July 15, 1958 C. C. CIPRIANI ET AL 2,843,107

COMBUSTION APPARATUS HAVING PILOT BURNER WITH BOOSTER

Filed Dec. 19, 1955 2 Sheets-Sheet 1

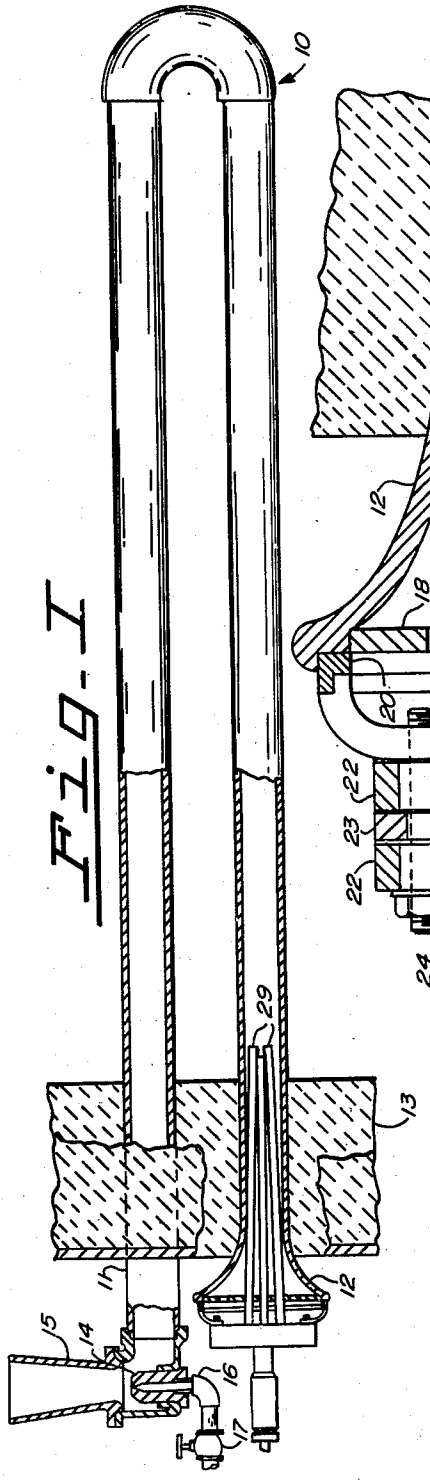


Fig. I

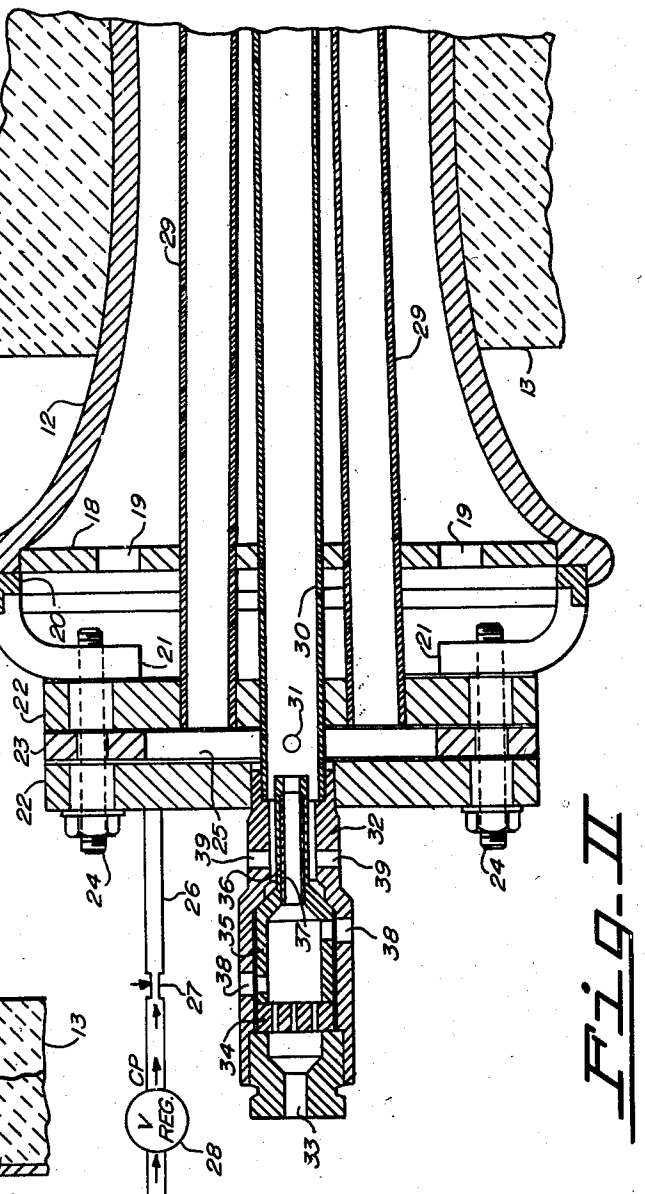


Fig. II

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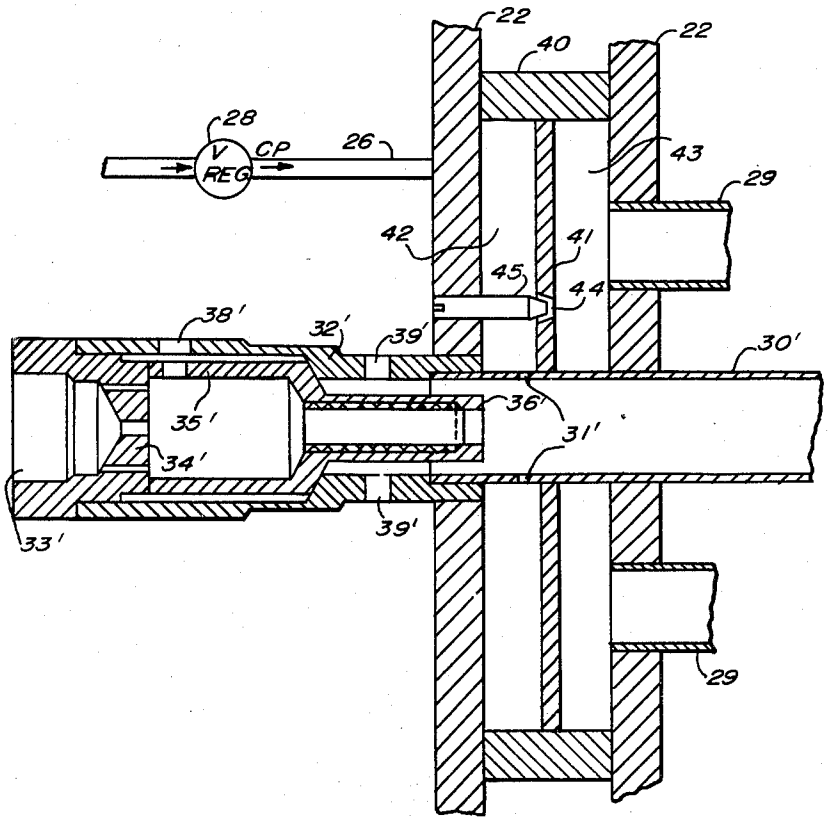


Fig. III

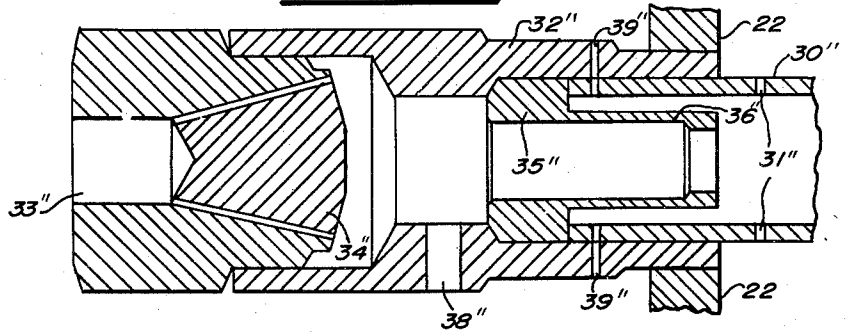


Fig. IV

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COMBUSTION APPARATUS HAVING PILOT BURNER WITH BOOSTER

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4 Claims. (Cl. 126—91)

This invention relates to a pilot burner with booster, for producing a flame at a location within a combustion apparatus that is relatively remote from the exterior of the apparatus.

In a combustion apparatus, such as a furnace, it is often desirable to cause a combustible mixture to ignite and burn at an ignition zone relatively remote from the exterior of the apparatus. That is true because a combustion apparatus or furnace is often provided with a relatively thick surrounding wall of firebrick, so that it is desirable that the flame formed from the combustible mixture be located entirely within the firebrick enclosure. If the ignition zone is located adjacent the exterior of a firebrick wall, so that the flame extends inward through an opening in the wall, the portion of the firebrick wall surrounding the opening through which the flame extends tends to become overheated and to deteriorate rapidly.

For these reasons, it is often desirable that a combustible mixture be supplied and ignited at a zone relatively remote from the exterior of a combustion apparatus, for example at a zone that is entirely within the enclosure formed by the firebrick wall of a furnace.

When a combustible mixture is thus supplied at an ignition zone relatively remote from the exterior of the combustion apparatus, it becomes important to provide a pilot burner which can be ignited from the exterior of the combustion apparatus, and which will produce a flame at the relatively remote ignition zone within the combustion apparatus. The present invention provides such a pilot burner. The accompanying drawings illustrate preferred embodiments of the invention.

In the drawings, Figure I is an elevation, partly in section, of a radiant tube installation embodying the invention.

Figure II is a fragmentary vertical section, on a larger scale, of the installation shown in Figure I.

Figure III is a fragmentary vertical section, on a still larger scale, showing a modification.

Figure IV is a fragmentary vertical section, on a further enlarged scale, showing a further modification.

These specific drawings and the specific description that follows merely describe and illustrate and are not intended to limit the invention.

The specific embodiment illustrated in Figures I and II comprises a radiant tube **10**, which may be employed for heating a furnace. In the form shown, the radiant tube is of hairpin shape and has an exhaust end **11** and a firing end **12**, extending to the exterior of the furnace through a firebrick wall **13**.

Associated with the exhaust end **11** is a draft producing device which may comprise a discharge nozzle **14** arranged to project a stream of fluid under pressure into an eductor tube **15**. The steam, compressed air or other fluid under pressure is supplied to the nozzle **14** by means of a supply pipe **16** provided with a valve **17**.

Pressed into the firing end **12** of the radiant tube is an air orifice plate **18** provided with orifices **19** through which

air is admitted to the firing end of the radiant tube. Also supported from the firing end of the radiant tube, by means of a mounting ring **20** provided with brackets **21**, are two plates **22**, which are separated by a spacing ring **23** provided with suitable sealing gaskets. The assembly consisting of the plates **22** and spacing ring **23** is held together by studs **24** threaded into the brackets **21**, and encloses a space forming a manifold **25**.

Fuel gas may be supplied to the manifold **25** through a pipe **26** having a variable orifice diagrammatically shown at **27**. Located ahead of the variable orifice **27** may be a constant pressure outlet valve **28**. Preferably the setting of the constant pressure outlet valve is such that the pressure on the outlet side of the valve is equal to atmospheric pressure.

Fuel gas may be led from the manifold **25** by a pair of fuel gas supply tubes **29** discharging at a point spaced from the firing end of the radiant tube and located inside of the firebrick wall **13**. With this arrangement, the valve **17** may be used to vary the suction produced by the draft producing device at the exhaust end of the radiant tube. Such variation in suction causes a corresponding variation in the rate at which fuel gas flows through the fuel gas supply tubes **29**. If the constant pressure outlet valve **28** is set to maintain an outlet pressure equal to atmospheric pressure, and if the variable orifice **27** remains at a constant opening, variation in the suction at the exhaust end of the radiant tube will cause the rate at which air enters through the apertures **19** to vary in the same proportion as the rate at which fuel gas enters through the fuel gas supply tubes **29**. Thus the proportions of fuel gas and air entering the radiant tube will remain constant at the desired ratio, so that the valve **17** provides efficient control of the rate at which heat is generated in the radiant tube.

In accordance with the invention, a flame tube **30** extends through the plates **22** and the air orifice plate **18**, and has its inner end terminating near the inner ends of the fuel gas supply tubes **29**. The flame tube **30** is provided with one or more apertures **31** for admitting fuel gas from the manifold **25**. Mounted in the outer manifold plate **22**, and forming an extension of the flame tube **30**, is a casing **32** provided with an inlet **33** through which is injected a pre-formed combustible mixture of fuel gas and air. Located near the outer end of the casing **32** is a ceramic fire screen **34**, which is provided with relatively narrow passages through which the pre-formed mixture of fuel gas and air flows, and which is designed to conduct heat away in the known manner so as to prevent a flame from striking back through the fire screen into the inlet **33**. A combustion chamber **35** is located in the casing **32** next to the fire screen **34**, and is provided with an outlet nozzle **36** which may contain a ceramic lining **37**. Extending through the walls of the casing **32** and the combustion chamber **35** are lighting holes **38**, which permit an operator to ignite the pre-formed mixture in the combustion chamber **35**. Passages **39** are provided in the casing **32** for admitting air into the outer end of the flame tube **30**.

The metal portions of the apparatus which are exposed to flame preferably consist of heat resistant alloy.

During the operation of this apparatus, a pre-formed mixture of fuel gas and air is injected continuously through the inlet **33**, and the rapidly flowing mixture burns constantly to form a flame which extends a short distance beyond the end of the nozzle **36**. The flow of the main supply of combustible gas may be started and stopped at will by turning on and off the supply of fluid under pressure entering the valve **17**. As soon as fluid under pressure is supplied to the valve **17**, suction is produced at the exhaust end of the radiant tube **10**, and fuel gas begins to flow through the fuel gas supply tubes **29**.

The suction applied to the exhaust end of the radiant tube also causes fuel gas to flow into the flame tube through the aperture or apertures 31, and causes air to flow into the flame tube through the passages 39. The flow of fuel gas and air into the flame tube is assisted by the fact that the nozzle 36 forms with the flame tube an eductor, the apparatus being so designed as to locate the aperture 31 in the region of reduced pressure produced by the jet issuing from the nozzle 36. The fuel gas and air entering the flame tube form a combustible mixture that is ignited by the flame issuing from the nozzle 36, and is propelled by the products of combustion from that flame, so that the resulting secondary flame is accelerated, and a flame emerges from the inner end of the flame tube 30 before the main supply of fuel gas accumulates in the radiant tube in an amount sufficient to cause an explosion. Thus whenever suction is applied to the exhaust end of the radiant tube, the early emergence of a pilot flame from the inner end of the flame tube produces smooth ignition of the main supply of fuel gas.

The early emergence of a pilot flame from the inner end of the flame tube 30 is due to the propelling action of the constantly flowing stream of a pre-formed combustible mixture which is injected through the inlet 33. Whenever suction is applied to the exhaust end of the radiant tube this propelling action accelerates the flow of the mixture of fuel gas and air entering the flame tube through the aperture 31 and the passages 39. The resulting early emergence of a pilot flame from the inner end of the flame tube 30 is important because it prevents an explosion which would be likely to extinguish all the flames, including the flame burning in the combustion chamber 35, and which would be undesirable for other obvious reasons.

When the fuel gas used is natural gas, it is often advantageous to design the apparatus so that for each volume of natural gas entering the flame tube through the aperture 31, about five volumes of air enter through the passages 39 instead of the ten volumes required for complete combustion. When that is done, considerable cracking of the excess gas takes place in the flame tube. The products of such cracking, which may contain atomic hydrogen, are highly combustible, so that the mixture burns strongly as it emerges from the flame tube and encounters a further supply of air. As shown in Figures I and II, the apertures 19 are distributed to provide a relatively uniform flow of air throughout the inlet end of the radiant tube, so that rapid and even mixing of the air and gas takes place in the tube.

It has been found that the particular apparatus illustrated in Figure II, if designed to operate properly when relatively low suction is applied to the exhaust end of the radiant tube, may not operate properly when relatively high suction is applied to the exhaust end of the radiant tube, for the following reasons:

Because of the pressure drop that exists across the variable orifice 27, the pressure in the manifold 25 tends to remain only slightly above the pressure prevailing in the firing end of the radiant tube. The pressure in the outer end of the flame tube 30 also tends to follow rather closely the pressure prevailing in the firing end of the radiant tube. Thus the pressure drop across the aperture 31 tends to remain relatively constant during wide variations in the suction applied to the exhaust end of the radiant tube, so that the rate at which gas flows from the manifold 25 into the flame tube 30 also remains relatively constant. At the same time however, since the pressure in the flame tube 30 follows rather closely the pressure in the firing end of the radiant tube, wide variations in the suction applied to the exhaust end of the radiant tube cause wide variations in the pressure drop across the passages 39 which admit air into the flame tube 30. Thus a substantial increase in the suction applied to the exhaust end of the radiant tube, while causing only a relatively slight increase in the pressure drop across the aperture 31, causes a relatively large increase in the pressure drop across the passages 39. Therefore, if the apparatus illustrated in Figure II is adjusted to provide for the admission of proper proportions of fuel gas and air to the flame tube when relatively low suction is applied to the exhaust end of the radiant tube, a substantial increase in the suction applied to the exhaust end of the radiant tube tends to cause air to flow through the passages 39 at a rate that is excessive compared to the rate at which fuel gas flows through the aperture 31 into the flame tube.

The embodiment illustrated in Figure III is designed to overcome this difficulty and to cause the proportions of fuel gas and air entering the flame tube to remain relatively constant during wide variations in the suction applied to the exhaust end of the radiant tube.

Although Figure III illustrates a specific embodiment of this improvement, the essence of the improvement resides in setting the constant pressure outlet valve 28 to maintain an outlet pressure substantially equal to atmospheric pressure, and in providing a separate connection leading from the constant pressure outlet valve 28 to the flame tube. Such an arrangement insures that the pressure drop in the passage leading from the constant pressure outlet valve 28 to the flame tube will remain substantially equal to the pressure drop across the passages through which air enters the flame tube, so that the proportions of fuel gas and air supplied through these passages will remain substantially constant throughout wide variations in the suction applied to the exhaust end of the radiant tube.

In the specific embodiment shown in Figure III, the plates 22 may be secured together in the same manner as the plates 22 shown in Figure II, but are separated by a relatively thick spacing ring 40 on both sides of which may be provided suitable sealing gaskets. A partition plate 41 fits tightly inside of the spacing ring 40 and outside of the flame tube 30', to form a separation between a primary manifold 42 and a secondary manifold 43. An orifice 44 in the partition plate 41, which provides an opening that may be varied by means of a set screw 45, takes the place of the variable orifice 27 of Figure II.

The operation of the embodiment shown in Figure III is the same as the operation of the embodiment shown in Figure II, except that when the constant pressure outlet valve 28 is set to maintain an outlet pressure substantially equal to atmospheric pressure, a pressure substantially equal to atmospheric pressure is maintained in the primary maniflod 42, so that the pressure drop across the orifices 31' is always substantially equal to the pressure drop across the passages 39'. Thus when the suction applied to the exhaust end of the radiant tube varies widely, the proportions of fuel gas and air drawn into the flame tube 30' through the apertures 31' and passages 39' remain substantially constant, and the proper proportions of fuel gas and air are supplied at all times to keep a flame burning properly in the flame tube 30'.

The embodiment shown in Figure IV is designed to give satisfactory operation either with natural gas or with coke oven gas. If the structure shown in Figure IV is designed and operated in such a manner that about five volumes of air enter the flame tube 30'' through the passages 39'' for every volume of fuel gas that enters the flame tube through the apertures 31'', the proportion of air will be sufficient for substantially complete combustion in the case of coke oven gas, although it is only about half of the amount required for complete combustion in the case of natural gas.

Because of the rapidity with which coke oven gas burns, the embodiment shown in Figure IV is designed to provide a relatively small enclosure between the fire screen 34'' and the nozzle 36'', so that a violent explosion will not occur when a pre-formed mixture of coke oven gas and air is ignited through the lighting hole 38''.

In order to be more suitable for use with coke oven gas, the apparatus shown in Figure IV is designed with a relatively deep fire screen 34'' to guard against striking back of the flame through the fire screen, and in general is designed to conduct heat away more rapidly so as to avoid overheating.

The pre-formed mixture of fuel gas and air may be supplied to the apparatus of Figure IV at a somewhat higher pressure. Although the flame produced when coke oven gas is used in the apparatus of Figure IV will not be as long as the flame produced when natural gas is used, the main supply of coke oven gas in the radiant tube ignites more readily than natural gas, so that when coke oven gas is used the gases emerging from the inner end of the flame tube will still be hot enough to ignite the main supply of gas in the radiant tube.

Various other embodiments of the invention may be devised to meet various requirements.

Having described the invention, we claim:

1. In a combustion apparatus within which a combustible mixture may be supplied at an ignition zone relatively remote from the exterior of the apparatus, in combination, a manifold for a combustible gas, means for conducting a main supply of combustible gas from the manifold to the ignition zone, a flame tube which extends from the manifold and has its inner end adjacent the ignition zone, and which has an aperture in direct communication with the manifold, a primary pilot combustion chamber, means to inject combustible gas into said chamber, a nozzle having a mouth within said flame tube adjacent said aperture, said nozzle being in communication with said chamber and being directed axially of said flame tube toward said ignition zone, the stream of gas from said chamber ejected from said nozzle along said flame tube, when ignited, being adapted to ignite and propel combustible gas entering the flame tube from the manifold, whereby, when gas is permitted to flow from the manifold, a pilot flame appears at the inner end of the flame tube before the main supply of combustible gas accumulates in an amount sufficient to cause an explosion.

2. In a combustion apparatus as claimed in claim 1, including a source of air, said flame tube having an aperture adjacent said nozzle mouth and in communication with said source of air, whereby air admitted to said tube is entrained in the stream from said nozzle to form a combustible mixture with gas admitted into the flame tube from the manifold.

3. In a radiant tube having a fuel gas supply manifold, means for conducting a main supply of fuel gas from the manifold into the tube to an ignition zone spaced a substantial distance from one end of the tube, and means for applying suction to the other end of the tube to draw air into the former end and to draw the main supply of fuel gas from the manifold, a pilot burner comprising, in combination, a flame tube which extends from the manifold into the radiant tube and has its inner end adjacent the ignition zone, the wall of said tube having a first aperture in direct communication with the manifold, and a second aperture adjacent said first aperture for admitting air into the flame tube to form a combustible mixture with fuel gas entering the flame tube from the manifold, a nozzle adjacent the outer end of the flame tube directed inward and axially with respect to the flame tube toward said ignition zone, said nozzle having a mouth in proximity to said first and second apertures to form with said flame tube an eductor tending to draw air and fuel gas into said flame tube when a stream of gas is injected into said tube therefrom, a source of gaseous combustible mixture connected to said nozzle to inject said mixture therefrom into said tube in a stream which, when ignited, is adapted to ignite and propel a combustible mixture formed in the flame tube, whereby, when suction is applied to the radiant tube, a pilot flame appears at the inner end of the flame tube before the main supply of fuel gas accumulates in an amount sufficient to cause an explosion.

4. In a combustion apparatus, in combination, a radiant tube, a source of fuel gas under a given pressure, means for conducting a main supply of fuel gas from such source into the tube, through a restriction, to an ignition zone spaced a substantial distance from one end of the tube, a source of air under substantially said given pressure, means for admitting air from said source, through a restriction, into such end of the tube, means for applying suction to the other end of the tube, to draw fuel gas and air into the tube through such restrictions, whereby the ratio of the volumes of fuel gas and air entering through such restrictions remains substantially constant with variations in suction, a flame tube having its inner end in the radiant tube adjacent the ignition zone, a separate connection for admitting fuel gas into the flame tube from said fuel gas source at a point spaced from said inner end, the wall of said flame tube having an aperture adjacent said connection for admitting air from said second source into the flame tube to form, with fuel gas admitted into the flame tube from such source, a combustible mixture in proportions that remain constant with variations in suction, a nozzle having a mouth adjacent said connection and said aperture, said nozzle being directed axially and inwardly of said flame tube toward said ignition zone to form with said flame tube an eductor tending to draw fuel gas from said connection and air through said aperture when a stream of gas is injected therefrom into said flame tube, and a source of a gaseous combustible mixture connected to said nozzle to eject therefrom into said flame tube a gas stream which, when ignited, is adapted to ignite and propel a combustible mixture formed in the flame tube, whereby, when suction is applied to the radiant tube, a pilot flame appears at the inner end of the flame tube before the main supply of fuel gas accumulates in an amount sufficient to cause an explosion.

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