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(54) CHANNEL DEFINING FUEL NOZZLE OF COMBUSTION SYSTEM

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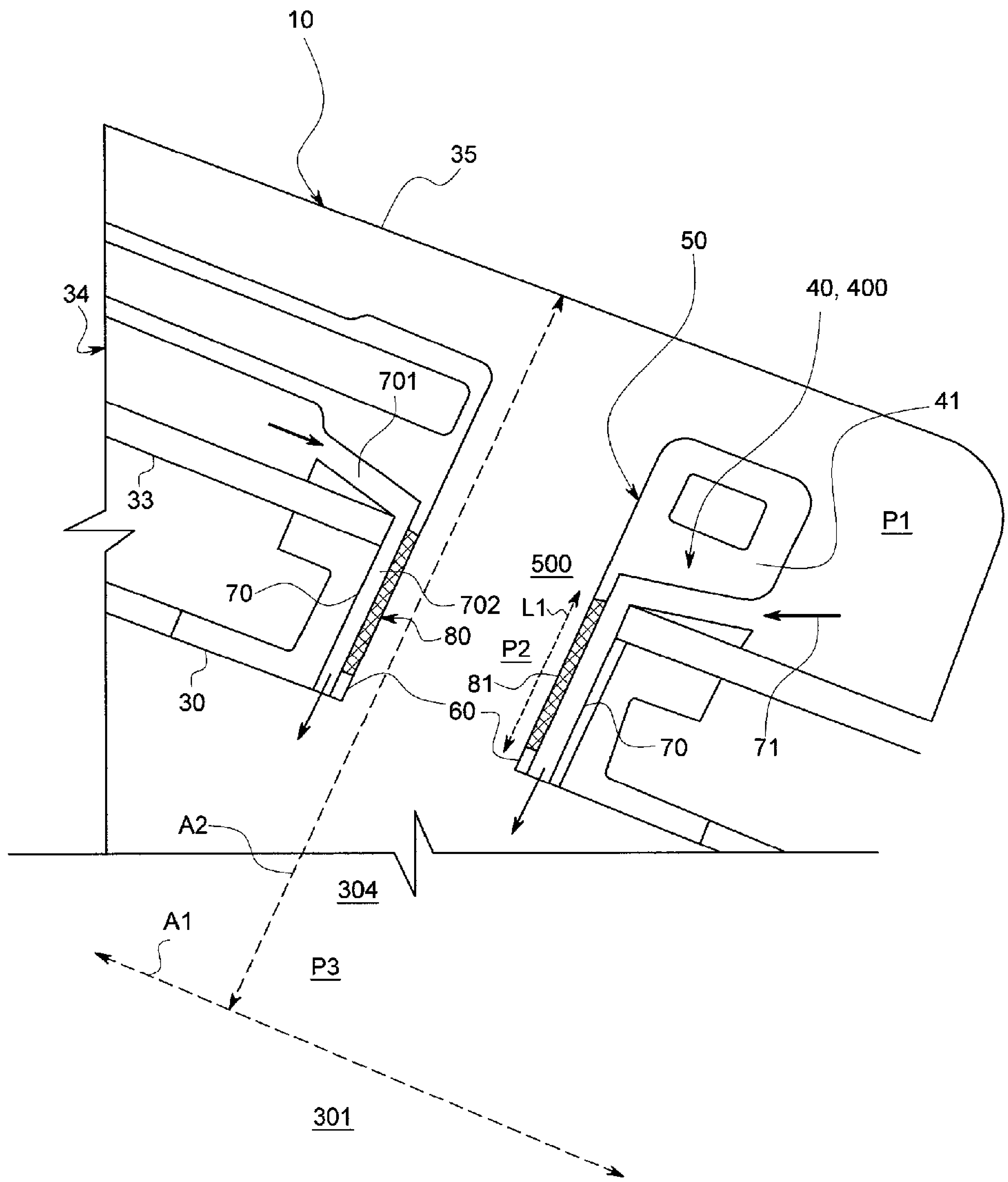
(57) **ABSTRACT**

A combustion system is provided and includes an annular body defining a combustion zone and a fuel nozzle. The fuel nozzle includes a tubular element having a hollow interior and is disposable such that the hollow interior fluidly communicates with the combustion zone. The tubular element includes wall portions defining a channel disposable for fluid communication with at least one of the hollow interior and the combustion zone. The defined channel is pressurizable with coolant at a pressure exceeding that of the combustion zone.



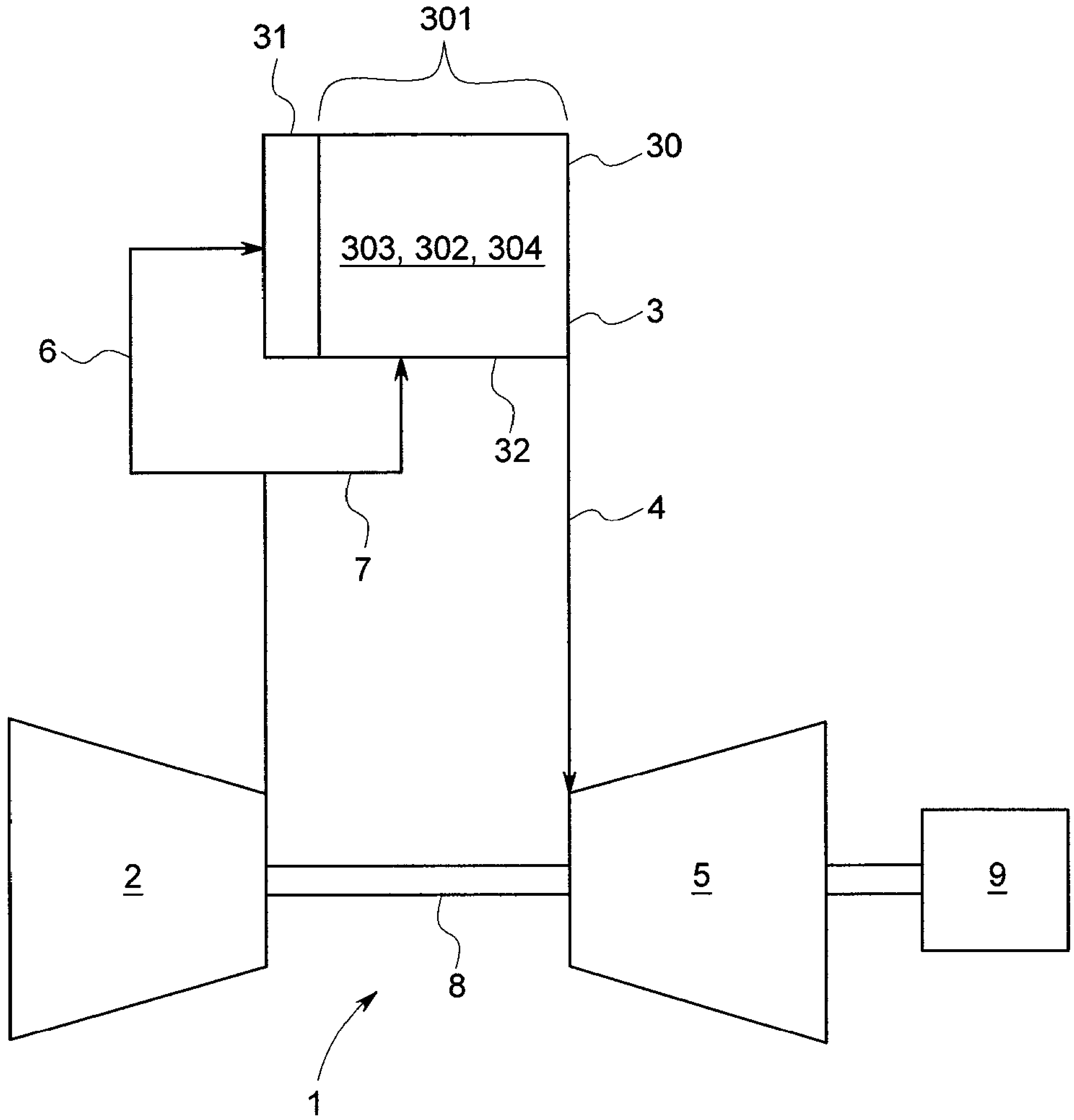


FIG. 1

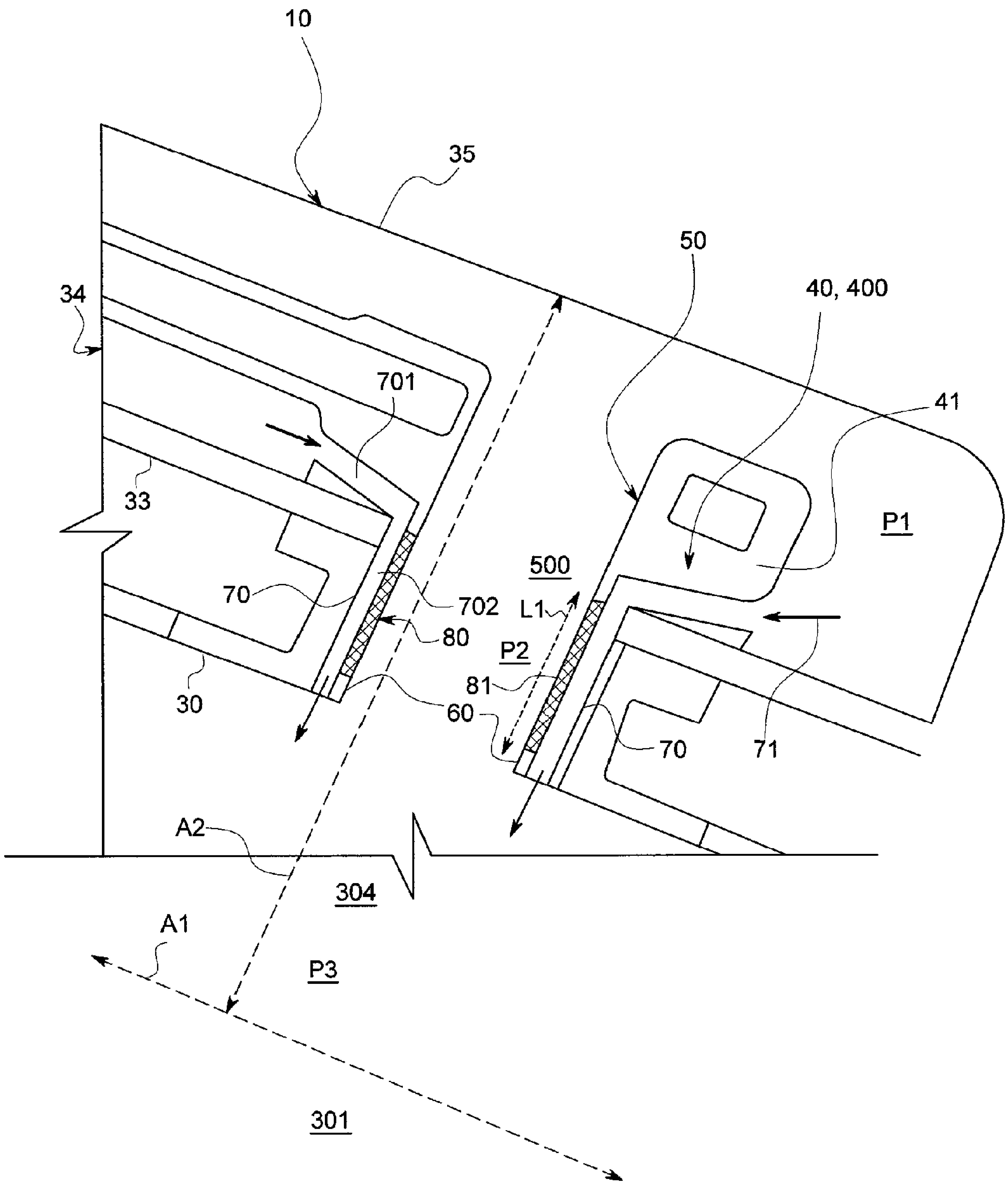

10
35
34
50
40, 400
701
41
33
P1
500
70
702
L1
80
P2
30
81
60
70
71
A2
304
A1
P3
301

FIG. 2

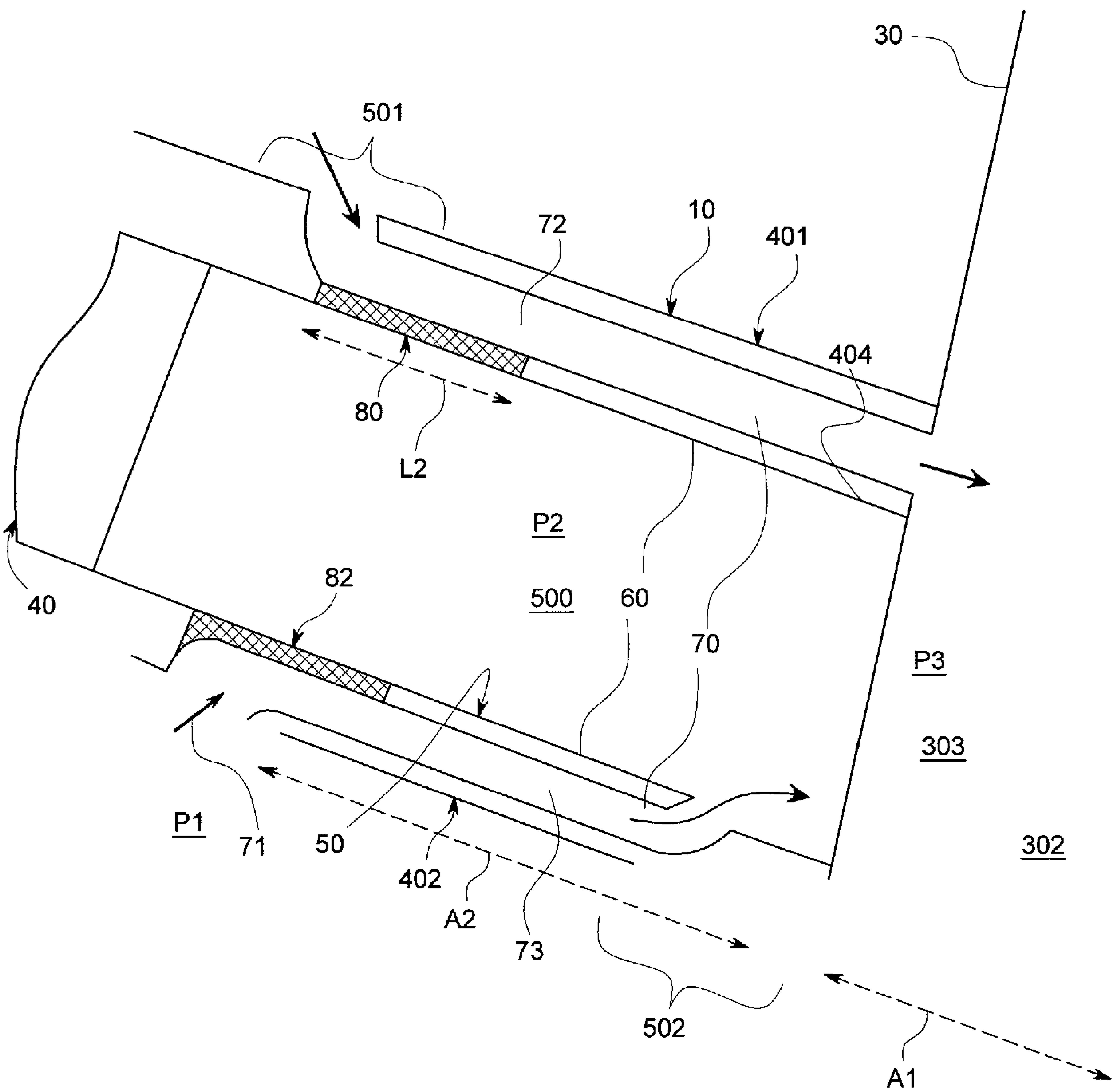

30
501
72
10
401
404
80
L2
P2
40
82
500
60
70
P3
303
P1
71
50
402
A2
73
302
502
A1

FIG. 3

CHANNEL DEFINING FUEL NOZZLE OF COMBUSTION SYSTEM

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to a combustion system and, more particularly, to a combustion system including fuel nozzle wall portions defining a channel.

[0002] In gas turbine engines, a compressor compresses inlet air and outputs the compressed inlet air to a combustor. Within the combustor, the compressed inlet air is mixed with fuel and combusted to produce a high temperature and high pressure working fluid. The working fluid is directed into a turbine section where it is expanded to drive operations of the compressor and a generator. The high temperatures and high pressures generated within the combustor can at times lead to flash back incidences or to flame holding. In such cases, the combustion of the compressed inlet air and fuel occurs too close to the combustor hardware and can lead to thermal damage of the hardware if the failure is not corrected or otherwise stopped from occurring.

[0003] Typically, devices for correcting or otherwise stopping flash back incidences and flame holding are fuel nozzle fuses. These fuses are installed in fuel nozzles of the combustor of a gas turbine engine and are configured to activate when flash back incidences or flame holding occurs. When activated, the fuses may shut down the combustion and thus act as an identifier that a failure has occurred.

BRIEF DESCRIPTION OF THE INVENTION

[0004] According to one aspect of the invention, a combustion system is provided and includes an annular body defining a combustion zone and a fuel nozzle. The fuel nozzle includes a tubular element having a hollow interior and is disposable such that the hollow interior fluidly communicates with the combustion zone. The tubular element includes wall portions defining a channel disposable for fluid communication with at least one of the hollow interior and the combustion zone. The defined channel is pressurizable with coolant at a pressure exceeding that of the combustion zone.

[0005] According to another aspect of the invention, a combustion system is provided and includes an annular body defining a main combustion zone and a downstream combustion zone downstream from the main combustion zone and a fuel nozzle. The fuel nozzle includes a tubular element having a hollow interior and is disposable such that the hollow interior fluidly communicates with the downstream combustion zone. The tubular element includes wall portions defining a channel disposable for fluid communication with the downstream combustion zone. The defined channel is pressurizable with coolant at a pressure exceeding that of the downstream combustion zone.

[0006] According to yet another aspect of the invention, a combustion system is provided and includes an annular body defining a combustion zone and a fuel nozzle. The fuel nozzle includes a tubular element having a hollow interior and is disposable such that the hollow interior fluidly communicates with an upstream-most portion of the combustion zone. The tubular element includes wall portions defining a channel disposable for fluid communication with at least one of the hollow interior and the combustion zone. The defined channel is pressurizable with coolant at a pressure exceeding that of the combustion zone and the hollow interior.

[0007] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0009] FIG. **1** is a schematic illustration of a gas turbine engine in accordance with embodiments;

[0010] FIG. **2** is a side schematic view of a combustion system of the gas turbine engine of FIG. **1**, which includes a fuel nozzle at a downstream combustion zone in accordance with embodiments; and

[0011] FIG. **3** is a side schematic view of a combustion system of the gas turbine engine of FIG. **1**, which includes a fuel nozzle at an upstream-most portion of a combustion zone in accordance with embodiments.

[0012] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0013] With reference to FIGS. **1-3**, a gas turbine engine **1** is provided and includes a compressor **2**, a combustor **3**, a transition piece **4** and a turbine section **5**. The combustor **3** includes an annular body **30** formed to define a combustion zone **301** having a main combustion zone **302**, an upstream-most portion **303** of the main combustion zone **302** and a downstream combustion zone **304** defined downstream from the main combustion zone **302**. The compressor **2** compresses inlet air and outputs the compressed inlet air to circuits **6** and **7**. Circuit **6** provides for a mixing of the compressed air with fuel and an injection of the resultant fuel/air mixture into a head end **31** of the combustor **3** and proximate to the upstream-most portion **303** of the main combustion zone **302**. Circuit **7** provides for a mixing of the compressed air with additional fuel and an injection of the resultant fuel/air mixture into a downstream section **32** of the combustor **3** or to the transition piece **4** and proximate to the downstream combustion zone **304**.

[0014] The fuel/air mixtures are combusted within the combustor **3** to produce a working fluid of high temperature and high pressure combustion products. The working fluid is directed into the turbine section **5** via the transition zone **4** and is expanded within the turbine section **5** to generate work. The expansion of the working fluid in the turbine section **5** causes a rotor **8**, which extends through the compressor **2**, the turbine section **5** and a generator **9**, to rotate and such rotation drives operations of the compressor **2** and the generator **9**.

[0015] As described below, a combustion system **10** is provided for use with the gas turbine engine **1** and includes the annular body **30** and a fuel nozzle **40** (see FIGS. **2** and **3**). The fuel nozzle **40** includes a tubular element **50** having a hollow interior **500** and is disposable on the annular body **30** such that the hollow interior **500** fluidly communicates with the combustion zone **301**. The tubular element **50** includes wall portions **60** that define a channel **70**. The channel **70** is disposable for fluid communication with at least one of the hollow interior **500** and the combustion zone **301**. The channel **70** is pressurizable with coolant **71** at a first pressure P**1**. In accordance with certain embodiments, the first pressure P**1** exceeds a second pressure P**2** of the hollow interior **500** and the second pressure P**2** of the hollow interior **500** exceeds a third pressure P**3** of the combustion zone **301**.

[0016] In greater detail, as shown in FIG. **2**, the combustion system **10** includes the annular body **30**, which defines the main combustion zone **302** with a longitudinal axis A**1** and the downstream combustion zone **304** in a position defined fluidly downstream from the main combustion zone **302**, and the fuel nozzle **40**. As shown, the fuel nozzle **40** may be provided as a late lean injection (LLI) fuel nozzle **400** and the annular body **30** may include a secondary annular body **33** and a tertiary annular body **35**. The secondary annular body **33** may be disposed about the annular body **30** and the tertiary annular body **35** may be disposed about the secondary annular body **33**. In this case, the fuel nozzle **40** includes a fuel nozzle body **41**, which is disposed proximate to an aft end of the secondary annular body **33**, and which traverses the secondary annular body **33** such that the tubular element **50** extends from the tertiary annular body **35** to the annular body **30** and a longitudinal axis A**2** of the tubular element **50** is oriented transversely with respect to the longitudinal axis A**1** of the annular body **30**.

[0017] With the tubular element **50** having the hollow interior **500** and the fuel nozzle **40** being disposed proximate to the aft end of the secondary annular body **33**, the hollow interior **500** is fluidly communicative with the downstream combustion zone **304**. As such, by way of the circuit **7** and fuel tube **34**, the fuel/air mixture can be injected into the downstream combustion zone **304** to thereby increase temperatures of the working fluid within the combustor **3** and the transition piece **4**. This increase in temperatures can lead to increased output of the generator **9**.

[0018] The increase in temperatures can also lead to an increased likelihood of flash back incidences and in turn to potential damage of the combustion system **10**. Examples of such damage may include thermal damage to the annular body **30** around the fuel nozzle **40**. As shown in FIG. **2**, however, the tubular element **50** includes the above-noted wall portions **60** that define at least one or more channels **70**. The at least one or more channels **70** may be disposable for fluid communication with an interior of the tertiary annular body **35** and the downstream combustion zone **304**. In this way, the coolant **71** may be supplied to the at least one or more channels **70** by the tertiary annular body **35** at the first pressure P**1**, which exceeds the second pressure P**2** of the hollow interior **500**, which in turn exceeds the third pressure of the downstream combustion zone **304**.

[0019] Each one of the at least one or more of the channels **70** may include a first portion **701** and a second portion **702**. The first portion **701** is oriented transversely with respect to the longitudinal axis A**2** of the tubular element **50** and the second portion **702** is oriented along the longitudinal axis A**2** of the tubular element **50**. Thus, a pressurized flow of the coolant **71** proceeds along the first portion **701** from the tertiary annular body **35** in a radially inward direction with respect to the longitudinal axis A**2** toward the hollow interior **500**. The pressurized flow of the coolant **71** then proceeds along the second portion **702** in a radially inward direction with respect to the longitudinal axis A**1** and toward the downstream combustion zone **304**. In so doing, the coolant **71** removes heat from the local portions of the annular body **30** and the fuel nozzle **40**.

[0020] In accordance with embodiments, the second portions **702** of the at least one or more channels **70** may be located near regions of the wall portions **60** that are most likely to experience high temperatures or heat due to flash back exposure. These regions may include fuses **80** having first fuse bodies **81**. The first fuse bodies **81** may be thinned as compared to other regions of the wall portions **60** such that they melt before the other regions of the wall portions **60**. Alternatively, the first fuse bodies **81** may be made of material that melts at a lower temperature than that of the other regions of the wall portion **60**. In an event of a flash back incidence, the thinned or otherwise low melting point material of the first fuse bodies **81** melts and such melting results in an enlarged flow area of the at least one or more channels **70**. This enlarged flow area permits an additional flow of coolant **71** and provides for a local source to push out the flash back incidence and prevent extensive hardware damage, as well as cause an increase in emissions that signals that a potential issue has occurred.

[0021] In accordance with embodiments and, as shown in FIG. **2**, the at least one or more channels **70** may be provided as a single channel **70** or as a plurality of channels **70**. In the latter case, the plurality of the channels **70** may be arrayed around the tubular element **50** in an annular or substantially circular array shape or in some other suitable array shape or formation.

[0022] As shown in FIG. **3**, the combustion system **10** includes the annular body **30**, which defines an end of the main combustion zone **302** with the longitudinal axis A**1** and the upstream-most portion **303** of the main combustion zone **302**, and the fuel nozzle **40**. As shown, the fuel nozzle **40** may be provided upstream of a burner tube assembly **401**, which surrounds the tubular element **50**. With the tubular element **50** having the hollow interior **500** and the fuel nozzle **40** being disposed proximate to the upstream-most portion **303** of the main combustion zone **302**, the hollow interior **500** is fluidly communicative with the upstream-most portion **303** of the main combustion zone **302**. As such, the fuel/air mixture can be injected into the upstream-most portion **303** of the main combustion zone **302** by way of the circuit **6** in combustion operations.

[0023] As described above, such combustion operations can lead to flash back incidences and to damage of the combustion system **10** with examples of such damage including thermal damage to the annular body **30** around the fuel nozzle **40**. As shown in FIG. **3**, however, the tubular element **50** includes the above-noted wall portions **60** that define at least one or more channels **70**. The at least one or more channels **70** may be disposable for fluid communication with an exterior of the burner tube **402** and at least one of the hollow interior **500** and the upstream-most portion **303** of the main combustion zone **302**. As such, the coolant **71** may be supplied from the exterior of the burner tube **402** to the at least one or more channels **70** at the first pressure P**1**, which exceeds the second pressure P**2** of the hollow interior **500**, which in turn exceeds the third pressure P**3** of the upstream-most portion **303** of the main combustion zone **302**.

[0024] Each one of the at least one or more channels **70** may be oriented along the longitudinal axis A**2** of the tubular element **50** and by extension along the longitudinal axis A**1** of the main combustion zone **302**. In accordance with embodiments, one of the at least one or more channels **70** may extend from an upstream portion **501** of the tubular element **50** and may terminate at a downstream end **502** of the tubular element

50. In accordance with alternative embodiments, one of the at least one or more channels **70** may extend from the upstream portion **501** of the tubular element **50** and may terminate proximate to the downstream end **502** of the tubular element **50**. In accordance with still further alternative embodiments, the at least one or more channels **70** may include first channels **72**, which extend from the upstream portion **501** of the tubular element **50** and terminate at the downstream end **502** of the tubular element **50**, and second channels **73**, which extend from the upstream portion **501** of the tubular element **50** and terminate proximate to the downstream end **502** of the tubular element **50**.

[0025] The second channels **73** of the embodiments of FIG. **3** provide for film-cooling effects of local portions of the tubular element **50** and the annular body **30**. It is to be understood that similar structures can be provided in the embodiments of FIG. **2** apart from the first fuse bodies **81**. In such cases, as with the second channels **73** of FIG. **3**, alternative embodiments of the second portions **702** of the at least one or more channels **70** of FIG. **2** can terminate proximate to the downstream end of the hollow interior **500** to provide for film-cooling effects of the local portions of the tubular element **50** and the annular body **30**.

[0026] In accordance with embodiments, the first channels **72** and the second channels **73** may be located near regions of the wall portions **60** that are most likely to experience high temperatures or heat due to flash back exposure. These regions may include fuses **80** having second fuse bodies **82**. The second fuse bodies **82** may be thinned as compared to other regions of the wall portions **60** such that they melt before the other regions of the wall portions **60**. Alternatively, the second fuse bodies **82** may be made of material that melts at a lower temperature than that of the other regions of the wall portion **60**. In an event of a flash back incidence, the thinned or otherwise low melting point material of the second fuse bodies **81** melts and such melting results in an enlarged flow area of the at least one or more channels **70**. This enlarged flow area permits an additional flow of coolant **71** and provides for a local source to push out the flash back incidence and prevent extensive hardware damage, as well as cause an increase in emissions that signals that a potential issue has occurred.

[0027] Fuel nozzles for gas turbine engines have employed fuses that help prevent catastrophic damage in the event of a flash back. These fuses can degrade, however, and cause a false outage. With this in mind, fuel nozzles with micro-channels, such as those described above, can be used for cooling purposes instead of or in addition to fuses and still provide for the introduction of coolant at flame-holding locations as an emissions trigger.

[0028] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

1. A combustion system, comprising:

an annular body defining a combustion zone; and

a fuel nozzle comprising a tubular element having a hollow interior and being disposable such that the hollow interior fluidly communicates with the combustion zone,

the tubular element comprising wall portions defining a channel disposable for fluid communication with at least one of the hollow interior and the combustion zone,

the defined channel being pressurizable with coolant at a pressure exceeding that of the combustion zone.

2. The combustion system according to claim **1**, wherein the pressure of the coolant exceeds that of the hollow interior with the hollow interior being pressurized at a pressure exceeding that of the combustion zone.

3. The combustion system according to claim **1**, wherein the annular body has a longitudinal axis and the tubular element has a longitudinal axis oriented transversely with respect to the longitudinal axis of the annular body.

4. The combustion system according to claim **3**, wherein the defined channel comprises:

a first portion oriented transversely with respect to the longitudinal axis of the tubular element; and

a second portion oriented along the longitudinal axis of the tubular element.

5. The combustion system according to claim **1**, wherein the defined channel is provided as a plurality of channels arrayed around the tubular element.

6. The combustion system according to claim **1**, wherein the annular body has a longitudinal axis and the tubular element has a longitudinal axis oriented along the longitudinal axis of the annular body.

7. The combustion system according to claim **6**, wherein the defined channel is oriented along the longitudinal axis of the tubular element.

8. The combustion system according to claim **1**, wherein the defined channel extends from an upstream portion of the tubular element and terminates at or proximate to a downstream end of the tubular element.

9. The combustion system according to claim **1**, wherein the defined channel is provided as a first channel and a second channel,

the first channel extending from an upstream portion of the tubular element and terminating at a downstream end of the tubular element, and

the second channel extending from the upstream portion of the tubular element and terminating proximate to the downstream end of the tubular element.

10. The combustion system according to claim **1**, wherein the wall portions comprise a flash back incidence fuse.

11. A combustion system, comprising:

an annular body defining a main combustion zone and a downstream combustion zone downstream from the main combustion zone; and

a fuel nozzle comprising a tubular element having a hollow interior and being disposable such that the hollow interior fluidly communicates with the downstream combustion zone,

the tubular element comprising wall portions defining a channel disposable for fluid communication with the downstream combustion zone, the defined channel being pressurizable with coolant at a pressure exceeding that of the downstream combustion zone.

12. The combustion system according to claim **11**, wherein the annular body has a longitudinal axis and the tubular element has a longitudinal axis oriented transversely with respect to the longitudinal axis of the annular body.

13. The combustion system according to claim **12**, wherein the defined channel comprises:

a first portion oriented transversely with respect to the longitudinal axis of the tubular element; and

a second portion oriented along the longitudinal axis of the tubular element.

14. The combustion system according to claim **11**, wherein the defined channel is provided as a plurality of channels arrayed around the tubular element.

15. A combustion system, comprising:

an annular body defining a combustion zone; and

a fuel nozzle comprising a tubular element having a hollow interior and being disposable such that the hollow interior fluidly communicates with an upstream-most portion of the combustion zone,

the tubular element comprising wall portions defining a channel disposable for fluid communication with at least one of the hollow interior and the combustion zone,

the defined channel being pressurizable with coolant at a pressure exceeding that of the combustion zone and the hollow interior.

16. The combustion system according to claim **15**, wherein the annular body has a longitudinal axis and the tubular element has a longitudinal axis oriented along the longitudinal axis of the annular body.

17. The combustion system according to claim **16**, wherein the defined channel is oriented along the longitudinal axis of the tubular element.

18. The combustion system according to claim **15**, wherein the defined channel extends from an upstream portion of the tubular element and terminates at a downstream end of the tubular element.

19. The combustion system according to claim **15**, wherein the defined channel extends from an upstream portion of the tubular element and terminates proximate to a downstream end of the tubular element.

20. The combustion system according to claim **15**, wherein the defined channel is provided as a first channel and a second channel,

the first channel extending from an upstream portion of the tubular element and terminating at a downstream end of the tubular element, and

the second channel extending from the upstream portion of the tubular element and terminating proximate to the downstream end of the tubular element.

* * * * *