June 12, 1928. 1,673,122

C. P. MILLS

RECUPERATOR

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FIG. 1

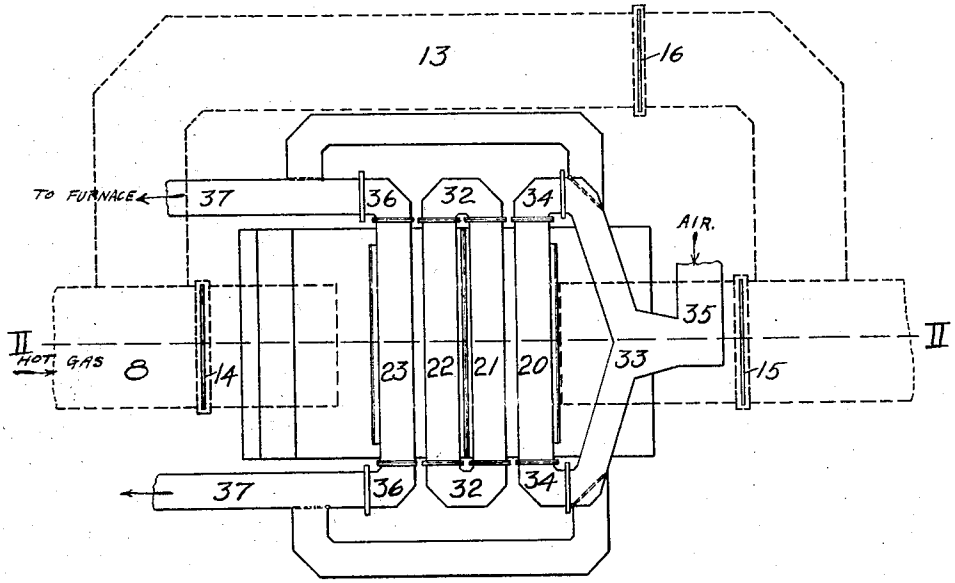
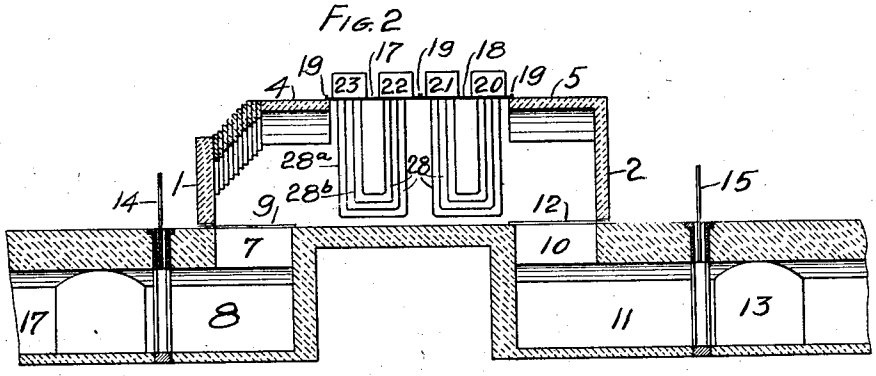


FIG. 2



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Fig. 5

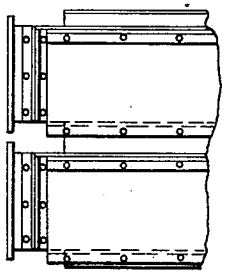


Fig. 3

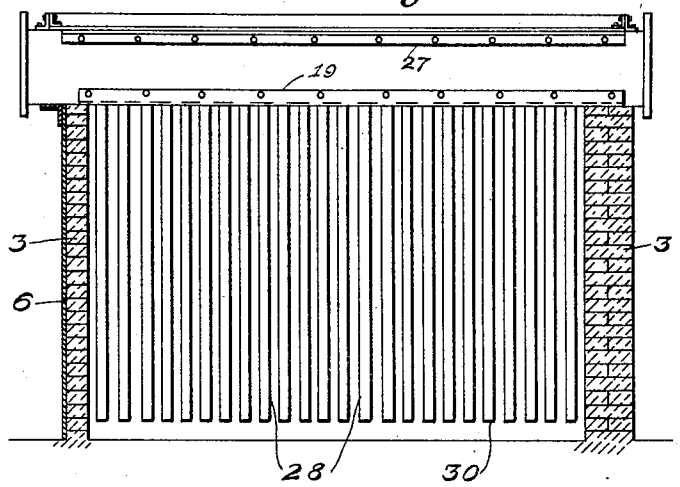


Fig. 4

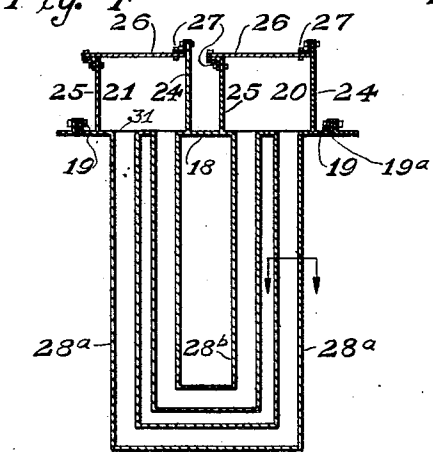
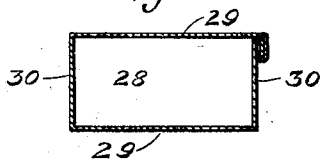


Fig. 6



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Fig. 7

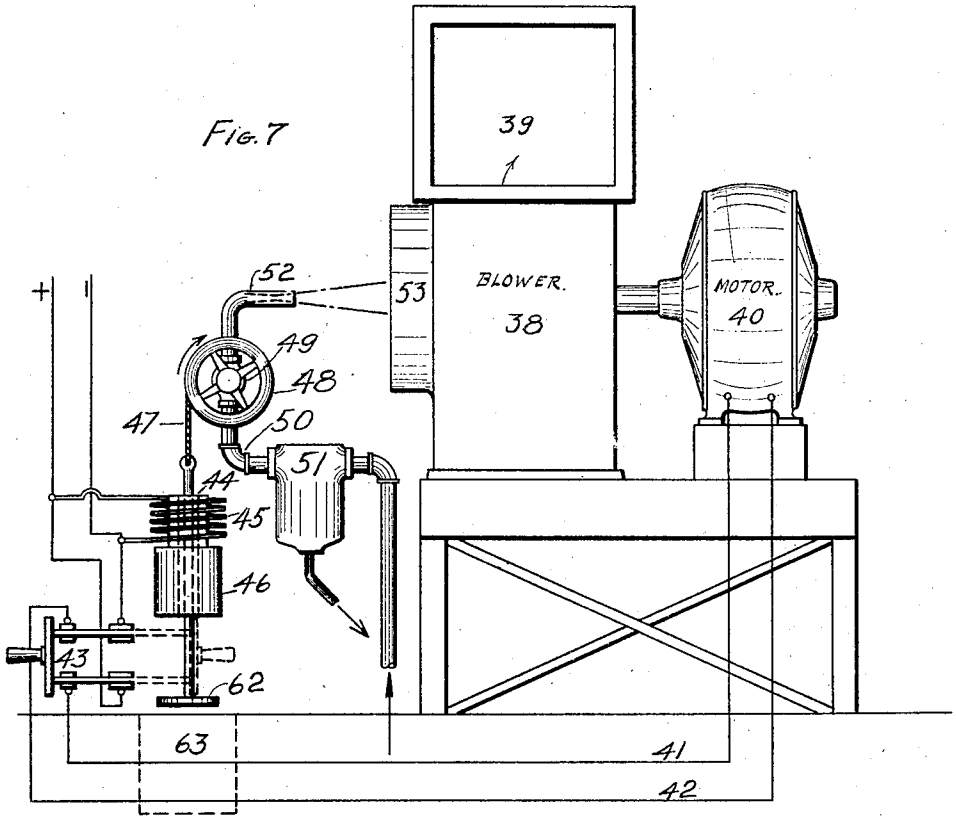
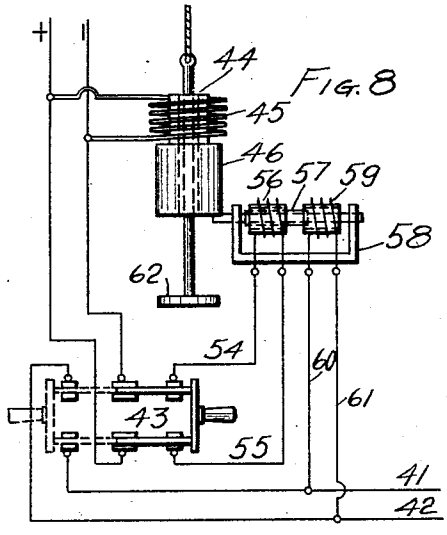


Fig. 8



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Patented June 12, 1928. 1,673,122

UNITED STATES PATENT OFFICE.

CHARLES P. MILLS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO THE DURALOY COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF DELAWARE.

RECUPERATOR.

Application filed March 30, 1925. Serial No. 19,277.

One of the objects which I have in view is the thorough mixing of the air as it passes through the recuperator tubes, and the elimination of cool spots and cool lines of flow. This object I attain by employing tubes of angular, preferably rectangular cross-sectional shape, and the manifolds with which the tubes are connected are also preferably of like cross-sectional shape.

A second object which I have in view is to improve the uniformity and distribution of the flow of air through the recuperator. I accomplish this purpose by providing a double feed and exhaust for the manifolds, such as by the introduction of the air into a manifold at both ends, and also exhausting the air from a manifold at both ends.

Another object is the provision of a wiping action of the waste gases on the recuperator tubes, and I effect this by causing gases to travel at right angles to the manifolds or substantially parallel with the long axes of the tubes.

Another object is an increase of the aggregate area of the recuperator tubes exposed to the waste gases or heat transference surface, and this I effect by employing tubes of rectangular cross-section with their long axes disposed in the direction of the gas flow. I further increase the exposed area by substituting for the relatively few flues of relatively large individual capacity, as in the present practice, a much larger number of tubes individually of much less capacity.

Another object in view is an improvement of the heat transference from the waste gases to the air in the recuperator tubes, and the avoidance of scale formation which would interfere with such transference. This object I attain by employing tubes made of relatively thin sheet chrome alloy, the thinness of the walls of the tube expediting the heat transference while chrome alloy is free from progressive oxidization or scaling.

Another object which I have in view is improved control of tube expansion and contraction, and the avoidance of leakage. This I accomplish by employing tubes of small cross-sectional area compared to their length. I prefer to make these tubes of chrome alloy, as such metal has the virtue of not burning up in case the air is shut off while the waste gases continue to travel through the recuperator.

I have discovered that a tube of angular or non-circular cross-sectional shape, preferably rectangular, evinces greater flexibility in response to variations in temperature, thereby permitting the use of a tube a mere fraction, such for instance one-fourth of the length of tubes of circular or nearly circular cross-sectional shape. This is due to the great section modulus in all directions of a circular hollow body compared to that of a non-circular hollow body.

In the operation of metallic recuperators in connection with industrial furnaces, frequent and usually very expensive repairs are rendered necessary when the travel of air through the recuperator is interrupted while the flow of waste gases therethrough continues. Thus when the air is supplied by a motor-driven blower, the power-current may fail or the blower may become inoperative due to other causes, while the furnace stack continues to draw the hot waste gases through the recuperator. Thus the cooling effect on the inner walls of the tubes ceases, while the external, heating effect is continued, frequently resulting in overheating and burning out the tubes.

To obviate this danger, I provide means whereby, when the blower ceases to force air through the recuperator tubes, a current of air or other cooling medium therethrough is established, thus preventing overheating and burning out.

Other objects and means for obtaining the same will appear from the following description.

In the accompanying drawings, wherein I illustrate a practical embodiment of the principles of my invention, Fig. 1 is a plan view of the recuperator; Fig. 2 is a longitudinal section taken along the line II—II in Fig. 1; Fig. 3 is a view of the recuperator looking from the left in Fig. 4; Fig. 4 is an enlarged detail of a portion of Fig. 2 and showing a pair of adjacent manifolds and their associated tubes; Fig. 5 is a broken plan on enlarged scale showing the ends of adjacent manifolds but with the connection-fittings omitted; Fig. 6 is a horizontal section on enlarged scale of one of the recuperator tubes; Fig. 7 is an elevation showing the

blower and the means for supplying a current of cooling medium to the recuperator tubes when the blower is inoperative, and Fig. 8 is a similar but incomplete view showing a modification.

The following is a detailed description of the drawings.

The recuperator is inclosed by means of the end walls 1 and 2, the side walls 3, and the front and rear roof arches 4 and 5. In Fig. 3 I show one of the side walls as formed of brick-work only, while the other side wall is of brick-work of less thickness with an outer wall 6 of steel plate attached to its outer face.

Beneath the front arch 4 is a port 7 which connects the interior of the recuperator with the low-level duct 8 through which the waste gases travel from the furnace. The port 7 may be provided with a horizontal, sliding damper 9. Beneath the rear arch 5 is a port 10 connecting with the stack-duct 11, and the port 10 may be provided with a sliding damper 12. 13 is a by-pass duct which connects the ducts 8 and 11 around the recuperator. 14 is a vertically sliding damper in the duct 8 between the end of the by-pass duct 13 and the port 7, and 15 is a similar damper in the duct 11 between the end of the by-pass duct 13 and the port 10. 16 is a similar damper in duct 13 to prevent the travel of waste gases therethrough when the dampers 9, 12, 14 and 15 are open.

The roof arch 4 is inclined downwardly toward its front end to prevent pocketing of the waste gases in the front of the recuperator and to induce a rearward travel of the same with a minimum of friction.

The top closure of the recuperator chamber between the roof arches 4 and 5 is formed by metal floor plates 17 and 18 which span the space between the side walls and whose lateral edges are provided with upturned flanges 19. The abutting flanges of the plates are connected together, as by bolts, as shown in Fig. 4, with an asbestos filler or gasket 19^a interposed between the flanges to allow for expansion and contraction and the outer lateral edges rest upon the front and rear roof arches. A sufficient number of said plates are employed to provide for the desired number of manifolds.

In the drawings four manifolds are shown, indicated at 20, 21, 22 and 23, but a greater or less number of manifolds may be provided, depending upon the desired capacity of the recuperator.

The preferred form of manifold is shown in the drawings. Thus, referring to Figs. 3, 4 and 5, a manifold is provided with the vertical side plates 24 and 25 which are welded or provided with some character of air-tight attachment at their lower edge to the floor plate. One wall, such as 24 is higher than the other wall, and the top plate 26 rests at one side on the lower wall 25 and abuts at its opposite edge against the wall 24. The top plate is detachably held in place by angle-bars 27 which are bolted to the side walls and the top plate, as shown. Thus the top plates may be readily removed for inspection and repairs.

The floor-plates 17 and 18 are formed of chrome alloy metal to resist the effect of the hot waste gases from the furnace. The plates 24, 25 and 26 may be of cheaper material.

The manifolds are connected together in pairs by means of depending substantially U-shaped recuperator tubes.

Said tubes, generally indicated by the numeral 28, are formed of chrome alloy steel of approximately twenty gauge material bent up and crimped or welded or both to produce a rectangular, and preferably oblong cross-sectional form, with side walls 29 of considerably greater width than the end walls 30, say twice the width of the latter, as shown in Fig. 6. The tubes are set so that their long axes are in the direction of the flow of the waste gases, as shown in Fig. 3.

The upper ends are inserted into and welded in place in ports 31 in the floor plates.

I prefer to make the tubes of small cross-sectional capacity and mount them in symmetrical groups comprised of a pair or more, 28^a and 28^b, in nested relation, as shown in Figs. 2 and 4, the latter being within the former and both being in the same vertical plane longitudinal of the recuperator. If desired, a single tube may be substituted for the nested group, but I prefer the latter arrangement since it provides an increased area of exposed wall for heat transference and provides greater flexibility under temperature variations.

It is thus seen that the air passes from one manifold, of a pair of associated manifolds, through the connecting tubes to the other manifold of the pair. From the last named manifold the air passes at both ends to the ends of the next succeeding manifold, and thence from the last named manifold through the connecting tubes to its associated manifold. Thus, the pairs of manifolds are connected together by their recuperator tubes, and are connected at their ends to the adjacent manifolds.

As shown in Fig. 1 the manifold 20 is connected to the manifold 21 by the recuperator tubes; the ends of the manifold 21 are connected to the ends of the manifold 22 by the return bends 32, and the manifold 22 is connected to the manifold 23 by the recuperator tubes. The ends of one end manifold, 20, in the recuperator are connected by the Y connection 33 and the elbows 34

with the pipe 35, which leads from the blower. The ends of the other end manifold, 23, are connected by elbows 36 to the pipes 37 which supply the heated air to the furnace.

When the damper 16 is closed and the dampers 9, 12, 14 and 15 are open, the waste gases from the furnace are drawn by the stack-draft through the duct 8 and port 7 into the interior of the recuperator and between the rows of the recuperator tubes 28 and thence out through the port 10 and duct 11 to the stack.

When the dampers 9, 12, 14 and 15 are closed and the damper 16 opened, the waste gases are by-passed around the recuperator through the duct 13.

When the furnace gases are travelling through the recuperator they are in close and intimate contact with the wider, side walls of the tubes 28, thus having contact with a maximum area of the tube-wall and having an advantageous wiping effect which prevents the deposit of carbon or other material which might form a heat-insulating layer.

By employing a relatively great number of tubes of small cross-sectional area I multiply the area for heat transference over and above that obtainable by the use of a less number of tubes having the same aggregate interior capacity. I also effect a more complete heating of the air travelling through the tubes because all of the air in the tubes is nearly adjacent to the planes of heat transference.

Again, the rectangular or non-circular tube cross-section prevents the formation of cool spots and lines or cores of coolness which cannot be avoided in cylindrical or cylindraceous tubes.

My improved tubes owing to their flexibility, do not loosen or break away from their anchorage under the influence of expansion and contraction.

It will be noted that the air enters the manifolds 20 and 22 at both ends and likewise leaves the manifolds 21 and 23 at both ends. This insures a uniform distribution of the air throughout all the tubes in its travel, thereby utilizing to its full value the heating capacity of the recuperator. I regard this double feed and discharge as advantageous but not obligatory.

To prevent the burning out of the recuperator in case the blower ceases to supply a current of air therethrough while the furnace gases continue to travel through the recuperator, I provide means for supplying a cooling medium to the tubes when the blower is idle. The most frequent cause of such failure is the interruption of the supply of electrical current to the blower-motor.

Thus in Fig. 7, 38 is the blower having a discharge port 39 to which is connected the pipe 35 (Fig. 1). The blower is shown driven by the motor 40 whose current-supply circuit is formed by the conductors 41 and 42 in which is interposed the switch 43.

44 is a solenoid connected between the conductors 41 and 42. The core 45 of the solenoid is connected to or integral with a weight 46 which is suspended by a cable 47 wrapped around a pulley 48 on the stem of a rotary valve 49 in a steam-supply pipe 50 connected to the boilers. 51 is a steam trap in said pipe to insure a supply of dry steam to the valve 49. On the other side of the valve 49 is a nozzle 52 which is directed at the intake 53 of the blower 38.

While the electrical current is on in the circuit 41 and 42, the core 45 and weight 46 are held elevated by the energized coil 44. Should said circuit become interrupted, thus halting the blower, the coil 44 becomes de-energized and the weight drops, opening the valve 49 and causing a jet of steam to be directed into the intake of the blower, thus aspirating a current of air through the blower and pipe 35 into and through the recuperator, and thereby preventing the burning out of the same.

Means are provided for preventing the operation of the steam jet when the main control switch is thrown to intentionally halt the blower, such as in cases where repairs are to be made and the waste gases are by-passed around the recuperator.

Thus the switch 43 may be so located that when thrown into its open position, shown in dotted lines in Fig. 7, it will be interposed beneath the weight and prevent its descent to a degree sufficient to open the valve 49.

In Fig. 8 I show the switch 43 as a double-throw switch and when in its position shown in dotted lines completing the motor circuit 41—42, and when in its reversed position shown in full lines, interrupting the circuit 41—42, closing the circuit 54—55 of one of the coils 56 of a double solenoid whose core 57 is a bar slidable horizontally in a yoke-support 58. When the coil 56 is energized, the end of the bar 57 is moved into a position under the weight 46 so as to support the same in its raised position, thereby preventing the operation of the steam-jet when the switch 43 is thrown to intentionally halt the blower.

59 is the other coil of the double solenoid, which, when energized tends to withdraw the core-bar 57 from under the weight 46, so that the latter is free to drop and open the valve 49. The coil 59 is connected to the main conductors 41—42 by the wires 60 and 61, respectively, so that when the switch 43 is in position to complete the motor circuit 41—42, the core-bar 57 is retracted out of the path of the weight and an interruption of the circuit 41—42 which would halt the fan and deenergize the sole-

noid coil 45, will result in the weight dropping and the valve 49 being opened.

The weight 46 is preferably provided with a depending foot 62 which may be arranged to enter a floor pit 63 and by contact with the bottom of the same, assume the support of the dropped weight, thus relieving the valve of the strain.

What I desire to claim is:—

1. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, a plurality of parallel U-shaped air tubes depending within said chamber and connecting together adjacent manifolds in pairs, and means for admitting the air to one of said manifolds and discharging the air from the other manifold of a pair, the air being admitted or discharged at both ends of the manifolds.

2. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, sets of parallel substantially U-shaped tubes depending within said chamber and connecting said manifolds together in pairs, connections between the members of adjacent pairs, means for admitting the air to one end manifold and for discharging the air from the other end manifold.

3. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, sets of parallel substantially U-shaped tubes depending within said chamber and connecting said manifolds together in pairs, means for connecting together the ends of adjacent manifolds of different pairs, means for admitting the air to one end manifold, and means for discharging the air from the other end manifold.

4. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, sets of parallel substantially U-shaped tubes depending within said chamber and connecting said manifolds together in pairs, means for connecting together the ends of adjacent manifolds of different pairs, means for admitting air to both ends of one end manifold, and means for discharging the air from both ends of the other end manifold.

5. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, a plurality of parallel U-shaped air tubes depending within said chamber and connecting together adjacent manifolds in pairs, and means for admitting the air to one of said manifolds and discharging the air from the other manifold of a pair, said tubes being of rectangular cross-sectional shape with two of their parallel walls disposed in parallelism with the travel of the waste furnace gases through said chamber.

6. In a recuperator, the combination of a chamber through which the furnace gases are horizontally passed, a plurality of horizontal manifolds mounted above said chamber and transversely disposed to the path of the waste gases, a plurality of parallel U-shaped air tubes depending within said chamber and connecting together adjacent manifolds in pairs, and means for admitting the air to one of said manifolds and discharging the air from the other manifold of a pair, said tubes being of oblong rectangular cross-sectional shape with their longer axes disposed in the direction of travel of the furnace gases through said chamber.

Signed at Pittsburgh, Pa., this 24th day of March, 1925.

CHARLES P. MILLS.