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Dada

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[54] **NOZZLE FOR CHEMICAL REACTION PROCESSES**

[75] Inventor: **Abdul G. Dada**, San Jose, Calif.

[73] Assignee: **General Electric Company**, San Jose, Calif.

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[52] **U.S. Cl.** **239/290**, 239/422, 239/424

[51] **Int. Cl.** **B05b 7/00**

[58] **Field of Search** 239/290, 291, 296, 400, 239/418, 419, 419.3, 419.5, 422, 424, 424.5, 425, 427, 427.3, 427.5, 428, 429, 430, 432, 522, 561

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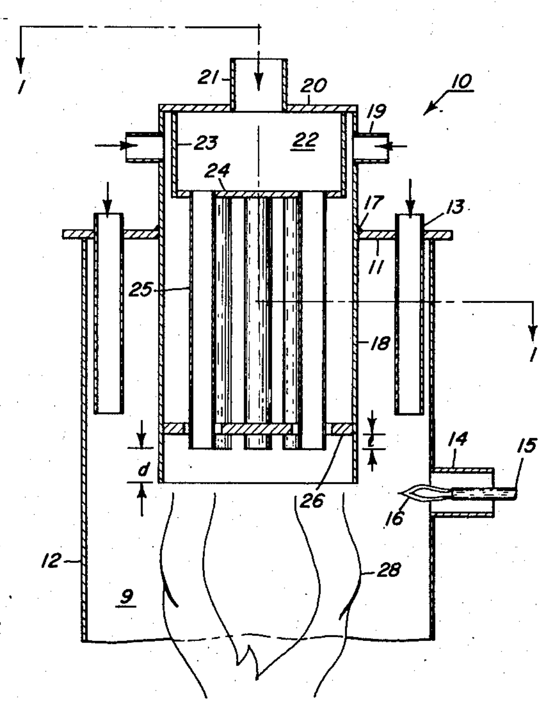
Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—John J. Love
Attorney, Agent, or Firm—Sam E. Laub; Samuel E. Turner; Ivor J. James, Jr.

[57] **ABSTRACT**

A nozzle for injecting fluid reactants into a reaction zone is presented in various embodiments. The nozzle is held by a supporting means and has a first inlet means for receiving and guiding a first fluid reactant into the reaction zone. The nozzle has a second inlet means for receiving and guiding a shielding fluid into the reaction zone for temporarily separating the fluid reactants entering the reaction zone. A third inlet means is disposed and slightly recessed within the second inlet means and has a chamber for receiving a second fluid reactant which chamber is connected preferably to a plurality of tubular members for guiding the second fluid reactant into the reaction zone. A directional control plate is secured transversely in the second inlet means and this plate is provided with openings through which the plurality of tubular members extend coaxially forming an annular opening around each tubular member enabling the shielding fluid in the second inlet means to flow unidirectionally through the annular openings and then into the reaction zone.

15 Claims, 8 Drawing Figures



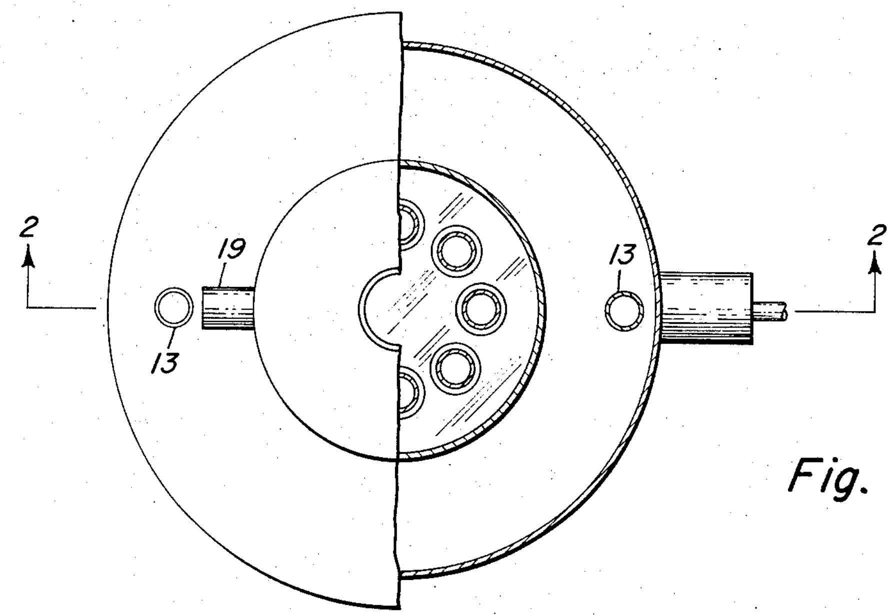


Fig. 1

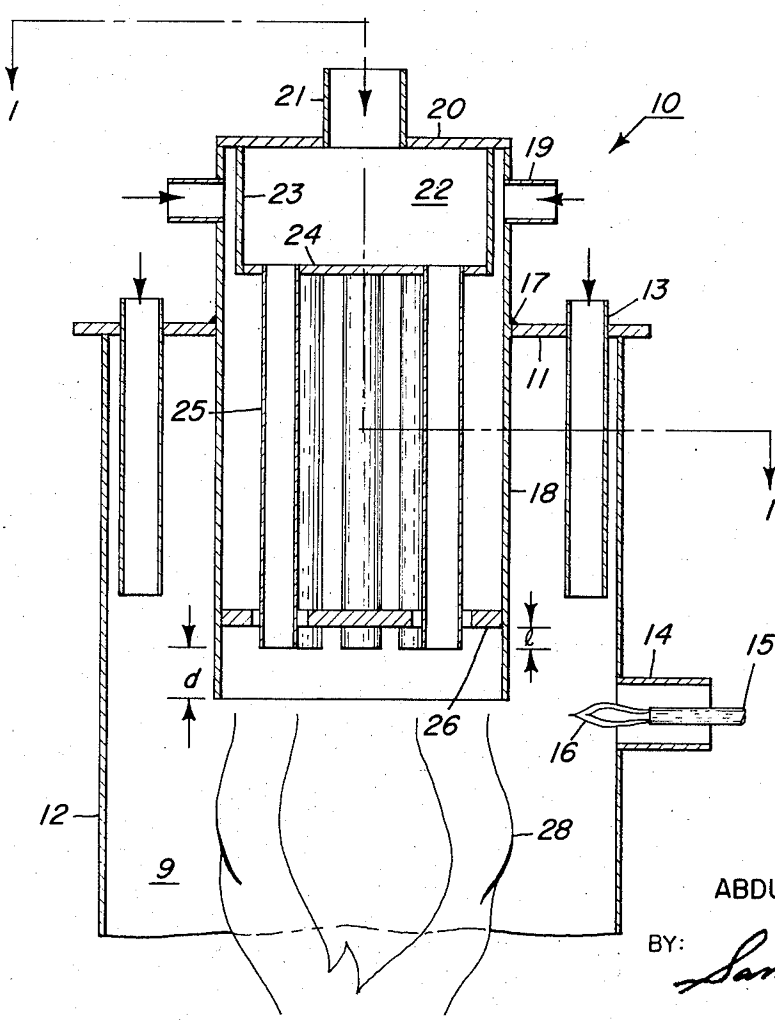


Fig. 2

INVENTOR:

ABDUL G. DADA

BY: Sam E. Laub

ATTORNEY

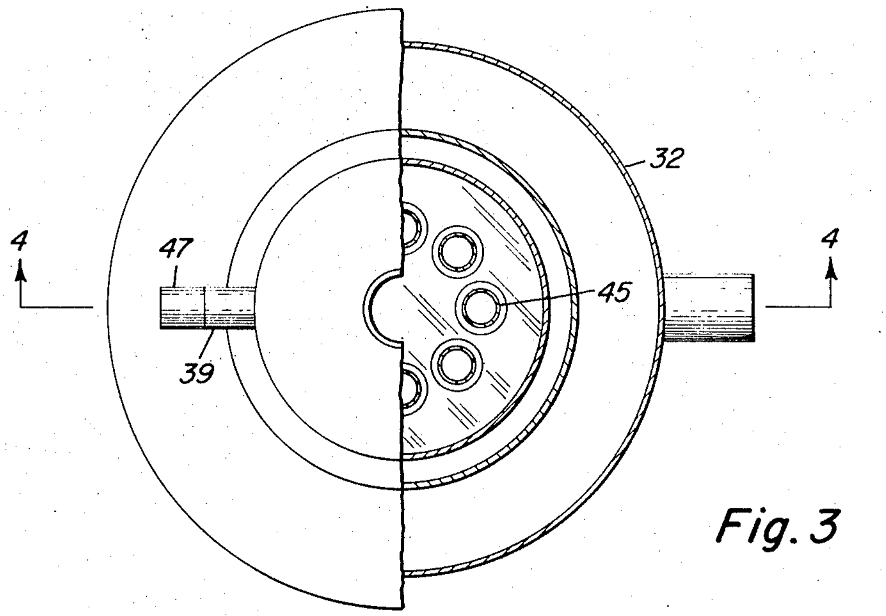

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Fig. 3

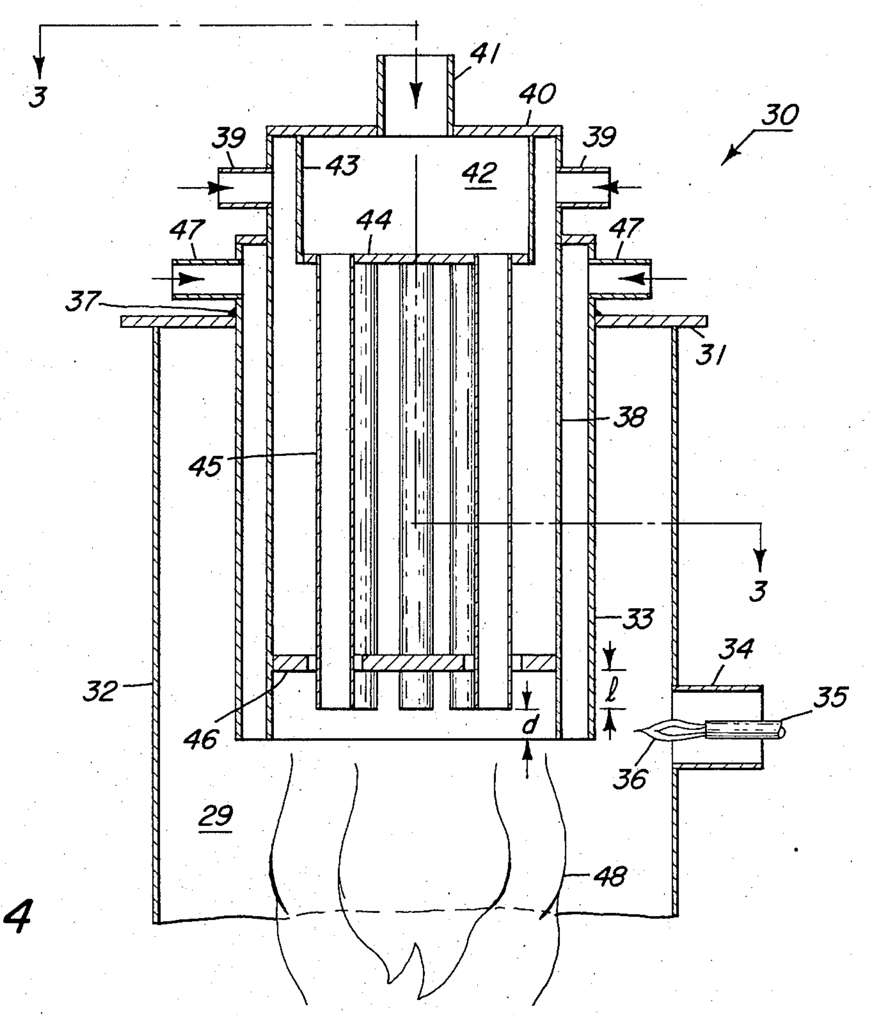
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Fig. 4

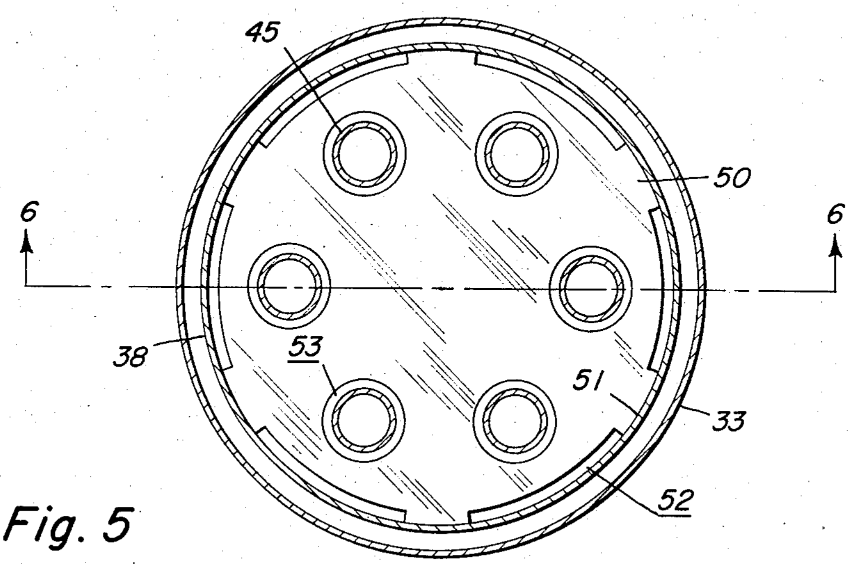

Fig. 5

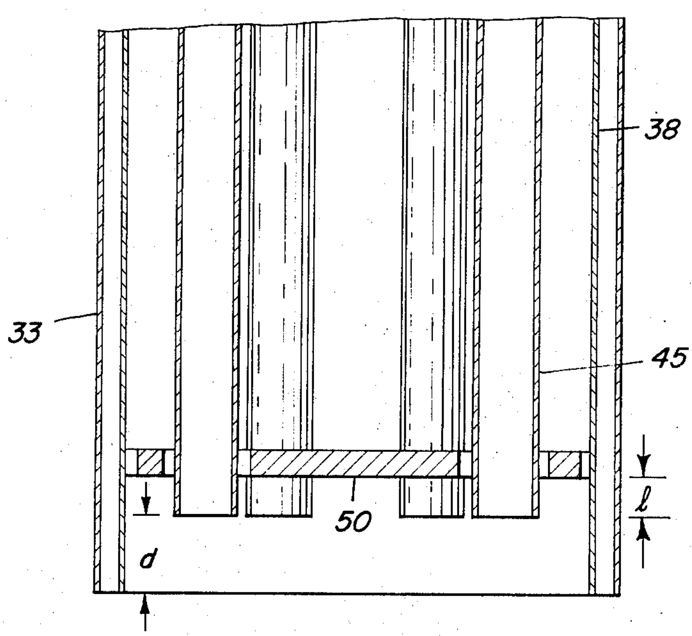

Fig. 6

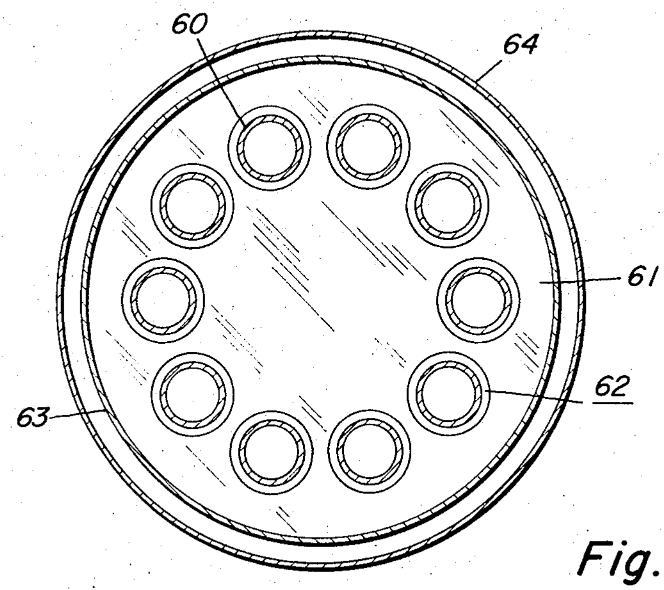

Fig. 7

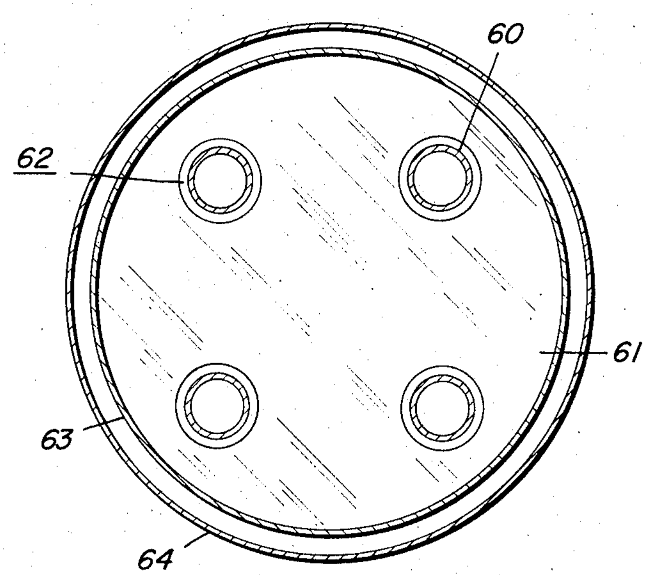

Fig. 8

NOZZLE FOR CHEMICAL REACTION PROCESSES

BACKGROUND OF THE INVENTION

It is known to conduct chemical reactions by feeding reactive fluids in nozzles having separate inlets to a reaction zone at proper conditions for carrying out the desired reaction usually by producing a flame. In many cases the nozzles for feeding the reactive fluids to the reaction zones are designed for specific purposes and are not useful in a wide variety of applications. In most instances the nozzles are such that the flame produced is rooted or attached at the opening of the inlets to the reaction zone and the result is that any solid product produced in the reaction is concentrated close to the inlets. In this manner a solid deposit of the reaction product can build up on the inlets and this build up of the solid reaction product can result in plugging of the inlets, thus impeding any further chemical reaction and necessitating disassembly of the apparatus for cleanup. Accordingly it has remained desirable to provide a nozzle for conducting a continuous chemical reaction leading to the production of solid reaction products so that no reaction occurs at the inlets to the reaction zone. In this manner interruption of the chemical reaction is avoided.

A preferred application of the present invention is the conversion of uranium hexafluoride to uranium oxide in a form which can be readily fabricated to shaped bodies having a low fluoride content. Copending U.S. Pat. application Ser. No. 77,446, now U.S. Pat. No. 3,796,672, entitled "Process for Producing Uranium Dioxide Rich Compositions From Uranium Hexafluoride," filed Oct. 2, 1970 in the names of W. R. DeHollander and A. G. Dada, presents a very satisfactory reaction for the conversion of uranium hexafluoride to uranium dioxide rich compositions. The foregoing patent is hereby incorporated by reference for convenience of presenting the present invention. In the process presented in Ser. No. 77,446, U.S. Pat. No. 3,796,672, the uranium hexafluoride is reacted with a reducing gas and an oxygen-containing carrier gas in a reduction-hydrolysis reaction in an active flame to yield a uranium dioxide rich composition. The uranium dioxide rich composition is a particulate, solid product, and it is desirable to have the reaction removed from the inlets introducing the reactants to the reaction zone to prevent plugging of the inlets. Accordingly it is especially desirable to have a nozzle for introducing to a reaction zone the reactants needed for producing uranium dioxide so that the resulting reaction flame is removed or lifted away from the nozzle used to introduce the reactants to the reaction zone.

OBJECTS OF THE INVENTION

It is an object of this invention to provide nozzle configurations for introducing fluid reactants to a reaction zone separated by a shielding fluid to prevent temporarily substantial mixing and reaction of the fluid reactants until the reactants are removed from the nozzle.

Another object of this invention is to provide nozzle configurations of improved design whereby reaction of fluid reactants issuing from the nozzle results in controlled location of solid reaction product away from the nozzle.

A further object of this invention is to control the point of formation of a reactive mixture between adjacent, generally unidirectional streams of fluid reactants introduced to a reaction zone initially separated by a shielding fluid.

Still another object of this invention is to provide a nozzle with a directional control plate producing unidirectional flow of a shielding fluid around tubular members introducing a reactant into a reaction zone thus temporarily and efficiently shielding and separating the reactant from another reactant in the reaction zone until cross diffusion of the reactants occurs.

An additional object of this invention is to provide apparatus in the in the form of a nozzle mounted in a cover adapted to fit a reaction vessel defining an enclosed reaction zone for flame conversion of fluid reactants avoiding the buildup of solid reaction products at the outlet of the nozzle and the back diffusion of reaction products to the outlet of the nozzle since the reaction is removed from the nozzle.

Other objects and advantages of this invention will become apparent to a person skilled in the art from a reading of the following summary and description of the invention along with the appended claims and by reference to the accompanying drawings.

SUMMARY OF THE INVENTION

This invention achieves the foregoing objects by presenting a nozzle for guiding fluid reactants into a reaction zone in various embodiments. The nozzle is held by a supporting means and has a first inlet means for receiving and guiding a first fluid reactant into the reaction zone. The nozzle has a second inlet means for receiving and guiding a shielding fluid into the reaction zone for temporarily separating the fluid reactants entering the reaction zone. A third inlet means is disposed within and recessed within the second inlet means and has a chamber for receiving a second fluid reactant which chamber is connected to at least one tubular member for guiding the second fluid reactant into the reaction zone. A directional control plate is secured transversely in the second inlet means and this plate is provided with an opening for each tubular member to extend there through so that the plate coaxially forms an annular opening around each tubular member enabling the shielding fluid in the second inlet means to flow unidirectionally through the annular opening and then into the reaction zone.

DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 show respectively a top view partially cut away and a cut away side view of the upper portion of a reactor having a nozzle as presented in this invention.

FIGS. 3 and 4 show respectively a top view partially cut away and a cut away side view of the upper portion of a reactor having another embodiment of the nozzle presented in this invention.

FIGS. 5 and 6 show respectively a top view and a sectional side view of the lower portion of a nozzle cut off above the directional control plate.

FIG. 7 shows a top view of a preferred embodiment of the lower portion of a nozzle which has ten tubular members symmetrically arranged on an imaginary circle.

FIG. 8 shows another top view of a preferred embodiment of the lower portion of a nozzle which has four tubular members symmetrically arranged on an imaginary circle.

DETAILED DESCRIPTION OF THE INVENTION

The foregoing objects have been accomplished in a new nozzle for thermal conversion of fluid reactants in the presence of an autogenous flame in a reaction zone. Referring to FIGS. 1 and 2 there is presented an apparatus having a nozzle generally designated by the number **10** mounted in a supporting means such as a cover **11** which forms an air tight seal (which can be disconnected) with reaction vessel **12** defining an enclosed reaction zone **9**. First inlet means in the form of two tubes **13** are mounted and sealed in cover **11** on opposite sides of tube **18**. Vessel **12** has an outwardly protruding space **14** which holds a pilot burner **15** which can receive gas and maintain a pilot flame **16** to initiate a flame reaction.

The nozzle **10** has a second inlet means in the form of tube **18** with two tubular inlets **19** for introduction of a fluid, particularly a shielding fluid. The tube **18** is positioned preferably in a centrally located opening in cover **11** and sealed in an air tight seal by seals **17**. The tube **18** has a cover **20** with an opening for a tubular inlet **21** for introduction of a fluid, particularly a second fluid reactant. A third inlet means is disposed within tube **18** in the form of tubular chamber **23** defining a volume **22** for receiving fluid from inlet **21**. Chamber **23** has eight openings in portion **24** of size equal to the outer diameter of eight tubes **25** which are connected to chamber **23** such as by welding or threading so that tubes **25** receive the gas mixture from chamber **23**. Tube **18** extends farther into the reaction zone **9** than tubes **25** by the distance generally designated "*d*." A directional control plate **26** is secured transversely in the lower portion of tube **18** at a distance "*l*" above the open ends of tubes **25** and this plate is provided with openings through which tubes **25** extend. The plate **26** coaxially forms an annular opening around each tube **25**. Plate **26** forces the shielding fluid to pass through the annular openings and then into the reaction zone surrounding the jets of fluid reactant from tubes **25**. The relation between the size of the holes in the plate and the thickness of the plate **26** is such that the shielding fluid passes between the plate and the tubes **25** in approximately unidirectional flow toward the reaction zone **9**. The symbol "*l*" is used to designate the distance between the open ends of tubes **25** and the bottom of the directional control plate **26**.

In a preferred use of the nozzle of this invention for conversion of uranium hexafluoride to a uranium dioxide rich composition, a continuous flow of a reactant of a reducing gas selected from the group consisting of hydrogen, dissociated ammonia and mixtures thereof is maintained in tubes **13** in the direction of the arrows throughout the reaction so that there is a strong reducing atmosphere generally maintained in the reaction zone **9**. A shielding gas is fed through inlets **19** into tube **18** in the direction of the arrows into the reaction zone **9**. The shielding gas can be a non-reactive gas selected from the group consisting of nitrogen, argon, helium, neon, krypton, xenon and mixtures thereof or the shielding gas can be a reactive gas selected from the group consisting of oxygen, air or a mixture thereof, or either air, oxygen or a mixture of air and oxygen with any of the foregoing non-reactive gases. A reactant comprising a mixture of uranium hexafluoride and an oxygen-containing carrier gas is fed through inlet **21**, chamber **23** and tubes **25** into reaction zone **9** in the direction of the arrow in inlet **21**. The oxygen-containing carrier gas is selected from the group consisting of oxygen, air and mixtures thereof. The flows of the gases in tubes **18** and **25** occur so that the shielding gas in tube **18** surrounds the jets of gaseous reactant coming from tubes **25** as the gases enter the reaction zone **9**. The shielding gas shields the mixture of uranium hexafluoride and the oxygen-containing carrier gas from the reducing gas for sufficient time so that the boundary of initiation of the reaction flame **28** in the reaction zone **9** is removed from contact with tube **18** and this is referred to as a "lifted flame." The reaction results in a bright orange flame.

Another configuration of the nozzle generally designated by the number **30** is presented in FIGS. 3 and 4 using two concentric outer tubes **33** and **38**. The nozzle **30** is mounted and sealed by seals **37** in a supporting means such as a cover **31** which forms an air tight seal (which can be disconnected) with reaction vessel **32** defining a reaction zone **29**. Vessel **32** has an outwardly protruding space **34** which holds a pilot burner **35** which receives gas and maintains a pilot flame **36** to initiate a flame reaction.

The nozzle **30** has a first inlet means in the form of tube **33** with tubular inlets **47** for introduction of a fluid reactant and a second inlet means in the form of tube **38** with two tubular inlets **39** for introduction of another fluid. Tube **38** has a cover **40** with an opening for a tubular inlet **41** for introduction of a fluid. A third inlet means is disposed in tube **38** in the form of tubular chamber **43** defining a volume **42** for receiving fluid from inlet **41**. Chamber **43** has eight openings in the portion **44** of size equal to the external diameter of tubes **45** which are connected to chamber **43** such as by welding or threading so that tubes **45** receive the fluid from chamber **43**. Tubes **33** and **38** extend further into the reaction zone **29** than tubes **45** by the distance generally designated "*d*." A directional control plate **46** is secured transversely in the lower portion of tube **38** at a distance "*l*" above the open ends of tubes **45** and this plate is provided with openings through which tubes **45** extend. The plate **46** coaxially forms an annular opening around each tube **45**. Plate **46** forces the shielding fluid to pass through the annular openings and then into the reaction zone surrounding the jets of fluid reactant from tubes **45**. The relation between the size of the holes in the plate and the thickness of the plate **46** is such that the shielding fluid passes between the plate **46** and the tubes **45** in approximately unidirectional flow toward the reaction zone **29**. The symbol "l" is used to designate the distance between the open ends of tubes **45** and the directional control plate **46**.

The preferred use of the foregoing nozzle of this invention is for conversion of uranium hexafluoride to a uranium dioxide rich composition similarly to that described for FIGS. **1** and **2**.

FIGS. **5** and **6** present another embodiment of the directional control plate here assigned the number **50** showing only the lower portion of the nozzle and **6** tubes **45**. The nozzle is similar to the nozzle presented in FIGS. 3 and 4. Plate **50** is fastened to the inside of tube **38** at points **51**. Plate **50** has a multiplicity of openings **52** enabling the shield gas to flow through the openings **52** as well as through the annular openings **53** around each of the six tubes **45**. This has the advantage that a double layer of shielding gas is formed, one layer immediately around each jet issuing from tube 45 and one layer generally surrounding all the tubes 45. This gives further protection against the build up of solid reaction products at the tip of tubes 38 and 33. While this embodiment of the plate has been presented for the nozzle of FIGS. 3 and 4, it can also be utilized with all the other embodiments as presented in this invention.

FIG. 7 presents another embodiment of this invention in which only a top view of the lower portion of the nozzle is shown and ten tubes 60 are arranged symmetrically on an imaginary circle inside tube 63 with directional control plate 61 having annular openings 62 for passage of the shielding fluid around tubes 60 through annular openings 62 toward the reaction zone. FIG. 8 presents still another embodiment of this invention in which only a top view of the lower portion of the nozzle is shown and four tubes 60 are arranged symmetrically on an imaginary circle inside tube 63 with directional control plate 61 having openings 62 for the passage of the shielding fluid around tubes 60 toward the reaction zone.

The term tube used in the description of this invention is meant to include any cross sectional configuration for such members including, but not limited to circular, square, rectangular and triangular cross sections. It is also preferred to have the tubes for the second reactive fluid positioned symmetrically so that if the points forming the centers of the tubes were connected they would form a circle, but it is also meant to be within the scope of this invention to have non-symmetrical arrangements of these tubes.

The dimensions of the directional control plate are controlled so that unidirectional flow of the shielding fluid occurs in the annular openings between the plate and the tubes (e.g., 25, 45, etc.) carrying the second fluid reactant. In particular the thickness of the directional control plate and the size of the openings in the plate are correlated so that unidirectional flow of the shielding fluid occurs in the annular openings. In practice, when the tube guiding the shielding fluid has an inside diameter in the range of about 2.0 to about 6.0 inches and the tubes guiding the second fluid reactant have an outside diameter of about 0.250 to about 0.840 inch, a directional control plate thickness of about 0.062 to about 0.750 inch and openings in the plate of about 0.375 inch to about 1.340 inches in diameter result in unidirectional flow of the shielding fluid through the annular openings in the plate. It is preferred that the distance *l* (i.e., the distance between the openings of the tubes guiding the second fluid reactant and the directional control plate) be in the range of 0.01 to about 2.0 inch. In this manner the plate is located close to the open ends of the tubes guiding the second fluid reactant so that the shielding fluid closely surrounds the jets of the second fluid reactant as they enter the reaction zone.

The distance *d*, which specifies the distance the tubes guiding the second fluid reactant are recessed within the tube guiding the shielding fluid, can vary depending upon the velocities of the shielding fluid and the second fluid reactant. Generally the smaller tubes guiding the second fluid reactant (i.e., 25, 45, etc.) terminate within the shielding fluid tube (i.e., 18, 38, etc.) by a distance of at least about one-eighth inch and preferably in the range of about one-eighth of an inch to about one-half an inch. As a general rule, the larger the diameter of the shielding fluid tube (i.e., 18, 38, etc.), the greater is distance *d*. This recessing of the tubes guiding the second fluid reactant more easily enables maintaining a lifted flame with lower flow rates than required without the recessing of the tubes guiding the second fluid reactant.

While preferred embodiments of the invention have been described, it is to be understood that changes and variations may be made without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A nozzle for injecting fluid reactants into a reaction zone comprising, in combination
   a. a supporting means supporting
   b. a first inlet for receiving and guiding a first fluid reactant into the reaction zone,
   c. a second inlet means for receiving and guiding a shielding fluid for temporarily separating the first fluid reactant and a second fluid reactant upon initial injection into the reaction zone,
   d. a third inlet means for receiving and guiding the second fluid reactant into the reaction zone, the third inlet means being disposed in the second inlet means and the third inlet means having a chamber with at least one opening therein which is connected with at least one tubular member with the tip of said tubular member being recessed within the second inlet means, and
   e. a directional control plate being secured transversely in the second inlet means, the plate having an opening for each of the at least one tubular member to extend therethrough coaxially forming an annular opening around the at least one tubular member so that the shielding fluid flows unidirectionally through the annular opening and then into the reaction zone.

2. The nozzle of claim 1 where the supporting means is a cover which removably fits with a vessel to define the reaction zone.

3. The nozzle of claim 1 in which the chamber of the third inlet means has four openings which are connected with four tubular members.

4. The nozzle of claim 1 in which the chamber of the third inlet means has six openings which are connected with six tubular members.

5. The nozzle of claim 1 in which the chamber of the third inlet means has eight openings which are connected with eight tubular members.

6. The nozzle of claim 1 in which the chamber of the third inlet means has ten openings which are connected with ten tubular members.

7. The nozzle of claim 1 in which the chamber of the third inlet means has a plurality of openings symmetrically located and the openings are each connected with a tubular member.

8. The nozzle of claim 1 in which the first fluid reactant is a reducing gas, the second fluid reactant is a mixture of uranium hexafluoride and an oxygen-containing carrier gas and the fluid is selected from the group consisting of nitrogen, argon, helium, neon, krypton, xenon, oxygen, air or mixtures of any of the foregoing.

9. The nozzle of claim 1 in which the first inlet means and the second inlet means are concentric tubular members.

10. The nozzle of claim 1 in which the first inlet means is a plurality of tubular members located at a po-

sition on the supporting means removed from the second inlet means.

11. The nozzle of claim **1** in which the directional control plate has openings in the form of slits adjacent the second inlet means so that a second layer of shielding gas is formed around the at least one tubular member.

12. The nozzle of claim **1** in which the third inlet means is recessed within the second inlet means by a distance of at least about one-eighth of an inch.

13. The nozzle of claim **1** in which the first fluid reactant is selected from the reducing gases consisting of dissociated ammonia, hydrogen and mixtures thereof.

14. The nozzle of claim **1** in which the second fluid reactant is a mixture of uranium hexafluoride and an oxygen-containing carrier gas selected from the group of oxygen, air and mixtures thereof.

15. The nozzle of claim **1** in which the shielding fluid is a gas selected from the group consisting of nitrogen, argon, helium, neon, krypton, xenon, oxygen, air or mixtures of any of the foregoing.

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