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(54) Improved method and apparatus for combustion of oil

(57) An improved apparatus and method for the combustion of oil produced by an oilwell during testing, provides a boom 20, supported on an oilwell platform 16, the boom supporting a burner assembly 25. Air may be secondarily added to the medium to be atomized after an initial mixing of the oil with water and/or air and prior to combustion. Secondary air may be added to the mixture of oil and water and/or air to improve the burn and give a desirable generally smokeless burn. The burner head is rotatably supported in the boom and can be remotely rotated to a desired positon as, for example, to direct the burner flame to compensate for wind. The burner head provides at least one venturi cone V, Fig. 2 (not shown), which provides a baffle mounted in a movable fashion with respect to a nozzle 35 through which the oil, air, and/or gas mixture is transmitted for atomization. The movement of the venturi cone baffle with respect to the nozzle is adjustable from a remote location allowing adjustability of air flow external to the nozzle, further providing further enhancement of a smokeless burn by control of air flow to the nozzle area.

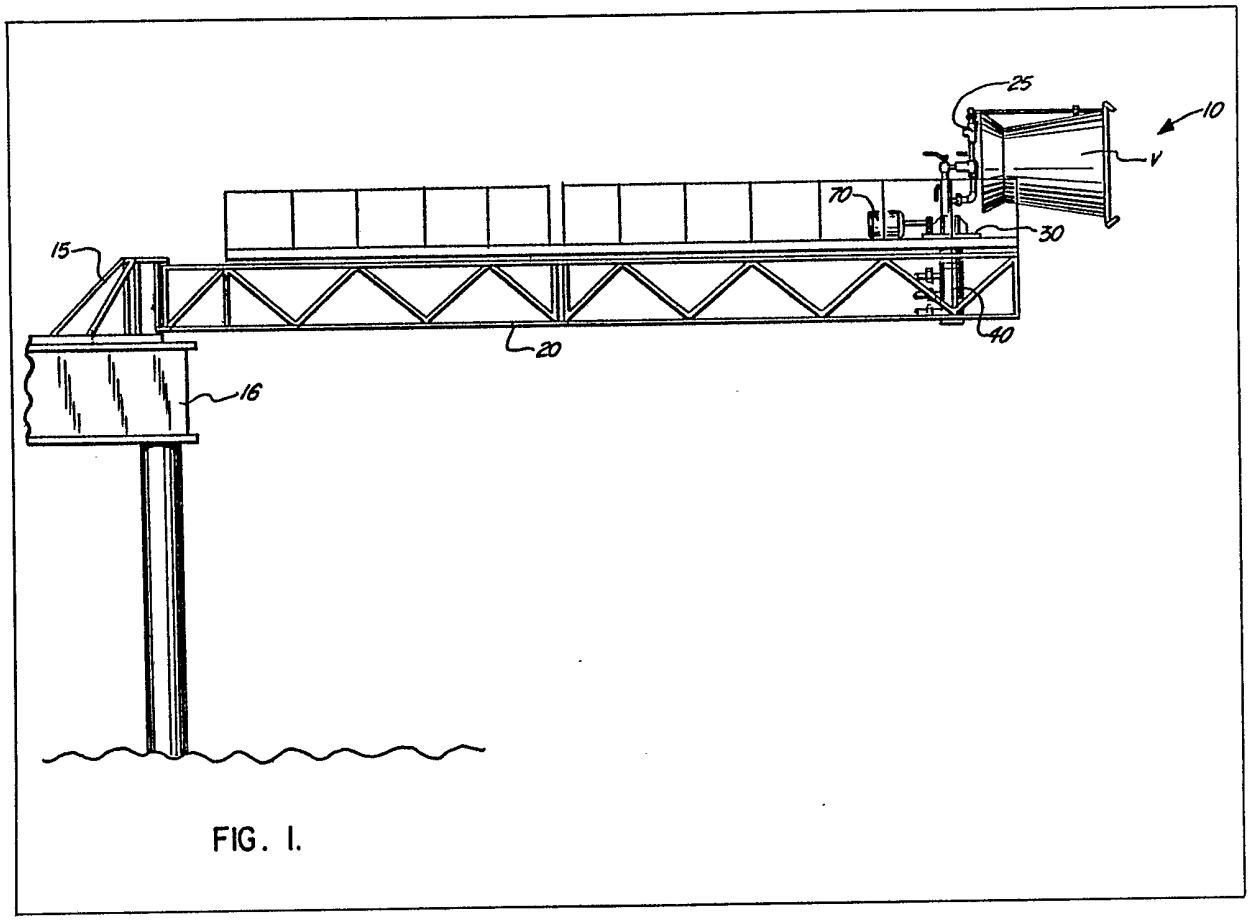

FIG. I.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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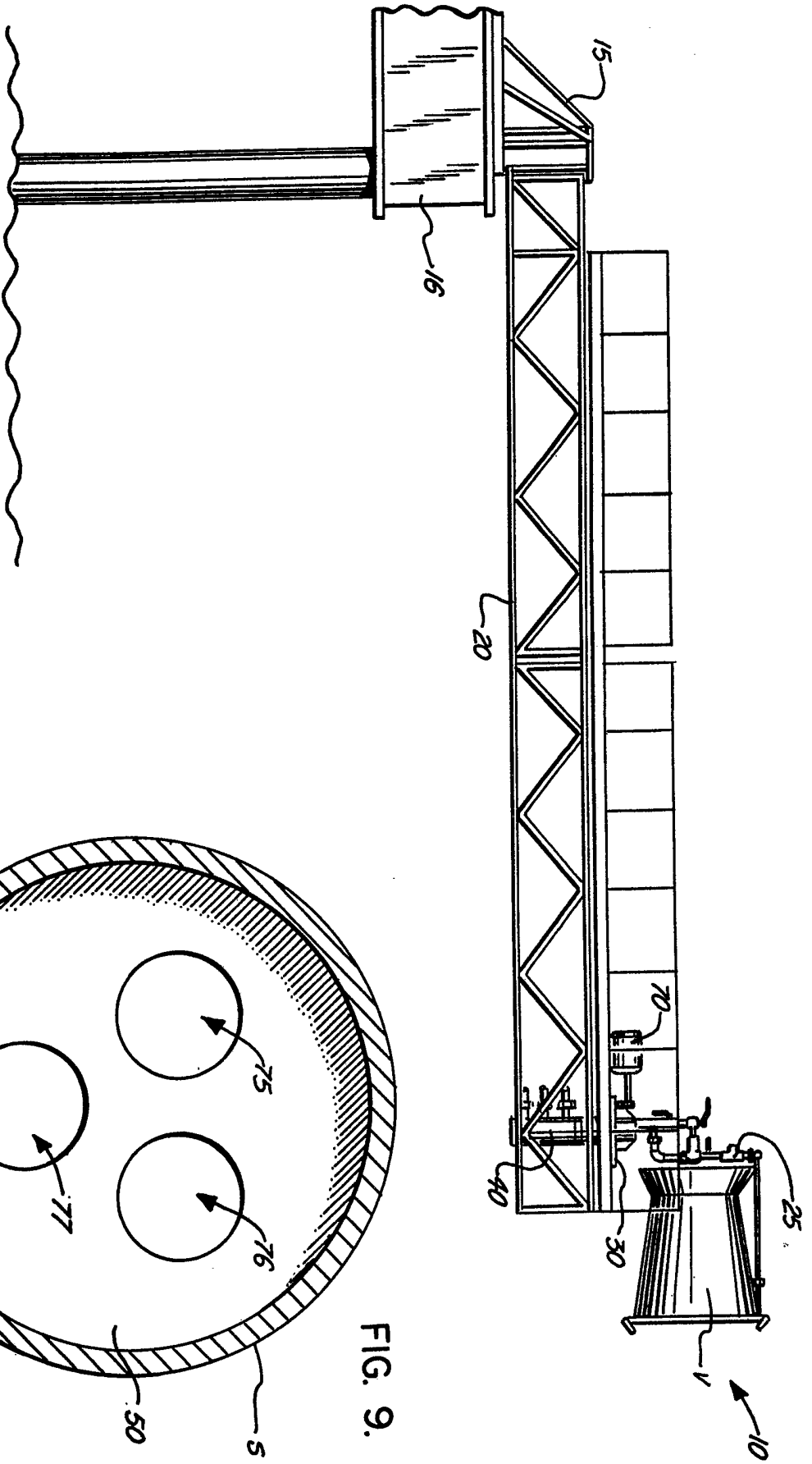

FIG. 1.

FIG. 9.

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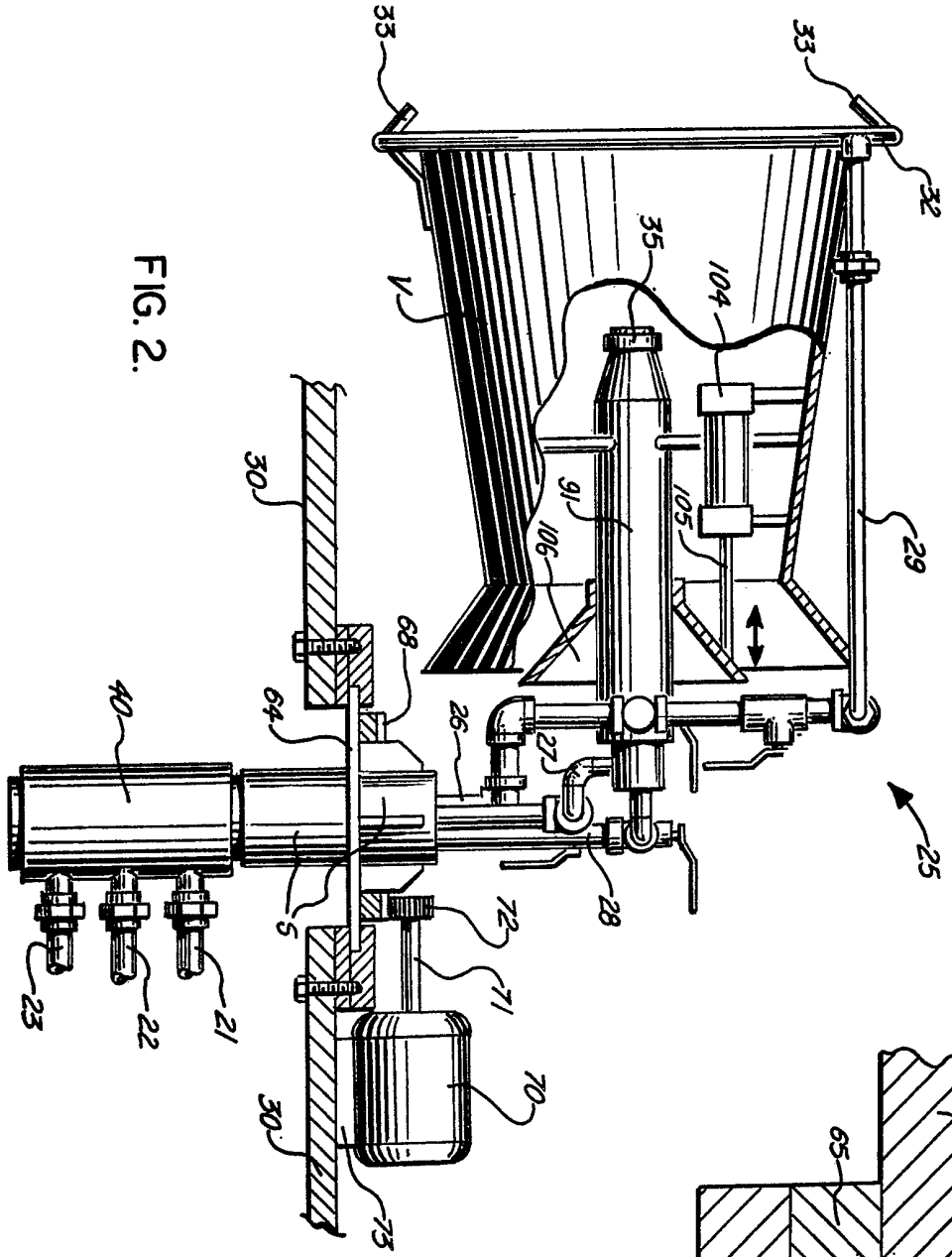

FIG. 2.

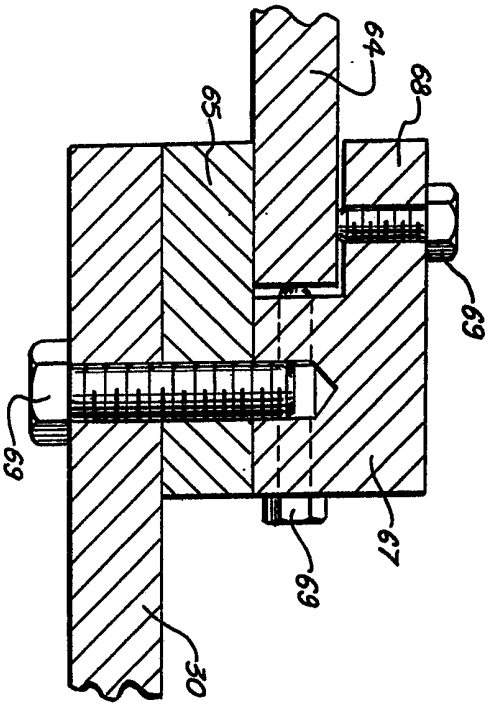

FIG. 3.

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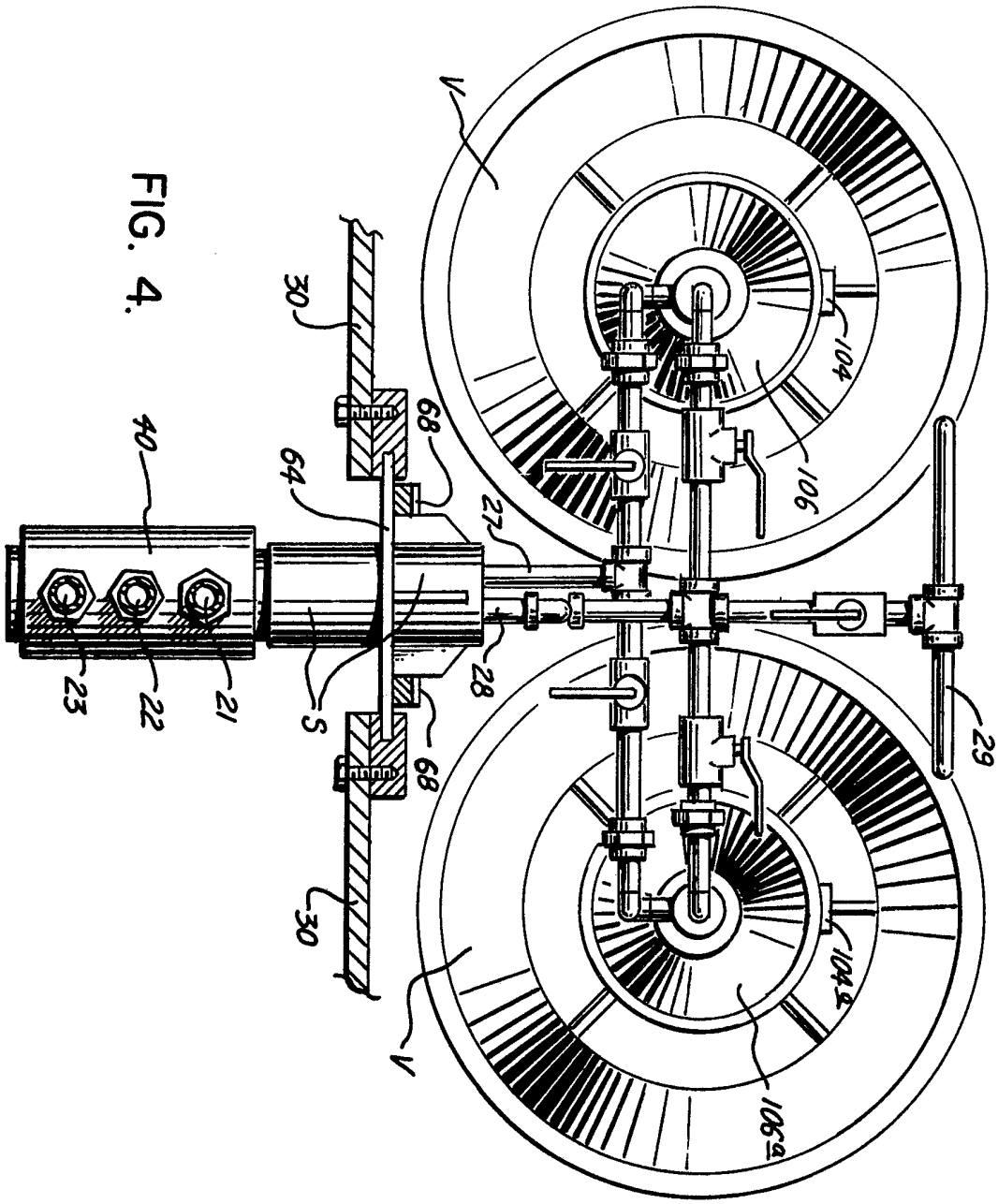

FIG. 4.

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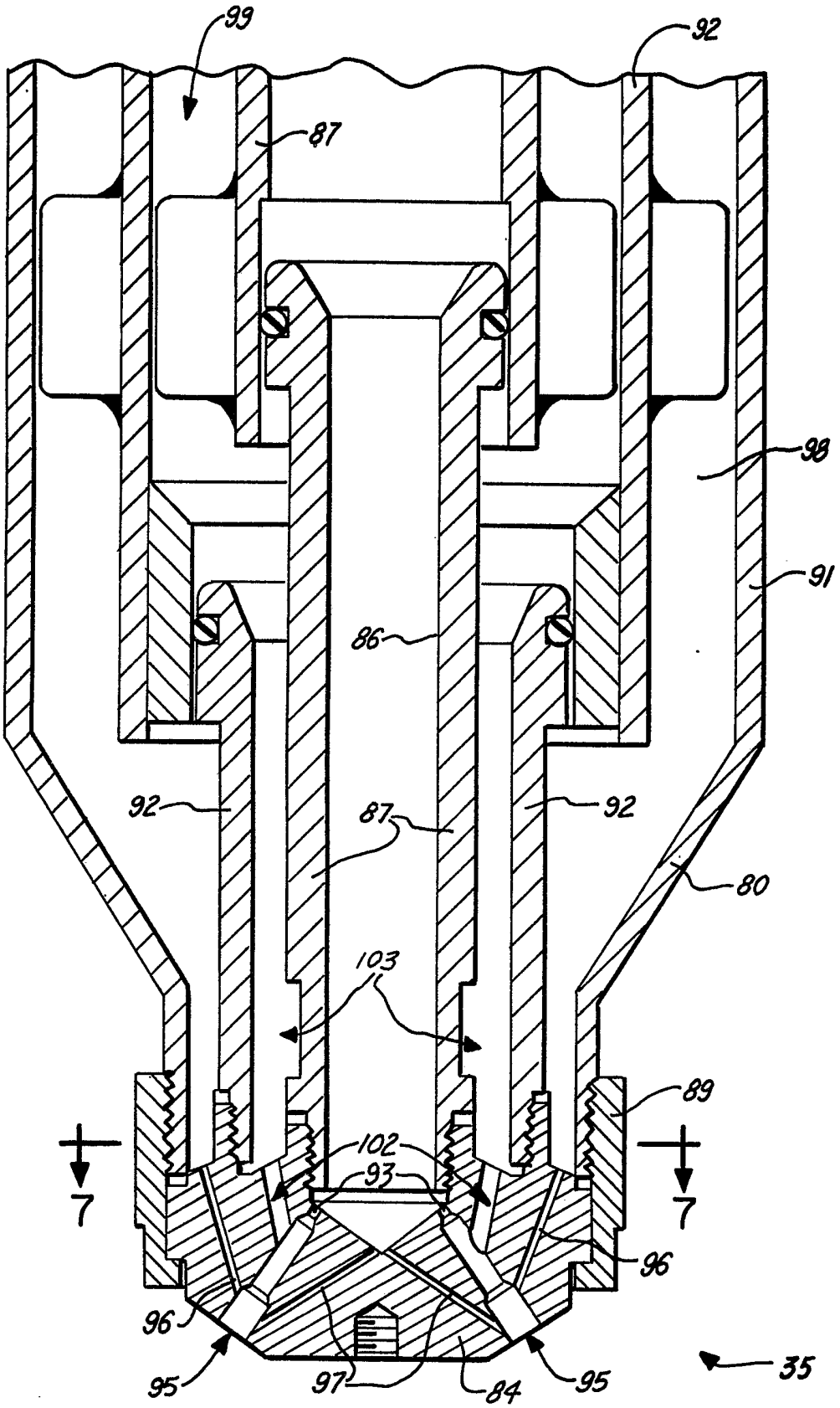

FIG. 5.

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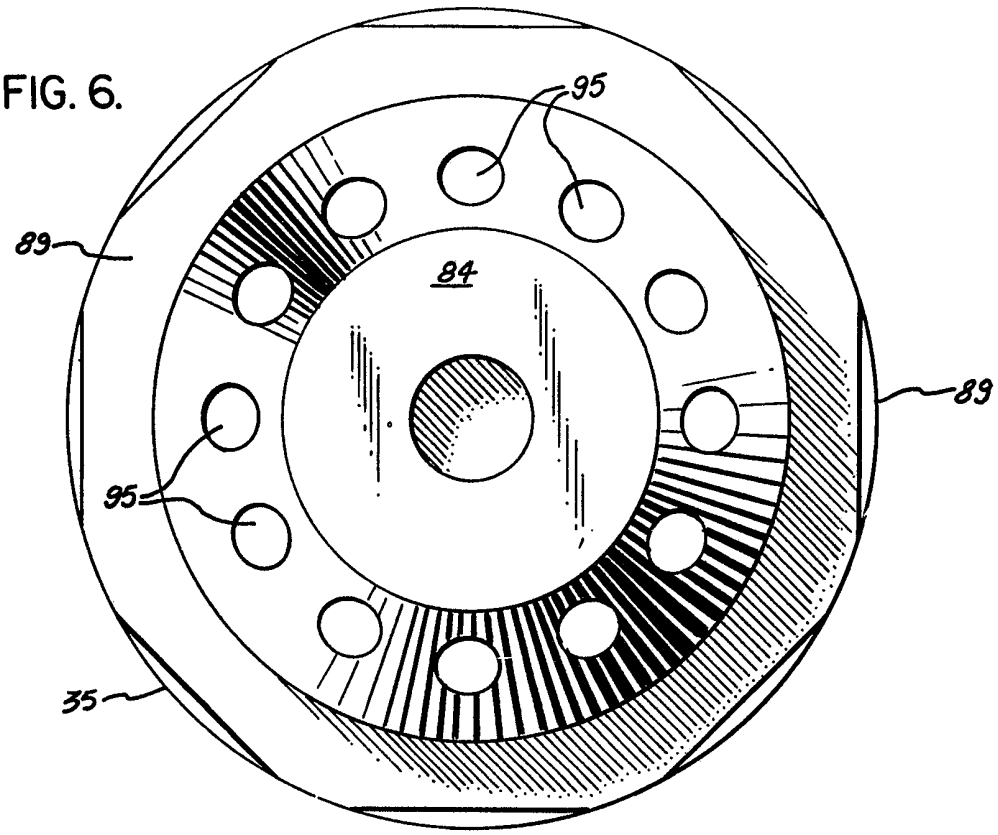
FIG. 6.



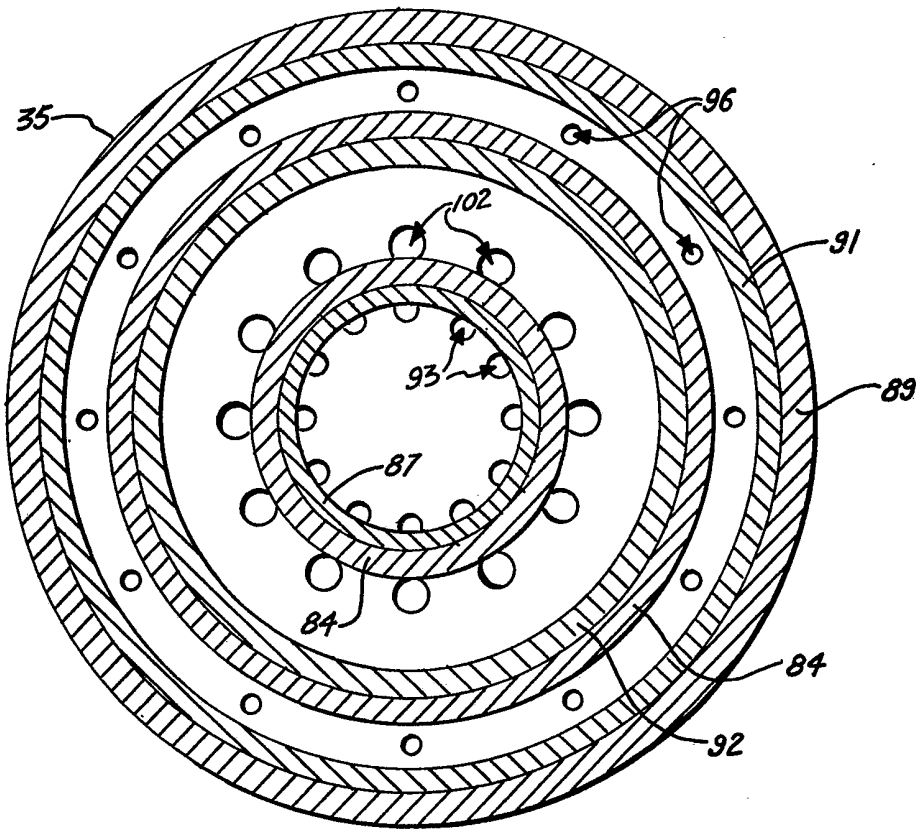


FIG. 7.

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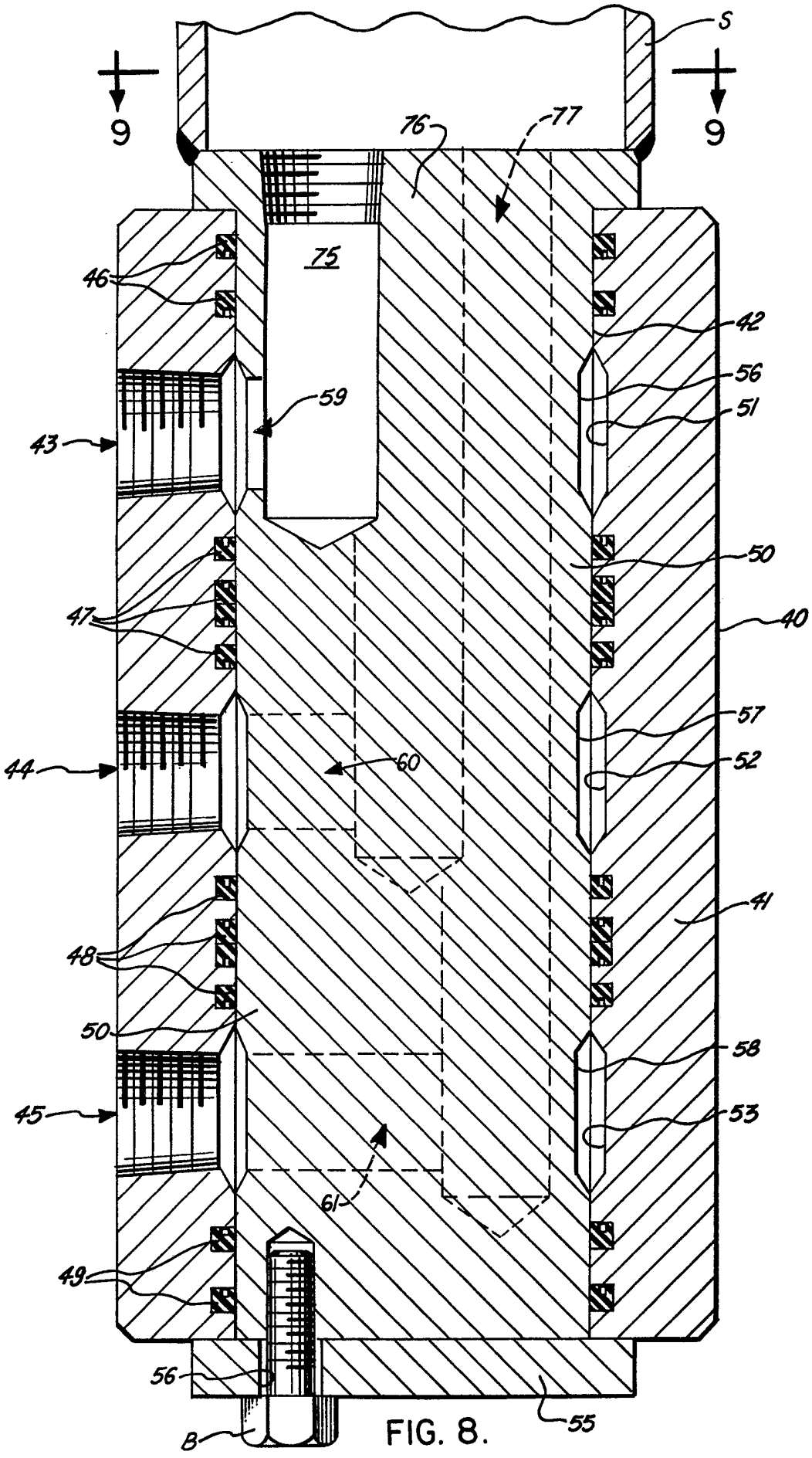

FIG. 8.

SPECIFICATION

Improved method and apparatus for combustion of oil

Technical Field

The present invention relates to an apparatus and method for the combustion of crude oil at, for example, the drilling site. More particularly, the present invention relates to a method and apparatus for the improved combustion of crude oil using an atomizing burner in which the burner assembly is adjustably movable from a remote location, and improvements enhance combustion, providing a smokeless burn to limit pollution and complete disposal.

Background Art

In the drilling and subsequent testing of oilwells it is sometimes necessary to dispose of large volumes of oil produced. Oil may be preliminarily stored in tanks upon the drill site, but eventually the oil must be either transmitted to a point of desired location, or disposed of in some manner which is of minimal impact to the environment.

The untreated disposal of unwanted crude oil upon the earth's surface or into the ocean causes intolerable environmental damage and such a practice is generally prohibited.

To transmit oil immediately from a remote drilling site may not always be possible or economically feasible. Crude oil used for testing the well may additionally be mixed with drilling mud, sand, or otherwise be impure or unusable. Weather conditions may bear on the ability to transmit such oil from a remote drilling site until piping can be set up, especially in very remote areas as the arctic regions of the earth, and in Alaska in the United States. In these frigid and arctic regions, the disposal of oil can be particularly acute in view of the fragileness of such ecological regions. To dispose of oil by combustion in artic regions requires a clean, complete combustion burn which is substantially smokeless.

Attempts have been made to overcome the disposal of excess or unwanted excess oil by the use of burners or combustion devices. See, for example, U.S. Patents Nos. 3,565,562; 3,632,287; and my prior U.S. Patent 3,807,832 entitled "Method and Apparatus for Combustion of Oil", which is hereby incorporated by reference, the present invention being an improvement of these earlier devices.

French Patent 2,391,903 to LeCompte discusses a flair support.

In U.S. Patent 3,797,992 issued to Straitz there is seen a "Crude Oil Burner".

A "Duel Fuel Burner" is the subject of U.S. Patent 3,153,438 issued to W.B. Brzozowski.

Powell discloses in U.S. Patent 2,882,843 a "Combustion Apparatus".

A patent to Sherman (U.S. 2,869,626) discloses a "Fluid Fuel Burning Apparatus".

U.S. Patent 2,861,629 issued to W.H. Dailey provides a "Burner Apparatus".

Phillips in U.S. 2,793,686 discloses a "Axially Adjustable Fuel Burner for Furnaces".

The Caracristi Patent 2,480,547 discloses a "Burner with Adjustable Air Distribution".

A "Combination Burner for Liquid and Gaseous Fuels" is the subject of U.S. Patent 2,368,178.

An "Air Directing Means in Gun Type Burners" is the subject of U.S. Patent 2,473,347.

A "Method and Apparatus for Burning Liquid Fuel" is the subject of U.S. 1,706,316 issued to Norton.

A "Process of Generating Gas from Kerosene and by Means of Wicks" is the subject of U.S. Patent 608,394.

Lucich discloses a "Burner for Heavy Liquid Fuels" in U.S. Patent 2,003,181.

A "Pulverized Fuel Burner" is the subject of U.S. Patent 1,878,926.

A "Fuel Burner" is seen in U.S. Patent 1,870,013 issued to Keenan.

Another "Apparatus for Liquid and Pulverized Fuel Furnaces" is seen in U.S. Patent 1,793,111 issued to J. McDonald.

The Zink Patent 2,274,818 discloses a "Combination Gas and Oil Burner".

Thompson shows in U.S. Patent 3,120,260 a "Waste Gas Disposal Flare" having an adjustable boom.

U.S. Patent 3,852,022 discloses a "Liquid Fuel Burner Head" issued to Medeot, et al.

U.S. Patent 3,918,885 issued to Palm, et al, discloses an "Apparatus for Reducing the Dynamic Pressure of Combustion Air at the Burner Head of an Oil Burning Appliance".

U.S. Patent 3,758,259 issued to Voorheis discloses a "Method for Preparing Fuels and also for Thereafter Feeding Them Into Furnaces and Burning Them Therein".

The Guerin patent 3,533,717 provides an "Emulsifier Burner for Hydrocarbons and Water with Mechanical Spraying A Controlled Flame and Having An Anti-Atmospheric Pollution Effect".

Walsh provides in U.S. Patent 3,413,069 a "Method and Apparatus for Eliminating Furnace Pulsations".

Spence discloses in U.S. 04,260 a "Burning Hydrocarbon" patent.

In U.S. patent 447,757 issued to Campbell there is disclosed an "Incandescent Burner and Method of Using the Same".

Denis shows in U.S. Patent 3,266,552 a "Burner for Producing A Stable Flame with A High Concentration of Heat Stabilized by A Shock Wave".

Straitz in U.S. Patent 3,861,857 discloses a "Flammable Liquid Waste Burner".

Glotin, et al, provides in U.S. Patent 3,894,831 "Methods and Apparatus for Burning Liquid Hydrocarbons" which employes a boom.

Bleyl in U.S. Patent 3,948,196 discloses an "Apparatus for Burning Fluid at a Burner Mounted on a Floating Vessel Subject to Wave Action". Booms are employed in supporting the burner assembly.

In U.S. Patent 3,749,318 issued to Cottell there

is provided a "Combustion Method and Apparatus Burning An Intimate Emulsion of Fuel and Water".

In U.S. Patent 1,976,523 issued to Vandeveer discloses a "Process for Burning Oil Insoluble Sludge".

Raulins discloses in U.S. Patent 4,072,190 a "Motion Compensator".

Theriot discloses in U.S. Patent 3,811,820 a "Well Test Burner".

The Zink Patent 3,814,567 provides a "Smokeless Flare Using Liquid Water Particles".

Charpentier discloses in U.S. Patent 3,875,998 an "Installation for Separation on the Seabed of the Effluents from Underwater Oil Wells".

Reed, et al, discloses in U.S. Patent 3,632,287 a "Burner Assembly for Combustion of Oil".

The Dunn Patent 3,748,080 discloses a "Combustion Control Apparatus Using A Liquid Spray".

Kubasta in U.S. Patent 3,666,395 discloses an "Offshore Gas Flare Apparatus".

A method and apparatus for oil and gas pollution control is disclosed in U.S. Patent 3,602,299 to Mozic.

The Sparrow Patent 3,756,765 discloses an "Automatic Flare Igniter and Counterbalanced Flare Stack".

One of the problems experienced in the burning of oil especially on offshore oil platforms is the direction of the flame in the event of windchanges and the like. Since these offshore structures contain at many times gas, oil, or other volatile substances, flames can be of great danger to the personnel and property of the structure itself. Thus the flame is generally burned at a distance from the structure by the use of a boom as shown in my prior U.S. Patent 3,807,832.

The boom itself may be threatened in the event of a wind change or the like and thus it would be desirable that the boom be adjustable with regard to direction.

Another problem with combustion of crude oil involves the environmental problems associated with smoke which is generated during the combustion as well as heavy matter which falls out on the ground. In delicate environments such as on the North Slope of Alaska, the creation of a great deal of heavy black smoke and/or fallout during the burning of crude oil can produce disastrous ecological consequences in such a fragile environment.

Such environmental problems are well-known in open pit burning as well in trying to dispose of oily waste in disposal wells or the like.

A great deal of expense would be involved in shipping this oil away from the fragile environment site because of the severe cost involved.

In high rates of burning such as many thousand barrels per day, the problem of achieving a smokeless environmentally clean burn is accentuated.

Often the oil being burned itself is not only oil but a much heavier product such as oil phase mud. This heavier material as well as the burning of certain toxic chemicals requires a highly efficient complete combustion in order to be environmentally safe. The above problems of burning various hard to dispose of waste materials such as crude, oily waste, oil phase mud, toxic chemicals, and mixture of the above at high rates to produce a clean smokeless burn with an assembly which is adjustable in a variety of wind and weather conditions is the problem to which the present invention is directed.

According to the present invention there is provided an apparatus for combustion of crude oil, comprising: boom means connected at its proximate end portion to a support; burner means connected to the distal end portion of said boom means, said burner means having means for atomizing crude oil and mixing crude oil with a gaseous atomizing medium to improve combustion; oil conduit means for supplying crude oil to said burner means; gas conduit for supplying said gaseous atomization medium to said burner means; and rotational connection means affixing said burner means to said boom means for remotely actuating rotational movement of said burner means with respect to said boom means.

The invention also provides a method of atomizing oil prior to combustion comprising the steps of: providing a boom having proximate and distal ends and comprising a plurality of structurally connected tubular members; supporting the boom at the proximate end; conveying oil, and a gaseous atomizing medium from the proximate to the distal end of the boom; providing an atomizing nozzle at the distal end of the boom; mixing a primary air stream and oil in the nozzle prior to atomization; mixing a secondary air stream with the air-oil mixture prior to atomization and after preliminary mixture of the oil with said gaseous atomizing medium and atomizing the air-oil mixture.

For a further understanding of the nature and objects of the present invention, reference should be had to the following detailed description, taken in conjunction with the accompanying drawings, in which like parts are given like reference numerals and wherein:

Figure 1 is an elevational view of the preferred embodiment of the apparatus of the present invention;

Figure 2 is a partially broken elevational view of the preferred embodiment of the apparatus of the present invention;

Figure 3 is a sectional fragmentary view of the swivel mount portion of the preferred embodiment of the apparatus of the present invention;

Figure 4 is a fragmentary view of the swivel and burner portions of the preferred embodiment of the apparatus of the present invention;

Figure 5 is a partial sectional view of the nozzle portion of the preferred embodiment of the apparatus of the present invention;

Figure 6 is a fragmentary front view of the nozzle portion of the preferred embodiment of the apparatus of the present invention;

Figure 7 is a sectional view taken along lines

7—7 of Figure 5;

Figure 8 is a sectional view of the swivel portion of the preferred embodiment of the apparatus of the present invention; and

Figure 9 is a sectional view taken along lines 9—9 of figure 8.

Best Mode for Carrying Out the Invention

Figure 1 best illustrates the preferred embodiment of the apparatus of the present invention designated generally by the numeral 10. In figure 1 there can be seen a boom 20 supported on a drilling platform 16, for example, at one end portion thereof by a boom support assembly bracket 15 which can be pivotally connected to support 15 by means of a pin connection. At the extreme end portion of boom 20 opposite support 15 is supported burner assembly 25 which would be movably attached to boom 20 in a pivotal fashion by means described hereinafter. Mounted upon boom 20 is burner mount plate 30 supporting swivel assembly 40 thereupon.

Burner assembly 25 would be desirably rotatably movable with respect to boom 20 (and preferably from a romote location) responsive to rotation of a portion of swivel assembly 40 to which burner assembly 25 is attached and supported at least in part. Rotation of burner assembly 25 could be by means of a motor 70 and gearing arrangement as best seen in figure 2.

Figure 2 shows swivel assembly 40 receiving thereto a plurality of flow lines 21—23 which would convey respectively oil, water, and a gaseous atomizing medium such as air. It should be understood, however, that instead of oil or crude oil any other material which is to be burned could be supplied such as hazardous waste, or a mud and oil combination.

Burner mount plate 30 is shown in fragmentary in figure 2 with an annular burner flange 64 being supported thereupon and allowed to rotate with respect to mounting plate 30. A detail of the connection of flange 64 and mount plate 30 is seen in figure 2 in sectional view with a bearing surface 65 which could be of any desirable substantially frictionless or low friction material or the like or a polished metallic substance. A retaining collar 67 provides an annular overlapping shoulder 68 which would retain flange 64 in a vertical direction against movement. Sufficient clearance would be provided to allow flange 64 to slide freely with respect to bearing surface 65 and collar 67. Set screws 69 as desired would be provided to firmly affix flange 64 with respect to mounting plate 30 if so desired.

In figure 2 there can be seen motor 70 supported by bracket 73 which motor 70 could be a hydraulic or electric motor, for example, and extend therefrom shaft 71 and at its distal end pinion gear 72. A toothed rack 68 would be annular and would be provided in a substantially 360° degree circular fashion about the edges of flange 64. Rotation of motor 70 would thus produce a rotation of shaft 71 and pinion 72 to rotate burner assembly 25 in a desired direction. Motor 70 would thus preferably be bidirectional in nature allowing rotation of shaft 71 in either of the two rotational directions.

Figure 2 further shows a plurality of risers 26—28 which would convey respectively water, oil, and air. Each riser would communicate with piping provided upon burner assembly 25 and convey fluid to nozzle 35. Water would also be conveyed through line 29 to water ring 32 and to the plurality of nozzles 33 disposed thereabout in a radial fashion.

The construction of swivel assembly 40 is seen more particularly in figures 8 and 9. Swivel 40 provides a housing 41 having an inner bore 42 which during operation will house swivel element 50. Swivel element 50 will rotate within housing as described more fully hereinafter. A plurality of annular seals 46—49 isolate therebetween three fluid retaining annular groove 51—53, each having communication with the exterior of housing 40 through ports 43—45 which would respectively connect to inflow lines 21—23. Thus, ports 43—45 would separately receive air, oil, water, or other desirable products to be used in the combustion process and to be mixed and atomized at the nozzle 35 portion of burner assembly 25.

A lowermost plate 55 would be equipped, for example, with a plurality of openings 56 through which suitable fasteners such as bolts B, for example, could be passed and attached to swivel 50. Swivel element 50 as best seen in figure 3 provides three annular grooves 56—58. The combination of annular grooves 51—53 of housing 50 and the annular grooves 56—58 of swivel element 50 provide liquid retaining reservoirs through which liquid or fluid could be transmitted from ports 43—45 to the three risers 75—77. Each annular groove 56—58 provides communication with its corresponding port 59—61 and further communicates with risers 75—77 which are shown in phantom lines in figure 8. From the above it can be seen that fluid supplied to ports 43—45 respectively would be communicated through swivel 50 and upwardly to risers 65—67, and piping 26—28 connected thereto, thus supplying fluid as desired to burner assembly 25.

The uppermost portion of swivel 50 shows bearing plate 64, and upper annular plate 63 which provides the annular toothed rack 68 which will communicate during operation with pinion gear 72.

In addition to the rotational movement of burner head assembly 25 with respect to boom 20, further adjustable means is provided for controlling the air flow through the venturi cones in the form of conical baffles 106 which are movable in a linear fashion with respect to nozzle assembly 80 as indicated by the arrow in figure 2.

Baffles 106 would be linearly adjustable by means of sliding engagement with nozzle assembly 80 responsive to expansion and contraction of pushrod 105 as urged by hydraulic

cylinder 104. Hydraulic cylinder 104 would be mounted upon brackets which would be attached by welding or like suitable means to venturi cone V, and would be supported thereby. Venturi cone V would be supported by nozzle assembly 80 by welding thereto, with nozzle assembly 80 being supported by piping 26—28 which is in turn supported by swivel element 50, swivel housing 41, skirt S, flange 64, plate 30 and then by boom 20. This would allow linear relative motion of baffle 22 with respect to venturi cones V and would increase or decrease the flow of air into venturi cones V from a remote location as would be desirable. Hydraulic lines (not shown) would be attached to cylinder 104 and be routed to a remote location by attaching hydraulic lines (not shown) to boom 20 and thence to a desired point of operation.

A water ring 32 would be affixed to the extreme end portion of venturi cones V and would be provided with a plurality of nozzles 29 through which water could be sprayed for engagement with the combustion area.

Figure 5 illustrates nozzle assembly 80 which provides a disk shaped plate 84 which forms the downstream end of nozzle assembly 80. A tubular member 86 is connected to conduit 87 and is threadably connected to disk 84, although tubular member 86 and the other members described hereinafter, may be connected in any suitable manner such as welding, or the like. A first sleeve 92 encircles the forward portion of the tubular member 86 and conduit 87. Sleeve 92 is threadably connected to plate 84. The upstream end portion of sleeve 87 joins the perimeter of conduit 87. Sleeve 92 is of a greater diameter than tubular member 86 and conduit 87, and an annular space 99 is provided around the periphery of tubular member 86. Piping would be connected to sleeve 92 for the purpose of admitting crude oil in the annular space 99.

Plate 84 is forced against second and outermost sleeve 91 by assembly collar 89 which is threadably attached to sleeve 91. The upstream end portion of sleeve 91 joins the perimeter of first sleeve 92. Sleeve 91 is of a greater diameter than sleeve 92 and an annular space 98 is provided therebetween. Connected to annular space 98 would be piping for the purpose of admitting water thereto.

A plurality of ports 93 are formed in plate 84 through which gaseous atomizing medium (such as air) may escape, providing primary air for atomization. These ports 93 preferably have their axes aligned with the axes of discharge openings 95. The openings 95 are of a larger diameter than ports 91. Apertures or channels 102, which are equal in number to discharge openings 95, provide communication between the annular space 99 at 103 and the discharge openings 95. Similar aperatures or channels 96 connect space 98 with discharge openings 95. The gaseous atomizing medium escaping through the openings 95 serves to draw oil from the annular space 99 and water from the annular space 98 into mixing channels between ports 93 and openings 95 to break the crude oil and water mixture into small droplets and propel it through the openings 95.

Secondary air through annular conduits or channels would be provided at discharge openings 95, also prior to atomization and combustion. These annular conduits or channels are seen as 97 in figure 5. The secondary air improves atomization and combustion.

The above construction provides an apparatus which produces an essentially smokeless burn and an adjustable apparatus which allows adjustment of burner assembly 25 position with respect to boom position, as well as the enhancement of a smokeless burn by using air flow control for controlling air to the nozzle and burner area both prior to and during combustion.

The above construction has been found to be particularly useful in the burning of crude oil, as well as the burning of oil phase mud, and uncut oil phase mud. The oil phase mud can be cut with an equal volume of diesel fuel to thin it out, however, the apparatus of the present invention can be used as well to burn uncut oil phase mud.

Because many varying and different embodiments may be made within the scope of the inventive concept herein taught, and because many modifications may be made in the embodiments herein detailed in accordance with the descriptive requirement of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.

CLAIMS

1. An apparatus for combustion of crude oil, comprising:

a. a boom means connected at its proximate end portion to a support;

b. burner means connected to the distal end portion of said boom means, said burner means having means for atomizing crude oil and mixing crude oil with a gaseous atomizing medium to improve combustion;

c. oil conduit means for supplying crude oil to said burner means;

d. gas conduit means for supplying said gaseous atomization medium to said burner means; and

e. rotational connection means affixing said burner means to said boom means for remotely actuating rotational movement of said burner means with respect to said boom means.

2. An apparatus according to claim 1, wherein said rotational connection means comprises in part a liquid interface provided by a liquid collector ring.

3. An apparatus according to claim 1 or 2, wherein said burner means comprises at least in part a nozzle, a venturi-shaped shroud, said nozzle being mounted within the confines of said shroud, a baffle movably mounted with respect to said shroud, and adjustable means connected to said baffle for providing relative adjustable movement of said baffle with respect to said nozzle.

4. An apparatus according to claim 3, wherein said adjustment means comprises a hydraulic cylinder mounted on said boom, and a pushrod extending from said cylinder to said baffle.

5. An apparatus according to any preceding claim, wherein said rotational connection means comprises a normally static swivel housing connected to said oil conduit means and said gas conduit means and a swivel element disposed within said housing and rotationally movable with respect thereto.

6. An apparatus according to claim 5, wherein said burner means is connected to said swivel element for rotation therewith.

7. An apparatus according to claim 6, comprising an upper annular rack means attached to said swivel element for imparting rotational motion to said swivel element, and driven gear means intermeshed with said rack means for moving said rack means.

8. An apparatus according to claim 7, wherein said driven gear means comprises in part a motor mounted on said boom for imparting rotational power to said gear means.

9. An apparatus according to claim 1 or 2, wherein said atomizing means is a nozzle.

10. An apparatus according to claim 9, wherein said nozzle provides means for the introduction of crude oil and air prior to atomization.

11. An apparatus according to any preceding claim, wherein said oil conduit means comprises at least in part a structural member of said boom.

12. An apparatus according to claim 11, wherein said oil conduit means comprises at least in part a longitudinal support stringer of said boom.

13. An apparatus according to any preceding claim, wherein said gas conduit means comprises at least in part a structural member of said boom.

14. An apparatus according to claim 13, wherein said oil conduit means comprises at least in part a longitudinal support stringer of said boom.

15. An apparatus according to claim 1, wherein said burner comprises in part a nozzle, and crude oil and a gaseous atomizing mixture are mixed within said nozzle.

16. An apparatus according to any preceding claim, further comprising water conduit means for supplying water to said burner means.

17. An apparatus according to claim 16, wherein said water conduit means comprises at least in part a structural member of said boom.

18. An apparatus according to any preceding claim, wherein said oil conduit means comprises in part said rotational connection means.

19. An apparatus according to any preceding claim, wherein said gas conduit means comprises in part said rotational connection means.

20. An apparatus according to claim 16, wherein said water conduit means comprises in part said rotational connection means.

21. An apparatus according to claim 1, further comprising water conduit means for supplying water to said burner means, wherein said rotational connection means comprises:

i. a swivel housing mounted upon said boom;

ii. means on said swivel housing for forming separate fluid connections with said gas, oil and water conduit means;

iii. a swivel element rotatably mounted within said swivel housing;

iv. separate gas, oil and water reservoirs within said swivel housing; and

v. riser means partly within said swivel element for transmitting separate fluid streams of air, oil and water to said burner means.

22. An apparatus according to claim 21, further comprising seal means for separating said gas, oil and said water reservoir.

23. An apparatus according to claim 21 or 22, wherein each of said reservoirs are annular spaces between said swivel housing and said swivel element.

24. An apparatus according to claim 21 or 22, wherein each of said reservoirs are annular grooves formed in said swivel elements.

25. An apparatus according to claim 21 or 22, wherein each of said reservoirs are annular grooves formed in said swivel housing.

26. An apparatus according to any one of claims 21 to 25, further comprising piping means for connecting said nozzle and said riser means.

27. An apparatus according to claim 15, comprising means for mixing gas and oil within said nozzle prior to combustion.

28. An apparatus according to claim 15, further comprising means for mixing water with said gaseous atomizing medium and said oil prior to combustion.

29. An apparatus according to any preceding claims wherein there is provided secondary air means for mixing air with the mixture of said oil and said gaseous medium after they have been mixed but prior to atomization.

30. A method of atomizing oil prior to combustion comprising the steps of:

a. providing a boom having proximate and distal ends and comprising a plurality of structurally connected tubular members;

b. supporting the boom at the proximate end;

c. conveying oil, and a gaseous atomizing medium from the proximate to the distal end of the boom;

d. providing an atomizing nozzle at the distal end of the boom;

e. mixing a primary air stream and oil in the nozzle prior to atomization;

f. mixing a secondary air stream with the air-oil mixture prior to atomization and after preliminary mixture of the oil with said gaseous atomizing medium; and

g. atomizing the air-oil mixture.

31. A method according to claim 30, wherein there is further provided the step between steps "d" and "e" of mixing water with the air-oil mixture prior to atomization.

32. A method according to claim 30 or 31, wherein in step "d" the nozzle provides a plurality of atomization ports with at least oil and a

gaseous atomizing medium being conveyed through said ports prior to atomization.

33. A method according to claim 32 wherein in step "d", the plurality of ports are radially spaced.

34. A method according to claim 30, 31, 32 or 33 wherein in step "c", oil is conveyed through one of the boom structural members.

35. A method according to any one of claims 30 to 34, wherein in step "c", water is conveyed through one of the boom structural members.

36. A method according to any one of claims 30 to 35, wherein in step "c", a gaseous atomizing medium is conveyed through one of the boom structural members.

37. A method according to any one of claims 30 to 36, wherein the nozzle provided in step "c" provides a primary mixing channel where the mixture of oil and the gaseous atomizing medium occurs, and a plurality of feed channels for transmitting fluid into the mixing channel.

38. A method according to claim 37, wherein the gaseous atomizing medium is first transmitted to the mixing channel before oil or water.

39. A method according to claim 38, wherein oil is secondly transmitted to the mixing channel after the gaseous atomizing medium.

40. A method according to claim 39, wherein secondary air is thirdly transmitted to the mixing channel after sequentially introducing the gaseous atomizing medium and oil.

41. A method according to claim 39, wherein water is thirdly transmitted to the mixing channel after sequentially introducing the gaseous atomizing medium and oil.

42. A method according to claim 37, wherein in step "c", a plurality of radially spaced mixing channels are provided in the nozzle, each being equipped with a plurality of feed channels communicating therewith.

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