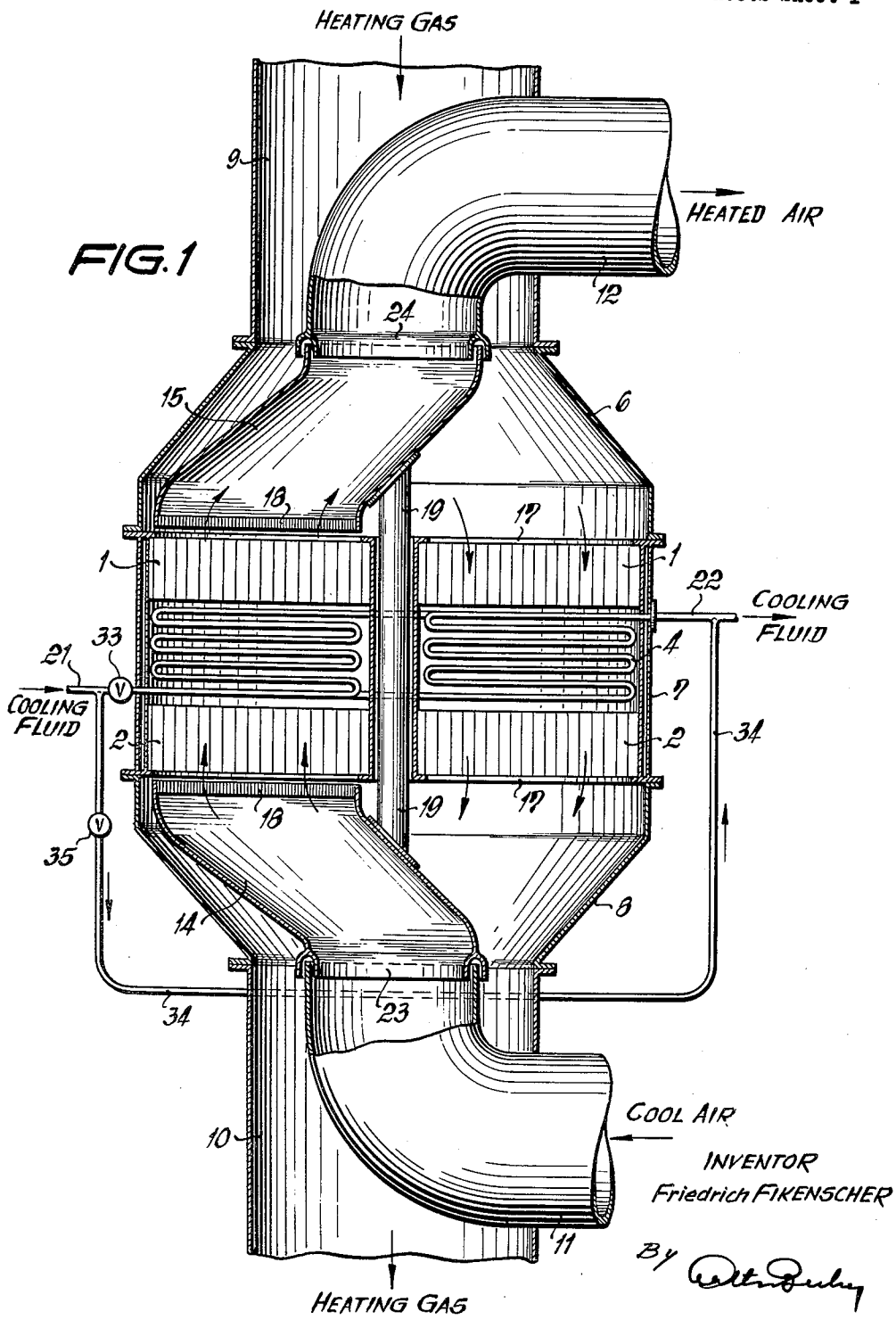
Feb. 19, 1963 F. FIKENSCHER 3,077,926

AIR PREHEATER

Filed April 29, 1959 5 Sheets-Sheet 1

FIG. 1



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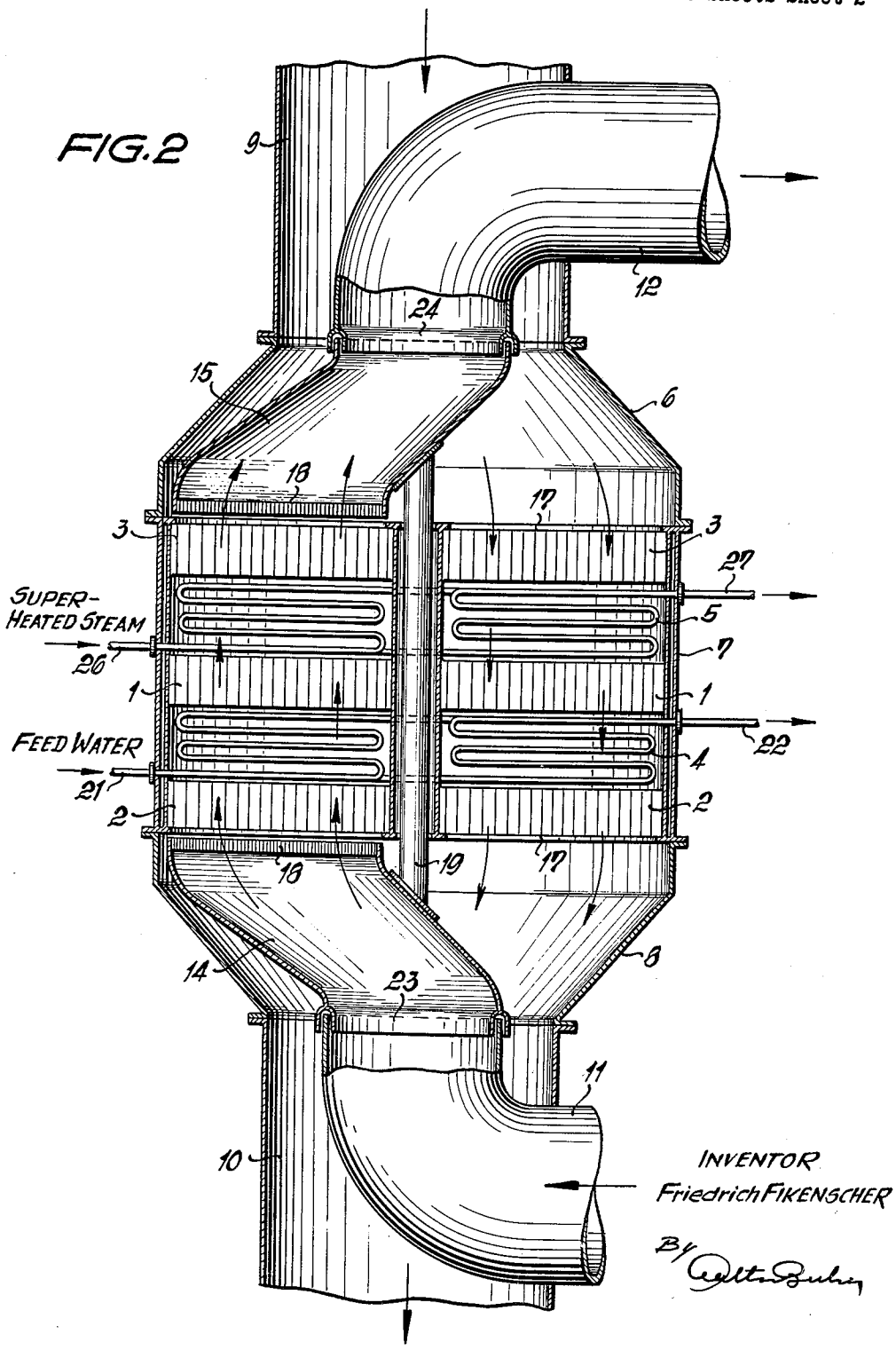
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Feb. 19, 1963 F. FIKENSCHER 3,077,926

AIR PREHEATER

Filed April 29, 1959 5 Sheets-Sheet 2

FIG. 2

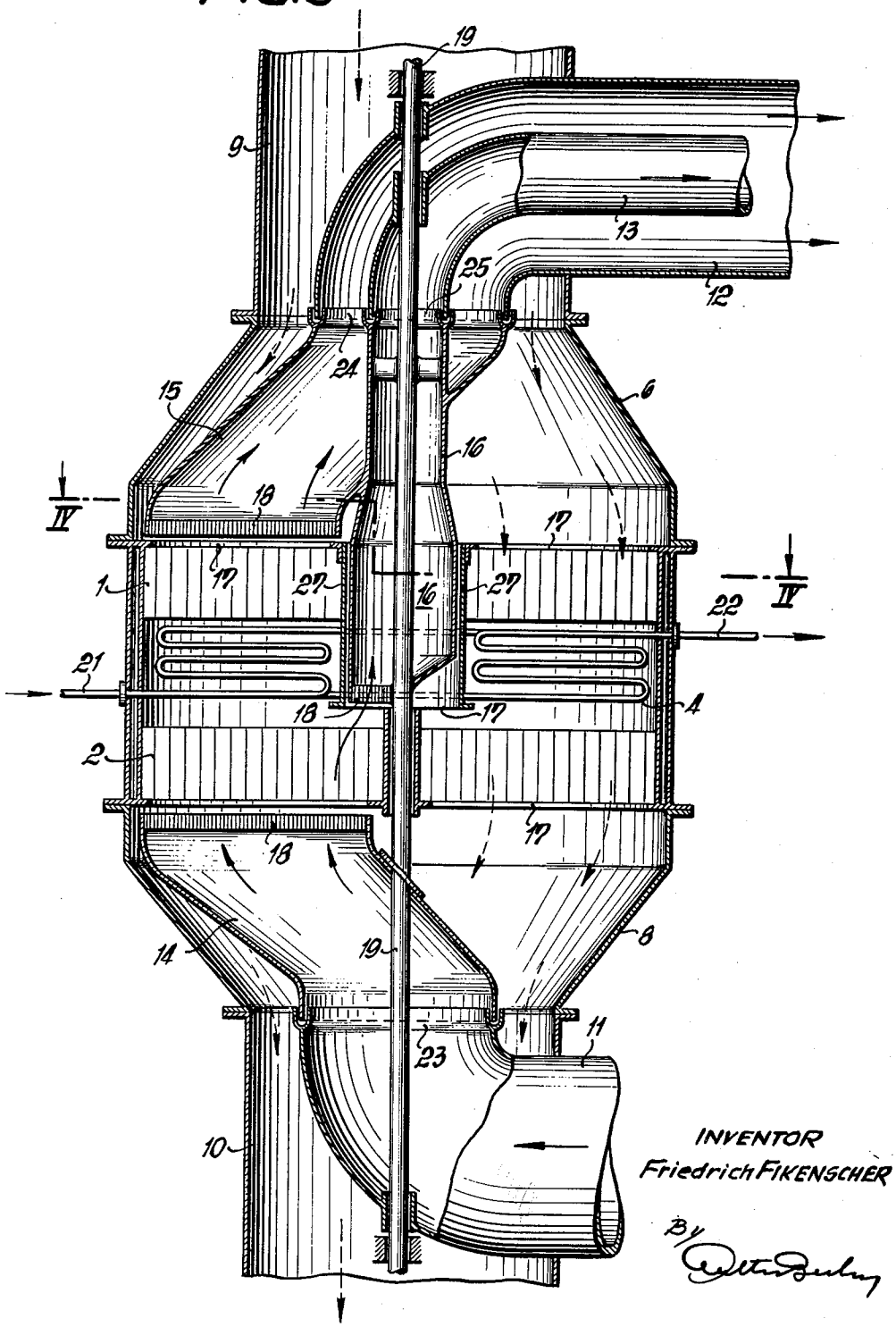


Feb. 19, 1963 F. FIKENSCHER 3,077,926

AIR PREHEATER

Filed April 29, 1959 5 Sheets-Sheet 3

FIG. 3



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AIR PREHEATER

Filed April 29, 1959 5 Sheets-Sheet 4

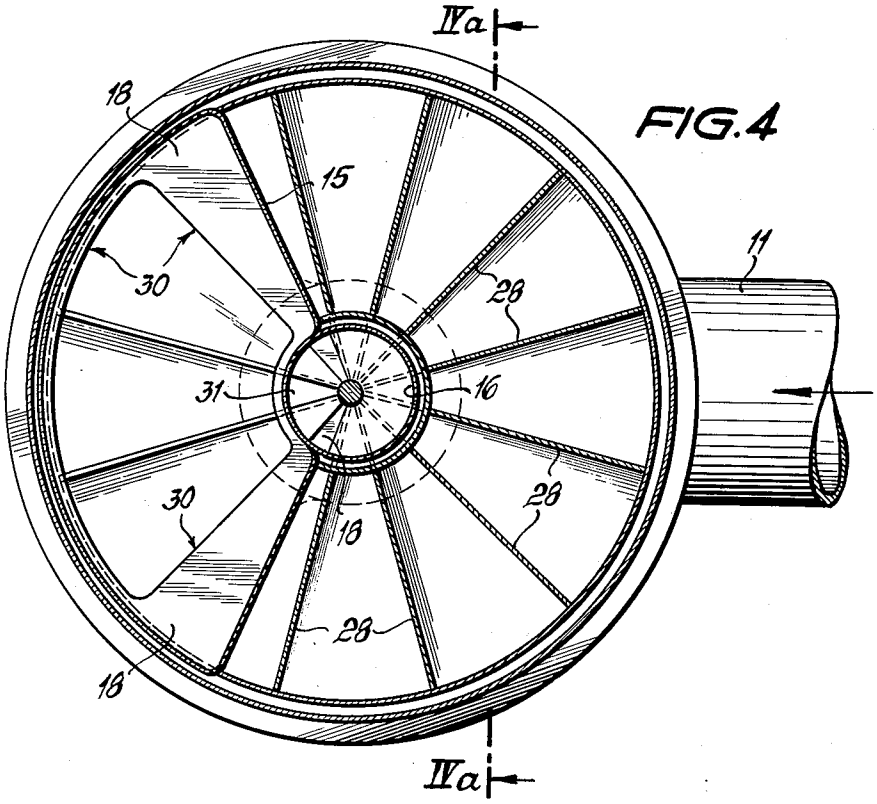
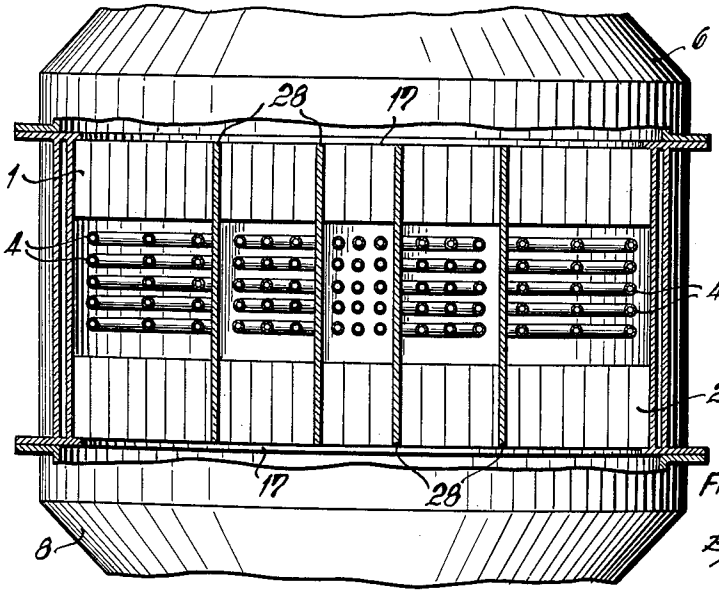


FIG. 4

FIG. 4a



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AIR PREHEATER

Filed April 29, 1959 5 Sheets-Sheet 5

FIG. 5

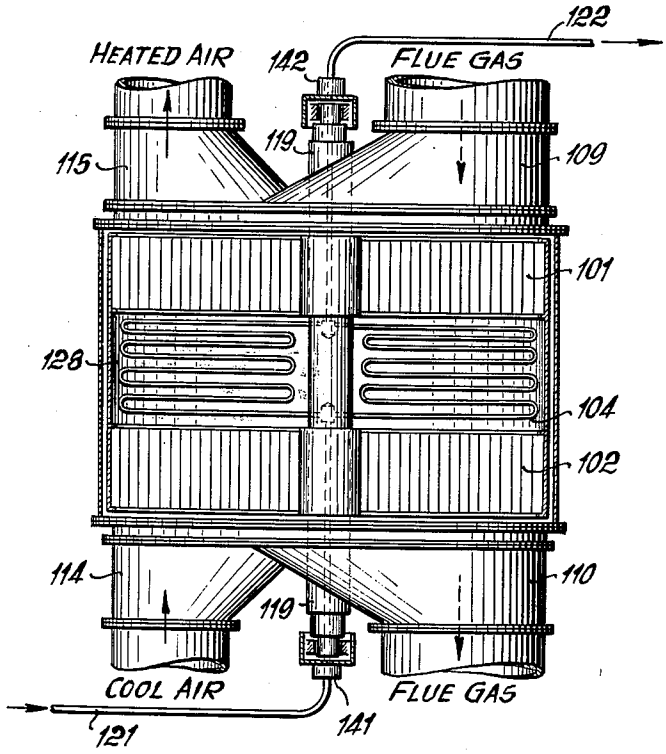
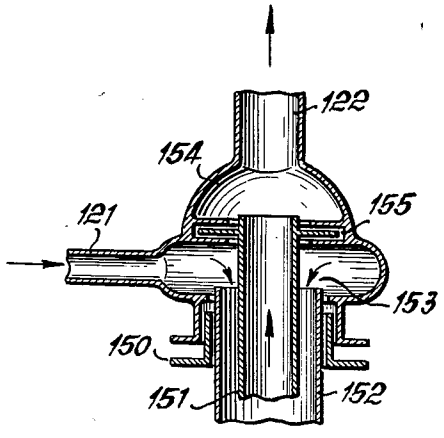


FIG. 6



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AIR PREHEATER

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3 Claims. (Cl. 165—7)

The present invention relates to an air heater and, more particularly, to a multi-stage regenerative air heater which, for purposes of obtaining high temperatures while simultaneously strongly cooling the flue gas, is subdivided into two or more stages by the interposition of one or more additional flue gas coolers.

Heretofore known air heaters of this type were so designed that the heat exchange bodies rotate about a horizontal or vertical axis, whereas the required connecting hoods for the flue gases and the air and also the additional flue gas coolers were arranged stationarily. Such design has the considerable drawback that, for purposes of journalling the heavy rotating heat exchange bodies, complicated constructions were required and high costs were involved, while additionally special sealing arrangements were required between the additional flue gas coolers and the adjacent exchange bodies of the air heater stages preceding or following the heat exchange bodies.

It is, therefore, an object of the present invention to provide a multi-stage regenerative air heater system which will overcome the above mentioned drawbacks.

It is another object of this invention to provide a multi-stage regenerative air heater system which will be considerably simpler in design and more reliable than heretofore known air heaters of the type involved.

It is also an object of this invention to provide an air heater of the type set forth in the two preceding paragraphs, which will make it possible, as will occasionally be desired, to withdraw additional air or to feed flue gas between the stages of the air heater.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 diagrammatically illustrates an embodiment of an air heater according to the present invention with two air heater stages and an additional flue gas cooler.

FIG. 2 is a diagrammatic illustration of an air heater system according to the invention which is somewhat modified over that of FIG. 1 and is suitable for particularly high temperatures.

FIG. 3 diagrammatically illustrates an air heater system similar to that of FIG. 1 but differing therefrom in that a portion of the air partly heated in the cooler air pre-heater stage is withdrawn directly from the air heater for certain purposes.

FIG. 4 is a simplified top view of FIG. 3 along the line IV—IV of FIG. 3.

FIG. 4*a* is a section along the line IV*a*—IV*a* of FIG. 4.

FIG. 5 is still another embodiment of the air pre-heater system according to the invention, in which the heat exchanging bodies rotate together with an additional flue gas cooler.

FIG. 6 is a diagrammatic section through a stuffing box with connections for the supply and discharge of the cooling means.

An arrangement according to the present invention as described in the present application and shown in the drawings is characterized in that a relative movement between the heat exchanging bodies of the air pre-heater stages and the additional flue gas coolers will be avoided and an undesired heating up or cooling off of the air passing through said flue gas coolers will be prevented by

adapting and approximating the temperature of the cooling means passing through the respective additional flue gas cooler to the temperature of the air passing by and already partly pre-heated.

Specifically referring to FIGS. 1 to 4, the heat exchanging bodies 1, 2 and 3 of the air pre-heater stages and the additional flue gas coolers 4 and 5 are arranged stationarily so that their weight representing the major portion of the total mass of the installation, together with the outer housing 6, 7 and 8 and the connecting passages for the flue gases 9, 10 and for the air 11, 12, 13 can be supported in a simple and known manner on the foundation (not shown in the drawings). Only the air connecting hoods 14 and 15 and the additional air withdrawal hood 16 together with the sealing means 18 move relative to said stationary parts, said sealing means 18 being slidable on the end faces 17 of the heat exchanging bodies 1 and 2, and 1 and 3. The rotatable air hoods 14, 15 and 16 are interconnected by means of a shaft 19 common thereto so that the required uniform rotation thereof will be assured. The driving devices for said air hoods, and in part also the required bearings of shaft 19 correspond to those known in connection with prior art devices of the type involved.

It is, a matter of course, that sealing sleeves 23, 24 and 25 or the like are provided between the rotatable air connecting hoods 14, 15 and 16 on one hand and the stationary connecting pipes 11, 12 and 13 pertaining thereto on the other hand. For the sake of simplicity, the drawings illustrate the connecting hoods of the air as single piece hoods. However, it should be kept in mind that in a manner known per se also twin arrangements may be employed which consist of two pairs of correspondingly smaller partial hoods located diametrically opposite each other and connected to each other.

The simplest arrangement of a system according to the invention is shown in FIGS. 1 and 2 which comprise two air pre-heater stages 1 and 2, and an additional flue gas cooler 4 the cooling means of which, particularly feed water, is conveyed through conduit 21 and discharged through conduit 22. Similar to the heretofore known regenerative air pre-heaters of the so-called Ljunyström design, also with the arrangement according to the present invention, the total cylindrical chamber and the heat exchanging bodies of the multi-stage air pre-heater are subdivided by a plurality of, for instance from fifteen to twenty-five, radially arranged partitions of the type of the partitions 28 of FIGS. 4 and 4*a* into a corresponding number of sector chambers of approximately triangular or trapezoidal cross section, said partitions 28 uniformly subdividing the circular cross section. These sector chambers must extend from the first to the last end face of the entire air pre-heater, i.e. must extend over the total length of the latter in an undivided manner and thus have correspondingly to sub-divide also the additional flue gas coolers 4 and 5.

For purposes of cooling the flue gases uniformly and continually and for purposes of avoiding an undesired heat exchange between the additional cooling means and the air passing by, it is necessary that the additional flue gas cooler 4 is so designed that at any time and in each of the individual sector chambers, the same mean temperature of the additional cooling means will be maintained. To this end, for instance, a plane spiral pipe coil may be employed, a plurality of windings of which is passed around the center of the shaft. Of the said windings, an even section is allotted to each component sector chamber, while the spiral or coil for purposes of a temperature balance has a plurality of windings bent back in a cross sectional plane in one direction and in a plane parallel thereto in the opposite direction with the same

number of windings. However, also other pipe assemblies known per se may be employed provided they will meet the above mentioned conditions.

It is also possible for all component sector chambers to employ pipe elements of the same design, preferably each with two separate passages for the cooling means, of which one passage for all component sectors is arranged one after another in the direction of rotation, whereas the other passage for the component sectors is arranged one after the other in the opposite direction of rotation.

The flue gas cooler 4 may be connected to a source of cooling fluid (not shown) through a conduit 21 and valve 33. Furthermore, conduit 21 may communicate directly with the discharge line 22 of cooler 4 through a bypass line 34 having a valve 35 interposed therein for selectively making said bypass line ineffective or effective or otherwise control the flow therethrough.

FIG. 2 illustrates an arrangement according to the invention which is especially suitable for particularly high air temperatures as they may occur with boilers for smelting chambers for fuels with a very high slag flow point, with a low content in volatile ingredients or also with high water and ash contents. With this arrangement, the air preheater heating surface, especially within a high temperature range, will be reduced by replacing the heretofore two air pre-heater stages by three air pre-heater stages namely a hot stage 3, an intermediate stage 1 and a cool stage 2. An additional flue gas cooler 5 arranged between the hot stage 3 and intermediate stage 1 is cooled by superheated steam or by a steam mixture of the boiler so that the said flue gas cooler 5 serves as steam superheater or as evaporator heating surface. The cooling means is supplied through conduit 26 and is withdrawn through conduit 27. The other additional flue gas cooler 4 arranged between the intermediate air pre-heater stage 1 and cool air pre-heater stage 2 is passed through by feed water similar to FIG. 1 and thus serves as economizer heating surface. The remainder of the arrangement corresponds substantially to that of FIG. 1.

FIG. 3 illustrates an arrangement which differs from that of FIG. 1 primarily in that a portion of the air, which has been partially pre-heated in the cooler air pre-heater stage 2, is directly withdrawn from the air pre-heater and, at a higher pressure but lower temperature than at the main air outlet 15—12, is conveyed for instance to a fuel mill for drying, sifting and feeding of the ground fuel or the fuel to be ground. This air after leaving the air preheater stage 2, instead of entering the additional flue gas cooler 4 and the subsequent air pre-heater stage, directly enters the air withdrawal hood 16 surrounding shaft 19. The said hood 16 rotates by means of shaft 19 in the same direction and at the same speed as the air intake hood 14 and the main air discharge hood 15. The air withdrawal hood 16 has a tubular upward extension passing through the main air discharge hood 15 and by means of the seal 25, which may for instance be designed in form of a sleeve, leads into the stationary withdrawal passage 13.

In a corresponding modification of the arrangement of FIG. 1, the heat exchange body of the air pre-heater stage 1 and the chamber housing the flue gas cooler 4 are advantageously, by means of a stationary pipe 27 surrounding the tubular air withdrawal hood 16, shielded against said air withdrawal hood 16 similar to the heat exchanging body of the air pre-heater stage 2 being shielded against shaft 19 passing therethrough.

FIG. 4 represents a simplified top view of FIG. 3 which diagrammatically illustrates the arrangement of the rotating main air discharge hood 15 and the air withdrawal hood 16 coaxially arranged thereto. Both hoods are provided with air passages 30 and 31 both of which are surrounded by shielding frames 18 which slide on the stationary end faces 17 pertaining thereto. This top view also shows the arrangement of the radial partitions 28 referred to above which partitions extend through the entire cylindrical chamber and the length thereof of the

air pre-heater including the heat exchange body and the additional flue gas coolers 4 and 5.

With regard to FIG. 4*a* representing a section along the line IV*a*—IV*a* of FIG. 4, this figure clearly shows the partitions 28. Arranged in the chambers formed by said partitions are located the coil means 4 uniformly distributed. The coils are preferably arranged substantially radially. FIG. 4*a* also shows the customary heat exchanging bodies 1 and 2 of the heat exchanger stages as referred to above.

FIG. 5 shows a further embodiment of the invention and, more specifically, illustrates an embodiment of an air pre-heater in which the heat exchange bodies 101 and 102 rotate together with the additional flue gas cooler 104 whereas the air intake hood 114, the air discharge hood 115 and the flue gas intake and discharge hood 109 and 110 are arranged stationarily. However, the bearings and the drive of the heavy rotating masses are not shown inasmuch as these correspond to the generally customary and heretofore known systems. Also with the arrangement of FIG. 5, the radially extending partitions 128 extend through the entire rotating air preheater unit. FIG. 5 also shows the heavy shaft 119 with the inner bores which connect the additional flue gas cooler 104 through the diagrammatically indicated stuffing boxes 141 and 142 with the supply conduit 121 and the discharge conduit 122 for the cooling means.

FIG. 6 shows a combined stuffing box with the connections 121 and 122 for the supply and discharge of the cooling means. This combination stuffing box requires merely a high pressure seal 150. The connection with the shaft is effected through two pipes 151 and 152 which are coaxially arranged one in the other and are fixedly connected with each other while being rotatably connected to the shaft. The cooling means flows in the annular chamber between said two pipes 151 and 152 to the cooler and leaves the latter through the inner pipe 151.

Between the collector hoods 153 and 154 for the supply and discharge there is provided only one low pressure stuffing box 155. With actual boiler installations, especially with refineries, it is frequently necessary to increase the temperature of the hot air beyond the value indicated for the normal load or the load limit, or at least to maintain said hot air temperature at said value when the actual load represents only a fraction of the normal load. In this instance, normally the hot air temperature will by itself drop but on the other hand, the ignition at low loads is more easily interrupted and lowers the fuel chamber temperature whereby with refineries the danger of the "freezing" of the melting chamber and the slag discharge opening will be increased. It is, therefore, suggested in accordance with the present invention to reduce the additional flue gas cooling and thereby to increase the heating of the air in the "cold" air preheater stage. To this end, it is suggested above all to reduce the defects of the cooling means in the additional flue gas cooler, i.e. to reduce the quantity of the feed water passing through said flue gas cooler. This is done in its simplest way as far as it is possible in the boiler installation, by temporarily reducing the feeding of the boiler, for instance by means of a throttle valve or by means of the feed valve which is provided anyhow, or by a controllable bypass conduit or valve which passes a certain quantity of the total amount of supplied feed water around the additional flue gas cooler so as to bypass the same. A second possibility of reducing the additional flue gas cooling and thereby to produce a further increase in the temperature of the hot air consists in increasing the temperature of the cooling means. At low temperature of the feed water, it would also be possible to this end to employ a feed water pre-heating for instance by means of withdrawal turbine steam, by means of live steam from the boiler or by means of other additional heat sources.

It is, of course, to be understood that the present invention is, by no means, limited to the particular constructions shown in the drawings but also comprises any modifications within the scope of the appended claims. Thus, while only the arrangement of FIG. 1 has been shown as being equipped with the members 33, 34, 35, also the other modifications shown in the drawings may be equipped with the said members 33, 34, 35.

What I claim is:

1. In combination in a multi-stage regenerative air pre-heater: a housing, a plurality of stationary cylindrical heat exchanging bodies coaxially arranged in said housing and in spaced relationship to each other and representing different heat exchanging stages, stationary coil means arranged in said housing and interposed between said heat exchanging bodies for connection with a source of liquid, radially extending partition means extending through said heat exchanging bodies and the space surrounding said coil means so as to form a plurality of sector chambers sealed in a gas-tight manner along their entire lengths through all of said heat exchanging bodies, stationary heating gas supply and discharge conduit means communicating with said heat exchanging bodies for respectively passing heating gas through said heat exchanging bodies and around said coil means and discharging the heating gas passed through said heat exchanging bodies, stationary air feeding and withdrawing passage means arranged in spaced relationship to said heat exchanging bodies, and rotatable connecting conduit means respectively communicating with said air feeding and withdrawing passage means and rotatable relative to said heat exchanging bodies and during rotation of said connecting conduit means successively communicating with at least one of said sector chambers while simultaneously closing off the respective other sector chambers with regard to said air withdrawing passage means.

2. A multi-stage regenerative air preheater provided with a plurality of stationary coaxial cylindrical heat exchange bodies having therebetween at least one intervening space and with stationary cooling elements in said space between said heat exchange bodies, heating gas supply and discharge conduit means communicating with said heat exchange bodies, air feeding and air withdrawing passage means arranged in spaced relationship to said heat exchange bodies, and rotatable connecting conduit means communicating with said air feeding and air withdrawing passage means and rotatable relative to said heat exchange bodies, said air preheater being further provided with radially extending partition means extending entirely through said heat exchange bodies and through said intervening space and dividing said heat exchange bodies and said space with the cooling elements therein into a plurality of annular sector-shaped chambers, said connecting conduit means, during rotation thereof, successively communicating with at least one of said sector-shaped chambers while closing off other of said chambers.

3. A multi-stage air preheater according to claim 2, wherein said heat exchange bodies and said cooling elements extend over the entire annular cross section of said air preheater.

References Cited in the file of this patent

UNITED STATES PATENTS

963,470	Dupont	July 5, 1910
1,951,996	Schaefer	Mar. 20, 1934
2,622,850	Tipler	Dec. 23, 1952
2,803,439	Fikenscher	Aug. 20, 1957

FOREIGN PATENTS

1,065,660	France	Jan. 13, 1954