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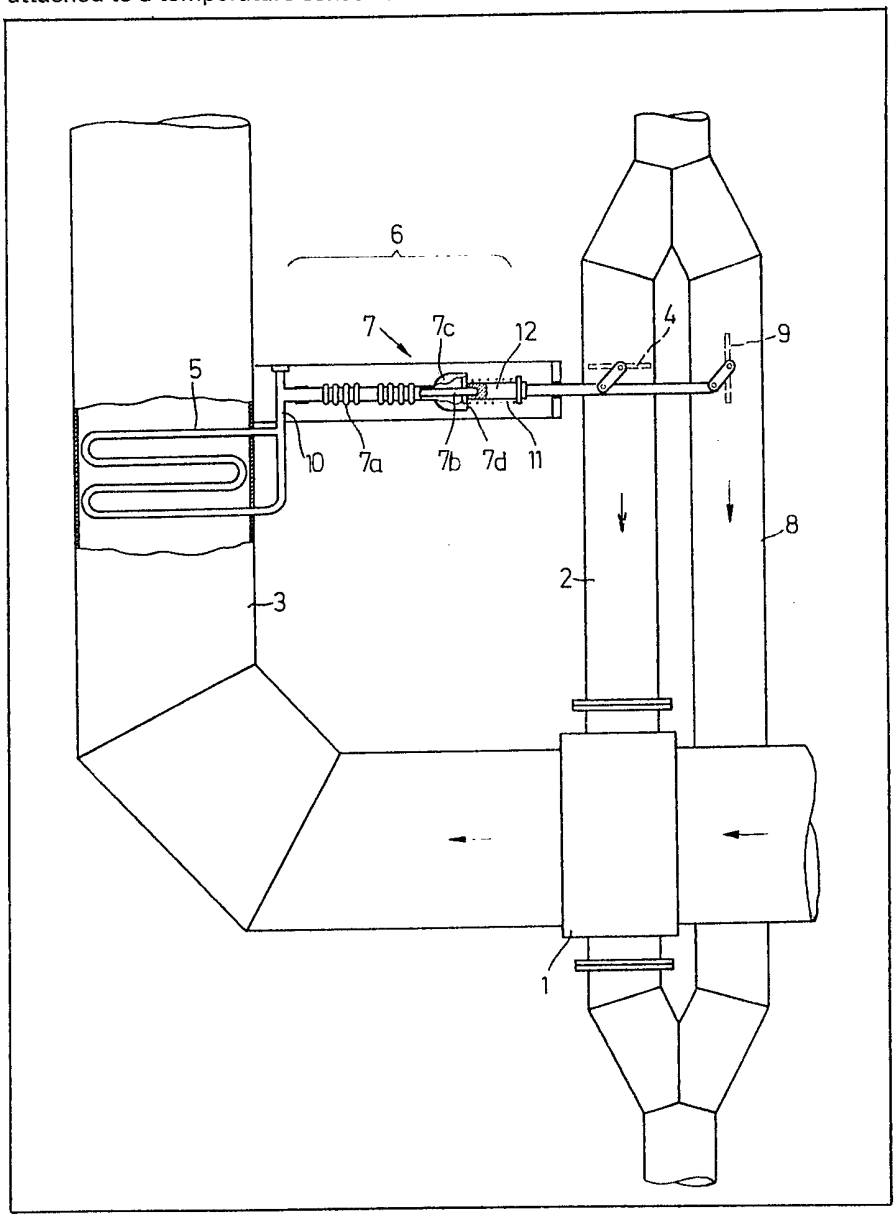
(54) Equipment for preheating a processing gas

(57) Equipment for preheating a processing gas by means of heat recovered from a waste gas comprises a processing gas duct 2, a waste gas duct 3 and a bypass duct 8. Flow rate regulators 4 and 9 acting in opposition in the processing gas and bypass ducts respectively are controlled by driving means 7 (which may be a piston and cylinder arrangement) attached to a temperature sensor 5 within the waste gas duct 3. In operation high temperature waste gas flows through duct 3 over the sensor 5. Thermally responsive hydraulic fluid within the sensor undergoes a volume change and acts upon the driving means against a return spring 11, thus activating the flow rate regulators and thereby varying the amount of processing gas which passes through the heat exchanger 1 to be preheated, before mixing with the remaining processing gas passing down the bypass duct 8. The equipment may be installed on an fuel-fired air heater.



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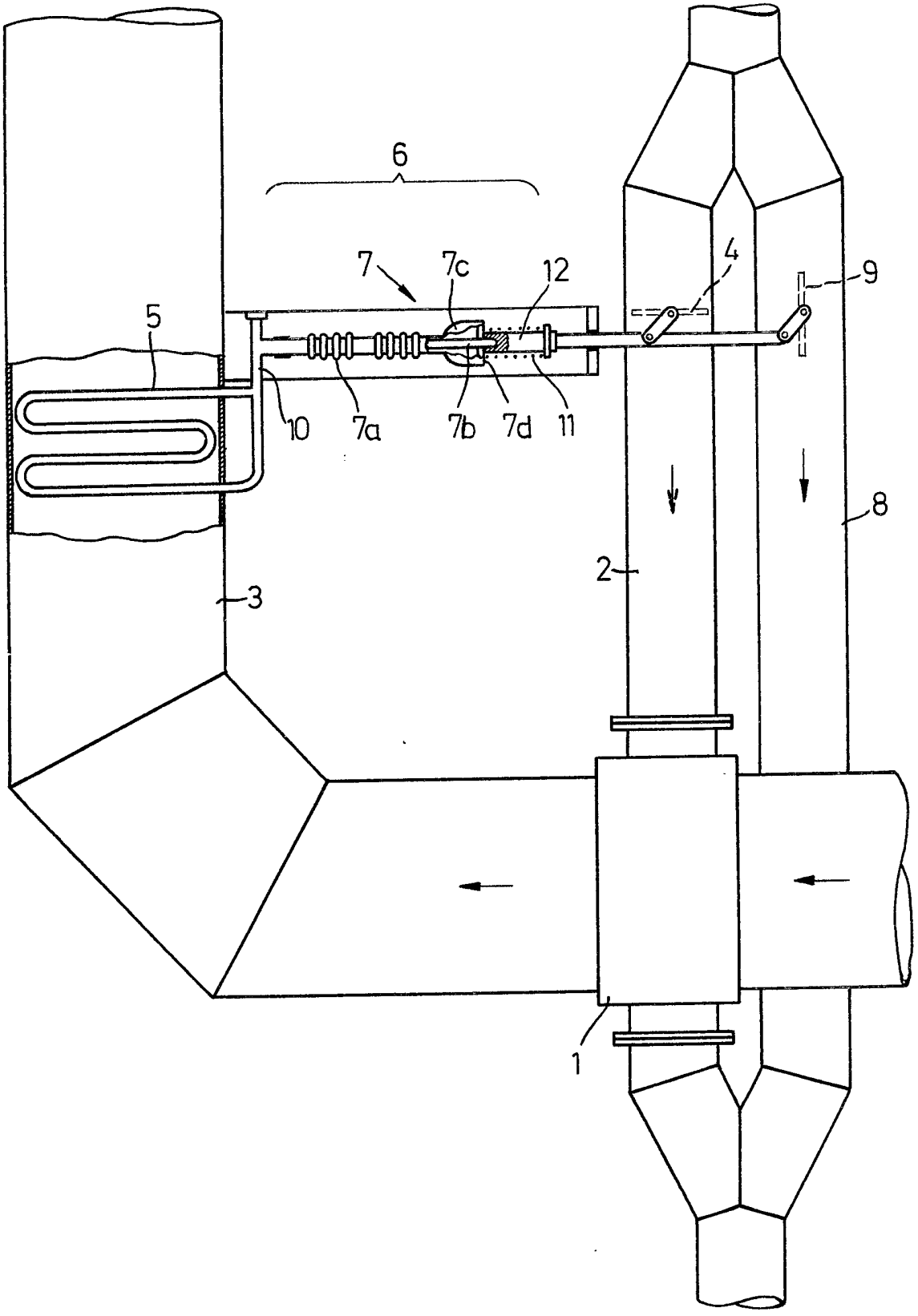
The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.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SPECIFICATION

Equipment for preheating a processing gas

This invention relates to an equipment for preheating a processing gas by means of sensible heat recovered from a waste gas, said equipment having a processing gas duct, a waste gas duct and a waste-gas heat exchanger, in which the processing gas duct has a flow rate regulator, the waste gas duct has a waste-gas temperature sensor, and a controller incorporating driving means is disposed between the waste-gas temperature sensor and the flow rate regulator, the driving means controlling the setting for the flow rate regulator as a function of the waste-gas temperature. In the context of the invention, the term "processing gas" more particularly denotes processing air, as used in a wide variety of processes, for example combustion air, drying air or the like. The term "waste gas" more particularly denotes spent gases, including for example the spent gases from fuel-consuming air heaters used to prepare the processing air. The purpose of preheating is to recover energy and thereby reduce energy consumption. The flow rate regulator may by a simple adjustable valve or a regulating valve of some other construction.

In known equipment of this type, the temperature sensor is usually a semiconductor temperature sensor, a thermistor or the like, and forms an integral part of an electrical measuring circuit. Correspondingly, the controller is constructed from electrical components and incorporates an electric motor and gearbox as the driving means. This involves special maintenance and the costly provision of redundant control means to eliminate faults, which can often lead to serious damage and constitute a safety hazard. Further problems often arise from the fact that the controls as a whole depend on the supply of electrical energy, so that emergency supply sources or manual valve-setting equipment must be provided to ensure that the equipment will operate safely even during mains failures. Furthermore, the steady operating state in equipment of this type usually differs from the starting-up state. In order to control the starting-up state equally well, additional special starting gear must be incorporated.

The object of the present invention is to provide equipment of the type in question that functions with adequate freedom from faults, independently of the availability of electrical energy.

According to the present invention, equipment for preheating a processing gas by sensible heat from a waste gas comprises a processing gas duct, a waste gas duct and a waste-gas heat exchanger, in which the processing gas duct has a flow rate regulator, the waste gas duct has a waste-gas temperature sensor, and a controller incorporating driving means is disposed between the waste-gas temperature sensor and the flow rate regulator, with the driving means controlling the setting for the flow rate regulator as a function of the waste-gas temperature, the waste-gas temperature sensor being adapted as a closed duct system with a connection to the controller and is filled with a hydraulic fluid which undergoes temperature-dependent volume changes, and the driving means controlling the setting under the action of the hydraulic fluid, in conformity with the volume changes depending on the temperature of the hydraulic fluid.

In a preferred embodiment of the invention, the closed duct system is set in the waste gas duct and consists of a simple or multiple tube coil. The preferred hydraulic fluid is a so-called thermal oil. The term "thermal oil" is commonly applied to a mineral oil which will not evaporate at relatively high temperatures such as are encountered in the closed duct system. The coefficient of expansion of the thermal oil and the length of the tube coil can readily be mutually adjusted so that the temperature fluctuations in the waste gas will bring about sufficiently large volume changes in the hydraulic fluid to actuate the driving means over a sufficient setting range. For this purpose, the driving means can be constructed as a cylinder and piston. Alternatively, a hydraulic pressure intensifier can be incorporated. The starting-up state can also be controlled without difficulties, by incorporating a compensator in the driving means for starting-up conditions at low waste gas temperatures, for example in the form of an escapement device, a prestressed spring or the like.

The accruing advantages are that the control gear in an equipment of the invention functions independently of the supply of electrical energy and without undue risk of faults. Particular advantages accrue from the preferred embodiment of the invention, which equally well controls the starting-up state by employing simple mechanical means. This eliminates the need for costly starting-up control gear.

One embodiment of the invention will now be described in more detail with reference to the accompanying drawing which depicts, schematically the layout of an equipment of the invention.

The equipment shown is adapted for preheating processing air by means of sensible heat recovered from a spent gas. The spent gas has a temperature of 370°C, for example, and the sensible heat of this spent gas is recovered in a heat exchanger 1 in which processing air is preheated to 250°C, for example. The basic components of the equipment are a processing gas duct 2, a waste gas duct 3 and a waste-gas heat exchanger 1. The processing gas duct 2 is provided with a flow rate regulator 4 in the form of an adjustable valve, and the waste gas duct 3 has a waste-gas temperature sensor 5. A controller 6 incorporating driving means 7 is disposed between the waste-gas temperature sensor 5 and the flow rate regulator 4, the driving means 7 controlling the setting for the flow rate regulator 4 as a function of the waste-gas temperature. In the embodiment shown, the processing gas duct 2 is supplemented by a branching bypass duct 8,

which circumvents the waste-gas heat exchanger 1 and contains another flow rate regulator 9, the flow rate regulators 4, 9 in the processing gas duct 2 and the bypass duct 8 functioning in opposition, as will be described later.

The waste-gas temperature sensor 5 is adapted as a closed duct system 5, 10 with a connection 10 to the controller 6 and the system is filled with a hydraulic fluid which undergoes temperature-dependent volume changes. The driving means 7, acted upon by the hydraulic fluid, control the setting in conformity with the temperature-dependent volume changes of the hydraulic fluid. The closed duct system 5, 10 is set in the waste gas duct 3 and constitutes a tube coil with several turns. The hydraulic fluid is a so-called thermal oil. As is indicated in the drawing the driving means 7 are constructed as a cylinder and piston and fitted with a return spring 11. In addition, the driving means 7 incorporate a compensator, not shown, for a starting-up state with a low waste-gas temperature, in the form of an escapement device.

The cylinder and piston 7 consists of a stem tube 7a and a guiding and stabilising rod 7b for the stem tube 7a, while the lower end of the stem tube 7a leads into a hydraulic intensifier compartment 7c closed by a pressure-loaded baseplate 7d. The setting rod 12 is attached to the baseplate 7d.

If for example the equipment is installed on a fuel-fired air heater for processing air and the waste-gas temperature is to be reduced from about 370°C to 250°C, this temperature reduction takes place in the waste-gas heat exchanger 1. Because of the low-temperature corrosion that takes place particularly in heavy-oil combustion systems, only a proportion of the processing air can be passed through the waste-gas heat exhchanger 1. The remainder of the air must circumvent the wast-gas heat exchanger 1 through the bypass duct 8 and then be mixed with the air preheated in the waste-gas heat exchanger 1. The preheated air is then admitted into the fuel-fired air heater. In the embodiment shown, the two air streams are determined by the two flow rate regulators 4, 9 in the form of adjustable valves operating in opposition, as indicated in the drawing. Overall control is essential since the volume of processing air varies according to the product.

In the embodiment shown, the expansion experienced by the hydraulic fluid as it is heated in the tube coil 5 is used as the setting force and the setting parameter. However, the setting sequence should not start until a certain waste-gas temperature has been attained. An escapement device is provided for this purpose in the form of an air-free space of suitable volume in the element 7. This air-free space is formed in the simplest manner by delaying the closure of the duct system 5, 10 on first starting up until the said response temperature has been attained. No setting force is generated until the system has heated up to the response temperature and the hydraulic fluid has expanded correspondingly. On cooling again, the necessary air-free space with its escapement action spontaneously develops again. At the same time, the flow rate regulators 4, 9 are simultaneously returned by means of the above mentioned return spring 11. The return spring 11 simultaneously has the function of holding the driving means 7 under a constant contact pressure and thereby preventing fluttering of the flow rate regulators 4, 9 during operation. For this purpose, the return spring 11 can also be combined with a damping member.

No special maintenance is required and there are virtually no wearing parts. For instance, there is no longer any risk of low-temperature corrosion in the spent gas heat exchanger 1 because of electrical supply failure. Even if a mechanical fault should develop in the system described, there is no risk of low-temperature corrosion, since the return spring 11 will always return flow rate regulators 4, 9 to their starting-up settings, and this is the setting at which all the air flows through the bypass duct 8.

CLAIMS

1. Equipment for preheating a processing gas by sensible heat from a waste gas, comprising a processing gas duct, a waste gas duct and a waste-gas heat exchanger, in which the processing gas duct has a flow rate regulator, the waste gas duct has a waste-gas temperature sensor, and a controller incorporating driving means is disposed between the waste-gas temperature sensor and the flow rate regulator, with the driving means controlling the setting for the flow rate regulator as a function of the waste-gas temperature, the waste-gas temperature sensor being adapted as a closed duct system with a connection to the controller and is filled with a hydraulic fluid which undergoes temperature-dependent volume changes, and the driving means controlling the setting under the action of the hydraulic fluid, in conformity with the volume changes depending on the temperature of the hydraulic fluid.

2. Equipment as in Claim 1, wherein the closed duct system is set in the waste-gas duct and consists of a tube coil.

3. Equipment as in Claim 1 or Claim 2, wherein the hydraulic fluid in the closed duct system is a thermal oil.

4. Equipment as in any of Claims 1 to 3, wherein the driving means are constructed as a cylinder and piston.

5. Equipment as in any of Claims 1 to 4, wherein the driving means incorporate a

compensator for starting-up conditions at low waste gas temperatures, for example in the form of an escapement device, a prestressed spring or the like.

6. Equipment for preheating a processing gas by sensible heat from a waste gas substantially as hereinbefore described with reference to the accompanying drawing.

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