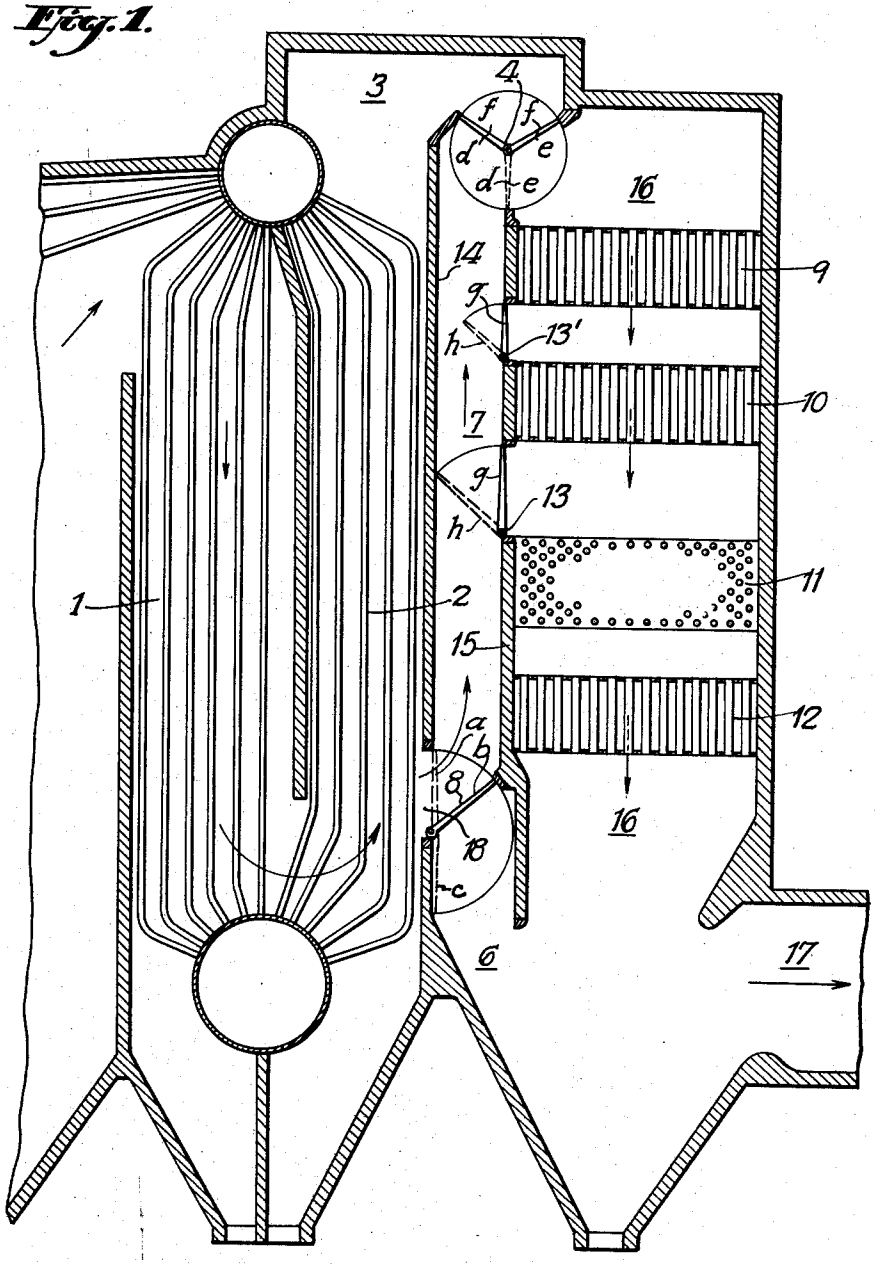
July 16, 1963 J. J. MARTIN 3,097,631

COMBUSTION GAS FLOW CONTROL IN BOILER FLUES

Filed Jan. 18, 1961

2 Sheets-Sheet 1

Fig. 1.



INVENTOR.
JOHANNES JOSEF MARTIN.
BY
K. A. Mayer
ATTORNEYS.

July 16, 1963 J. J. MARTIN 3,097,631

COMBUSTION GAS FLOW CONTROL IN BOILER FLUES

Filed Jan. 18, 1961 2 Sheets-Sheet 2

Fig. 2.

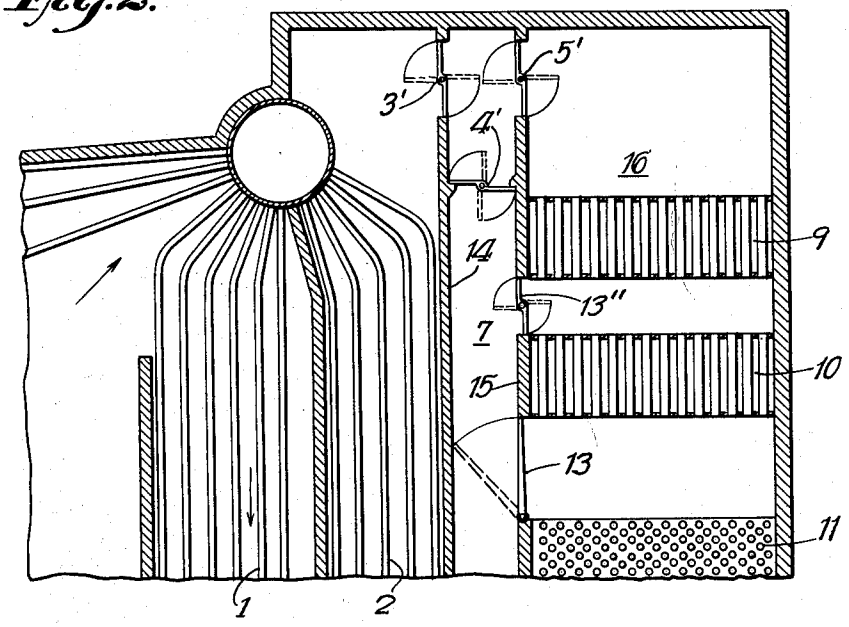
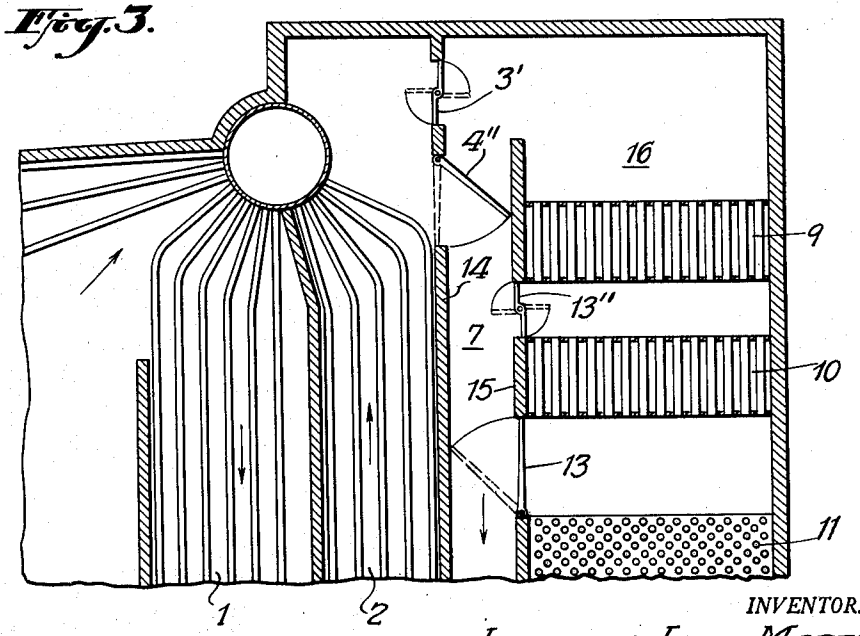


Fig. 3.



INVENTOR.
JOHANNES JOSEF MARTIN.
BY
K. A. Mayr
ATTORNEY.

United States Patent Office 3,097,631 Patented July 16, 1963

3,097,631

COMBUSTION GAS FLOW CONTROL IN BOILER FLUES

Johannes J. Martin, 14 Montsalvatstrasse, Munich 23, Germany

Filed Jan. 18, 1961, Ser. No. 83,431
Claims priority, application Germany Jan. 20, 1960
4 Claims. (Cl. 122—235)

The present invention relates to means for controlling the flow of heating gas through the flues of a steam boiler or water heater.

It is conventional to provide means for controlling the flow of heating gas through the flues of steam boilers or water heaters, which flues contain supplemental heating surfaces, for example, for superheating the produced steam, for preheating the feedwater, and/or for preheating combustion air. When starting the boiler or hot water heater, the combustion gas is so much cooled by the main heating surfaces that it reaches the supplemental heating surfaces at such a low temperature that certain components of the combustion gas cause corrosion of the supplemental heating surfaces and also do not sufficiently heat the heating surfaces of air preheaters, if such are present, to avoid corrosion of the air side of the heat exchanging surfaces of the air heaters by constituents of the combustion air flowing therethrough. In order to avoid these undesired effects of too cool combustion gases it has been proposed to by-pass the cool combustion gases around the flues containing the supplemental heating surfaces until the gases reaching these flues are sufficiently hot to avoid corrosion effects. The by-passed gases are directly conducted into the stack or a flue leading thereto. This conventional arrangement is satisfactory when used during the relatively short starting periods. If the steam boiler or water heater is operated at partial load during relatively long periods, by-passing of all combustion gas around the last boiler flue which contains an air preheater and/or an economizer considerably reduces the operating efficiency and cannot be done continuously. If during such periods too cold combustion gases are passed over the air preheater or economizer surfaces, corrosion is unavoidable.

It is an object of the present invention to provide a system for controlling the flow of combustion gases through the flues of a steam boiler or a hot water heater whereby the heating surfaces placed in the last part of the gas passage are never exposed to combustion gases which are so much cooled that there is condensation or other corrosion-producing effect on said heating surfaces, particularly if the boiler or water heater is operated at low load or fuel of low heat value is fired during considerable periods of time. With the system according to the invention the heating surface in the last part of the gas passage is either not exposed to combustion gases or is exposed to combustion gases whose temperature is so high that there is no danger of corrosion.

In the system according to the invention means are provided for controlling the flow of combustion gases through a by-pass duct by-passing the last part of the gas passage or flue of a boiler or water heater wherein heating surfaces are located. These means include gas flow control means at the inlet and at the outlet of the by-pass duct and connections between intermediate parts of the by-pass duct and the last part of the gas passage and a connection between the main flue of the boiler or water heater and the by-pass duct. The system according to the invention permits passage of combustion gas from a main gas duct of a boiler or water heater directly into the uptake and, if desired, prevention of any gas flow through subsequent portions of the main gas duct and through a flue containing supplemental heating surfaces, for example, of air preheaters and economizers. The system also permits passage of combustion gas from a main gas duct of a boiler or water heater through a by-pass duct into a flue containing supplemental heating surfaces whereby flow of gas through subsequent portions of the main gas duct may be completely prevented. In addition to the aforesaid operations the system permits passage of gas through the flue of a boiler or water heater containing an economizer and/or an air preheater, or through a by-pass duct by-passing said flue. The by-pass duct preferably has a wall in common with the aforementioned flue, openings being provided in said wall and valve means being placed in said openings for controlling the flow of combustion gas therethrough so that a portion or all of the gases passing through the by-pass duct can be introduced into selected portions of the flue containing the air preheater and/or economizer.

By proper positioning of the valves controlling the flow of the combustion gases the gases may be conducted at different flow rates past different supplemental heating surfaces so that the temperature of all heating surfaces is sufficiently high to prevent condensation, although the enthalpy of the combustion gases available for heating the supplemental heating surfaces is low.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing wherein:

FIG. 1 is a diagrammatic vertical sectional illustration of the convection portion of a boiler or hot water heater.

FIGS. 2 and 3 are diagrammatic vertical sectional illustrations of the upper part of modified convection portions.

Referring more particularly to the drawing, combustion gases which are produced in a combustion chamber, not shown are conducted consecutively through flues **1** and **2** in which tubular heating surfaces are placed which receive heat from the hot products of combustion mainly by convection. The gases leaving the flue or duct **2** pass through an intermediate duct portion or outlet **3** into the inlet of a flue **16** through which they travel in a downward direction. A conventional by-pass duct **7** is interposed between the duct **2** and the flue **16**. Heat transfer surfaces are placed in the flue **16** to receive heat from the hot combustion gases traveling therethrough. The heat exchange surfaces forming packages **9**, **10** and **12** may be for the purpose of heating combustion air and the heating surfaces forming a package **11** may be tubular and serve for preheating feedwater. The heat exchange surfaces may be arranged in any other suitable way within the flue **16**.

The by-pass duct **7** has an upper end communicating with the intermediate duct **3**, a three-way flap valve **4** having two flaps extending from a common axis being placed at the upper end of the by-pass duct **7** for controlling the rate of flow of gases through the by-pass duct **7** and through the flue **16**. The by-pass duct **7** has a lower end **6** communicating with a final flue or uptake **17** through which the gases are removed from the boiler or water heater. The by-pass duct **7** has a wall **14** in common with the last flue or duct **2** of the main combustion gas passage. The wall **14** has an opening **18** forming a gas passage in the neighborhood of the inlet of the flue **2** and the lower end **6** of the by-pass duct **7**. A valve **8** is mounted on the wall **14** adjacent to the opening **18** for controlling the flow of combustion gas through the opening **18** and through the by-pass duct **7**.

The by-pass duct **7** and the flue **16** have a wall **15** in common. A plurality of openings are provided in the wall **15** at different elevations thereof. The number and elevation of these openings depend on the number and

arrangement of heat exchange sections such as air preheaters and feedwater heaters. The openings in the wall **15** are preferably provided between heat exchanger sections in the flue **16**. Closure means, for example flap valves **13, 13'** as shown, are associated with the last mentioned openings for controlling the flow of combustion gases therethrough.

FIG. 2 shows a modification in which instead of one flap valve **4** provided at the upper end of the by-pass duct **7** and of the flue **16** three valves of the butterfly type are arranged. A valve **3'** is placed at the outlet of the duct **2**. A valve **4'** is placed at the upper end of the by-pass duct **7** and a valve **5'** is placed at the inlet of the flue **16**. The closure means in the uppermost opening of the wall **15** is formed by a butterfly type valve **13''**.

If one-flap valves are used such as the valves **8, 13, 13'**, counterweights or springs may be provided in the conventional manner to balance the valves. Instead of flap valves, slide valves, louvers or other conventional means may be provided.

The two flaps of the valve **4** shown in FIG. 1 are rigidly connected and are swingable through 360° on a common fulcrum. During normal operation the valve may be in either one of three main positions. When the two flaps are in the position *d, d* the upper end of the by-pass duct **7** is closed so that the heating gases pass through the intermediate duct **3** into the flue **16**. When the valve **4** is in the position *e, e* all gas coming from the duct **3** is passed into the by-pass duct **7**. When the valve **4** is in the position *f, f* which is shown in solid lines in FIG. 1, the by-pass duct **7** as well as the flue **16** are closed and no gas can leave the main duct **2**.

The valve **4** may be composed of flaps swingable on a common axis and so arranged that the angle at which the flaps are set relatively to each other can be changed.

The flap valve **8** is also used in three principal operating positions. In the position *a* the opening **18** is closed. In the position *b* which is shown in FIG. 1, a portion of the combustion gases coming from the main duct **1** passes into the by-pass duct **7**. When the valve **8** is in the position *c* hot combustion gases from the main duct **1** pass through the opening **18** and the lower end **6** of the by-pass duct **7** into the uptake **17**.

The flaps **13** and **13'** may occupy two main positions. If they are in the position *g* which is shown in solid lines in FIG. 1, no gas can pass from the by-pass duct **7** through the openings in the wall **15** into the flue **16**. When the valve **13** is in the position *h* shown in dotted lines in FIG. 1, the valve closes the by-pass duct **7** and all gas passing through the upper portion of the by-pass duct flows into the flue **16**. The valve **13'** is smaller and if it is in the position *h* closes only a portion of the flow area of the by-pass duct **7** and directs a portion of the combustion gas entering the by-pass duct **7** into the flue **16**.

With the system according to the invention and illustrated in FIG. 1 the following effects may be produced:

(1) In order to prevent contact of cold products of combustion which may cause corrosion of the heat exchanger groups placed in the colder part of the combustion gas passage during starting of the boiler or water heater, the valve **8** is placed in the position *c*, the valve **4** in the position *f, f* and the valve **13** in the position *h*. With this arrangement the combustion gases flow only along a part of the main heating surfaces of the boiler or hot water heater and leave the duct **1** through the opening **18** in the wall **14**. The combustion gases flow from the opening **18** directly into the uptake **17**. No still too cold combustion gases can flow along the heating surfaces in the duct **2** and in the flue **16**.

(2) When the enthalpy increases and water begins to circulate in the tubes placed in the duct **2** the valve **8** may be placed into the position *a* for closing the aperture **18**, the valve **4** may be placed into the position *e, e* and the valves **13, 13'** in the position *g* so that no gas flows through the flue **16**.

(3) When, due to increased heating, the gases leaving the duct **2** and flowing through the intermediate duct **3** have enough enthalpy and temperature to avoid danger of corrosion in a portion of the heating surfaces placed in the flue **16**, the valve **8** may be maintained in closed position and the valve **4** in the position *e, e* while the valve **13** is gradually opened and the valve **13'** is gradually opened after the valve **13** has reached full open position so that the heating gases can transfer an admissible amount of heat first to the heating surfaces **11** and **12** and subsequently also to the heating surface **10**.

(4) At a further increase of the heat produced in the combustion chamber the valve **8** may be retained in the position closing the opening **18**, the valve **4** may be turned into the position *d, d* and the valves **13** and **13'** may be simultaneously closed so that all gas coming from the duct **2** passes through the flue **16** and transfers its heat to the heating surfaces **9** to **12**. This is the full load position of the system.

The valves **13** and **13'** may be slightly opened for regulating the temperature of the combustion air heated in the heating sections **9, 10** and **12** and/or the temperature of the feedwater heated in the economizer **11**. Since the flow resistance of the by-pass duct **7** is much smaller than the flow resistance in the flue **16**, very slight opening of the valves **13** and **13'** is sufficient to produce effective control.

(5) If at partial load operation or at low heating value of the fuel burned the temperature of the gases passing into the flue **16** past the valve **4** which is in the position *d, d* is too low to produce the desired combustion air temperature in the air heaters **9, 10** and **12**, the valve **8** may be placed into the position *b*, the valve **4** into the position *f, f* and the valves **13, 13'** into the position *g* so that the hot combustion gases flow from the duct **1** through the by-pass duct **7** into the flue **16** and do not transfer any heat to the heating surfaces in the main duct **2**. The reduced heat absorption by the main heating surfaces of the boiler or water heater results in a higher temperature of the gas entering the flue **16** which contains the supplemental heating surfaces **9** and **10** so that the air moving along these surfaces soon obtains the desired temperature. By slightly moving the valve **4** toward the position *e, e* gas is conducted through the duct **2** and transfers heat to the boiler heating surface therein so that the temperature of the gas admitted to the heating surfaces **9** and **10** is reduced and a very fine adjustment of the temperature of the air heated thereby is obtained.

(6) If it is desired to produce a relatively low heating effect in the air heaters although the heat output of the combustion chamber and the temperature of the combustion gases in the intermediate duct **3** are high, this can be accomplished by the system according to the invention. The valve **8** is placed in the position *a* and the valve **4** is moved to the position *e, e* so that gas cooled in the main duct **2** enters the by-pass duct **7**. The valves **13** and **13'** are moved toward the position *h* to an extent corresponding to the desired air heating effect and combustion gases are admitted to the heating surface sections **11** and **12**, and, if desired, also to the section **10**, i.e. the gases pass only a portion of the entire air heater surface before they leave the plant through the uptake **17**. The air temperature produced in the air preheater in the flue **16** can be controlled within a medium temperature range by placing the valve **13'** into a position between the position indicated by letters *g* and *h* in FIG. 1 or by slightly opening the valve **4** to admit some combustion gas also to the air heater section **9**.

Instead of the rotary flap valve **4** shown in FIG. 1 three simple flap valves **3', 4', 5'** can be used as shown in FIG. 2. The valves **3', 4', 5'** in combination with the valves **8, 13** and **13'** or **13''** permit the same variations

of the combustion gas flow as they have been described in connection with FIG. 1. The valve 4' may be placed at a location in the by-pass duct 7 different from the location shown in FIG. 2.

If only a part of the operations described in paragraphs numbered (1) to (6) must be effected, the valve 4 shown in FIG. 1 or the valves 4' and 5' shown in FIG. 2 may be omitted and a valve 4'' may be provided as shown in FIG. 3. The valve 4 controls flow of gas into the by-pass duct 7 and also an opening in the wall 14 at the upper end of the by-pass duct 7.

The invention is not limited to boilers or water heaters having vertical flues. It can equally well be applied to boilers whose flues are in an inclined position or even horizontal.

For placing the various valves in the most effective positions at varying outputs of the plant and particularly for obtaining an optimal combustion air temperature, conventional temperature sensitive devices may be inserted in the streams of the combustion gas, of the preheated air and of the feedwater and the valves controlled according to the indications of these devices.

When starting the plant or at rapid changes of the output it may be necessary to very quickly change the position of the valves to effect the operations described in the paragraphs numbered (1) to (6). For this purpose it is advisable that all valves are mechanically balanced and are arranged to be controlled by remote control from a service platform where also the gauges showing the temperatures of the combustion gas, of the preheated air, and of the feedwater are located.

The invention is not limited to the placement of the by-pass duct 7 through which heating gases may be selectively conducted in one direction or in the opposite direction, between a flue pass containing main boiler heating surfaces and a flue pass containing an air preheater or an economizer. The invention may also be applied to a plant in which a by-pass duct is located between a duct containing a main boiler heating surface and a flue pass containing a steam superheater whereby by proper positioning of the valve system according to the invention the superheat temperature may be controlled, if desired, in addition to or in combination with conventional attemperators.

The provision of an auxiliary or by-pass duct between flues of a boiler or water heater which flues contain different heating sections and of valves in combination with the auxiliary duct to selectively conduct combustion gases therethrough in one or in the opposite direction not only affords operation of the plant at any partial load in such manner that the combustion gases leave the plant at a temperature which is above the dew point so that corrosion of heating surfaces is avoided but also affords a very fine control of the temperature of the air preheated by the combustion gases between a minimum value and the maximum value desired for the particular boiler or water heater whereby the heat content of the gases entering the flue containing the economizer and/or air preheater is substantially equally well utilized at varying partial loads.

The system according to the invention permits firing of widely different fuels also in plants having relatively very large supplemental heating surfaces such as modern high pressure steam generators, without condensation on the relatively cool heating surfaces. The invention permits, for example, to fire waste material of little heating value and containing much water together with the normal fuel in steam generators which are designed to fire high-grade fuel having a low water and sulphur content and which are designed for a correspondingly low combustion gas dew point, without causing corrosion of the relatively low temperature heating surfaces.

I claim:

1. A heat exchanger for transferring heat from hot combustion gases to heating surfaces, comprising:
a first flue having an inlet and an outlet,
first heating surfaces placed in said first flue,
a second flue having an inlet connected to said outlet for receiving heating gas therefrom,
an uptake for discharging combustion gases from the heat exchanger,
said second flue having an outlet connected to said uptake for discharging combustion gases,
second heating surfaces placed in said second flue,
a gas duct having a first end portion connected to said uptake,
a first passage connecting the inlet of said first flue and said first end portion of said gas duct,
said gas duct having a second end portion forming a second passage connecting said gas duct and the inlet of said second flue,
damper means placed adjacent to said second gas passage for controlling the flow of combustion gases through the outlet of said first flue, through said second passage, and through the inlet of said second flue, and
gas flow control means placed adjacent to said first passage and constructed and arranged so as to simultaneously control the gas flow from the inlet of said first flue through said first passage and through said gas duct.

2. A heat exchanger for transferring heat from hot combustion gases to heating surfaces, comprising:
a first flue having an inlet and an outlet,
first heating surfaces placed in said first flue,
a second flue having an inlet connected to said outlet for receiving heating gas therefrom,
an uptake for discharging combustion gas from the heat exchanger,
said second flue having an outlet connected to said uptake,
second heating surfaces placed in said second flue,
a gas duct having a first end portion connected to said uptake,
a first passage connecting the inlet of said first flue and said first end portion of said gas duct,
said gas duct having a second end portion forming a second passage connecting said gas duct and the inlet of said second flue,
first damper means placed adjacent to said first passage and swingable into said first end portion of said gas duct for closing said first passage and opening said first end portion of said gas duct, or for opening said first passage and closing said first end portion of said gas duct, or for opening said first passage and said first end portion of said gas duct,
said outlet of said first flue, the inlet of said second flue and said second end portion of said gas duct forming a common conduit portion wherein said outlet of said first flue, said inlet of said second flue and said second end portion communicate,
and a three-way damper device rotatably supported within and substantially centrally of said common conduit portion for selectively opening said second passage and closing the connection between the outlet of said first flue and the inlet of said second flue, or for closing the inlet of said second flue and for opening said second passage for connecting said outlet of said first flue and said gas duct, or for opening the connection between the outlet of said first flue and the inlet of said second flue and for closing said second passage.

3. A heat exchanger as defined in claim 2 wherein said three-way damper device is formed by two rigidly connected flaps placed at an angle of 120° and being re-

volvable through 360° around an axis extending through the apex of the angle formed by said flaps.

4. A heat exchanger as defined in claim 2 wherein said three-way damper device is formed by two hingedly connected flaps of like configuration individually swingable around the axis of the hinge connection.

References Cited in the file of this patent

FOREIGN PATENTS

35,321	Austria	Nov. 25, 1908
574,164	Germany	Apr. 10, 1933
724,084	Germany	Aug. 18, 1942