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R. K. BEHR

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BOILER

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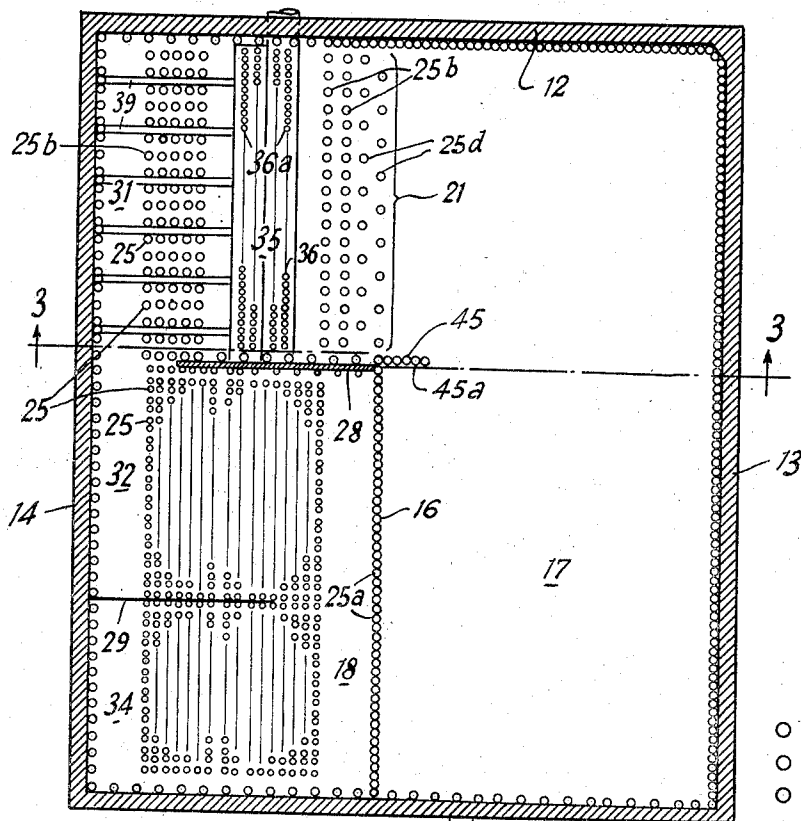


Fig. 4

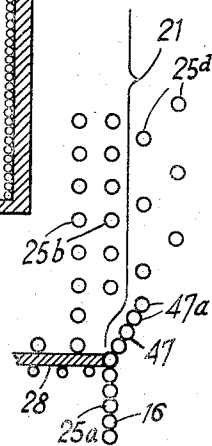


Fig. 5

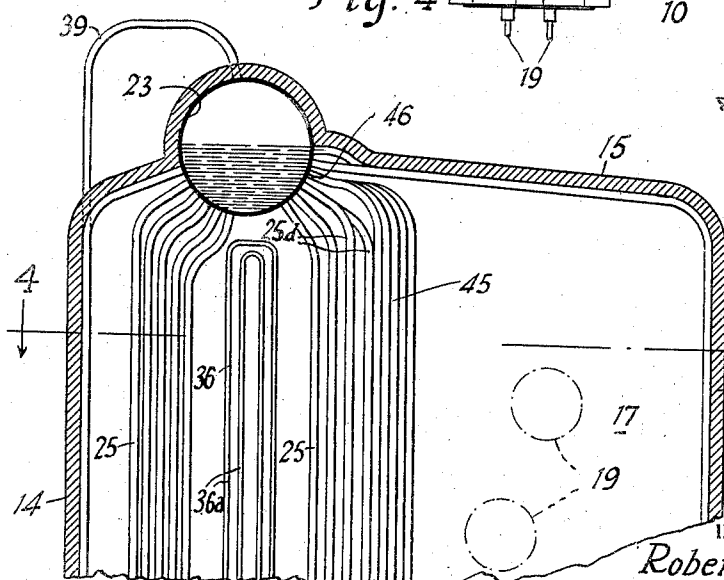


Fig. 3

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BOILER

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1 Claim. (Cl. 122—336)

1

The invention herein disclosed relates to the construction and operation of a type of water tube boiler having a considerable portion of its heating surface formed of water tubes arranged laterally adjacent an associated combustion chamber.

My invention relates especially to boilers of the character described wherein the space containing boiler tubes is partitioned from the combustion chamber and an entrance for heating gases is provided at one end adjacent a wall of the setting. The boiler tubes are suitably arranged in a bank extending between opposite walls of the setting and the heating gases which enter from the combustion chamber adjacent one of the walls are usually directed horizontally in one or more heating gas passes across the boiler tubes for discharge from the setting adjacent the opposite wall.

With certain combustion chamber arrangements, including for example the disposition of firing means for the chamber, the heating gases approaching the entrance to the boiler space are caused to flow through the combustion chamber in a direction generally longitudinally of the partition wall whereupon, after entering the space, the gases flow through the heating pass or passes in the opposite direction also generally longitudinally of the wall. The gases are therefore compelled to make an abrupt turn of substantially 90° to enter the first heating gas pass and thereafter to completely reverse their previous direction of flow to continue their passage to the boiler gas outlet.

In such constructions, there is a tendency for uneven distribution of heating gases to boiler tubes at the entrance to the first heating gas pass, both as to gas temperature and gas quantity and, as a result, certain of the boiler tubes adjacent the entrance are deprived of their proportionate share of the heating effect of such gases which to some extent impairs the efficiency of the boiler unit. When the fuel is pulverized coal or the like, those boiler tubes which lie in the path of concentrated heating gas flow are apt to become heavily coated with slag which also contributes to decreased operating efficiency of the unit, besides necessitating frequent cleaning of the tubes.

Unequal distribution of gas flow into the first heating gas pass may also have a detrimental effect on superheater operation particularly when the superheater is positioned adjacent the entrance to the pass as is often the case. On the other hand, uniform distribution of gases to the pass and across the superheater enables a maxi-

2

mum transfer of heat to be obtained throughout the superheater without exceeding the maximum safe operating temperature of the superheater tube metal.

An object of my invention is therefore to provide substantially uniform distribution of heating gases to the heating surface of a boiler unit such as described.

Another object of the invention is the provision of upright boiler tubes disposed in suitable relation to the entrance to a heating gas pass to effect substantially uniform distribution of combustion gas flow into the pass.

An additional object is the provision of a limited number of boiler tubes arranged in a series angularly disposed with respect to the defining wall of a heating gas pass to effect substantially uniform distribution of heating gases to the pass in a horizontal direction.

A further object is the method of effecting even distribution of heating gases to a heating gas pass having its entrance disposed at an abrupt angle to the approaching course of flow of such gases.

Among other objects is the provision of means for effecting even distribution of furnace gases to a first boiler heating gas pass while causing ash or other entrained solids to be discharged from the heating gas stream.

While baffles forming an angular extension of the partition have been used in steam boilers of this general type as shown in U. S. Patent 2,186,919, E. G. Bailey, in such cases the baffle extended across substantially the entire width of the entrance pass, and functioned primarily to prolong the flow path of the gases in the furnace chamber and to shield substantially all of the tubes in the first pass from radiant heat. With such constructions the heating gas flow is confined to the relatively narrow space between the end of the partition extension and the rear wall. A gas throttling effect results which tends to promote a large eddy current or recirculation effect across the forward rows of tubes in the first pass. This effect is confirmed by the fact that in the commercial operation of such units, any slag carried by the heating gases tends to deposit on the tubes directly opposite the gas entrance.

The various features of novelty which characterize my invention are pointed out with particularity in the claim annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and

descriptive matter in which I have illustrated and described preferred embodiments of my invention.

Fig. 1 of the drawings is a sectional elevation illustrating a form of water tube boiler in which my invention is embodied;

Fig. 2 is a sectional plan of the boiler shown in Fig. 1, taken along line 2-2;

Fig. 3 is a fragmentary view similar to Fig. 1 showing an embodiment of my invention in modified form;

Fig. 4 is a sectional plan of the boiler shown in Fig. 3, taken along line 4-4; and,

Fig. 5 is a fragmentary view, in sectional plan similar to Fig. 4, showing a further modification.

The boiler unit shown in Figs. 1 and 2 is generally of the type disclosed in the aforesaid U. S. Patent 2,186,919 and comprises a setting of rectangular cross section having upright front and rear walls 10 and 12, respectively, upright side walls 13 and 14, and an upper enclosing wall or roof 15. The space within the setting is divided horizontally by a partition 16 formed of upright boiler tubes to be later described, the space at one side of the partition serving as a combustion chamber 17, and the space at the opposite side a boiler compartment or passage 18 receiving hot heating gases from the combustion chamber 17.

Burners 19 of a type suitable for burning the kind of fuel desired are positioned in the front wall 10 for projecting flame horizontally through the combustion chamber toward the rear wall 12, the hot gases of combustion entering the boiler passage 18 through the entrance opening 21 formed between one end of the partition 16 and the rear wall 12. The spent heating gases are suitably discharged from the boiler passage 18 through a gas outlet, not shown, from a region adjacent the front wall 10 as disclosed for example in the aforesaid patent.

The boiler structure comprises horizontally disposed upper and lower boiler drums 23 and 24 connected by a boiler tube bank 25 having its tubes arranged upright in rows extending longitudinally of the drums 23 and 24. In the embodiment disclosed the tubes have the major portions of their lengths straight and vertically disposed with their upper and lower end portions bent to enter the drums radially.

Each of the setting walls 10, 12, 13, and 14 is lined with fluid cooling tubes 10a, 12a, 13a, and 14a suitably connected to the drums 23 and 24, in parallel with the boiler bank 25, to provide natural circulation sections of the complete boiler circulatory system; the side wall tubes 13a being extended upwardly along the roof 15 to connect with the upper drum 23, and terminating at their lower ends in a header 26 from which connections are made to the lower drum 24 through the floor tubes 27, similar to the arrangement shown in the above mentioned patent.

Transverse baffles 28 and 29 are positioned intermediate the front and rear walls 10 and 12 to provide a plurality of serially connected passes 31, 32, and 34 through which a substantially horizontal flow of heating gases is maintained over the tube bank 25 from the entrance opening 21 into the first pass 31 to the above mentioned gas outlet leading from the third pass 34.

Tubes 25a of the bank 25 are arranged in tube-to-tube relation to form the partition 16

which extends across the second and third heating gas passes 32 and 34 from the inner end of the baffle 28 to the front wall 10.

Tubes 25b of the bank 25 in the first pass 31 are preferably of larger diameter and are more widely spaced, both longitudinally and transversely, than the tubes 25c in the succeeding passes 32 and 34, the tubes 25b being arranged in horizontally spaced groups to provide an intermediate space 35 for a superheater 36, here shown as being formed of a succession of vertically extending looped tubes 36a having their lower ends connected to inlet and outlet headers 37 and 38 respectively; the inlet header 37 being suitably connected to the upper stream and water drum 23 by means of a plurality of longitudinally spaced tubular connectors 39 extending downwardly along the side wall 14 between certain of the side wall cooling tubes 14a and thence inwardly between transverse rows of boiler tubes 25b in the first pass 31.

Forwardly of the superheater 36 the tubes of the boiler bank 25 are formed in a group comprising two rows of tubes 25b arranged and spaced substantially as the tubes 25b disposed rearwardly of the superheater, and two rows of tubes 25d arranged in staggered relation to form a well known pattern of slag screen whereby increased entrance area is provided for admission of heating gases into the bank 25.

The heating gases generated in the combustion chamber 17 are first directed longitudinally of the chamber toward the fluid cooled wall 12 at the rear, by reason of the burners 19 being positioned in the front wall 10, the velocity of gas flow being sufficiently high to provide a tendency for the gases to maintain their original direction of flow beyond the end of the partition wall 16, with the result that when their direction of flow changes to enter the first pass 31, there is a greater concentration of gas flow through the rear portion of the entrance opening 21 adjacent the wall 12 than through the front portion adjacent the transverse baffle 28.

In order to effect substantially uniform distribution of gas flow into the boiler tank 25, and across the superheater 36, a baffle structure is provided comprising spaced gas deflector units or baffles 41 arranged in stepped succession in a row extending obliquely across the opening 21 into the first pass 31; the baffle 41a at the front end of the row being positioned adjacent the inner end of the partition wall 16, and the baffle 41b at the rear end of the row being positioned adjacent the rear wall 12 of the combustion chamber.

Each of the deflector baffles 41 as shown is formed of boiler tubes 41x, 41y, and 41z having the major portions of their lengths straight and vertically disposed in parallel relation to corresponding straight length portions of the boiler bank tubes 25b and 25d; the baffle tubes having their upper and lower end portions suitably bent for radial entrance into the boiler drums 23 and 24 in circumferentially spaced longitudinal rows 42 and 43. The straight length portions of the tubes forming each baffle 41 are preferably arranged at spacings sufficiently small to provide an appreciable directional influence on the approaching stream of heating gases which is to be guided thereby into the first heating gas pass 31. In the illustrated embodiment the spacing is at a minimum since the component tubes 41x, 41y, and 41z are in contacting relation to provide a baffle structure substantially impervious to gas flow between adjacent tubes. Suitable known

means, not shown, may be utilized for maintaining successive baffle tubes in contiguous relation, or for otherwise maintaining each group of tubes 41x, 41y, and 41z as a unitary substantially continuous, gas deflecting structure. Individual baffles 41 may alternatively be formed by two or more spaced tubes, with suitable closure means provided for the intertube space or spaces.

The row of deflector baffles 41 is inclined at approximately 45° to the plane of the partition 16, with each succeeding baffle disposed farther from the plane of the partition than the preceding baffle; successive baffles being arranged at substantially equal spacings within the row, with the end baffles 41a and 41b arranged at somewhat smaller spacings from the partition and from the rear wall 12. The straight length portions of tubes 41x and 41y of each baffle have their center lines in a common plane normal to the longitudinal axes of the drums 23 and 24, while the tube 41z is displaced forwardly of the common plane at an angle of from 45° to 60° thereto to provide a baffle 41 having its leading edge or portion oblique to the longitudinal direction of flow of the approaching combustion gases.

In the specific arrangement shown, each baffle of the series extends outwardly from the opening 21 to a position where its outer edge is at least in alignment with, if not actually overlapping, the inner edge of the next adjacent baffle; for example, the front tube 41z of baffle 41a and the rear tube 41x of the next adjacent baffle 41 are tangent to a common plane parallel to the partition 16 and to the generally longitudinal direction of flow of the approaching heating gases.

Each baffle 41, which is arranged transversely with respect to the general flow of gases toward the rear of the combustion chamber 17, has two distinct effects on gas flow conditions each of which contributes to improved distribution of the gases across the gas discharge opening 21. First, there is a deflecting action resulting from the transversely extending face of the baffle being impinged upon by a portion of the gas stream flowing longitudinally of the chamber 17; this forward face acting to deflect the major portion of the gas intercepted thereby and directing that major portion toward the side wall opening 21, particularly because the outer edge of the baffle farther from the opening is slightly upstream with respect to the inner edge adjacent the opening. Secondly, some of the gas that impinges on the outer leading edge of the baffle, as well as gas flowing longitudinally of the furnace past the outer edge of the baffle, expands laterally into the space adjacent the rearward side of the baffle whereby a gas eddy is set up which induces a lateral deflection of gas from the stream passing the outer edge of the baffle and thus acts to cause a second diversion of gas toward the entrance to the gas pass 31. The same set of actions is repeated with succeeding lateral divisions of the total gas stream by the successively spaced baffles 41 in the diagonal row. Thus with the gases of combustion more or less uniformly distributed across the width of the combustion chamber between its defining walls 13 and 16, and with the deflection and redistribution of the gases in advance of the opening 21 by the baffles 41, an optimum distribution of gas flow throughout the width of the pass 31 is effected, both with respect to thermal and quantitative characteristics, whereby the entire heating surface of the superheater 36, or other heat exchange surface similarly positioned, may be utilized to its maximum

heat absorbing capacity without risk of damage to the metal of its tubes.

In the modified construction shown in Figs. 3 and 4, the boiler unit is of the same integral furnace type as that previously described, and in view of the similarity a number of previously disclosed details of structure have been omitted for simplicity of illustration and description. The boiler is represented however as being of greater capacity, utilizing a greater number of transverse rows of boiler tubes than in the former embodiment and a correspondingly greater depth of furnace and combustion chamber 17 between the front and rear walls 10 and 12. The comparative ratios of furnace depth relative to furnace width are approximately, somewhat greater than 1:1 for the unit of Figs. 1 and 2 and somewhat greater than 2:1 for the unit of Figs. 3 and 4.

The hot gases of combustion are projected longitudinally of the chamber 17 toward the rear wall 12 as in the former embodiment and due to their relatively high velocity of flow there is a marked tendency for a greater proportion of the gases to enter the first pass 31 through an area adjacent the rear wall 12 than through the remaining area adjacent the transverse baffle 28.

The means employed in this instance for improving distribution of gas flow into the first pass 31, and across the superheater 36, is a modification of the structure previously described and comprises a baffle 45 extending into the combustion chamber 17 from adjacent the rear end of the partition wall 16. The baffle 45 also extends beyond the front row of boiler tubes 25d which as shown is substantially in alignment with the row of tubes 25a forming the partition 16.

The baffle 45 is conveniently formed by tubes 45a corresponding in diameter to the tubes 25a of the partition 16, and the baffle constituting, in effect, an angularly disposed extension of the partition 16. The tubes 45a have the major portions of their lengths straight and vertically disposed, similar to the formation and disposition of other tubes of the boiler; the upper and lower ends of the tubes 45a being suitably bent for radial entrance into each of the boiler drums 23 and 24 in a single longitudinal row 48. As shown, each baffle tube 45a is in contact with the tube adjacent throughout the row, in which relation such tubes may be held by suitable means, not shown.

The baffle or deflector 45 is thus positioned in the path of the approaching gases where it is impinged upon by a marginal portion of the total gas stream, thereby causing the impinging portion to be deflected into the main body of combustion gases and breaking up a part of their velocity head as the gases enter the region fronting the entrance 21 to the first pass 31. Such impingement and deflection tends to effect substantially complete redistribution of the flowing gases so as to improve both thermal and quantitative distribution throughout the entire gas body before the gases contact tubes of the boiler bank 25. Furthermore, as described in connection with each baffle 41, the flow of gases around the end of baffle 45 results in the creation of an eddy adjacent the rear side of the baffle which assists in the distribution of furnace gases in a horizontal direction at the side toward the entrance 21, and thus serves to equalize flow of the gases substantially throughout the entire entrance area into the first pass 31. Although the baffle 45 is shown at right angles to the partition 16, it is not essential that this particular angular relation be

maintained in every case provided the angularity selected is sufficient to effect the thoroughness of gas redistribution desired.

The modification shown in Fig. 5 employs a narrow tubular baffle 47 formed as an extension of the partition wall 16 and projecting across the entrance 21 to the first heating gas pass 31 in advance of the closely spaced boiler tubes therein. The baffle 47 extends in oblique relation to both the partition wall 16 and the transverse baffle 28 to define with the partition, at the furnace side, an included angle of approximately 150°.

In conjunction with this arrangement of extension baffle, the rows of boiler tubes in front of the superheater 36 may be so arranged as to position the first row of slag screen tubes 25d forwardly of the end of baffle 47, about as shown, and the first row of the more closely spaced tubes 25b substantially in or to the rear of a plane with the tubes 25a forming the partition 16. The baffle tubes 47a are practically in wall-to-wall contact to form a substantially impervious baffle; nevertheless, if it is desired to completely block off the intertube spaces, or to provide tube spacers to maintain the tubes 47a in alignment, suitable means for such purposes may be selected from devices well known in the art.

Comparing the arrangement of Fig. 5 with that of Fig. 4, it will be noted that several tubes 25b and 25d toward the front of the first pass 31 have been omitted to provide space for the baffle 47. The baffle tubes 47a may therefore be connected to the drums 23 and 24 in the same row or rows with the remaining tubes 25b and 25d without the necessity of providing an additional row of tube holes 46 as in Fig. 3.

The baffle 47 functions in substantially the same manner as the baffle 45 in improving distribution of gas flow into the first heating gas pass 31 throughout the area of the opening 21. The baffle 47 extends into the path of the approaching gases and thus acts to divert that portion of the gas stream flowing marginally of the combustion chamber adjacent the partition 16 into the main portion of the stream flowing through the central portion of the chamber, thereby causing a mixing and redistribution of these gas stream portions as they enter the furnace region fronting the entrance to the heating gas pass 31. As the gases turn to enter the pass 31, an eddy is created adjacent the rearward or downstream surface of the baffle 47, as described in connection with baffle 45, and with each of the baffles 41, thereby causing the gases to enter the pass more uniformly throughout the area of the entrance 21 instead of providing a concentration of gases toward the side of the pass adjacent the rear wall 12 as would normally result from their longitudinal direction of approach if the baffle 47 were not present.

When a fuel such as pulverized coal is being burned in the chamber 17, the baffle 45 or 47 serves a further purpose in that it prevents any concentrated flow of solid products of combustion along the partition 16 from entering the convection bank in the gas pass 31; the additional wall surface presented by the baffle 45 or 47 being disposed in the path of gases carrying such solids and effecting a separation of ash and slag particles from the impinging stream.

The extension baffle 45 or 47, whichever is used, is preferably so proportioned and arranged as to cause the eddy formed along its rearward surface to be localized to a region adjacent the en-

trance opening 21, as measured between the transverse baffle 28 and the rear wall 12, in alignment with the partition 16, the object being to secure as uniform thermal and quantitative gas distribution as possible before the gases enter the rows of heat exchange tubes of the unit which lie to the rear of the opening 21, particularly those tubes in which the internal fluid is maintained at the highest temperatures, such as the superheater tubes 36a which carry vapor and thus afford the maximum internal fluid film resistance to the transfer of heat.

It will be understood from the foregoing description that substantial uniformity of heating gas distribution should be adequately established at a position forwardly of any tubular heating surface the operation and length of service of which would be adversely affected by maldistribution of gas flow thereover. It is essential therefore, since optimum distribution of gas flow through the pass 31 depends on the creation of an eddy at the rear of each baffle 41, 45, or 47, that the magnitude of the eddy be controlled and its formation restricted to a region adjacent the opening 21 in advance of any row or group of tubes over which the distribution of gases is critical.

The horizontal extent of the baffle within the combustion chamber must therefore be limited and its actual width dimension determined in relation to the proportions of the combustion chamber with which the baffle is associated. Thus, for units of the general construction herein described, and for the purposes specified, it is contemplated to limit the distance that the baffle 41, 45, or 47 extends toward the side wall 13 and toward the rear wall 12 to twenty per cent of the total width of the particular gas flow path involved. For example, in the embodiments illustrated, the width of a baffle 41, 45 or 47, first, as projected on a plane normal to the longitudinally approaching gases, should not exceed twenty per cent of the total width of the gas flow path between the partition 16 and the side wall 13; and second, as projected on a plane normal to the flow of gases entering the opening 21, should also not exceed twenty per cent of the total width of the gas flow path afforded by the opening 21 between the end of the partition 16 and the rear wall 12.

I claim:

A fluid heater comprising a bank of upright heat exchange tubes disposed in a space laterally adjoining a combustion chamber, said chamber having oppositely arranged front and vertically disposed rear outer walls together with an inner side wall formed as an upright partition wall separating said space from said chamber and terminating in spaced relation to said rear wall to provide an opening from the side of said combustion chamber for the discharge of heating gases into said space, said chamber having a gas tight vertically disposed outer side wall connecting said outer front and rear walls, burner means associated with said front wall effecting substantially horizontal flow of heating gases rearwardly through said chamber throughout the total width thereof between said side walls at a velocity tending to concentrate said gases toward said rear wall in their flow through said opening, and means for distributing heating gas flow substantially throughout the width of said opening, said last named means comprising a gas deflecting structure constituting the sole gas distributing means within said chamber, said gas

deflecting structure extending a substantial distance into said stream of rearwardly flowing gases from adjacent the end of said partition without causing any substantial throttling of the gas flow between the combustion chamber and said tube space, and said structure being formed of closely spaced tubes arranged in a plane disposed at an acute angle to said partition and terminating in a free outer edge arranged parallel to said outer rear and side walls and extending a distance toward said outer side wall up to but not exceeding twenty per cent of the total width of said chamber and a distance toward said rear wall

up to but not exceeding twenty per cent of the width of said gas discharge opening.

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The following references are of record in the file of this patent:

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