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(54) **Apparatus for preventing the formation of deposits on vertical heat exchanger walls.**

(57) An elongate cleaner member (32) is at the top suspended at the uppermost end of the side of each duct wall swept by combustion gases in a multi-duct heat exchanger. The cleaner member extends throughout the height of the duct (I2) without physical contact with the wall, and extends a distance down into lower chamber (II). To the lowermost part of the cleaner member there is secured a deflector element (36) having asymmetrical mass and area distribution in relation to the point of interconnection between the deflector element and the cleaner member. In a preferred embodiment the cleaner member (32) consists of a chain with links (34, 35) having various widths; the chain links (35) in lower chamber (II) being smaller than the largest (34) of the links lying between the ends of the duct.

Due to the influence on the deflector element from the combustion gas flow in the lower chamber the whole chain will perform a combined motion comprising an undulating movement with hortizontal amplitudes and a twisting motion forth and back about the vertical axis of the cain. This combined motion influences the gas flow along the duct wall and prevents particulate material entrained with the combustion gas flow from depositing on the wall.

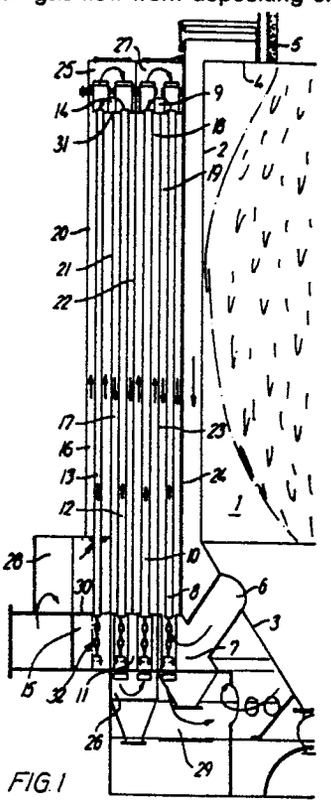

FIG. 1

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Apparatus for preventing the formation of deposits on vertical heat exchanger walls.

The present invention relates to an apparatus or appliance for preventing particulate matter entrained in a gas flowing through vertical ducts of a boiler or other heat exchanger, from accumulating in the form of unwanted deposits on the5duct walls.

It is well-known that the heat transfer through a heat exchanger wall, which is swept by hot combustion gases, is seriously impeded if a layer of ashes, soot or other solids is allowed to build up on the wall and several attempts have been made to devise simple and efficient apparatus, including mechanically acting scraper devices and steam or pressurized air operated soot blowers, for carrying out a cleaning of such walls. The problem is aggravated by the increasing use of pulverized coal firing (PCF), especially with coal of poor quality and extremely high ash content.

Danish patent specification No. 129,875 discloses an apparatus for cleaning vertical fire or smoke tubes of a boiler or other heat exchanger, which apparatus comprises a sheet metal screw extending through the height of each tube with a small clearance between the inner tube wall and the peripheral edge of the screw flight. Each screw is suspended from a carrier located above the associated tube and coupled to a drive mechanism adapted to impart a vertically reciprocating movement to the screw at suitable intervals. Due to the clearance within the tube the vertical movement of the screw will be accompanied by small lateral movements whereby the edge of the screw collides with the tube wall and exerts a combined impact and scraper effect on deposits present on the wall.

According to the present invention there is provided an apparatus for preventing the accumulation, on the wall of a vertical duct in a multi-duct heat exchanger, of particulate matter entrained in a gas flowing through the duct; comprising

an elongate cleaner member freely suspended with its axis in parallel with the wall and with a lower end protruding below the wall,

said elongate cleaner member being composed of an articulated series of operative elements interconnected with a high degree of flexural and torsional freedom, each of said elements being formed with an operative surface extending transversely from the axis of the elongate cleaner member without physical contact with the wall,

and a deflector element formed with two opposed major surfaces, the height and width of which are large in comparison with the thickness of the element, said deflector element being secured to the lower end of the elongate member adjacent its upper end at a location laterally offset from its centre of mass.

In contrast to known appliances, which are actuated intermittently to remove deposits formed during a preceding non-actuated and non-operative period, the apparatus according to the present invention is continuously operative and it functions by influencing the gas flow along the wall in such a way that particulate matter entrained therein is kept in constant movement and thus prevented from settling down on the wall. It has been found that even quite low gas velocities in a plenum chamber, into which the ducts open at their lower ends, is capable of causing transverse and twisting movements of the asymmetric deflector element which propagate upwards through the length of the elongate member in the form of travelling waves or undulations in a ver tical plane and slow oscillations forth and back about the longitudinal axis of the member. Although these movements will normally be very gentle, they have proved to be sufficient for creating a constantly changing pattern of the gas flow along the duct wall, thereby constantly disturbing the inherent tendency towards the maintenance of a stagnant boundary layer adjacent the wall and ensuring the constant movement of the particulate matter mentioned above. Tests carried out on a PCF boiler equipped with an apparatus according to the invention have demonstrated that after several thousand hours of operation the smoke tubes of the boiler's convection passes were still free of harmful deposits. Under similar operating conditions, but without the apparatus, the tubes were completely fouled in less than 24 hours. Since the apparatus functions without any drive mechanism or other external power source, it is both inexpensive and very reliable in operation.

In a preferred embodiment the operative elements of the elongate memter are shaped as chain links. In comparison with more sophisticated designs, e.g. comprising specially made vanes etc. secured in spaced relationship to a flexible wire or cable, this embodiment is very cheap because it can be made from standard components available on the market in a large number of different sizes and at low prices, and its efficiency has been demonstrated by the above mentioned tests.

According to a feature of the invention the dimensions of the chain links may vary along the length of the chain. It is conceivable that the varying size of the chain links results in different amplitudes of the chain's wave motion in different levels and that the gas flow pattern may be favourably influenced thereby.

It is advantageous to form the portion of the chain, which protrudes below the duct wall, from chain links which are more slender than a major part or fraction of the links located between the ends of the duct. In this embodiment the amplitudes of the transverse movement of the protruding chain portion, including the deflector, will be correspondingly larger than the amplitudes occurring within the duct. They may even become so large that neighbouring deflector elements collide from time to time, which may assist in keeping all chains in constant motion as long as there is a gas flow through the ducts.

When the cross-section of the ducts is circular, the maximum transverse dimension of a chain link should preferably be between 25% and 40% of the diameter of the duct, e.g. about one third of the duct diameter.

The deflector element may be shaped as an inverted U comprising an upper, horizontal limb secured to the elongate member and two parallel vertical limbs. An element of this design can be manufactured from bar stock, of round or other cross-section, by simple bending operations and it is both efficient and inexpensive.

The lengths of the vertical limbs may be unequal, which enhances the twisting effect exerted on the element by a lateral velocity component of the gas flow in the plenum chamber below the ducts.

An asymmetric mass distribution in the deflector may be obtained, in a simple manner, by interconnecting the vertical limts of the U-shaped deflector element by a crossbar secured to one of the major surfaces of the element.

The invention will now be described in more detail with reference to the accompanying, rather - schematical drawings, in which

Fig. I is a vertical part-section through a gas-to-air heat exchanger equipped with apparatus embodying the present invention,

Fig. 2 is a vertical section, on a larger scale, of a single smoke tube from the heat exchanger of Fig. I,

Fig. 3 is a lateral view, on a still larger scale, of a deflector element, and

Fig. 4 is a view of the deflector element seen from the edge in the direction of arrow IV in Fig. 3.

The heat exchanger illustrated in the drawings includes a central furnace chamber I defined by a shell, which comprises an upper, cylindric part 2, a conical bottom part 3 and a top cover 4. A fuel burner (not shown) is mounted in a central tubular member 5 of reduced diameter, extending upwardly from top cover 4. A plurality of outlet tubes 6 for combustion gases produced in furnace chamber I extend outwardly from the conical bottom part 3, and each tube 6 opens into a plenum or turning chamber 7 from which a plurality of smoke tubes 8 extend vertically upward. The smoke tubes are distributed along a pitch circle concentric with the shell of furnace chamber I, and at their upper ends they open into one or more plenum chambers 9, from which another plurality of smoke tubes I0 extend downwardly along a circle concentric with the pitch circle of smoke tubes 8. Each smoke tube I0 opens into a lower plenum chamber II concentric with plenum chamber 7 and separated therefrom by a vertical partition wall. As illustrated in Fig. I, the heat exchanger comprises two further, circular rows of smoke tubes I2 and I3, respectively, which conduct the combustion gases from each plenum chamber II via an upper plenum chamber I4 concentric with chamber 9 to a lower plenum chamber I5 from which the combustion gases are discharged through an outlet (not shown).

A plurality of series-connected air flow passages I6, I7, I8, and I9, each of which surrounds a respective group of smoke tubes, is defined between a succession of vertical walls 20, 2I, 22, 23, and 24, all coaxial with the shell 2 of furnace chamber I. The air passages are interconnected through alternate upper and lower plenum or turning chambers 25, 26, and 27. Air to be heated flows through an inlet (not shown) to a distributor chamber 28 into which the lower ends of air passages I6 open, and the heated air is discharged from the heat exchanger through a collector chamber 29 into which the lower ends of air passages I9 open.

Fig. 2 is a vertical section through one of the smoke tubes I2 which at its ends is sealingly secured in the top wall 30 of plenum chamber II and the bottom wall 3I of plenum chamber I4, respectively. Through the wall of tube I2 heat from the upwardly flowing combustion gases is to be transferred to the air flowing downwardly through the surrounding air passage I7.

In order to keep the inner wall of tube I2 constantly clean and thus obtain maximum efficiency of the heat transfer, a chain generally designated by 32, is suspended centrally within each of the total number of smoke tubes in the heat exchanger. Each chain 32 extends throughout the height of the associated tube from a supporting pin 33 welded to the tube adjacent its upper end down to a level below the top wall 30 of the lower plenum chamber II.

As illustrated in Fig. 2 chain 32 is composed of successive groups of relatively larger and smaller chain links designated by 34 and 35, respectively. As mentioned earlier in this description the transverse dimension or width of chain links 34 may be approximately one third of the inner tube diameter, and the width of links 35 may be correspondingly smaller, as shown. It is preferred that the portion of

chain 32, which protrudes below wall 30 into chamber II, is composed of the smaller links 35.

To the lowermost chain link 35 there is secured, such as by welding, a deflector or twister element 36 which is shown on a considerably larger scale in Figs. 3 and 4. Deflector element 36 is U-shaped with a horizontal upper limb 37 and two parallel vertical limbs 38 and 39 of which limb 38 is substantially longer than limb 39. A crossbar 40 is welded to the vertical limbs 38 and 39 on one side of the deflector element so as to create an "unbalanced" mass distribution of the element in the sense that its centre of mass will be offset, both in the general plane of the element and at right angles thereto, relative to the longitudinal axis of chain 32 when deflector element 36 is welded thereto at the center of its upper limb 37, as shown in Fig. 2.

It will be evident that, as also illustrated in Fig. I, in plenum chamber II as well as in each of the other plenum chambers, the flow of combustion gases through the chamber, as illustrated by arrows 4I in Fig. 2, will have a horizontal velocity component which, as explained in some detail above, will cause the asymmetric deflector element 36 to swing slowly forth and back, as illustrated by horizontal arrows 42, and also to rotate slowly about the vertical axis of chain 32, as illustrated by an arrow 43. Although each of these motions will generally be rather slow and gentle, they are on the other hand sufficiently strong to set chain 32 in a similar combined motion, including an undulating component as illustrated by arrows 44, and a twisting component forth and back about the vertical axis. It has surprisingly been found that notwithstanding the rather small amplitudes and low frequencies of these motion components, they are sufficient to influence the gas flow through the ducts such that even after prolonged period of operation on fuel with high ash content the walls of the smoke tubes remain clean. It has also been found that this highly desirable effect is obtained irrespective of whether the gas flows upwards or downwards through the tube.

Claims

I. Apparatus for preventing the accumulation, on the wall of a vertical duct (I2) in a multi-duct heat exchanger, of particulate matter entrained in a gas flowing through the duct; comprising

an elongate cleaner member (32) freely suspended with its axis in parallel with the wall and with a lower end protruding below the wall,

said elongate cleaner member (32) being composed of an articulated series of operative elements (34, 35) interconnected with a high degree of flexural and torsional freedom, each of said elements being formed with an operative surface extending transversely from the axis of the elongate cleaner member without physical contact with the wall,

and a deflector element (36) formed with two opposed major surfaces, the height and width of which are large in comparison with the thickness of the element, said deflector element being secured to the lower end of the elongate member (32) adjacent its upper end at a location laterally offset from its centre of mass.

2. Apparatus as claimed in claim I, **characterized** in that the operative elements (34, 35) of the elongate cleaner member (32) are shaped as chain links.

3. Apparatus as claimed in claim 2, **characterized** in that the dimensions of the chain links (34, 35) vary along the length of the chain.

4. Apparatus as claimed in claim 2 or 3, **characterized** in that the portion of the chain (32), which protrudes below the duct wall, is composed of chain links (35) which are more slender than a major part of the links located between the ends of the duct (I2).

5. Apparatus as claimed in any of claims 2-4, and for use in a duct (I2) of circular cross-section, **characterized** in that the maximum transverse dimension of a chain link (34, 35) is between 25% and 40% of the diameter of the duct.

6. Apparatus as claimed in any of claims I-5, **characterized** in that the deflector element (36) is shaped as in inverted U with an upper, horizontal limb (37) secured to the elongate cleaner member and two parallel vertical limbs (38, 39).

7. Apparatus as claimed in claim 6, **characterized** in that the lengths of the vertical limbs (38, 39) are unequal.

8. Apparatus as claimed in claim 6 or 7, **characterized** in that the vertical limbs (38, 39) are interconnected by a crossbar (40) secured to one of the major surfaces of the deflector element (36).

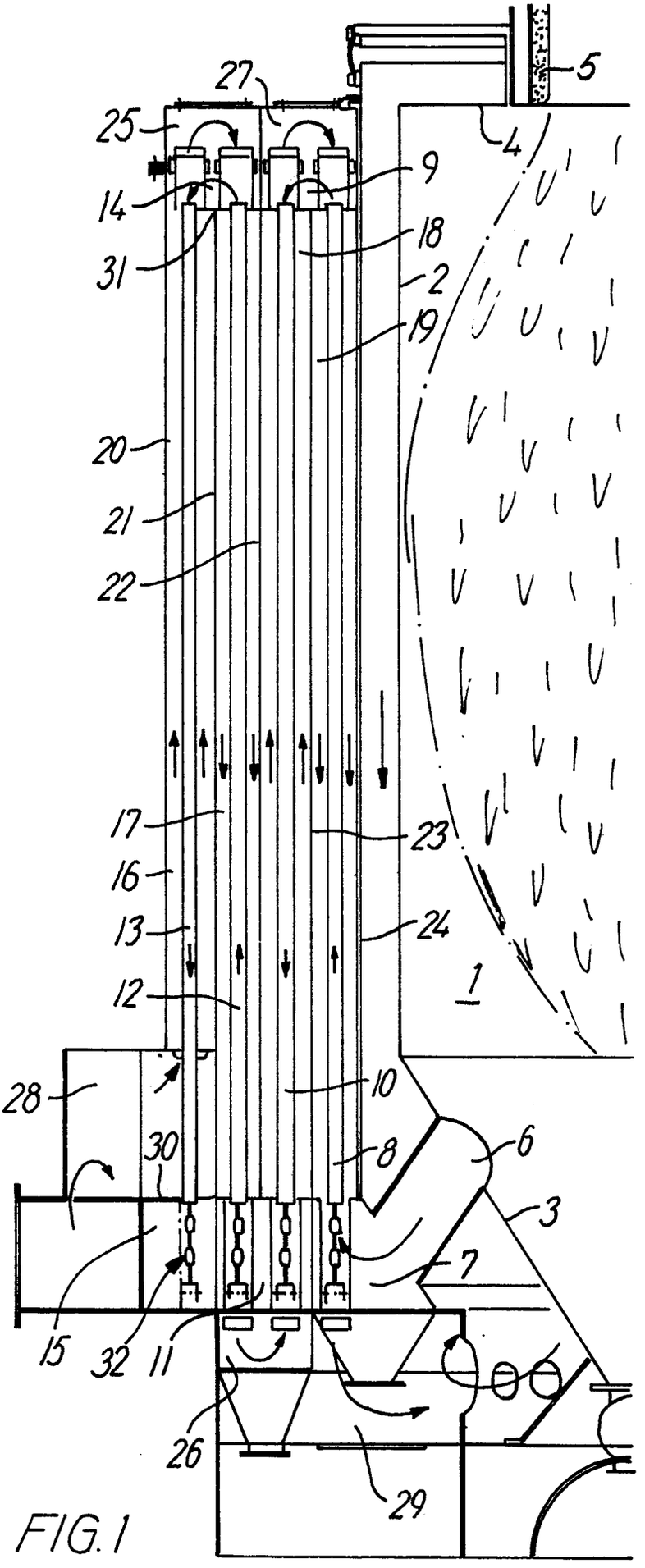
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FIG. 1

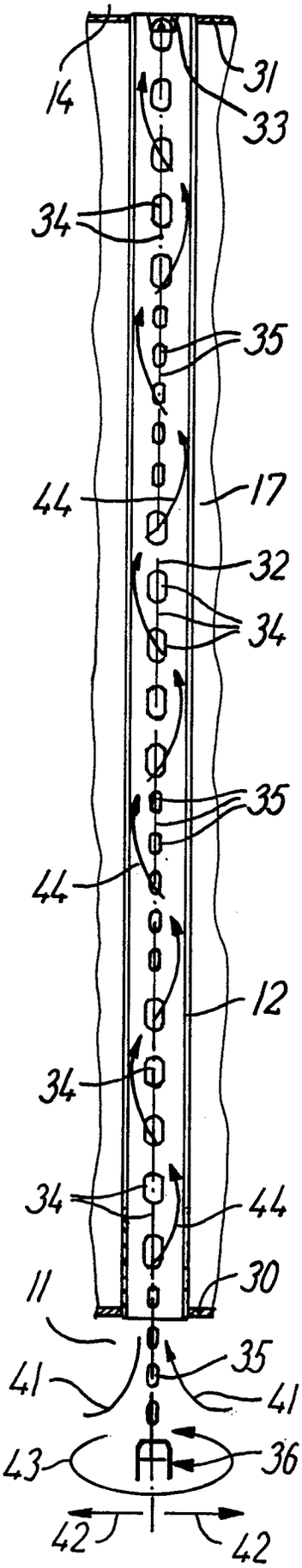

FIG.2

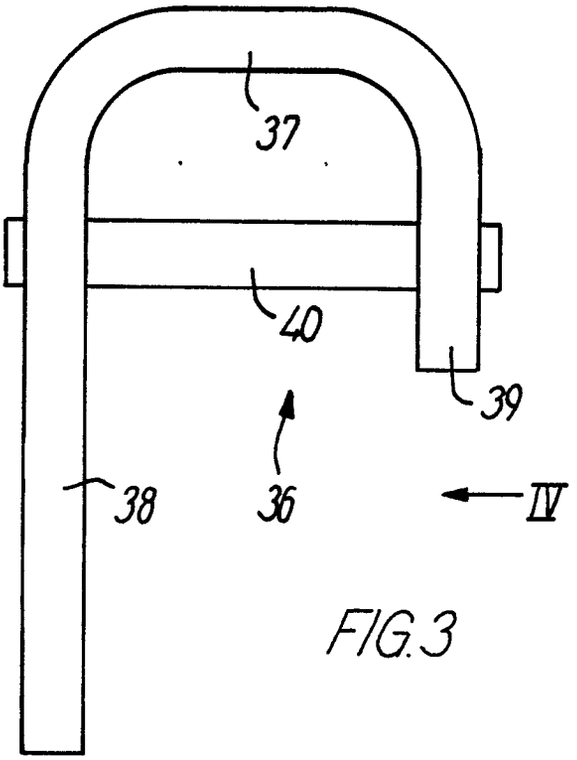

FIG.3

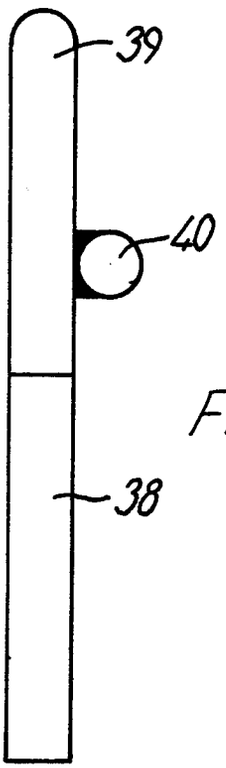

FIG.4

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EUROPEAN SEARCH REPORT

Application number

EP 86 30 7355

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DE-A-3 327 321 (J. WECKENMANN) * Whole document *	1-3	F 28 F 19/00
A	FR-A-1 027 888 (SCHACK) * Figure 2 *	5	
A	CH-A- 505 360 (YGNIS SA) * Whole document *	1	
A	DE-C- 457 572 (P. CIMBOLEK) * Whole document *	1	
A	DE-B-1 003 905 (R. HINGST) * Whole document *	1	
A	GB-A-2 124 322 (W.J. HOLDEN)		TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 28 F F 28 G F 23 J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13-01-1987	SMETS E.D.C.

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