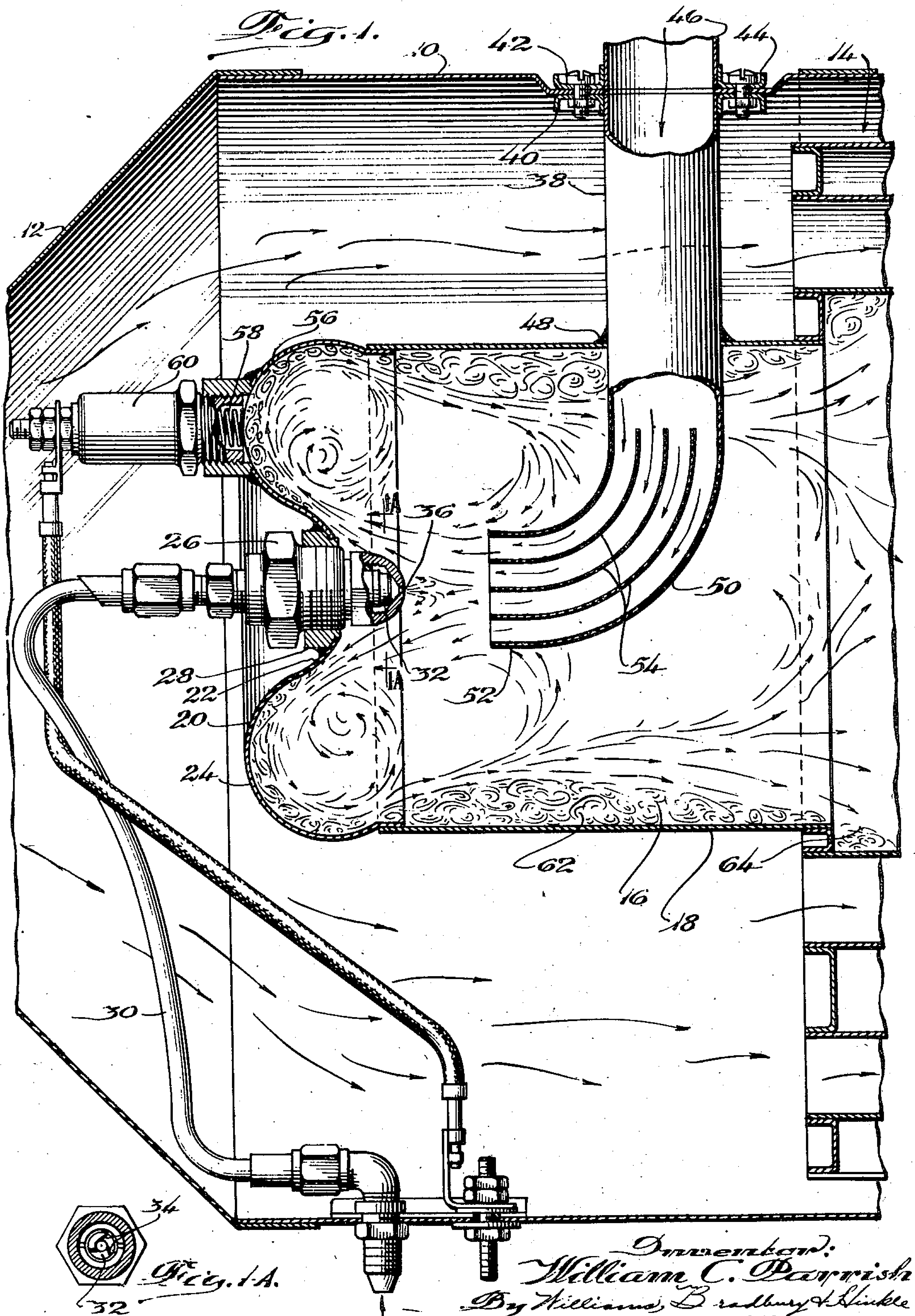
Oct. 4, 1949. W. C. PARRISH 2,483,737

INTERNAL-COMBUSTION BURNER FOR HEATERS

Filed July 10, 1943 5 Sheets-Sheet 1



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INTERNAL-COMBUSTION BURNER FOR HEATERS

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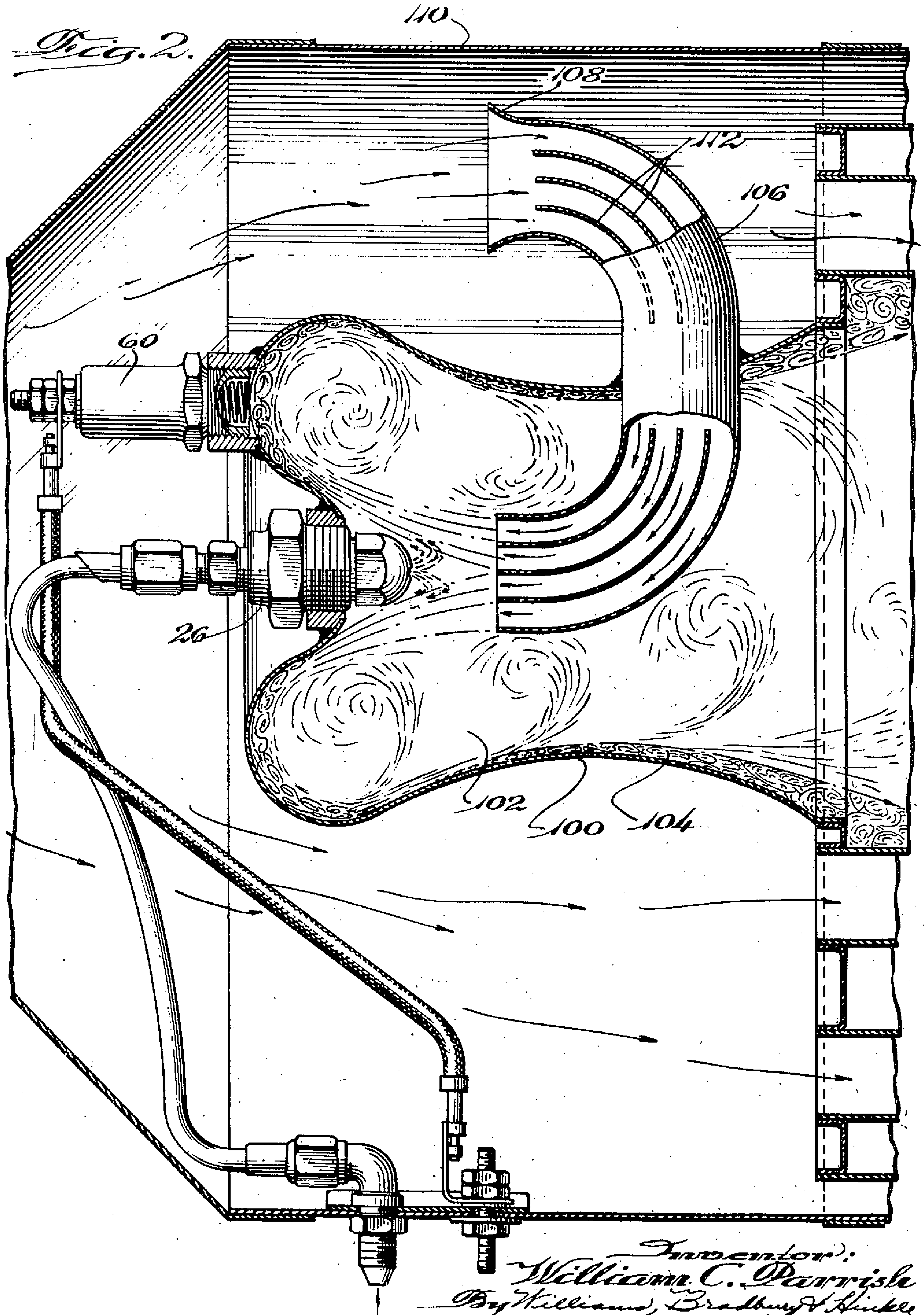
Fig. 2.



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INTERNAL-COMBUSTION BURNER FOR HEATERS

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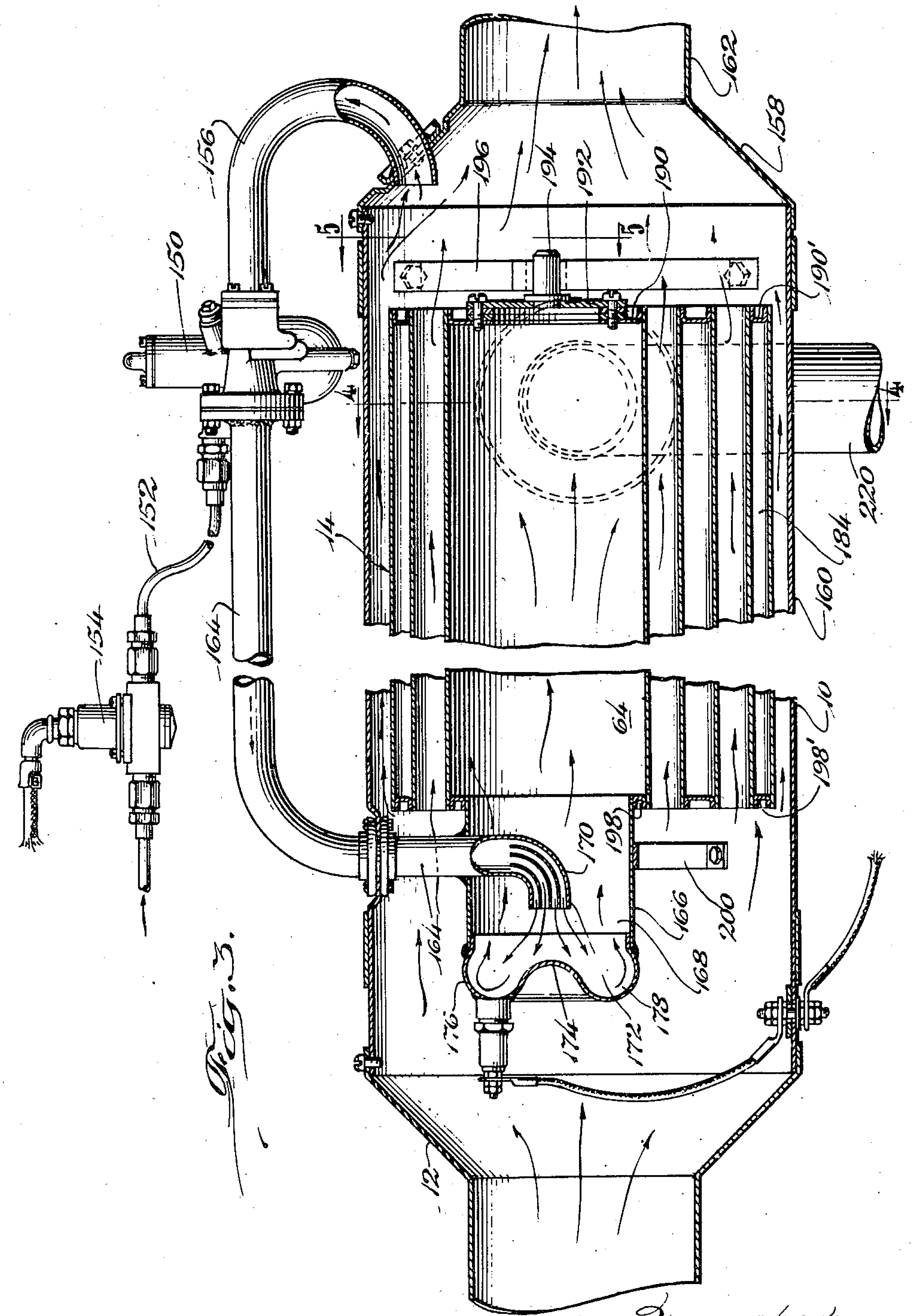

Fig. 3.

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INTERNAL-COMBUSTION BURNER FOR HEATERS

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Fig. 4.

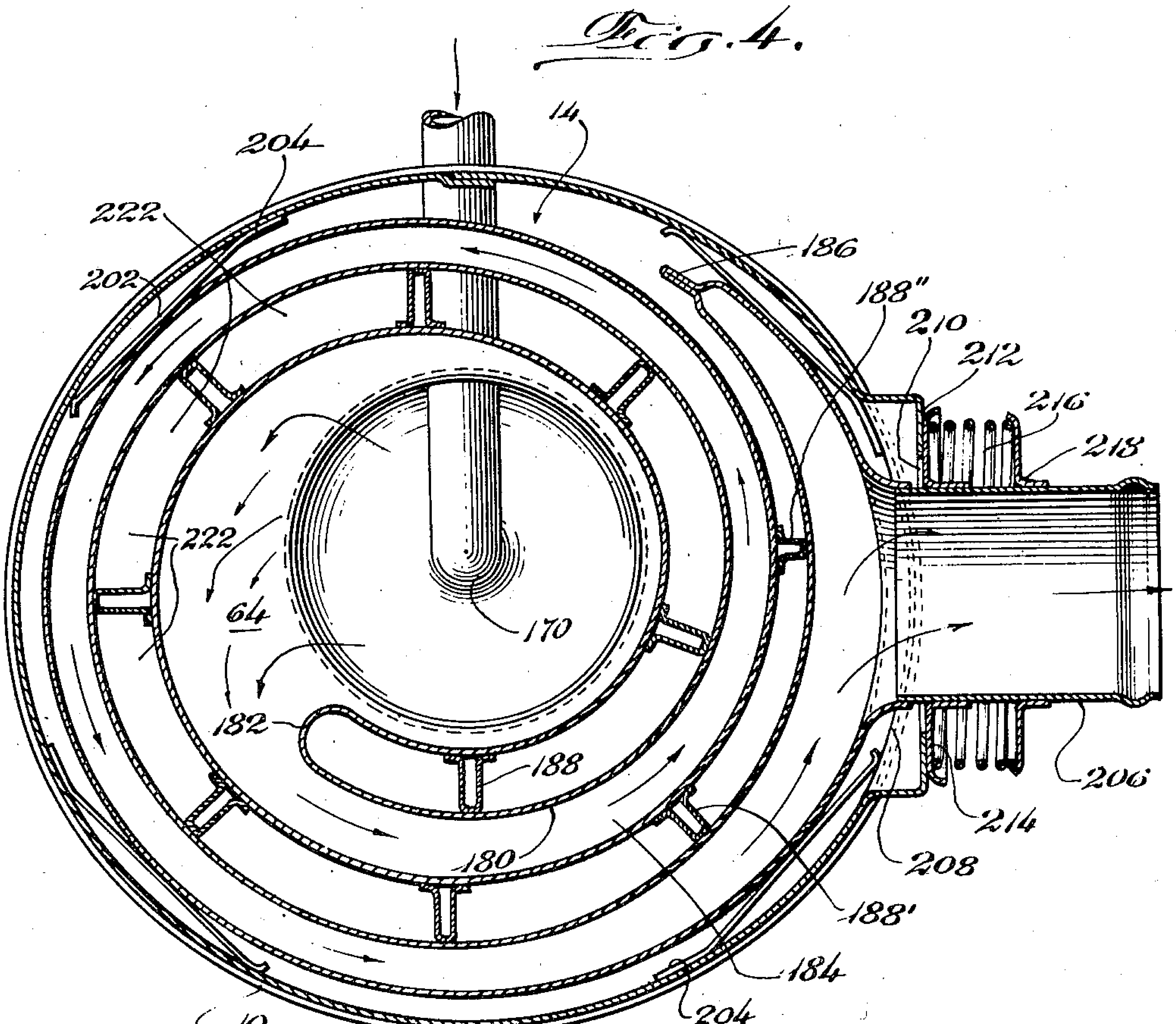
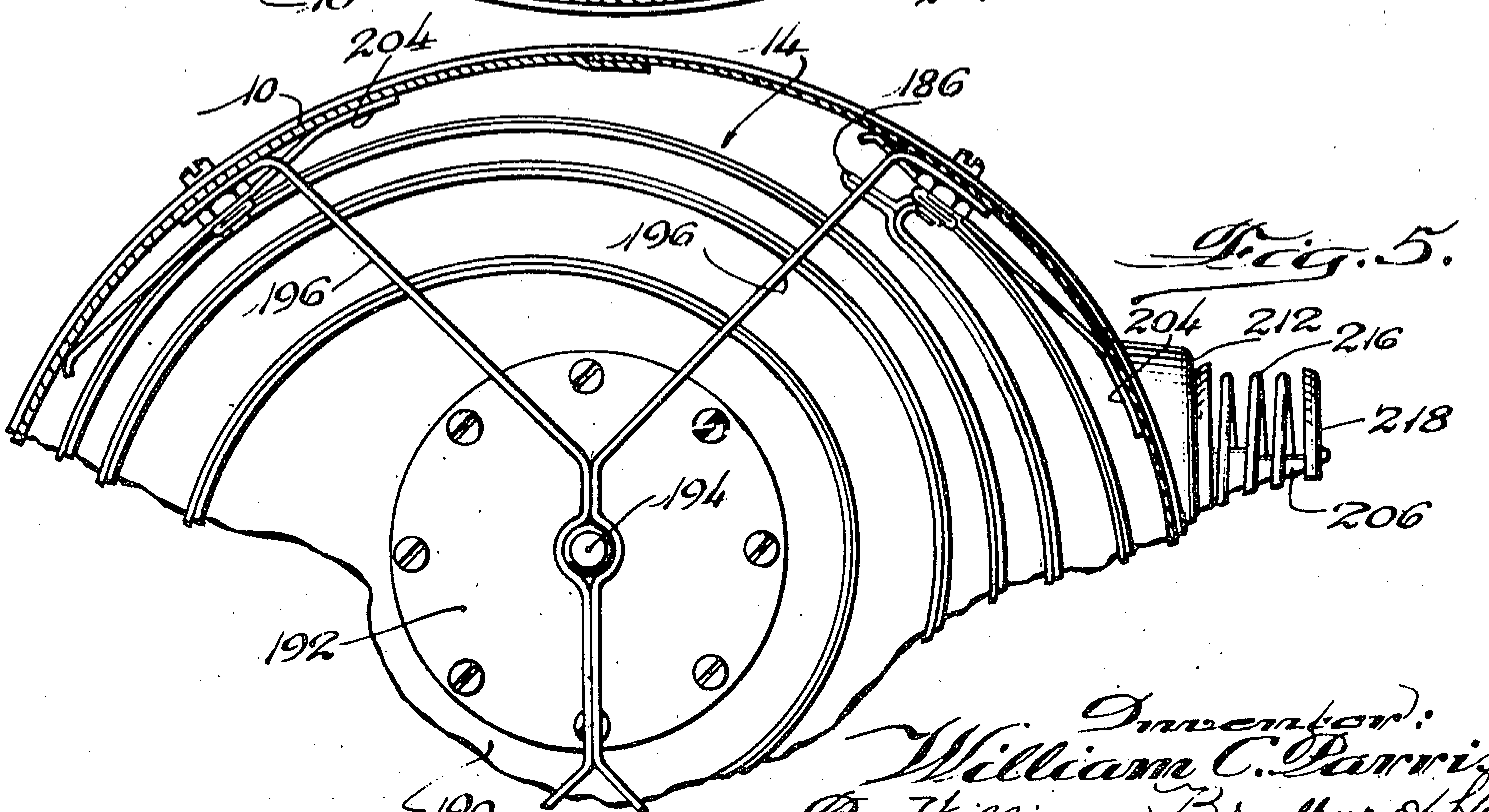


Fig. 5.



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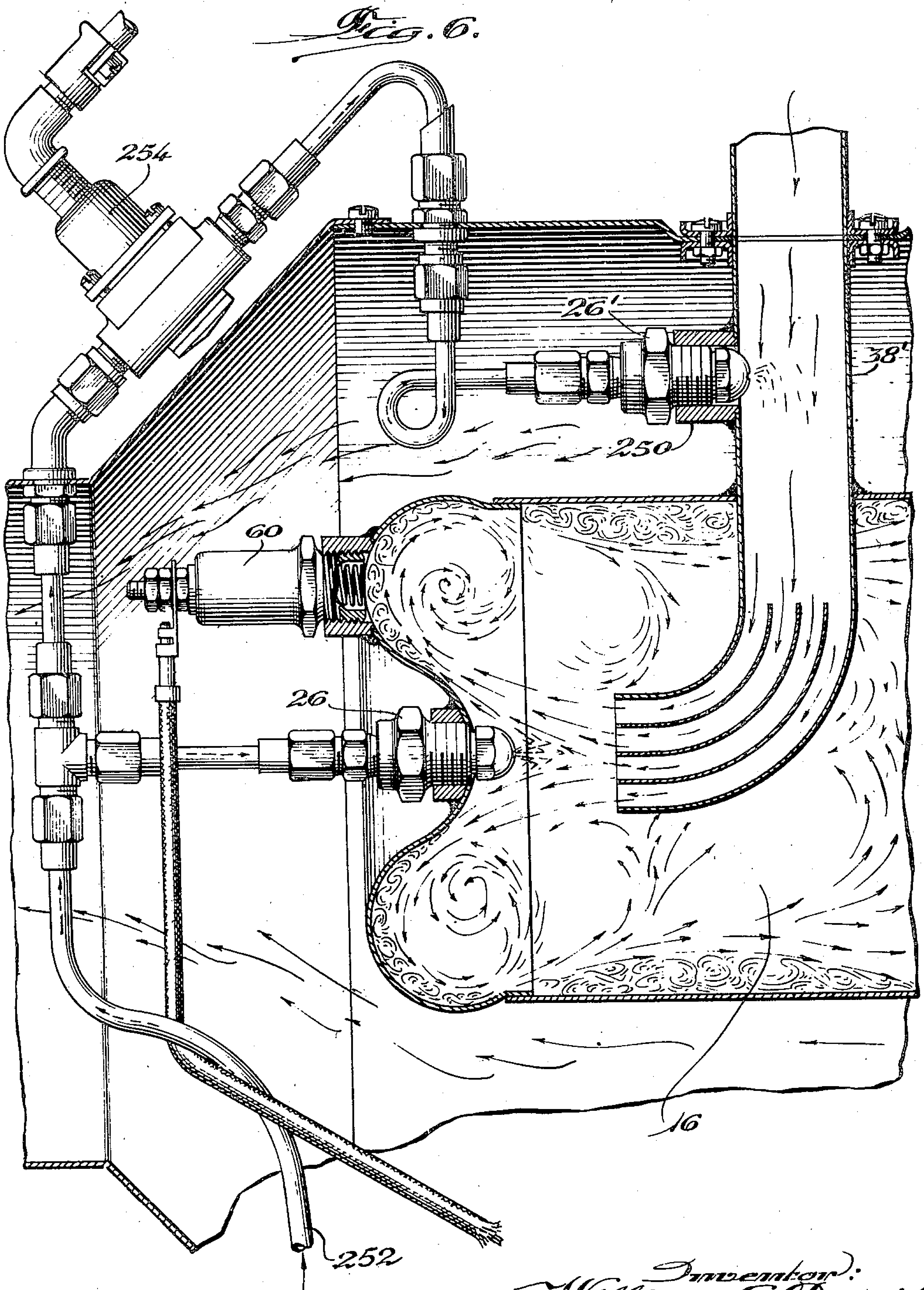
INTERNAL-COMBUSTION BURNER FOR HEATERS

Filed July 10, 1943 5 Sheets-Sheet 5

Fig. 6.



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Patented Oct. 4, 1949

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UNITED STATES PATENT OFFICE

2,483,737

INTERNAL-COMBUSTION BURNER FOR HEATERS

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Application July 10, 1943, Serial No. 494,155

3 Claims. (Cl. 158—28)

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My invention relates to internal combustion heaters, and is more particularly concerned with, but is not limited to, internal combustion heaters of the kind used in aircraft for heating the cabins and other spaces.

An object of my invention is to provide a new and improved internal combustion heater, wherein the combustion of the fuel is more complete and efficient than in the heaters of the prior art.

Another object of my invention is to provide a new and improved internal combustion heater, wherein the fuel is sprayed into the combustion chamber in a direction counter to the incoming combustion air to insure thorough vaporization of the fuel and thorough admixture of the vaporized fuel and air.

Another object of my invention is to provide an internal combustion heater having a new and improved combustion chamber.

Another object of my invention is to provide an internal combustion heater wherein the combustion chamber is specially designed to promote thorough intermixing and combustion of the burning gases.

Another object of my invention is to provide an internal combustion heater having a novel design of combustion chamber which shortens the length of the flame created by the burning gases.

Another object is to provide an internal combustion heater having a novel combustion chamber which prevents the flame leaving the combustion chamber from concentrating on any particular part of the heat exchanger.

Another object of my invention is to provide a new and improved internal combustion heater which may be operated more efficiently to give off different quantities of heat.

Another object of my invention is to provide a new and improved internal combustion heater wherein the ventilating air may flow through the heater in either direction.

Another object of my invention is to provide a new and improved internal combustion heater which is capable of operating with nozzle supplied fuel under lower fuel pressures than were heretofore deemed necessary.

Other objects and advantages will become apparent as the description proceeds.

In the drawings:

Fig. 1 is a longitudinal section through part of an internal combustion heater embodying one form of my invention;

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Fig. 1A is a sectional view through the fuel supply nozzle, and is taken on the line *1a*—*1a* of Fig. 1;

Fig. 2 is a view similar to Fig. 1, but showing a modified form of my invention;

Fig. 3 is a longitudinal sectional view through a third form of internal combustion heater embodying my invention. In this figure, the carburetor and related connections to the heater are diagrammatically shown in side elevation.

Fig. 4 is a transverse section taken on the line 4—4 of Fig. 3;

Fig. 5 is a partial transverse section taken on the line 5—5 of Fig. 3; and

Fig. 6 is a partial longitudinal section through the fourth form of internal combustion heater embodying my invention.

The heater shown in Fig. 1 has a casing 10 provided with an inlet 12 adapted to be connected to a ram, blower, or any other suitable source of ventilating air. The right-hand end of the casing is not shown but is designed to discharge the heated ventilating air either directly into a cabin or other space to be heated, or into a duct having one or more outlets at any desired location or locations in one or more spaces requiring heat. A heat exchanger indicated generally by reference numeral 14, is located in the casing 10 and is supplied with hot products of combustion by a combustion chamber 16 attached in any suitable manner to the left-hand end of the heat exchanger. The particular heat exchanger indicated in Fig. 1 is shown more fully as part of the embodiment of Fig. 3, and will be discussed in greater detail in the discussion of the modification of that figure.

The combustion chamber 16 has a cylindrical side wall 18 preferably formed of sheet metal or other suitable material, and an end wall 20 welded or otherwise suitably secured to the cylindrical side wall 18. An important feature of my invention lies in the particular configuration of the end wall 20. This end wall has a central inward projection 22 which merges in a curved surface with an annular groove 24 which is semi-circular in cross section, as clearly shown in Fig. 1 of the drawings. Fuel is supplied to the combustion chamber through a nozzle 26 which is threaded into a ring 28 welded or otherwise suitably secured to the central projection of the end wall 20.

The nozzle 26 is connected to a fuel supply pipe 30 which receives gasoline or other liquid fuel under pressure from a fuel pump or any other suitable source. In accordance with usual practice, suitable means may be provided to vary the rate of fuel delivery from the nozzle orifice 36 by varying the pressure in the fuel pipe 30, and thus vary the heat output of the heater. The nozzle 26 has a spinner 32 provided with tangentially arranged fuel delivery passages 34, which give the fuel a whirling motion so that it emerges from the nozzle orifice 36 in the form of a fine cone-shaped spray. The dimensions of the structural parts of the nozzle may be varied to give any desired included angle to the spray, and this included angle should be selected to meet particular conditions of heater operations and sizes of heater. I have found, however, that an included angle of 80° operates very successfully in the heater shown in Fig. 1. It is to be understood, however, that changes in any of the dimensions or arrangements of the several parts of the fuel mixing parts of this heater may make some other angle of fuel delivery more desirable.

Combustion air is supplied to the combustion chamber 16 by way of a combustion air pipe 38. This pipe is illustrated as having a flange 40 welded to its upper end and as being secured to the casing 10 by bolts 42 which pass through this casing and flange 40. In the particular embodiment illustrated, these bolts also secure to the casing 10 the flange 44 of connecting pipe 46 which is supplied with combustion air by a ram, blower, or other suitable means. The combustion air pipe 38 extends through the cylindrical wall 18 of the combustion chamber in a direction radial to the axis of this chamber, and is welded to this side wall as indicated at 48. The lower or delivery end of the pipe 38 is curved as indicated at 50, to bring the extreme straight end portion 52 of the pipe in axial alignment with the nozzle 26. The delivery end of the pipe 38 is preferably provided with partitions or vanes 54 which maintain substantially even distribution of the air throughout the cross section of the pipe and prevent a majority of the air from following closely along the outside wall of the curve.

The air discharged by the pipe 38 flows directly toward the rounded head of the nozzle 26 and in a direction generally opposite to that of the fuel spray leaving the nozzle. This counter-flow of fuel and air promotes vaporization and thorough intermixing of the fuel with the combustion air to form a substantially homogeneous, highly combustible mixture. It should be noted that that portion of the combustion air pipe 38 which is located in the combustion chamber serves as a preheating means for the combustion air so that when the heater is in operation, the preheating of the combustion air aids in the vaporization of the fuel sprayed into this air by the nozzle 26.

The counter-flow of air delivered by the pipe 38 reverses the spray delivered by the nozzle 26, in the manner indicated by the small arrows in Fig. 1, and the mixture of fuel and air formed adjacent the outlet end of the nozzle 26 flows around the sides of this nozzle in a conical pattern and into the annular groove 24.

Particular attention is directed to the fact that the inwardly projecting portion 22 of the end wall 20 is so curved that the mixture of fuel and air is deflected away from the transversely curved wall of the annular ring 24, as clearly shown by the arrows in Fig. 1. This leaves a relatively dead space 56 between the whirling vortex of the incoming air and fuel and the adjacent curved portion of the end wall 20. This space is filled with eddy currents of combustible mixture, and these eddy currents may be readily ignited by the hot wire 58 of the usual electrical igniter 60, whereas if the wire 58 of this igniter were located directly in the main stream of air and fuel entering the annular groove, the flow of this mixture would tend to cool the wire 58 below igniting temperature. The igniter 60 is preferably provided with the usual thermostatic switch (not shown) for cutting out this igniter after the heater has attained normal operating temperature. Thereafter the burning eddy currents in the dead space 56 effectively maintain combustion so that the usual reigniter may be dispensed with.

The whirling vortices of burning gases which are first formed in the annular recess or groove 24, move from this groove toward the heat exchanger 14, and as these whirling vortices move lengthwise of the combustion chamber, they move readily inward of this chamber, as indicated by the arrows in Fig. 1. As these vortices converge inward, they strike each other to create further intermixing of the burning gases and thereby produce ideal conditions for rapid and complete consumption of all fuel contained in these cases. This is an important feature of my invention, as it insures most complete and efficient combustion of the fuel and has the further advantage of shortening the total length of the flame under any given conditions of operation. This means that the combustion chamber may be made of minimum length, and that for any given size of combustion chamber the flame will extend a minimum distance into the heat exchanger 14. In this connection, it should be understood that in aircraft operation, the flame lengthens as the plane ascends, since the combustion air must be delivered to the combustion chamber at a greater volumetric rate of flow to compensate for its decrease in density.

In heaters of this type, and particularly in aircraft heaters where the flame is greatly elongated at high altitudes, it is ordinarily impracticable to make combustion chamber of such length that all combustion takes place therein. In this type of heater, therefore, part of the combustion occurs in the adjacent end of the heat exchanger, and in that type of heater wherein the burning gases are given a spiral flow, these burning gases contact the heat exchanger mainly over a relatively restricted surface. The tendency is to heat this restricted surface to an unduly high temperature, with the result that this part of the heat exchanger has a shorter life than other parts of the heater.

Another important feature of my invention is to provide a type of combustion chamber which causes the burning gases to issue therefrom in a substantially uniform flame directed longitudinally of the heat exchanger so that the inner walls of the heat exchanger which are most closely adjacent the combustion chamber are evenly contacted by this flame, and no particular spot of wall surface is unduly heated thereby. In the combustion chamber of Fig. 1, the whirling vortices of burning gases converge inwardly as they move lengthwise of the combustion chamber from the annular groove 24 to about the center of the side wall 18. This converging of the whirling vortices, as hereinabove pointed out, creates additional intermixing of the burning gases and promotes most efficient combustion. The converging vortices tend to break up as they converge and interengage, and to produce a continuous uniform flame extending lengthwise of the combustion chamber, and fanning out from the center thereof toward the heat exchanger. The whirling gases tend to form a cone with its narrower or more pointed end in the heat exchanger, and the narrower end of this cone is surrounded by axially flowing gases which are burning at a lesser rate than the centrally located vortices, or are completely burned out. This flame structure is indicated by the arrows in Fig. 1, and leaves an annular dead space 62 adjacent the side wall of the combustion chamber. As clearly indicated in Fig. 1, this dead space 62 is of greatest width adjacent the longitudinal center of the combustion chamber, and is filled with eddy currents. The flaming gases entering the central chamber 64 of the heat exchanger 14, fan out as indicated in this figure, and engage the adjacent portion of the wall of this chamber substantially uniformly throughout its circumference.

As hereinabove pointed out, the length of the flame created by the burning gases will vary with altitude, and at high altitudes this flame may extend a very appreciable part of the length of the central chamber 64 of the heat exchanger. Regardless of the extent to which the flame penetrates this chamber, however, the wall of this chamber is heated to a substantially uniform temperature throughout a circumference at any given distance from the combustion chamber.

A still further feature of my invention lies in the fact that the stream of combustion air flowing directly toward the fuel nozzle 26 prevents the accumulation of soot on the exterior surface of this nozzle and maintains the nozzle clean at all times. The stream of combustion air also cools this nozzle and prevents it from becoming overheated and warped, or otherwise impaired. This cooling of the nozzle also aids in preventing both the occurrence of vapor-lock in the nozzle due to gasification of the fuel within the nozzle or fuel supply line, and "cracking" of the fuel with resultant deposit of carbonaceous material in the tangential slots 34. This cooling of the nozzle, therefore, promotes maintenance of proper spray characteristics throughout the life of the heater.

In Fig. 1, the ventilating air is illustrated as entering the tapered end 12 of the heater casing 10. With this direction of airflow, the air first passes over the combustion chamber and absorbs some heat therefrom, and then passes into the heat exchanger 14 where it receives additional heat. This particular direction of flow, however, is not important, and my novel heater will operate equally well if the flow of ventilating air is reversed so that it first passes through the heat exchanger and then over the combustion chamber.

In Fig. 2, I have illustrated a modified form of my invention wherein the side wall 100 of the combustion chamber 102 is given a Venturi-like shape so that this side wall more nearly approaches the flow pattern of the whirling vortices of burning gases. This Venturi-like shape of side wall reduces the thickness and length of the annular dead space 104 formed adjacent the interior of this wall, and by reducing the volume of eddying gases in the combustion chamber, reduces resistance to flow through this combustion chamber, and thereby reduces the overall flow resistance of the heater.

The heater of Fig. 2 may in all other respects be identical with that of Fig. 1. In Fig. 2, however, instead of supplying the combustion air from a separate ram or blower, the combustion air is supplied by the same ram or blower which furnishes the ventilating air for the heater, although either source of combustion air supply is equally available for use in either of these modifications. In Fig. 2, the combustion air pipe 106 has a bent and slightly flared upper end 108 directed opposite to the general direction of flow of ventilating air in the adjacent portion of the heater casing 110, so that part of this ventilating air enters the combustion pipe 106. The lower end of this pipe 106 may be identical with the lower end of the combustion air pipe 38 of the previous embodiment. In Fig. 2, both of the curved portions of the combustion air pipe 106 are provided with vanes or transverse partitions 112 to provide more uniform flow of air throughout the entire cross section of the pipe 106.

In Figs. 3, 4, and 5, I have illustrated my invention as being applied to a heater, which is supplied with combustible mixture by a carburetor 150 of any conventional or suitable type. This carburetor receives fuel through a fuel supply pipe 152 controlled by the usual solenoid valve 154. The carburetor receives combustion air through a combustion air pipe 156 which passes through the tapered outlet end 158 of the heater casing 160, and this end of the combustion air pipe is so positioned that part of the heated air leaving the heat exchanger 14 flows into this pipe end to the carburetor 150. The remainder of the heated air leaving the heat exchanger 14 passes into a duct 162 leading to the aircraft cabin or other space or spaces requiring heat.

The combustible mixture of fuel and air formed by the carburetor 150 passes into an induction pipe 164 which extends through a wall of the heater casing 160, and a wall 166 of the combustion chamber 168. The delivery end of the induction pipe 164 may be identical with the delivery ends of the combustion air pipes of the previous embodiments. As shown in Fig. 3, the delivery end of the induction pipe 164 is curved as indicated at 170, and has a straight outlet portion 172 coaxial with the cylindrical wall of the combustion chamber, and directed toward the dome-shaped inward projection 174 provided by the end wall 176 of the combustion chamber.

This end wall has essentially the same shape as the end walls of the two previous embodiments so that the mixture flows into the annular recess 178 and forms whirling vortices of burning gases as in the previous embodiments. The dome-shaped projection 174 is so curved that the combustible mixture flowing into the annular recess 178 does not closely follow the walls of this recess, but provides a dead space as in the previous embodiments. The combustible mixture in this dead space is initially ignited by the igniter 60 as is the embodiments of Figs. 1 and 2.

The heat exchanger 14 is generally of the type disclosed and claimed in my Patent No. 2,432,929, issued December 16, 1947, and has a heat transfer means formed of a piece of sheet metal 180 bent back upon itself, as indicated at 182, to form a double walled structure which is spiraled about the axis of the heater, successive spirals of the double walled structure being spaced from each other to form therebetween a spiral passage 184 communicating at one end of the central chamber 64. The end of the spiral gas passage 184 is formed by welding or otherwise securing together the edges of the metal sheet 180, as indicated at 186.

From Fig. 4 it will be apparent that the double walled structure is provided with longitudinally extending spacing ribs 188 which determine the thickness of the double wall structure. I have found it most desirable to decrease the thickness of this double wall structure as it approaches the casing 10 and I have accordingly made the end ribs 188′ and 188″ of progressively decreasing height, as clearly shown in Fig. 4.

The righthand ends of the central chamber 64 and of the spiral gas passage 184 communicating therewith are closed by a plate 190 having a spiral-like extension 190′ and secured to the edge of the sheet metal plate 180 by welding or in any other suitable manner. The plate 190 has attached thereto a supporting bracket 192, having a pin 194 carried in a second bracket 196 bolted or otherwise suitably secured to the casing 10.

Another plate 198 having a spiral extension 198′ serves to attach the cylindrical wall 166 of the combustion chamber to the lefthand end of the heat exchanger and to close the lefthand end of the spiral gas passage in this heat exchanger. A bracket 200 supports the combustion chamber and adjacent end of the heat exchanger in the casing 10.

A plurality of resilient clips or plates 202 (Fig. 4) each have an end 204 welded or otherwise suitably secured to the interior of the casing 10. The other ends of these clips or plates are free to slide against the inner wall of the casing 10. These clips or plates serve to center the heat exchanger 14 in the casing 10 while permitting adjustment of the heat exchanger relative to the casing resulting from expansion and contraction of the heat exchanger due to starting and stopping of the heater. In effect, there is a floating mounting for the heat exchanger which provides for clockwise and counter-clockwise rotation of the outer portion of the heat exchanger relative to the casing and which also permits the heat exchanger to shift sidewise of the casing to prevent any portion of the outer part of the heat exchanger from approaching too closely to the casing. The pin 194 is also arranged so that it may slide axially in its supporting bracket 196 to provide for axial expansion and contraction of the heat exchanger.

The products of combustion are discharged through an exhaust nipple 206 which is welded or otherwise suitably attached to the outwardly flared walls 208 of an opening punched in the sheet metal 180. This nipple extends through a relatively large opening 210 formed in an adjacent portion of the wall of the casing 10 whereby the nipple 206 may shift both circumferentially and axially of the casing with expansion and contraction of the heat exchanger. This portion of the casing wall is pressed outwardly to provide a flat shoulder 212 against which an annular sealing member 214 is pressed by a spring 216. The sealing member 214 is slidably mounted on the nipple 206 and serves to form a sealed connection between this nipple and the shoulder 212. An annular spring abutment 218 is

welded or otherwise suitably secured to the nipple 206. Any suitable exhaust pipe 220 (Fig. 3) may be connected to the nipple 206 and from this figure it will be observed that the nipple 206 is located adjacent the righthand end of the heat exchanger so that the products of combustion travel a maximum distance before passing out of the exhaust nipple.

The inlet 12 is supplied with air by a ram, blower or other suitable means and this air first passes around the combustion chamber from which it absorbs some heat. Some of this air then passes through the longitudinal air passages 222 formed between the longitudinal ribs of the heat exchanger. The remainder of the air passes between the outermost portion of the heat exchanger and the casing 10. As the air travels either of these paths, it receives additional heat from the heat exchanger and is discharged into the outlet 158. Some of the heated air enters the combustion air pipe 156 leading to the carburetor 150, whereas the remainder passes through duct 162 to the space or spaces to be heated. While I have shown the air as traveling from left to right through the casing 10, the heater is equally adapted for opposite direction of air flow by simply transferring the inlet end of the combustion air pipe from one end of the heater to the other.

Where the fuel is supplied to the combustion chamber in the form of a combustible mixture delivered from a carburetor of any usual or suitable design, any usual or suitable means may be provided for regulating the heat output of the heater by varying the rate of fuel supply to the combustion chamber. However, where the fuel is delivered to the combustion chamber by means of a spray nozzle like the spray nozzle 26 of Figs. 1 and 2, the fuel must be delivered to the nozzle at some minimum pressure or the fuel will merely drip from the nozzle instead of issuing therefrom in the form of a spray. A fuel spray is necessary for proper vaporization and mixing of the fuel and air, and while the pressure necessary to cause the fuel to issue from a nozzle in the form of a spray will vary with different nozzles in accordance with their dimensions and details of design, it is undesirable, particularly in aircraft practice, to deliver the fuel to the nozzle at high pressure. Therefore, the pressure range available for varying the rate of fuel delivery is relatively small and since the rate of fuel delivery varies as the square root of the pressure, this constitutes a serious limitation to the operation of a heater over a wide heat output range. In Fig. 6, I have illustrated a modified form of my invention which is particularly adapted to overcome this difficulty.

In this figure, I have illustrated a heater which may be identical with that shown in Fig. 1, except for the details hereinafter pointed out. In this Fig. 6, a part only of the fuel is delivered to the combustion chamber 16 by the nozzle 26 when the heater is operating at maximum heat output. A second nozzle 26′ is provided and this second nozzle discharges into the combustion air pipe 38′, which is identical with the pipe 38, except for the provision of a threaded nipple 250 into which the nozzle 26′ is screwed.

While the nozzles 26 and 26′ may be made of any relative sizes so that the total fuel consumption of the heater is split between these nozzles in any desired ratio, I have found it preferable to utilize identical nozzles so that each delivers one-half of the total fuel supplied to the heater at maximum operation.

Both of the nozzles 26 and 26′ are connected to fuel supply pipe 252 which may be provided with any usual shut off valve. A solenoid or other remote control valve 254 is interposed between nozzle 26′ and pipe 252 so that the fuel delivery to the nozzle 26′ may be cut off independently of the fuel delivery to the nozzle 26. The fuel spray delivered by the nozzle 26′ is transverse to the direction of flow of the combustion air in pipe 38′ and does not initially form a homogeneous mixture with this air. This mixture, however, is improved as it absorbs heat from the lower end of the pipe 38′ and any remaining lack of homogeneity in this mixture is overcome when this mixture is admixed with the spray from the nozzle 26 to form a final combustible mixture. This final mixture is ignited by the igniter 60 and burns in the manner described in the discussion of Fig. 1.

When the heater is operating at maximum output, both nozzles 26 and 26′ are supplying fuel. If it is desired to operate the heater at one-half maximum heat output, it is only necessary to close the solenoid valve 254, thereby cutting off all fuel supply to the nozzle 26′. Under this condition of operation, the nozzle 26 supplies all of the fuel burned in the heater and the operation is identical with that of Fig. 1.

In most instances it will be sufficient to provide a heater having only two stages of operation and for such use the heater of Fig. 6 is ideally suited. For these conditions the fuel can always be supplied to the nozzles at minimum effective operating pressure and all heat output control is effected by opening and closing the solenoid valve 254. This is particularly desirable where conditions of use dictate a low pressure fuel supply for the heater. Where the heater is to be used under operating conditions which call for greater flexibility in heat output, the necessary additional flexibility can be secured by varying the pressure at which the fuel is supplied to the nozzles 26 and 26′ in the same manner in which different heat outputs are obtained in the embodiments of Figs. 1 and 2.

In describing the previous embodiments of my invention, I have referred to the fact that the air may flow through the heater casing in either direction. In this Fig. 6, I have shown the air as flowing from right to left, although in the embodiment also the ventilating air may flow in either direction through the heater casing. In this particular embodiment, however, an additional advantage is obtained by having the air flow from right to left, since the ventilating air first passes over the heat exchanger and absorbs heat therefrom. This ventilating air, therefore, is substantially heated by the time it contacts the combustion air pipe 38′.

Some heat from the ventilating air is transmitted to the combustion air pipe 38′ and prevents undue chilling of the combustion air where the spray from the nozzle 26′ enters this air. This is particularly important where atmospheric conditions are such as to favor ice formation or accumulation where the temperature of the atmospheric air is further reduced.

While I have described several forms of my invention, it is to be understood that my invention is not limited to the particular forms described but may assume numerous other forms and that my invention includes all modifications, variations and equivalents coming within the scope of the appended claims.

I claim:

1. A burner of the class described comprising means forming a combustion chamber having an annular wall and an end wall, said end wall having an inwardly extending projection on the axis of said annular wall and having an annular recess surrounding said projection, said projection, said end wall and said annular wall merging smoothly to form a surface of revolution which consists of substantially half a tore, a spray nozzle disposed at the end of said projection and oriented to direct a spray of liquid fuel axially of said combustion chamber and in a direction away from said end wall, combustion air delivery means disposed within said combustion chamber comprising a pipe extending substantially radially into a position in front of said combustion chamber, the inner end of said pipe being curved so that the opening at the inner end thereof faces said projection, and vanes within the curved portion of said pipe for subdividing and transversely distributing the flow of air therethrough so that the spray from said nozzle and the stream of combustion air are in counterflow relation to each other, means to supply liquid fuel under pressure to said nozzle, and means to supply air under pressure to said combustion air delivery means.

2. A burner of the class described comprising means forming a combustion chamber having an annular wall and an end wall, said end wall having an inwardly extending projection on the axis of said annular wall and having an annular recess surrounding said projection, said projection, said end wall and said annular wall merging smoothly to form a surface of revolution which consists of substantially half a tore, and means in said combustion chamber for directing a stream of mixed fuel and air at said inwardly extending projection and in substantially axial alignment therewith comprising a pipe extending substantially radially into a position in front of said combustion chamber, the inner end of said pipe being curved so that the opening in the inner end thereof faces said projection, and vanes within the curved portion of said pipe for subdividing and transversely distributing the moving stream therein so that said stream is divided by said projection and flows radially outwardly in all directions to form a vortex within said combustion chamber.

3. A burner of the class described comprising means forming a combustion chamber having an annular wall and an end wall, said end wall having an inwardly extending projection on the axis of said annular wall and having an annular recess surrounding said projection, said projection, said end wall and said annular wall merging smoothly to form a surface of revolution which consists of substantially half a tore, and means in said combustion chamber for directing a stream of mixed fuel and air at said inwardly extending projection and in substantially axial alignment therewith comprising a pipe extending substantially radially into a position in front of said combustion chamber, the inner end of said pipe being curved so that the opening in the inner end thereof faces said projection, vanes within the curved portion of said pipe for subdividing and transversely distributing the moving stream therein so that said stream is divided by said projection and flows radially outwardly in all directions to form a vortex within said combustion chamber, and means for introducing

fluid fuel into said pipe at a point upstream of said curved portion.

WILLIAM C. PARRISH.

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