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K. WAKABAYASHI
METHODS FOR COMPLETE COMBUSTION OF FUEL IN BOILERS AND ARRANGEMENTS THEREFOR
Filed May 28, 1940

Serial No.
337,713

4 Sheets-Sheet 1

Fig. 1.

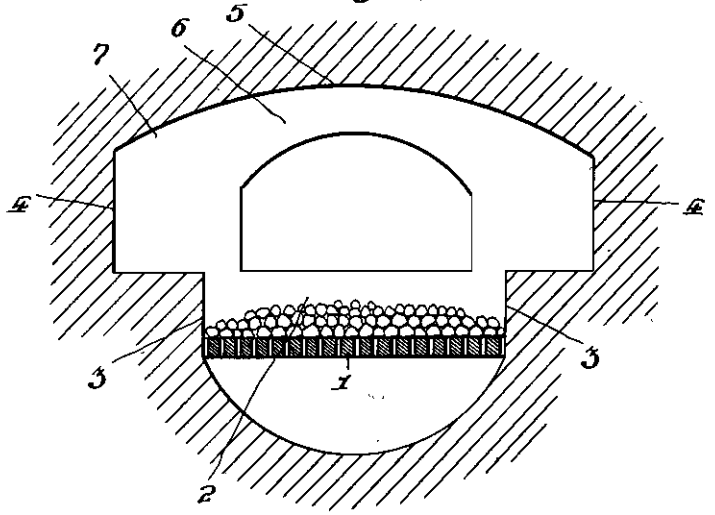

Fig. 2.

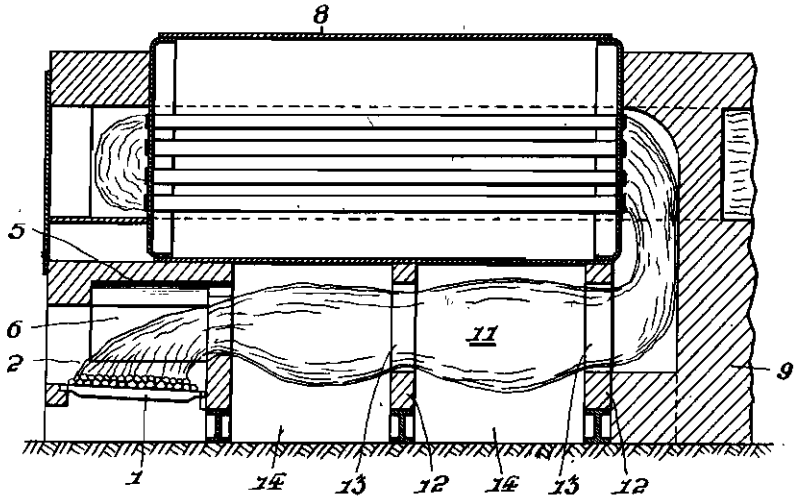

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Fig. 3.

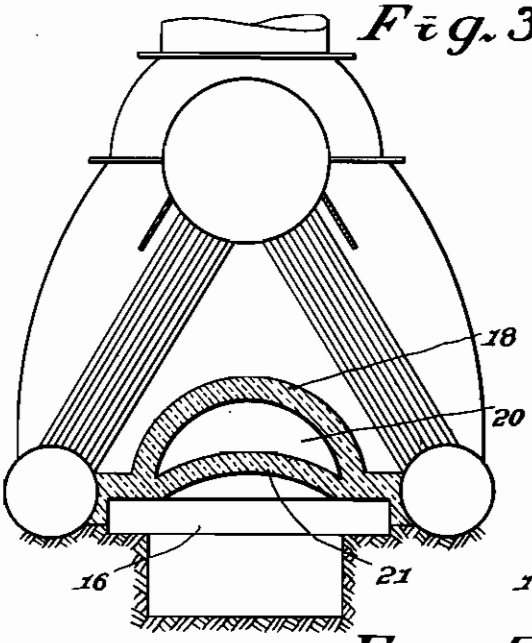

Fig. 4.

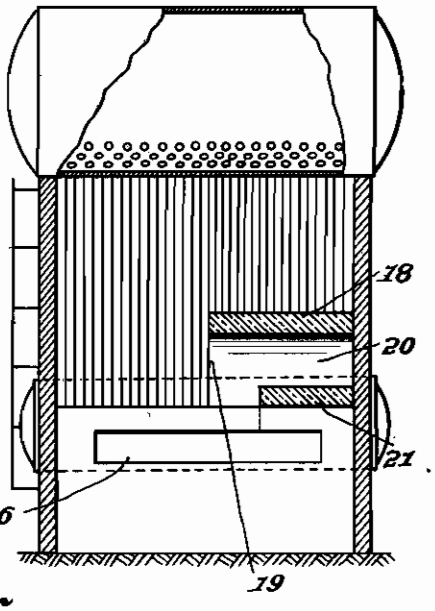

Fig. 5.

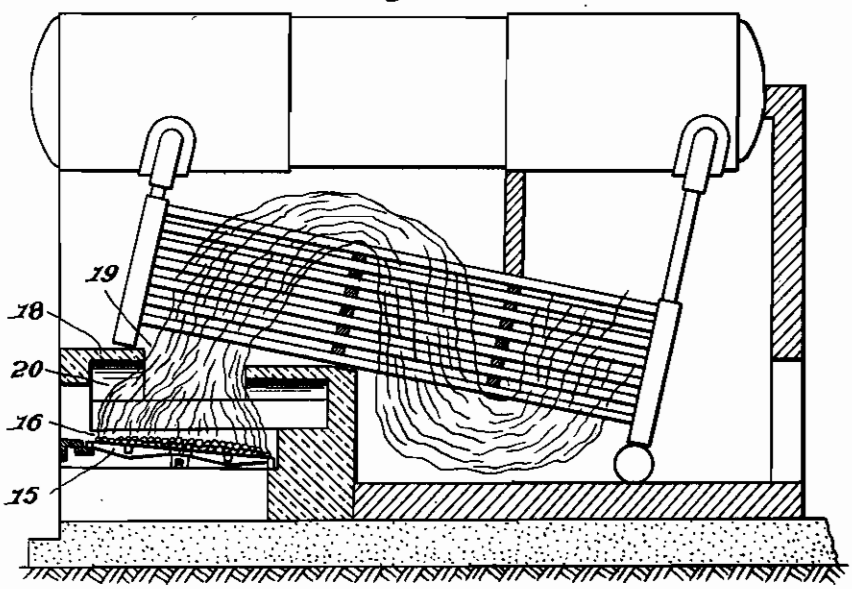

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Fig. 6.

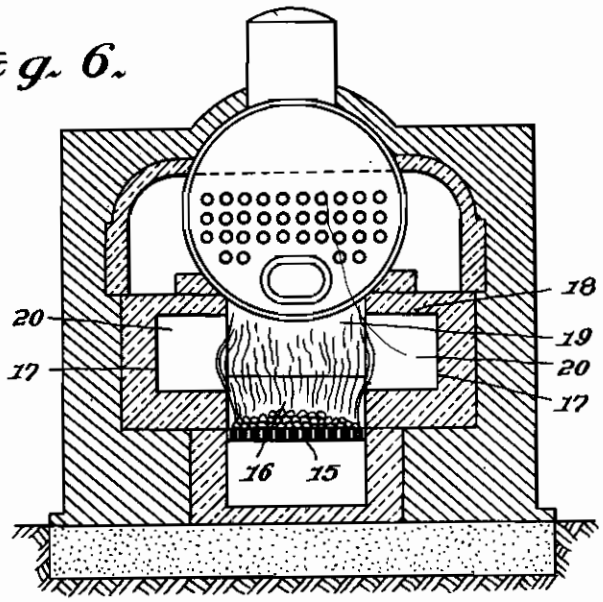

Fig. 8.

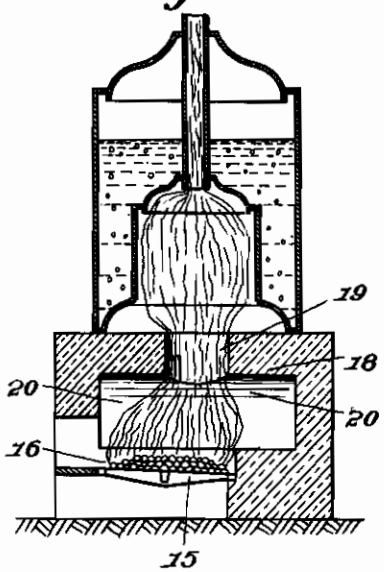

Fig. 7.

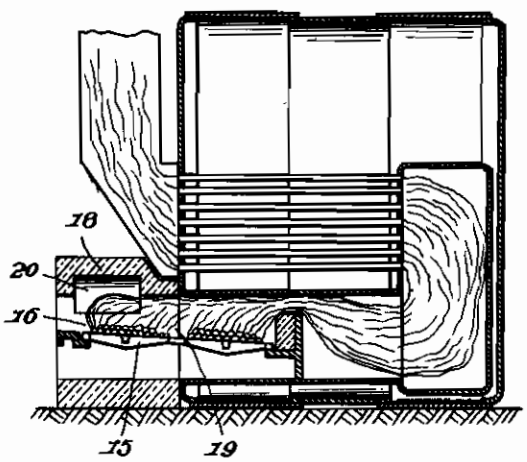

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Fig. 9.

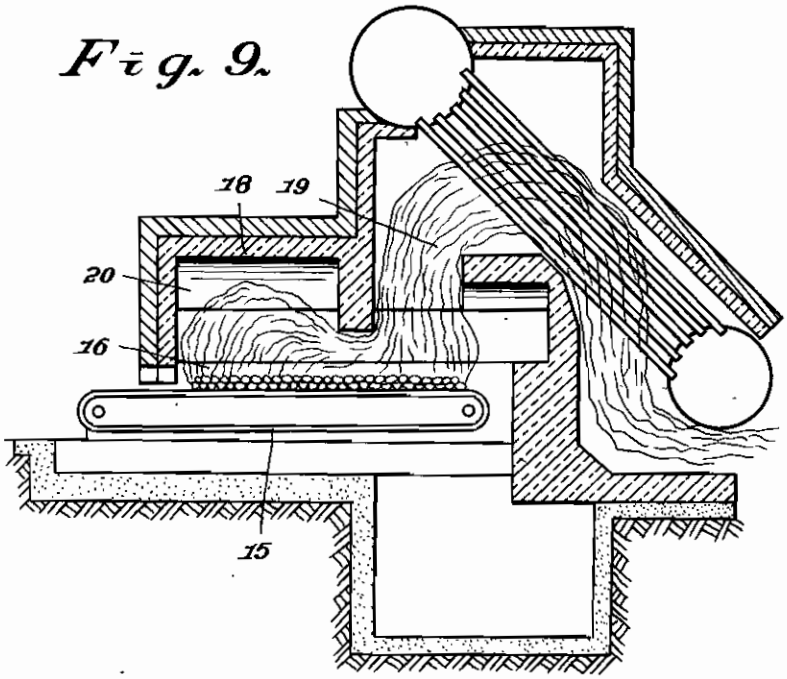
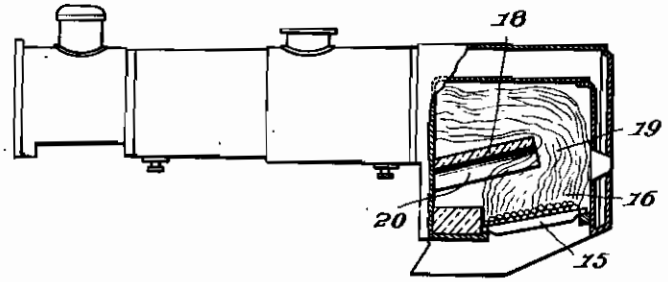


Fig. 10.



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ALIEN PROPERTY CUSTODIAN

METHODS FOR COMPLETE COMBUSTION OF FUEL IN BOILERS AND ARRANGEMENTS THEREFOR

Kotaro Wakabayashi, Tokyo-shi, Japan; vested in the Alien Property Custodian

Application filed May 28, 1940

This invention relates to method and arrangement, effective for ensuring complete combustion of fuel in boilers and improving heat transmission efficiency.

The object is to provide a method and an arrangement, by which air necessary for complete combustion of the burning gases produced by the combustion of fuel or flame in the furnace of the boiler is automatically heated in the furnace and automatically supplied into the burning gases or flame in an effective manner.

In the accompanying drawings;

Fig. 1 is a cross sectional view of a furnace for illustrating the principle of the invention;

Fig. 2 is a transverse sectional view of an embodiment of the invention applied to an externally-fired boiler;

Fig. 3 is a front view of a Japanese Admiralty-Type boiler with an embodiment of the invention applied thereto, partly cut way for the clarification of an inner view;

Fig. 4 is a side view of Fig. 3 partly cut away for the clarification of an inner view;

Fig. 5 is a transverse sectional view of a Babcock and Wilcox boiler with an embodiment of the invention applied thereto;

Fig. 6 is a cross sectional view of an externally-fired horizontal multitubular boiler with an embodiment of the invention applied thereto;

Fig. 7 is a transverse sectional view of a marine boiler with an embodiment of the invention applied thereto;

Fig. 8 is a vertical sectional view of a vertical boiler with an embodiment of the invention applied thereto;

Fig. 9 is a transverse sectional view of a Takuma-Type boiler with an embodiment of the invention applied thereto; and

Fig. 10 is a transverse sectional view of a locomotive boiler with an embodiment of the invention applied thereto.

According to the invention, the rising stream of the burning gases produced by the combustion of fuel or flame in the furnace of a boiler is caused to spread against natural phenomena of taking the shape of cones and then to resume the original rising state again, whereby air retaining spaces or pockets are formed between the surface of the flame and the furnace wall. The film of the entrained air enveloping the flame is caused to be retained and heated in the air retaining spaces or pockets. On the other hand, the moisture contained in the flame is caused to evaporate and to form superheated steam, being facilitated by the spreading of the flame, which steam will rush out of the flame due to the activity of the steam particles and the less density of the spread flame. Thus, the steam will rush into the air retaining spaces or pockets and the heated air retained the air retaining spaces or pockets rush into the flame, that is, an interchange of the steam and the heated air is effected in the flame, and the heated air will be utilized as secondary supplied air in the flame to cause complete combustion of the flame. In general, the flame is caused to spread by providing a flame chamber formed by walls extending beyond the walls of the fire box to communicate with the fire box in which fuel burns, and the air retaining spaces or pockets are caused to be formed by the shape of the walls and the top or crown, as the spread flame resumes the original rising state to take the shape of cones. The said extended walls of the flame chamber may be provided in two sides or one side or the fore or rear part of the fire box. In practice, the fire box 2 is formed with vertical side walls 3 extending upward a certain length from the fire grate, so that the flame will rise upward along the walls from the fire grate, so as to reach the top or crown 5, as shown in Fig. 1. The part of the fire box above the side walls 3 is enlarged and defined by the vertical sides 4 and an arcuate top or crown 5 in order to form a flame chamber 6. The flame will spread in the flame chamber 6 due to the enlargement of space and the striking against the crown 5, but it will not circulate in the upper corners, so that air spaces or pockets 7 will be left there.

In Fig. 2 showing another application of the invention, the combustion chamber 11 communicating with the fire box 6 of the furnace 9 under a horizontal smoke tube boiler 8 is provided with partition walls 12 having passages 13 for flame. The location and size of the passages 13 is determined so as to cause flame to bias toward the heating surface of the boiler and to leave air retaining spaces or pockets 14 around the flame. With this construction, the air entraining with and enveloping flame is partly arrested by the wall on its passage and will be retained in the air retaining spaces or pockets.

The invention is to solve the question for ensuring complete combustion of fuel in steam boilers by investigating precisely the spreading condition of flame and air and the proportion in volume of flame and air and by observing the combustion state of fuel on the fire grate and in the furnace. In general, it is well known that a combustion chamber of a definite dimension

is necessary for a definite grate area, and accordingly it is rational to vary the dimension of the combustion chamber depending on the variation of quantity of volatile products of the combustion, which is larger on the beginning of combustion and decreases gradually as the combustion proceeds, but such is unpracticable. It is evident by the fact that when coal is put on the fire in the furnace, volumes of murky smoke rise from the chimney at the beginning, the generated volatile products being discharged in an incomplete combustion state due to an insufficient dimension of the combustion chamber to meet the quantity of the volatile products generated, and the smoke becomes light gradually as the combustion proceeds. According to the invention, the flame rising from the fire grate is caused to spread, whereby the combustion extends to the center of the flame to minimize the quantity of the volatile products discharged in an incomplete combustion state. The spreading of the flame promotes also the evaporation moisture in fuel and air contained in the flame, and causes the fuel and moisture to be evaporated in a superheated state by the high heat of the flame. A part of air entering through air inlets of the fire box will flow along the stream of the flame so as to envelop the stream of the flame, but will be retained in the air retaining spaces or pockets due to the walls and passages therein. The retained air is heated by the flame. Thus, the superheated steam generated in the spread flame will rush from the flame into the air retaining spaces on pockets, due to its high activity, on seizing occasion of less density of the flame, while the heated air in the air retaining spaces or pockets will be drawn into the flame by the induction of draught, so that the interchange of the steam and the air will be instantaneously and easily effected in the flame, and the heated air will serve as secondary supplied air in the flame. This secondary supply of the heated air in the flame is controlled by the steam generated depending on the combustion state, and accordingly is effective to control the supplement of air. Thus, the admission of excessive air in practical working is not so serious, and accordingly the adjustment of the passage for air need not be so precise, as the excessive air is availed in the above mentioned manner. As the air enveloping the flame impairs the heat transmission from the flame, it is advantageous to arrest the air enveloping the flame by the restricted passages for air, particularly to cause the flame to bias toward the heating surface of the boiler. Further, the heat of the flame according to the invention may be transmitted rationally on the furnace and other heating surface. According to the invention, the flame rising from the fire grate is caused to spread, whereby the combustion is caused to extend into the central part of the flame and facilitate the evaporation and escapement of the moisture contained in the flame, and the air film enveloping the flame is caused to be retained in the air retaining spaces or pockets provided in the furnace, which air is heated and utilized as secondary supplied air for the flame by causing the air to interchange with the steam generated in the flame, whereby incomplete combustion gases are caused to make complete combustion and heat transmission efficiency is increased.

The embodiments of the invention are illustrated in Figs. 3–10 inclusive by way of example. A flame chamber is formed above the fire box 16 to extend over a suitable length in the fore part (Figs. 1, 4 and 7), or to extend over the full length of the fire box (Fig. 6), or to extend further backward (Figs. 5, 8, 9 and 10), which chamber is formed by means of the arcuate top or crown 18 (Figs. 3 and 4), or the side walls 17 of a width larger than the distance between the side walls of the fire box (Fig. 6) and the arcuate top or crown 18 (Figs. 5–10). The flame chamber is provided on its rear part (Figs. 3, 4 and 7), or on the middle part of the top (Figs. 5, 6, 8 and 9), or on the fore part of the top with an opening 19, whereby the flame chamber communicate with the combustion chamber, the air retaining spaces or pockets 20 being provided in the upper corners of the flame chamber. Substantially, the flame chamber having an arcuate top or crown is essentially formed so as to extend partly, or over the full length or rearwardly beyond the full length on the sides or side of the fire box, and to make its transversal sectional area larger than that of the fire box by means of the side walls extended outwardly from the side walls of the fire box, the flame chamber being communicated with the combustion chamber through the opening in the rear part or top. As shown in Figs. 3 and 4, an additional top or crown 21 may be provided in the communicating passage between the fire box and the flame chamber. In case of an internally-fired boiler, the fire box and the combustion chamber may be formed adjacent to its front and plate.

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