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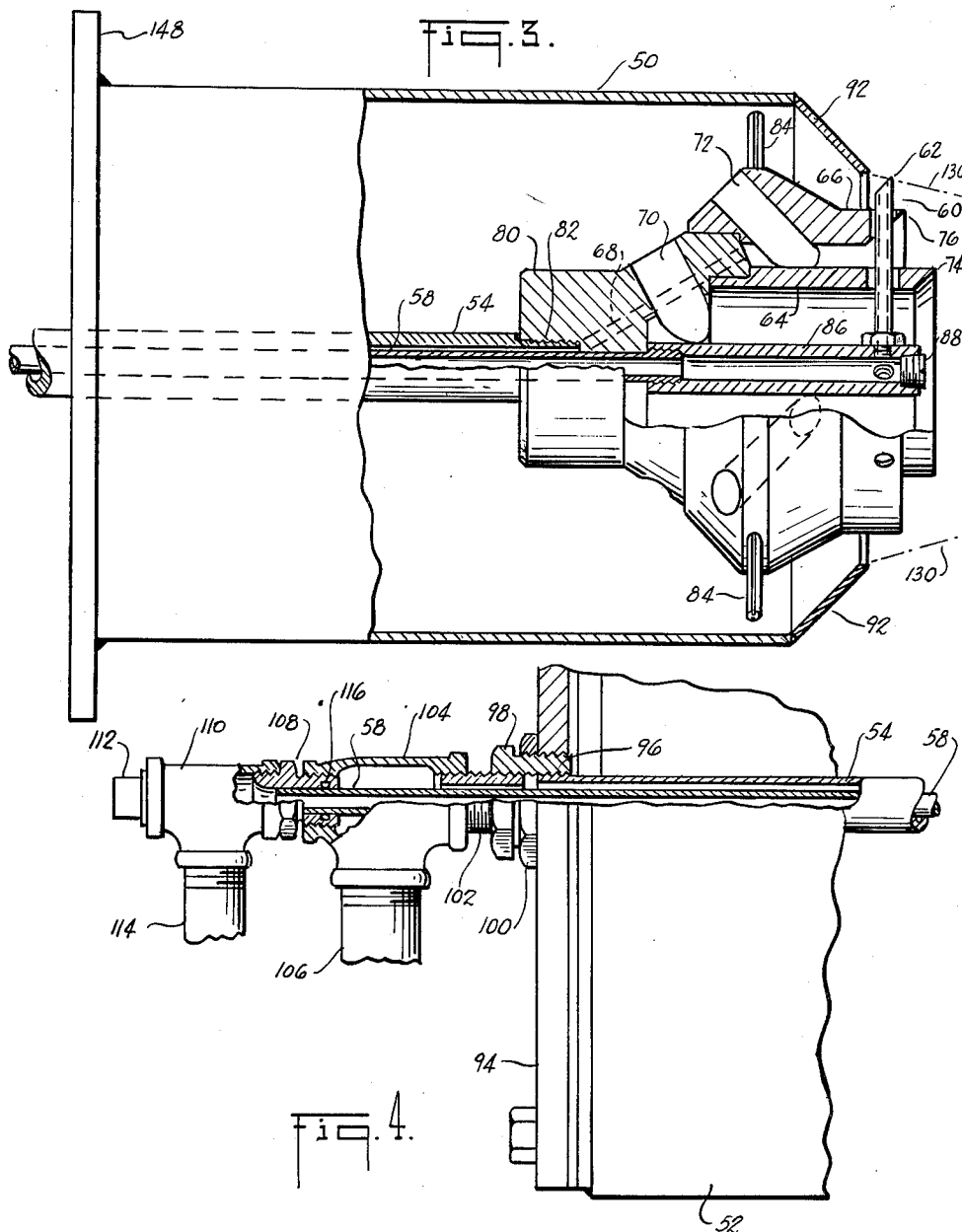
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LOW AIR PRESSURE BURNER

Filed Nov. 20, 1959

3 Sheets-Sheet 2



INVENTOR
ALEXANDER J. TURPIN

BY *James and Franklin*
ATTORNEYS

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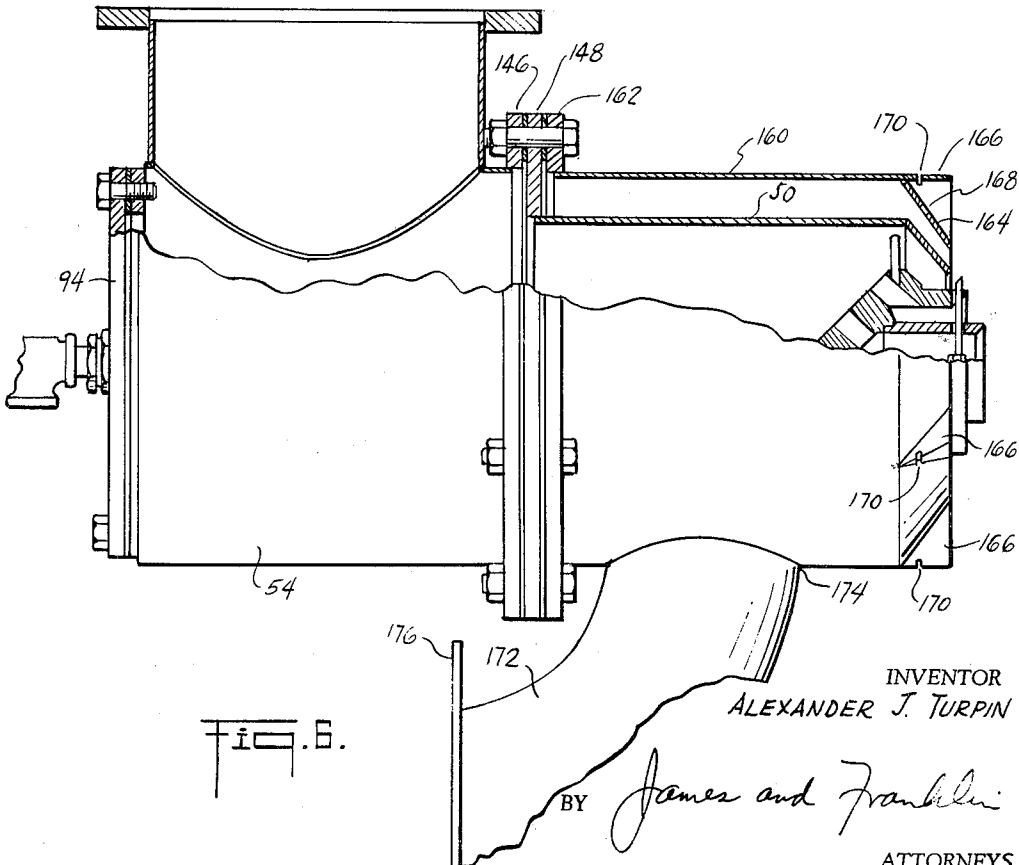
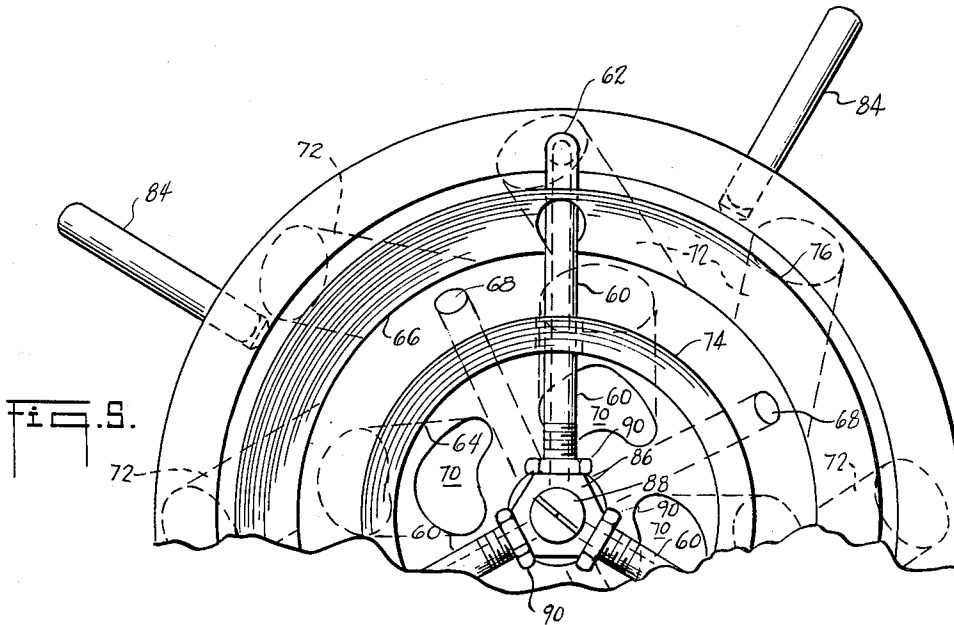
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LOW AIR PRESSURE BURNER

Alexander J. Turpin, Stewart Manor, N.Y., assignor to Hauck Manufacturing Co., Brooklyn, N.Y., a corporation of New York

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23 Claims. (Cl. 158-76)

This invention relates to burners for fluid fuel, and more particularly to a burner using low pressure air.

The primary object of the present invention is to generally improve burners, particularly for use in rotary kilns or dryers, typically for the drying of sand or gravel.

Such dryers are used to dry the sand or gravel before mixing the same with asphalt for hot truck delivery. The equipment is large. For example, a typical mixer may mix a four ton batch in less than a minute, with an output of 300 tons an hour. The drying operation may require two or more gallons of fuel oil per ton, so that the burner must burn, say 600 to 1000 gallons of fuel per hour.

There are important advantages in using the burner with only low pressure air, and in dispensing with the use of steam and/or high pressure air for atomizing the fuel oil. In contrast with steam, air has a drying action of its own, and low pressure air is more readily and cheaply available than is high pressure air. The piping for supplying the low pressure air is large, and may range from, say 8-inch diameter pipe for a burner operating at 250 gallons per hour, to a 14-inch diameter pipe for a burner operating at 1000 gallons per hour.

To automatically control or modulate the air supply then requires a correspondingly large valve, which in turn must be motor operated, preferably in controlled relation to the oil supply. The latter may be controlled automatically, as by means of a thermostat responsive to the temperature of the sand or gravel as it leaves the dryer. With ordinary burners it is not feasible to reduce the oil supply rate without reducing the air supply because otherwise the flame is extinguished by the air. The needed equipment would be simpler and less expensive if the air supply could remain constant while controlling only the fuel. This is particularly true in the case of a dryer or kiln as here contemplated, because the maintained air supply would not be wasted and instead would have an important and relatively inexpensive drying action of its own.

One primary object of the present invention is to provide a burner which will maintain ignition if the main oil supply is reduced or even stopped without reducing or modulating the air supply. This object is fulfilled generally by the provision of a pilot oil supply leading to pilot nozzle tubes which are independent in operation, although physically close to the main oil nozzle. An ancillary object of the present invention is to prevent the maintained air supply from blowing out the pilot flames, and with this object in view, the latter are located outside the high velocity air stream.

Still another object is to combine the pilot nozzle tubes with a main oil nozzle of a particularly efficient character, the latter making use of multiple concentric oil discharge rings with knife edges, and being so arranged that air flows on both sides of each ring.

Still another object is to provide for adjustment of the effective length of the pilot nozzle tubes, that is, their effective radius relative to the radius of the high velocity air stream, which adjustment may be made outside the burner at the rear end thereof.

To accomplish the foregoing general objects, and other more specific objects which will hereinafter appear, my invention resides in the constant low pressure burner elements, and their relation one to another, as are hereinafter described in the following specification. The specification is accompanied by drawings in which:

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FIGURE 1 is a schematic elevation of a dryer utilizing my improved burner;

FIGURE 2 is a partially sectioned elevation of a burner embodying features of my invention;

FIGURE 3 is a section through the nozzle end of the burner drawn to enlarged scale;

FIGURE 4 is a partially sectioned fragmentary view taken through the rear end of the burner;

FIGURE 5 is a fragmentary front elevation of the nozzle drawn to still larger scale; and

FIGURE 6 is a partially sectioned elevation similar to FIGURE 2 but showing a modification arranged for seasonal gas firing.

Referring to the drawing, and more particularly to FIGURE 1, the rotary dryer or kiln 12 is mounted on and rotated by appropriate rollers symbolized at 14. It is supplied with wet sand or gravel through a suitable hopper 16, and as the dryer rotates, the material moves from right to left until it is discharged at the left end into a suitable hopper 18. The dryer is somewhat lower at the left end, thus causing a gravitational shift of the material as the dryer rotates.

The burner is indicated at 20. It is supplied with constant low pressure air through a suitable pipe 22. It is supplied with oil through pipe 24. A main oil supply is controlled by a valve 26, and a pilot oil supply is controlled by a valve 28.

Following an ignition cone 30, the combustion gases are confined and expanded in a combustion chamber 32, which leads directly into the left end of the dryer. Thus the hot combustion gases flow counter to the sand or gravel which moves from right to left. The used combustion gases are collected at 34, and led to a flue 36 and a stack or chimney 38. Ordinarily an exhaust blower 40 is provided, this being located between the flue 36 and the stack 38. The blower is driven by an electric motor 42. A suitable filter or separator of known type may be disposed in the flue 36, as indicated at 44.

The main oil valve 26 may be controlled by a suitable actuator 46, which in turn is responsive to circuitry at 48, responsive to a thermostatic element 50 located in the hopper 18. The arrangement is such that the volume or rate of fuel oil supplied through the burner is modulated or varied in accordance with the needs of the dryer, as by maintaining a constant discharge temperature, and at times the main oil supply may be entirely cut off. However, the burner is not wholly extinguished unless and until the pilot valve 28 is closed, which in the present case is done manually, and only in the event of a true complete shut-down of the equipment.

The burner 20 is shown only symbolically in FIGURE 1, but is drawn to larger scale in FIGURE 2. This shows a burner comprising an air pipe 50 leading directly from an air body 52. There is a main oil tube 54 extending axially through the air pipe 50. An oil atomizing nozzle, generally designated 56, is located at the forward end of the oil tube 54 and the burner. A pilot oil tube 58 extends axially through the main oil tube 54. The motor controlled valve 26 controls the main oil supply, that is, the supply of oil to the tube 54, while the manually operated valve 28 controls the supply of oil to the tube 58.

There are a plurality of radial pilot nozzle tubes 60 at the forward end of the pilot oil tube 58. These have tips 62 which are located outside the high velocity air stream so that ignition is maintained if the main oil supply is stopped without reducing the air supply. If the radial pilot nozzle tubes 60 are too short and consequently are disposed directly in the high velocity air stream, the pilot flames will be extinguished by the high velocity air, and it is therefore important to properly adjust the length of the pilot nozzle tubes 60, that is, their effective radius

from the axis of the burner, relative to the radius of the air stream.

In FIGURES 2 and 3 it will be observed that the tip 62 of the radial pilot nozzle tube 60 is cut at an angle, so that it slopes outward in the direction of flow. This provides the individual pilot nozzle tube with a knife edge from which oil is atomized as it is wiped by the flowing air.

Considering the main oil nozzle 56 in greater detail, and referring to FIGURES 2, 3 and 5 of the drawing, this comprises one or more annular oil discharge rings 64, 66, with means, in this case a plurality of sloping passages 68, to deliver oil from the main oil tube 54 to the rings. There are air passages 70 and 72 so arranged as to deliver air from the air pipe 50 to both sides of the rings. The rings terminate in annular knife edges 74 and 76, and the air flowing on both sides of the oil discharge rings serves to wipe the oil from the knife edges and to atomize the same.

It will be noted that the knife edges 74 and 76 constitute the innermost end of the burner, and that the pilot nozzle tubes 60 preferably pass radially through the rings 64 and 66 to a radius greater than the radius of the rings.

The main nozzle provides for rapid atomization and combustion of large quantities of fuel oil. Some whirl or spin of the air supply preferably is provided, and the passages 70 and 72 are directed somewhat sideward or tangentially. The oil is brought to a knife edge in order to avoid accumulation of oil such as would take place at a thick edge. The sharper the knife edge the better, and in practice it is brought down to a wire edge, that is, it is sharp but not so sharp that one would cut oneself by mere contact with the edge.

To atomize a large quantity of oil it is desirable to increase the linear length of the knife edge. This is done by making each ring of adequate diameter, and by utilizing more than one ring and knife edge. With sufficient length of knife edge, the oil may be brought down to a thickness of only a few microns at the knife edge, which is good for atomization.

I find that the oil may be delivered to the knife edge on one side, or the other, or both, indifferently, provided that the oil is wiped from the knife edge by air on both sides. Failure to deliver air on both sides will cause oil to accumulate into undesirable droplets on the side having no air.

Referring now to FIG. 3, the oil discharge rings 64 and 66 are secured to a hub-like element 80, which in turn is secured to the forward end of the main oil tube 54, as is indicated by the threaded connection at 82. The element 80 has the air passages 70 and 72 and the oil passages 68. The assembly also carries three dowel-like elements or spacers 84 which serve to center the nozzle relative to the air pipe 50.

The pilot oil tube 58 passes through the hub-like element 80 and its forward end threadedly receives a nipple or extension 86. This is closed at its forward end by a suitable plug 88. The nipple 86 receives the radial pilot nozzle tubes 60 previously referred to. In the present case, there are three such tubes.

Referring now to FIGURE 5, the nipple or extension 86 may be hexagonal in cross section, thereby facilitating the mounting of three pilot nozzle tubes 60 on alternate faces. It could be square in section for four tubes, and so on. The inner ends of tubes 60 may be threaded, and are threadedly received in mating holes in nipple 86. The rotative position of each tube 60 is important because of its sloping tip 62 which must be properly oriented, and to permit this the tubes 60 are provided with lock nuts 90 which may be tightened after properly orienting the tubes.

The air pipe 50 (FIG. 3) is preferably terminated at its forward end by a frusto-conical portion 92. This causes the air stream to be convergent as indicated by broken lines 130 at the end of the burner. The por-

tion 92 is desired not only for normal operation, and to insure adequate flow of air through the passages 70 and 72, but also for an additional advantage later described.

The various parts just described which are located at the forward end of the burner are preferably made of high temperature metal. For example, they may be made of a type 309 stainless steel, which has 25% chromium and 12% nickel. The oil tubes may be made of a type 304 stainless steel which has 18% chromium and 8% nickel.

Referring now to FIGURE 4 of the drawing, the air body 52 of the burner is closed at its rear end by means of a plate 94. The main oil tube 54 terminates at 96 where it is received in a bushing 98, which is itself threadedly received in plate 94 for adjustment, and its adjustment is locked by means of a lock nut 100. A nipple 102 leads to a T 104, to which the oil supply pipe 106 is connected. The oil flows around the pilot oil tube 58 and then into the oil tube 54. The opposite end of T 104 is closed by a threaded bushing 108. This receives a T 110, which acts as an elbow, its opposite end being closed by a plug 112 which is removable for cleaning. Pilot oil is supplied through a pipe 114 to the T 110.

It would be difficult to assemble the pilot oil tube 58 with a threaded connection, because of the need to bring the many threaded connections at both ends of both oil pipes to a tight condition, while registering the pilot nozzle tubes with the main nozzle. For this reason, packing is employed instead of a threaded connection, and in the present case there is an O ring 116 between the bushing 108 and the tube 58.

Reverting to FIGURE 3, the convergent air stream is indicated in broken lines at 130. The tip 62 is located just outside the air stream. It will be evident that adjustment of tip 62 toward the right will bring it further outside the air stream, while adjustment toward the left will bring it further into the air stream. It is thus possible to vary the effective radius of tip 62 relative to that of the air stream, and thereby to bring about a desired relationship such that pilot ignition may be maintained, without reduction in air supply and regardless of changes in the main fuel oil supply.

The said adjustment is obtained by means of the threaded bushing 98 and lock nut 100 shown in FIGURE 4. Rotation of bushing 98 moves the entire nozzle assembly toward the right or left. This is not an adjustment which is made frequently, and usually the adjustment is made only once, either at the factory, or at the time of installation. The adjustment has the advantage of greatly increasing the dimensional tolerances when making the burner.

Reverting now to FIGURE 2, the air body 52 has secured thereto, as by welding, a pipe 140 with flange 142 which is suitably dimensioned for connection to an air pipe leading to the burner. Body 52 is inwardly flanged at 144 to receive the end plate 94, and it is outwardly flanged at 146 to receive a reducing flange 148, which is welded to and forms a part of the pipe 50 constituting the forward part of the burner.

Air is supplied by a centrifugal blower, although it can be supplied by a positive displacement blower. The centrifugal blower has the advantage of using less power when less air is required. The pressure may be selected in a range up to five pounds per square inch.

In referring to a "constant pressure" air supply, it is meant that the air supply is not "modulated" in conformity to the oil supply. However, on occasion it may be adjusted, as by means of a manually adjustable butterfly valve or by adjustment at the blower, to take care of a rather permanent change in requirement. For example, the burner may have a capacity of 400 g.p.h., but the condition of the sand or gravel, while variable, may require a maximum of 300 g.p.h. to dry the same, in which case the air supply may be reduced to take care of 300 instead of 400 g.p.h.

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In the springtime the sand may be quite wet and may require a greater fuel consumption than in the fall when the sand is relatively dry. Thus, the air supply may be varied as between the spring and the fall, but such a variation or adjustment is relatively infrequent, and is to be differentiated from a continuous change or modulation such as is produced by the thermostat in the discharge hopper.

Although the present burner is primarily an oil burner, in some installations it may be desired to provide for conversion from oil to gas, for seasonal gas firing. This takes care of a location where it is more economical to use oil in winter when gas is being heavily used for heating, and yet more economical to use gas in summer when an excess is available at low cost. Such a burner is shown in FIGURE 6. This burner is substantially the same as that previously described, except for the addition of a gas body 160 having a flange 162 which is secured to the flanges 146 and 148 previously described. The gas body 160 concentrically surrounds the air pipe 50 and it terminates at its forward end in a frusto-conical part 164.

The air stream draws gas along with it. However it is desirable to provide flame retention means which permits some of the gas to burn with some of the air which eddies behind the end of the burner and which therefore is not moving at high velocity. In the present case, a number, say six, of small chambers 166 are provided around the outside of the conical portion 164. As here shown, these chambers have the configuration of a three-sided pyramid, each chamber requiring only two triangular sides, while the conical portion 164 acts as the third side. Each chamber is open at the front or right end. The conical portion 164 has an aperture 168 leading to each of the chambers to feed it some of the gas, and the outer edge of each chamber is preferably apertured or slotted as shown at 170. This ring of small chambers around the end of the burner acts as a flame retention means when burning gas.

The gas supply is connected to an elbow 172 which is welded to the gas body 160 at 174, and which is provided with a flange 176 for connection to a suitable gas supply pipe.

It will be understood that the oil supply is shut off when using gas. The gas is ignited by a gas pilot flame which is not shown in the present drawing, and which may be conventional. This gas pilot flame also may be used for ignition of the oil burner, and it is common to ignite a large oil burner in that manner. The gas pilot flame itself may be ignited electrically by spark ignition, or in other desired fashion. When a gas pilot is used to ignite the oil burner, the pilot flame may be left on if gas is cheaply available, or shut off if gas is expensive, as when bottled gas is being used solely for ignition purposes.

In respect to the oil burner pilot nozzle tubes, whether or not an auxiliary gas jacket is employed, it may be explained that when the nozzle tubes project out too far, the oil flowing from their tips is not atomized, and falling out of the air stream, will collect on the fire brick lined ignition cone 30 (FIGURE 1), and then run out on the ground, or if it remains, it will build up as carbon. The pilot flames will remain lit, but the oil drip and the carbon collection both are objectionable. On the other hand, if the pilot nozzle tips are too far in, relative to the high velocity air stream, the pilot flames will be extinguished. The correct adjustment avoids both difficulties.

The pilot oil pipe 58 may be collateral and outside of instead of within the main oil pipe 54, but we deal here with a burner for very heavy oil which must be preheated, and the coaxial arrangement shown has an advantage in that the pilot oil flowing through the inner pipe is kept warm and may even be additionally preheated, as well as being insulated from the cooling action of the air supply, by the main oil supply flowing between pipes 58 and 54.

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At the burner tip a concentric arrangement is preferred, but for a different reason. One advantage is to provide equal oil distribution to the three pilot tubes, and another advantage is that all of the pilot tubes may be made alike and interchangeable. Accordingly, if the pilot oil pipe 58 is collateral instead of coaxial, it nevertheless preferably turns inward and is connected to a nipple 86 at the burner tip, which nipple preferably is in concentric relation to the burner tip.

The pilot tubes 60 need not be straight radial tubes as shown, but such tubes are the simplest to make and assemble. Other constructions might be employed provided, however, that the discharge of pilot oil is located at the proper distance from the burner axis, that is, near the outside of the high velocity air stream.

It should be understood in the present burner that the oil is supplied at low pressure, and that it is a heavy oil which would not be atomized by its own jet action. It does not contain enough kinetic energy for atomization, and instead it is the air which atomizes the oil.

The burner is a convenient one to use because a single low pressure air supply serves for the pilot as well as the main burner, even though a heavy oil must be atomized in large quantity. Moreover, only a single fuel supply is needed. Although the pilot oil and the main oil are separately controlled, they come from a single source indicated at 24 in FIG. 1, so that only one oil pump and one oil preheater are needed. Although the oil is a heavy oil pumped at low pressure, it is usable for the pilot flame as well as the main flame.

With three or more pilots, as here shown, there is a uniform ignition around the burner, and there is no distortion of the flame pattern.

As previously explained, the present burner accommodates a "wide turndown," that is, the main oil supply may be turned down greatly without modulating or reducing the air supply, and without the burner being extinguished. Indeed, the main oil supply may be shut off completely, without reducing the air supply, and without extinguishing the pilot flames. With a correct oil-to-air ratio, ordinary burners can be turned down only, say, 30% (without modulating the air supply). With a rich oil-to-air ratio, they can be turned down more. However, with the present burner, the main oil supply can be turned down to a very low value, say 20% or 10%, and yet the oil being supplied will be atomized and burned by the pilot flames. At such a low value, the pilot oil and pilot flames themselves form a substantial part of the burner action, and they supply a substantial part of the burner heat.

It is believed that the construction and operation of my improved low air pressure burner, as well as the advantages thereof, will be apparent from the foregoing detailed description. It will also be apparent that while I have shown and described my invention in several preferred forms, changes may be made in the structures shown, without departing from the scope of the invention, as sought to be defined in the following claims.

I claim:

1. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube extending through the air pipe and having a forward end, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube extending through the main oil tube and having a forward end, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes being open at said tips for discharge of oil.

2. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube

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having a forward end, a main oil supply means for said main oil tube, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube having a forward end, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube, said pilot nozzle tubes having tips located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes being open at said tips for discharge of oil, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply, said pilot nozzle tubes passing through said atomizing nozzle and having an effective radial length greater than the radius of the atomizing nozzle.

3. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube extending axially through the main oil tube and having a forward end, a plurality of radial pilot nozzle tubes disposed radially at the forward end of the pilot oil tube, said pilot nozzle tubes having tips located near the periphery of the high velocity air stream, from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes being open at said tips for discharge of oil, said pilot nozzle tubes passing through said atomizing nozzle and having an effective radial length greater than the radius of the atomizing nozzle.

4. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube having a forward end, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outward and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes being open at said tips for discharge of oil, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply.

5. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube extending axially through the main oil tube and having a forward end, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outward and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes being open at said tips for discharge of oil.

6. A heavy oil burner having a forward end and comprising an air pipe for constant pressure air, said pipe being open at its forward end and from which pipe a high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an oil atomizing nozzle at the forward end of the oil tube and burner, a pilot oil tube having a forward end, a single source of heavy oil for both the pilot oil tube and the main oil tube, said nozzle being non-rotatable, a valve controlling the supply of oil to the main but not the pilot oil tube, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube, said pilot nozzle

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tubes having tips which slope radially outward and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply, said pilot nozzle tubes passing through said atomizing nozzle and having an effective radial length greater than the radius of the atomizing nozzle.

7. An oil burner having a forward end and comprising an air pipe for constant pressure air, said pipe being open at its forward end and from which pipe a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an oil atomizing nozzle at the forward end of the oil tube and burner, said nozzle being non-rotatable, a pilot oil tube extending axially through the main oil tube and having a forward end, a valve controlling the supply of oil to the main but not the pilot oil tube, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outward and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes passing through said atomizing nozzle and having an effective radial length greater than the radius of the atomizing nozzle.

8. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the annular rings, means to deliver air from the air pipe to both sides of said rings, a pilot oil tube providing an oil supply which is maintained independently of the control of the main oil supply, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube and burner, said pilot nozzle tubes having oil discharge tips, the oil discharge tips of said pilot nozzle tubes being located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply.

9. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the annular rings, means to deliver air from the air pipe to both sides of said rings, said knife edges constituting the forward end of the burner, a pilot oil tube extending axially through the main oil tube and having a forward end, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes passing radially through said annular rings of said atomizing nozzle to a radius larger than the radius of said rings.

10. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the annular rings, means to deliver air from the air pipe to both sides of said rings, a pilot oil tube extending through the burner, and having a forward end, pilot nozzle tubes disposed radially at the

forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outwardly and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply.

11. An oil burner having a forward end and comprising an air pipe for generally constant pressure air, said pipe being open at its forward end from which pipe a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the annular rings, means to deliver air from the air pipe to both sides of said rings, said knife edges constituting the forward end of the burner, a pilot oil tube extending axially through the main oil tube and having a forward end, a valve controlling the supply of oil to the main but not the pilot oil tube, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outward and forwardly at a radius large enough to come near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes passing radially through said annular rings of said atomizing nozzle to a radius larger than the radius of said rings.

12. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising a plurality of concentric annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the region between the annular rings, means to deliver air from the air pipe to the inside of the inner ring, means to deliver air from the air pipe to the region between the rings, means to deliver air from the air pipe to the outside of the outer ring, a pilot oil tube providing an oil supply which is maintained independently of the control of the main oil supply, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube and burner, said pilot nozzle tubes having oil discharge tips, the oil discharge tips of said pilot nozzle tubes being located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply.

13. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising a plurality of concentric annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the region between the annular rings, means to deliver air from the air pipe to the inside of the inner ring, means to deliver air from the air pipe to the region between the rings, means to deliver air from the air pipe to the outside of the outer ring, said knife edges constituting the forward end of the burner, a pilot oil tube extending axially through the main oil tube and having a forward end, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips located near the periphery of the high velocity air stream from the air pipe and adjustable to a position outside the air stream, said pilot nozzle tubes passing radially through said annular rings of said atomizing nozzle to a radius larger than the radius of said rings.

14. An oil burner having a forward end and comprising an air pipe open at its forward end and from which a

high velocity air stream may flow, a main oil tube having a forward end, a main oil supply line for said main oil tube, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising a plurality of concentric annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the region between the annular rings, means to deliver air from the air pipe to the inside of the inner ring, means to deliver air from the air pipe to the region between the rings, means to deliver air from the air pipe to the outside of the outer ring, a pilot oil tube having a forward end, pilot nozzle tubes disposed radially at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope radially outward and forwardly at a radius large enough to come outside of the high velocity air stream from the air pipe, whereby ignition is maintained even after wide turndown of the main oil supply without reducing the air supply.

15. An oil burner having a forward end and comprising an air pipe for generally constant pressure air, said pipe being open at its forward end from which pipe a high velocity air stream may flow, a main oil tube extending axially through the air pipe and having a forward end, an atomizing nozzle at the forward end of the oil tube and burner, said nozzle comprising a plurality of concentric annular oil discharge rings having knife edges, means to deliver oil from said main oil tube to the region between the annular rings, means to deliver air from the air pipe to the inside of the inner ring, means to deliver air from the air pipe to the region between the rings, means to deliver air from the air pipe to the outside of the outer ring, said knife edges constituting the forward end of the burner, a pilot oil tube extending axially through the main oil tube and having a forward end, a valve controlling the supply of oil to the main but not the pilot oil tube, a plurality of radial pilot nozzle tubes at the forward end of the pilot oil tube, said pilot nozzle tubes having tips which slope outward in the direction of flow at a radius large enough to come outside of the high velocity air stream from the air pipe, said pilot nozzle tubes passing radially through said annular rings of said atomizing nozzle to a radius larger than the radius of said rings.

16. An oil burner, as defined in claim 1, in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is so shaped, that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream.

17. An oil burner, as defined in claim 5, in which there is a main fuel oil supply means for said main oil tube, and in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is so shaped that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream in order thereby to obtain a desired relationship such that pilot ignition is maintained without reduction in air supply regardless of change in the main fuel oil supply rate.

18. An oil burner, as defined in claim 9, in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is so shaped, that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream.

19. An oil burner, as defined in claim 11, in which there is a main fuel oil supply means for said main oil tube, and in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe

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of the burner is so shaped that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream in order thereby to obtain a desired relationship such that pilot ignition is maintained without reduction in air supply regardless of change in the main fuel oil supply rate.

20. An oil burner, as defined in claim 12, in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is so shaped, that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream.

21. An oil burner, as defined in claim 15, in which there is a main fuel oil supply means for said main oil tube, and in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is so shaped that the high velocity air stream is tapered, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream in order thereby to obtain a desired relationship such that pilot ignition is maintained without reduction in air supply regardless of change in the main fuel oil supply rate.

22. An oil burner, as defined in claim 7, in which there is a main fuel oil supply means for said main oil tube, and in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe

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of the burner is frusto-conical and convergent so that the high velocity air stream is convergent, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream, in order thereby to obtain a desired relationship such that pilot ignition is maintained without reduction in air supply regardless of change in the main fuel oil supply rate.

23. An oil burner, as defined in claim 11, in which there is a main fuel oil supply means for said main oil tube, and in which the pilot oil tube with its radial pilot nozzle tubes is adjustable in axial direction relative to the burner, and in which the forward end of the air pipe of the burner is frusto-conical and convergent so that the high velocity air stream is convergent, whereby said axial adjustment has the effect of varying the effective radius of the pilot nozzle tubes relative to that of the stream, in order thereby to obtain a desired relationship such that pilot ignition is maintained without reduction in air supply regardless of change in the main fuel oil supply rate.

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