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(54) **Method and apparatus for burning straw or like combustible material.**

(57) A furnace 10 for cylindrical bales 46 of straw has support means 14 whereby the bale is rotated about an axis 20 while it is burnt and heat is transferred to water in a jacket 12. Paddles 40 circulate partially burnt straw through the

combustion zone. Air is injected tangentially with respect to the bale surface and in the direction of rotation. Bales are loaded into the furnace axially by an openable end cover 44 mounted on rails 50 and actuated by rams.

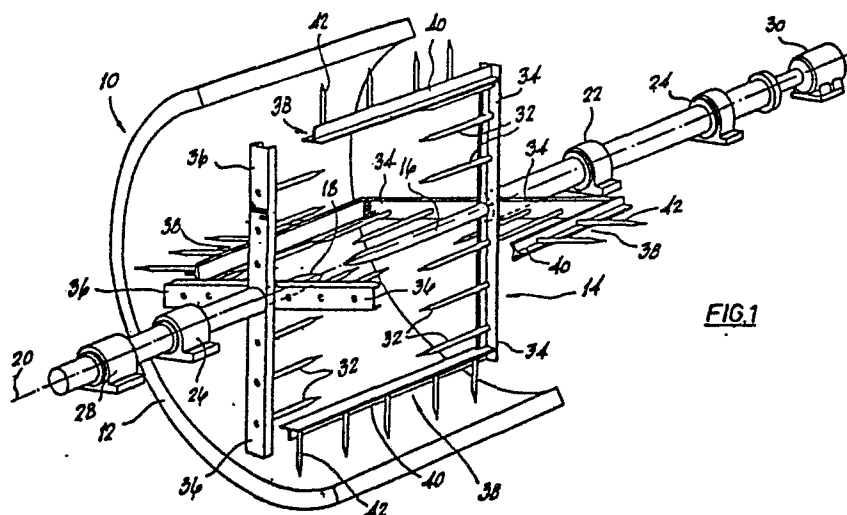


FIG.1

METHOD AND APPARATUS FOR BURNING STRAW OR LIKE COMBUSTIBLE MATERIAL.

This invention relates to a method and apparatus for burning straw or like combustible material . An example of the invention is a furnace or boiler for burning straw from cereal crops such as wheat and barley . The invention may also be applicable to the combustion of other combustible materials.

Presently available apparatus for burning straw is unsatisfactory in many respects , resulting in inefficient utilisation of the straw , low burning efficiency , the production of large amounts of waste ash , difficulties of ignition , and limitations in performance with regard to fuel quality , condition and size.

This latter requirement is of particular significance. Although proposals have been made for the combustion of large cylindrical bales of straw , these proposals have so far fallen short of the above-identified requirements for effective burning of straw.

An object of the present invention is to provide a method and apparatus for burning straw and like crop materials , and indeed other combustible materials , offering improvements in relation to one or more of the matters discussed above , or generally .

According to the invention there is provided combustion apparatus as defined in the accompanying claims .

In an embodiment described below combustion apparatus comprises rotatable support means for supporting combustible material during combustion . The support means is constructed to receive and support a mass , such as a cylindrical bale of crop or like material such as straw . Drive means is provided to rotate the combustible material during combustion. The combustible material is arranged to be rotated about a generally horizontal axis .

Air supply means is provided to draw air for combustion into the apparatus . The rate of supply of air is controllable. The control of the air supply is under automatic regulation . Such control , and control of the rotation of the support for the combustible material , is provided by micro-processor means. The air supply means causes air to enter the combustion apparatus in a direction generally tangential with respect to the direction of rotation of the combustible material.

Ignition means for the combustible material is provided comprising a gas burner unit operable to apply to the combustible material a gas flame while said material rotates .

In the embodiment , a method of burning straw or like crop or other combustible materials , comprises supporting said material on rotatable support means , and rotating same during combustion of said material. The method comprises a further step of supplying air to the burning material in a direction generally tangential with respect to rotation thereof. The method further comprises the step of causing rotatable

paddle or rake means to pass partially burnt combustible material back into the combustion zone.

In the embodiment there is described a method and apparatus for supplying combustible material to the combustion apparatus as defined above. The supply apparatus comprises conveyor means whereby individual batches of crop material are selected from a battery or store thereof and fed to the combustion apparatus . Preferably , the fuel material is transferred into the combustion apparatus in the axial direction with respect to rotation of the fuel material therein. The fuel feed means may be arranged to be automatically operated in response to combustion of the fuel in the furnace.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which :

Fig. 1 shows a sectioned perspective view of combustion apparatus with certain parts removed for clarity of illustration ; and

Fig.2 shows a further embodiment with a bale of crop material mounted therein and the end of the furnace opened.

As shown in Fig. 1 , combustion apparatus 10 for burning cylindrical straw bales comprises a cylindrical housing 12 and support means 14 for the crop material.

Housing 12 is in the form of a water jacket connected to a pump (.not shown) whereby water can be circulated

through the jacket to effect heat transfer to a hot water supply system .

Support means 14 comprises axially opposed mandrels 16 and 18 mounted for rotation about a common horizontal axis 20 which is also the axis of cylindrical housing 12 . The mandrels 16 , 18 are mounted for rotation on respective bearings 22 , 24 and 26 , 28 . Mandrel 18 is freely rotatable . Mandrel 16 is connected to a drive motor 30 for rotation about axis 20.

The crop support means 14 further comprises axially extending crop support elements which complement the mandrels 16 , 18 , and are in the form of tines or pins 32 extending parallel to axis 20 . Pins 32 and mandrels 16 , 18 are sharpened at their inner ends for crop penetration. The pins 32 are mounted at spaced intervals on radial support arms carried by mandrels 16 , 18 and disposed at 90 degree intervals , four support arms 34 on mandrel 16 , and four support arms 36 on mandrel 18 , the former being driven by motor 30 , and the latter being freely rotatable with mandrel 18 .

Each of the radial support arms 34 carries an axial paddle or rake assembly 38 at its radially outer end. Each paddle assembly comprises a support bar or paddle 40 carrying spaced radial tines 42 , for a purpose to be described.

Fig. 2 shows the apparatus of Fig. 1 with certain modifications, but including certain features omitted from Fig. 1 for reasons of illustration .

Thus , in Fig. 2 , water jacket 12 is shown with an openable end door 44 in an open position and with a bale 46 mounted on support 14 for rotation by motor 30 .

End cover 44 is mounted on a carriage 48 for sliding movement parallel to axis 20 on rails 50 , to open and close the furnace. The crop support assembly comprising mandrel 18 , tines 32 and support arms 36 (not seen in Fig. 2) is mounted on and moves with the furnace end cover 44 . The other , axially opposed , crop support means , comprising mandrel 16, tines 32 etc. is mounted in an axially fixed position within boiler shell 12 at the remote end thereof , as seen in Fig. 2 . End cover 44 and carriage 48 are mounted for axial opening and closing movement under the control of two hydraulic rams , not shown.

A crop support and feed member 52 in the form of an arcuate section trough is mounted at the loading end of the apparatus in a fixed position. End cover 44 has an arcuate slot to receive the trough 52 on which it is a sliding fit. The trough extends axially close to the end of the furnace to support and feed crop material into it .

Ignition means for the furnace is provided in the form of a pair of axially spaced burners 54 for liquid petroleum gas (LPG) . These burners extend through water jacket 12 to produce an axially spread out flame to ignite the straw at the commencement of combustion.

At the remote end of housing 12 , as seen in Fig. 2 , the housing is closed by a fixed end wall , not shown. A sector-shaped opening is formed in the end wall to receive a correspondingly-shaped scraper or purging member (not shown) mounted for axial sliding movement on rails 50 under the control of a drive . During combustion , the scraper closes the end wall of the furnace. After combustion , it is moved back and forth on its rails to purge the furnace of ash etc. prior to commencement of the next burn . The sector-shaped opening and the purging member correspond in size approximately to the bale support trough 52 and are located at the bottom dead centre position of the housing 12 .

A heat exchanger 56 is connected to housing 12 to receive hot gases therefrom . An induced draught fan , not shown , has its suction side connected to the outlet end of the heat exchanger and applies suction through the heat exchanger to housing 12, whereby the net pressure in the housing is slightly below atmospheric pressure . The pressure side of the fan delivers spent gases to a chimney .

The heat exchanger is connected to boiler 12 by a duct , not shown , containing baffles which slow down the rate of air flow and cause char (a black particulate combustion product of straw) to be deposited therein . An openable trap is provided for removal of char and the like.

A forced draught fan 58 is connected through a manifold 60 and ducts 62 so that its pressure side

delivers air to the interior of boiler or furnace 12. In Fig. 2 the air delivery is shown in an axial direction through end cover 44 . A flexible duct 64 delivers air for injection into boiler 12 through the side wall thereof. An important feature of the apparatus is the direction of injection of air through the walls of boiler 12 into the combustion zone 66 . It has been found that marked advantages are obtained by delivering the air in a direction approximately a tangent to the outer surface of the cylindrical bale 46 . The air may be injected at one or more axially and/or circumferentially spaced positions on boiler 12 . The preferred direction is so that the air is moving within the boiler in the same direction as the peripheral rotational direction of movement of the bale. Means may be provided for adjusting the angle of delivery of air into the boiler.

The air output capacity of the forced draught fan 58 is lower than that of the induced draught fan connected to heat exchanger 56 , whereby the resultant pressure within boiler 12 is somewhat below atmospheric so that air is drawn into the furnace through the small clearance openings therein such as that between trough 52 and end cover 44 . It may be arranged that the tangential air delivery to boiler 12 is made substantially along the full axial length thereof from fan 58.

In use , the boiler is first opened by moving end cover 44 to its fully open position . Conveyor means , not shown , then delivers a bale to trough 52 . The conveyor is positioned with its discharge end close to the inner end of trough 52 . A pivoted support

member or draw bridge (not shown) moves into position between the end of the conveyor and trough 52 and supports the bale as it rolls into the trough . The support member then pivotally retracts.

End cover 44 and its tines 32 and mandrel 18 are then moved inwards . First they engage and penetrate the bale , then arm members 36 push the bale along trough 52 towards mandrel 16 and into boiler 12 and up against radial arms 34. The bale is then supported on the tines 32 and the mandrels 16 , 18 with the paddle members 40 at its outer periphery. End cover 44 is closed against housing 12 and the sector shaped purging member at the other end is moved to its closed position. Motor 30 then rotates the bale and burners 54 ignite its periphery for a limited period of time. Combustion then proceeds while the bale rotates . The rate of rotation increases during combustion , whereby the peripheral speed of the bale is rendered more constant as its diameter reduces during combustion. The rate of rotation may be up to 25 revolutions per minute , the preferred range being from 3 to 14 r.p.m.. The motor may be programmed to rotate the bale a number of turns in one direction , for example 5 turns , then a similar number in the opposite direction. Preferably , the bale should be rotated in the direction which (having regard to the direction in which it was rolled during formation on the farm) will tend to maintain the straw in a rolled rather than unrolled condition. If this direction is not known , then it is preferred to rotate the bale alternately in opposite directions.

Heat from combustion directly heats the water in the water jacket of housing 12 . Similar heat extraction from the hot gases occurs in heat exchanger 56 whereby the gases are further cooled and discharged to the chimney . Boiler 12 and heat exchanger 56 may be connected to a common water heating system fed by a pump.

During combustion , the paddles 40 and tines 42 stir up the burning loose straw on the base of the furnace and cause it to be cascaded through the central burning zone , whereby complete combustion is assured .

A micro-processor controls all operations of apparatus 10 including the rate of rotation of the bale , the period of ignition , the direction of rotation of the bale , the air supply and all other variables , whereby the maximum efficiency of operation is achieved.

After combustion , all that is needed to reload the furnace is to re-open end cover 44 and to move the purging member along the boiler chamber to push any small amount of combustion products out of the open end of the furnace. The purging member then retracts to its closed position .

Among the advantages of the embodiment described above are its fully automatic operation , the highly efficient burning facility arising from the rotation of the bale , whereby the entire cylindrical surface of the bale is burnt continuously , giving a even burn . Moreover , the rotating paddle members promote

reburn so as to complete combustion of partially burnt straw .

Waste products from burning are readily removed from the furnace before placement of a new bale for combustion. The rotation of the bale during burning also promotes higher efficiency of heat transfer to a water jacket.

Among modifications which could be made in the above embodiment while remaining within the scope of the invention are changes to the structural details of the method of supporting and rotating the bale . For certain applications it might be possible to mount the combustible material for rotation about an upright or vertical axis. For other combustible materials , modified support means may be needed. If the material to be burnt has an axis of symmetry , then it should be rotated about this axis . If not , then a compromise axis of rotation may need to be chosen.

Considerable modification of the heat exchanger arrangements can of course be envisaged by those skilled in the art.

In the above-described embodiment the mainly internal support for the fuel to be burnt by means of fuel support elements which penetrate the fuel mass , the provision of external fuel supports which might reduce heat transfer from the furnace is minimised. Nevertheless , with certain combustible materials it may be beneficial to support the latter by means of an external support or container such as a metallic cage which is likewise rotated. For certain fuels such as cotton waste , such an arrangement may be beneficial since it permits the

fuel to be more loosely distributed . In such a case , rotation about an upwardly extending axis with a corresponding upward air flow may be beneficial , with provision for heat exchange above the fuel on and around the rotation axis. Other combustible materials for which this approach may be suitable include copra , bamboo trash , waste paper , cardboard and the like. These materials may be baled or not according to particular requirements.

For heat exchange purposes , a water tube boiler arrangement may be provided , either of the conventional kind or with water tubes arranged in series. The water tube output may be mixed with the water output of a secondary heat exchanger.

CLAIMS :

1. Combustion apparatus characterised by a rotatable suport (14) for combustible material (46) during combustion.
2. Apparatus according to claim 1 characterised in that the rotatable support (14) is constructed to receive and support a mass of said combustibile material , such as a bale of crop or like material.
3. Apparatus according to claim 1 or claim 2 characterised by drive means (30) to rotate the combustibile material (46) during combustion.
4. Apparatus according to any one of the preceding claims characterised in that the combustibile material is arranged to be rotated about a generally horizontal axis (20) .
5. Apparatus according to any one of the preceding claims characterised by air supply means adapted to draw air for combustion into the apparatus.
6. Apparatus according to any one of the preceding claims characterised by air supply means arranged to cause air for combustion to enter the apparatus in a direction generally tangential with respect to rotation of the periphery of the combustibile material.
7. Apparatus according to any one of the preceding claims characterised by a gas burner (54)

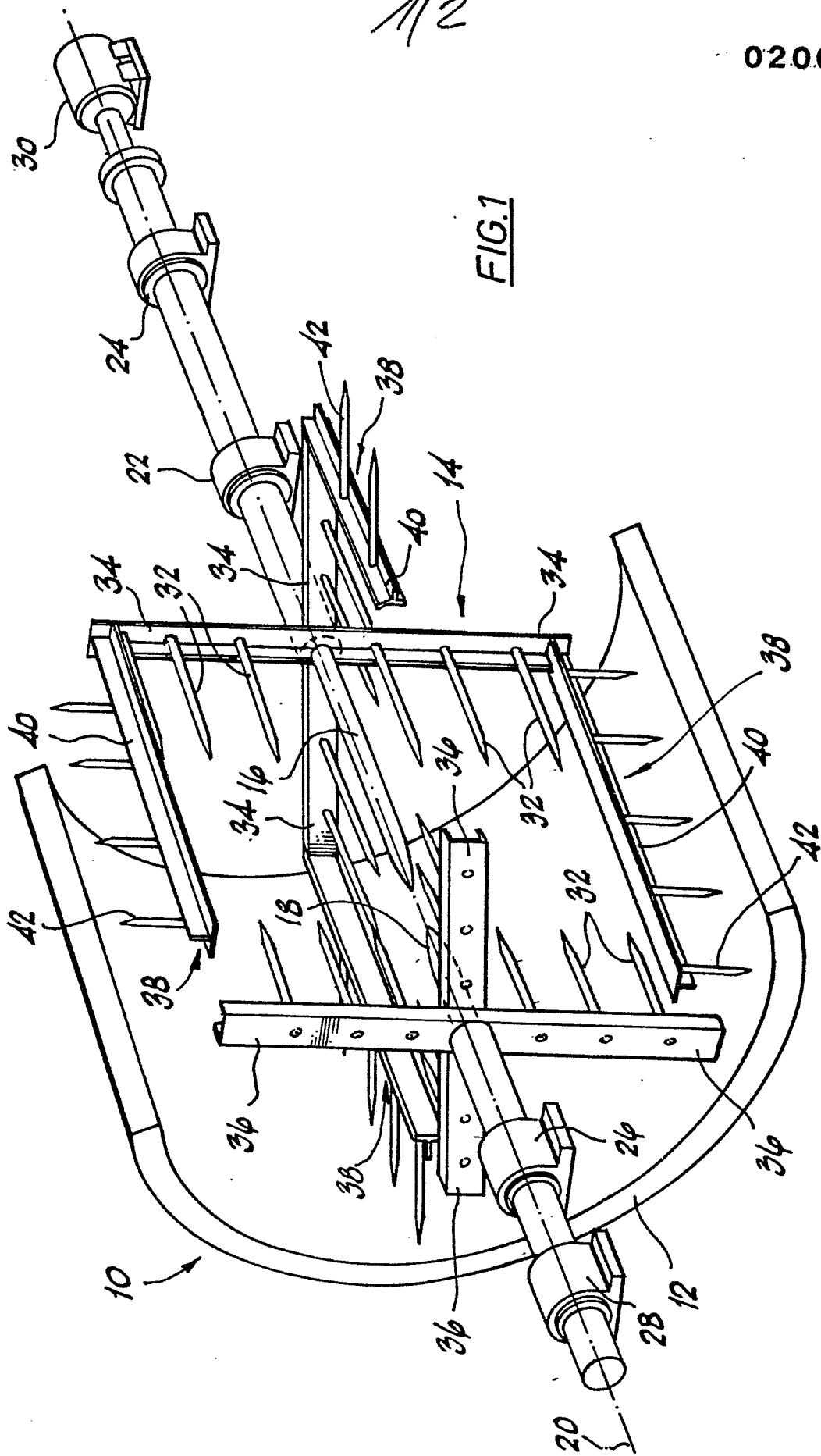
operable to apply to the combustible material a gas flame while said material rotates.

8. A method of burning straw or other combustible materials characterised by supporting said combustible material (46) on rotatable support means (14) therefor and rotating same during combustion of said material.

9. A method according to claim 8 characterised by the step of supplying air to the burning material during combustion in a direction generally tangential to the direction of movement of the periphery thereof.

10. A method according to claim 8 or claim 9 comprising the step of causing rotatable paddle or rake means to engage partially burnt material in the base of the apparatus and to lift same and to drop it through the combustion zone.

FIG. 1



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