

Feb. 23, 1932.

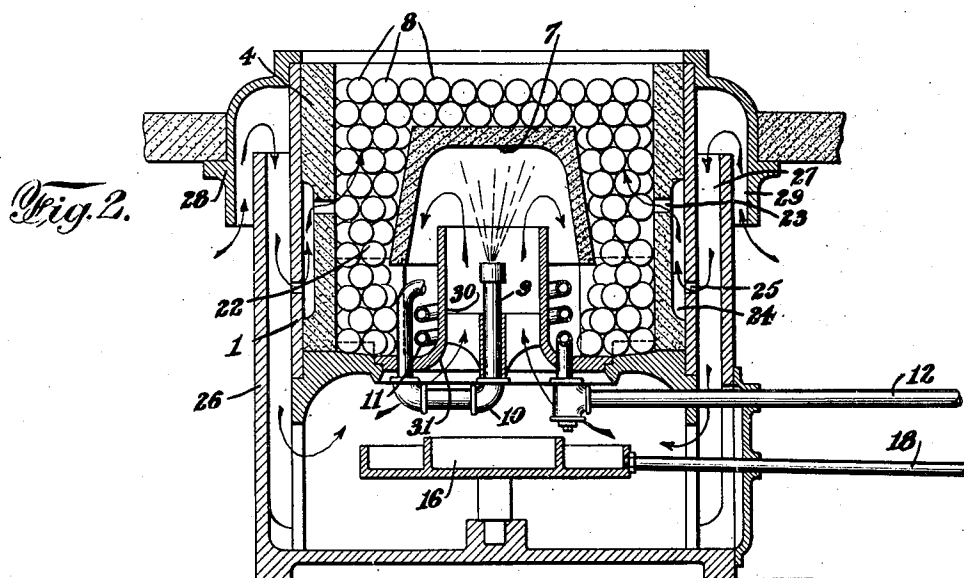
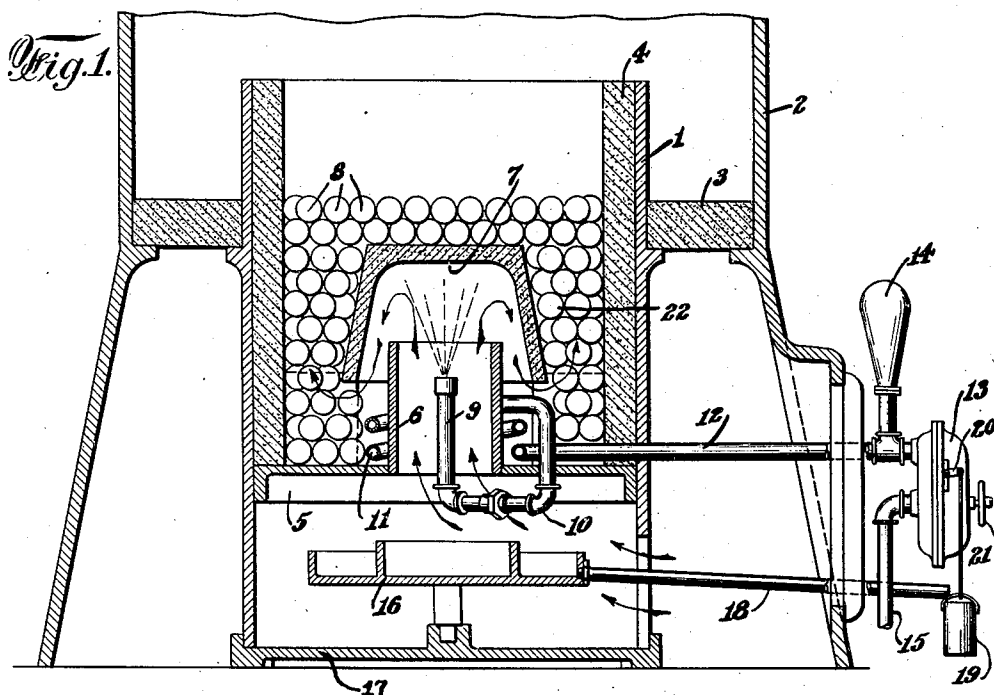
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1,847,020

APPARATUS FOR BURNING FLUID FUEL

Filed Nov. 17, 1927

4 Sheets-Sheet 1



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Fig. 3.

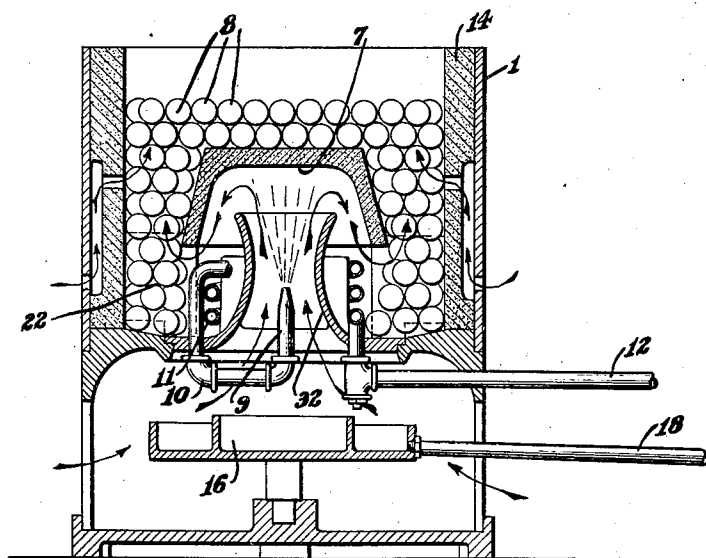
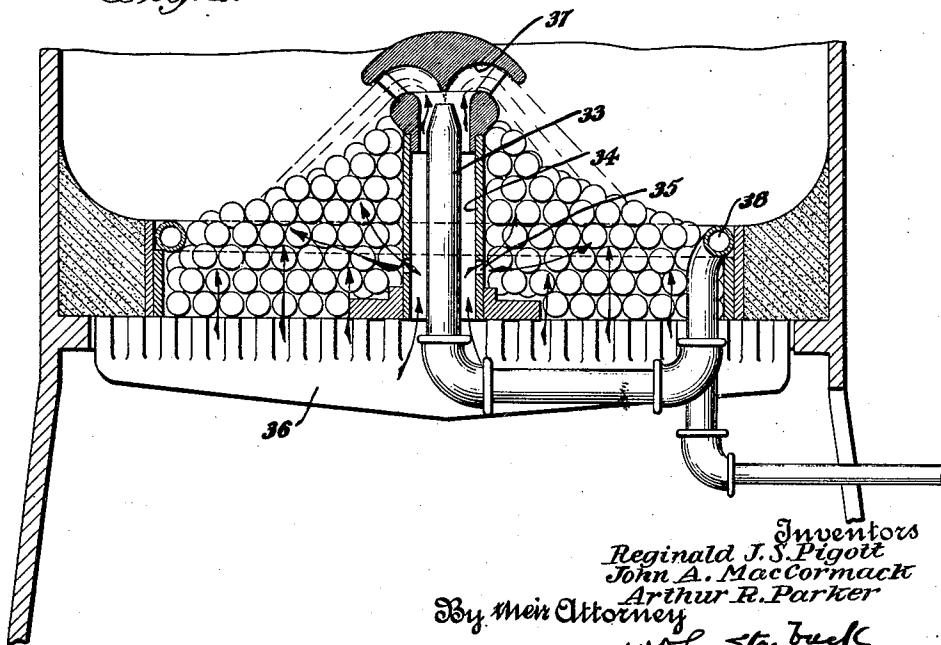


Fig. 4.



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Fig. 5.

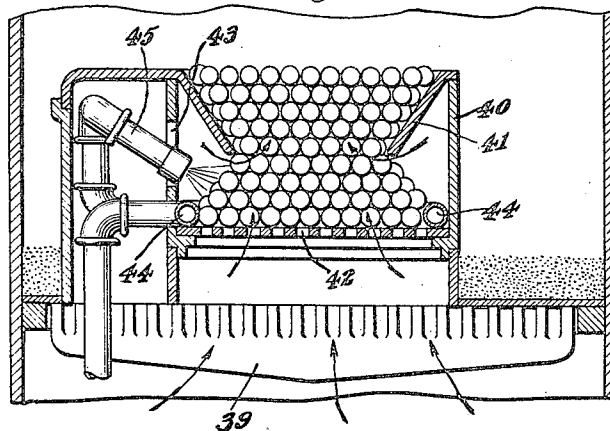


Fig. 6.

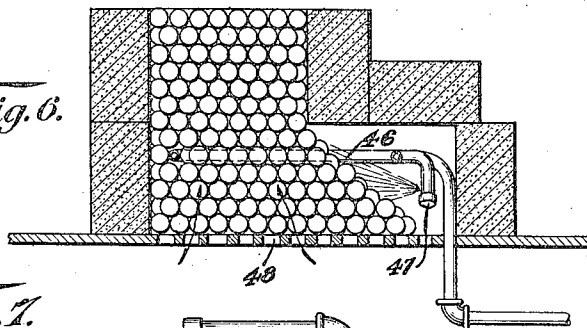
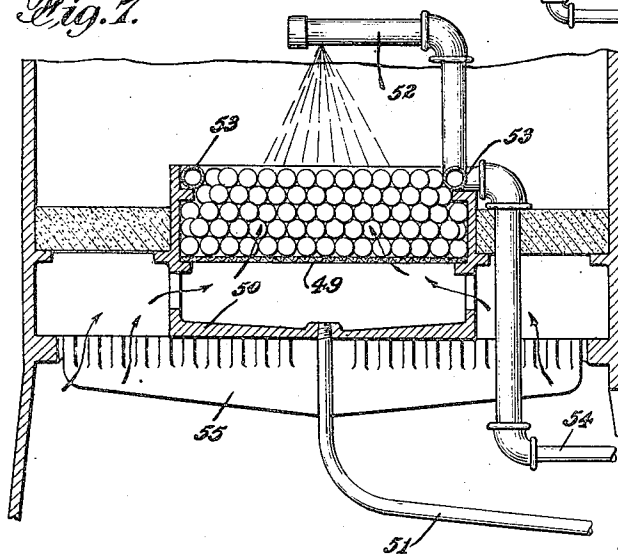


Fig. 7.



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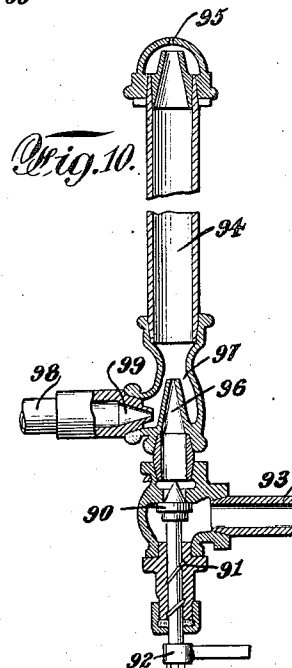
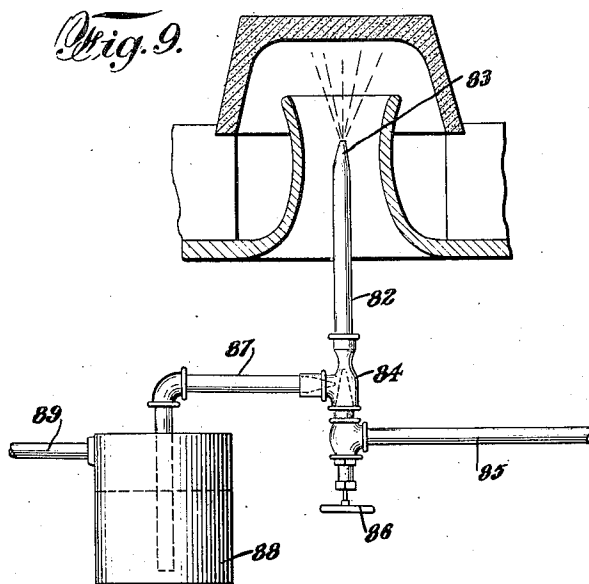
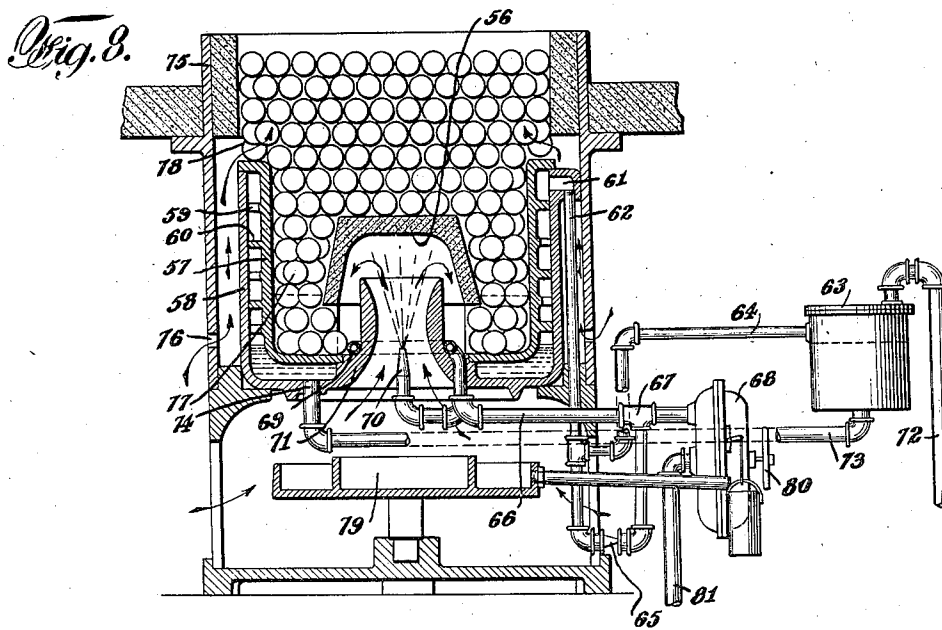
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APPARATUS FOR BURNING FLUID FUEL

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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APPARATUS FOR BURNING FLUID FUEL

Original application filed October 2, 1925, Serial No. 60,043. Divided and this application filed November 17, 1927. Serial No. 233,811.

This is a division of our co-pending application for "apparatus and method for burning fluid fuel", Serial No. 60,043, filed October 2, 1925 and relates to an apparatus for burning fluid fuel and is particularly illustrated by the application of the principle to the burning of oil.

It has long been desired in the art to produce a burner for fluid fuel which would use very low pressures and be without moving parts or auxiliaries so that there would be freedom from mechanical and operating troubles. By employing the principle of our invention as it will hereafter be disclosed, we produce a burner of very simple construction having among other attributes those just mentioned and which gives a maximum heating effect per unit of fuel without sooting and with minimum stack and flue losses.

The conditions necessary for such results require that there be the maximum intermixture of fuel and air which in turn necessitates that the fuel be very finely divided, vaporized or atomized in order that each particle may come in contact with the necessary air for combustion and where this occurs there is complete combustion with the greatest degree of radiation and an absence of flame. Therefore, the correct air supply for any given rate of fuel feeding becomes of great importance for if there is too little air, combustion will be incomplete with probable ignition of unburned gases in the flue and stack and much sooting will follow; the result of these conditions being considerable losses and low effectiveness of the burner. On the other hand, an excess of air will cause heat losses due to the heating of this excess air without corresponding combustion effect. It is one of the aims of our invention always to provide the correct amount of air for combustion under all operating conditions. Furthermore, with fluid fuel, not only must the correct amount of air be supplied in intimate mixture with the fuel, but the combustion when once initiated, must be sustained so that there is no sensible lowering of the temperature by absorption of heat due to the admission of cold air, contact with cold parts of the combustion chamber or contact with the heat-

ing surface of any apparatus, such as a boiler, and the mixture must be kept at high temperatures at all times. In the particular form in which we have chosen to illustrate our invention, we utilize a high velocity jet which is completely surrounded by induced air and we cause this mixture to impinge upon the surface of an auxiliary chamber or hood which effects, in the first place, a degree of turbulence, uniform distribution of the mixture and a degree of mixing. After this impingement and distribution, the further turbulence and mixing is created by reversing the direction of the mixture and passing it into a secondary combustion chamber where the direction is again reversed. This secondary chamber contains a number of elements of substantially equal size so that the voids between them are approximately equal and for purposes of illustration, we show these elements as being composed of refractory material in substantially spherical form, so that the passages between them are irregular, substantially equal and offer uniform resistance to the flow of the mixture which accordingly will be divided into a plurality of substantially equal streams flowing in tortuous paths. By having the voids practically equal in resistance to fluid flow throughout the mass of refractory material, the distribution of the mixture is equalized throughout and the combustion, as progressively described from the high velocity jet, is completed in this secondary combustion chamber with the result that the refractory material will become incandescent without appreciable flame beyond the refractory and with a maximum of radiant heat.

Furthermore we may, if it is desirable, introduce a part only of the air required for complete combustion around the high velocity jet; introducing at the proper point in the secondary chamber a controlled amount of secondary air either preheated or at room temperature. The point of entrance of this secondary air is preferably at a point below the top of the refractory material. The effect of this secondary air and the method of its introduction permits of an intimate mixing with the partially burned fuel mixture and

assists in providing a practically complete combustion at an earlier point in the passage of the fuel through the secondary chamber. Inasmuch as the intimate mixture of fuel and air is an essential to complete combustion, we can further aid this combustion by preheating the fuel within either of the combustion chambers or by any other means although the former is preferred and by so preheating, the velocity of the issuing fuel is greatly increased without increasing the initial fuel pressure and in this manner very fine division of the fuel may be obtained or if sufficiently preheated, the fuel may be completely gasified. As a further aid to a fine division of the fuel we may introduce superheated steam which has the advantage not only of atomizing and vaporizing the fuel through forming what may be termed an emulsion therewith, but also assists in maintaining the temperature of that fuel.

It will be noted that the degree of superheat which we prefer to utilize is such that after coming in contact with the fuel there is a considerable degree of superheat remaining in the steam which has the function of sustaining the temperature of the combustible mixture after issuance to prevent condensation of either fuel or mixture when the air of combustion is introduced or where cold portions of the furnace or neighboring parts are contacted. Furthermore, while we propose to illustrate our invention by the use of oil as a fuel, it will be understood that we are not limited in this regard but may use other fuels with equal facility such as gas, powdered coal or any fuel which may be of fluid form or which may be handled as a fluid. Other and further advantages will be found in the following specification and drawings.

Figure 1 is a section in elevation of a furnace embodying our invention.

Figure 2 is similar to Figure 1 except that the introduction of secondary air is shown.

Figure 3 shows the application of a convergent-divergent type of tube with secondary air.

Figures 4 to 7 inclusive are variations in the application of the principle of our invention.

Figure 8 is a furnace employing a convergent-divergent type of tube with superheated steam and secondary air.

Figure 9 is a variation of Figure 8 in the application of the use of superheated steam.

Figure 10 shows a variation in the type of burner for use with steam.

In Figure 1 is shown a casing 1 which may be set within a boiler shell or the like as at 2 and having blocks 3 to prevent influx of air. The casing 1 may be insulated as at 4 with fire brick or other heat insulating substance as is common in the art and this lining 4 may rest upon a plate 5 through the center opening of which is the tube 6. Over the tube 6

and supported on the plate 5 is the part or hood 7 which forms the primary combustion chamber. Filling the remaining space within the furnace are the elements 8 which we prefer to have in substantially spherical form and which may be of any suitable refractory material although it will be understood that any material may be used which will withstand high temperatures and which can be formed so that the voids between the individual members of the mass will be practically equal. Within the tube 6 is a nozzle 9, preferably placed concentrically therewith and connected with the pipe 10 which in turn forms part of the coil 11 which we show as being placed around the tube 6. The pipe 12 connects with the coil 11 and also with the valve 13. Between the valve 13 and pipe 12 is placed a dome or the like 14 for a use to be hereafter described. Also leading to the valve 13 is the pipe 15 coming from the source of oil supply.

Underneath the nozzle 9 we place a drip pan or container 16 which rests upon the base plate 17 of the furnace as shown. From the pan 17 leads the pipe 18 which is so arranged that it will empty into the container 19 depending from the arm 20 of the valve 13 as shown. The hand valve 21 of the valve 13 controls the flow of the fuel from pipe 15 and this is the only manual control necessary for our burner. It will be understood that the pipe 15 supplies oil to the burner and this oil need only have a pressure to a head of three or four feet, although higher pressures may be used if it is so desired. In starting up this burner, the valve 21 is opened whereupon cold oil will flow through the pipe 15 into the valve 13, through the pipe 12 and the coil 11 and the nozzle 9 and will drop down into the pan 16 where it collects. This collected oil is then ignited which serves the double purpose of lighting the oil at the nozzle 9 and also somewhat heating the pipe 10. As ignition takes place, air will be induced through the pipe 9 and combustion will occur in the primary combustion chamber 7, the products passing out through the refractory material in the secondary chamber which I may designate as 22. As combustion progresses, the temperature will rise with the result that the oil in the coil 11 will become vaporized and issue from the nozzle 9 at high velocity and as this velocity increases up to its maximum, depending upon the amount of oil admitted, the supply of air through the tube 6 will be increased in proportion so that the entire mixture will impinge on the surface 7 and be evenly distributed and mixed while burning. The products of combustion then reverse their direction and pass downward and into the secondary combustion chamber 22 which produces further turbulence and mixing with increase of combustion until those products

enter between the spaces of the spherical refractories.

These spaces or voids being practically equal, the mixture will distribute itself 5 equally throughout the mass thereof and be further mixed so that before the mixture reaches the top layer of refractories, the combustion is complete and no flame will appear but the upper portion of the refractory mass 10 will become incandescent. Since the flame does not extend beyond the upper surface of the refractories, combustion is complete before leaving the refractories and it is therefore impossible for any soot formation to 15 occur on any cool surfaces met with due to their chilling effect extinguishing a part of the flame. The use of the valve 13, while not essential to the action of our invention, is obvious as a safety device for the reason that if 20 the nozzle should fail to function at first, or should there be a leakage in the fuel line or for any reason fuel should collect in the pan 16, such fuel will flow through the pipe 18 into the container 19 and as this container 19 25 fills, it will depress the lever 20 and shut off the fuel from the pipe 15. Therefore no further fuel can flow to the nozzle 9 until the cause of the flooding has been removed and the valve 13 manually reset. As stated, the 30 oil is preheated or vaporized in the coil 11 and this vaporization is ordinarily liable to cause surging in the supply line 12. That is, a portion of fuel may suddenly become vaporized, its pressure rise and a surge will be 35 created in pipe 12. Then as this vaporized fuel passes out of the nozzle 9, a fresh supply may surge forward through pipe 12 and the operation be repeated. To overcome this difficulty and to permit of smooth operation, 40 we insert a dome 14 in which is an air cushion and this air cushion so equalizes these surges that the operation of the burner is quiet and even. It will be clear that other valves or means may be supplied to regulate the fuel 45 flow and other means than an air cushion used to suppress surging without affecting the operation of the burner and it will also be seen that this burner operates with a gravity flow of fuel and without auxiliary apparatus 50 or moving parts. The combustion is complete for all rates of fuel flow and there are none of the disadvantages commonly found in other oil burners.

In Figure 2, the same principle is carried 55 out with the addition that we show in this instance the use of secondary air which is heated prior to its entrance into the secondary combustion chamber 22. This modification necessitates the lining 4 having openings 60 such as at 23 and air passages connected therewith as at 24. Likewise the shell 1 has openings 25 and is surrounded by a casing 26 which forms air passages 27. In this connection we prefer to use a member 28 through 65 which air is taken in the passage 29. In all

other respects the burner is the same as in Figure 1 and this method of combustion is carried on in the same manner with the addition that the air in passing through the passages 29, 27 and 24 is heated by the absorption of heat from the burner and passes 70 into the secondary combustion chamber 22 through the opening 23 in the lining 4. The opening 23 is preferably somewhat below the uppermost zone of combustion so that this 75 secondary air is distributed throughout the secondary combustion chamber (there being a multiplicity of openings 23) so that this air will mingle intimately with the mixture in the process of combustion. This secondary 80 air is in addition to the primary air induced by the velocity of the jet through the tube 30 and therefore provides the capacity for completely burning a larger quantity of fuel, thus increasing the capacity of the burner. 85 It will be noted in this Figure 2 that tube 30 has a somewhat different form from tube 6 of Figure 1 in that the lower corners 31 are rounded to increase the induction effect of the fuel jet 9 so that a larger amount of air 90 is drawn in for a given quantity of fuel. The same parts may be affixed to the pipes 12 and 18 as were supplied to the similar pipes in Figure 1 or any other equally efficient parts 95 may be used.

In Figure 3 a further variation is indicated and which lies principally in the form of the tube 32. Figure 1 shows a straight tube 6 and will provide a satisfactory operation but 100 in the tube 32 of Figure 3 we have supplied a convergent-divergent tube with the result that a still greater quantity of air may be induced through this tube for a given jet velocity or quantity of fuel. This variation 105 in no way affects the principle of our invention for while we show here in Figure 3 the use of secondary air as in the case of Figure 2, this will operate satisfactorily without the use of such secondary air although it is preferable to use it for higher capacities. 110

Figure 4 is another variation wherein the nozzle 33 induces the main supply of air through tube 34 which has openings 35 which 115 supply part of the secondary air to the mass of refractory material, the remainder of the secondary air being supplied through the grate 36. The primary combustion chamber 37 in this instance is in somewhat different form but provides the same functions of turbulence and reversal of flow which takes 120 place on or slightly below the top surface of the refractory material where it meets the upward flowing currents of secondary air. This meeting of the downward flow of mixture and the upward flow of secondary air 125 provides the usual mixing and complete combustion will take place in the secondary combustion chamber of the figures just described. The combustion in this instance will occur on and slightly below the surface of the refrac- 130

tory material and will be completed there by the intermixture of the up-flowing secondary air. While it is possible to have the coil 38 closer to the tube 34 as previously illustrated, we prefer to show it on the outer boundaries of the refractories, although it might well be located nearer the center if so desired. Again we see in this Figure 4 the induction of air by jet velocity, turbulence and mixing, followed by a reversal of flow, a heating with the refractory material having equally spaced voids with distribution and mixture and a secondary reversal of flow, the principle in this instance being no different from that previously described.

In Figure 5, a still further variation is applied to the grate 39 and here the casing 40 is a hopper-like arrangement 41 in which the refractory material is placed and which spreads on the grate 42. Here the jet 45 does not induce the air through a tube but rather induces a certain portion through the opening 43, the remainder being supplied through the grate 42 under the action of suitable draft. The fuel being thoroughly vaporized in the coil as before (coil 44), it will enter the body of refractory in a highly atomized or vaporized form and be distributed there-through in the voids between the spheres to meet the upcoming air. Because of the spherical form of this refractory material and the tortuous channels through which the fuel and air must travel, the mixture will be very complete, the combustion finished and no flame will appear above the burner but rather will have the same characteristics heretofore spoken of.

In Figure 6, the principle is varied by having the highly atomized or vaporized fuel from the coil 46 and the nozzle 47 impinge upon the refractory material in a direction substantially horizontal while air through the grate 48 is induced by the draft. Hence this highly atomized fuel is completely mixed with the air in the upward passage through the tortuous channels between the refractory materials; the distribution being uniform because of the substantial equality of voids heretofore described. Here again we have the turbulence, thorough mixing and change of direction and the same combustion characteristics as in the other variations. It will be noted in this figure that the coil 46 passes back around through the refractory and forward to meet the nozzle 47 which is bent at an incline to the coil as indicated, the figure showing only the back portion of the coil and the sections of the front portion.

In Figure 7, the application is somewhat similar to Figure 4 except that the fuel from nozzle 52 is applied directly upon the bed of refractory where the turbulence occurs, mixing the upcoming currents of air through the grate 49 with the highly atomized or vaporized fuel below the surface of the refractory

bed; this application showing the use of the burner associated with a grate 55 and having a lower chamber 50 with the overflow pipe 51 for use in starting and to control overflow or flooding conditions as in the case of pan 16 of Figure 1. The coil 53 heats the oil in passing from pipe 54 to nozzle 52.

The modification shown in Figure 8 embodies features shown in Figures 1, 2 and 3 with the addition that we utilize superheated steam as a preheating and atomizing or vaporizing agent. The formation of the primary combustion chamber 56 and the secondary chamber 77 are each similar except that the lining of part of the secondary combustion chamber is formed of an inner portion 57 and an outer portion 58 which together form a watertight container which also covers a part of the bottom of the secondary combustion chamber as shown. In the form in which we show this water jacket, there are baffles or separators 59 and 60 which are so arranged that there is free passage around them from one space to another as indicated. This jacket has an exit passage 61 into which enters the pipe 62 having a connection to the water container 63 through the pipe 64 which will be known hereafter as the equalization pipe. The pipe 62 extends downward and connects with a check valve 65 and from there leads into the pipe 66 at the injector 67 which has a connection with the valve 68. The pipe 66 to the burner, the vaporizing coil 69 and the nozzle 70 are as previously described, it being noted that we prefer to use in this instance the tube 71 of the convergent-divergent type. Water container 63 has a supply pipe 72 and a control means not shown (such as a ball float) for maintaining a constant level while from the bottom leads pipe 73 which enters the jacket at a lower point, such as at 74. We also use in this instance, preheated secondary air which enters the side of the casing 75 at an opening such as at 76 and is passed into the secondary combustion 77 at selected points such as 78. In operation, the burner is started as in other instances by igniting overflow oil which collects in the pan 79 when the valve 80 is open. Water is in the water jacket as indicated to a level predetermined by the control means in the water container 63 and remains at that predetermined level throughout. As combustion progresses through the primary and secondary combustion chambers the fuel will become vaporized and steam will form in the water jacket and become highly superheated due to the large area exposed to the heat of the secondary combustion chamber. This superheated steam passes through to the injector 67 and in so doing, draws with it the required amount of fuel through the pipe 81 and the valve 68 by means of this injector 67.

As the superheated steam meets the oil, the two will pass together through the pipe

66 and in this passage the oil becomes heated and vaporized and the steam will lose a portion of its superheat in heating the oil but as before mentioned, this superheat is of such degree that no condensation occurs during the process. The superheated steam and vaporized oil pass through the coil 69 where they receive additional heat and they then pass out of the nozzle 70 at high velocity and in intimate mixture. Thereafter the reaction is as described as before which includes turbulence, reversals of direction and passage through the substantially equal and tortuous channels of the refractory material so that the combustion which is initiated in the primary combustion chamber 56 progresses in the lower part of the secondary combustion chamber 77 and is completed in the upper part of the chamber where the secondary preheated air enters. Because of the high degree of superheat used, a portion only of which is used in heating and vaporizing the fuel, a considerable degree of superheat remains when the mixture emerges from the nozzle so that there can be no condensation in the mixture upon contact with the cooler induced air. Besides complete vaporization, the presence of superheated steam greatly aids combustion and prevents the formation of soot or smoke. The presence of superheated steam with the oil in coil 69 also prevents the formation of any deposit of carbon or other harmful material in or from the coil.

In Figure 9 we show a type of burner which may be used with any of the foregoing variations in conjunction with superheated steam although for purposes of illustration we show it in diagrammatic form only. This burner which is shown in detail in Figure 10 comprises a tube portion 82 and a top portion 83 and a body portion 84 which acts as an injector. Superheated steam may be supplied by the pipe 85 and controlled by the valve 86. The oil enters through the pipe 87 from any given container 88 which in turn is supplied by the pipe 89; the oil level in container 88 being maintained constant by any suitable means such as a float. This burner nozzle, as shown in Figure 10, has a quick acting valve 90 moved by the threads 91 through the handle of stem 92. As steam is admitted through the pipe 93 it will pass into the tube 94 and through the tip 95. The velocity of the steam through the jet 96 creates a vacuum in the body of the portion 97 and this will draw oil through the pipe 98 and the jet 99 and because of the relative location of these jets 96 and 99 at predetermined dimensions, the amount of oil drawn in will be at all times proportional to the amount of steam passing through the body 97. Therefore we control the rate of combustion entirely by controlling the steam so that a burner embodying these features

will accomplish a degree of combustion beyond what has yet been possible with but one control; namely, a control of the steam only, which may be accomplished in a variety of ways such as by a thermo-couple or by pressure means or other regulating devices.

It will be evident from the foregoing description of our burner and its variations that they are all susceptible to the same control mechanism shown in Figure 1 or any similar or equally efficient device and that all of the variations may be used with or without superheated steam and a variety of forms of nozzles are interchangeable in each instance with each of the variations of the burner which we have described. In fact, we may adopt any of the combinations set forth and any of the part or parts described in any one of the variations according to the demand and conditions to be met and we do not limit ourselves in this regard. Furthermore, we have assumed throughout for the purpose of illustration that the stack or flue draft has been such as to be proper for the combustion conditions. This is a matter of supplemental manual or automatic control and does not enter into our invention other than to assume that such draft would be maintained at the proper condition by one skilled in the operation of burners. It is evident that the principle of our invention as disclosed is susceptible to a great variety of changes and adaptations and we include all such changes and adaptations within the scope of our claims for the foregoing specification with its drawings has been made for the purpose of illustration only and we are not confined to any one method or apparatus described.

We claim:

1. In an apparatus for burning fluid fuel, means to heat the fuel, a discharge nozzle, a tube surrounding the nozzle, a hood member over the tube, a plurality of substantially spherical members surrounding said tube and hood and means to confine said spherical members.

2. In an apparatus for burning fluid fuel, a primary combustion chamber comprising means to form an air passage and a hood member over and spaced away from said means, a secondary combustion chamber surrounding said primary combustion chamber and communicating therewith through the space between said hood member and said means, and a plurality of substantially spherical elements disposed within said secondary combustion chamber and surrounding and covering said primary combustion chamber.

3. In an apparatus for burning fluid fuel, a secondary combustion chamber containing a body of substantially spherical elements, a primary combustion chamber surrounded and covered by said elements, means associated

with the secondary combustion chamber adapted to generate superheated steam, means associated with the primary combustion chamber to heat the fuel and means to
 5 form a combustible mixture with the fuel and superheated steam in the primary combustion chamber.

4. In an apparatus for burning fluid fuel, a secondary combustion chamber containing
 10 a body of substantially spherical elements, a primary combustion chamber disposed within said body, means to admit additional air to the secondary combustion chamber and means to ignite a combustible mixture in the primary combustion chamber.

5. In an apparatus for burning fluid fuel, a secondary combustion chamber containing a body of substantially spherical elements in which is a primary combustion chamber composed of a tube member and a hood member,
 20 means to generate superheated steam, means to heat the fuel and means to eject the mingled steam and fuel through said tube member.

6. In an apparatus for burning fluid fuel, means for initially igniting the fuel, a body of substantially spherical elements and means to direct the ignited combustible mixture therethrough and other means to admit additional
 30 air to the mixture in the body of spherical elements.

7. In an apparatus for burning fluid fuel, means to create and ignite a combustible mixture, a body of substantially spherical elements, means to create turbulence in the ignited mixture and thereafter distribute it through said body of substantially spherical elements and means to admit additional air to the mixture in the body of said spherical
 40 elements.

8. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, a hood member inverted over the tube member and in spaced relation therewith, and
 45 a plurality of substantially spherical elements covering and surrounding the hood member.

9. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, a hood member inverted over the tube member and in spaced relation therewith, a plurality of substantially spherical elements covering and surrounding the hood member and means to admit additional air
 55 to the spherical elements.

10. In an apparatus for burning fluid fuel, a tube member, a hood member inverted over the tube member and in spaced relation therewith, a plurality of substantially spherical elements covering and surrounding the hood member and means to eject mingled fuel and steam through the tube member.

11. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, a hood member inverted over the tube

member and in spaced relation therewith, a plurality of substantially spherical elements covering and surrounding the hood member and means to preheat the fuel.

12. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, means to preheat the fuel, a hood member inverted over the tube member and in spaced relations therewith, a plurality of substantially spherical elements covering and
 75 surrounding the hood member and means to generate and supply superheated steam to the fuel supply means.

13. In an apparatus for burning fluid fuel, a tube member, a hood member inverted over the tube member and in spaced relation therewith, a plurality of substantially spherical elements covering and surrounding the hood member, means to eject mingled fuel and steam through the tube member and means
 85 to admit additional air to the spherical elements.

14. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, a hood member inverted over the tube member and in spaced relation therewith, a plurality of substantially spherical elements covering and surrounding the hood member, means to preheat the fuel and means to admit additional air to the spherical
 95 elements.

15. In an apparatus for burning fluid fuel, a tube member within which is a fuel supply means, imperforate baffle means above the tube member and in spaced relation therewith and a plurality of substantially spherical elements covering the baffle means.

In testimony whereof, we have signed our names to this specification this 15th day of November, 1927.

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 REGINALD J. S. PIGOTT.

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