

July 24, 1951

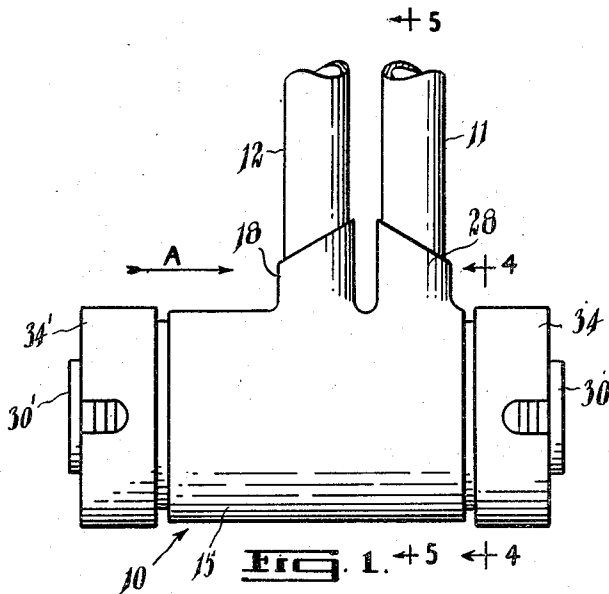
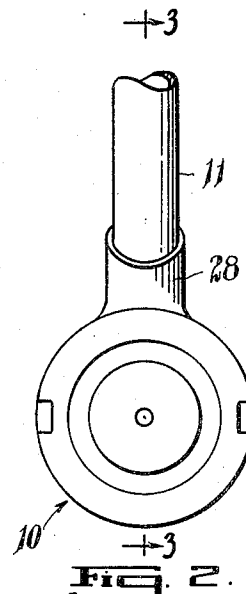
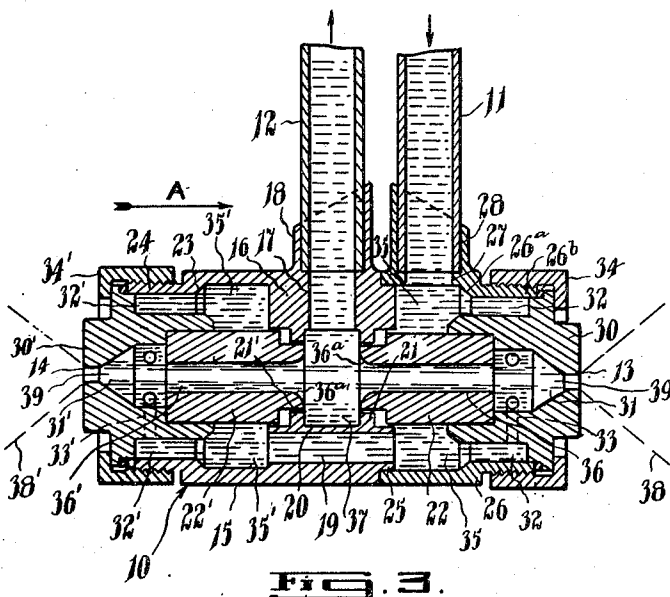
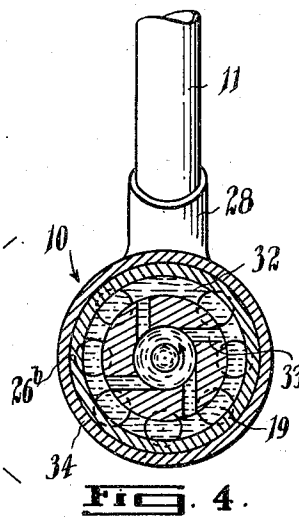
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2,561,939

DUAL SPRAY NOZZLE FOR FUEL BURNERS

Filed Dec. 30, 1948

2 Sheets-Sheet 1



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DUAL SPRAY NOZZLE FOR FUEL BURNERS

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2 Sheets-Sheet 2

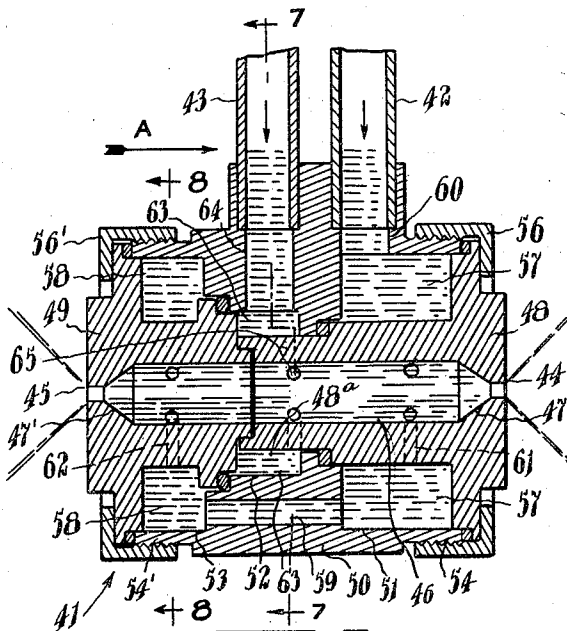


FIG. 6.

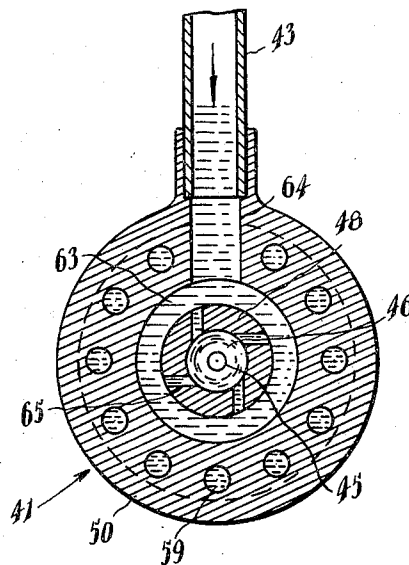


FIG. 7.

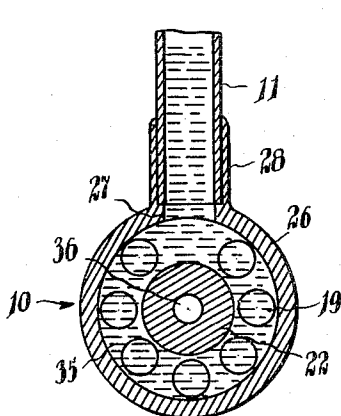


FIG. 5.

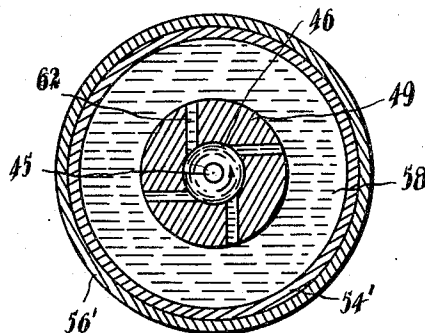


FIG. 8.

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UNITED STATES PATENT OFFICE

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DUAL SPRAY NOZZLE FOR FUEL BURNERS

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9 Claims. (Cl. 299—114)

1

This invention relates to improvements in fuel burners and in particular to burners for the combustion chambers of gas turbine engines.

In a gas turbine the fuel is injected into an air stream which has a high speed of flow and in order to obtain efficient combustion it is important that the fuel should be thoroughly atomized and distributed as evenly as possible across the air stream. It is also important that good atomization and distribution should be obtained at all speeds throughout the range of operation of the turbine and at all rates of fuel flow.

Atomization is commonly achieved by arranging the various ducts and chambers inside the burner so that the fuel in the burner is caused to rotate at a very high speed before emerging from the nozzle of the burner into the air stream. This rotation results in the fuel being sprayed from the nozzle in a cone of fine particles, but variations in fuel pressure and rate of flow directly affect this atomization and at low pressures the swirling of the fuel is reduced to such an extent that atomization is seriously impaired. Various devices have been adopted to overcome this difficulty and of these the so-called spill-type burner is perhaps the most effective. In the spill-type burner the supply pressure is preferably kept constant, thus ensuring constant rate of swirl, and fuel in excess of requirements at the nozzle is allowed to return to the tank through a controlled outlet line. Although this type of burner overcomes some of the chief problems of atomization, a single burner is liable to cause too great a concentration of fuel in limited areas of the air stream at high rates of flow, resulting in inefficient combustion and waste of fuel. To meet this difficulty a number of burners can be employed, but unless these are arranged co-axially in the combustion chamber their cones of particles overlap, causing an uneven pattern of fuel distribution. In any case, the use of a multiplicity of burners of the usual type is liable to be cumbersome. Furthermore, in all known forms of burners utilizing a swirl of fluid inside the burner, the swirling fluid and the air core which is created by the swirl must impinge at the inner end on the rear wall of the swirl chamber, which may be either a fixed wall or a wall of fluid in the spill passage. Consequently an undesirable drag effect is caused, and the air-core is likely to become unstable, causing corresponding instability of the spray.

An object of this invention is to provide a burner in which two nozzles are arranged co-axially in such a way as to eliminate the instability of

2

flow which is inherent in all types of burners having one or more independent swirl chambers.

A further object of this invention is to obtain improved atomization at lower inlet pressures, for any given rate of flow, by the use of two nozzles supplied from a common feed and in the case of the spill-type burner controlled through a common outlet line.

All of the foregoing and still further objects and advantages of the invention will become apparent from a study of the following specification, taken in conjunction with the accompanying drawings, wherein like characters of reference indicate corresponding parts throughout the several views and wherein:

Fig. 1 is a side view of a spill form of burner constructed in accordance with this invention;

Fig. 2 is an end view of the said burner;

Fig. 3 is a cross sectional view on the line 3—3 of Fig. 2;

Fig. 4 is a cross sectional view on the line 4—4 of Fig. 1;

Fig. 5 is a cross sectional view on the line 5—5 of Fig. 1;

Fig. 6 is a longitudinal vertical cross sectional view of another form of burner, namely, a burner of the duplex type, constructed in accordance with this invention;

Fig. 7 is a cross sectional view on the line 7—7 of Fig. 6; and

Fig. 8 is a cross sectional view on the line 8—8 of Fig. 6.

The spill burner illustrated in Figs. 1-5 comprises a body, indicated generally by reference numeral 10, the said body being cylindrical in shape and being supported in the combustion chamber of a gas turbine by inlet and outlet pipes 11 and 12 respectively. At opposite ends of the body are nozzle orifices 13 and 14 and the burner is so placed in the combustion chamber that its axis lies substantially parallel to the flow of air through the chamber as indicated by the arrow A, the nozzle orifice 13 facing downstream of the air flow and the nozzle orifice 14 facing upstream.

The body 10 includes a cylindrical barrel member 15 having a thick-walled portion 16 in which an outlet orifice 17 is provided; registering with the orifice 17 and secured to the thick-walled portion 16 of the barrel member 15 is a sleeve 18 which receives an outlet pipe 12. Seven longitudinally disposed passages 19 are provided in the barrel member, these being symmetrically arranged around its axis. The thick-walled portion 16 of the barrel member is formed with an

annular recess 20, and annular shoulders 21 and 21' which indirectly engage (being in practice spaced therefrom by packing glands) with the inner ends of central tubes 22 and 22' extending downstream and upstream respectively. The barrel member 15 has at the upstream end an annular stepped portion 23 and an externally threaded extension 24, and has at the opposite end an outer annular shoulder 25 which engages with a second barrel member 26 in which an inlet orifice 27 is provided; registering with the orifice 27 and secured to the barrel member 26 is a sleeve 28 which receives an inlet pipe 11. The second barrel member 26 has at the downstream end an annular stepped portion 26^a and an externally threaded extension 26^b. Closely fitting over the outer ends of the central tubes 22 and 22' respectively are the end blocks 30 and 30' in which are provided the nozzle orifices 13 and 14 co-axially communicating with tapered swirl chambers 31 and 31'. The swirl chambers are connected to annular recesses 32 and 32' by ports 33 and 33' respectively, the ports entering the swirl chambers tangentially as shown in Fig. 4. The end blocks 30 and 30' are held in place by internally threaded caps 34 and 34' which are screwed on the ends of the barrel members 26 and 15 respectively.

It will be seen that the arrangement of parts of the body at the downstream end defines an annular chamber 35 having a relatively narrow annular recess 32; and at the upstream end defines an annular chamber 35' having a relatively narrow annular recess 32'. The two chambers 35 and 35' are interconnected by the longitudinal passages 19, and chamber 35 is connected to the swirl chamber 31 by the tangential ports 33 whereas chamber 35' is connected to the swirl chamber 31' by the tangential ports 33'. The swirl chambers 31 and 31' are connected through the open passage constituted by the bores 36 and 36' of the central tubes 22 and 22', respectively, and by the central cylindrical chamber 37, which is defined by the annular recess 20; the bores 36 and 36' are chamfered at 36^a and 36^b, respectively. The diameter of the bores 36 and 36' is less than the diameter of the swirl chambers 31 and 31' but materially greater than the diameter of either of the nozzle orifices 13 and 14. The central chamber 37 communicates with the outlet pipe 12.

In the operation of the spill burner, fuel under high pressure enters the burner through the inlet pipe 11 and fills the downstream annular chamber 35, passing through the longitudinal passages 19 to fill the corresponding upstream chamber 35'. Considering first the operation of the downstream end of the burner, it will be apparent that fuel from the chamber 35 flows through the ports 33 into the swirl chamber 31. Since the ports 33 enter the swirl chamber 31 tangentially in like torque-inducing directions, the incoming flow of fuel is given a rotary motion, and under the high pressure applied the speed of rotation is very great. The fuel emerging from the nozzle orifice 13 is in the form of a conical spray of finely divided particles 38. Fuel in excess of requirements is spilled off through the bore 36 to the central chamber 37 whence it may be allowed to escape through the outlet pipe 12. By controlling the outlet flow by a suitable valve it is possible to control the depth or thickness of the rotating layer of fuel in the swirl chamber 31 and thus the quantity of fuel emerging from the nozzle

orifice 13. The inlet pressure is maintained at an approximately constant value throughout the range of flow required.

In the same manner, fuel is introduced into the upstream swirl chamber 31' through the ports 33' and emerges from the upstream nozzle orifice 14 in a conical spray 38', excess fuel being spilled off through the bore 36' to the outlet pipe 12. Thus the two swirl chamber-nozzle systems are fed by a common inlet and spill to a common outlet, which provides for a common control of their rate of spill. It will be noted that the ports 33 and 33' are arranged in relation to their respective swirl chambers 31 and 31' so that the swirl in each is in the same direction, that is, anti-clockwise when viewed from a point downstream of the burner. The most important consequence of this arrangement is that the two systems have a common air core 39. In all burners employing the swirl principle, an air core is formed around the axis of the rapidly spinning fluid and the stability of the flow from the nozzle depends on the stability of this core. If the inner end of this core, that is the end remote from the nozzle, impinges upon a wall of the swirl chamber or upon a wall of fluid in the spill passage, it is likely to be unstable at varying rates of flow; stability therefore can only be achieved if the air core is open and unobstructed at both ends, and this result is obtained by the invention as herein described.

By the employment of a common outlet system and a common inlet pressure, and swirl chambers of equal diameter, the depth of fuel in the downstream swirl chamber 31 is equal to the depth of fuel in the upstream swirl chamber 31'. Thus the fuel emerging from the nozzle orifices 13 and 14 can be apportioned by the choice of the diameters of these orifices, in a manner appropriate to the fuel distribution required for efficient two stage combustion in the air stream.

Another embodiment of the invention, in which the invention is applied to a burner of the duplex type, is shown in Figs. 6, 7 and 8. In the normal duplex burner two fuel inlets are employed, the one imparting an approximately constant pressure and rotation to the fuel while the other, through an independent system, superimposes a variable pressure and rotation by which the burner is controlled. As shown in Fig. 6, the body of the burner, indicated generally by reference numeral 41, is supported in the combustion chamber by primary and secondary inlet pipes 42 and 43 respectively. At opposite ends of the body 41 are the nozzle orifices 44 and 45, directed downstream and upstream respectively, which are connected by a single longitudinal central chamber 46, which provides at opposite ends interconnected terminal swirl chambers 47 and 47'. It will be noted that the swirl chambers are in practice provided in end blocks 48 and 49. A barrel member 50, having annular channelled portions 51, 52 and 53 and threaded ends 54 and 54', is secured around the end blocks 48 and 49 by threaded end caps 56 and 56'.

The end blocks 48 and 49 are peripherally channelled to define, in cooperation with the peripheral channels 51 and 53 in the barrel member, annular chambers 57 and 58, at the downstream and upstream ends respectively. The said annular chambers are connected by longitudinal passages 59 which are symmetrically arranged around the axis of the burner. The primary fuel inlet pipe 42 communicates directly with the annular chamber 57 through the inlet orifice

60. The annular chambers 57 and 58 are connected to the central chamber 46 by ports 61 and 62 respectively, which enter the chamber 46 tangentially.

The end block 48 is also peripherally channelled at 48^a to define, in cooperation with the inner face of the end block 49 and the peripherally channelled portion 52 in the barrel member 50, a relatively small secondary annular chamber 63, with which the secondary inlet pipe 43 directly communicates through the secondary inlet orifice 64. The secondary annular chamber 63 is connected to the central chamber 46 by secondary ports 65 which, like ports 61 and 62, enter the chamber 46 tangentially.

The operation of the duplex burner is similar to that of the spill burner, except that the control of the fluid flow is effected by changes in pressure in the secondary inlet pipe 43 which changes the speed of flow through the secondary ports 65 and thereby directly affects the velocity of swirl in the chamber 46. The primary inlet pressure is preferably kept substantially constant. As in the spill burner, an air core common to both ends of the burner is created and a corresponding stability of flow is achieved.

It is thought that the construction and use of the invention will be apparent from the above description of the various parts and their purpose. It is to be understood that the forms of this invention, herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size and arrangement of the parts may be resorted to, without departing from the spirit of the invention and the scope of the subjoined claims.

What I claim as my invention is:

1. A burner for liquid fuels comprising, a body having nozzle orifices at opposite ends, a passageway within the body connecting the nozzle orifices, interconnected annular chambers encircling the passageway, fuel ports leading from the annular chambers and entering the passageway non-radially to cause a swirling action of the fuel in the passageway, means for conducting fuel from a source of supply under pressure to the annular chambers, and a flow-regulating conduit communicating with the passageway, the passageway being adapted to provide between the nozzle orifices a continuous annular body of swirling fuel having an air-core extending through both nozzle orifices in the body.

2. A burner for liquid fuels comprising, a body, tapered swirl chambers within the body, the swirl chambers terminating in nozzle orifices situated at opposite ends of the body, interconnected annular chambers disposed coaxially in the body, fuel ports leading from the annular chambers and entering the swirl chambers non-radially to cause a swirling action of the fuel in the swirl chambers, an inlet conduit for conducting fuel under pressure to the annular chambers, an open passageway connecting the swirl chambers and adapted to provide between the swirl chambers a continuous annular body of swirling fuel having an air-core extending through the nozzle orifices in the swirl chambers, and a flow-regulating conduit communicating with the passageway.

3. A burner for liquid fuels comprising, a body having nozzle orifices at opposite ends, tapered swirl chambers within the body having communication with the nozzle orifices, interconnected annular chambers disposed co-axially in the body, fuel ports leading from the annular cham-

bers and entering the swirl chambers non-radially to cause a swirling action of the fuel in the swirl chambers, an inlet conduit for conducting fuel under pressure to the annular chambers, an open passageway connecting the swirl chambers and adapted to provide between the swirl chambers a continuous annular body of swirling fuel having an air-core extending through the nozzle orifices in the body, and a flow-regulating spillway communicating with the passageway.

4. A burner for liquid fuels comprising, a body having nozzle orifices at opposite ends, tapered swirl chambers within the body adjacent to the nozzle orifices, interconnected annular chambers disposed co-axially in the body, fuel ports leading from the annular chambers and entering the swirl chambers non-radially to cause a swirling action of the fuel in the swirl chambers, an inlet conduit for conducting fuel under pressure to the annular chambers, a central chamber in the body, passageways connecting each of the swirl chambers to the central chamber and adapted to provide between the swirl chambers a continuous annular body of swirling fuel having an air-core extending through the nozzle orifices in the body, and a flow-regulating outlet conduit communicating with the central chamber.

5. A burner for liquid fuels comprising, a body having nozzle orifices at opposite ends, tapered swirl chambers within the body having communication with the nozzle orifices, interconnected annular chambers disposed co-axially in the body, fuel ports leading from the annular chambers and entering the swirl chambers non-radially to cause a swirling action of the fuel in the swirl chambers, a primary inlet conduit for conducting fuel under pressure to the annular chambers, a passageway connecting the swirl chambers and adapted to provide between the swirl chambers a continuous annular body of swirling fuel having an air-core extending through the nozzle orifices in the body, and a flow-regulating secondary inlet conduit communicating with the passageway.

6. A burner for liquid fuels comprising, a body having nozzle orifices at opposite ends, a passageway within the body connecting the nozzle orifices and having convergingly tapered end portions constituting swirl chambers, interconnected annular end chambers disposed around and spaced from the end portions of the passageway, primary fuel ports leading from the annular end chambers and entering the end portions of the passageway non-radially whereby a continuous annular body of swirling fuel having an air-core extending through the orifices in the body is provided, a primary inlet conduit for conducting fuel under pressure to the annular end chambers, an annular control chamber disposed around the passageway between the annular end chambers, secondary fuel ports leading from the annular control chamber and entering the passageway non-radially, the said secondary fuel ports being adapted to increase the swirling motion of the fuel in the passageway, and a flow-regulating secondary fuel inlet for conducting fuel under pressure to the annular control chamber.

7. A burner for liquid fuels comprising, a body containing an elongated passageway of circular cross-section for containing a rotating body of fuel and having axially directed discharge orifices at opposite ends, the body having two groups of fuel inlet ports leading into the passageway for delivering rotation-inducing jets of fuel at high velocity, each group of ports leading into one of

the opposite end portions of the passageway, each port entering the passageway non-axially and non-radially and all the ports in both groups entering the passageway in the same rotary sense, each group of ports constituting means whereby the jets discharged therefrom will cause rapid vortical motion in the fuel in the corresponding end of the passageway around an air core and the two groups of ports co-operating to cause the air core produced by each group of ports to merge with the other air core into a continuous air core surrounded by a continuous annular body of swirling fuel and extending to full length of the passageway through both discharge orifices, and means for conducting fuel under high pressure from a source of supply to the fuel inlet ports.

8. A burner for liquid fuels comprising, a body containing an elongated passageway of circular cross-section for containing a rotating body of fuel and having axially directed discharge orifices at opposite ends, an annular chamber in the body and encircling the passageway, the body having two groups of fuel inlet ports leading into the passageway for delivering rotation-inducing jets of fuel at high velocity, each group of ports leading into one of the opposite end portions of the passageway, each port entering the passageway non-axially and non-radially and all the ports in both groups entering the passageway in the same rotary sense, each group of ports constituting means whereby the jets discharged therefrom will cause rapid vortical motion in the fuel in the corresponding end of the passageway around an air core and the two groups of ports co-operating to cause the air core produced by each group of ports to merge with the other air core into a continuous air core surrounded by a continuous annular body of swirling fuel and extending the full length of the passageway through both discharge orifices, means for conducting fuel under high pressure from a source of supply to the annular chamber, and a flow-regulating conduit communicating with the passageway.

9. A burner for liquid fuels comprising, a body

containing an elongated passageway of circular cross-section for containing a rotating body of fuel, the opposite ends of the passageway providing swirl chambers terminating in axially directed nozzle orifices situated at opposite ends of the body, the body having two groups of fuel inlet ports leading into the passageway for delivering rotation-inducing jets of fuel at high velocity, each group of ports leading into one of the swirl chambers, each port entering the passageway non-axially and non-radially and all the ports in both groups entering the passageway in the same rotary sense, each group of ports constituting means whereby the jets discharged therefrom will cause rapid vortical motion in the fuel in the corresponding swirl chamber around an air core and the two groups of ports co-operating to cause the air core produced by each group of ports to merge with the other air core into a continuous air core surrounded by a continuous annular body of swirling fuel and extending the full length of the passageway through both discharge orifices, and means for conducting fuel under high pressure from a source of supply to the fuel inlet ports.

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