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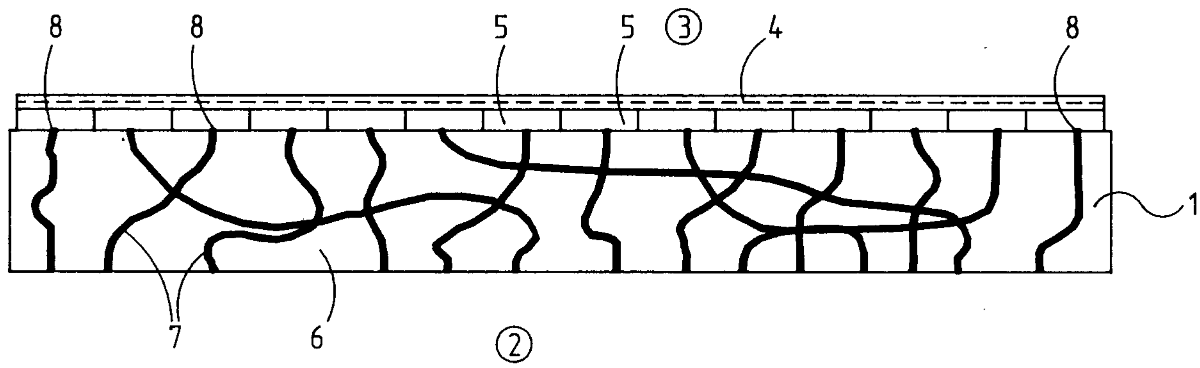
(71) Applicant: **N.V. NEDERLANDSE GASUNIE**
Postbus 19
NL-9700 MA Groningen (NL)

(72) Inventor: **Aptroot, Rob**
Langestraat 46
NL-9804 PL Noordhorn (NL)

(74) Representative: **Krijgsman, Willem et al**
Octrooibureau DSM,
P.O. Box 9
NL-6160 MA Geleen (NL)

(54) Burner for gaseous fuel.

(57) Burner for gaseous fuel with adjustable fuel flow, comprising a mixing chamber (2) for mixing the fuel with an oxidation gas, a combustion chamber (3) for burning the gas mixture formed in the mixing chamber and a dividing wall (1) between mixing chamber and combustion chamber, the said dividing wall being provided with a burner deck (4) and with throughgoing channels (7) for conveyance of the gas mixture from the mixing chamber to the burner deck, wherein the channels all begin in one and the same plane on the side of the dividing wall which faces the mixing chamber and end in one and the same plane on the side of the dividing wall which faces the combustion chamber, each channel having a travel time for sound waves and there being at least one channel with a shortest travel time and at least one channel with a longest travel time different from the shortest travel time, the travel times being spread between the longest and the shortest travel time.



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The invention relates to a burner for gaseous fuel with adjustable fuel flow, comprising a mixing chamber for mixing the fuel with an oxidation gas, a combustion chamber for burning the gas mixture formed in the mixing chamber and a dividing wall between mixing chamber and combustion chamber, the said dividing wall being provided with a burner deck and with throughgoing channels for conveyance of the gas mixture from the mixing chamber to the burner deck.

The burning of the gas mixture causes acoustic vibrations, which, in the case of the customary burner designs, are amplified and can lead to resonance in the burner system. From DE-A-4014217 a burner of the type described in the opening paragraph is known in which means are used to avoid resonance of the burner. The occurrence of resonance is avoided by ensuring that the frequencies at which individual flames of the burner can resonate are different. In particular this is achieved by placing the flow openings in an irregular pattern or by providing the openings with a collar having different dimensions.

The flames on the various openings thus have not only their own resonance frequency but also their own combustion behaviour.

Consequently, when the burner is modulated, some parts of the burner will already be able to enter the optimum range whilst other parts have not yet done so. This can restrict the modulation depth of the burner to an undesirable degree.

The object of the invention is to provide a burner of the type specified in the opening paragraph in which these disadvantages are avoided.

This object is achieved according to the invention in that the channels all begin in one and the same plane on the side of the dividing wall which faces the mixing chamber and end in one and the same plane on the side of the dividing wall which faces the combustion chamber, each channel having a travel time for sound waves and there being at least one channel with a shortest travel time and at least one channel with a longest travel time different from the shortest travel time, the travel times being spread between the longest and the shortest travel time.

The differences in travel time result in phase differences in the resonances in the individual channels. These mutual phase differences prevent positive interference between the resonances of the individual channels and destructive interference even occurs with the result that the resonances damp each other. This provides a considerable reduction in the noise level generated in the burner. This favourable effect occurs regardless of the gas flowrate through the channels, so that the cross-section of the channels can be freely chosen, which is advantageous because the distribution of the flow across the burner can thus be optimized.

Uniformly spread differences should be understood to mean that the travel times in the range between the longest and the shortest travel time are distributed in such a way that the interval between one travel time and the next longer travel time is the same or virtually the same, within, for instance, 10%, over the entire range. This is particularly important when only a small number of channels, for instance up to 15, are present in the burner. In the case of larger numbers, for instance upwards of 20, the spread of the travel times in the range mentioned may be chosen randomly. Statistically, with such numbers the dampening effect may be expected to correspond with that of a uniform distribution. With these numbers it is also acceptable that several channels in the burner have the same travel time.

The above is meant to adequately ensure that for each generated sound wave exiting with a particular phase from one of the flow openings a corresponding wave in the opposite phase is generated. For this to be achieved it is sufficient when the difference between the longest and the shortest travel time is at least approximately equal to one period of the wave in question. It should be noted here that differences in travel time of an integer number of periods do not influence the phase of the wave at the flow opening. Consequently the required uniformity of the spread in travel times should also be assessed in terms of the travel times after these have been reduced to the range between 0 and 1 period by subtracting the largest possible number of whole periods from the actual travel time.

It is advantageous from an engineering and construction point of view for the channels all to begin in one plane and also to end in one plane so that the differences in travel time are only introduced in the channels themselves.

It is known from WO-A-92/17737 to apply channels of different lengths by varying the thickness of the dividing wall. However, these differences in length do not introduce any differences in travel time for sound waves. This is because, as far as the travel time of sound waves is concerned, it makes no difference whether the waves travel through a channel or travel a certain distance through an open space if that distance is equal to the length of the section cut off from that channel by a recess in the dividing wall, as is the case in the design in WO-A-92/17737.

The principle of the invention can also be applied in a burner of this type, in which the thickness of the dividing wall varies. Care should then be taken to ensure that the differences in travel time between the channels do not coincide with the differences in travel time directly resulting from the

differences in length resulting from the variations in wall thickness. This cannot be accomplished with straight, throughgoing open channels.
From US-A-4.737.102 it is known to apply channels of different diameters. This does not introduce any differences in travel time for sound waves but merely differences in resistance to the combustion mixture flowing through them. This causes flames of different sizes to form on the burner deck. Since flames of different sizes induce different frequencies, resonance of the burner can be prevented in this way, too. A disadvantage of such a design, however, is that optimum differences in frequency can be attained only in a narrow modulation range. When the burner is turned up or down, the differences in flame size, and so the differences in the frequencies generated, become smaller, resulting in a risk of resonance. This same principle is applied as an alternative in WO-A-92/17737, again in combination with a varying thickness of the dividing wall. In that case, too, no differences in travel time for sound waves are introduced.

Other characteristics and advantages of the invention will become clear from the following description, reference being made to the appended sheet of drawings. On this, Fig.1 schematically shows a cross-sect ion of a dividing wall between a mixing chamber and a combustion chamber according to the invention.

Figure 1 shows a dividing wall 1 that can be used between a mixing chamber, schematically indicated by 2, and a combustion chamber, schematically indicated by 3. Viewed from the combustion chamber in the direction of the mixing chamber, the dividing wall comprises in succession a burner deck 4 in which a large number of small holes are provided, on which the actual combustion takes place, a number of compartments 5 located next to each other, which each supply some of the holes in the burner deck with the gas mixture to be burned and between which there is no pressure differential, and a layer of filling material 6. The burner deck 4 covers the compartments 5 at the side of the combustion chamber.
In the burner deck, any known burner deck material can in principle be used, so long as a seal is provided between the burner deck and the compartments so that the gas mixture can only enter the combustion chamber through the holes in the burner deck.
Each of the compartments 5 is connected to the mixing chamber 2 via at least one channel 7 which runs through the filling material 6 and comes out in the compartment in a flow opening 8. All the channels should end in the same plane at the side of the mixing chamber 2. The channels can be designed as preferably tubular voids in the filling material if the latter is a dimensionally stable material, for example a ceramic material or gypsum. The channels may also be designed as, for example, small metal tubes with which air can then also be used as the filling material in addition to the materials noted above.
The differences in travel time for sound waves are mainly introduced through differences in path length for the gas mixture in the individual channels from the mixing chamber to the combustion chamber. These path length differences can be introduced by suitably choosing the geometry of the channels. In the simplest embodiment the individual channels have a different length, with both straight and curved channels being possible. Differences in path length can also be introduced by providing baffles in the channels in staggered fashion on opposite walls, so that the gas mixture is forced to flow in a zig-zag pattern. By varying the number and the size of the baffles for the individual channels, the desired differences in travel time can be achieved even if the channels are of equal length. In a further embodiment the channels are provided with baffles in a labyrinthine pattern. In a further suitable embodiment all of the filling material and channels consist of a porous material, in which the channels are formed by the pores in that material. By providing local differences in the number, size and shape of pores, the travel time of the gas mixture across the burner surface can be varied.

In the embodiment shown in figure 1 the channels differ in length and are curved in different ways. In this case all flow openings may be of the same size, so that differences in combustion behaviour are prevented. The minimum difference in path length between the longest and the shortest channel is determined by the frequency to be suppressed, with which the desired phase shift must be able to occur. The abovementioned frequency is dependent on the dimensions of the burner and the composition of the gas mixture and can easily be determined experimentally by conducting noise measurements on an operational burner in which no differences in the travel time for sound waves have been introduced, for example simply by placing a burner deck between a mixing chamber and a combustion chamber. It is noted that the size of the combustion chamber has little or no influence on the value of the resonance frequency. With most commonly used burners the resonance frequency for the relevant exciting mechanism, namely the combustion of the gas mixture, lies between 300 and 1600 Hz.

Preferably all phases occur between 0 and 2π.In that case, for a wave with any random phase, a wave in the opposite phase is also present, so that the two waves cancel each other out to a greater or lesser extent depending on their amplitude. The abovementioned minimum difference in path length should for that purpose be at least 1 wavelength. Preferably the differences in path length of the other channels with respect to the shortest channel are evenly spread between 0 and the difference in length between the longest and the shortest channel. The phase differences are then also evenly spread and maximum destructive interference occurs, thereby causing maximum damping of the possible resonance.

Surprisingly it has been found that in a burner in which the greatest difference in length between the shortest and longest channel is approximately 1/2 of a wavelength or even less, almost complete damping of the resonance takes place, despite the fact that in that case at least half of all possible phases between 0 and 2π is missing. For frequencies of approximately 1000 Hz, for instance, a maximum difference in length of approximately 12-16 cm has been found to be satisfactory for a reduction of the noise level of the resonance by at least 30 dB. If this maximum difference in length is too small, particularly smaller than 1/4 of a wavelength, the desired damping phenomena will only occur to an unsatisfactory degree. For this reason, the difference in length between the channel with the longest travel time and the channel with the shortest travel time is between 1/4 and 1/2 of a wavelength of a sound wave of the frequency to be suppressed.

It is of particular importance that the resistance to flow offered by the different channels to the gas mixture to be burned is substantially the same. This can be accomplished by compensating for the resistance differences brought about by the differences in path length for the gas mixture in the different channels, by making the channel dimensions other than those which influence the abovementioned path length different for the different channels. Preferably the cross-section of the channels is made different for this purpose. If required this cross-section can vary for each channel over the length of that channel.

The invention will be explained on the basis of the following example.

<u>Example I</u>

A burner of the type shown in Figure 1, in which the burner deck is 1 cm thick and which has approximately 100 flow openings, which together make up 20 % of the surface of the burner deck but in which the channels and the filling material are missing, is installed between a combustion chamber and a mixing chamber having a depth of 5 cm. The obtained burner system is used for the combustion of a natural gas-air mixture. The sound spectrum on the outside wall is measured. This spectrum exhibits a peak at approximately 1050 Hz. The corresponding wavelength for sound waves is 32.3 cm. The noise level, measured on the outside wall of the combustion chamber, is 100 dB.

The described burner is modified to provide a burner according to the invention by installing between the burner deck and the mixing chamber a separating layer consisting of a layer of 4 cm, in which 10 aluminium tubes run, each coming out into a flow opening. The layer of air is separated from the mixing chamber in a gas-tight arrangement by means of an aluminium plate into which the channels run, so that the natural gas - air mixture can only reach the burner deck via the channels.

The difference between the shortest and the longest channel is 13 cm, which corresponds with 0.4 times the wavelength. The lengths of the other channels are between that of the shortest and the longest channel, with the difference in length between each channel and the next-higher in length being on average 1.3 cm. When the abovementioned natural gas - air mixture is burned in the same conditions as with the non-modified burner, the noise level is 40 dB. This corresponds with a reduction in noise level of 60 dB, as a result of the presence of the channels with different travel times for sound waves in the burner.

Claims

1. Burner for gaseous fuel with adjustable fuel flow, comprising a mixing chamber for mixing the fuel with an oxidation gas, a combustion chamber for burning the gas mixture formed in the mixing chamber and a dividing wall between mixing chamber and combustion chamber, the said dividing wall being provided with a burner deck and with throughgoing channels for conveyance of the gas mixture from the mixing chamber to the burner deck, characterized in that the channels all begin in one and the same plane on the side of the dividing wall which faces the mixing chamber and end in one and the same plane on the side of the dividing wall which faces the combustion chamber, each channel having a travel time for sound waves and there being at least one channel with a shortest travel time and at least one channel with a longest travel time different from the shortest travel time, the travel times being spread between the longest and the shortest travel time.

2. Burner according to claim 1 in which the travel times are spread uniformly or randomly between the longest and the shortest travel time.

3. Burner according to claim 2 in which the difference between the longest and the shortest travel time at least approximately corresponds with one period of a resonating sound wave generated in the burner.

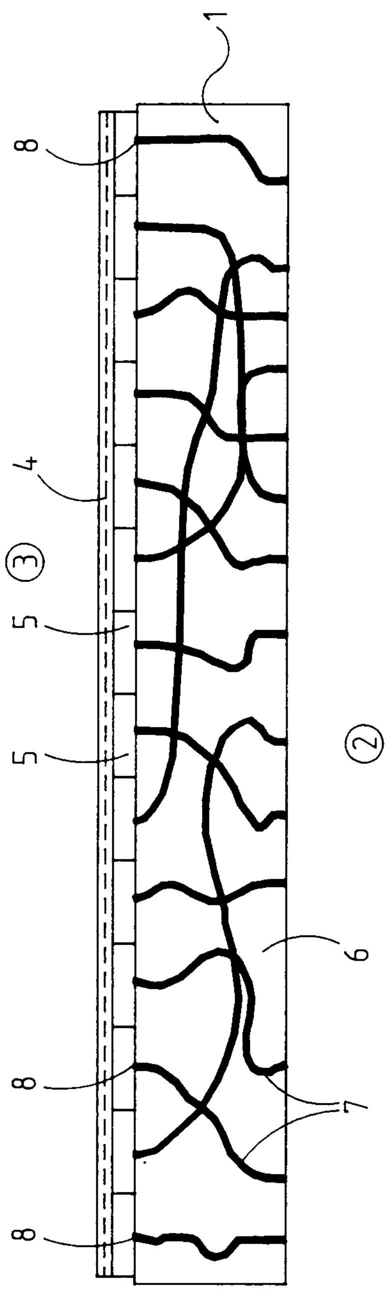
4. Burner according to claim 1, in which channels have different lengths to cause their difference in travel times.

5. Burner according to claim 2, with the difference in length between the channel with the longest travel time and the channel with the shortest travel time being between 1/4 and 1/2 of the wavelength of a sound wave generated in the burner.

6. Burner according to any one of claims 1-3, characterized in that channels that differ in length also differ in cross-section.

7. Burner according to any one of claims 1-4, characterized in that the channels have a cross-section which varies over their length.

8. Burner as substantially described and elucidated by the examples and the drawing.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EUROPEAN SEARCH REPORT

Application Number
EP 94 20 3048

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y,D	WO-A-92 17737 (KRIEGER) * page 2, line 19 - page 3, line 14 * * page 3, line 23 - page 3, line 28 * * page 11; claims 1,2 * * page 12; claims 5,6 * * figures 1-7 * ---	1,4,7	F23D14/58 F23D14/46
Y	PATENT ABSTRACTS OF JAPAN vol. 14, no. 91 (M-0938) 20 February 1990 & JP-A-01 302 020 (MATSUSHITA ELECTRIC) 6 December 1989 * abstract * ---	1,4,7	
A,D	US-A-4 737 102 (JINNO) * column 4, line 54 - column 4, line 68 * * figure 6 * ---	1,6	
A	DE-C-42 02 588 (BUDERUS HEIZTECHNIK) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F23D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 February 1995	Phoa, Y

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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