Jan. 18, 1966 A. GETTO 3,229,752

COUNTER FLOW REGENERATIVE HEAT EXCHANGER

Filed Nov. 16, 1961 2 Sheets-Sheet 1

Fig. 1

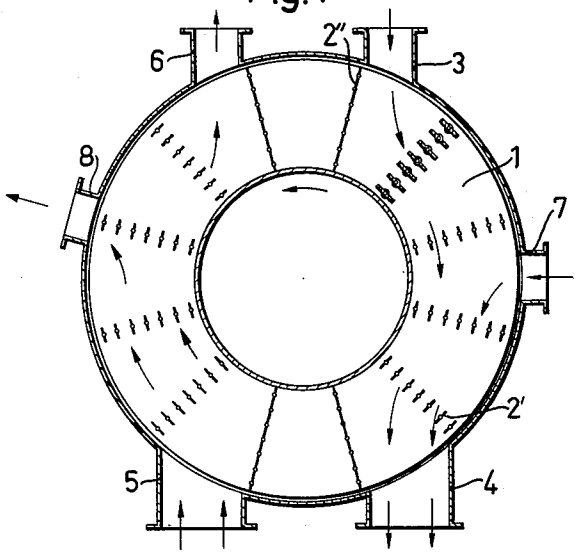
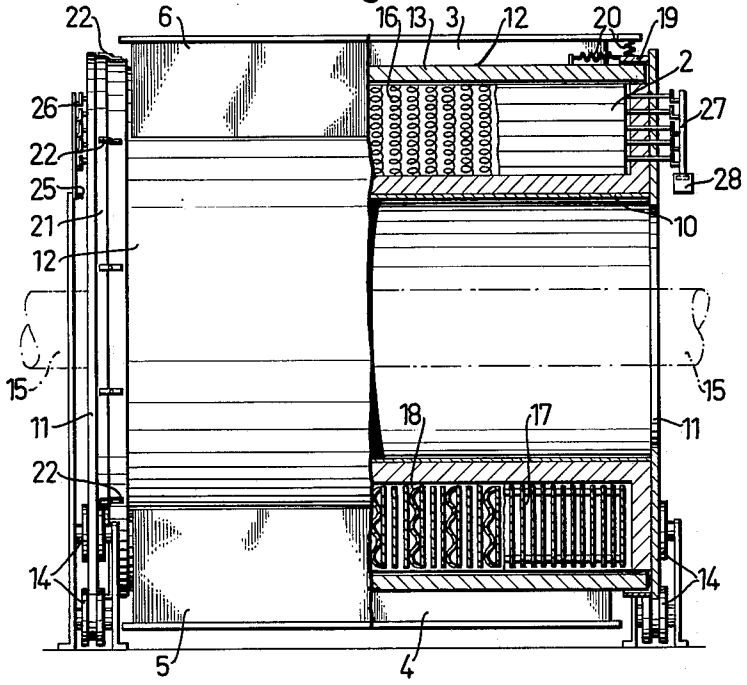


Fig. 4



COUNTER FLOW REGENERATIVE HEAT EXCHANGER

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Fig. 2

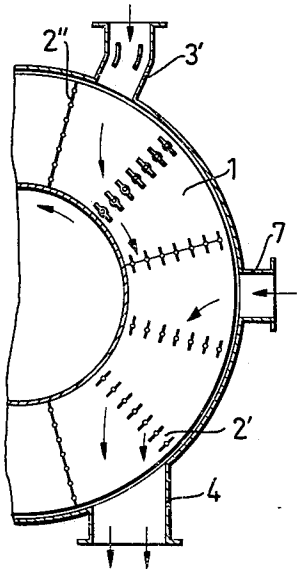


Fig. 3

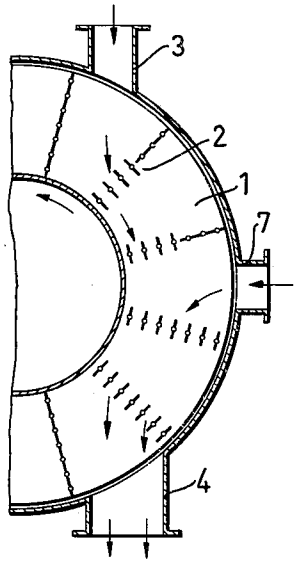
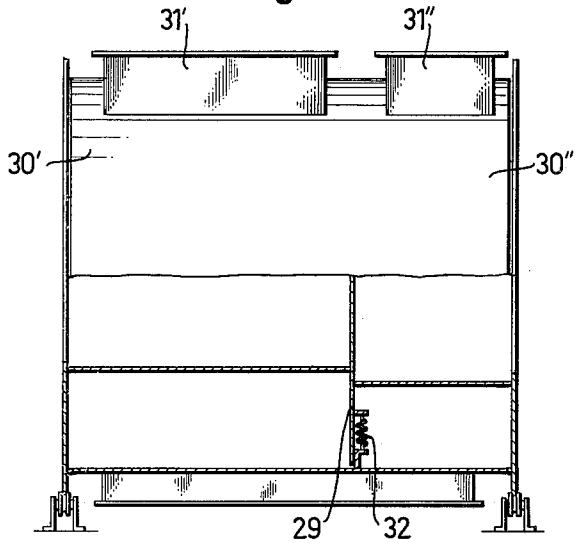


Fig. 5



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COUNTER FLOW REGENERATIVE HEAT EXCHANGER

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4 Claims. (Cl. 165—7)

This invention relates to a regenerative heat exchanger with heat-retaining and heat-rejecting mass hereinafter sometimes referred to regenerative heat exchanging material movable in counter-current relation to the heat exchanging media. This working principle is per se already known. So for instance is already a regenerative heat exchanger disclosed comprising a rotor supported in a stationary housing and revolving therein, which rotor is provided with a heat-retaining mass traversed alternately by the heat imparting and heat absorbing media, respectively. According to this embodiment the heat-retaining mass is annularly mounted along the periphery of the rotor and divided up into individual sectors by valve means which may consist of damper elements governable in response to the rotation of the rotor so that to effect heat exchange the sectors are traversed by the heat imparting and heat absorbing medium, respectively, in counter direction to the revolving of the rotor in order to carry the mentioned counter-current principle into effect.

The regenerative heat exchanger according to the present invention represents a further development of the embodiment indicated above. The present heat exchanger has also a rotor supported in a stationary casing and divided up into individual annular sectors by means of valve means governable in response to the position of rotation of the rotor, which sectors counter to the direction of their movement successively are traversed by the heat imparting and by the heat absorbing medium. According to the invention between the inlet and the outlet of the heat imparting and/or heat absorbing medium at least a further connection is provided to the channel in question serving as admission or exhaust means at this point of a partial stream.

In such a rotary regenerative heat exchanger in which the heat-retaining mass is traversed by the heat exchanging media in counter-current flow with respect to each other it is already known to arrange the heat-retaining mass in a plurality of stages and to admit a branch stream of the heat imparting medium into the partition zone. On the other hand it is also known to branch off a partial stream of the heat absorbing medium into a different zone which partial stream on account this premature exhaust is only moderately heated. The present invention deals with the application of these principles known per se in certain embodiments of regenerative heat exchangers to exchangers of the type indicated above and to constructional means for carrying the invention into effect.

The regenerative heat exchanger according to the invention also permits supplying a partial stream of the heat imparting medium into the partition zone. This may be the case when such a partial stream with its original high temperature is branched off and is to be utilized on heating surfaces, for instance heating surfaces of a feed water heater, whereafter this somewhat cooled down flue gas stream is mixed with the remaining portion of the original stream at a point at which its temperature also is somewhat decreased in the first stage of the preheater and may show a temperature just about equal to that of the admitted partial stream. In other cases a partial flue gas stream may be exhausted from the partition zone and by way of example be utilized to dry

damp fuels for which purpose the flue gases with their original high temperature are unsuitable due to the danger of ignition.

The similar possibilities may also be of interest on the side of the heat absorbing medium, that is to say in the case of an air preheater on the air side. For coal firing, air of medium temperature is required which easily can be exhausted from the partition zone. Without this possibility the required air of medium temperature had to be produced in some other way, since when escaping the air preheater on the hot side the air would have too high a temperature and would not be utilizable immediately. In such cases in which the air preheater does not allow a withdrawal of air in an intermediate zone the measure will be that from the hot air leaving the hot side a partial stream is branched off and to this via a fresh air bypass cool air is mixed thereto so that in this way the required amount of air of the desired medium temperature is produced.

In other cases preheated air arises from working processes. Such air can be admitted into the intermediate zone so that the air in the hot stage is further heated together with the air of lower temperature so that in this way the present heat is rendered useful for the combustion air.

The solution described can also be realised in such manner that the rotor is divided in a plane perpendicularly to the axis of the rotor into two axially adjacent sections which are separated by sealing means so that the heat exchanger can operate with different pressures. In rotary regenerative heat exchangers with media flowing in cross-current to the heat-retaining filling it is already known to divide the air side and in this way to operate with two air streams of different pressures connected in parallel. The same is possible in the present case by dividing up the rotor in the manner set forth. Also the possibility exists to operate with two partial streams as regards the side of the heat imparting medium, the pressures of which are different in relation to each other.

The heat-retaining mass may consist of any desired arrangement of a material which is suitable for this purpose. One arrangement which has proved to be especially effective consists of a series of coil springs which because of their large surface area and the small wire thickness produce a relatively high heat transmission factor and will thus transmit relatively large amounts of heat. The heat-retaining masses may, however, also consist of sets of flat sheet-metal plates with intermediate spacing members or wartlike projections, or of sets of corrugated sheet-metal plates.

The two ends of the rotor are preferably provided with annular disks which are sealed relative to the stationary housing. The sealing means for sealing the inside of the rotor from the outer air preferably consist of slip rings which are preferably composed of individual segments, or of asbestos packing rings, asbestos cords, or the like which are acted upon by compression springs and form a tight seal along the outer wall of the stationary housing as well as along the inner surfaces of the revolving disks. By such sealing means it is possible to prevent practically any leakage losses.

The means for driving the rotor at a speed which, depending upon the particular size and construction of the regenerative heat exchanger, only has to amount to 5 to 15 revolutions per hour, preferably consist of friction rollers which not only rotate the rotor on the annular disks thereof but also support the same. If the heat exchanger only has to be of a smaller and therefore lighter size, it is, of course, also possible to support and drive the rotor by means of a central shaft.

In order to illustrate the principle of the invention certain embodiments are shown as examples in the drawings, in which:

FIG. 1 shows a cross-section through the heat exchanger provided with each an intermediate connection for each channel.

FIGS. 2 and 3 each show a varied form of the heat exchanger in a similar partial section.

FIG. 4 shows a side view of a regenerative heat exchanger as in FIGS. 1, 2 or 3, partly in longitudinal section.

FIG. 5 shows a side view of a heat exchanger for gaseous flows of different pressures.

In the embodiment according to FIG. 1 the heat-retaining mass, which in a manner known per se is disposed in an annular arrangement along the periphery of the rotor, is divided by valve means, for example individual groups of hinged vane-type shutters **2**, into individual annular sectors **1**, each of said group of shutters being operated in response to its momentary position during the rotation of the rotor, so that either the shutters are open as the valves **2'**, or closed as the valves **2''**. The counter clockwise direction of rotation of the rotor is indicated by an arrow in the hub space.

As regards the heat exchanging media it is assumed in the following that the heat imparting medium, for instance hot flue gases, enters to the right at the top through an inlet socket **3** and is discharged to the right at the bottom through an outlet socket **4**, while the passage of the heat absorbing medium, for instance combustion air, takes place through an inlet socket **5** and an outlet socket **6**. On the flue gas side of the heat exchanger an intermediate connection **7** is provided through which a partial flow of flue gas is admitted upstream of the outlet connection **4** and already partially utilized for heating purposes may be conveyed therein as the admission arrow indicates. This illustrates the most important use of the intermediate connection. However, by means of this intermediate connection a partial stream of somewhat cooled down flue gas alternatively may be drawn off. The intermediate connection **8** on the air side in the first hand serves to draw off moderately preheated air so that likewise this operating condition is illustrated by an arrow. However, instead of that preheated air may be admitted through this intermediate connection, so that said air together with the air admitted through the connection **5** will be further preheated.

As the inserted arrows of flows of both the media shows, the flows of both the media are in counter-current direction to the movement of the heat-retaining mass.

The adjusted position of the vane-type shutters **2** is dependent on their actual local position, viz. on the momentary position of the rotor during its rotation. As is evident from FIG. 1 the illustrated positions of the vane-type shutters clearly show that in this case both the media have free passage through their corresponding channels but are sealed against each other by means of the set of shutters ''. If the rotor is revolved so far that after the open sets of shutters **2'** have passed ports **3** and **5** the said sets of shutters will be closed. In the same way the sets of closed shutters **2''** will be opened after passing the outlets **4** and **6**. Upon further revolving of the rotor by the angle of a sector, for example, in the case illustrated about 30°, the process will be repeated. The adjustment of the shutter elements may be performed automatically by cam devices or the like, in a manner known per se.

If a partial flue gas stream is admitted through the intermediate connection **7** on the flue gas side the admission to the heat-retaining mass should be equalized as far as possible. According to this requirement it is desirable to convey the gas stream admitted through the inlet **3** of the flue gas stream as close to the space adjacent the hub section as possible even if without extraordinary measures a portion of the flue gas stream would arrive thereto. A

deflection as intended to the center is achieved in the embodiment shown in FIG. 2 providing the inlet socket **3'** with an approximately radial inlet opening and is so formed that the flue gas stream entering the same on the whole is deflected in the direction to the part of the heat-retaining mass adjacent to the rotor hub as illustrated by the inflow arrow. Upon the passage of the corresponding sector **1** of the heat-retaining mass past the intermediate connection **7** the admission of the partial flow is simplified, since the same is at first hand easily accessible to the marginal zone of the rotor.

The same purpose is fulfilled in the embodiment according to FIG. 3 by means of special guiding by the shutter elements, in which additionally of course a corresponding form of the inlet socket **3'** according to FIG. 2 may assist. In the heat exchanger according to FIG. 3 the action on the through-flow solely is effectuated by the governed shutters **2**. The outer shutters of a sector partition wall will be closed immediately after passing the intermediate port **7** so that the flue gas flow admitted through inlet port **3** is forced to flow mainly in the inner zone adjacent the hub. The outer shutters **2** remain closed until just prior to outlet **6** (FIG. 1) so that the partial flue gas stream admitted through intermediate inlet **7** then may enter into the marginal zone, previously empty. Even if the flue gases admitted through the main inlet **3** may to a certain extent be distributed over the total heat-retaining mass of a rotor sector before its arrival at the intermediate inlet **7**—as also in the embodiment according to FIG. 2—in both cases a certain guiding action is obtained which brings about an admission to the heat-retaining mass which to some extent is uniform.

In FIG. 4 the regenerative heat exchanger according to the invention comprises a rotor **10** in the form of a hollow cylinder which carries on each end an annular disk **11** and is surrounded by a stationary cylindrical housing **12**. Rotor **10** including disks **11**, as well as housing **12** are protected from the heat of the heat exchanging means by insulating layers **13** so that any changes in size or stresses in the material due to the temperature influences will be avoided.

By means of its disks **11**, rotor **10** rests on friction rollers **14** which are driven from the outside by suitable means, not shown. Instead of driving rotor **10** by means of the rollers **14**, it is, however, also possible to do so by providing a central drive shaft **15**, as indicated diagrammatically by dot-and-dash-lines, which is then supported by suitable bearings.

The heat-retaining masses may consist, for example, of coil springs **16** which insure an excellent heat transmission, or of sets of flat sheet-metal plates **17** which are separated by spacing members, or of sets of corrugated plates **18** which are disposed at right angles to each other.

In order to prevent the media which flow into the heat exchanger under pressure from escaping, it is necessary to seal the annular slot between the stationary housing **12** and the disks **11** of rotor **10**. This may be attained by different means, two of which are indicated in FIG. 4. Thus, for example, a slip ring **19** which may be composed of several segments may be placed around the outer peripheral wall of housing **12**, as shown adjacent to the right end thereof, and this slip ring may be acted upon by compression springs **20** in such a manner that its outer edge will slidably engage with the inner surface of disk **11** and thus form a tight seal. Since this slip ring **19** is mounted on the outside of housing **12**, it is likewise protected by the insulating layer **13** from the heat of the gases and may be easily lubricated with oil, grease, or the like. The sealing means may, however, also consist of an asbestos cord **21** which forms a continuous ring and is placed around the outer wall of housing **12**. This asbestos ring **21** may be pressed by springs **22** against the respective disk **11**, as indicated at the left side of FIG. 4, and will thus seal the gap between rotor **10** and the stationary housing **12**.

The operation of shutters 2 is preferably controlled by the rotary movement of rotor 10, for example, by mechanical means in the form of stationary cams 25, rods, tappets, or the like, each of which is operatively associated with a rod 26 which is connected to one set of shutters 2 so as to open or close the latter. The operation of the different sets of shutters 2 may also be effected automatically by counterweights which open or close the shutters in accordance with their particular position during the rotation of rotor 10. Shutters 2 may, however, also be controlled by pneumatic, hydraulic, or electric means, as indicated diagrammatically in FIG. 4 by a control rod 27 which is hydraulically controlled by a piston 28.

In order to close the individual shutters 2 of each set as securely as possible, each of them is preferably provided with a separate spring, not shown, which is connected to the common connecting rod 26. In this event, if a foreign body should enter with the heat-supplying current and should settle on one of the shutters of one set and thereby prevent the same from closing tightly, the resilient pressure of the other shutters of this set when closed by the common connecting rod 26 will prevent them from being also affected by the same foreign body and will insure that they at least will close tightly.

It should be understood that the sealing means and shutter operating means heretofore described are of standard known construction as disclosed in British Patent 921,168 to Gunter Scholl.

The embodiment according to FIG. 5 is a side elevation of which the lower part is shown in section, viz. so that the view may represent one of the heat exchangers described above seen from the left or the air side. This embodiment illustrates the operation with different pressures. Such condition is in the first hand of practical importance as regards the air side. The rotor is axially divided by means of an intermediate wall 29 into partial drums 30′ and 30″ corresponding to the different pressures of the air flows. The partial rotor 30′ may be provided for the air of lower pressure and larger volume. The sockets which also correspond to this ratio may be arranged adjacent each other. Of these only the outlet sockets 31′ and 31″ are visible.

The intermediate walls 29 serve to prevent the mixing together of both these flows. For this purpose the wall is provided along its entire circumference with sealing means 32 engaging the jacket of the housing. Since heat exchangers of this type rotate only with a very small number of revolutions the sealing means may comprise slip members such as disclosed in the referred to British Patent 921,168. It may also be noted that the individual rotor drums each according to the particular requirements may be filled with heat surface in different ways.

The inlet and outlet sockets for the flue gas can extend undivided over the whole length of the rotor. In FIG. 5 the outlet socket 4 for the flue gas is visible. Generally it is sufficient to supply both the rotor portions in simple manner proportionally with flue gases without any particular governing. On the other hand if a governing is necessary so are also the flue gas sockets to be divided according to the dividing up of the rotor and to be provided with regulating shutters or the like.

In the foregoing solely the simplest case has been dealt with for illustration of the inventive idea, which according to FIGS. 1–3 solely is provided with a single intermediate connection. Self-evidently it is also possible to provide several intermediate connections, that is to say to undertake a division in more than two stages as such already known in air preheaters of the Ljungström type. As regards the operation on gaseous streams of different pressures the same applies, that is to say on the side of heat imparting as well as on the side of the heat absorbing medium a division in more than two partial flows is possible when a such on account of particular working conditions should be necessary. It may also be mentioned that such an operation with several streams of different pressures also is possible without multistage division according to FIGS. 1–3.

What is claimed is:

1. A regenerative heat exchanger comprising a stationary housing, first port means peripherally spaced in said housing comprising at least two inlet ports for the separate passage of heat imparting medium and heat absorbing medium and at least two outlet ports for the separate escape thereof, a rotor rotatably supported in said housing and communicating with said port means to allow passage of said media through the rotor comprising a mass of regenerative heat exchanging material and a plurality of sets of radially extending valve means dividing said material into a plurality of sectors, means for turning said rotor in a direction counter to that of the flow of said media between the respective inlet and outlet ports, means for operating said valve means to confine each of said media to a separate path of flow through said rotor, and second port means peripherally spaced in said housing and comprising at least two ports each disposed intermediate an inlet port and its corresponding outlet port and communicating with the path of flow of one of said media, one of the ports of said second port means being provided for the extraction of a portion of one of said media from its flow path for an additional use, and another of the ports of second port means being provided for the introduction into the flow path of a portion of the other of said media extracted from its flow path upstream of the point of introduction, the extracted portion being introduced at a point between the corresponding inlet and outlet ports at which both the respective medium passing therethrough and the introduced portion of medium are at substantially the same temperatures.

2. A regenerative heat exchanger comprising a stationary housing, first port means peripherally spaced in said housing comprising at least two inlet ports for the separate passage of heat imparting medium and heat absorbing medium and at least two outlet ports for the separate escape thereof, a rotor rotatably supported in said housing and communicating with said port means to allow passage of said media through the rotor perpendicular to the axis of rotation of said rotor, said rotor comprising a mass of regenerative heat exchanging material and a plurality of sets of radially extending valve means dividing said material into a plurality of sectors, means for turning said rotor in a direction counter to that of the flow of said media between the respective inlet and outlet ports, means for operating said valve means to confine each of said media to a separate path of flow through said rotor, second port means peripherally spaced in said housing comprising third and fourth ports, said third port being intermediate one of said inlet ports and its corresponding outlet port in communication with said heat absorbing medium and being provided for the extraction of a portion of said heat absorbing medium from its flow path, the extracted portion being used for performing additional heating and drying functions, said fourth port being intermediate another of said inlet ports and its corresponding outlet port in communication with said heat imparting medium, said fourth port being provided for the introduction therethrough of a portion of said heat imparting medium bypassed upstream of the inlet port with which said heat imparting medium is in communication, the bypassed portion being provided for additional heating and drying purposes, the physical conditions of said extracted heat absorbing medium being dependent upon the position of said third port relative to the inlet and outlet ports with which said heat absorbing medium is in communication, and said fourth port being so located that the portion re-introduced therethrough is at substantially the same temperature as the heat imparting medium flowing between the inlet port and its corresponding outlet port.

3. An exchanger according to claim 1 wherein said sets of valve means are each divided into radially inner and radially outer valve groups, and whereby said means for operating said valve means is further adapted for the separate actuation of said inner and outer valve groups, the inner and outer valve groups confining the flow of said media to a limited flow path, the outer valve group being closed between the port of said second port means into which said bypassed portion is introduced and its corresponding inlet port, the flow of the medium therebetween being substantially confined through the open inner valve groups, whereby the bypassed portion introduced through said second port means is easily received into the flow path.

4. An exchanger according to claim 1 further including means for dividing said rotor in a plane transverse the axis of said rotor, the dividing means separating the rotor into at least two axially adjacent sections, said first and second port means being in communication with one of said axially adjacent sections, sealing means communicating with said dividing means for separating said axially adjacent sections and preventing the flow of media therebetween, further ports peripherally spaced in said housing and in individual communication with those axially adjacent sections not in communication with said first port means, said further ports being substantially identical in function to said first port means, whereby at least one of said media may be simultaneously passed into said rotor through separate axially adjacent sections at different pressures.

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