My invention relates to fluid fuel burning apparatus, for example, space heaters and driers employing fluid fuel such as oil.

The invention has among its objects an improved way of burning the fuel.

Another object of the invention is a space heater and drier having provision for burning the fuel under pressure in a drum-like combustion chamber the walls of which are provided with relatively closely spaced, small perforations for escape of the combustion products which when they escape mix with a blast of air in contact with the walls of such chamber for producing a hot gaseous medium which is projected into the space to be heated or against a surface of the like to be dried.

The above and other objects of the invention, however, will be best understood from the following description when read in the light of the accompanying drawings of an embodiment of the invention selected for illustrative purposes, while the scope of the invention will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a side elevation of a portable space heater and drier according to the invention;

Fig. 2 is a side elevation of the space heater and drier according to Fig. 1 as viewed from its side opposite that shown by Fig. 1;

Fig. 3 is a section on the line 3--3 of Fig. 5, with parts in elevation and parts omitted;

Fig. 4 is a section on the line 4--4 of Fig. 1;

Fig. 5 is an end elevation of the space heater and drier according to Fig. 1 as viewed from the left;

Fig. 6 is a section on the line 6--6 of Fig. 5;

Figs. 7 and 8 are sections on the lines 7--7 and 8--8, respectively, of Fig. 6 on an enlarged scale; and

Fig. 9 is a section on the line 9--9 of Fig. 3 on an enlarged scale.

Referring to the drawings, the space heater and drier illustrated comprises an elongated cylindrical oil tank 1 which adjacent one of its ends is provided with opposite wheels 3 and adjacent its other end with opposite legs 5. These wheels and legs are adapted to rest upon the floor F. As shown, the end of the tank adjacent the legs is provided with a handle 7 so that the legs may be raised from the floor while the wheels still rest upon it, thus enabling the apparatus readily to be wheeled about by use of the handle.

Above the oil tank 1 in spaced parallel relation thereto is shown an open ended, cylindrical, sheet metal shell or casing 9. As illustrated, the shell is permanently supported on and secured to the tank by pairs of posts 11 at opposite ends, respectively, of the shell, which parts are welded at one of their ends to the shell and at their opposite ends to the tank.

As illustrated, within the shell 9 adjacent one end thereof and coaxially therewith is positioned a cylindrical drum 13 forming a combustion chamber in which the heating fuel is burned. The drum, which is formed of relatively thin, heat refractory, sheet metal, for example stainless steel about 0.03 inch thick, has the lateral wall 15 and opposite end walls 17 and 19. As shown, the end wall 17 has an outturned peripheral flange 21, while the end wall 19 is provided with an internally perforated peripheral flange 23, these flanges being welded to the lateral wall 15 of the drum.

In accordance with the invention the wall of the drum 13 is provided with an area or areas of relatively closely spaced small perforations 25. The perforated area or areas may be confined to the lateral wall of the drum or to the end wall 17 thereof or may be included as part or parts of the extent of both of said walls. In all of these cases, although the perforated area may be coextensive with the wall, it need not necessarily be so. For example, particularly when a high pressure is to be maintained in the drum as hereinafter more fully explained, the lateral wall may have one or more bands constituting the perforated area or areas thereof, say a single band at about the center portion of the length of the drum, or say two bands about equally spaced from each other and the ends of the drum, while the end wall 17 may have one or more ring-like bands of perforations concentric with the drum axis or have a single centrally positioned perforated area in all of these cases the remainder of the wall in respect to its perforated area or areas being imperforate.

As shown, the drum 13 is supported adjacent its opposite ends on brackets 29 (Figs. 3 and 9) carried interiorly of the shell 9. Each of these brackets, as illustrated, has an arcuate portion 31 which at opposite ends has legs 33 terminating in feet 35, the latter being welded to the shell. At its left hand end, as viewed in Fig. 3, the drum carries an angle clip having a vertical leg 37 welded to the outer side of its end wall 19 and a horizontal leg 39 which hooks under the arcuate portion 31 of the adjacent bracket 29. At the opposite end of the drum the arcuate portion 31 of the adjacent bracket 29 has welded to its under side the horizontal leg 41 of an angle clip provided with a downwardly projecting leg 43. Removably secured to this vertical leg by a bolt 45 is the vertical leg 47 of a second angle clip having a horizontal leg 49 which hooks over the flange 21 of the adjacent end wall 17 of the drum. In an obvious manner by this construction the drum is removably secured within the shell.

Coaxially with the opening 27 in the end wall 19 of the drum at the outer side of said wall is provided an open ended blast tube 51. This tube, as shown, is secured to said end wall by angle clips 53 welded to said wall and said tube.

As illustrated, within the blast tube adjacent the opening 27 in the end wall 19 of the drum and coaxially with said opening is positioned an oil atomizing nozzle 55 carried at the end of an oil supply pipe 57, which latter projects from the opposite end of the blast tube, this pipe being carried by a bracket 59 positioned internally of the blast tube and secured thereto by bolts 61. Positioned adjacent the nozzle 55 are a pair of ignition electrodes 63 extending through insulating bushings 65 secured to the pipe 57 by clips 67, the electrodes, as shown, having the end terminals 69 adjacent the rearward end of the blast tube. Also carried by the pipe 57 is a plate formed to present an annular series of inclined vanes 70 which act to cause whirling of the combustion air discharged by the blast tube and so as to effect the mixing of such air with the oil sprayed from the nozzle 55. For causing an ignition spark between the electrodes their terminals 69 are shown as connected to leads 71 (Figs. 3 and 6) from the secondary of a transformer 73, which latter is mounted upon a plate 75 (Fig. 2) carried adjacent one of its ends by a like auxiliary post 76 and adjacent its opposite end by a like auxiliary post 76.

As further illustrated, the shell 9 is provided at its
upper portion with a rearward extension 77 of arcuate transverse cross-section, removably secured to the shell by screws 79 (Fig. 2), the arcuate cross-section of the extension providing it with an open bottom.

Extending upwardly from the oil tank and carried thereby is shown a post 81 which at its upper end carries a platform 83 upon which rests and to which is secured the base of an electric motor 85 the shaft of which is positioned coaxially of the shell 9. Projecting laterally from the post 81 is an arm 87 having at its outer end a sleeve 89 through which extends and to which is removably secured the extension 91 of the casing 93 of an oil pump 85. The shaft 97 of the electric motor 85 is shown as carrying a belt pulley 99 about which a belt pulley 101 carried by the driving shaft 103 of the pump passes a belt 105 for driving the pump. As indicated, the pump has a suction pipe 107 (Fig. 1) extending into the oil tank, in which pipe is inserted an oil filter 108. The pump has a discharge pipe 109 (Fig. 4) leading to an oil filter 111. From the filter 111 the oil is forced through a pipe 113 connected to the rearward end of the pipe 57, which latter at its forward end carries the oil atomizing nozzle 55.

The pump, which is of known construction, is provided at its outlet with a relief valve (not shown) connected by a pipe 115 (Fig. 1) for by-passing part of the oil discharged from the pump back to the oil tank, this relief valve being manually adjustable for regulating the amount of oil so bypassed. Thus, it is possible to control and maintain constant selected pressures of the oil supplied to the nozzle.

As shown, the shaft 97 of the electric motor 85 carries a fan 117 having the four fan blades 119. Within the shell in the space between the fan and the entrance end of the blast tube 51 is positioned a parallel portion 121 the peripheral edge of which fits and is welded to the shell. This partition is provided with a central opening 123 coaxial with the blast tube and drum, giving the partition an annular shape. The fan blades 119 are of common construction, having portions wider adjacent the periphery of the fan than adjacent its hub, so that the bulk of the air discharged from the fan is from these wider portions of the fan blades. In an operative sense this causes the bulk of the air to be discharged from the fan in the form of an annular blast of air directed toward the partition 121. The fan is of such diameter relative to the shell 9 that this operative annular blast of air adjacent the interior surface of the shell. The annular partition 121 is of such radial width that this annular blast of air is directed against it.

At the side of the partition 121 adjacent the fan are shown four radial vanes or baffles 125 arranged in quartering relation and each extending from the axis of the shell outwardly to its interior surface, these baffles being welded at their outer edges to the shell, and to each other at the axis of the shell. The operatively annular blast of air from the fan which strikes the partition is turned inwardly by it toward the axis of the shell and flows toward said axis in the spaces between adjacent baffles 125, which latter in and of themselves, and in conjunction with the partition, form passages between adjacent baffles for conducting the air toward the central opening 123 of the partition. As these passages are of progressively decreasing cross-sectional area as they extend from the partition they act progressively to increase the pressure of the air in them as such air flows through them so that the air discharges through the central opening of the partition under increased pressure, the air discharging through the blast tube 51, through its entrance end for passage therefrom into the combustion chamber, with the result of increasing the pressure within the combustion chamber over that which would exist if the fan or any part thereof discharged directly into the blast tube. The air leaving the fan tends strongly to whirl about the axial line of the fan, and the vanes or baffles 125 prevent such whirling of the air flowing between them, which acts by converting the velocity head of the whirling to pressure head also to increase the pressure of the blast of air discharged into the blast tube 51.

As illustrated, the partition 121 is provided with an annular series of circular openings 127, and between the partition and entrance end of the blast tube is positioned a ring-shaped plate 129 of the same radial width as the partition. The plate 129, as shown, is provided with an annular series of circular openings and is position mounted for moving these openings thereof more or less into registry with the openings 127 of the partition. In other words, the plate 129 is adapted to act as a damper for controlling the effective cross-sectional discharge area of the openings 127 of the partition.

The rotatable annular plate is held loosely against the partition by bolts 133 having heads 135 (Fig. 8) welded to the partition. The shanks of the bolts extend through arcuate slots 137 in the partition so that the plate may be rotated relative to it, the nuts 138 on the shanks of the bolts being prevented from turning by welding them to said shanks. As shown, adjacent its outer periphery the plate carries an angle bracket 139 (Figs. 6 and 7) one leg of which lies against the plate and is welded thereto and the other leg of which lies adjacent the interior surface of the shell 9. Through a perforation in the last mentioned leg and a short arcuate slot 141 extending circumferentially of the shell (Fig. 5) is passed the screw through the shank of a bolt 143 the head 145 of which is welded to that leg. Exteriorly of the shell the shank of the bolt carries a washer 147 and a thumb nut 149. In an obvious manner by loosening the thumb nut the plate 129 may be rotated into adjusted positions and held in such positions by the shank of a metal partition bolted against the partition.

The openings 127 in the partition 121 are shown as aligned with the annular space 151 between the lateral wall of the drum 13 and the shell 9 so that a fraction of the operatively annular blast of air discharged from the fan passing through said openings will be projected into and through that space. In passing through such space the air is heated by contact with and heat radiated from the lateral wall of the drum. Also if the lateral wall is provided with perforations 25 such air will mix with the gaseous products of combustion discharged through such perforations and, if the end wall 17 of the drum has perforations 26, the blast of air and the gaseous products discharged through them, whereby to form a hot gaseous medium which is projected beyond the shell. The strength of the blast passing through the openings of the partition is augmented by reason of the vanes or baffles associated with the partition preventing whirling of the air in the spaces between the baffles so that a strong blast of hot gaseous medium is projected from the shell by angular adjustment of the damper plate 129 the fraction of the operatively annular blast of air projected by the fan into the space 151 may be adjusted relative to the fraction of said blast which discharges through the central opening of the partition 121 into the drum, in that way selectively to vary the degree of pressure within the drum.

Most of the air which is projected through the central opening 123 of the partition 121 will be projected into the entrance end of the drum and thus positioned close to the partition. Any air passing through this opening which does not enter the blast tube will be discharged into and pass through the annular space 151 about the drum. Likewise air which is projected by the central portion of the fan blades will admix with the whirling and flowing radially inward between the vanes or baffles 125 and be discharged through the central opening of the partition.

In the above construction by reason of the fuel being burned within the drum-like combustion chamber under increased pressure it has been found that the amount of fuel burned in a given time in a given size combustion chamber may be much increased. Preferably the perfora-
tions 25 are as small as possible, about 0.08 inch di-

ameter, for practical reasons in producing them economi-

cally, being their minimum size. To prevent the forma-
tion and discharge through them of smoke and dangerous
amounts of carbon monoxide, it has been found that they
should be distributed over the wall surface of the
perforations 25 of the burner so as to present approximately
0.05 to 0.14 square inch of total transverse cross-
sec-
tional area per square inch of perforated surface, such
perforated surface, as above explained, not necessarily
being confined to any one wall of the drum, or when con-

fined to a single wall not necessarily being a continuous
surface. Further, to prevent the formation and discharge
through them of smoke and dangerous amounts of carbon
monoxide, it has been found that provision must be made
for securing a flame pattern within the drum such that the
flame is in such proximity to the perforated portion or
portions of the walls of the drum to heat at least those
portions to incandescence but in out-of-contact relation
with such portion or portions so as to be separated from
said portions by gaseous combustion products. Con-

veniently this flame pattern may be secured by proper de-

sign of the nozzle, and alternately, as explained in my
co-pending application Serial Number 439,653, filed June
28, 1934, may be secured by a line of small holes or a
fluid fuel nozzle adjacent the wall of the drum where the fuel oil nozzle is positioned. Under these conditions by properly pro-

portioning the amounts of air and fuel supplied the com-
bustion chamber and the total cross-sectional area of the
perforations 25 of the burner it has been found that complete combustion of the fuel will be sec-
cured and therefore with full assurance of total absence
of discharge of smoke and carbon monoxide from the
device.

In respect to the effect of pressure within the drum
increasing the fuel burning capacity of the device it has
been found that by having the total area of the perforated
portion or portions of the walls of the drum so propor-
tioned to the cubic contents of the drum such area in
square inches is arithmetically approximately from
15 to 35 percent of the arithmetical value of the cubic
contents of the drum expressed in cubic inches, and hav-
ing the air, of the oil-air mixture being discharged into the drum, in amount sufficient to maintain in the
drum, while combustion proceeds, a pressure of approxi-
mately from 0.025 to 0.2 inch of water above normal atmo-
spheric pressure at sea level, fuel oil can be burned with
in the drum under the above conditions at the high
rate of one gallon per hour per 550 to 1600 cubic inches of
the cubic contents of the drum, provided this pressure varies approximately directly and linearly with the
amount of fuel oil within the range of fuel oil just spec-
i-

ified. For example, a drum 9.5 inches in diameter and

12 inches long, having perforations about 0.08 inch in
diameter uniformly spaced on 4.5 inch centers and form-
ing a perforated band at the center of the length of the
drum presenting a total cross-sectional area of perfora-
tions about 18 percent of the arithmetical value of the
cubic contents of the drum, will completely burn com-

mercial No. 2 fuel oil at the high rate of one gallon per
hour per 850 cubic inches of the cubic contents of the
drum by supplying the air to the mixture in such amount
as to maintain the pressure in the drum at about 0.13
inch of water above normal atmospheric pressure, all the
walls of the drum being heated to incandescence through-
out their entire extent. Other No. 3 fuel oil, kerosene, gasoline, and the like may be completely burned in the above way by observing the precautions herein specified, the temperature secured be-
ing commensurate with the B. t. u. value of the particu-
lar fuel oil burned. It will be understood in these con-
nexions that increasing the amount of fuel oil burned
within the drum results in its walls being heated to a
 correspondingly higher temperature. However, it has
been found that with pressures within the drum of less
than approximately 0.025 inch of water the sub-

stantial increase in the amount of fuel oil that can be burned
is effected by varying the pressure, while with pressures
above the 0.2 inch of water the amount of air that must be
supplied the mixture to maintain the pressure presents
so much excess air in respect to the amount thereof
necessary to suppress incandescence that the temperatures
secured are not commensurate from an economic stand-
point with the concomitant increased amount of fuel oil
that then can be burned.

It will be understood that within the scope of the

applied claims wide deviations may be made from the
form of the invention described without departing from
the spirit of the invention.

I claim:

1. A heater having, in combination, a drum combus-
tion chamber having end and lateral walls, the lateral
wall being formed with a multitude of relatively closely
spaced small diameter perforations for discharge of
gaseous combustion products, a casing extending about
said lateral wall in spaced relation thereto for receiving
said products, an open ended combustion air blast tube
of lesser transverse cross-sectional area than that of said
chamber opening into said chamber adjacent its axial
line through one of its end walls, a fluid fuel nozzle asso-

associated with said blast tube for discharging fuel that mixes
with such combustion air, a partition in said casing
extending transversely thereof adjacent the entrance end
of said blast tube, which partition is provided with an
opening adjacent said axial line for discharging air into said
blast tube; means for directing, against a portion of
said partition that surrounds said opening thereof at
that side thereof which is remote from said chamber, an
operatively annular blast of air surrounding said opening;
baffles associated with said partition operatively forming
passages extending from said portion of said partition
to said opening, which passages are of progressively de-
creasing transverse cross-sectional area as they approach
said opening and are adapted to direct arcuate fractions
of said annular air blast striking said portion of said
partition to said opening for discharge therethrough into
said blast tube and by reason of such progressively de-
creasing cross-sectional area to increase the pressure of
the air discharged from them into said opening, and
means for projecting a blast of air through the space be-

tween said casing and the lateral wall of said chamber
for admixture with the combustion products discharged
into said space through the perforations of said lateral

wall.

2. A heater according to claim 1 in which the means for
projecting a blast of air through the space between
the casing and the lateral wall of the combustion cham-

ber comprises openings, formed in that portion of the
partition against which the annular blast of air impinges,
for passage into said space of a portion of such annular

blast.

3. A heater according to claim 1 in which the means
for projecting a blast of air through the space between
the casing and the lateral wall of the combustion cham-

ber comprises openings, in that portion of the partition
that is immediately adjacent against which the annular blast of air impinges, formed for passage into said space of a portion of said annular blast, and
means for regulating the amounts of air discharged
into said space and into said blast tube for regulating the
pressure in said chamber.

4. A heater according to any of claims 1, 2, or 3 in which the
means for projecting a blast of air through the space be-

tween the casing and the lateral wall of the combustion cham-
ber comprises openings, formed in that portion of the
partition against which the annular blast of air impinges,
for passage into said space of a portion of such annular
blast, and means operatively forming dampers associated with said openings for regulating the relative amounts of air discharged therethrough and through the passages formed by the baffles, whereby to regulate the pressure in said chamber.

5. A heater according to claim 1 in which the means for projecting a blast of air through the space between the casing and the lateral wall of the combustion chamber comprises openings, formed in that portion of the partition against which the annular blast of air impinges, for passage into said space of a portion of such annular blast, and a rotatably adjustable plate operatively associated with said partition and formed with openings adapted by such adjustment to be placed more or less in registry with said openings in said partition for regulating the amounts of air discharged through said openings in the partition and through the passages formed by the baffles, whereby to regulate the pressure in said chamber.

6. A heater having, in combination, an open ended cylindrical outer shell, a cylindrical drum of less diameter and shorter length than said shell positioned therein coaxially therewith, the lateral wall of said drum being formed with a multitude of relatively closely spaced small diameter perforations for discharge of gaseous combustion products from said drum into the annular space between said lateral wall and said shell for discharge through one of the ends of said shell, an open ended air blast tube within said drum opening at one of its ends into the interior of said drum adjacent its axial line through that end wall of said drum which is remote from such discharge end of said shell, a fuel oil atomizing nozzle adjacent the discharge end of said blast tube, means for supplying said nozzle with fuel oil under pressure, a fan positioned coaxially of said shell in spaced relation to the entrance end of said blast tube, said fan being of such diameter relative to the diameter of said shell that it discharges the bulk of the air projected by it as an annular stream adjacent the interior wall surface of said shell toward said drum, a partition in said shell extending transversely thereof in the space between said fan and entrance end of said blast tube, which partition is formed with an air discharge opening opposed to the entrance end of said blast tube for discharge of combustion air into said tube for admixture with the atomized fuel oil discharged from said nozzle, baffles in the space between said fan and partition associated with the latter and extending radially of said shell toward the opening of said partition, the spacings between said baffles decreasing as they so extend operatively to form passages which are of progressively decreasing cross-sectional areas as they approach the axis of said shell, which passages direct toward said opening annular fractions of said annular air stream projected by said fan against said partition and by reason of said progressively decreasing cross-sectional areas of said passages progressively increase the pressure of the air flowing through them toward said opening so as to cause the combustible mixture discharged into said drum to be under relatively high pressure, said partition adjacent the wall of said shell having openings for discharge of part of said annular air stream from said fan into the annular space between said drum and shell for admixture with the combustion products discharged into said space through the perforations of said drum, and adjustable damper means associated with the last mentioned openings of said partition for regulating the relative amounts of air discharged through such openings and the first mentioned opening of said partition for regulating the pressure in said drum.

7. The method of burning fuel oil to secure substantially its complete combustion without formation of carbon monoxide, utilizing a combustion chamber consisting of a drum of thin heat refractory metal exteriorly defined by lateral and end walls, at least one of which walls, excluding one of said end walls, is formed with perforations not exceeding approximately 0.018 square inch in transverse cross-section and distributed in spaced relation in such number as to present approximately from 0.05 to 0.14 square inch of total transverse cross-section per square inch of perforated surface of such surface in square inches being arithmetically approximated from 15 to 35 percent of the arithmetical value of the cubic contents of the drum expressed in cubic inches, which method comprises discharging the fuel oil into said drum at said excluded end wall thereof toward its opposite end in atomized state mixed with combustion air at the rate of approximately one gallon of such oil per hour for each 550 to 1600 cubic inches of the cubic contents of the drum and burning within the drum the mixture in the form of a flame that is of such pattem that it is in such proximity to at least the perforated wall portion or portions so as to heat them to incandescence but in out-of-contacting relation to such portion or portions so as to be separated from them by gaseous combustion products, the amount of combustion air mixed with said atomized fuel oil so discharged into the drum being sufficient to maintain in the drum a pressure of approximately from 0.025 to 0.2 inch of water above normal atmospheric pressure varying approximately directly and linearly with the amount of fuel oil so discharged into the drum, such air being substantially the only air admitted to said drum; and discharging the combustion products from said drum substantially solely through said perforations.

8. The method according to claim 7 in which the perforations are confined to the lateral wall of the drum.

9. The method according to claim 7 in which the perforations are confined to that end wall of the drum which is opposite its end wall at which the mixture is discharged therethrough.

10. The method according to claim 7 in which the perforations are in both the lateral wall of the drum and that end wall of the drum which is opposite its end wall at which the mixture is discharged therethrough.

11. A heater having, in combination, a drum combustion chamber having end and lateral walls, at least one of said walls, excluding one of said end walls, being formed with a multitude of relatively closely spaced small perforations for discharge of gaseous combustion products from said chamber, a casing having a portion surrounding said lateral wall in spaced relation thereto, a combustion air tube of transverse cross-sectional area that is of said chamber opening at one of its ends into said chamber adjacent the axial line of the latter through said excluded end wall and opening at its opposite end into said casing in spaced relation to that end wall, a fluid fuel nozzle associated with said blast tube for discharging fuel into said chamber, means for supplying combustion air to said blast tube through its said opposite end for admixture with such fuel so discharged, and air to the space within said casing about said lateral wall for flow therethrough in contact with said lateral wall and for admixture with the products of combustion discharged through said perforations, which means comprises a blower for directing an operatively annular blast of air surrounding the axial line of said blast tube toward the said opposite end to said tube, means including baffles between said blower and the said opposite end of said tube in the path of said annular blast for directing part of said blast inwardly toward said axial line, which last mentioned means of directing such air so directed that forms passages for conducting such air so directed that extend toward said axial line and are of progressively decreasing transverse cross-sectional area as they so extend for compressing such part and causing it to be projected at high velocity into said blast tube through its said opposite end, the last mentioned means having provision for causing another part of said annular blast to be directed toward and into the space surrounding said lateral wall.

12. A heater according to claim 11 having adjustable
damper means, associated with the means which includes the baffles, for regulating the amounts of air constituting the part of the annular air blast directed inwardly toward the axial line of the blast tube and the part of said blast directed toward the space surrounding the lateral wall of the combustion chamber, whereby to regulate the pressure within said chamber.