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METHOD OF REDUCING NOISE IN OIL BURNERS

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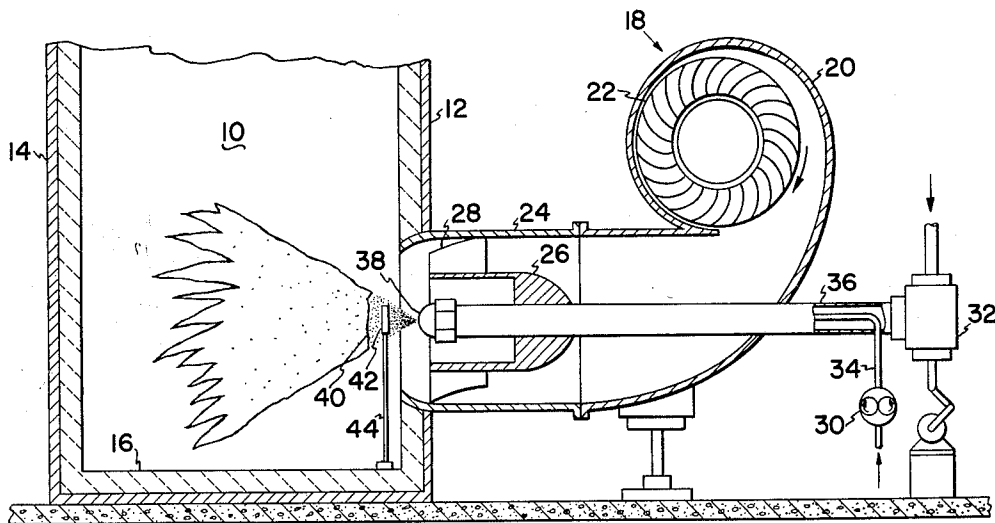


FIG. 1

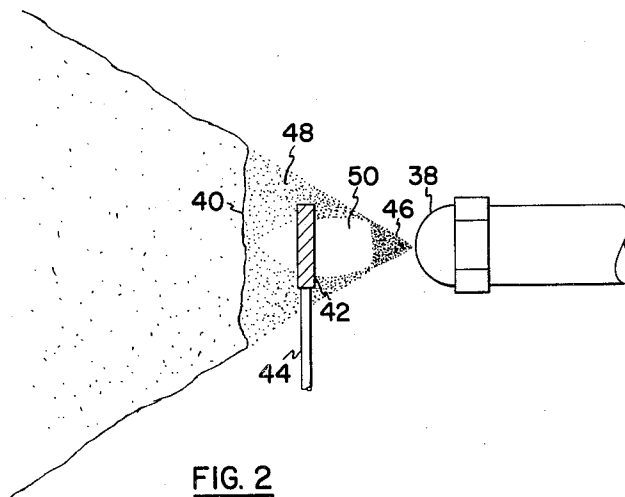


FIG. 2

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METHOD OF REDUCING NOISE IN OIL BURNERS

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Original application Aug. 1, 1958, Ser. No. 752,662. Divided and this application Nov. 30, 1960, Ser. No. 72,734

2 Claims. (Cl. 158—117.5)

This invention relates to oil burning devices. It relates particularly to oil burning devices for heating purposes. It relates more particularly to high efficiency oil burning devices for heating purposes having a furnace region in which oil is consumed. It relates still more particularly to conditions affecting the stability of flames in such devices, and it relates even still more particularly to the effect of flame stability in these devices on their noise output.

The present application is a division of an application Serial No. 752,662, filed in the United States Patent Office on August 1, 1958, now abandoned.

One significant problem encountered in the operation of furnace-type oil burning devices is that of noise. Oil burner noise may be generally divided into three components, mechanical noise, random flame noise, and pulsation noise. The noise problem is especially significant when oil burning devices are used for home heating because of the involvement of personal comfort. In this respect the pulsation component of oil burner noise, occurring as a single frequency oscillation of between 20 and 50 cycles per second, is the most annoying.

The majority of furnace-type combustion devices in home heating systems using oil as a fuel are of the gun variety comprising an oil spray nozzle surrounded by an air barrel or blast tube fitted internally with vanes whereby swirl is imparted to the air of combustion for turbulent mixing thereof with oil leaving the nozzle.

Home heating combustion devices of the variety described may be classified further as low pressure or high pressure with reference to the oil supply. In low pressure units oil is supplied to the spray nozzle at pressures in the range of 2 to 15 pounds per square inch. A small amount of air, perhaps 1 to 5 percent of that theoretically required to burn the fuel, is mixed with the oil ahead of or within the nozzle. The principal function of this air is to help break up the oil stream into fine droplets upon leaving the nozzle, the oil being thereafter mixed with air from the blast tube to achieve a combustible mixture. The air supplied by the blast tube will be at a pressure only slightly above atmospheric. In order to operate the burner at high efficiency, the velocity and direction of this air must be carefully controlled to provide turbulent mixing within the combustion chamber. This enables the oil to burn without smoking at low excess air which is required for efficient operation. The most common air pattern is a controlled swirl around the nozzle axis.

In high pressure units oil is supplied to the spray nozzle at a pressure of about 100 pounds per square inch, and is not mixed with any air ahead of the nozzle. As in the low pressure unit, the blast tube supplies air for combustion at only a very slight positive pressure and requires special devices for turbulent mixing of the air and oil. In both the low and the high pressure units for home heating, oil rates do not often exceed 1.70 gallons per hour, and air rates are compatible therewith as needed for smoke-free burning.

In the course of a research program directed at identifying and eliminating sources of noise in home heating furnaces using combustion devices of the variety described,

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high speed motion pictures were taken of burner flames in both low and high pressure units. These pictures showed not only a marked variation in the sizes, shapes and locations of the flames during what were ostensibly periods of steady combustion, but also that the flames would disappear entirely and then be recreated on a cyclic basis.

To recount a typical flame behavior, suppose initially the existence of a flame body having a front about 2 inches out from the spray nozzle. This body would not be stationary, but would be in motion toward the nozzle. As it came fairly near thereto, it would degenerate into a ring of flame closely surrounding the nozzle. Then the flame would move rapidly across the combustion chamber away from the spray nozzle and blast tube as though it were being violently blown. In the course of such movement it would be attenuated and finally extinguished. After a perceptible period of time during which no flame at all was evident, a pin point of light would appear more or less on an axial line with the spray nozzle and about 3 inches away from the tip thereof. This pin point would grow rapidly into a body of flame having an overall translatory motion toward the nozzle, and as the front of this flame came within 2 inches of the nozzle the events just described would be repeated sequentially.

Analysis of the high speed pictures on a time basis showed that the cyclic frequency of the events of flame growth and attenuation in a low pressure unit was equal to that of the pulsation component of burner noise. This correspondence of frequencies indicated strongly that pulsation noise was caused by unevenness in the rate of heat release from the oil burner unit. Inferentially it was indicated that pulsation noise could be reduced by making the flame more stable.

Flame stabilization experiments were conducted on a home heating furnace having a low pressure oil burner. The obvious controllable variables were air flow through the blast tube, oil and atomizing air flow through the spray nozzle, operation of the ignition system, and composition of the fuel. No significant effect on flame behavior nor on any noise component was obtained by any of the following steps applied singly or in combination: moderate increase in blast tube air pressure, substantial increase in oil and atomizing air supply pressure, continuous operation of the ignition system, and wide variation of fuels including typical heating oil products now marketed, fuels composed entirely of cracked products, pure compounds, and fuels containing special additives.

On the basis of further study there appeared to be an explanation for the cyclic actions of the burner flames in the units observed if the alternate formation and destruction of a partial vacuum at the spray nozzle tips were assumed. Although no means were available for measuring instantaneous pressures in the burner tip region directly, such an assumption was deemed reasonable considering the action of the air supply from the blast tube and the oil itself as it left the spray nozzle of a representative home heating unit operating at either high or low oil pressure.

It was hypothesized that swirling action imparted to the air leaving the blast tube by the special devices in the tube, usually designated turbulator vanes, tended to create a vacuum on an axial line with the spray nozzle, and accordingly as the oil particles diverged to form a hollow spray cone of about 80-degree included angle a region of reduced pressure would be present within the boundaries of this cone near the tip thereof. The spray cone would be limited as its edges broke down due to continuous thinning out of the oil particles and their mixing with air supplied by the blast tube. The spray cone would thus be closed in toward its center and the region of reduced

pressure bounded on the side away from the nozzle by a vapor body comprising air and particles of oil mixed in a combustible ratio, and being generally at a positive pressure. The tendency of this vapor body would, of course, be to expand into the region of reduced pressure and restore it to a positive pressure.

If the combustible mixture were ignited and a flame front established defining at least part of the interface of the hypothesized regions of positive and reduced pressure, behavior of the flame according to the high speed pictures could be rationalized with the further assumption of a temperature in the combustion chamber of the furnace sufficiently high for self-ignition of combustible mixtures of oil and air.

With the foregoing assumptions as a basis for experiment, successful attempts were made according to the present invention to stabilize or hold the flame in and so eliminate pulsation noise from an oil-fired, low pressure home heating furnace by suppressing fluctuations of pressure in the region extending outwardly from the spray nozzle tip of the burner unit of this furnace within the spray cone. The nature and substance of this invention will be more clearly perceived and fully understood by referring to the following description and claims taken in connection with the accompanying drawing in which:

FIG. 1 represents a view in sectional elevation through a heating furnace showing part of the combustion chamber and a gun variety, low pressure oil burner unit, and particularly illustrating an apparatus embodiment of this invention comprising a baffle located within the oil spray cone from the burner unit, and

FIG. 2 represents an enlarged view in the same plane as FIG. 1 showing the region around the spray nozzle of the burner unit, and particularly illustrating hypothesized conditions of combustion having the characteristic of a region of sub-atmospheric pressure and fluctuating size extending outwardly from the spray nozzle tip within the oil spray cone, this region existing in the absence of utilization of the present invention.

Referring now to the drawings in detail, especially FIG. 1 thereof, 10 designates the combustion chamber space of a heating furnace. This space is bounded by a front wall 12, a back wall 14, and a bottom 16. A centrifugal blower 18 comprising a casing 20 and a rotor element 22 supplies air to the combustion chamber through a blast tube 24 penetrating front wall 12. Commercial centrifugal blowers of the type illustrated are designed to move relatively large quantities of air at relatively low pressures, pressures of about one inch of water, for example. Within blast tube 24 is a baffle element 26, between which and the inner wall of the tube an annular air passage is formed. At the outlet of this passage is a ring of turbulator vanes 28 whereby swirl is imparted to the main body of combustion air.

A pump 30 and a compressor 32 supply oil and atomizing air respectively. Pump 30 discharges through line 34 and compressor 32 through line 36, which two lines may run concentrically up to nozzle 38. The oil pump and the atomizing air compressor may be located within or without casing 20 of centrifugal blower 18 according to well known arrangements. They may, like the blower, be driven by any suitable means such as an electric motor or motors. No part of this invention resides in the design of the blower, the oil pump, or the atomizing air compressor as individual equipments, nor in their layout as an equipment assembly.

A spray of oil emanates from nozzle 38, and, after mixing with air from the blast tube, burns with a flame having a front 40 nearest the nozzle. Positioned within the oil spray cone between the tip of nozzle 38 and flame front 40 is a substantially solid baffle 42 which is supported from furnace floor 16 by a stanchion 44 of suitable heat resistant material.

Referring next to FIG. 2, 46 designates the bounding surface of the spray of oil as it emanates from nozzle 38

in the form of a conical sheet which breaks up into fine particles which in turn form a mixture 48 with air from the blast tube. Extending outwardly from the nozzle tip within oil sheet 46 and extending into the mixture 48 is a region 50 which is hypothesized to exist at sub-atmospheric pressure and to alternately expand and contract in the absence of utilization of the present invention. Accordingly, the region through which the boundaries of region 50 expand and contract constitute a region of fluctuating pressure. If region 50 be considered as shown at its maximum expansion, and to contract to substantially zero volume, then evacuated region 50 as illustrated coincides with the hypothetical region of fluctuating pressure.

The apparatus embodiment of this invention comprising baffle 42 located within the spray cone and substantially normal to the axis of the nozzle may not itself break a vacuum in region 50, but it will prevent pressure surges in mixture 48 from carrying flame front 40 back to nozzle 38. On account of its location within the oil spray cone, baffle 42 may be subject to coking. If coke does develop upon it, it should be cleaned from time to time.

Considering installation of the apparatus of this invention, baffle 42 should be set out from nozzle 38 beyond the crumbling edge of oil sheet 46, but within such distance of the nozzle that flame front 40 cannot be established between it and the nozzle. The separation of nozzle 38 and baffle 42 will depend to some extent on the diameter of the baffle, assuming it to be circular, because the baffle must not extend so far into the spray pattern as to unduly disrupt the normal flow and mixing of combustion air and particles of oil.

The data gathered in experiments employing the afore-described apparatus embodiment of this invention will now be presented. These data were obtained in the course of operating a forced warm air furnace, model WAP-72, constructed by Gilbert & Barker Manufacturing Co. This furnace was provided with a low pressure oil burner unit rated at 0.4 to 1.4 gallons of oil per hour. In all experimental runs the following conditions obtained:

Fuel: No. 2 heating oil
Fuel rate: 0.65 gal./hr. at 4.5" Hg
Furnace draft: 0.015" H₂O (above combustion chamber)
Ignition: Continuous operation
Flue gas: 12% CO₂, smoke free

Noise output of the furnace was measured and evaluated with a noise level meter and octave band analyzer whose pickup microphone was located about 3 feet out from the furnace on the burner side thereof, and about 40 inches above the floor. The centerline of the blast tube of the burner was about 8 inches above the floor.

Pulsation frequency was established at 30 cycles per second. At this frequency the normal sound pressure level (absent use of this invention) and the lowest sound pressure level obtainable using this invention were:

Baffle:	Sound pressure level ¹ at pulsation frequency (30 c.p.s.), db
Not used	92
Used	76

¹ Ref: 0.0002 microbar

A pressure level of 92 decibels at the reference indicated and 30 cycles per second is extremely annoying, while a level of 76 decibels at this reference and frequency represents about a five-fold reduction in noise and is quite satisfactory. At this level the pulsation component of furnace noise may be regarded as substantially suppressed, bearing in mind that the sound pressure levels cited are total values representative of noise of all kinds, mechanical, random flame, and pulsation. High speed pictures taken of the flame at this noise level showed it to be substantially stable.

Although this invention has been described with a certain degree of particularity, it is to be understood that the present disclosure has been made only by way of example, and that numerous changes in the details of oil

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burner unit and baffle elements and their assemblies may be resorted to without departing from the spirit and scope of this invention as set forth in the following claims which are to be construed as broadly as the state of the relevant art allows.

What is claimed is:

1. In the operation of a heating furnace including a combustion chamber and an oil burner unit directed there-into which is characterized by an oil spray cone generat-
ing nozzle and a tube surrounding said nozzle where-
through the greater amount of air for the support of
combustion is supplied, the method of decreasing pulsa-
tion noise which comprises preventing backflow of the
front of a flame ignited in said combustion chamber by
solidly baffling a substantial way but less than all the way
across the oil spray cone emanating from said nozzle, this
baffling being effected along a plane which is oriented
normally with respect to the axis of the oil spray cone and

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which is in sufficiently closely spaced relation to said nozzle that the front of a flame cannot be established be-
tween the nozzle and a baffle at this plane.

2. A method according to claim 1 carried out in a
5 heating furnace of which the burner unit consumes oil
at a rate not greater than about 1.70 gallons per hour.

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