Feb. 17, 1953 D. P. HEATH 2,628,475
JET COMBUSTION DEVICE EMBODYING PRETREATMENT
OF FUEL BEFORE COMBUSTION
Filed June 26, 1946 2 SHEETS--SHEET 1

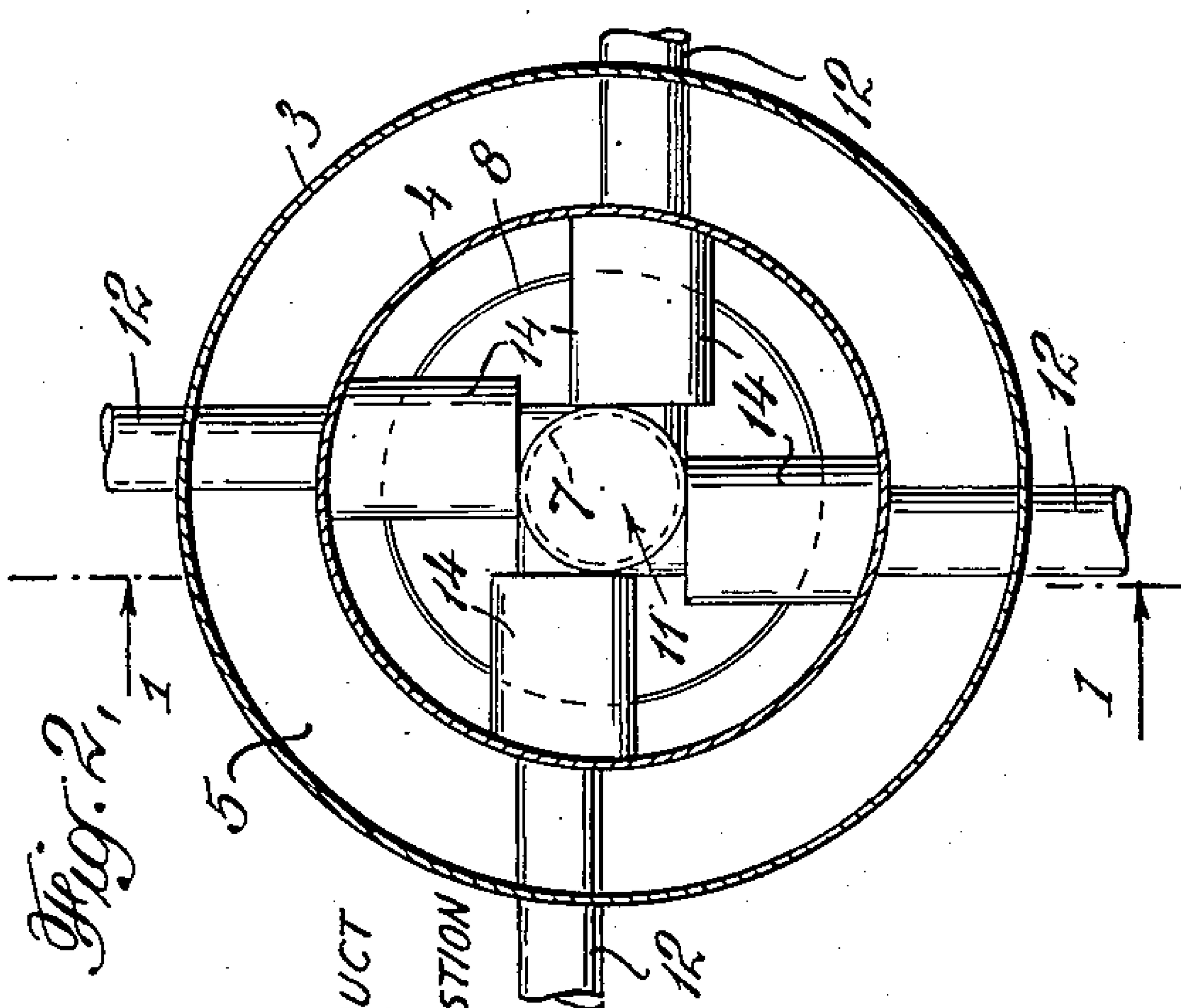

Fig. 2

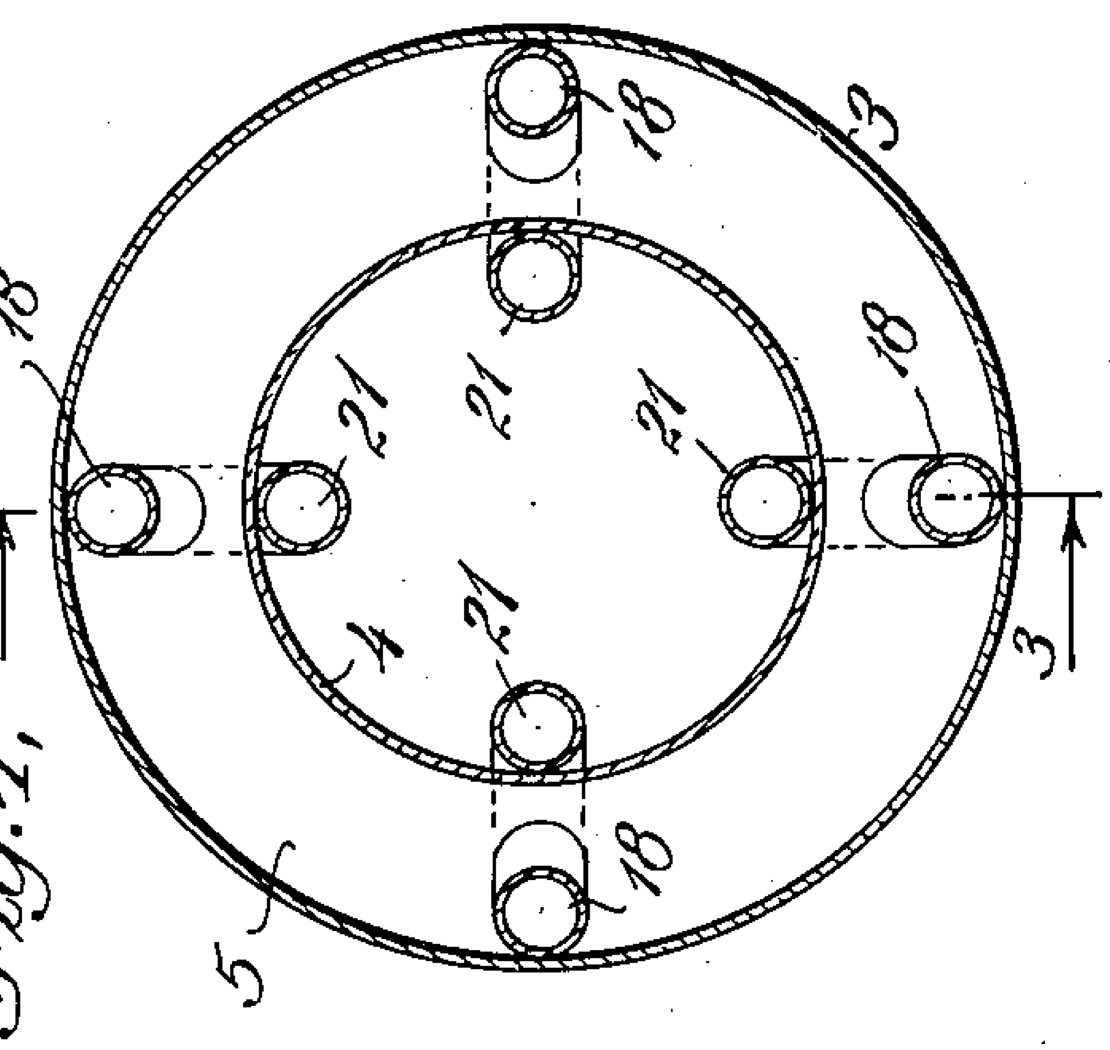

Fig. 4

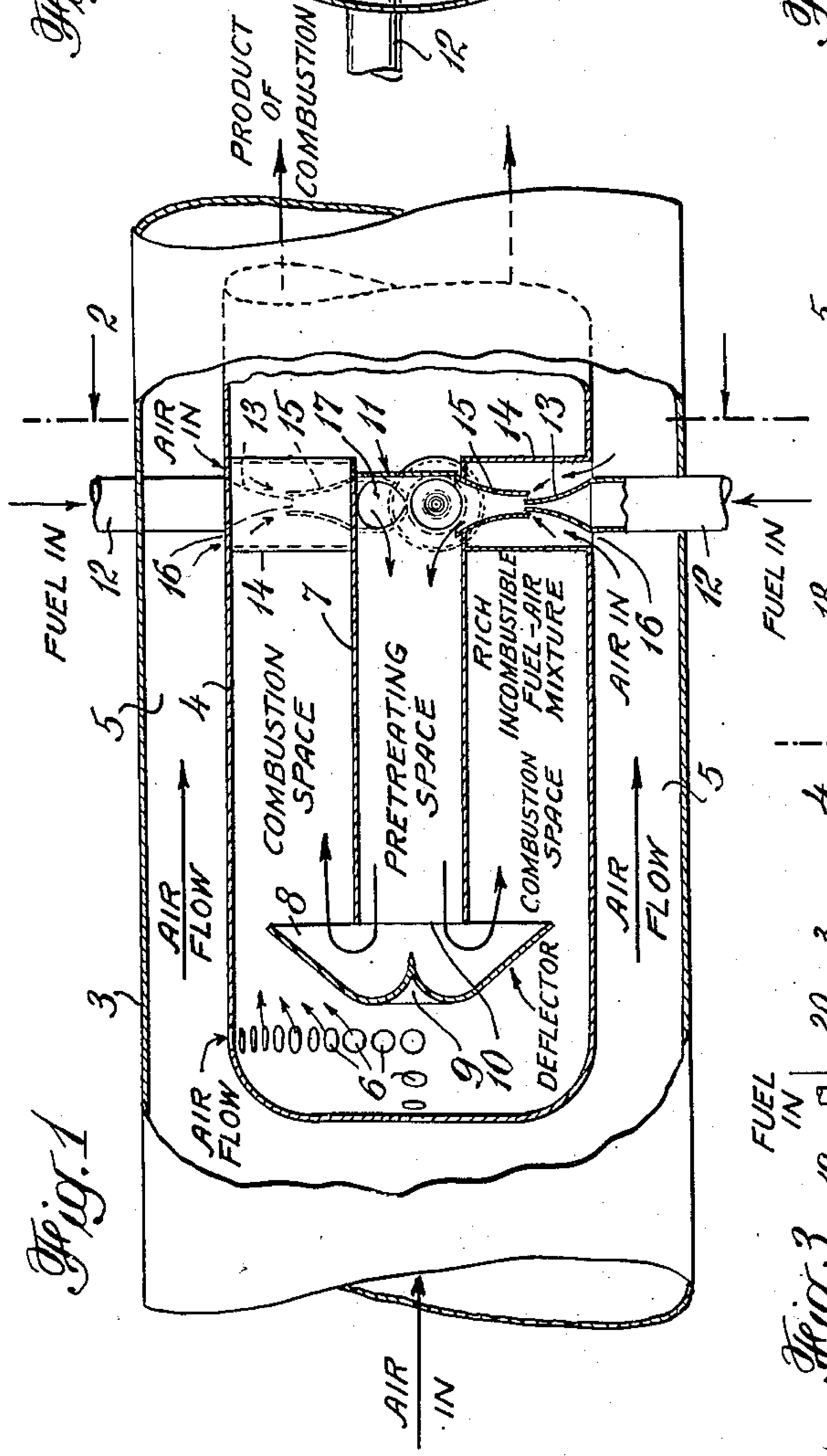

Fig. 1

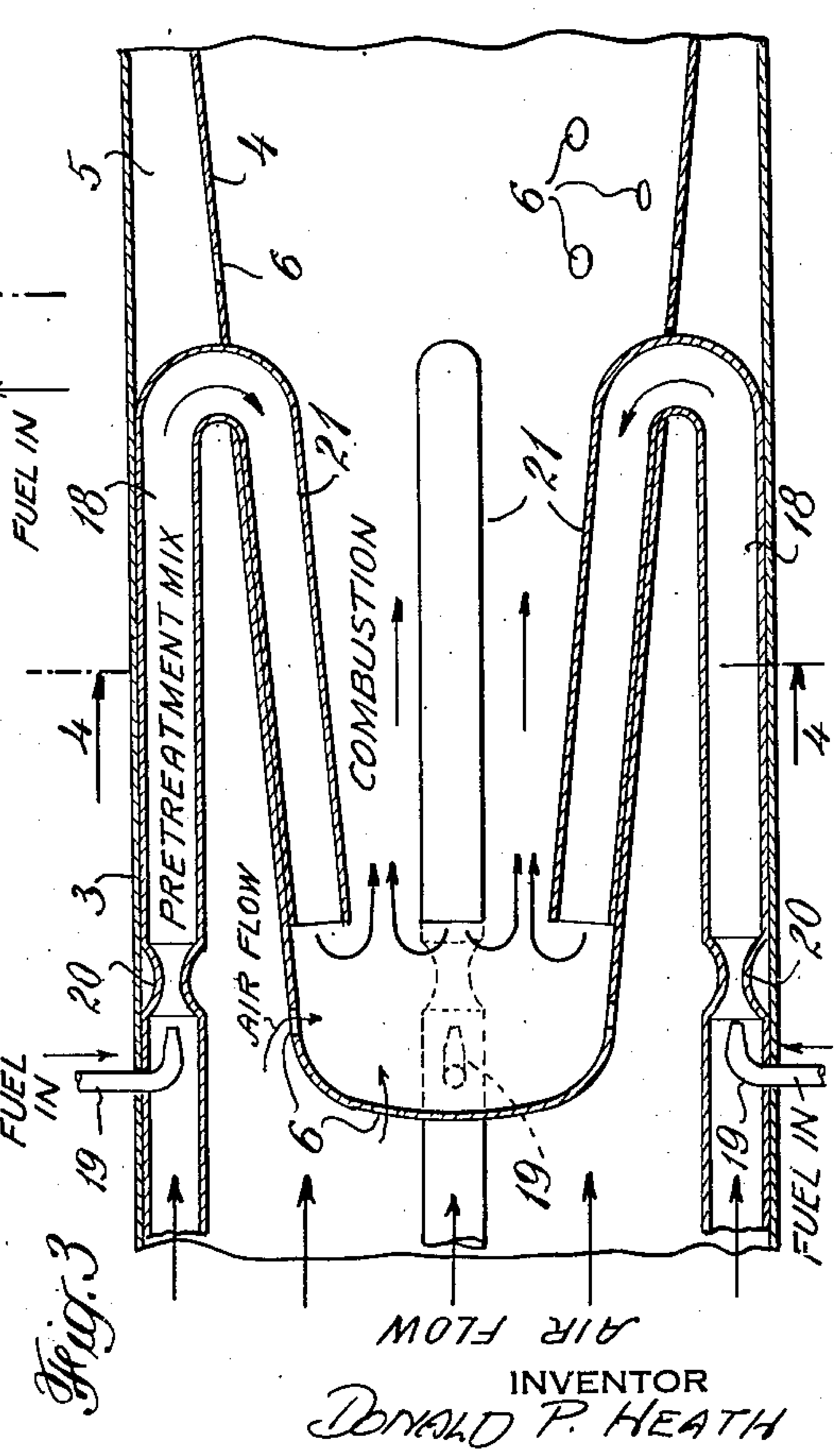

Fig. 3

INVENTOR
DONALD P. HEATH
BY
Myron J. Burkhard
ATTORNEY

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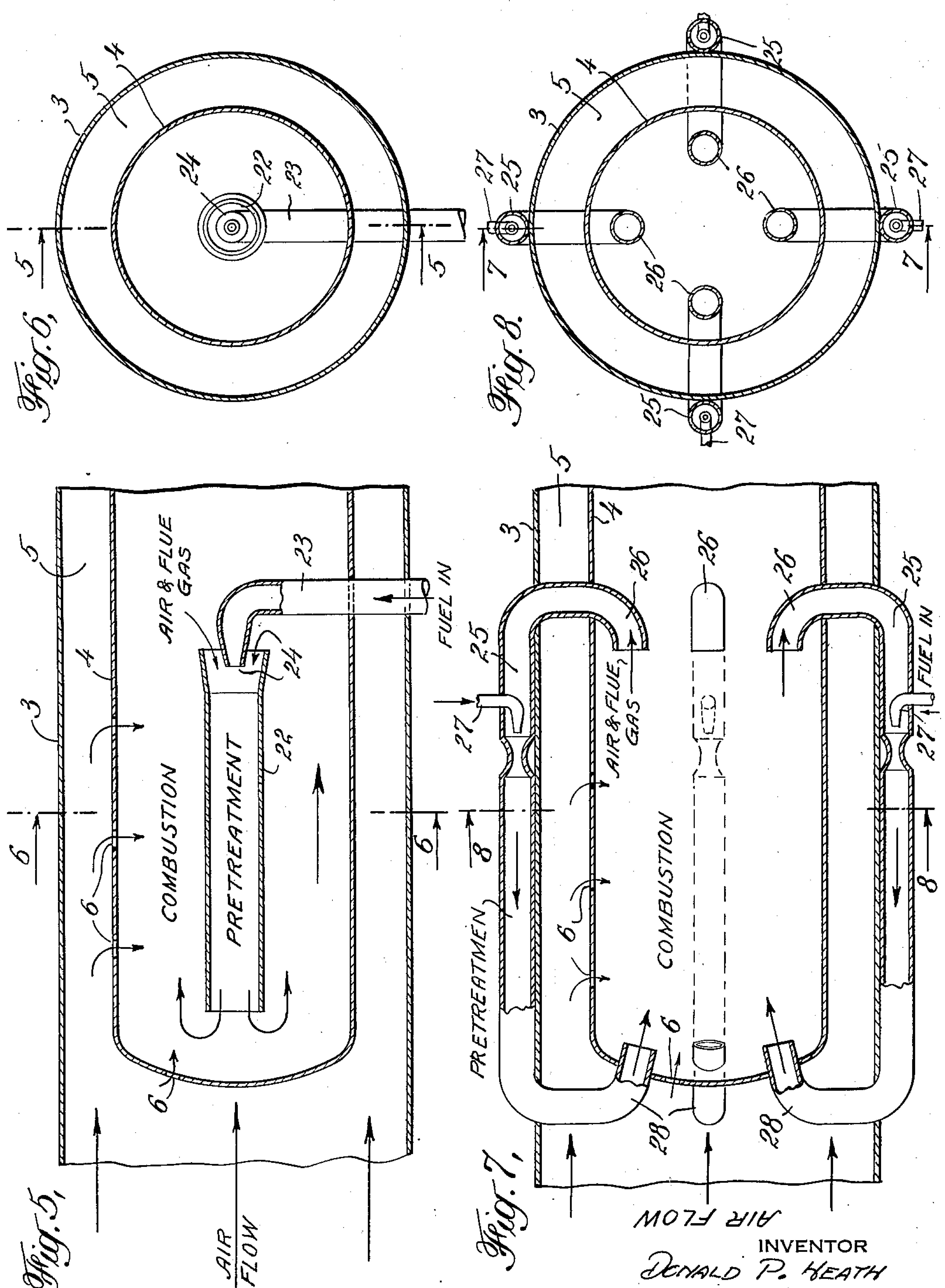

INVENTOR

DONALD P. HEATH

BY

ATTORNEY

Patented Feb. 17, 1953

2,628,475

UNITED STATES PATENT OFFICE

2,628,475

JET COMBUSTION DEVICE EMBODYING PRETREATMENT OF FUEL BEFORE COMBUSTION

Donald P. Heath, Delaware Township, Camden County, N. J., assignor to Socony-Vacuum Oil Company, Incorporated, a corporation of New York

Application June 26, 1946, Serial No. 679,434

6 Claims. (Cl. 60—39.71)

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This invention has to do with improvements in jet combustion devices.

Jet combustion devices have received prominence recently in connection with jet propulsion. In essence, jet combustion as now commonly used, and as used herein, refers to a method of combustion wherein fuel is continuously introduced into and continuously burned in a confined space for the purpose of deriving power directly from the hot products of combustion.

The simplest jet propulsion device is a tube, closed at one end, in which a fuel is burned. The gases of combustion emitted from the open end of the tube give rise to a reaction effect driving the tube in a direction opposite to that of the emission of gases. The most complicated jet propulsion mechanisms yet proposed consist of a plurality of somewhat similar combustion tubes, plus a compressor to supply air to the combustion tubes, plus a gas turbine arranged to take enough energy from the effluent combustion gases to drive the compressor, plus a jet tube or reaction tube through which the gases are exhausted to provide driving power. Similar combustion tubes are utilized in gas turbines, which usually differ from the jet propulsion engine above described only in that provisions are made to extract most of the energy from the gases in the turbine rather than by reaction from the exhaust. In some cases of jet propulsion, the compressor and its driving turbine are dispensed with, combustion air being furnished by the "ram" effect, i. e., air in desired quantities flows into the combustion tube solely by virtue of the movement of the jet propulsion mechanism with respect to the surrounding air.

In all such combustions, whether for jet propulsion or for a gas turbine, moving or stationary, the optimum performance is that which will attain the highest stable rate of heat release in the combustion.

Selecting as typical an airplane jet propulsion mechanism of the coupled compressor-burner-turbine-reactor type, study shows that various design considerations reduce the many variables which might affect the rate of heat release to only a few. Air rate within the combustion tube, preselected by design to always give an excess, becomes a function of ambient air pressure once the compressor is selected, and is relatively fixed for any altitude of operation, air speed, and ambient temperature. Turbulence within the combustion chamber is held at a high level, but, since it is achieved only at the expense of the overall efficiency of the mechanism, may be regarded as non-variant. Substantially the sole variable which remains is the fuel. It is not only imperative that the fuel have high flame stability, i. e., ability to burn at a high rate without blowout, but also that the fuel have a high heat release, as measured by taking the temperature difference across the combustion tube at a given air rate. With fuels of the same general order of flame stability, the more useful fuel is the one which will deliver the greater heat release at a given air rate.

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This invention is based upon the discovery that certain changes in the manner of handling the fuel immediately prior to and at the point of combustion give rise to increases in flame stability and rate of heat release of a fuel. These changes may readily be incorporated in the combustion mechanism, and when so incorporated effect significant improvements in the use of any fuel appropriate to the burner in which they are incorporated.

It is an object of this invention to provide a jet combustion mechanism capable of effecting a thermal pretreatment of the fuel prior to combustion. This and other objects which are in part obvious and which in part may be referred to hereinafter may be understood by reference to the drawings of this specification.

In the drawings, Figure 1 shows in section on line **1—1** of Figure 2, and Figure 2 shows in end view, a combustion tube so modified as to embody the teachings of my invention.

The other figures of the drawing, namely Figures 3 and 4, in which Figure 3 is a longitudinal section taken along line **3, 3** of Figure 4 and Figure 4 a cross section along line **4, 4** of Figure 3; Figures 5 and 6, in which Figure 5 is a longitudinal section taken at line **5, 5** of Figure 6 and Figure 6 is a cross section taken at line **6, 6** of Figure 5; and Figures 7 and 8 in which Figure 7 is a longitudinal section taken at line **7, 7** of Figure 8 and Figure 8 is a cross section taken at line **8, 8** of Figure 7 show other forms of modified combustion tubes. The invention will be explained particularly in connection with Figures 1 and 2.

In Figure 1 of the drawing, **3** is the outer casing or shell of the combustion tube, and **4** is the combustion tube itself, the casing **3** and tube **4** being so arranged, coaxially, as to provide an annular passage **5** for the flow of combustion air which air enters under pressure, either due to a compressor or to ram effect, at the left hand end of the burner as shown. Combustion tube 4 is provided with a number of holes 6 both at its left hand end and spaced along its length, whereby air from passage 5 may enter the interior of combustion tube 4. For the purpose of clarity only a few such holes 6 are shown. In practice, they will be spaced along tube 4 somewhat in keeping with the demands for air in its interior, and will be most plentiful in number at the closed end (left hand in the drawing), of the combustion tube 4. This manner of introducing air to a combustion tube and of controlling its rate and point of entry thereto is common in the art.

In the ordinary combustion tube, fuel is delivered at the center of the tube by a single jet pipe or nozzle extending thereinto.

In contrast thereto I have provided a central tube 7 in which fuel is introduced to the burner tube 4 and in which the fuel is preconditioned or preheated to give it enhanced flame stability and heat release capability. Since the fuel upon release must be reversed in direction, I have also provided a turning baffle 8 of cupped shape in which, if desired, there may be placed a reentrant conical flow splitter 9. Tube 7 is, of course, open at its forward end, at 10, and is closed at its rear end by plate 11. Fuel is fed to tube 7 through one or more fuel pipes 12. (Four such pipes with attendant parts are shown in the drawing—see Figure 2.) Each fuel pipe 12 terminates in a nozzle 13 mounted in a casing 14. Within casing 14 there is a Venturi tube 15, into the throat of which nozzle 13 extends. Air from passage 5 is permitted to enter the space within casing 14 through ports 16 and is entrained with fuel in the injector formed by venturi 15 and nozzle 13, the resulting mixture being passed into tube 7 through an opening 17. For many purposes, in fact for most, the relative amounts of air and fuel thus mixed can be predetermined by proportioning of the nozzle 13 and throat 15. However, should flexibility in this proportioning be desired or desirable, adjustability can be achieved quite simply by providing a sleeve mounting for fuel tube 12 and an external adjustment of any convenient kind, such as a threaded mount, whereby nozzle 13 may be advanced and retracted with respect to throat 15.

In any event, the amount of air admixed with the fuel and passing through tube 7 is insufficient for combustion of the fuel supplied thereto. However, this fuel-air mixture, too rich for combustion, is exposed to a high degree of heat by radiation and convection from the walls of tube 7, which are surrounded by the combustion space. Under such heat and in the presence of limited amounts of oxygen, I have found that a preconditioning of some sort takes places in the fuel which permits of more efficient combustion and higher rates of fuel burning, i. e., higher heat release for a given air rate. In other words, if one operates the burner here disclosed in parallel with a burner of ordinary type, in which fuel is merely introduced into the left hand end of combustion tube 4 through a simple nozzle, both burners being operated with air at the same pressure and temperature fed to each at the same rate, feeding the same fuel to each burner, and gradually increasing the rate of fuel supply until blowout is experienced, the novel burner here disclosed will be found to be capable of burning more fuel than the conventional burner.

I do not wish to advance any explanatory theory in such manner as to be bound thereby, but it is my present belief that a combination of incipient

oxidation and high temperature cracking of the fuel is responsible.

The temperatures attained in this novel burner are of somewhat the following order. Air at inlets 16, about 500° F. Fuel-air mixture at ports 17, 500–600° F. Temperature of gases in combustion space just outside wall of tube 7, around 4000° F. Temperature of preconditioning mixture inside tube 7, about 1500° F.

Whatever the reason be, I have found that with the novel burner substantially more fuel per pound of air can be burned than with the conventional type of burner, and that a stable flame can be maintained over a wider range of pressure and air flow conditions.

Turning now to Figure 3 and its companion Figure 4, I show a different construction. In this figure jacket tube 3 and combustion tube 4 defining annular air space 5, from which air can pass into the combustion space through holes 6 are essentially the same as before. The pretreatment mixture is attained by disposing a number of tubes 18 (four only are shown, although there may be more or less) around the inside of the jacket tube 3 in such manner that air will enter their left hand end. Fuel is introduced into these tubes 18 through fuel jets 19 and, with or without the assistance of a venturi 20, the fuel and an amount of air insufficient to support combustion are mixed. This mixture flows along tube 18 and is returned through that portion of the tube designated lying inside the combustion chamber wherein the pretreatment mixture is subjected to the high temperature of combustion, finally being discharged inside the closed left hand end of the combustion tube 4.

In Figures 5, 6, 7, and 8 a slightly different application of the same principle is shown. It will be remembered that the products of combustion contain a very considerable amount of excess air and are at a quite high temperature, therefore these products of combustion may be admixed with a fuel in proper proportions and a similar pretreatment achieved. In Figure 5, combustion tube 4, jacket tube 3, annular air space 5 and communication holes 6 are found as before, but in this modification all of the fuel is introduced through a jet 23 which terminates in an aspirator 24 at the downstream end (considered with respect to flow of combustion gases) of pretreatment tube 22. After pretreatment in tube 22 the fuel mixture is discharged as before into the combustion chamber.

In Figure 7, another modification along the line of this latter idea is shown. Here again jacket tube 3, combustion tube 4, air passage 5 and the communication holes 6 are found. In this case a plurality of tubes 25 are arranged around the external periphery of jacket tube 3 and provided each with an end 26 wherein the air rich combustion gases may enter urged both by their own velocity and also by the aspirating action of fuel introduced through jet 27. Pretreatment of the fuel mixture then takes place in the leftward extension of tube 25 under the influence of the temperature of the gases aspirated at 26 and the heat thrown into tube 25 chiefly by radiation from the adjacent combustion, after which the pretreated fuel mixture is discharged into the left hand end of the combustion chamber by pipe 28.

It will be obvious that many other modifications embodying the general idea set forth herein and even the specific ideas set forth in the figures may be made and all such are considered to be within the scope of the invention subject only to such limitations as are found in the following claims.

I claim:

1. A jet combustion burner comprising an air tube, a combustion tube, and a pretreatment tube coaxially assembled, to provide an annular air passage around the combustion tube and an annular combustion space around the pretreatment tube, a closed end on the combustion tube toward the inlet end of the air tube, orifice means to introduce air from the annular air passage into the combustion tube at spaced points near its closed end and along its length, the pretreatment tube being shorter than the combustion tube, terminating in an open end near the closed end of the combustion tube, the opposite end of the pretreatment tube being closed, means to introduce fuel into the pretreatment tube near its closed end, and means to admix a limited amount of air with said fuel in said pretreatment tube.

2. A jet combustion burner comprising an air tube, a combustion tube, and a pretreatment tube assembled with the combustion tube inside the air tube to provide a passage for air around the combustion tube, and with the pretreatment tube inside the combustion tube a closed end on the combustion tube toward the inlet end of the air tube, orifice means to introduce air from the annular air passage into the combustion tube at spaced points near its closed end and along its length, the pretreatment tube being shorter than the combustion tube, terminating in an open end near the closed end of the combustion tube, the opposite end of the pretreatment tube being closed, means to introduce fuel into the pretreatment tube near its closed end, and means to admix a limited amount of air with said fuel in said pretreatment tube.

3. A jet combustion burner comprising an air tube, a combustion tube, and a pretreatment tube coaxially assembled, to provide an annular air passage around the combustion tube and an annular combustion space around the pretreatment tube, a closed end on the combustion tube toward the inlet end of the air tube, orifice means to introduce air from the annular air passage into the combustion tube at spaced points near its closed end and along its length, the pretreatment tube being shorter than the combustion tube, terminating in an open end near the closed end of the combustion tube, the opposite end of the pretreatment tube being closed, means to introduce fuel into the pretreatment tube near its closed end, means to admix a limited amount of air with said fuel in said pretreatment tube and means adjacent the open end of said pretreatment tube adapted to distribute fuel-air mix effluent therefrom into said combustion tube.

4. A jet combustion burner comprising an air tube, a burner tube of smaller diameter than said air tube and coaxially mounted within said tube, a pretreatment tube mounted within said air tube with at least a portion thereof located within said burner tube, means defining a passageway through which air may be admitted to said pretreatment tube, an ejector nozzle mounted in said pretreatment tube adapted to admit a continuous stream of fuel into said pretreatment tube such that a proportionate amount of air insufficient to support combustion is induced to flow therein, means for providing fuel to said nozzle, means defining an exit at the end of said pretreatment tube within said burner tube located near the upstream end of said burner tube, inlet means for admitting air into said burner tube to burn continuously therein the pretreated fuel emitted from said exit, and means defining an outlet at the downstream end of said burner tube to permit the passage of combustion gases therefrom.

5. In a jet combustion burner, an air tube and a combustion tube coaxially mounted therewith, said combustion tube being closed at its upstream end, orifice means located near the closed end and spaced along the length of said combustion tube to admit air thereto, at least one elongated pretreatment tube terminating within said combustion tube near the closed end thereof, and additionally being arranged for indirect heat transfer between products of combustion and contents of the pretreatment tube for a substantial portion of the length of the pretreatment tube, means to admit fuel to said pretreatment tube near its inlet end, inlet means to admit a limited amount of oxygen containing gas to mix with the fuel in said pretreatment tube, and outlet means for combustion gases at the rearward end of said combustion tube.

6. In a jet combustion burner, an air tube and a combustion tube coaxially mounted therewith, said combustion tube being closed at its upstream end, orifice means located near the closed end and spaced along the length of said combustion tube to admit air thereto, at least one elongated pretreatment tube, said pretreatment tube lying at least partially within the combustion tube and terminating therein near the closed end thereof, and additionally being arranged for indirect heat transfer between products of combustion and contents of the pretreatment tube for a substantial portion of the length of the pretreatment tube, means to admit fuel to said pretreatment tube near its inlet end, inlet means to admit a limited amount of oxygen containing gas to mix with the fuel in said pretreatment tube, and outlet means for combustion gases at the rearward end of said combustion tube.

DONALD P. HEATH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
85,663	Hill	Jan. 5, 1869
408,644	Wilson et al.	Aug. 6, 1889
438,513	Wilson et al.	Oct. 14, 1890
471,361	Rogers	Mar. 22, 1892
1,310,927	Reichhelm	July 22, 1919
1,509,706	Bryan et al.	Sept. 23, 1924
2,398,654	Lubbock et al.	Apr. 16, 1946
2,398,883	Clarkson	Apr. 23, 1946
2,438,858	Lindsey et al.	Mar. 30, 1948

FOREIGN PATENTS

Number	Country	Date
151,503	Switzerland	Mar. 1, 1932