignite the non-ignited layer and burn the entire mass, and cooling said mass into a clinker cake.



8. A method for making aggregate from non-combustible material comprising mixing a combustible supplement with the non-combustible material, passing said mixture to an ignition chamber to form a pile therein having a sloping side, directing a flame against the sloping side of said pile to form a pre-ignited pilot layer of said mixture, rolling said pre-ignited pilot layer beneath said sloping side to turn said pilot layer upside down, positioning a layer of non-ignited mixture upon the pilot layer after it has been so turned, forcing air against the pre-ignited pilot layer to ignite the non-ignited layer and burn the entire mass, and cooling said mass into a clinker cake.

9. A method for making aggregate from carbonaceous shale or the like comprising feeding shale to an ignition zone, directing at least a substantial portion of said shale rearwardly to form a pilot layer, directing flame perpendicular to the surface of said pilot layer to pre-ignite said pilot layer, rolling the pre-ignited pilot layer to turn the pilot layer upside down, moving the pilot layer after it has been so turned into and through an exhaust zone, feeding shale onto said pre-ignited pilot layer to form an upper layer of non-ignited shale thereon, and moving said layers together into and through a combustion zone, said pre-ignited pilot layer igniting said upper layer from the bottom up in said combustion zone.

10. Apparatus for making aggregate from carbonaceous shale or the like comprising an ignition chamber, means for feeding material to the ignition chamber and directing at least a substantial portion of the material rearwardly, ignition means in the ignition chamber for directing flame perpendicular to the surface of said rearwardly directed material for pre-igniting a layer of the material to form a pre-ignited pilot layer, a forwardly traveling grate arranged and adapted to receive the pre-ignited pilot layer and roll the pilot layer to turn the pilot layer upside down, means for positioning upon the pilot layer after it has been so turned an upper layer of non-ignited material, and a combustion chamber adjacent to the ignition chamber and into and through which both layers of the material are adapted to be carried by the traveling grate, the upper layer being adapted to be ignited from the bottom up in the combustion chamber by the pre-ignited pilot layer.

11. The apparatus defined in claim 10 wherein a leveling gate is positioned between said ignition and combustion chambers and is adjustable to determine the height of the material entering the combustion chamber.

12. Apparatus for making aggregate from carbonaceous shale or the like comprising an ignition chamber, means for feeding material to the ignition chamber to form a pile therein having a sloping side, ignition means adapted to be directed toward said sloping side and positioned in the ignition chamber to pre-ignite a pilot layer of the material on the sloping side, a forwardly traveling grate positioned under the ignition chamber and arranged and adapted to receive the pre-ignited pilot layer and roll the pilot layer beneath the sloping surface to turn the pilot layer upside down, means for positioning upon the pilot layer after it has been so turned an upper layer of non-ignited material, and a combustion chamber adjacent the ignition chamber and into and through which both layers of material are adapted to be carried by the traveling grate, the upper layer being adapted to be ignited from the bottom up in the combustion chamber by the pre-ignited pilot layer.

13. The apparatus defined in claim 12 having means for drawing the hot gases from the ignition chamber through said pile to aid ignition therein and for directing

said hot gases into said combustion chamber to assist in maintaining combustion.

14. Apparatus for making aggregate from carbonaceous shale or the like comprising an ignition chamber, means for feeding material to the ignition chamber and directing at least a substantial portion of the material rearwardly, means for directing flame perpendicular to the surface of said rearwardly directed material for igniting a layer of the material in the ignition chamber to form a pre-ignited pilot layer, a forwardly traveling grate positioned under the ignition chamber and adapted to receive the pre-ignited pilot layer, means causing the pre-ignited pilot layer to move in a direction opposite to the traveling grate for deposit thereon, the traveling grate rolling the pre-ignited pilot layer to turn the pilot layer upside down, means for positioning upon the pilot layer after it has been so turned a layer of non-ignited material, and a combustion chamber adjacent to the ignition chamber and into and through which both layers of the material are adapted to be carried by the traveling grate, the upper layer being adapted to be ignited from the bottom up in the combustion chamber by the pre-ignited pilot layer.

15. Apparatus for making aggregate from carbonaceous shale or the like comprising an ignition chamber, a forwardly traveling grate beneath the ignition chamber, an ignition grate in the ignition chamber above the traveling grate, means for feeding a layer of shale to the ignition grate, means in the ignition chamber for directing flame perpendicularly to the surface of the layer of shale on the ignition grate to form a pre-ignited pilot layer, the pre-ignited pilot layer being moved rearwardly along the ignition grate and deposited on the traveling grate and being rolled by the latter to be turned upside down, means for depositing a layer of non-ignited shale upon the pre-ignited pilot layer after the pilot layer has been so turned, and a combustion chamber into and through which the two layers of shale are carried together by the traveling grate.

16. The apparatus defined in claim 15, wherein the grate in the ignition chamber is inclined downwardly in the opposite direction to the direction of movement of the traveling grate.

17. The apparatus defined in claim 15, wherein the ignition grate is of the vibrating type and moves the pre-ignited pilot layer therealong to discharge it from one end of the ignition grate onto the traveling grate.

18. Apparatus for making aggregate from carbonaceous shale or the like comprising an ignition chamber, a combustion chamber, a vented exhaust chamber located between the ignition chamber and the combustion chamber, a forwardly traveling grate moving through said chambers, means for feeding a layer of shale to the ignition chamber, means for directing flame perpendicular to the surface of the layer of shale in the ignition chamber to form a pre-ignited pilot layer, the traveling grate rolling the pre-ignited pilot layer to turn the pilot layer upside down and carrying the pilot layer through the exhaust chamber, means for forcing air through the traveling grate and pilot layer during their passage through the exhaust chamber, and means for depositing an upper layer of non-ignited shale on the pre-ignited pilot layer after the pilot layer has been so turned and as the pilot layer leaves, the exhaust chamber, the traveling grate moving the two layers together into and through the combustion chamber.

**References Cited by the Examiner**

UNITED STATES PATENTS

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|---|---|---|---|
| 2,148,052 | 2/39 | Ahlmann | 263—53 X |
| 2,672,412 | 3/54 | Burrow et al. | 263—28 X |


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