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F. C. EMERY ET AL

2,279,564

APPARATUS FOR FLAME HARDENING TUBULAR STRUCTURES

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FIG. 1.

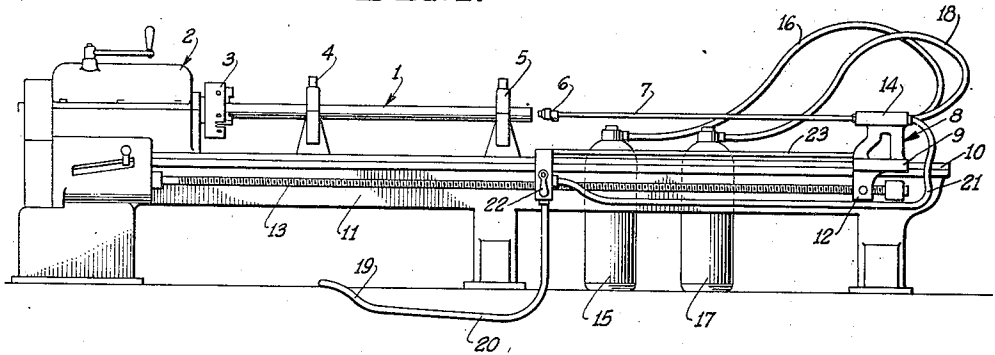


FIG. 2.

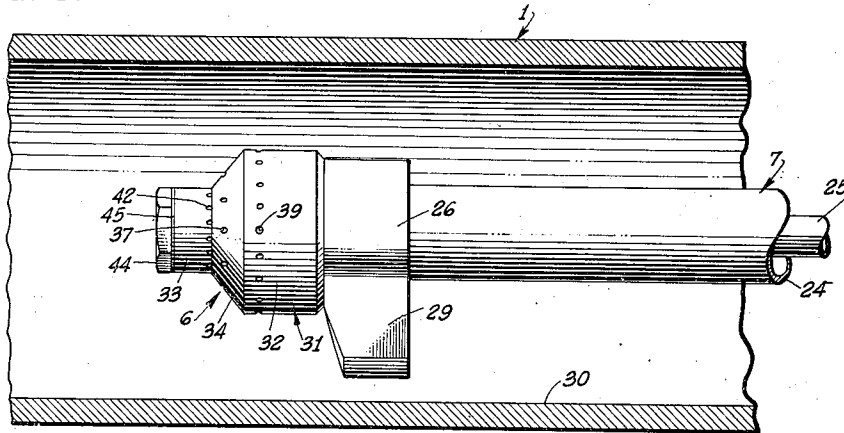
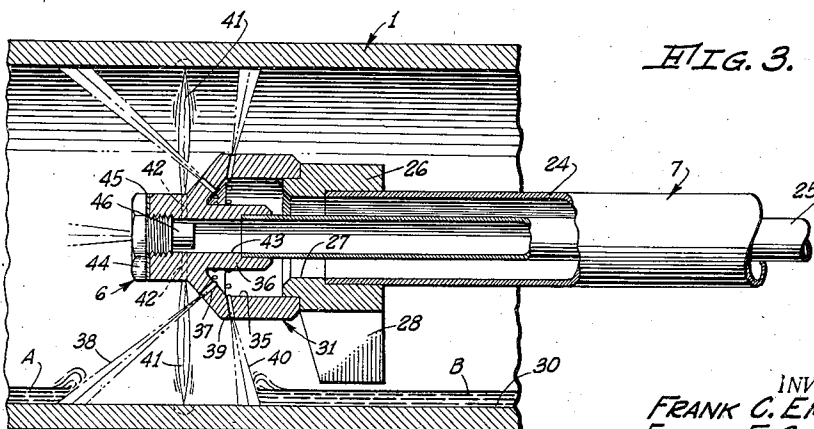


FIG. 3.



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APPARATUS FOR FLAME HARDENING
TUBULAR STRUCTURES

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Application October 30, 1939, Serial No. 301,923

8 Claims. (Cl. 266—4)

Our invention relates to an apparatus for flame hardening the interior surfaces of bores.

In many industries it is desired to harden the interior surfaces of bores on various pieces of machinery and the most effective means heretofore known for accomplishing this result has been to employ a case hardening process which is laborious and expensive and which process frequently leaves the hardened surfaces with scale or coatings of oxide which must be subsequently removed in order to provide smooth surfaces, particularly if the bores are to receive other machinery parts which move within the bores as is the case with engine and pump cylinders, linings therefor, sleeves, bushings, and the like.

While it will be understood that our invention is obviously applicable to the treatment of bores in any machine elements or parts regardless of length and diameter of the bores, our invention is particularly useful in connection with the manufacture of oil well pumps, wherein the barrel of the pump is usually formed of a relatively long length (up to twenty or more feet) of relatively small bore and thin walled tubing (internal diameters which range upwardly from about one inch and the wall thickness of which may be one-eighth of an inch or more). These barrels provide the pump cylinder within which reciprocates a pump plunger which must make sealing contact. It is therefore essential that the interior surface of the barrel be extremely smooth throughout its length, accurately sized throughout its length and present to the reciprocating plunger a hard, wear-resistant surface.

Though it is necessary to harden only the interior surface of any such bores, it is impossible, when using the case hardening process, to accurately and uniformly control the distribution of heat through all parts of the metal surrounding the bore to avoid the building up of undesirable internal stresses which, for example in thin walled structures, will result in the warping of the parts to such extent that many of them must be scrapped.

Because of the difficulties of accurately and uniformly hardening of the internal surfaces of pump barrels and the amount of spoilage which occurred as a result of the use of case hardening processes, it has been common practice to employ liners within the barrel constructed of a plurality of short sections of accurately sized tubing to provide the necessary accurately sized and hardened surface for cooperation with the pump plunger.

It is therefore an object of our invention to provide an apparatus by which bores may have their internal surfaces flame hardened by a flame hardening process in which a burner may be bodily introduced into the bore to direct jets of flame against the interior surface of the bore and in which a cooling medium is so introduced ahead of and behind the flame as to confine the application of heat to the surface to be hardened and to prevent the setting up of internal stresses which would be detrimental to the piece of machinery under treatment.

In our copending application Serial No. 301,922, filed October 30, 1939, we have described and claimed a method of flame hardening which may be successfully employed and the present invention is directed particularly to the novel and practical apparatus by which the foregoing object and other objects stated herein may be accomplished.

Another object of our invention is to provide a burner construction which may be employed for the flame hardening of bores in which the burner is so constructed as to provide a plurality of jets directed radially against the internal surface of the bore to provide a substantial circle of flame extending about the cross section of the bore and confining the heated area in a direction longitudinal of the bore by cooling medium which is introduced ahead of and behind the flame jets.

Another object of our invention is to provide a burner of the character described in the preceding paragraph wherein the cooling medium is introduced through the burner and acts to cool the gases supplied to the burner and to cool the burner itself and thereby avoid flash-backs or pre-ignition of the gases employed to produce the flame.

Another object of our invention is to provide a burner as described in which the cooling medium is ejected from the burner as two groups of spray streams, one group directed rearwardly of the flame jets and the other directed forwardly of the flame jets so as to produce, in effect, a pair of spaced circles of cooling medium extending across the cross section of the bore and defining a short zone between them within which the application of heat to the surface of the bore is confined.

It is also an object of our invention to provide an apparatus of the character set forth in the preceding paragraph in which means is provided for rotating the device having the bore to be treated about a horizontally disposed longitu-

dinal axis while the flame is being passed there-through to permit the use of water or other liquid cooling medium for both quenching and preventing pre-heating.

Another object of our invention is to provide an apparatus as set forth in the preceding paragraph wherein the cooling medium is introduced into the rotating bore to be treated as two separate injections, one directed forwardly of the advance of the flame and the other directed rearwardly of the flame so as to provide two continuous streams extending throughout the entire length of the bore, except the zone under treatment.

It is also an object of our invention to provide an apparatus of the character set forth in the preceding paragraph with a means for adjusting the rate of travel of the flame through the bore to control the depth to which the interior surface of the bore is heated to the desired temperature.

It is a still further object of our invention to provide in an apparatus of the character set forth in the preceding paragraphs a means for adjusting the heat of the flame, the rate of travel of the flame through the bore, and the rate of flow of cooling medium to the heated portions of the bore to permit the control of depth to which the surface is hardened, the degree of hardness imparted thereto and the degree of tempering effected upon the hardened portions of the surface.

It is a further object of our invention to provide in an apparatus of the character set forth in the preceding paragraph a means for supporting a burner centrally of the bore as it is passed longitudinally therethrough.

Other objects and advantages of our invention will be apparent from a study of the following specifications, read in connection with the accompanying drawing, wherein:

Fig. 1 is an elevational view illustrating one form of flame hardening apparatus of our invention;

Fig. 2 is a fragmentary enlarged longitudinal section illustrating the appearance of the burner shown in Fig. 1 and its relation to a bore in which it is inserted; and

Fig. 3 is a view similar to Fig. 2 but showing the burner in cross section to illustrate the details of construction.

Referring to the drawing, we have illustrated in Fig. 1 one form of flame hardening apparatus of our invention which is particularly adapted to the hardening of the internal surface of a long length, small diameter tube such as might be used for pump barrels. This apparatus is illustrated as including a means for supporting a relatively long length of small bore tubing 1 for rotation about its horizontally disposed longitudinal axis. The means for so holding and rotating the tubing 1 is illustrated in Fig. 1 as comprising a conventional engine lathe 2, it having been found that such a lathe is particularly adapted for this use, although it is to be understood that other types of apparatus capable of performing the desired functions would be equally suitable. The tubing 1 is grasped by a lathe chuck 3 so as to be rotated by the spindle rotating mechanism of the lathe 2. The mid-portion and out-board ends of the tubing 1 may be supported for rotation by means of steady rests 4 and 5.

A combination burner and spray head 6 is mounted for longitudinal axial movement along

the interior of the tubing 1, being supported upon a supporting tubular structure 7. The tubular supporting structure 7 may be carried in the tool post upon the conventional lathe carriage but we have found it desirable to substitute a carriage construction 8 which includes a guiding means 9 resting upon ways 10 of the lathe bed 11 and adapted to be slid therealong. The carriage 8 preferably includes a downwardly depending portion 12 which carries a means engaging a conventional lathe feed screw 13 so that rotation of this feed screw will operate to advance the carriage 8 along the ways 10 to cause the burner 6 to pass at a uniform rate longitudinally through the tubing 1.

The carriage 8 is provided with a manifold 14 into which is secured the tubular supporting structure 7. The manifold 14 preferably includes a means for adequately mixing in the proper proportions oxygen, which may be delivered from an oxygen supply tank 15 by means of a flexible hose 16, and acetylene, or other combustible gas, which may be obtained from a gas supply tank 17 and delivered to the manifold 14 by means of a flexible hose 18.

Provision is also made in the manifold 14 for receiving, but keeping separate from the mixture of oxygen and acetylene, a cooling medium, such as water, which may be supplied thereto from a suitable supply 19 by means of fluid connections 20 and 21. A control valve 22 is preferably interposed between the fluid supply lines 20 and 21 so that the rate of flow of cooling medium may be adjusted. The control valve 22 is preferably formed as a small carriage and includes means cooperating with the ways 10 of the lathe bed 11 to permit the control valve 22 to slide along these ways. The valve structure 22 is preferably connected by means of a bar 23, or similar connecting means, to the carriage 8 so that as the carriage 8 moves along the lathe bed 11 the control valve 22 is also caused to move therealong. The length of the bar 23 is so adjusted as to dispose the control valve 22 adjacent the burner 6 so that an operator disposed adjacent the control valve 22 may observe exteriorly the effects of the burner 6 within the tube 1 and control the amount of liquid flow in terms of what is observed.

We have illustrated in Figs. 2 and 3 the details of construction of the preferred form of combination burner and spray head 6 and tubular supporting structure 7 therefor. The tubular supporting structure 7 preferably comprises a relatively thin walled tubing 24 within which is concentrically mounted a similar but smaller piece of tubing 25. The tubing 25 is so connected to the manifold 14 as to convey to the burner 6 the mixture of combustible gases which is received from the supply tanks 15 and 17. The annular space between the exterior of the tubing 25 and the interior of the tubing 24 is connected within the manifold 14 to the liquid supply line 21 so that the cooling medium which is delivered thereby to the burner 6 surrounds the combustible gas which is contained within the tubing portion 25.

The combined burner and spray head 6 preferably includes a guiding or supporting portion 26 which is provided with an axially extending bore 27 adapted to receive the end of the outer tubing 24 and be secured thereto by any suitable means, such as brazing or silver soldering. The guiding and supporting structure 26 is provided with a pair of downwardly and outwardly directed feet

28 and 29 which are adapted to rest upon the interior surface 30 of the tubing 1 and operate to support the burner 6 substantially concentrically in the tubing 1 and relieve the load which is imposed by the burner 6 upon the relatively long length of the tubular supporting structure 7.

A burner head 31 is secured to that end of the supporting structure 26 which is opposite to that end secured to the tubing 24. The burner head 31 is preferably provided with a large diameter cylindrical portion 32 and a small diameter cylindrical portion 33 which are interconnected by a tapering or conical section 34. The enlarged cylindrical portion 32 is preferably machined so as to provide an internal recess 35 which is annular in shape having an internal boss 36 disposed centrally therein. The annular space 35 communicates with the bore 27 provided in the supporting structure 26 so that cooling medium which is conveyed through the annular space between the tubings 24 and 25 is conducted through the bore 27 and into the annular space 35.

A set of spray openings 37 comprising relatively small bore orifices are provided in the conical section 34 of the burner head 31 and communicate between the cooling medium space 35 and the exterior of the burner. Each of the orifices 37 is directed forwardly at an angle to the axis of the tubular support 7 so that jets of cooling medium 38 which are discharged therefrom are projected forwardly and strike the interior surface 30 of the tubing 1 at a point in advance of the forward end of the burner 6. A similar coacting set of orifices 39 is also provided which communicates between the exterior surface of the large diameter cylindrical portion 32 and the annular space 35. The orifices 39 are preferably directed rearwardly at an angle to the axis of the tubing 1 so that jets of cooling medium 40 discharged therefrom will strike the interior surface of the tubing 1 at a rearwardly directed angle thereto and at a position disposed to the rear of the orifices 39.

It will be observed that as the tubing 1 is disposed with its axis substantially horizontal and is being continually rotated about this axis by the spindle driving mechanism of the lathe 2 that the jets of cooling medium 38 which are directed forwardly will impinge upon the interior surface 30 of the tubing 1 at a forwardly directed angle so as to operate to force a continuous stream A of the cooling medium forwardly along the tubing to be discharged out that end which is carried in the lathe chuck 3. In a similar manner, the cooling medium which is directed against the interior wall 30 of the tubing 1 by the jets 40 will be forced thereby in a continuous stream B rearwardly along the tubing 1 to be discharged out the end thereof which is carried by the steady rest 5.

It will be apparent that the operation of the sets of jets 38 and 40 is to apply the cooling medium substantially uniformly to the entire interior surface of the tubing 1 with the exception of a relatively short cylindrical zone disposed between the zones of application to the interior surface 30 of the jets 38 and 40. It is against this longitudinally limited zone of the interior of the tubing 1 that a multiplicity of individual flame jets 41 is directed. The flame jets 41 are each preferably disposed substantially normal to the axis of the tubing 1, this disposition being obtained by providing a multiplicity of burner openings 42 which communicate be-

tween the exterior surface of the small diameter cylinder portion 33 and a longitudinal bore 43 extending therethrough. The bore 43 communicates with the interior of the gas supply tubing 25 and extends through the cylindrical boss 36 to which the end of the tubing 25 may be secured as by brazing or silver soldering.

The number of openings 42 employed is preferably made equal to or a multiple of the number of spray jet openings 37 employed, each of the openings 42 being disposed in staggered relationship relative to adjacent openings 37 so that the flame jets 41 are caused to pass between adjacent cooling medium jets 38. The extreme forward end of the bore 43 may be closed by means of a screw plug 44 threadedly engaged with the forward end of the bore 43 and adapted to clamp a seal or gasket 45 against the forward end of the small diameter cylindrical portion 33. The plug 44 is preferably formed with a longitudinally extending boss 46 which projects into the bore 43 so that by selecting the diameter and length of the boss 46 or by adjusting the extent to which it is located in the bore 43, the passage for gases through the bore and jets 41 may be regulated to produce the desired throw of the flames from the jets as well as to produce a steady, smooth, uniform flow of the gases therefrom.

In operation, the apparatus is set up in the fashion illustrated in Fig. 1, the proper proportions of oxygen and acetylene or other combustible gas are provided in the burner 6 and the burner ignited to provide the flame jets 41. A flow of cooling medium is then started by means of the fluid control valve 22 and the tubing 1 is rotated and the feed screw 13 engaged to cause the carriage 8 to advance to the left, as illustrated in Fig. 1, and cause the burner 6 to enter and pass through the interior of the tubing 1. As the burner 6 passes through the tubing, the cooling medium supplied by the jets 38 operates to cool the portions of the tube which are disposed ahead of the flame jets 41 to prevent preheating of the tube either by conduction through the metal or by the hot gases resulting from the combustion of the gases supplied to the burner.

It will be observed that as the burner 6 is advanced through the tubing, the flame jets 41 operate to heat that zone which lies between the two zones of application of the cooling medium jets 38 and 40. The rate at which the gases are supplied to the burner and the rate at which the burner is advanced through the tubing is so adjusted that this zone is heated to above the critical temperature of the particular steel from which the tubing is made.

As the burner 6 advances through the tubing the rearwardly directed jets 40 immediately come into contact with those portions of the interior of the tubing 1 which have been heated by the flame jets 41 and operate to quench these heated portions and harden the interior surface of the tubing in a well known manner. The cooling medium which is forced out the rear end of the tube by the jets 40 operates to continually cool the hardened portions of the tube to prevent annealing or tempering of these portions. It has been found, however, that if the rate of flow of cooling medium is properly controlled the hardened portions of the tubing may be reheated by conduction from the heated zone to provide a tempering of these hardened portions. It will be observed that the amount of tempering which is provided may be readily controlled by con-

trolling the rate of flow of the cooling medium to the burner.

Attention is also called to the fact that the depth to which the walls of the tubing 1 are heated to a temperature in excess of the critical temperature depends upon the rate of gas flow to the burner 6 and the rate at which the burner is moved through the tubing, while the degree of hardness is dependent upon the severity of the quenching action, which may be controlled by regulation of the amount of cooling medium which is supplied through the burner. Thus accurate control of the depth to which the hardening process is carried, the degree of hardness which is attained, and the amount of tempering which is applied to the hardened portions is readily obtained. In this fashion a bore may be provided with an extremely hard, wear resisting interior while retaining a tough, strong core or body for withstanding shocks and impact loads.

By employing a burner of the character described herein by which the cooling medium surrounds the supply pipe leading to the burner and also comes into intimate contact with the burner, the combustible gas mixture and the burner are maintained at such low temperatures as to prevent flash-backs and our burner can be successfully employed within tubes or bores having diameters in the order of one inch or less.

It has been found that an operator, by experience, may observe and recognize the operating conditions as regards the depth to which the hardening of the tubing is carried and the degree of hardness thereof by observing the exterior of the tubing at the location of the flame 41 within the tubing. It accordingly lies within the scope of this invention to centralize all of the controls of the apparatus upon the carriage which supports the fluid control valve 22 so that all of the variable conditions affecting the operation of the apparatus may be controlled by an operator immediately adjacent the point at which he must observe the exterior of the tubing in order to determine the interior operating conditions.

While the application of our invention to the hardening of small bore tubes has been, for purposes of illustration, specifically described herein, it will be understood by those skilled in this art that the principles of our invention may be readily employed for the flame hardening of the interior surfaces of other types of bores and for the effective treatment of other types of machinery in which the same problems are presented, and we, therefore, do not desire to be limited to any of the details illustrated and described herein, except as defined in the appended claims.

We claim:

1. In an apparatus for hardening the interior surfaces of bores in machine elements, the combination of: a burner; means for advancing said burner longitudinally through said bore; means on said burner for heating the interior surface of said bore to a temperature in excess of the critical temperature; and means associated with said burner for applying a cooling medium to said element within said bore on opposite sides of said burner to confine the heat to a short cylindrical zone and to quench and to harden the surface immediately after it is heated.

2. In an apparatus for hardening the interior surface of bores in machine elements, the combination of: a burner; means for advancing said burner longitudinally through said bore; means on said burner for directing flame against the

interior surface of said bore to heat a short cylindrical zone to a temperature in excess of the critical temperature; means associated with said burner for directing a cooling medium against said interior and about the entire periphery thereof immediately in advance of said zone to prevent pre-heating the metal in advance of the burner; and means associated with said burner for directing a cooling medium against said interior surface after it is heated to quench and harden said heated surface.

3. In an apparatus for hardening the interior of bores in machine elements, the combination of: means for rotating said element about the longitudinal axis of said bore disposed horizontally; a burner; means for advancing said burner longitudinally through said bore while said element is rotating; means for conveying a flame producing combustible mixture to said burner; means on said burner for directing flame against the interior surface of said bore to heat a short cylindrical zone to a temperature in excess of the critical temperature; and means associated with said burner for confining the heating effect of said flame to said zone comprising means for directing a cooling medium against said interior surface and forwardly in advance of said zone; and means for directing a cooling medium against said interior surface immediately after it is heated to quench and harden the heated surface.

4. In an apparatus for hardening the interior surface of bores in machine elements, the combination of: a burner; means for advancing said burner longitudinally through said bore; means on said burner for directing flame against the interior surface of said bore to heat a short cylindrical zone to a temperature in excess of the critical temperature; means associated with said burner for directing a cooling medium against said interior surface and about the entire periphery of said bore immediately in advance of said zone to prevent pre-heating thereof; means associated with and movable with said burner for directing said cooling medium against said heated surface immediately after it is heated to quench and harden said surface; a conduit for conducting said cooling medium to the location of said burner; valve means in said conduit for controlling the amount of cooling medium conveyed to said burner to control the severity of the quench; and means mounting said valve means for movement with said burner exteriorly of the bore along the side of said element.

5. In a burner for use in flame hardening the interior of bores, the combination of: a head insertable in said bore for advancing movement longitudinally therethrough; a gas passage in said head, a plurality of outwardly directed burner openings in said head communicating with said passage for directing flame against the interior surface of said bore included within a short cylindrical zone; a cooling medium space in said head surrounding said gas passage; one set of spray openings communicating with said medium space for directing a cooling medium therefrom against said surface and about the entire periphery thereof immediately behind said flame to quench and harden said surface after it is heated; and another set of spray openings also communicating with said medium space for directing said cooling medium therefrom against said surface and about the entire periphery thereof immediately in advance of said flame to prevent preheating thereof until said flame is brought into contact therewith.

6. In a burner for use in flame hardening the interior of bores, the combination of: a head insertable in said bore for advancing movement longitudinally therethrough; a gas passage in said head; a plurality of radially disposed burner openings in said head communicating with said passage for directing flame against the interior surface of said bore included within a short cylindrical zone; a liquid space in said head surrounding said gas passage; one set of spray openings disposed behind said burner openings communicating with said liquid space and directed rearwardly of said flame openings for directing a cooling medium therefrom against said interior surface rearwardly of the advancing flame to quench and harden said interior surface after it is heated; and another set of spray openings also disposed behind said burner openings communicating with said liquid space and directed forwardly of said flame openings for directing said cooling medium therefrom against said interior surface in advance of said flame to prevent pre-heating of the surface until said flame is brought into contact therewith.

7. In a burner for use in flame hardening the interior of bores, the combination of: a head insertable in said bore for advancing movement longitudinally therethrough; a gas passage in said head; a plurality of radially disposed burner openings in said head communicating with said passage for directing flame against the interior surface of said bore included within a short cylindrical zone; a liquid space in said head surrounding said gas passage; one set of spray openings disposed behind said burner openings communicating with said liquid space and directed at an angle rearwardly of said burner openings

for directing a cooling medium therefrom against said interior surface rearwardly of the advancing flame to quench and harden said interior surface after it is heated; and another set of spray openings also disposed behind said burner openings communicating with said liquid space and directed at an angle forwardly of and between adjacent ones of said burner openings for directing said cooling medium therefrom against said interior surface in advance of said flame to prevent pre-heating of the surface until said flame is brought into contact therewith.

8. In a burner for use in flame hardening of bores; a hollow substantially cylindrical burner body; a gas passage extending longitudinally therethrough; a gas conduit coupled to the burner at one end of said gas passage; a set of substantially radially extending gas openings communicating with said gas passage near the opposite end thereof; plug means in said opposite end having means thereon projected into said gas passage to restrict the passage adjacent said openings for producing a uniform flow of gas therefrom; a cooling medium conduit surrounding said gas conduit and coupled to said body to pass a cooling medium about said gas conduit and into the interior of said burner body; and a plurality of circumferentially spaced spray openings extending outwardly through said body for the passage of cooling medium, a part of said spray openings being spaced in staggered relation to the spacing of the gas openings and directed forwardly therebetween, the remainder of said spray openings being directed rearwardly.

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