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E. M. POWELL ET AL

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SUPERHEATER BAFFLING

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2 Sheets-Sheet 1

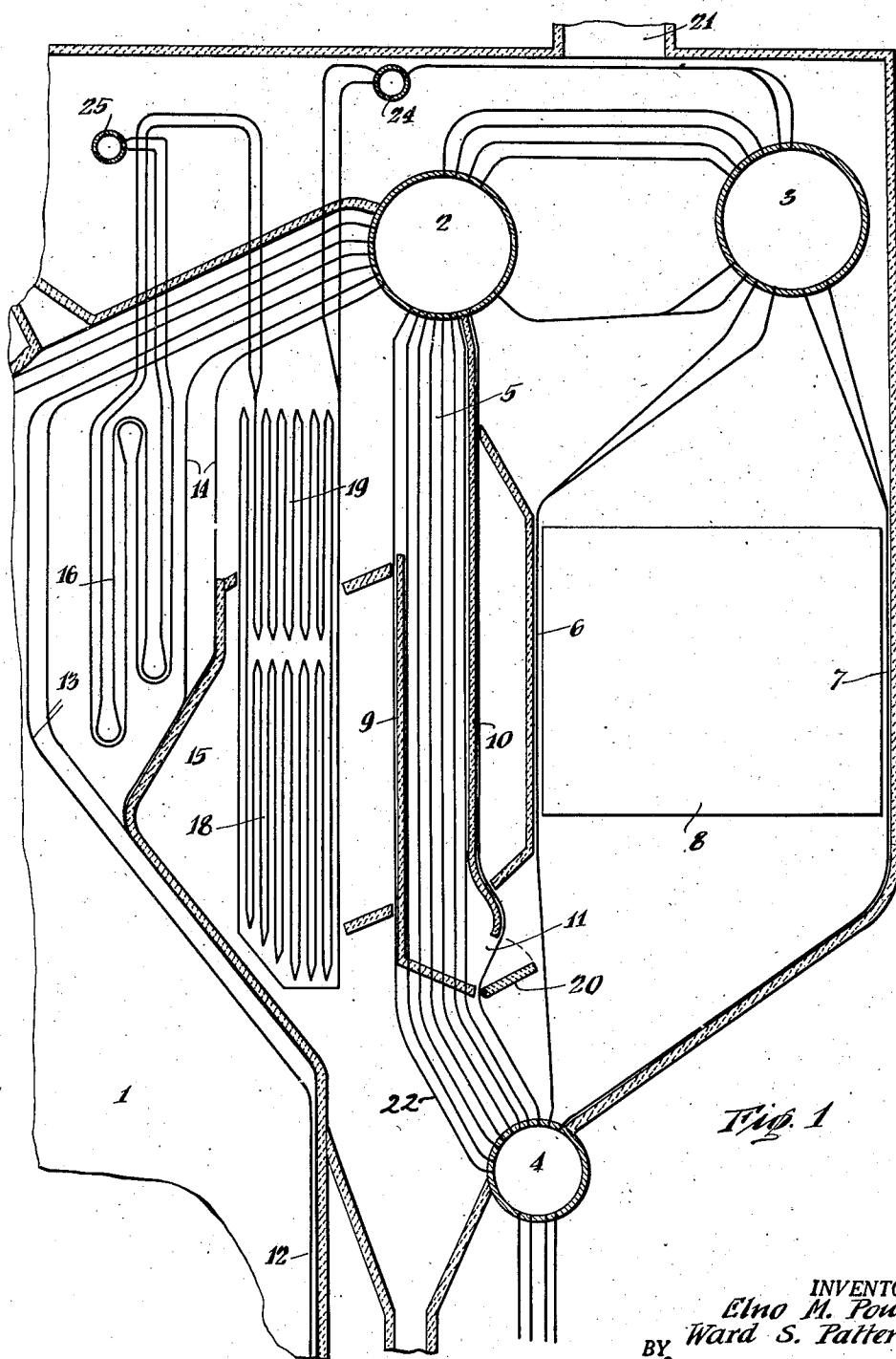


Fig. 1

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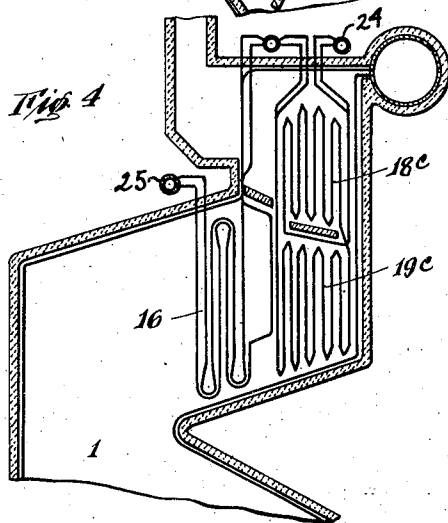
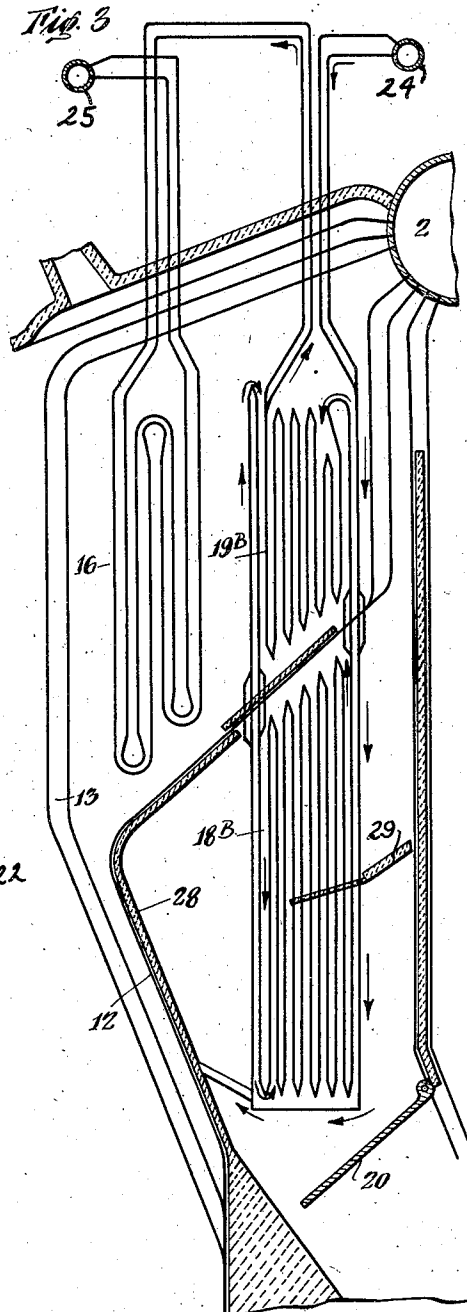
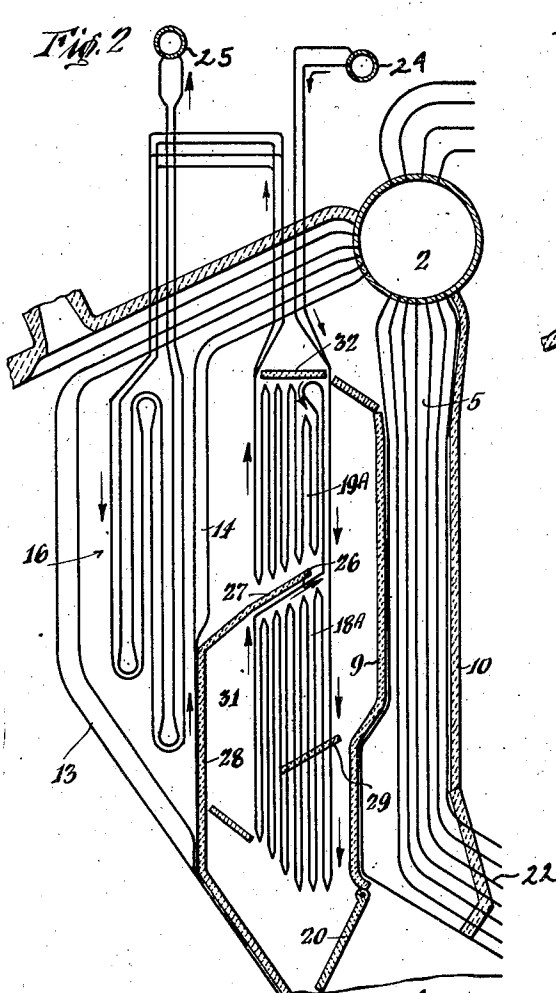
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SUPERHEATER BAFFLING

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3 Claims. (Cl. 122—480)

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This invention relates to improved superheater installations for steam generating units.

As contemplated herein a superheater installation includes, besides the heat transfer surface, means for confining the gases within the superheater space, means for directing the gases over the heating surface in the desired manner, and means for controlling the quantity of gas flowing over the superheater. Superheaters embodying in some form or other one or more of these features are commonly used on all high pressure, high capacity steam generating units, but this invention relates to several novel changes in the arrangement now known to the art, which will greatly increase performance, economy of manufacture, and life of equipment.

In superheaters for high pressure steam generators, it is common practice to heat the steam to 925° F. or higher. One of the limitations has been the metal available for fabrication of the tubes in which the steam is heated but, as progress in alloy steels proceeds, the more serious limitations may be in other aspects of design. For example, when heating steam to the present high temperatures, there is a definite quantity of heat absorption required for each pound of steam, approximately 270 B. t. u. In a convection superheater, this heat must come from the gases passing over the superheater of which there is a definite quantity, for each pound of steam, of the order of magnitude of 1.2. Therefore, each pound of gas must give up 225 B. t. u. or over, which is equivalent to a temperature drop of approximately 800 F.

It is well known in the art of heat transfer that only in a counterflow superheater can the heating gases be reduced in temperature below the temperature of the heated fluid. Heat exchangers may be designed to approach the desirable counterflow principle in varying degrees but the most efficient design will be that in which both fluids are made to flow counter to each other in all parts of the heat exchanger. It is one of the features of this invention to introduce improvements in the design of a known type of superheater so that its performance will approach that of the ideal counterflow arrangement.

Besides economy in design, the counterflow principle offers other advantages, which are obvious when one studies the effect on gas temperatures. For example, a common design of pendant type convection superheater has the tubes so arranged and interconnected that the flow of steam from tube to tube is cross current to the flow of gas. With such a design, the steam at nearly

final temperature is in tubes contacted by the coolest portion of the gases. Obviously, with such a design, the gases leaving the superheater must be at a higher temperature than the steam leaving the superheater in order to transfer heat to the steam. Thus, if the steam is to be heated to 950 F., the exit gases must be at, preferably, not less than 1050 F. But in a convection superheater the gas temperature drop corresponding to the required heat may exceed 800 F., thereby establishing 1850 F. or over as the gas temperature entering the superheater. Add another 200 F. to 400 F. for the gas drop through steam generating tubes ahead of or adjacent to the superheater and the required gas temperature leaving the furnace becomes well over 2000 F., even at the lowest load on the unit for which the 950 F. steam has been specified. This is above the ash-fusion temperature of some coals and, obviously, any improvement in design that will lower the required gas temperature is very desirable.

One of the most difficult thermal design problems is to provide a constant yet high steam temperature over a wide range of capacity. Here the demands of the users have only been limited by the ability of the designers. It is apparent from the foregoing illustrative calculations that if 950 F. is required from half load to full load, the required gas temperature leaving the furnace at the low load automatically establishes such a high temperature at higher loads as to limit the application of an ordinary convection type superheater.

The lowest capacity at which a superheater is expected to heat the steam to maximum temperature is called the "control point." In designing for this point, it is desirable to utilize the available heat in the gases in the most efficient manner so as to require the least amount of heating surface in tubes arranged on the widest possible spacing and yet occupying the least possible space and requiring the lowest possible entering gas temperature. The least amount of heating surface under given temperature conditions results from using the highest product of mean temperature difference times gas side heat transfer rate. Obviously, the highest product will result when each of the individual factors is the highest; and, it is well known in the art of heat transfer that it requires counterflow to result in the highest mean temperature difference and gas flow transverse to the axis of tubes to give the highest heat transfer rate, other things being equal, such as, the power loss resulting from the friction between the gases and the tube surface.

It is one of the objects of this invention to combine both these desirable features in the same arrangement.

When operating a convection superheater at capacities above the "control point," the tendency is for the steam temperature to be higher because of higher gas temperature and one method of preventing this is by decreasing the quantity of gas which is directed over the superheater surface. It is obvious to one skilled in the art that the greatest reduction in steam temperature by this control means can be obtained with the least quantity by-passed if the flow of the by-passed gases is so directed as to completely miss all, or a major portion, of the superheater surface; or, in any event, so as not to come in contact with superheater surface in a manner which would result in a high rate of heat transfer. Obviously any arrangement that permits the by-passed gases to first contact considerable superheater surface in a flow path transverse to the axis of the tubes is defeating the purpose of the by-pass and will seriously limit the amount of temperature control. It is one of the objects of this invention to disclose a method of directing the by-passed gases in the preferred manner, the purpose of which is to decrease the by-passed quantity, the required size of the by-pass, the required size and cost of by-pass damper, and to improve steam temperature control.

Since the by-passed gas does not pass over the superheater surface, it enters the by-pass at a high temperature. Furthermore, it is not always possible with arrangements heretofore used to cool the by-passed gases to the same temperature as the main body of gases which has passed over the superheater. This has often resulted in two streams of gases of widely different temperatures, which, without sufficient opportunity to mix, have then been directed over the next section of heating surface of the boiler unit. Very frequently the water heating economizer follows directly after the by-pass damper in the direction of gas flow, and a non-uniform gas temperature and/or velocity entering this equipment is very undesirable. This invention includes a novel arrangement of a superheater and its associated by-pass and by-pass damper, which accomplishes mixing of the two gas streams in a portion of the unit where steam is being generated and where, therefore, the stratification is of minor importance. The arrangement has the added advantage of absorbing heat from the two gas streams while they are being mixed, thereby making more effective use of the installed heating surface and increasing the efficiency of the unit without additional material cost.

In a superheater comprising an adjacent by-pass and its associated damper, the resistance of the two parallel flow paths must be such that the desired division of the gas stream can be accomplished. Reduction of the quantity to be by-passed is an important step in the right direction and will result from the application of gas-directing means mentioned above; but the fact remains that when gas is directed through the by-pass, the draft loss in the parallel superheater pass is decreased and, consequently, with the damper design now in common use, the capacity of the by-pass is very limited unless an unusually large by-pass and correspondingly large and expensive damper is provided. Therefore, it is one of the features of the proposed arrangement to locate and pivot the damper in such a way as to add resistance in the superheater pass when the

damper is opened and thereby insure that the capacity of the by-pass is not wholly dependent on the proportions of the two parallel gas passes. This novel feature results in a saving in material, expense, and size of equipment, or, alternately, in increased range of superheat control if by-pass and damper are not decreased in size.

All of the above improvements are possible in a superheater of the preferred pendant type that may be suspended entirely from supporting members not subject to the destructive action of the high-temperature gases. Such a superheater generally employs forged return bends between adjacent tubes of the individual elements. Economy of manufacture and the principle of vertical suspension require that the superheater tubes have their axis substantially vertical. Special means as described herein, and transverse flow of the heating gases, therefore, is necessary with this design in order to take full advantage of the desired counterflow principle. The use of a gas flow path at right angles to the axis of the tubes has the further advantage of high heat transfer rate even with a relatively wide spacing between tubes, and experience has shown that a wide spacing is very desirable when burning coals of low ash fusion temperature. But full advantage of cross flow in a long vertically-disposed pendant type superheater is not possible except by the use of the novel arrangements herein disclosed.

The present invention will be best understood upon consideration of the following detailed description of various embodiments when read in conjunction with the accompanying drawings in which

Figure 1 is a sectional elevation of a steam generator with its associated superheater of the type heretofore used; and

Figures 2 to 4 are partial sectional elevations of embodiments of the improved superheater adapted to the steam generator of Fig. 1.

In Fig. 1 the major part of the steam generating unit is located beyond the outlet at the top of the furnace 1 and includes a bank of tubes 5 connecting steam and water drum 2 with water drum 4. Spaced rows of tubes 6 and 7 connecting drum 4 and another steam drum 3 encase an economizer 8. The bank of boiler tubes 5 is provided at either side with baffles 9 and 10 so arranged as to cause the gases to flow from the top downwardly along the tubes of said bank. Baffle 9 has a lower part spaced above drum 4 and extending diagonally downward across the bank 5 to an outlet opening 11 formed between the lower ends of the two baffles. Furnace 1 has its rear wall faced with steam generating tubes 12 some of which are bent to form a screen 13 over which the gases from furnace 1 first pass while others form a second screen 14 spaced outwardly from the first. Preferably all of the walls of the furnace are faced with steam generating tubes. Between the spaced screens 13 and 14 is one section 16 of the superheater. In the downpass 15 intermediate the screen 14 and the bank 5 is located another part of the superheater; this may be constructed as a single group of parallel tubes interconnected for serial flow of steam through successive tubes and extending for substantially the full length of pass 15 or it may be constructed as shown in two superimposed groups of tubes 18 and 19 connected for series flow of steam there-through.

The gases leaving the furnace pass over screen 13, section 16 of the superheater; screen 14, and thence downwardly along and parallel to the tubes

of superheater sections 19 and 18. Some of the gases upon entering superheater section 19 may pass thereacross and enter the top of the steam generating bank 5, thence pass downwardly through said bank to outlet 11. The gas flow through said bank may be regulated by damper 20 which thus controls a by-pass around the superheater. The gases leaving the superheater turn and pass transversely over the bottom ends of the tubes of bank 5 and then join the gases flowing through the superheater by-pass to flow together through economizer 8 to the boiler off-take 21.

From superheater inlet header 24 steam flows downwardly and serially through superheater groups 18 and 19 to the section 16 as indicated by the arrows. It will be noted that the lower group 18 receives the coldest steam which then passes to the upper group 19 to meet the hotter gases before leaving that section of the superheater. In this way partial counterflow of steam and gases is established. From superheater group 19 the steam then passes to superheater section 16 and after passing through this section is delivered to offtake header 25. In general the gases pass over superheater sections 18, 19 along or parallel to the superheater tubes. The above described arrangement is conventional.

Because the heat transfer rate with gases flowing parallel to the axis of tubes is substantially less than that when flowing across the tubes, the corresponding sections 18A, 19A of Fig. 2 of our improved superheater are arranged for a flow of the gases transverse to the axis of the superheater tubes throughout the gas path as well as for a counterflow of the gases with respect to the steam. Figure 2 shows a partial section of a steam generator and associated superheater with superheater sections 18A and 19A through which the steam flows serially as shown by the arrows. The steam leaving the front of section 18A is conveyed by tubes 26 to tubes at the rear of section 19A. The tubes 26 extend between the two sections and across from the front to the rear thereby forming a support for a special baffle 27 mounted intermediate and separating the sections. Baffle 27 is spaced forwardly from bank baffle 9 and extends forwardly to meet a baffle 28 mounted on a row of furnace tubes which are spaced forwardly with respect to the section 18A to form a gas chamber 31. At about the middle of section 18A a finger baffle 29 extends from the forward bank baffle 9 toward the front side of section 18A. By this arrangement the furnace gases enter the upper section 19A, flow transversely of the tubes, and in counterflow with respect to the steam flowing through the tubes thence pass downwardly and transversely over the upper portions of the tubes of section 18A in parallel flow with respect to the steam, thence pass through gas chamber 31 and across the lower ends of the tubes of group 18A again in counterflow with respect to the steam flow.

In this arrangement of the superheater sections and baffling therefor the advantages of cross flow and counterflow are more nearly realized than heretofore and it has been found that a reduction in the total heating surface is obtained; it also permits an increase in the tube spacing, which has the advantage of reducing the gas velocities and the draft loss through the superheater as well as reducing the tendency of slag adhesion. It also permits easier removal of slag from the tubes by lancing or by soot blowers.

Above superheater section 19A is a baffle 32

which baffle extends from baffle 9 over section 19A at a level above the tubes of section 16. In this way any gas that is by-passed through the boiler bank is forced to pass above the top of the superheater and out of contact therewith. In the conventional arrangement of Fig. 1, the by-passed gases flow over the superheater sections 16, 19 and thence into the by-pass so considerable superheat is generated, which tends to minimize the control of superheat through by-passing the gases because the rate of heat transfer at this point in the superheater is still relatively high; or an excessive amount of gases must be by-passed to obtain the desired control. According to the improved arrangement shown in Fig. 2, these objections are completely overcome. It is an advantage to by-pass the gases coming from the top of the furnace rather than from a point lower down in the furnace since the gases that reach the top of the furnace have given up more of their heat to the furnace tubes and are relatively cooler thereby resulting in less heat to be absorbed in the by-pass and less severe service on the baffles, dampers etc.

A further advantage of our arrangement of Fig. 2 is that the by-pass damper is located at a lower point of the tube bank and baffle 10 extends downwardly across the bent parts of the tubes in the lower part of the bank so as to direct the gases downwardly into the stream from the superheater pass. The gases leaving the by-pass may be hotter than those leaving the superheater and by this arrangement intermingle with the latter below the tubes of the banks and pass over the bottom ends of the tube bank to be thoroughly mixed so as to enter the economizer at a uniform temperature. This distinguishes from the arrangement shown in Fig. 1 where because the gases flow through a shorter by-pass with less heat absorbing surface they leave hotter and are then directed upwardly into one part of the economizer which is therefore in danger of becoming overheated.

In the modification shown in Figure 3, some of the furnace tubes 12 which form the support of the baffle 28 between the furnace and the superheater, pass between the superheater sections 18 and 19. The path of steam flow through the tubes as shown by the arrows is somewhat different from that in Fig. 2 with the result that the gases flow across the tubes of section 19B in counterflow with respect to the steam as in Fig. 2 thence across the upper portion of the section 18B in counterflow instead of parallel as in Fig. 2 and thence across the lower portion of section 18B in parallel flow rather than counterflow as in Fig. 2. Obviously additional superheater sections may be added in additional passes wherein the steam flow will be generally counter to the gas flow.

In Figure 4 the gases flow into an up-pass communicating with the furnace and the superheater sections 16, 18C and 19C are all so disposed and their interconnections for fluid flow so arranged that the gases flow transversely of the tubes and the steam flows counterflow with respect to the gases.

While several modifications of the invention have been illustrated and described in detail, it is to be understood that the invention is not limited to the precise forms or arrangements shown but comprehends other alternatives and mechanical equivalents of the apparatus herein illustrated and falling within the scope of the appended claims.

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What we claim is:

1. A steam generator comprising a water-cooled furnace defined by bottom, side and end walls and a roof with a gas outlet in one wall near the roof, an offtake, and means defining a gas pass intermediate and in communication with said furnace outlet and boiler offtake; a superheater including at least two sections of interconnected tubular elements arranged one above the other in said gas pass with the axes of the tubes of each section disposed substantially vertically; baffle means associated with said sections and mounted transversely with respect to the tubes thereof so as to cause flow of furnace gases across the tubes of the sections, the sections being so interconnected that fluid flowing therethrough advances from tube to tube in major part at least counter to the gas flow.

2. A steam generator comprising a water-cooled furnace defined by bottom, side and end walls and a roof with a gas outlet in one wall near the roof; an offtake, and spaced wall means defining a gas pass intermediate and in communication with said furnace outlet and boiler offtake; a superheater including at least two sections of interconnected tubular elements arranged one above the other in said gas pass with the axes of the tubes of each section disposed substantially vertically; baffle means disposed between said superheater sections and extending from one wall of said gas pass to a point short of its other wall and other baffle means extending partially across the tubes of the lower section from said other wall to a point short of said one wall to cause

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flow of furnace gases transversely of the tubes of the upper section and thence back and forth across the tubes of the lower section, the tubes of the superheater being so interconnected that fluid flows therethrough in major part counterflow to the gas flow.

3. A steam generator comprising a water-cooled furnace defined by bottom, side and end walls and a roof with a gas outlet in one wall near the roof, an offtake, and spaced wall means defining a gas pass intermediate and in communication with said furnace outlet and boiler offtake; a superheater including at least two sections of interconnected tubular elements arranged one above the other in said gas pass with the axes of the tubes of each section disposed substantially vertically; baffle means disposed between the superheater sections and extending from one wall of said gas pass to a point short of its other wall with other baffle means extending partially across the tubes of the bottom section from said other wall to a point short of said one wall to cause flow of furnace gases transversely of the tubes of the top section, and thence back and forth across the tubes of the bottom section, the tubes of the top section being so interconnected that fluid flowing therethrough advances from tube to tube in counterflow to the gas flow and the tubes of the bottom section being so interconnected that fluid flowing therethrough from tube to tube is in parallel flow to the first flow of the gases thereover and in counterflow to the second flow of gases thereover.

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