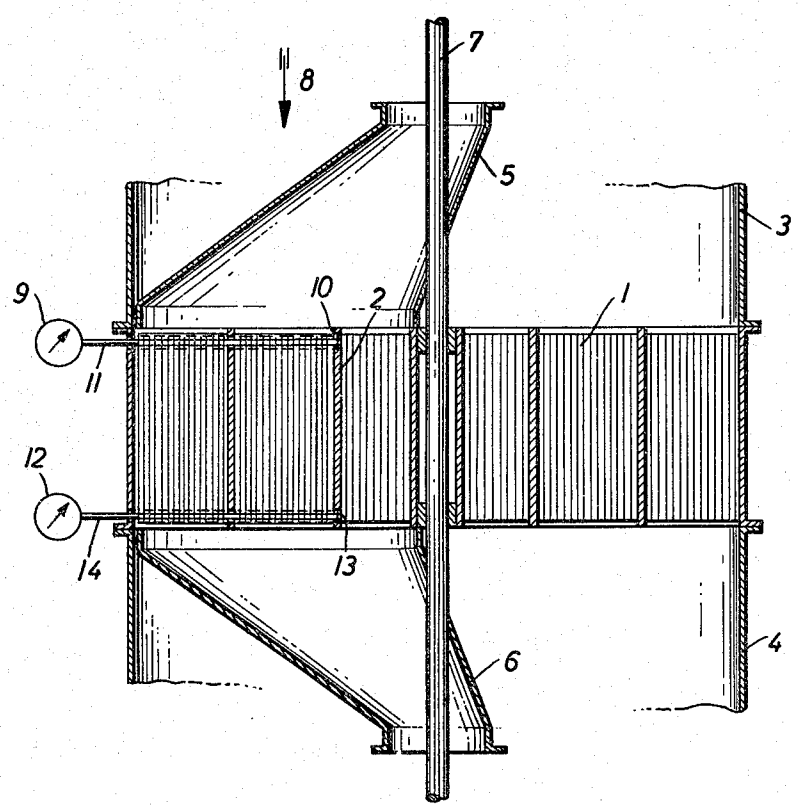
May 18, 1965 H. BRANDT 3,183,961

METHOD AND APPARATUS FOR CONTROLLING THE TEMPERATURE AND HUMIDITY OF A REGENERATIVE AIR-HEATER

Filed Sept. 8, 1960 2 Sheets-Sheet 1

Fig. 1



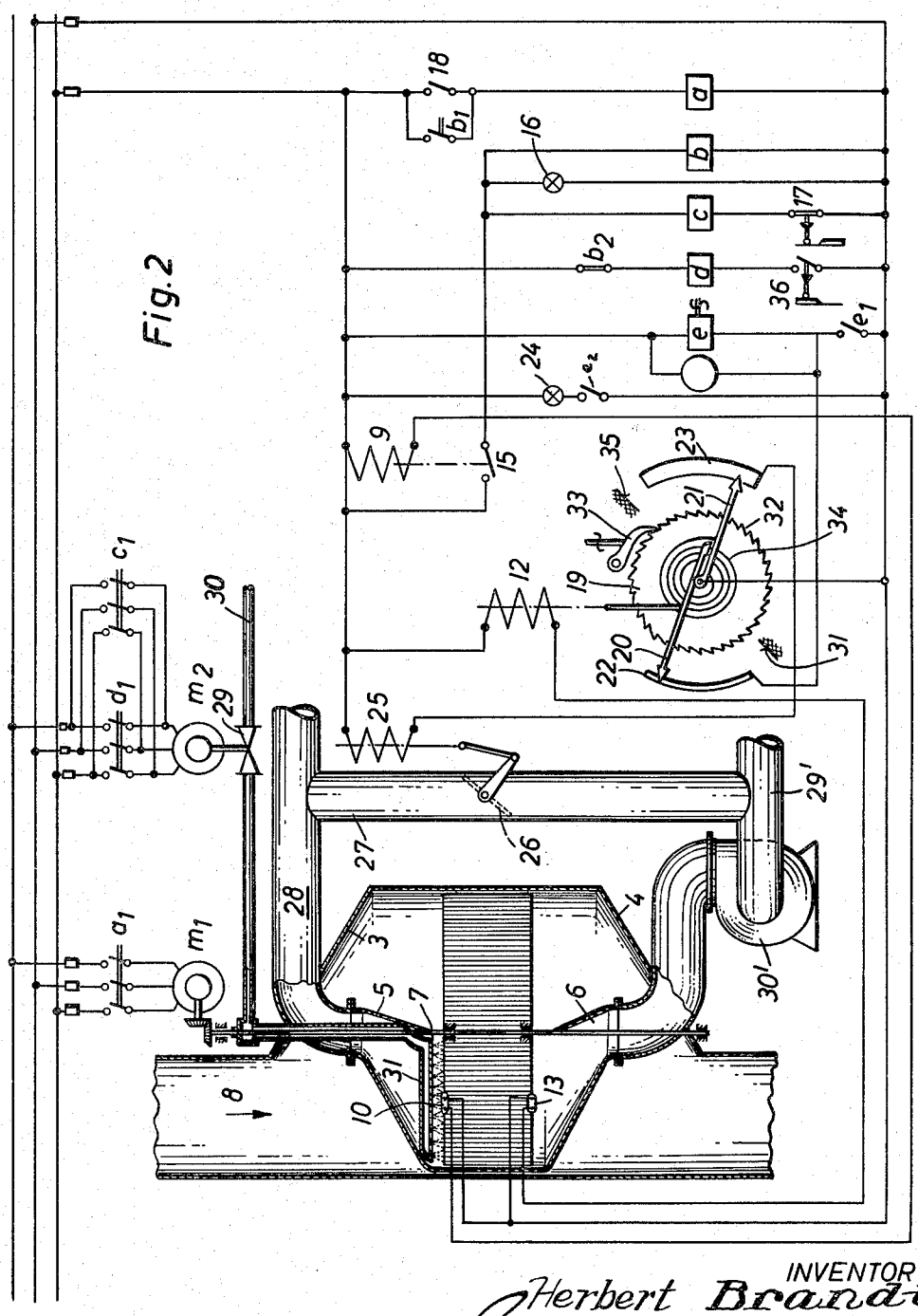
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Fig. 2



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METHOD AND APPARATUS FOR CONTROLLING THE TEMPERATURE AND HUMIDITY OF A REGENERATIVE AIR-HEATER

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The present invention relates to heat exchangers for flowing media, in particular regenerative air heaters for preheating combustion air for furnaces which in the known manner comprise a packet of thin sheet heat absorbing and yielding metal elements carried in a holding structure. Sectors of the packet are swept in succession by hot gases, usually combustion gases and the elements absorb heat, whereupon the sector just heated is swept by colder air to be heated when the heat previously absorbed by the elements is yielded up to the air. This alternation of two gaseous media is advantageously produced by a rotation of end connections for the air disposed within stationary end connections for the combustion gases if the elements are stationary, or by rotation of the holding structure with the elements, between stationary connections for both air and combustion gases.

According to the invention, in such a regenerative air heater, detectors are introduced which respond to the permissible operating temperature range of the packet of elements, the detectors including at least one which responds if a certain upper limit temperature (a temperature just below that at which combustible deposits on the elements are ignited) is exceeded and at least one dew-point detector, which responds to the deposition of moisture independently of the temperature.

A regenerative air heater is exposed to risk of the outbreak of fire through the ignition of combustible material deposited after prolonged operating periods from suspension in the combustion gases, which when the temperature of ignition is reached begins to smoulder or glow and then in the heat passage of air which brings oxygen with it, may burst into flame.

A regenerative air heater is also exposed to risk of corrosion through deposition of moisture on the elements if through too low a temperature of the air to be heated, the elements and holding structure of the heat exchanger are cooled below the dew-point of the combustion gases next to be blown through.

By means of the invention an optimum in heat transfer is obtained under varying operating conditions by maintaining the highest permissible temperature range. This is upwardly limited by the temperature of the elements above which there is risk of fire by spontaneous ignition of combustible deposits on the surface of the hottest elements, and downwardly limited by the lowest temperature of the elements the coldest of which must not be below the dew-point of the heating gases. The problem so presented is solved by the simultaneous use of only two types of detector, namely a temperature detector for the ignition temperature and a dew-point detector to deal with a fall down to or below the dew-point.

The detectors are advantageously provided with separate devices for indicating overheating and undercooling respectively of the elements, as well as cooperating with control devices which set in action means for cooling and heating respectively of the elements, and they are mounted in recesses in the holding structure so that the surface of the detectors forms a part of the thermally effective surface exposed alternately to the combustion gases and air, of the regenerative air heater and are exposed to the same thermal effects as the latter. The connections between the detectors and the indicating or controlling devices arranged outside the air heater can be laid in protected spaces such as recesses or passages in the holding structure.

The high temperature detector can be a thermo-couple, a temperature responsive electrical resistance element or preferably a bimetallic snap switch, while the dew-point detector can be a dew-point meter of known kind e.g. a surface current path in which the sudden reduction in the electrical resistance caused by the deposition of moisture when the temperature falls to or below the dew-point is used to give a response.

The high temperature detector is mounted at the end of the packet at which the combustion gases enter which is the region of greatest risk of fire and the dew-point detector at the end of the packet at which the air enters which is the region of greatest risk of corrosion.

Better to guard the regions of the air heater most exposed to the risks in question, the arrangement according to the invention may comprise a plurality of detectors of each type distributed over the regions concerned.

The high temperature detector may through a relay control the opening of a valve admitting water for spraying or rinsing the air heater, and advantageously at the same time switch on the drive for the rotating parts of the air heater to ensure cooling of all endangered parts of the heater, while the low temperature or dew-point detector (corrosion protection) may through a relay open a by-pass conduit connecting the air supply and air outlet of the air heater, through which a part of the heated air is propelled back into the path through the heat exchanger whereby the cooling of the elements is reduced.

In the accompanying drawings

FIG. 1 shows by way of example and diagrammatically a regenerative air heater equipped according to the invention, and

FIG. 2 shows by way of example a circuit diagram for the operation of devices for preventing damage under the control of the detectors.

In FIG. 1, **1** indicates generally the packet of sheet metal elements in the holding structure of generally cylindrical form, the tangential walls **2** of which are shown in section. Within the combustion gas connections **3** and **4**, air connection **5** and **6** rotate in synchronism being held and driven by a shaft **7**.

It is assumed that the hot combustion gases flow through the heater in the direction of the arrow **8** and the air in counter current in the opposite direction. A high temperature detector **10** (e.g. in the form of a bimetallic snap switch), is mounted for fire protection at the hot end of the packet, a dew-point detector **13** (here assumed to be a surface current path) for corrosion protection is mounted at the cold end.

The detectors **10** and **13** are each mounted in a recess in one of the walls **2** of the holding structure. The connecting cables **11** and **14** from the detectors to respective relays **9** and **12** so far as they lie inside the air heater are carried in grooves or bores in radial walls.

Referring now to FIG. 2, if the temperature rises above the permissible limit, the high temperature detector relay **9** closes a contact **15**. This switches on a warning device exemplified by a clamp **16** and effects the energisation of two contactor or relay windings *b* and *c*. It should be understood that each of the contacts *a*1, *b*1, *b*2, *c*1, *d*1, *e*1 and *e*2 correspond to and is operated by the respective relay winding designated by the same letter. The contact *b*1 closed by energization of the winding *b* energizes the winding of relay *a* of a main circuit breaker if this is not already energized, which is normally the case when the air heater is in operation, over a contact **18** belonging to the normal operating control and the

contact *a*1 thereof closes. The contact *a*1 sets the motor *m*1 for rotating the air connections 5, 6 in operation, if at the time the bimetallic snap switch of detector 10 responds the contact 18 was open and this motor was not in operation. Further a rest contact *b*2 is opened by energization of the winding *b*, and a contact *c*1 is closed by energization of the winding *c*. The former is in the circuit of a contactor or relay winding *d* but this is already open circuited at a limit switch 36 and the contact *d*1 is open. The contact *c*1 closes the supply circuit to a motor *m*2 coupled to a valve 29 which sets it in rotation in such direction as to open the valve. This opens a water supply line 30 to a spray nozzle 31 which is mounted in the air outlet connection 5. As soon as the valve 29 starts to open it closes the limit switch 36 and when it is fully opened it operates a limit switch 17 which open-circuits the winding *c* thereby the contact *c*1 being electromagnetically operated by relay *c* opens and the motor *m*2 stops.

For the execution of such a circuit scheme, a motor with a suitable worm drive means may be used. In this case the motor operates through the drive means which has to rotate only in a certain angle, e.g. 180°, in order to shut or to open the valve 29 completely. The stationary arranged limit switches 17 and 36 are operated in the end positions of this angle of rotation by stops which are fixed on the drive means.

Both limit switches are so connected that by means of the stops the limit switches during running in to the corresponding end positions are opened and when running out of the end positions are shut again.

As is shown in FIG. 2, 17 is the limit switch which is opened when valve 29 is completely opened and 36 is the limit switch which is opened when valve 29 is completely shut.

When the elements in the packet have been cooled sufficiently to remove the risk of fire, the bimetallic snap switch of high temperature detector 10 opens and de-energizes relay 9, thereby contact 15 being electromagnetically operated by this relay 9 opens and denergizes lamp 16 and relay winding *b*. The contact *b*1 opens and the main circuit breaker *a* is de-energised if at the time the high temperature detector responded the contact 18 was open. In that case the circuit of the motor *m*1 is opened at the contact *a*1, and the motor *m*1 is again put out of operation.

As the switch 36 is already closed, the de-energisation of winding *b* with the consequent closing of rest contact *b*2 also energises the winding *d* which operates electromagnetically its contact *d*1 and closes a supply circuit to the motor *m*2 which sets it in rotation in such direction as to close the valve 29. When the valve is completely closed, the limit switch 36 is opened as described before thus de-energising the winding *d*, opening the contact *d*1 and stopping the motor *m*2.

In the case of moisture being deposited on the dew-point detector 13 (e.g. a surface current path as described before) a current of larger or smaller value flows through the relay winding 12. This electromagnetically operates a pointer operating mechanism 19 in such a way that the movement of the pointers depends on the value of the current being for example substantially proportional to it. This mechanism has two pointers 20 and 21 rotatable on a common shaft and relatively disposed in opposite directions, normally at 180° to one another. When the relay winding 12 is energized by responding of dew-point detector 13 the pointer 20 being electromagnetically operated by relay winding 12 is directly displaced and by a part extending beyond the shaft it engages and so carries the pointer 21 forward through the same angle, winding up a spring 34 attached to the pointer 21. The shaft and the two pointers are connected to one phase of the supply. In the illustrated displaced position, the pointer 20 is touching an arcuate contact 22 and thus energises a motor-operated time switch *e*.

Contacts *e*1 and *e*2 which are operated by the time switch *e* are thereby immediately closed. The contact *e*2 causes energisation of a warning device, such as a lamp 24 and the contact *e*1 holds the time switch on until the lapse of an adjustable delay period for example 30 minutes after energisation through the arcuate contact 22 ceases when there is no more moisture deposition on the surface current path of the dew point detector 13 whereupon the time switch automatically switches itself off.

In the position shown, the pointer 21 is touching a resistance segment 23 disposed symmetrically opposite the contact 22, thereby providing a supply to the operating coil 25 which operates a flap valve 26 electromagnetically. The greater the displacement of the pointer 21 the smaller the resistance in circuit so that the current in the coil 25 corresponds in value to the deflection of the pointer 21 and therefore to the quantity of deposited moisture on the surface current path of detector 13. In this way the flap valve 26 is opened against a restoring force e.g. gravity by a corresponding amount.

The valve 26 is in a return duct 27 which runs from the hot air outlet duct 28 to the cold air duct 30 leading to the suction side of a cold air blower 30' which supplies the heater, so that the duct returns a corresponding quantity of hot air which mixes with the entering cold air and raises the air entry temperature to the air heater. Acordingly the temperature of the elements to which this warmer air is led, rises.

After the detector 13 has dried off, the circuit of the corrosion protection relay 12 is broken. The pointer 20 is returned (by a restoring force such as gravity) to an abutment 31 where it is clear of the contact 22 thus opening the direct supply to the time switch 22 and from this instant the delay time of the switch commences.

When the pointer 20 is returned in this way, the pointer 21 remains in deflected position under the action of a pawl 33 controlled by the time switch *e* engaging a ratchet wheel 32 attached to the pointer, so that the valve 26 remains opened to a corresponding amount. The release of the valve so that it can close only takes place when the time switch releases some time e.g. 30 minutes after the detector 13 has dried. At the expiration of this delay the time switch *e* disengages the pawl 33 from the wheel 32 and the pointer is returned by the spring 34 to an abutment 35. The winding 25 is thereby de-energised and the valve 26 closes the return duct 27. In this way the result is obtained that the release of the device operated according to the invention for reducing the risk of corrosion only takes place when after a change in the operating conditions a certain stability has been reached.

In a similar manner by means of the flap valve 26, a flap valve not shown in a combustion gas conduit which as a regulating device by-passes part of the heating surfaces preceding the air heater, of the boiler plant with which it is associated, may be more or less opened so that the temperature of the combustion gases reaching the air heater and therefore also of the coldest elements is correspondingly raised by the response of the dew-pointer detector, though less effectively and economically than is achieved by mixing hot air with the cold air.

The raising of the temperature of the elements in response to the dew-pointer detector can also be effected in other ways, for example by the switching on of a heat source to pre-heat the cold air or by admixing with the cold air of hotter air from some other source.

What I claim is:

1. A method for maintaining a predetermined maximum temperature gradient between the temperature of the heat yielding gases and the temperature of the heat absorbing gases at the opposite points of entry of both such gases into a rotary regenerative heat exchanger, said method comprising the steps of measuring the temperature of the entering heat yielding gases, controlling a cooling means in response to such temperature to cool said

heat yielding gases when the temperature thereof approaches the ignition temperature of combustion residues present in the heat exchanger, simultaneously measuring the humidity of the entering heat absorbing gases and simultaneously controlling a heating means in response to such humidity measurements to maintain the temperature of the entering heat absorbing gases slightly above the dew point to prevent condensation of moisture on the surfaces of the heat exchanger.

2. In a regenerative gas preheater having a heat exchange unit, means for subjecting said unit to hot gases for the heating of said unit, an inlet duct leading to said unit for a second gas to be heated and an outlet duct leading from said unit for the heated second gas, second means for preventing a temperature rise of said unit above a predetermined maximum and for maintaining said unit at said predetermined maximum temperature to prevent ignition of deposits on said unit, third means for maintaining the entering temperature of said second gas above the dew point, said second means comprising a temperature sensitive element disposed in the inlet path to said unit of said first gas and means for cooling said unit, control means actuated by said temperature sensitive element upon said first gas reaching a predetermined high temperature to control the operation of said cooling means to apply a cooling medium to said unit, said third means comprising a humidity sensitive element disposed in the inlet path to said unit of said second gas, and means controlled by said humidity sensitive element for maintaining the entering temperature of said second gas above the dew point, said temperature responsive control means and said humidity responsive control means operating simultaneously.

3. In a regenerative gas preheater according to claim 2, in which the means for applying a cooling medium to the unit includes a device for spraying the unit with cool water.

4. In a regenerative gas preheater according to claim 2, in which the means for maintaining the entering temperature of said second gas above the dew point includes means for preheating said second gas in the inlet duct by the heated second gas in the outlet duct.

5. In a regenerative gas preheater according to claim 2, in which the means for maintaining the entering temperature of said second gas above the dew point includes a by-pass duct connecting the inlet and outlet ducts for said second gas, and a valve controlled by the humidity sensitive element for mixing said second heated gas and said second gas to be heated.

6. In a regenerative gas preheater according to claim 2, in which the heat exchange unit comprises a plurality of metallic sheets mounted in transversely spaced parallel relation, the means for heating the unit comprising a second duct for the heating gases having an inlet and an outlet positioned respectively on opposite sides of the edges of the plurality of sheets, the temperature and humidity sensitive elements comprising means for providing an electrical output signal for operating the control means, the temperature sensitive element being mounted in recesses in the sheets at the inlet end of the second duct and the humidity sensitive element being mounted in recesses in the sheets at the outlet end of the first duct, and conductors leading from the elements to the control means through the grooves in the sheets.

7. In a regenerative gas preheater according to claim 6, further including warning means operated by the control means upon operation thereof by the temperature and humidity sensitive elements.

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