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## (54) Peat drying apparatus and method.

(57) In drying apparatus for removing moisture from peat, hot gases generated by a furnace 4 are sucked through a rotary drum drier 1 by a downstream blower 16. Peat is fed into the drum drier 1 by a conveyor 3 and entrained with the gas flow for direct contact heat exchange and intensive drying action during its passage through the drier. Downstream of the drier 1, the peat and hot gases are separated by cyclone units 8 and 14. A substantial proportion of the hot gases separated from the gas and peat mixture are returned by duct 17 to the upstream end of the drying system for recycling through the drying stage. The returned gases are input to the furnace 4 by blower 6, where they are mixed with fresh combustion gas and reheated. Oxygen content in the hot gases leaving the system is monitored by sensor 58 and peat input to the drier 1 is only allowed when the oxygen content is less than 12%. Temperature within the drier is also monitored by sensor 55 and peat input only takes place when enabled by oxygen content and also when appropriate temperature conditions prevail in the drier. A water input 52 to the drying system is also enabled and disabled by the oxygen sensor 58, and water injection takes place, when enabled, if drier temperature rises to an excessive level.

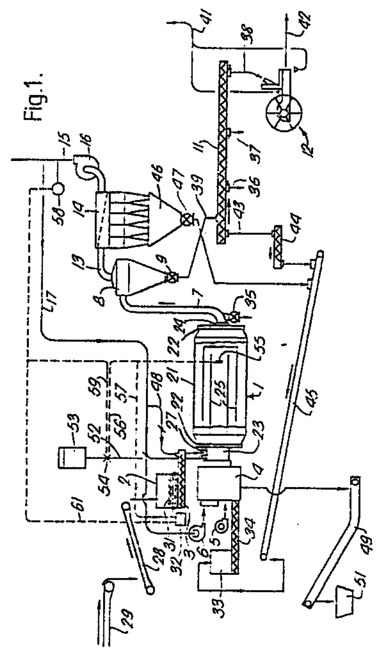

Fig.1.

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**Description**

"Peat Drying Apparatus and Method"

This invention relates to the drying of peat, and in particular to an apparatus and method for reducing the moisture content of raw peat to a level facilitating the carrying out of further processing operations, such as compression, on the dried peat, to form, for example, pellets or briquettes.

Raw peat can contain up to about 90% moisture. Natural drying may serve to reduce the moisture percentage to about 55%, but a further reduction in moisture content is required, if the peat is to be brought to a condition suitable for the manufacture of briquettes or other compressed peat products. It is known to reduce the moisture content of peat by indirect heat exchange methods, in which the peat is passed through a suitable heat exchange apparatus on one side of a barrier or wall, while a hot medium serves to heat the barrier or wall from the other side. A variety of heat exchanger constructions may be employed, and, in particular, vertically disposed such installations have been provided, in which the peat was passed through one or more tubes extending longitudinally of a cylindrical vessel, while hot gases circulated within the vessel around the exterior of the tube(s). Further known drying installations have used the passage of steam through the raw product to achieve the required moisture reducing action.

A system of this last kind is disclosed in European Patent Specification No. 0,184,372A, directed to a process and apparatus for drying low grade coals and peat. The product to be dried is subjected to a superheated gaseous medium, most suitably superheated steam, and a substantial portion of the superheated gases produced are recycled back into contact with the material being dried, but sufficient heat is added to the recycled gases to maintain them in a substantially superheated condition throughout.

Other known configurations of drying apparatus for peat represent adaptations of equipment for drying other products, such as grain and a variety of foodstuffs, for example, potatoes, to the drying of peat. Such adaptations of apparatus constructed for other purposes are not necessarily appropriate to the peat industry, in particular, in that finely divided peat in powder form is highly combustible, and peat fines may produce an explosive mixture, depending on the conditions and circumstances within which the fines are contained.

British Patent Specification No. 2,005,394A relates to a system for drying wood pulp, in which the wood pulp is dried by direct contact with heated air in a drying chamber. The heated air is recycled in sufficient quanitty for the hot gas coming into contact with the wood pulp material to have an oxygen content of less than 10% by volume so that the risk of fire may be reduced. A generally similar configuration of drying apparatus is disclosed in British Patent Specification No. 888,845. British Patent Specification No. 2,188,134A describes a method of controlled drying in which hot gases, such as air, are passed over product, and a component of the hot gases, preferably oxygen, is monitored and regulated in order to obtain a predetermined residual moisture content in the product after drying. In the arrangement shown and described in this Patent Specification, the hot air used is a mixture of recycled drying air, fresh hot air and atmospheric air. The apparatus described and illustrated also encompasses arrangements for spraying atomised water into the hot air to serve as an artificial drying load, in particular during an initial period at the start of the drying operation, to thereby reduce the oxygen content of the hot air.

It is an object of the present invention to provide an improved drying process for peat capable of reducing the moisture content of raw peat to a selected predetermined value, while also providing improved economy in the drying operation.

Another object of the invention is the provision of a process and apparatus for drying peat, of lesser complexity and cost than known arrangements for this purpose, but nonetheless providing a high level of safety in operation, having regard to the explosive potential of peat fines.

According to a first aspect of the invention, there is provided apparatus for removing moisture from peat, comprising drier means in which peat is brought into direct contact with hot gases in a hot gas and peat mixture, separator means in which the peat is removed from the hot gas and peat mixture, means for transferring the hot gas and peat mixture from said drier means to said separator means, and means for maintaining the oxygen content of the hot gases in the drier means below a predetermined value, said predetermined value being less than the oxygen content of atmospheric air; said oxygen content maintaining means including means for redirecting at least a portion of the hot gases separated from the hot gas and peat mixture back for input to the drier means, at least during substantially steady-state operation of the apparatus, means for establishing the oxygen content of the hot gases within the apparatus, and means for allowing the addition of water to the hot gases when said oxygen content establishing means indicates an oxygen level corresponding to or in excess of said predetermined value, for the generation of steam within the drier means by the action of the hot gases on the added water. By means of the invention, therefore, the oxygen content of the hot gases in the drier means may be brought back to or maintained below said predetermined value, should the oxygen content rise towards or reach an unacceptable level during steady-state operation, and the system also comes into operation as required during the start-up phase of a peat drying operation to reduce oxygen content. A suitable oxygen content limit defining said predetermined value is 12%, the danger of an explosion of peat fines within the drier means being obviated when the oxygen content of the hot gases within the drier is 12% or less. Preferably said oxygen content establishing means is arranged to measure the oxygen level in the hot gases leaving the apparatus, downstream of the drier means, said level being indicative of the oxygen content of the hot gases within the drier means.

Said means for allowing addition of water may include water supply means and valve means for controlling flow of water from said water supply means for addition to said hot gases, the apparatus then also comprising a temperature sensor for establishing an indication of the temperature of the hot gases within the drier means, said valve means being enabled when said oxygen content as established by said oxygen content establishing means corresponds to or is in excess of said predetermined value so that said valve means may be opened for flow of water therethrough, and said valve means being disabled when said oxygen content is less than said predetermined value so that said valve means then remains in a closed condition, and the opening and closing of said valve means, when enabled, being controlled in dependence on said temperature indication as established by said temperature sensor.

The apparatus may also comprise input means for feeding peat to said drier means, said peat input means being enabled when said oxygen content as established by said oxygen content establishing means is less than said predetermined value so that peat may be directed to said drier means, and said peat input means being disabled when said oxygen content corresponds to or is in excess of said predetermined value so as to prevent peat from being directed to said drier means, and the operation of said peat input means, when enabled, being controlled in dependence on said temperature indication as established by said temperature sensor.

Said peat input means may include conveyor means and drive means for the conveyor means, the working of said drive means being regulated in dependence on said temperature indication. Said drive means may be an electric motor, the motor being switched on and off in dependence on the gas temperature within the drier.

Alternatively, the motor may be a variable speed machine, the speed of which is controlled in dependence on said gas temperature as measured by the temperature sensor of the apparatus.

Thus the motor and the water valve are enabled or disabled in response to safety signals provided by an oxygen sensor of the apparatus, and each said unit of the apparatus, when enabled, operates under the control of the temperature sensor measuring gas temperature within the drier means.

As a result of the steam evolved during the drying process, either by evaporation from the raw peat for steady state operation, or by means of water injection, the latter being the case during the start-up phase or in the presence of excess oxygen, the gases leaving the system at the downstream end contain a lower proportion of oxygen than atmospheric air, even without flue gas recirculation, and thus represent a gas flow relatively high in inert gas content. Recycling of a proportion of this gas flow for re-input to the drier means facilitates regulation of oxygen content within the drier means, so that it may be maintained below said predetermined value in a particularly controllable and economical manner.

In a favoured configuration of the apparatus, the drier means is a cylindrical drum unit, most suitably mounted for rotation about a substantially horizontal axis. An especially favoured arrangement of the drum drier incorporates baffles for establishing a three-pass flow of peat and gases through the cylindrical unit between an inlet at one axial end thereof and an outlet at the other axial end.

Alternatively, the drier means is a generally cylindrical unit disposed with its longitudinal axis extending in a generally vertical direction, this configuration being especially suited to a flash drying variant of the invention.

In either arrangement of the apparatus, the hot gases input to the drier may be provided by a furnace, and the combustion gases of said furnace are directed to inlet means of the drier. The peat to be dried may also be directed to said drier inlet means, for example by a said conveyor, which withdraws the peat from a raw peat storage hopper.

Recycled hot gases from the separator means may be mixed with said furnace combustion gases preparatory to gas input to the drier, but most suitably, said recycled gases form a second gas input to the furnace, in addition to an atmospheric air input, and both such inputs are preferably blown by compressor means of the apparatus.

Said means for allowing the addition of water is preferably arranged to inject water into the flow of combustion gases and recycled gases at the peat and gas inlet means of the drier, for example, where said gases are associated with the peat input to the drier.

The separator means most suitably comprises at least one cyclone unit, and preferably, a main cyclone and a multi-cyclone disposed in series are provided. The separated gases are expelled from the multi-cyclone and forwarded to exhaust means of the system, such as a flue or chimney, by a blower, downstream of which the portion of the gases to be recycled is withdrawn from the flue gas flow. Oxygen content is most suitably also measured at this stage of the gas flow. The peat and hot gas mixture is transferred from the drier to the main cyclone through suitable duct means, the mixture being drawn along under the influence of the flue gas blower downstream of the cyclones.

In a particular configuration of the apparatus of the invention, peat dried to the required moisture criterion is withdrawn from the main cyclone such as by airlock means and transferred by conveyor means to one or more peat discharge points for further processing. Such further processing may consist, for example, of the formation of peat briquettes. The provision of a plurality of discharge points along the length of a longitudinally disposed conveyor enables peat to be withdrawn at a variety of discharge locations. For briquette manufacture, withdrawal of treated peat from the conveyor may take place towards its downstream end, whereas peat for processing to form pellets may be withdrawn from the conveyor means at a more upstream location.

For briquette manufacture, a suitable moisture level in the treated peat is 10%, whereas pellet production may be undertaken at higher water percentages. The apparatus of the invention is suited to drying peat to substantially any prescribed moisture percentage. The heat input to the drier may be substantially fixed during operation of the apparatus, the rate of gas flow and the temperature of the hot gases remaining constant throughout a drying operation, and the final moisture content of the treated peat may then be determined by varying the rate of peat throughput, such as by controlling the on-time or speed of the motor driving the input conveyor.

The feedstuff for the furnace may be provided by a portion of the dried peat, typically 20% by weight, the greater part of which is provided by peat withdrawn from the discharge conveyor of the apparatus at an upstream location thereon, relative to the briquetting or pelleting withdrawal points. In addition, a further but relatively minor part of this peat stock may be provided by peat fines separated in the multi-cyclone. However, this represents a relatively small percentage of the total peat handled in the apparatus, since the major part of the separating action takes place in the main cyclone, the peat from which passes onto the discharge conveyor.

In another aspect, the invention also provides a method for removing moisture from peat, comprising the steps of:

(a) bringing peat into direct contact with hot gases in a hot gas and peat mixture for removal of moisture therefrom,

(b) subsequently separating the peat from the hot gas and peat mixture, and

(c) maintaining the oxygen content of the hot gases in contact with the peat below a predetermined value, said predetermined value being less than the oxygen content of atmospheric air, by redirecting at least a portion of the hot gases separated from the hot gas and peat mixture back for input to said hot gas and peat mixture, at least during a substantially steady state phase of said method, and by adding water to said hot gases when the oxygen content thereof corresponds to or is in excess of said predetermined value, for the generation of steam in the hot gas and peat mixture by the action of the hot gases on the added water.

Said water addition may be enabled when said oxygen content corresponds to or is in excess of said predetermined value and disabled when said oxygen content is less than said predetermined value, and said addition of water is then preferably regulated in dependence on the temperature of the hot gases in the hot gas and peat mixture.

Input of peat to be dried to said hot gas and peat mixture may be enabled when said oxygen content is less than said predetermined value and disabled when said oxygen content corresponds to or is in excess of said predetermined value, and peat input, when enabled, is then preferably regulated in dependence on the temperature of the hot gases said hot gas and peat mixture.

In carrying out the method of the invention, the oxygen content of the hot gases is therefore maintained at a level less than a predetermined value, and this is achieved by recycling a proportion of the hot gases separated from the hot gas and peat mixture, for re-input to said mixture during the drying step, and, when necessary, by adding water to the hot gases during or preparatory to the drying operation, the amount of water added being dependent on the temperature of the hot gases.

The remainder of the hot gases brought into contact with the peat are provided by combustion gases from a furnace, and removal of water from the peat takes place during an advancing movement of the mixture of new furnace gas, recycled hot gas, and peat towards the separating means for removing the dried peat from the hot gas and peat mixture. The recycled gas may be associated with the furnace combustion gases preparatory to mixing of the peat therewith and preferably forms a gas input to the furnace, so that the recycled gas is also reheated before entering the drier.

In a favoured arrangement, the method may also include the further step of returning a portion of the dried peat for burning to provide said combustion gases. Said portion may include fines withdrawn from the peat and gas mixture during the separating step.

An embodiment of apparatus according to the invention together with certain variants thereon will now be described, having regard to the accompanying drawings, in conjunction with a description of the method according to the invention. In the drawings:

Figure 1 is a schematic representation of a peat drying plant in accordance with the invention,

Figure 2 is a longitudinal part-sectional schematic view of the rotary drum drier of the apparatus of Figure 1,

Figure 3 shows an alternative configuration of peat drying plant, similar to that of Figure 1, but without return of peat for use in the furnace, and

Figure 4 is a modified version of the plant of Figure 3, adapted for flash drying by the substitution of a vertical drier for the horizontal rotating drum of Figure 3.

The plant according to the invention shown in Figure 1 is first described in general outline, preparatory to a detailed description of its various component sections. As shown in Figure 1, peat is dried in a rotary drum drier 1, to which the raw peat is fed from a hopper 2 by means of a screw conveyor 3. Hot combustion gases are also input to the rotary drier 1 from a furnace 4, and the peat is dried within the drier 1 by direct contact with the hot gases. During the passage of the peat and hot gas mixture through the rotary drier 1, the greater part of the moisture contained in the raw peat is removed. The hot gas and peat mixture passes through the drier in a continuous flow drawn forward by blower means 16 located downstream of the drier. At the exit from the drier means, the hot gas and peat mixture is transferred through a suitable duct 7 to a main cyclone unit 8, where the greater proportion of the dried peat is separated from the hot gas and peat mixture. This separated peat is removed from the cyclone unit 8 through an airlock 9 and transferred to a feed conveyor 11 for supply to one or more downstream peat processing devices, such as, for example, a briquetting press 12.

The hot gases and whatever quantity of peat remains in them are passed forward from the main cyclone 8 through further duct means 13 to a multi-cyclone 14, where the remaining peat fines are removed from the mixture. The fines collected in the multi-cyclone 14 are returned to the furnace 4 in which the combustion gases are generated, for burning therein to provide the heat input to the plant. The hot gases exiting from the multi-cyclone 14 are forwarded to a chimney or flue 15 of the system by a suitable blower, but a part of the hot gases is recycled, as indicated schematically by reference 17, to provide a further blown input to the furnace. The purpose of this recycling will be subsequently described in greater detail.

Considering now the various elements of the plant in greater detail and referring also to Figure 2, the rotary drier 1 consists of a substantially cylindrical drum unit 21 mounted for rotation about a generally horizontal axis on suitable bearing means 22. Rotary joints at each end of the cylinder communicate between the interior of the drier drum 21 and respective inlet 23 and outlet 24 ducts. The interior of the drier is provided with a number of baffles 25, so that hot gases and peat flowing together in a mixture through the drier follow a three-pass path indicated by arrows 26a, b, c.

In the inlet duct 23, one lateral wall portion is provided with a funnel shaped peat inlet opening 27, through which peat is fed from the screw conveyor 3 which removes it from the hopper 2.

The raw peat hopper 2 is itself fed with peat by suitable conveyor means indicated in schematic form by references 28 and 29 in Figure 1. The lower region of the hopper is provided with peat removal means 31, co-operating with screw conveyor 3, which is driven by suitable motor means 32, for displacing the peat forwardly to the leading end of the conveyor 3, where it passes into the drier through the inlet opening 27 in the drier inlet duct 23.

The furnace 4 of the apparatus burns a proportion of the dried peat returned from the conveyor 11, along with peat fines recovered from the multi-cyclone, the feedstock being fed into the furnace from a hopper 33 by means of suitable conveyor means 34. Blower 5 provides a suitable air feed to the furnace 4, so that the appropriate level of combustion is maintained for evolution of combustion gases, at a temperature of, typically, 500° C. These combustion gases pass from an outlet region of the furnace 4 to the inlet duct 23 of the drier 1, where they encounter the peat passing through the lateral peat opening 27. The hot gases and peat then pass together into the interior of the drier 1, where they are thoroughly mixed together by the rotary three-pass action to define a hot gas and peat mixture, in which the peat is rapidly dried by direct contact with the hot gases.

At the exit 24 of the drier 1, the outlet duct portion 25 of the drier is coupled to the further duct 7 by which the hot gas and peat mixture is transferred to the main cyclone unit 8. Immediately downstream of the exit from the drier 1, removal means in the form of an airlock 35 is provided for withdrawing any accumulation of larger particles within the transfer duct 7. These particles are not recycled, but are discharged to waste.

In the main cyclone 8, separation of the greater part of the dried peat from the hot gas and peat mixture takes place. This dried peat is withdrawn from the cyclone 8 by airlock means 9 and transferred to the input end of feed conveyor 11, by which it is advanced to one or more discharge points 36, 37, 38, for further processing. As shown in Figure 1, a first discharge point 36 for processing the peat to provide pellets is located a relatively short distance downstream of the input point 39, while a briquetting press point 38 is located at the extreme downstream end of the conveyor 11. An emergency discharge point 37 is located between the pellet and briquette locations 36 and 38. More than one downstream processing line may be supplied by a single plant according to the invention.

From this press-feeding conveyor 11, the dried peat is fed continuously into the briquetting press 12. The stamp pressure in the form channel of the press 12 serves to produce a briquette on every rotation of the press flywheel. Typically, a briquette having a cross-section of 65 millimetres by 180 millimetres is produced. The thickness of the briquette is controlled by the press speed. A briquette strand is produced and guided in the direction indicated by arrow 42 from the connecting launder of the press, which is provided with a breaking-out device, into a briquetting cooling launder, at the end of which the strand passes into one or more briquette baling machines. Suitable vapour and gas withdrawal means, indicated schematically on the drawing by reference 41, collects vapour and gas from the briquetting press 12.

Peat withdrawn from the press conveyor 11 at location 43 is transferred to a further return conveyor 44, from where it passes in turn to a return conveyor belt 45, which feeds the peat, along with fines from multi-cyclone 14, back into the furnace feed hopper 33. Ash removal means are provided in the furnace, the ash being discharged to an ash removal conveyor 49, from which it is transferred to an ash hopper 51 or other disposal means.

In the multi-cyclone 14, the hot gases together with any remaining fines undergo a further separation process. Fines are gathered at the base of the multi-cyclone 14 in a hopper region 46, from which they are withdrawn by suitable airlock means 47 for return to the furnace input by means of the fines collecting conveyor belt 45. Alternatively, the lower region of the cyclone 14 may contain a fines collecting conveyor. Hot gases leave the multi-cyclone 14 and are discharged to the atmosphere through flue or chimney 15 by blower 16. However, a proportion of these hot gases is tapped off and returned to the furnace input along the duct indicated schematically by reference 17 in the drawing, under the action of blower means 16 and 6. Blower 6 is preferably located in the vicinity of the furnace 4, to suck these recycled gases along the duct 17 and direct them into the furnace 4 at a suitable boost pressure. A subsidiary feed from this recycling line is also provided to the raw peat conveyor, as indicated in Figure 1 by reference 48, to reduce the oxygen content in the conveyor also.

An oxygen sensor 58 is in communication with flue 15 downstream of blower 16, to establish the level of oxygen in the hot gases at this point in the gas flow, and thereby to also provide an indication of the oxygen content of the gases within the drier 1. Fan 16 pulls the gases and dried peat through the plant under reduced pressure. Hence atmospheric air may be drawn into the interior of the system through any leakage points in the units or ducts of the system. If such ingress of air takes place, then the greatest concentration of oxygen will be encountered at the downstream end of the flow path, which must necessarily be downstream of all entry points for atmospheric air and the oxygen contained therein. Thus oxygen measurement at the downstream end of the system will inevitably reflect any incipiently unsafe condition at upstream locations along the flow path. Signal communication links, designated by references 59 and 61 in Figure 1, serve to transfer a signal indicative of oxygen level to the peat feed conveyor motor 32 and to a valve means 54, to be described, for purposes to be described hereinafter.

In addition to the combustion gas input to the drier 1 and the peat feed, a further water feed 52 is also connected to the drier inlet duct region 23, the water duct 52 being indicated schematically on the drawing. This duct connects water supply means such as a water tank 53 to the drier inlet duct 23. Flow of water through the water line is controlled by valve means 54. A temperature sensor 55 located within the drier 1 is in communication with the peat feed conveyor motor 32 and the valve 54 in the water duct 52, to control the activation of the motor 32 and the opening of the valve 54 in dependence on temperature conditions within the drier 1. The sensor 55 to valve 54 and motor 32 communication links, which are most suitably electrical and constitute part of the plant control system, are indicated schematically in Figure 1 by references 56 and 57 respectively, while the further control inputs to motor 32 and valve 54 from the oxygen sensor 58 are applied along the links 59 and 61. The condition to be sensed by the sensor 55 is the temperature of the hot gases within the drier 1. Thus the control links of the invention enable peat and water input to the drier to be regulated both in dependence on the oxygen content of the hot gases and also in response to the temperature of the gases within the drier as reported by sensor 55, which provides an output signal indicative of said temperature.

The operation of the plant will now be described, having regard to a particular size and capacity of plant. 12.5 tonnes per hour of raw peat having a grain size of less than 10 millimetres is input at 55% moisture to the hopper 2. The screw conveyor 3 transfers the raw peat to the drier 1, where it is dried down to provide a residual moisture content of 10%. Drying air, heated in the burner or furnace 4, which operates under a slight vacuum, comes into contact with the fresh raw peat product in the rotating drier drum 1. The drum 1 is rotated relatively rapidly and at a sufficient speed for the many baffles 25 to keep throwing the peat product into the hot air stream, resulting in intensive evaporation. This action has the highly desirable effect of separating the light and dry portions of the peat from the heavier and still damp parts thereof. The light portions are quickly carried out of the drier 1 by the strong air stream established by the blower 16 while the coarser heavier material remains exposed to the hot air stream for a longer period, so that it also reaches the desired degree of dryness by the time it leaves the drum 1. Given the input conditions specified, a water evaporation rate of approximately 6,200 kg/h may be achieved for a combustion gas input temperature of 500°C and a primary air blower 5 capacity of 11,000 $Nm^3/h$.

From the discharge duct 24 of the drier 1, the dried material is conveyed pneumatically along duct 7 under the drawing action of blower 16 to the main cyclone 8, where it is separated from the hot gases and transferred to the press feed conveyor 11. Fine particles discharged from the cyclone 8 along with the continuing hot gas stream go to the multi-cyclone 14, and thence to the furnace feeder or screw conveyor 34, for combustion in the furnace. Flue gas conditions at the exit from the multi-cyclone are typically 97-100°C, with volume flow of 41,000 $Nm^3/h$. The oxygen content of this flue gas flow is less than 12% dry under steady state conditions.

The mass of dried peat removed from the main cyclone 8 is approximately 6.200 kg/h, at a moisture content of 10% and a temperature of 70°C. Returned fines amount to approximately 1,150 kg/h, at a moisture content of less than 10%. This quantity is sufficient to provide for the generation of an adequate supply of combustion gas.

Approximately 19,900 $Nm^3/h$ of the combustion gas is recycled to the furnace 4, to which it is input by the recycled-gas blower 6. This recirculation of exhaust flue gas reduces the oxygen content of the hot gases within the drier 1, and also cuts down on fuel costs and exhaust pollution.

In operation of the plant, sensing of gas flow conditions indicative, in particular, of oxygen content within the drier drum 1 is automatic, and the control system is arranged to automatically detect any possibly unsafe circumstance arising, for example, due to increase of the oxygen percentage in the hot gases within the drier 1 above the limit of 12%. The control system is arranged to terminate peat input to the drier 1, if the oxygen content rises above 11%, while any increase in the oxygen content above this level also enables the initiation of water injection through line 52. In other words valve 54 is unlocked or placed in a condition in which water injection may take place, under the control of temperature sensor 55.

Water injection then takes place as required under the control of a temperature signal indicative of the temperature of the hot gases within the drum and provided by sensor 55, once the water valve has been enabled or unlocked by oxygen sensor 58. When peat or turf input is stopped by the termination of motor 32 drive under the action of the oxygen sensor, temperature will start to rise in the drier, owing to the cessation of evaporation of water contained in the peat. In order to keep the temperature down under these conditions, water is added through valve 54 and line 52, under control of sensor 55. The duration and/or extent of opening of valve 54 is controlled by the temperature sensor 55, once the valve has been unlocked or enabled by the oxygen sensor 58. The further control signal then provided or appearing at the motor 32 by temperature sensor 55 has no effect on operation of the motor, however, under these conditions, since the motor has already been placed in a switched-off disposition by the action of the oxygen sensor 58.

This arrangement represents a safety mode or loop, but in addition, the various control links also a define a normal operating loop. In a normal operating mode, the motor 32 is switched on and off to control peat input to the drier in a stop/start manner. In these circumstances, the water valve 54 is locked or disabled by a signal provided by the oxygen sensor 58, while the motor 32 is enabled, also by a signal from the oxygen sensor 58. However, whether or not the motor is switched on at any given time is determined by the temperature signal provided by the temperature sensor 55. As peat is fed into the drier, the water evaporating from it pulls down the temperature within the drier. If the temperature falls to an excessively low value, the motor 32 is switched off by the sensor 55, until such time as temperature conditions within the drier return to the normal operating temperature specified for the system. No water input is required, since the water entrained in the raw peat acts to pull the temperature down during the drying process.

Thus in summary, in the safety mode of operation, the feed motor is disabled and the water valve is enabled, both by means of signals from the oxygen sensor, for the termination of peat input and the injection of water under the control of the temperature sensor signals, to prevent gas temperature in the drier from rising unduly under these conditions. In the normal operating mode, the motor is enabled and the water valve disabled or locked in an off condition, again in each case by means of the oxygen sensor and its associated control circuitry, for on/off action of the motor under the control of the temperature sensor, in this case to prevent the gas temperature in the drier from falling to an excessively low value.

Under both operating regimes an advance visual or audible warning may also be provided to signal the need for manual intervention to rectify the incipient change in conditions, and the automatic systems forming particular features of the invention only come into play if manual action fails to achieve the desired restoration of normal or safe operating conditions.

During the start-up phase of operation, water injection also takes place, so that the oxygen content of the hot gases within the drier is reduced by evaporation of the injected water. No peat is input during this start-up phase, but gas recirculation does take place. When steady-state conditions are reached, peat may be input, and the maintenance of the steady-state conditions is aided by the recirculation of approximately one half by volume of the flue gases leaving the multi-cyclone 14. These flue gases are relatively rich in inert constituents compared with atmospheric air, the oxygen content being less than 12%, and the addition of this inert-gas-rich mixture to the combustion gases from the furnace 4 ensures that an oxygen content of the required low level is maintained within the drier drum. By keeping the oxygen level below 12%, the risk of an explosion of peat fines within the drier 1 is eliminated, so that the direct contact of the hot gases with the flow of peat, required by the apparatus and method of the invention, may take place.

Thus, during the start-up phase, the oxygen content is brought down to approximately 10% by water injection. Peat is then introduced into the system, following which the oxygen content in the drier will typically stabilise at a figure of approximately 10% during continuing steady-state operation.

Accordingly, the rotary direct contact drying arrangement which is a particular feature of the present invention represents a novel configuration compared with certain previous systems, in which drying was carried out using vertical tubular heat exchangers with indirect heating of the peat through the walls of the heat exchanger tubes.

Further ancillary safety features consist of the provision of a spark detector in the exit duct 7 from the drier 1, together with the fitting of explosion panels to the main cyclone 8, multi-cyclone 14 and press feed conveyor 11.

In the foregoing description of the method of the invention described in relation to Figures 1 and 2, the output from the system is stated to have a moisture content of some 10%. By varying the peat throughput during system operation, the dried peat may emerge from the system with a substantially higher moisture content, for discharge to final processing equipment of a kind other than a briquette press. In certain other processes such as pelletising, a substantially higher moisture content of the order of 30% is acceptable.

Figure 3 shows an alternative drying system similar to that of Figure 1, but without the equipment relating to the return of peat, peat fines and dust, for use in furnace 4. In the arrangement shown in Figure 3, an independent fuel source is used, the fuel being deposited in hopper 73 for feed to furnace 4. A variety of alternative fuels may be used with this arrangement. In particular, screenings, which represent the residue from briquette manufacture, may serve as the furnace feedstock. Screenings consists of broken pieces of briquettes, together with dust and other fine peat material. Screening material has approximately the same moisture content as the feedstock used in the arrangement of Figure 1, and its use to generate the hot gases brings about no significant changes in operation and control of the system. In particular, no change in the drier region of the apparatus is required.

A further alternative fuel is coal dust. This fuel is available very cheaply from coal suppliers. Other combustible materials, in particular by-products of industrial processes, may also be used.

Again the nature of the fuel supplied to furnace 4 is of no major significance in regard to the configuration and operation of the drying system as a whole. The recycling of waste from the drying system shown in the embodiment of Figure 1 is not a fundamental feature of the invention.

Figure 4 shows a further variant of the drying system of the invention. In this case, a flash drier 81 is substituted for the drier drum 1. In other respects, the arrangement shown in Figure 4 is similar to the configuration of Figure 3. The flash drier 81 consists of a vertical tubular unit, through which hot flue gas and peat are drawn by blower 16, as in the case of the arrangement of Figure 1, but in a vertically - directed flow, rather than horizontally as in the first embodiment. During transit of the flash drier 81, the flue gas and peat are brought into contact, and there is extremely rapid drying of the peat, as moisture is withdrawn from it by the hot gases. No mechanical elements for conveying the peat are provided within the drum 81, and its passage through the drier takes place under the pneumatic action of blower 16 to cyclone 8 and multi-cyclone 14, where separation of the hot gases and peat takes place. Apart from the mode of transit of the peat through the flash drier 81, the system operates in substantially the same manner as already described for the Figure 1 configuration, and it is provided with the same control and safety features as the first embodiment.

Known arrangements for safety in flash driers consist of explosion panels and spark detection. The embodiment of the invention described in regard to Figure 4 incorporates gas recycling and control and safety features in accordance with the invention based on the monitoring of oxygen content in the downstream gas flow. In the case of the flash drier, the temperature sensor 55 is located within the unit 81, in similar manner to the Figure 1 configuration. Spark detection may also be used in any of the configurations of the present invention. The spark detection system is preferably linked with the water injection line 52 and valve 54, so that water injection takes place instantly whenever a spark is detected, so as to quench the inflow of hot gases and avoid any risk of explosion within the system.

## Claims

1. Apparatus for removing moisture from peat, comprising drier means (1,81) in which peat is brought into direct contact with hot gases in a hot gas and peat mixture separator means (8,14) in which the peat is removed from the hot gas and peat mixture, means (7,13,16) for transferring the hot gas and peat mixture from said drier means (1,81) to said separator means (8,14), and means (6,17,52,53,54,58,59) for maintaining the oxygen content of the hot gases in the drier means (1,81) below a predetermined value said predetermined value being less than the oxygen content of atmospheric air; said oxygen content maintaining means (6,17,52,53,54,58,59) including means (6,17) for redirecting at least a portion of the hot gases separated from the hot gas and peat mixture back for input to the drier means (1,81), at least during substantially steady-state operation of the apparatus, means (58) for establishing the oxygen content of the hot gases within the apparatus, and means (52,53,54,59) for allowing the addition of water to the hot gases when said oxygen content establishing means (58) indicates an oxygen level corresponding to or in excess of said predetermined value, for the generation of steam within the drier means (1,81) by the action of the hot gases on the added water.

2. Apparatus according to Claim 1, wherein said means (52,53,54,59) for allowing addition of water includes water supply means (53) and valve means (54) for controlling flow of water from said water supply means (53) for addition to said hot gases, and the apparatus comprises a temperature sensor (55) for establishing an indication of the temperature of the hot gases within the drier means (1,81), said valve means (54) being enabled (59) when said oxygen content as established by said oxygen content establishing means (58) corresponds to or is in excess of said predetermined value so that said valve means (54) may be opened for flow of water therethrough, and said valve means (54) being disabled (59) when said oxygen content is less than said predetermined value so that said valve means (54) then remains in a closed condition and the opening and closing of said valve means (54), when enabled being controlled (56) in dependence on said temperature indication as established by said temperature sensor (55).

3. Apparatus according to Claim 2, comprising input means (3) for feeding peat to said drier means (1,81), wherein said peat input means (3) is enabled (61) when said oxygen content as established by said oxygen content establishing means (58) is less than said predetermined value so that peat may be directed to said drier means (1,81), said peat input means (3) being disabled (61) when said oxygen content corresponds to or is in excess of said predetermined value so as to prevent peat from being directed to said drier means (1,81), and the operation of said peat input means (3), when enabled, being controlled (57) in dependence on said temperature indication as established by said temperature sensor (55), and said peat input means (3) optionally comprising conveyor means (3) and drive means (32) for said conveyor means (3), the working of said drive means (32) being regulated (57) in dependence on said temperature indication.

4. Apparatus according to any preceding Claim, wherein said oxygen content establishing means (58) is arranged to measure the oxygen level in the hot gases leaving the apparatus, downstream of the drier means

(1,81), said level being indicative of the oxygen content of the hot gases within the drier means (1,81), and/or said means (52,53,54,59) for allowing the addition of water is arranged for injection of water into peat and/or gas inlet means (23) of the drier means (1,81).

5. Apparatus according to any preceding Claim, wherein the drier means (1) is a cylindrical drum unit (1), mounted for rotation about a substantially horizontal axis, and the drum unit (1) optionally incorporates baffles (25) for establishing a three-pass flow (26a,26b,26c) of peat and gases through the cylindrical unit (1), between an inlet (23) at one axial end thereof and an outlet (24) at its other axial end.

6. Apparatus according to any of Claims 1 to 4, wherein the drier means (81) is a generally cylindrical unit (81) disposed with its longitudinal axis extending in a generally vertical direction.

7. Apparatus according to any preceding Claim comprising a furnace (4) having an atmospheric air input (5) the combustion gases from said furnace being directed to inlet means (23) of the drier means (1,81) to provide a hot gas input thereto, and said means (6,17) for redirecting hot gases from the separator means (8,14) optionally provides a second gas input to the furnace (4), in addition to the atmospheric air input (5).

8. A method for removing moisture from peat, comprising the steps of:

(a) bringing peat into direct contact with hot gases in a hot gas and peat mixture for removal of moisture therefrom.

(b) subsequently separating (8,14) the peat from the hot gas and peat mixture, and

(c) maintaining (6,17,52,53,54,58,59) the oxygen content of the hot gases in contact with the peat below a predetermined value, said predetermined value being less than the oxygen content of atmospheric air, by redirecting (6,17) at least a portion of the hot gases separated (8,14) from the hot gas and peat mixture back for input to said hot gas and peat mixture, at least during a substantially steady state phase of said method, and by adding water (52,53,54,59) to said hot gases when the oxygen content (58) thereof corresponds to or is in excess of said predetermined value, for the generation of steam in the hot gas and peat mixture by the action of the hot gases on the added water.

9. A method according to Claim 8, wherein said water addition (52,53,54,59) is enabled (59) when said oxygen content (58) corresponds to or is in excess of said predetermined value and disabled (59) when said oxygen content (58) is less than said predetermined value, and said addition of water (52,53,54,59) is regulated (56) in dependence on the temperature (55) of the hot gases in the hot gas and peat mixture.

10. A method according to Claim 7 or Claim 8, wherein input (3) of peat to be dried to said hot gas and peat mixture is enabled (61) when said oxygen content (58) is less than said predetermined value and is disabled (61) when said oxygen content (58) corresponds to or is in excess of said predetermined value, and peat input, when enabled (61) is regulated (57) in dependence on the temperature (55) of the hot gases in said hot gas and peat mixture.

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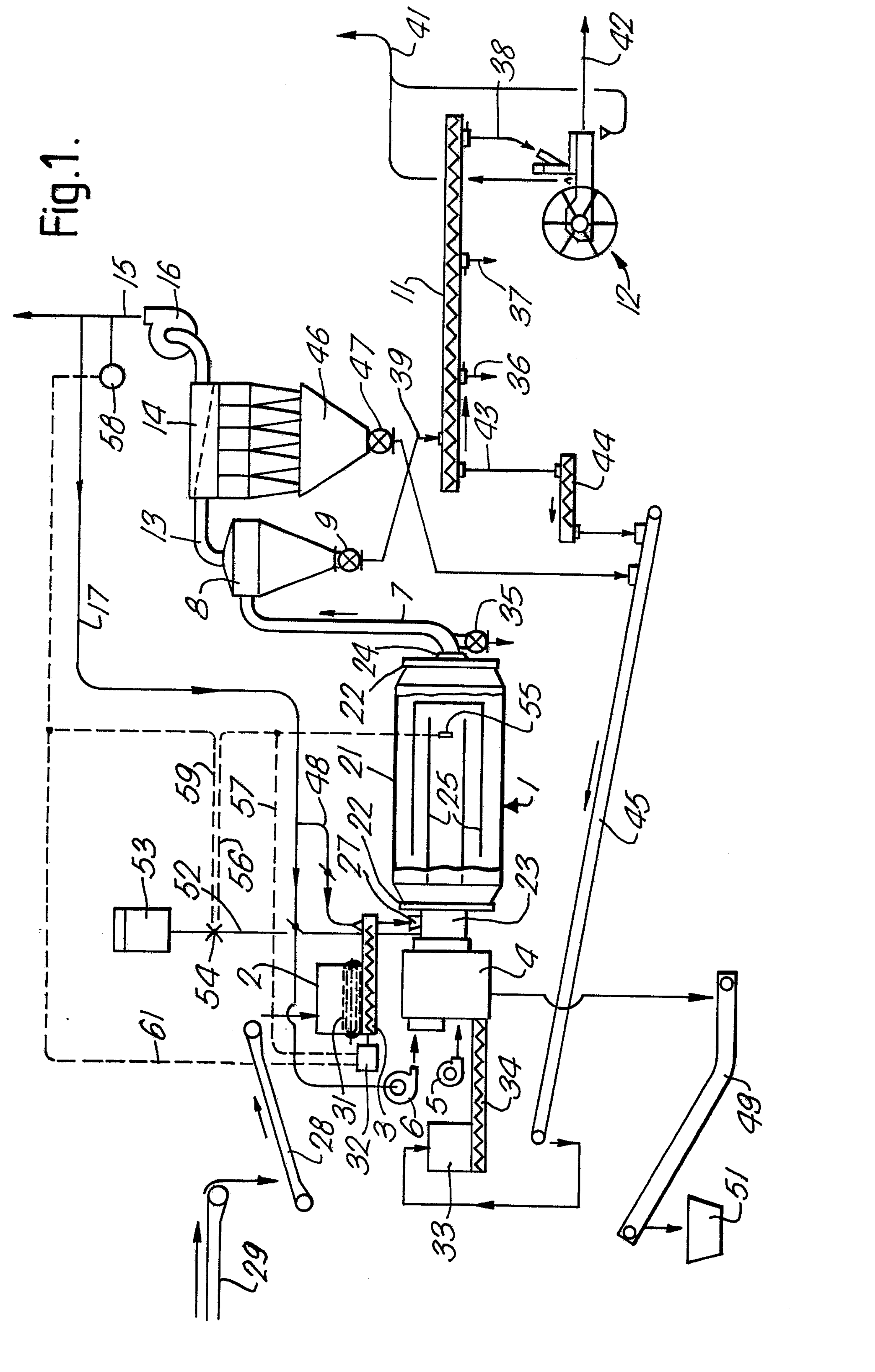


Fig.1.

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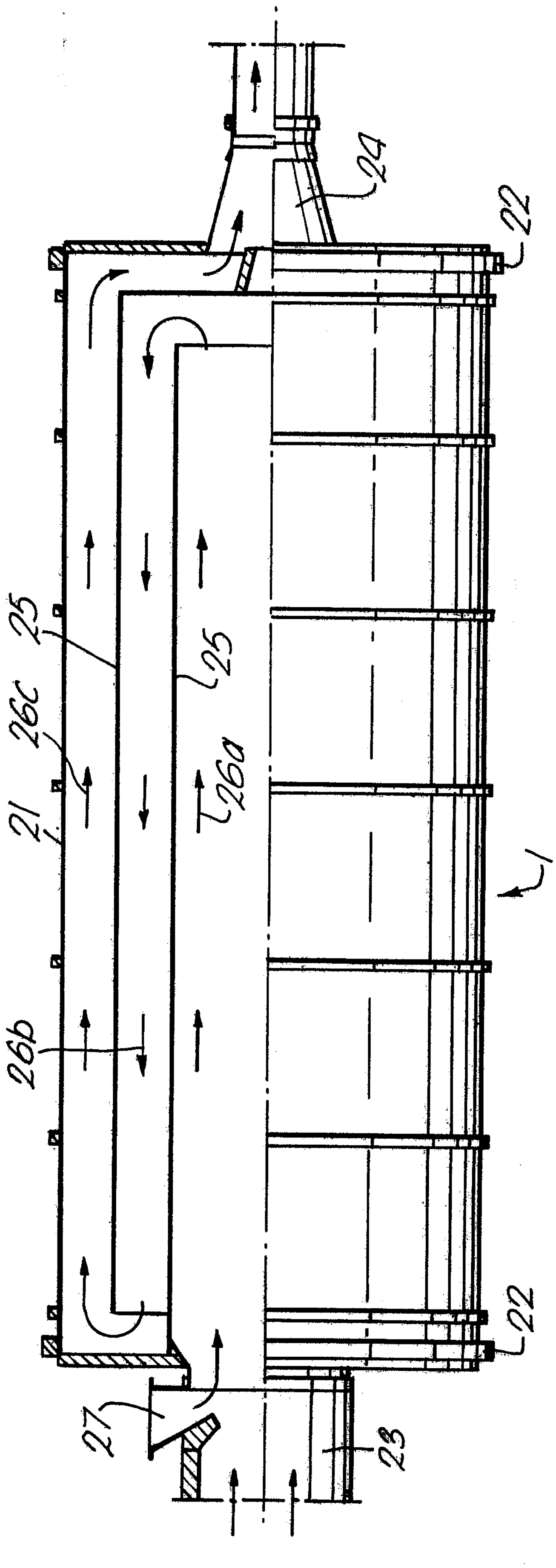


Fig.2.

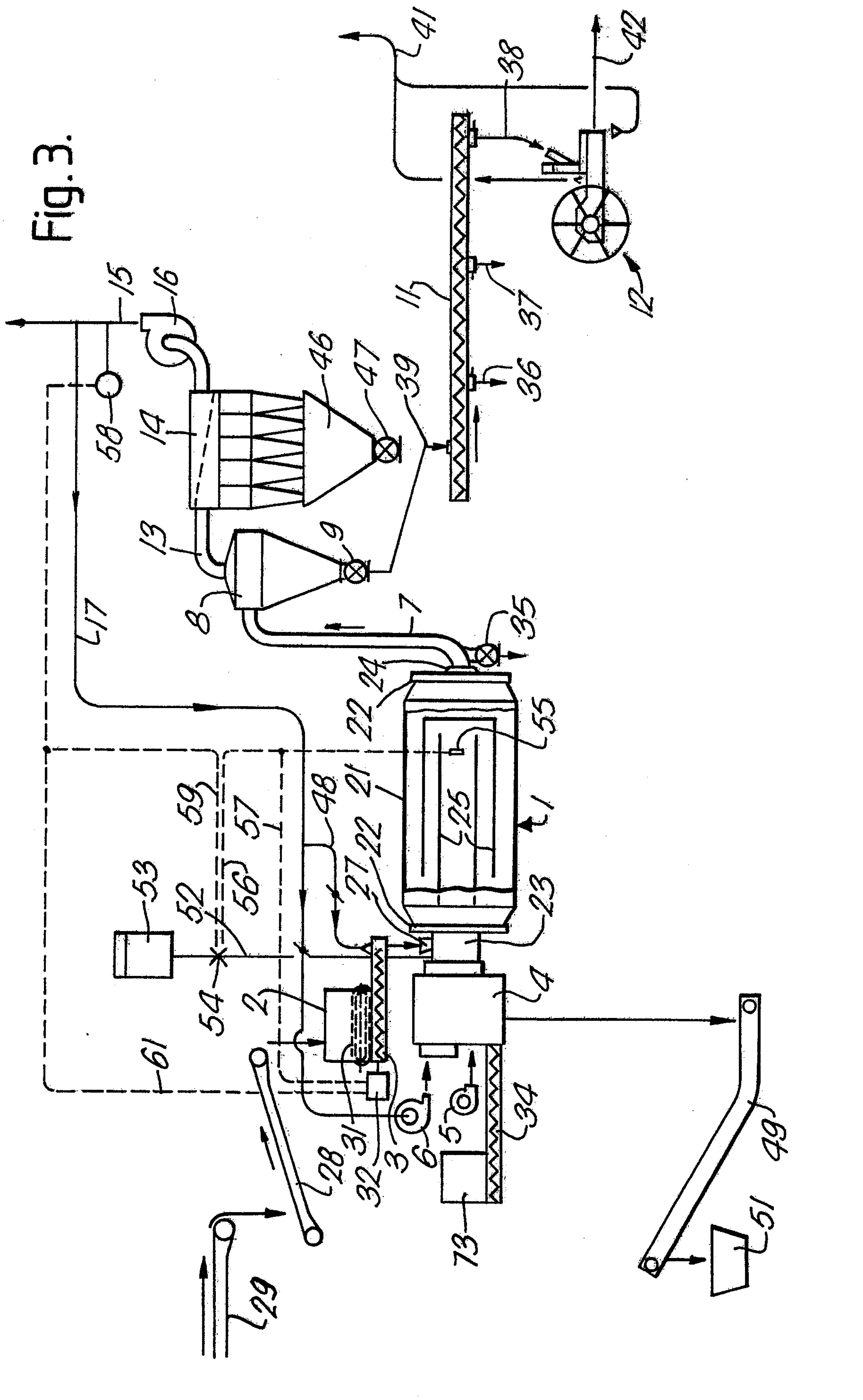
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Fig. 3.

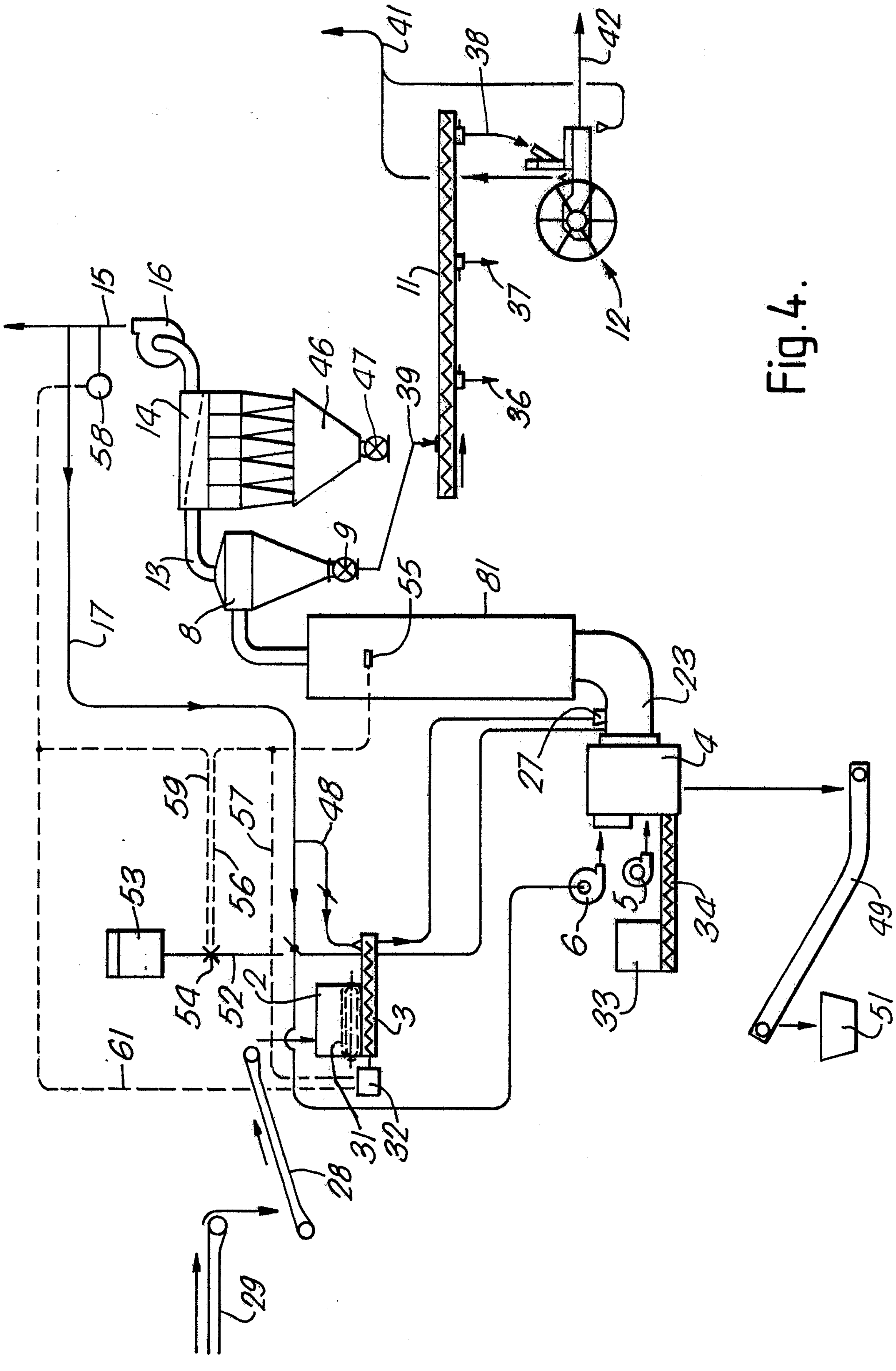

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Fig. 4.