

**Oct. 20, 1936.**

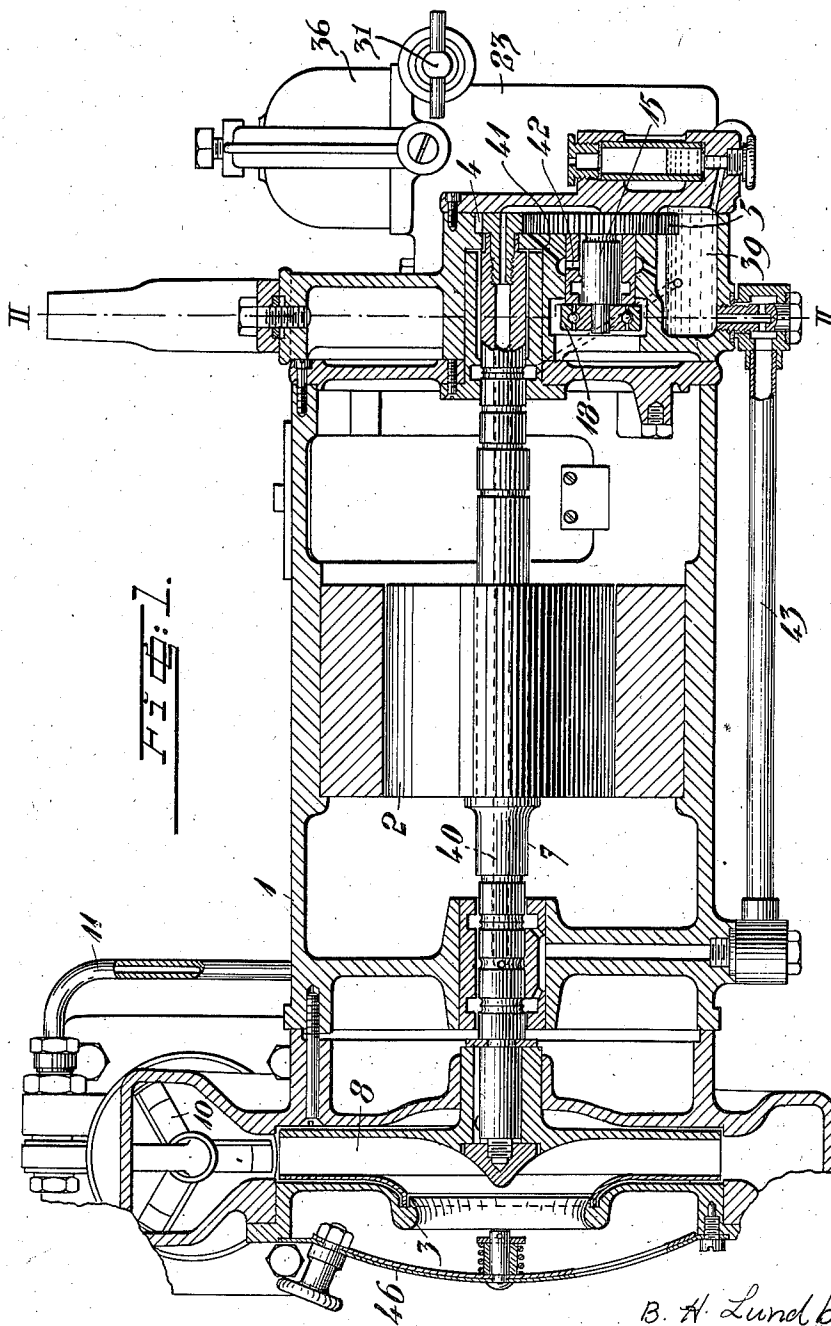
B. H. LUNDBORG ET AL

**2,058,089**

# METHOD OF BURNING LIQUID FUEL

Filed Oct. 13, 1933

3 Sheets-Sheet 1



B. A. Lundborg  
O. V. Tillberg  
INVENTORS  
By: Marko & Clerk  
Attys.

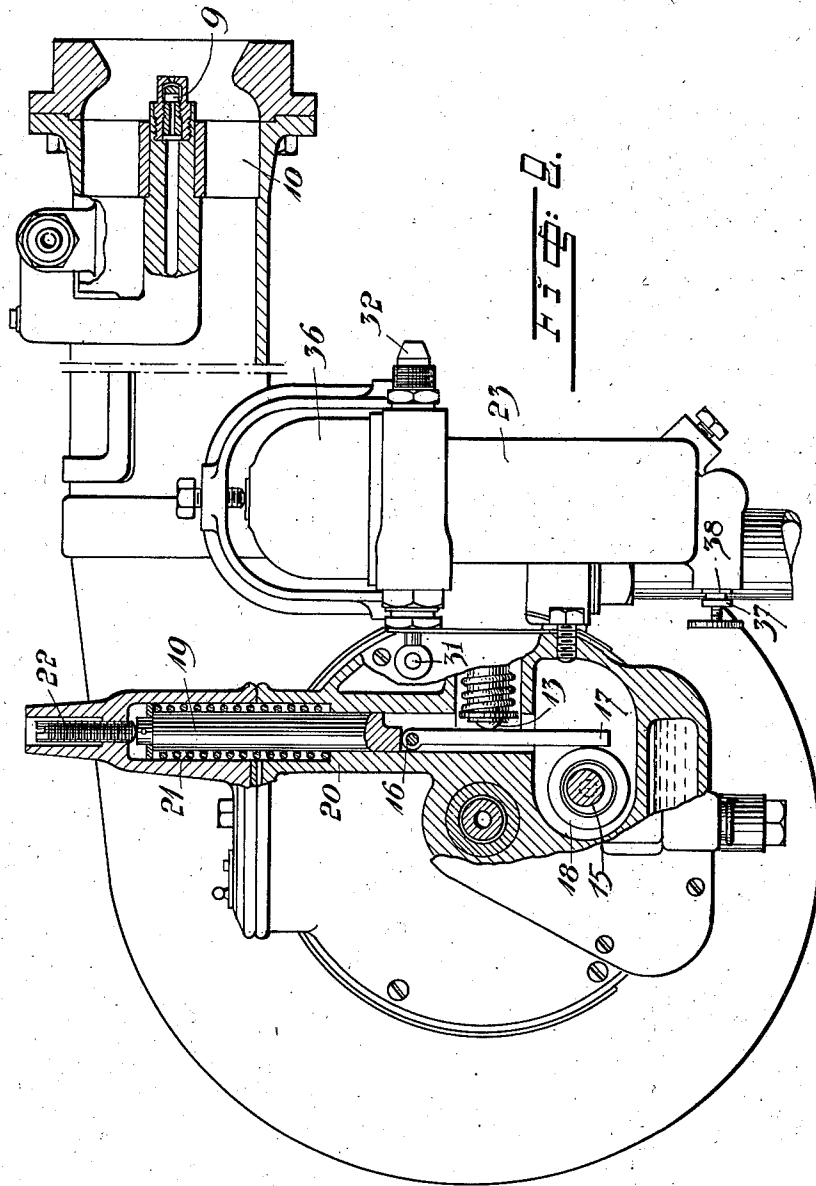
Oct. 20, 1936.

B. H. LUNDBORG ET AL  
METHOD OF BURNING LIQUID FUEL

2,058,089

Filed Oct. 13, 1933

3 Sheets-Sheet 2



B. H. Lundborg  
O. V. Gillberg  
INVENTORS

By: Marks & Clerk  
ATTYS.

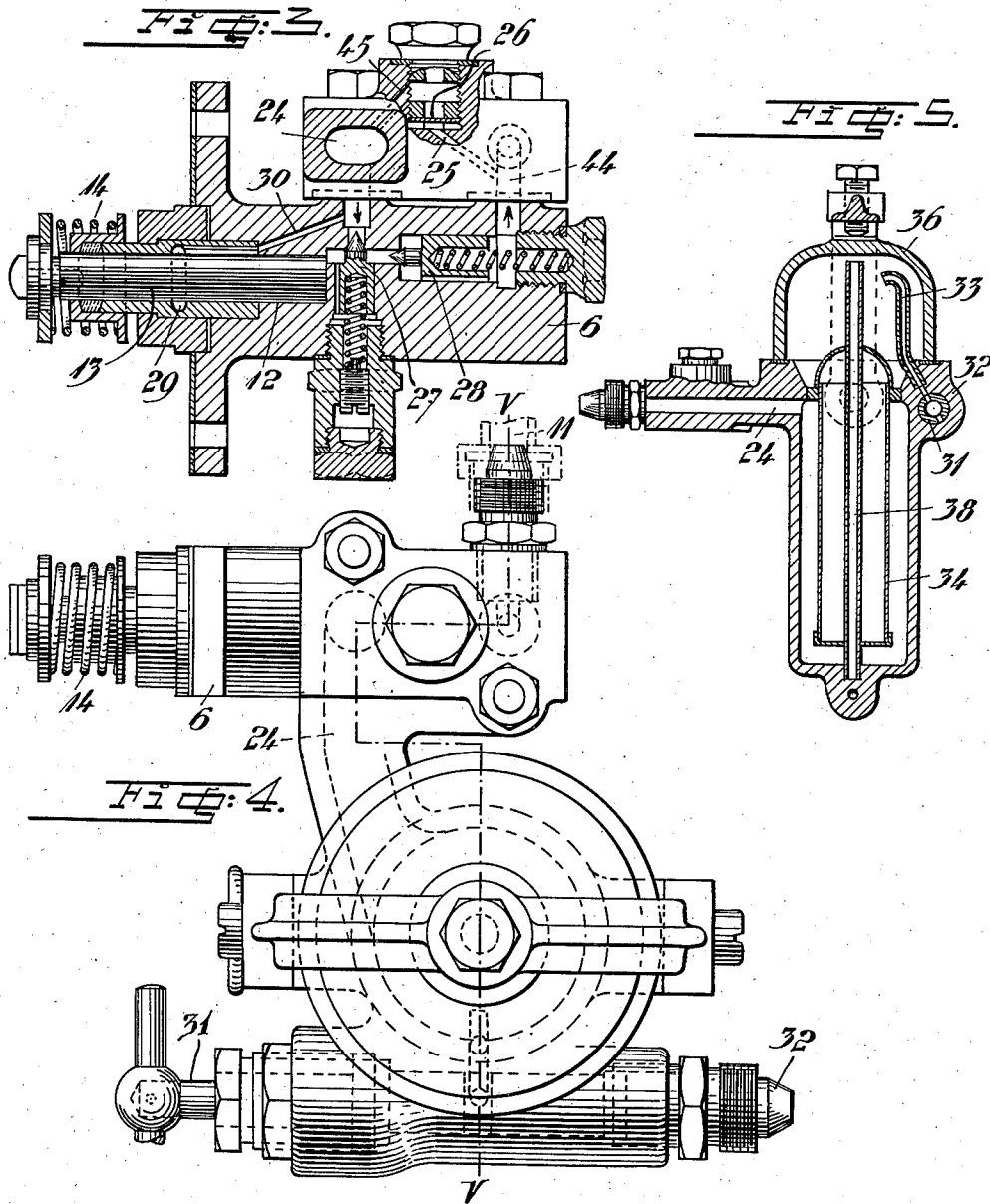
Oct. 20, 1936.

B. H. LUNDBORG ET AL  
METHOD OF BURNING LIQUID FUEL

2,058,089

Filed Oct. 13, 1933

3 Sheets-Sheet 3



B. H. Lundborg  
O. V. Tillberg  
INVENTORS

By: Marks & Clerk  
Attys.

## UNITED STATES PATENT OFFICE

2,058,089

## METHOD OF BURNING LIQUID FUEL

Bror Henning Lundborg and Olof Valfrid Tillberg, Stockholm, Sweden, assignors to Aktiebolaget Nordiska Armaturfabrikerna, Stockholm, Sweden, a limited company of Sweden

Application October 13, 1933, Serial No. 693,516  
In Sweden November 17, 1931

8 Claims. (Cl. 158—117.5)

When firing with liquid fuel at or in the neighbourhood of atmospheric pressure, the fuel was hitherto continuously fed into the furnace through suitable nozzles.

5 The spreading and mixing of the fuel with the necessary air of combustion was, as a rule, accomplished by giving the fuel a certain velocity or a rotary motion by means of a centrifugal sprayer or by use of compressed air, steam or in some  
10 other way, so as to effect a good mixture of the fuel with air before the combustion.

In such a continuous fuel supply it has, however, proved difficult to obtain a satisfactory combustion of minor fuel quantities per time unit.  
15 Smaller quantities than about 5 kg. oil per hour could not, with safety, be combusted in a reliable and regular manner, although in minor heating plants, such as central heating systems for villas and minor apartment houses, often a combustion  
20 of only 1-2 kg. oil per hour is necessary.

The present invention relates to a method of supplying the fuel, whereby a particularly wide-ranged control of the supplied quantity of fuel is made possible, and the invention is characterized by the fact that the fuel is sprayed into  
25 the combustion space intermittently or in a pulsating manner, that is in an increasing and decreasing quantity. Besides the advantage of efficient and complete combustion, the economically  
30 important advantage is gained that the fuel consumption corresponds with great accuracy to the actual need by regulating the supply, for example by changing the stroke of the pumping piston, when a supply pump is used.

35 When carrying out the method, the fuel is, without the addition of air, supplied to one or several spraying nozzles in such a way that, when leaving the nozzle, it flows in an intermittent current or in a pulsating current with great variations in quantity.  
40

To obtain perfect combustion and a fully satisfactory fire without danger of soot formation or extinguishing the fire, it is found that certain requirements and data concerning both the  
45 variations in pressure and quantity of the liquid fuel as well as the number of such variations per time unit must be observed.

By tests made accordingly it has been proved  
50 that the maximum pressure of the oil in the burner should not be less than 2 atm., and that the pressure should vary between this lowest maximum pressure and zero or substantially zero, and that the number of injections should be at least  
55 60 and preferably 100-500 per minute depending

on the viscosity of the fuel, inflammability, and velocity of flame propagation.

In minor plants working with comparatively light burning, refined oils, 4 to 10 atmospheres may be adopted as a suitable maximum pressure  
5 with 300-500 sprayings per minute.

According to the invention, however, both a higher maximum pressure and a greater number of injections per minute than the above mentioned may be used. It is, however, of importance  
10 to so adapt the number of injected charges per minute that the combustion of any one fuel charge is not wholly completed when the next charge is admitted.

When using a pulsating current with great variations it should be observed that the last mentioned object is attained in such a way that the injected quantity of fuel decreases by at least  
15 25-30% and when working with very small quantities of fuel may even decrease by 40-50% of the maximum quantity of fuel. In certain cases  
20 with small plants working with a very low fuel consumption per hour, for example oil-fired minor central heating systems for villas, it has proved convenient to work with so great variations  
25 of the injected fuel quantity as 70 to 80% and even up to 90%.

The injection of the fuel is conveniently carried out by means of an intermittently acting pump without the interconnection of any device acting  
30 as an air vessel. However, the injection may also be carried out in other ways, for example by means of a member, such as a valve, which is arranged in the spraying nozzle or the fuel supply conduit and adapted to open periodically and  
35 to close more or less.

To obtain a perfect combustion of the fuel injected from the spraying nozzle as an intermittent or pulsating current, the fuel is suitably mixed  
40 with and finely divided in a continuously admitted air current before the fuel reaches the combustion chamber.

To conduct the oil to the spraying nozzle it is suitable to use a piston pump. It is then of particularly great importance that the connecting  
45 conduits between the pump and the nozzle be as non-yielding or unelastic as possible, and it must be observed that the conduits do not contain any pockets wherein air and gases might accumulate. It has also been proved that even the smallest  
50 of such accumulations acts as an air vessel and prevents the intermittent or strongly pulsating injections from taking place.

Other characteristics of the invention will be more clearly set forth in connection with the  
55

following description of the form of the invention illustrated by way of example on the accompanying drawings. The drawings disclose a plant provided with pump, burner, air blower, electric motor and oil purifier.

Fig. 1 shows in longitudinal section an elevation of an injecting device according to the invention. Fig. 2 is an end view thereof, partly in section on the line II—II in Fig. 1. Fig. 3 shows a section on a larger scale along the same line through the pump and associated parts. Fig. 4 shows a plan view of Fig. 3, and Fig. 5 shows in elevation a section on line V—V of Fig. 4.

1 is a mantle or housing, wherein an electrical motor 2 is mounted. At one end of said housing a fan 3 is arranged, and at the other end a gearing 4, 5 for operating the fuel oil pump 6 is mounted.

The fan 3 consists of a fan wheel 8 mounted on the shaft 7 of the motor 2, whereby an air current is forced through the spiral-shaped fan housing, past the burner nozzle 9 arranged at the end thereof and surrounded by curved guides 10 for the air so that the latter is given a rotating or whirling motion to be intimately intermingled with the finely divided fuel injected by the nozzle 9. The fuel is admitted through the conduit 11 connected to the pressure side of the pump 6.

The pump itself consists of a cylinder 12 with a pump piston 13 therein. The piston is subjected to the action of a spring 14, which forces the piston to accomplish its suction stroke, whereas the pressure stroke is effected by means of a cam or eccentric disc mounted on the shaft 15 of the gear 5, said cam 18 acting on a lever 17 pivotally journaled about the pin 16. Said lever 17 bears against the back end of the pump piston 13 between the pin 16 and the point of contact of the cam 18 against the lever 17. The pin 16 is mounted on the lower end of a rod 19, which is movably arranged in a sleeve 20 and subjected to the action of a spring 21, which tends to maintain the rod 19 and, thus, the lever arm 17 in a raised position. The highest position of the rod 19 is determined by a pin 22 screwed into the upper end of the sleeve 20, which pin can be adjusted manually or by means of a thermostat or the like. The sleeve 20 is mounted perpendicularly to the pump piston and in such a position in relation to the cam 18 that the lever arm 17, when swung to the position farthest away from the shaft 15, is perpendicular to the longitudinal axis of the pump piston.

By this device the pump piston, in all the control positions of the rod 19, is in a fully inserted position, whereby with safety any air present is driven out and a regular suction of the fuel is insured. The fuel is sucked from the oil-purifier 23 through the conduit 24 and is forced into the conduit 44, which is connected to the conduit 11 leading to the burner nozzle 9, and to the conduit 25, which latter conduit is closed off by means of a bursting washer 26 and on the other side thereof, communicates with the suction conduit 24 by means of a channel 45 or with the open air or directly with the fuel container. By this arrangement the bursting of the conduit 11 is prevented in case the nozzle 9 should be filled up. The bursting washer must be practically non-yielding, if the intermittent feeding of the fuel through the nozzle is to be maintained. The washer is therefore made with a very small diameter, for example 4–5 mm. 27 and 28 are the

suction and exhaust valves respectively of the pump. To prevent leakage of fuel oil past the pump piston 13, the pump cylinder 12 is provided with an annular channel 29 about its central portion. This annular channel 29 communicates with the suction conduit 24 through an additional channel 30.

The fuel supply to the oil purifier is effected through a supply conduit 32 provided with a closing cock 31. The oil is admitted into the purifier at the top through the conduit 33 and passes thence through the filter 34 to the conduit 24, which forms the suction conduit of the pump. In the upper portion of the oil-purifier covered by a glass hood 36, any air present in the oil is separated off, and this air is removed through the conduit 38 provided with a closing cock 37.

For the lubrication of the various bearings the gearing 4, 5 in the illustrated example is used as a gear driven pump, which obtains lubricating oil out of the well 39 and forces this through an axial boring 40 in the shaft 7, the bearings of the same and also through the channels 41 and 42 to the shaft 15. 43 is a return conduit from the left bearing of the shaft 7 to the well 39.

In a pumping plant of the present kind it is to be noted that even apparently insignificant resiliency in the conduit may upset the intended result. This is clearly the case where we consider piston strokes of a length of only 0.2–5 mm. and a piston diameter of 6–10 mm.

The fuel injecting nozzle should be of such a character that the fuel is very finely divided when injected into the furnace. To make the division more or less fine, the nozzle may be controlled for example by means of a displaceable rod screwed thereto and connected with a sprayer body.

It is not necessary that the air be supplied by means of a fan or compressor as illustrated. The air necessary for the combustion may be admitted into the combustion chamber by a natural draught. The advantages connected with the intermittent or pulsating fuel supply are maintained also in such a supply of the air of combustion.

The method and means according to the invention may, of course, be used in connection with the now common automatic devices for igniting and extinguishing under control of one or several thermostats, which are influenced by the pressure or the temperature in the boiler or the temperature in the fire-place etc. At the point of control of the fuel supply, a regulation of the air of combustion should also take place. For this purpose one may in the illustrated arrangement cover the suction opening of the fan by a rotatable valve 46 of a known character. As previously stated the pin 22 may be controlled by a thermostat and when this is the case the same thermostat may control the adjustment of the valve 46 or an additional thermostat may be used for the latter purpose.

Having now particularly described the nature of our invention and the manner of its operation, what we claim is:

1. The method of combusting liquid fuel in the combustion chamber of a furnace at substantially atmospheric pressure which includes the steps of injecting the fuel into the combustion chamber in a pulsating current, mixing air therewith and igniting said mixture and varying the quantity of fuel in said current per time

unit, the current attaining its maximum from 100 to 500 times, per minute.

2. The method of burning liquid fuel in the combustion chamber of a furnace which comprises spraying a current of fuel into the chamber at a maximum pressure of 4 to 10 atmospheres, mixing air with said fuel, igniting said mixture and varying said current from substantially 10% of its maximum to a maximum and vice versa from 300 to 500 times per minute.

3. The method as claimed in claim 2, in which the air is supplied in a continuous current which moves with the fuel into the combustion chamber.

4. The method of burning liquid fuel in the combustion chamber of a furnace which comprises injecting the fuel in a current of constantly fluctuating content, mixing air with said fuel and igniting the mixture in the combustion chamber.

5. The method as claimed in claim 4 in which an increasing part of the fuel current reaches the combustion chamber and mixes with air for combustion while a decreasing part of the fuel current is still burning.

6. The process of burning liquid fuel in the combustion chamber of a furnace which com-

prises the steps of forcing the fuel as a spray into the chamber, varying the flow of the fuel from a minimum to a maximum a number of times of the order of 100 to 500 per minute, mixing air with said fuel and igniting said fuel in said combustion chamber.

7. The process of burning liquid fuel in a furnace which comprises passing a continuous current of air into the furnace, spraying a current of fuel into said current of air, mixing air with said fuel, igniting said mixture, varying said current of fuel in the range of  $\frac{1}{2}$  kg. of the liquid fuel per hour, to 5 kg. of said fuel per hour, said variations taking place at the rate of 100 to 500 per minute.

8. A method of burning liquid fuel in a combustion chamber which comprises flowing a current of air into the combustion chamber, impregnating said current with a spray of liquid fuel, igniting said mixture, and varying the quantity of fuel sprayed from a maximum to a minimum of from 10 to 75% of said maximum, said variations being continuous and at the rate of from 100 to 500 per minute.

BROR HENNING LUNDBORG.  
OLOF VALFRID TILLBERG.