

June 18, 1946.

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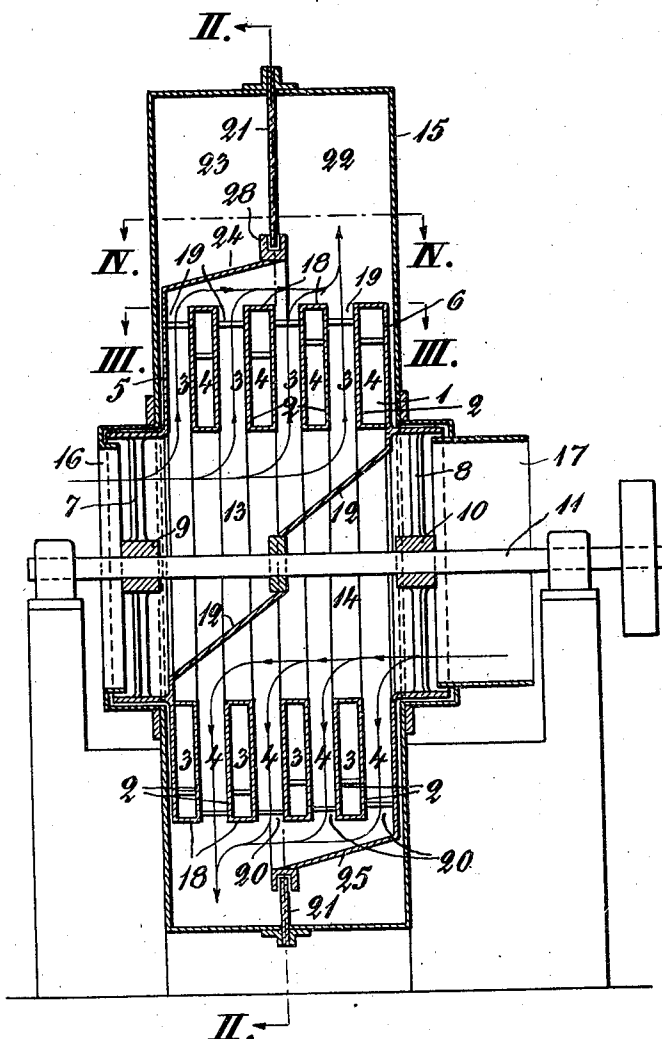
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RECUPERATIVE HEAT EXCHANGER FOR GASEOUS MEDIA

Filed March 27, 1943

5 Sheets-Sheet 1

Fig. 1.



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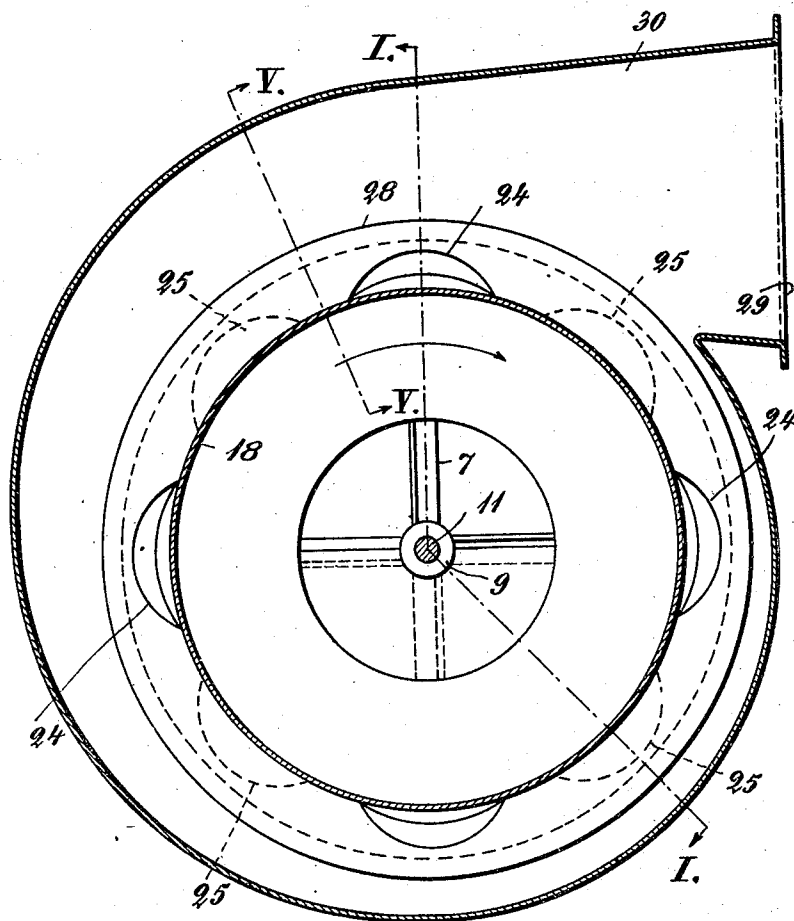
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Fig. 2.



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RECUPERATIVE HEAT EXCHANGER FOR GASEOUS MEDIA

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Fig. 3.

Fig. 4.

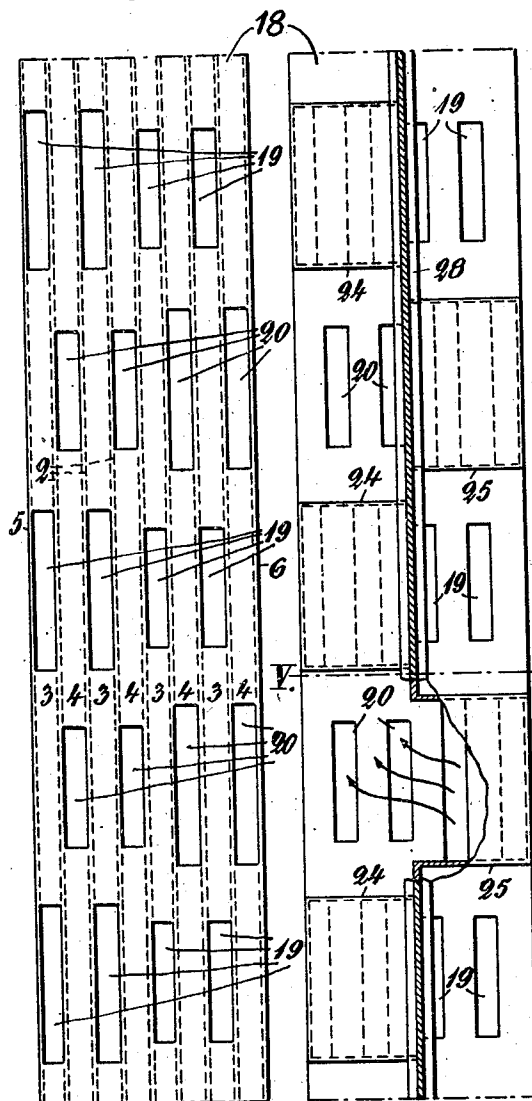
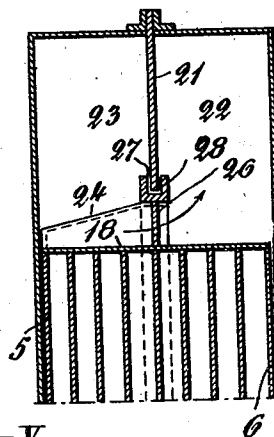


Fig. 5.



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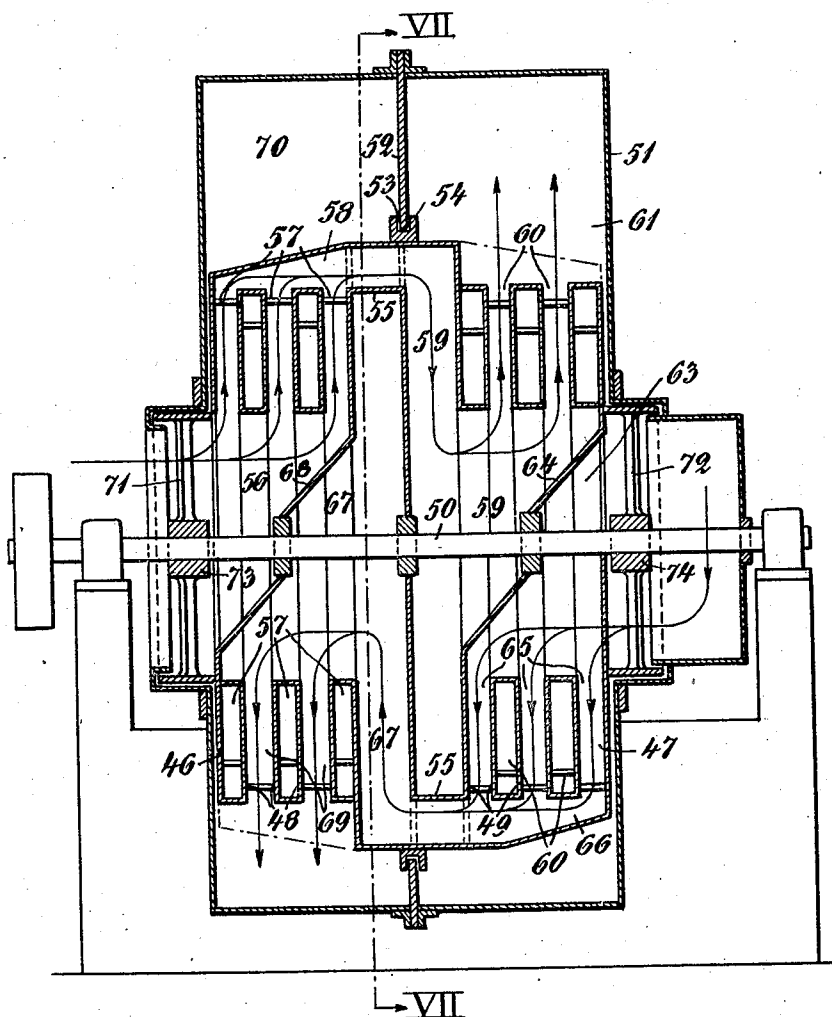
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RECUPERATIVE HEAT EXCHANGER FOR GASEOUS MEDIA

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Fig. 6.



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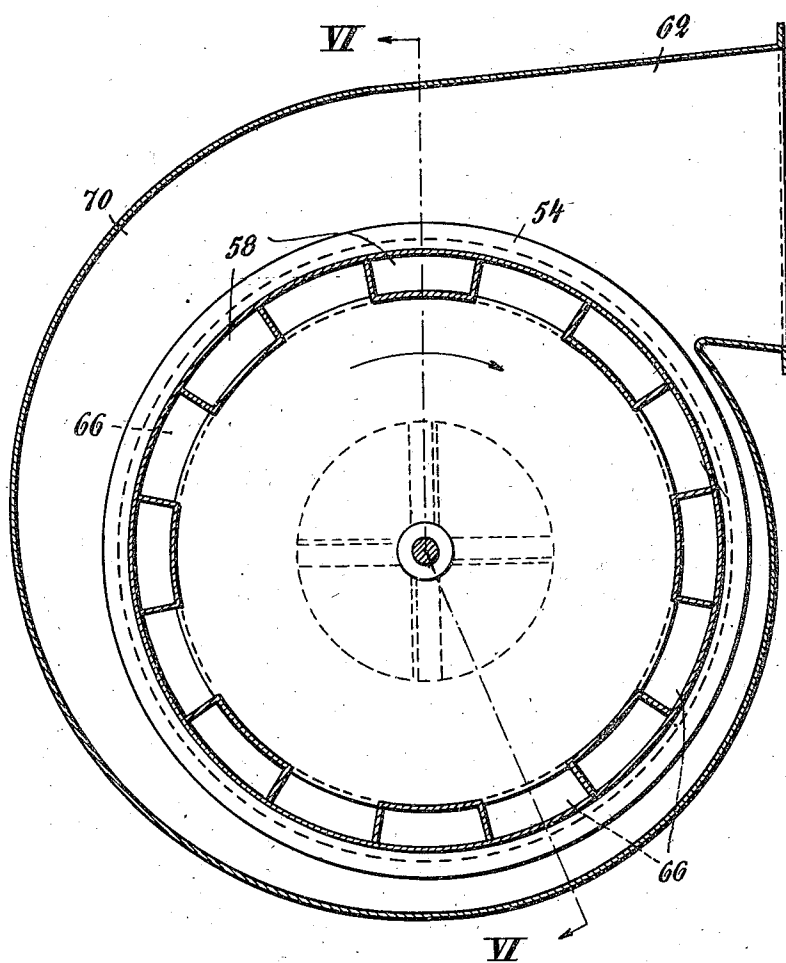
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RECUPERATIVE HEAT EXCHANGER FOR GASEOUS MEDIA

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Fig. 7.



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UNITED STATES PATENT OFFICE

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RECUPERATIVE HEAT EXCHANGER FOR
GASEOUS MEDIA

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4 Claims. (Cl. 257-244)

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The present invention relates to improvements in such known recuperative heat exchangers for gaseous media which comprise a housing, a rotor therein fixed on an axis of rotation and forming a set (one or more) of passages of flow for each medium, which sets of passages are adapted for heat exchange between the media through the walls of the passages, each set of passages being connected to a separate interior axial inlet chamber and to a separate outer outlet chamber.

The two axial inlet chambers may for example in a known way be separated by a partition wall participating in the rotation of the rotor, and the two outlet chambers may for example be separated by a stationary radial partition wall constituting a part of or being connected with the housing.

It is known per se in such known heat exchangers to provide the rotor with fan vanes and to form the outlet chambers as spiral-shaped diffuser channels curved about the rotor to obtain a rotary heat exchanger which acts at the same time as a fan for propelling the heat exchanging media.

The present invention has for its object to greatly improve the efficiency of the heat exchange between the media and at the same time to considerably reduce the necessary dimensions of a recuperative heat exchanger of the above mentioned kind.

The invention is based on the knowledge that heat exchange is improved with increasing relative velocity between the heat exchanger and the gaseous media and with decreasing thickness of the layers of the gaseous media. The velocity of the gaseous media through the passages formed in a rotor of the above mentioned kind is composed partly of a radial velocity, partly of a peripheral velocity. Of these two components the radial velocity determines the length of time for the media to pass through the rotor, that is the time during which the heat exchange between the media takes place. Thus an increase of the radial velocity shortens the period of heat exchange which is unfavourable. According to the invention, the relative velocity between the heat exchanger and the gaseous media is instead increased by increasing the peripheral velocity between the same as much as possible. This has not been observed in the hitherto known heat exchangers of the aforementioned kind, in which the gaseous media have been forced to participate in the rotary motion of the passages or forced to rotate by means of vanes or the like secured to the rotor so that the relative velocity

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between the rotor and the gaseous media was reduced to nothing or to a low value.

According to the invention the heat exchange is considerably improved in comparison with the known devices in that the rotor consists of several smooth, preferably plane, metal discs acting as heat exchangers and arranged perpendicular to the axis of rotation and forming several annular slot-shaped passages of flow alternately for one and the other medium respectively which passages are unobstructed to the flow of the gaseous media so that the conveying action of the rotating smooth discs upon the gaseous media in the peripheral direction is effected by the friction between the discs and the media in order to obtain at a high velocity of rotation of the discs a high relative velocity in the peripheral direction between the discs and the gaseous media during the radial outward motion of the latter.

The spaces between the discs forming the passages of flow for the gaseous media are quite free from projecting parts which might act to propel the media, and the feature of the discs being substantially smooth is, of course, to be understood in this sense. The only force acting upon the media in a peripheral direction is the friction between the rotating discs and the gaseous media, and therefore the peripheral relative velocity must reach the highest possible value. At the same time it is possible by reducing the distance between adjacent discs to divide the gaseous media in thin layers which also is very favourable for a good heat exchange.

As it is possible to rotate a heat exchanger according to the invention at a high rotary velocity, the dimensions of the same will be correspondingly reduced in comparison with hitherto known heat exchangers of the afore-mentioned kind.

A number of embodiments of the recuperative heat exchanger according to the invention are illustrated in the accompanying drawings, in which

Fig. 1 is a sectional elevation of an embodiment with a rotor consisting of a plurality of plane discs taken along the line I—I in Fig. 2.

Fig. 2 is a cross-sectional elevation along the line II—II in Fig. 1.

Fig. 3 is a fragmentary development in the plane of the cylindrical circumference of the rotor seen from the line III—III in Fig. 1.

Fig. 4 is a fragmentary development in the plane of the rotor seen from the line IV—IV in Fig. 1.

Fig. 5 is a section along the line V—V in Figs. 2 and 4.

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Fig. 6 is a sectional elevation along the line VI—VI in Fig. 7 of an embodiment consisting of two rotors secured to a common drive shaft, each rotor having a plurality of plane discs.

Fig. 7 is a cross-section along the line VII—VII in Fig. 6.

In the embodiment according to Figs. 1-5, 1 designates the rotor of the recuperative heat exchanger. The rotor 1 is composed of a plurality of smooth, preferably plane, annular metal discs 2 which are perpendicular to the drive shaft 11 of the rotor. Between the plane discs 2 a corresponding number of annular slot-shaped flow passages 3 and 4 are formed which passages are unobstructed to the flow of gases. The end discs 5 and 6 of the rotor are secured to the drive-shaft 11 by means of spokes 7, 8 and hubs 9, 10. The space in the rotor internally of the discs 2 is divided into two axial inlet chambers 13 and 14 separated from each other by means of a diagonal partition wall 12, which is connected to and participates in the rotation of the rotor. The rotor is enclosed by a stationary housing 15 which is provided with an axial intake 16 for one of the gaseous media (in this example air) and an axial intake 17 connected to a supply conduit not shown for the second gaseous medium (for example hot flue gases). The inlet chamber 13 communicates with the air intake 16, and the inlet chamber 14 with the flue gas intake 17.

The flow passages 3, 4 alternately communicate with one of the inlet chambers 13, 14 and are shut off from the other one. Thus all the passages 3 communicate with the inlet chamber 13, while all the passages 4 communicate with the inlet chamber 14 as shown in Fig. 1.

The outlet ends of the passages 3 and 4 are covered by a cylindrical wall 18 which is shown developed in a plane in Fig. 3. In the cylindrical wall 18 there are provided for each passage 3 and 4 respectively a number of outlet openings 19 and 20 respectively, which are elongated in the peripheral direction and are distributed about the circumference of the rotor, the openings 19 communicating with the air passages 3, and the openings 20 with the flue gas passages 4. The openings 19 and 20 are arranged in axial rows distributed about the circumference of the rotor, the rows of openings 20 being peripherally offset in relation to the rows of openings 19 as shown in Fig. 3.

The housing 15 is divided by a radial stationary partition wall 21 into two separate outer outlet chambers 22 and 23 about the rotor, of which the chamber 22 communicates with the outlet openings 19, but is shut off from the outlet openings 20, whereas the chamber 23 communicates with the outlet openings 20 but is shut off from the outlet openings 19. This connection of the outlet openings with the respective chambers 22 and 23 is effected by hollow screening members 24 and 25 respectively, arranged just outside those outlet openings 19 and 20. Thus the wall 21 and the members 24 together screen off the openings 19 from the outlet chamber 23, while the wall 21 and members 25 screen off the openings 20 from the outlet chamber 22. In the shown example the members 24 and 25 are hood-like and project from the cylindrical wall 18.

26 (Fig. 5) designates a radial wall welded to the cylindrical wall 18 in the same plane as the wall 21. To the wall 26 a ring 28 with a circular groove 27 is welded. The inner edge of the wall 21 enters the groove 27 and forms a substantially fluid tight joint separating the chambers 22 and

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23. The hoods 24, 25 extend from the wall 5 or 6 respectively to the wall 26, in which an opening is provided equal to the cross-section of the channel in the hood. Thus the hoods 24 and 25 extend towards the wall 26 alternately in opposite directions from opposite end walls of the rotor and screen off the openings 19, 20 from each other as described above.

The outlet chambers 22 and 23 are shaped to form spiral-shaped channels, the cross-sectional area of which increases continually towards a diffuser channel 30 provided with an outlet opening 29.

The plane discs 2 when rotated at high velocity exert a certain fan action upon the gaseous media, but as they act upon the media only by means of friction, the fan action of the discs alone upon the media may not be sufficient to propel the media through the apparatus. However, the projecting hoods 24 and 25 will also act as fan vanes, and if this fan action should not be enough, special fan vanes may be provided on the rotor.

Furthermore, the surfaces of the spokes 7, 8 may be pitched or feathered so as to assist by a propeller-like action in the transport of the media through the apparatus. The major part of the kinetic energy of the gaseous media leaving the rotating rotor is transformed into pressure energy in the spiral-shaped outlet chambers and the diffuser 30 so that the fan energy of the apparatus may be utilised for further transport of the media.

In the embodiment according to Figs. 6 and 7 two rotors 46 and 47, each consisting—in accordance with Figs. 1-5—of a plurality of plane discs 48 and 49 respectively, are secured to a common drive-shaft 50 and arranged inside a common stationary housing 51, which is divided into two halves by a radial partition wall 52 arranged in a groove 53 in a ring 54 welded to the cylindrical wall 55 of the combined rotor 46, 47.

In this embodiment the air is heated in two steps, and the hot flue gases are cooled in two steps. In the first step air enters the axial inlet chamber 56 of the rotor 46, and is led through the annular slot-shaped air passages 57 of this rotor and the channels 58 communicating with said passages to an axial chamber 59 in the second rotor 47, from where the preliminarily heated air is led through the annular slot-shaped air passages 60 in the rotor 47 into the spiral-shaped outlet channel 61 which leads to a diffuser 62.

The incoming hot flue gas enters first the axial inlet chamber 63 in said second rotor 47, in which the chamber 63 is separated from the chamber 59 by the diagonal partition wall 64 which participates in the rotation of the rotor. From the inlet chamber 63 the hot gases pass through the passages 65 in the rotor and the channels 66 communicating with the passages 65 to an axial chamber 67 in the rotor 46, which chamber is separated from the chamber 56 by the diagonal partitioning wall 68 rotating with the rotor 46.

From the chamber 67 the gases pass through the passages 69 in the rotor 46 into the surrounding spiral-shaped outlet-channel 70 which also leads to a diffuser 62.

Thus the air will be heated in two steps according to the counter-current principle being in the first step (rotor 46) preliminarily heated by the flue gases that have passed through and been cooled in the rotor 47, in which the preheated air is finally heated in the second step by the hottest flue gas. In this manner the cold medium

(air) may be heated to a final temperature that is higher than the final temperature of the hot medium (flue gases) when leaving the heat exchanger.

The combined rotor 46, 47 is as a unit secured to the drive shaft 50 by the spokes 71, 72 and the hubs 73, 74. The surfaces of the spokes 71, 72 may also in this embodiment be formed with a pitch to assist in the propulsion of the gaseous media in a propeller-like fashion.

I claim:

1. A recuperative heat exchanger for two gaseous media having different temperatures comprising a housing, a rotor rotatable in said housing and including a plurality of annular, radially arranged metal discs forming a plurality of annular, slot-shaped passages of flow for the gaseous media between the discs, a shaft rotatable in said housing and connected with the outer discs of the rotor, a wall arranged internally of the rotor and forming inlet chambers for the gaseous media, a separate outlet chamber for each gaseous medium leaving the rotor, the alternate passages between the discs for the flow of one gaseous medium communicating with one of the inlet chambers and with one of the outlet chambers, means closing communication between the intermediate passages for the flow of the second gaseous medium and said one inlet chamber and said one outlet chamber, said intermediate passages communicating with the other inlet and outlet chambers, and means closing communication between the alternate passages and said other inlet and outlet chambers, the passages between the discs being substantially unobstructed to the flow of gaseous media, said discs acting as heat exchanging members for adjacent passages of flow and being substantially smooth so that the gaseous media while flowing through the passages are actuated in the peripheral direction substantially only by means of the friction from the rotating discs.

2. A recuperative heat exchanger according to claim 1, and in which said passages of flow are

covered at the outer circumference of the rotor by a cylindrical wall, in which for each passage a number of outlet openings are provided, which openings are distributed along the circumference of the rotor, outlet openings belonging to the same set of passages being arranged in a corresponding number of axial rows, the rows of outlet openings belonging to different sets of passages being mutually offset peripherally, the different rows of outlet openings being screened off from each other by hollow members forming channels communicating with outlet openings of the respective row and with the respective outlet chamber.

3. A recuperative heat exchanger according to claim 1, and in which said passages of flow are covered at the outer circumference of the rotor by a cylindrical wall, in which for each passage a number of outlet openings are provided, which openings are distributed along the circumference of the rotor, outlet openings belonging to the same set of passages being arranged in a corresponding number of axial rows, the rows of outlet openings belonging to different sets of passages being mutually offset peripherally, the different rows of outlet openings being screened off from each other by hollow members forming channels communicating with outlet openings of the respective row and with the respective outlet chamber, and in which said hollow screening members are hood-like and project from said cylindrical wall being adapted to act as fan vanes at the rotation of the rotor.

4. A recuperative heat exchanger, in which two heat exchangers according to claim 1 are secured to the same drive-shaft and interconnected by channels in such a manner that the medium to be heated is preheated in one rotor in a first step by heating medium that has already been utilised in the second rotor, in which the medium to be heated is finally heated in a second step by the heating medium in its hottest state.

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