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(54) Combustion apparatus incorporating a noise reduction arrangement

(57) A combustion apparatus such as a boiler comprises a standing wave arm (15, 15') for establishing a standing wave connected to a flue gas outlet (14) of a burner (10) of the device. A gas flue outlet system (17) is connected to the standing wave arm at the zero pressure point or mid-point (16) of the standing wave. The standing wave arm (15, 15') is configured to generate a standing wave in proportion to one half of the wavelength of a resonant frequency to be attenuated.

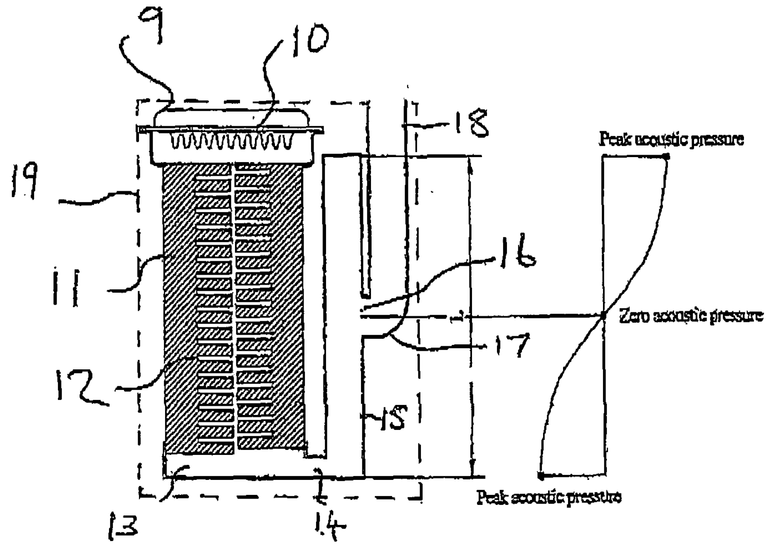

Fig. 1

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Description

[0001] This invention relates to noise reduction in combustion apparatus, such as the flue and associated parts of a gas fired water heating apparatus.

[0002] Noise is produced in combustion systems, such as gas fired boilers, due to resonance of oscillations set up in the gas stream and associated components that share a natural frequency or its harmonics, and consequent vibration of ducting and other parts as well as the directly generated sound.

[0003] Efforts in the art to reduce noise have concentrated upon absorption of generated sound, or the provision of baffle systems to break up the resonant gas column. In JP2003166689 (Tokyo Gas) a standing wave is established by locating a buffer tank in an exhaust pipe, and a plurality of branch pipes are connected to the main pipe, each branch pipe having a different resonant frequency, and spaced by respective distances from the baffle tank related to their respective resonant frequencies. This has the effect of creating interference which suppresses the wave, and thus reducing the noise level.

[0004] Such a device, using a plurality of frequencies is relatively complex, and an object of the invention is to provide a noise reduction arrangement which is simple in construction but nevertheless effective.

[0005] In accordance with a first aspect of the invention, there is provided a combustion apparatus incorporating a noise reduction arrangement, the apparatus comprising a burner and a standing wave arm for establishing a standing wave connected to a flue gas outlet of the burner, characterised in that a flue gas outlet system is connected to the standing wave arm at a mid-point of the standing wave.

[0006] The standing wave arm may be configured to generate a standing wave in proportion to one half of the wavelength of a resonant frequency to be attenuated. The standing wave arm may be configured to generate a standing wave that is substantially equal to one half of the wavelength of the resonant frequency to be attenuated or it may be configured to generate a standing wave that approximates sufficiently closely to one half of the wavelength of the resonant frequency to be attenuated as required to achieve an acceptable level of attenuation in a given application. The flue gas outlet may be fluidly connected with the standing wave arm at one end of the arm or it may be fluidly connected with the standing wave arm at a position between the ends of the arm.

[0007] The standing wave arm may comprise a column. The length of the column may be adjustable. The column may be aligned generally upright and a condensate drain may be provided at a lower end of the column.

[0008] The flue gas outlet system may be orthogonally connected with the standing arm at the mid-point of the standing wave leading to a flue outlet. The configuration of the flue gas outlet system may be as desired and have such other features as may be required to achieve other objectives, such as prevention of rainwater entry, condensation traps, and cleansing the outlet gas of noxious or environmentally damaging components.

[0009] The burner may be a dual port burner.

[0010] The apparatus may comprise a gas boiler including the burner, a heat exchanger and a sump. In which case, the flue gas outlet may be taken from the sump of the boiler.

[0011] The apparatus may also include a Helmholtz resonator. Where the apparatus comprises a boiler having the burner, a heat exchanger and a sump, the Helmholtz resonator may be mounted to the sump of the boiler, integrated into the standing wave arm or elsewhere in the flue system. The Helmholtz resonator may be configured to attenuate a first resonant frequency and the standing wave arm may be configured to generate a standing wave in proportion to one half of the wavelength of second resonant frequency. The standing wave arm may be configured to generate a standing wave that is substantially equal to one half of the wavelength of the second resonant frequency to be attenuated or it may be configured to generate a standing wave that approximates sufficiently closely to one half of the wavelength of the second resonant frequency to be attenuated as required to achieve an acceptable level of attenuation in a given application.

[0012] In accordance with a further aspect of the invention, there is provided a combustion apparatus noise reduction device comprising a flue conduit connected to a flue gas outlet of a burner, comprising means for establishing a standing wave in the flue conduit, including a standing wave arm and a section of the flue conduit, the arm and the said section of the flue conduit defining a half-wavelength standing wave of the resonant frequency concerned, and the conduit having a connection to a gas outlet from the zero pressure point (mid point) of the standing wave.

[0013] Preferred embodiments of the invention are illustrated by way of example only with reference to the accompanying drawings, in which;

Figure 1 is a schematic diagram showing a burner and flue system according to a first embodiment of the invention; and

Figure 2 is a schematic diagram showing a burner and flue system according to a second embodiment of the invention

[0014] As shown in Figure 1, a heating installation comprises a boiler 9 having a gas burner 10 and a heat exchanger 11. The heat exchanger has one or more gas passages 12 through which combustion or flue gas is passed from the burner into a sump 13 at the base of the heater exchanger stack. The heat exchanger stack may also have features to aid heat transfer from the gas passing through the one or more passages 12 such as pins or fins as is known in the art. The flue gas exits the sump via a burner gas outlet 14.

[0015] From the outlet 14, the flue gas enters a generally vertical column 15 which is closed at its upper end and which forms a standing wave arm. At a mid-point 16 of the column, a horizontal connection is made to a gas flue outlet system 17, which in the present embodiment includes a conduit forming a vertical flue section 18.

[0016] The apparatus as so far described is typically provided as a boiler unit encased in an outer casing, indicated schematically by dashed lines 19. The upper end of vertical flue section 18 is provided with a connector (not shown) for connection with an external flue conduit system (also not shown) to lead the flue gas to an external outlet in a known manner. The external flue conduit system may extend vertically or horizontally, or indeed in any other direction, from the end of the vertical flue section 18 depending on the requirements of the installation. The gas flue outlet system 17 and/or the external flue conduit system may be outfitted as necessary with any cowls, gas cleansing devices or the like required for efficiency or effectiveness or to comply with local environmental regulations or laws. It should also be appreciated that the gas flue outlet system 17 may take other forms than that shown in the illustrated embodiment depending on the application requirements, provided that it is connected with the standing wave arm at the mid-point of the standing wave as discussed below.

[0017] The standing wave arm 15 is configured to generate a standing wave in the column. The flue gas outlet system 17 is connected to the standing wave arm 15 at the mid-point 16 of the standing wave where the acoustic pressure is substantially zero (see the graph to the right of the Figure 1). The standing wave arm 15 is filled with flue gas, of which that which is in the upper half above is effectively trapped, and the main flow of gas into the flue gas outlet system 17 is taken off at 16 at the zero acoustic pressure point, so that the gas entering the flue gas outlet system 17 has zero, or very little acoustic energy and so generates only a low level of noise. This arrangement operates to reduce noise levels by acoustically decoupling the flue gas outlet system 17 from the burner, which is typically the source of resonance in a combustion system. This accordingly leads to quieter gas heating installations, and reduced noise pollution.

[0018] Combustion systems generate noise at particular resonant frequencies and the standing wave arm 15 is configured to attenuate a particular resonant frequency of the system. Ideally the standing wave arm 15 is configured to generate a standing wave which is one half the wavelength of the resonant frequency to be attenuated and accordingly will have a length L which is one half the wavelength of the resonant frequency. The wavelength A of the resonant frequency in the flue gas is given by the following equation:

$$1)\ \lambda = C/f$$

Where:

C = speed of sound in the flue gas at a typical operating temperature, and

f = frequency of resonance.

Thus the theoretical length L of the standing wave arm for maximum attenuation is given by the following equation:

$$2)\qquad L = \lambda/2$$

[0019] However, there is increasing pressure to reduce the size of boiler units and in practice a standing wave arm 15 having a length L which is equal to one half the wavelength of the resonant frequency may be too long to incorporate in a commercially viable boiler unit. Nevertheless, significant benefits can still be obtained by using a standing wave arm 15 having a length L which is less than one half the wavelength A of the resonant frequency and a certain amount of compromise is required to achieve acceptable levels of attenuation whilst meeting packaging requirements in terms of the overall size of the boiler unit.

[0020] In one example which has been tested by the applicant, a boiler system had a resonant frequency f of 320 Hz and the speed of sound C in the flues gas at an operating temperature of 80° Celsius was 380 m/s. Applying equation 1 above, the wavelength A of the resonate frequency is = 1188 mm and by applying equation 2, the theoretical length L of the standing wave arm to produce a standing wave which is one half the wavelength of resonance is 594mm. In tests, when the above boiler system was used with a standing wave arm having a length L of 594mm, an excellent level of attenuation was found to be achieved. The system was also found to be tolerant to variations in the gas/air mixture in the burner such that the products of combustion in the flue gas could vary in excess of +/- 2% CO_2 without any significant resonance problems. However, due to space constraints, a standing wave arm 15 having a length of 594 mm was not viable in a commercial embodiment of the boiler and a standing wave arm having a length of 460mm was adopted. The shorter standing wave arm was found to provide satisfactorily levels of attenuation but with a reduced tolerance to variations in the gas/air ratio such that a maximum difference of +/- 1% CO_2 in the products of combustion could be accommodated. This was deemed to be acceptable in the particular application.

[0021] Whilst significant benefits can be obtained using a standing wave arm 15 having a length which is shorter than the theoretical length L required to produce a standing wave equal to one half of the resonant frequency, it will be appreciated that performance is enhanced if the standing wave arm has a length which approximates as closely as is possible to the theoretical length L. Other factors may also affect the level of resonance attenuation and it will also be appreciated that a certain amount of empirical investigation may be required to achieve an acceptable level of attenuation for any particular application.

[0022] In the arrangement shown in Figure 1, the gas leaving the sump 13 enters the standing wave arm 15 through its lower end. However, as illustrated in Figure 2, the standing wave arm 15' can be offset downwardly relative to outlet 14 from the sump so that the flue gas enters the standing wave arm 15' through the side of the arm 15' at a position between its ends. This may be advantageous in allowing the use of a standing wave arm 15' which is longer than could otherwise be accommodated in a given size of casing. The amount X by which the standing arm 15' is offset is selected in accordance with requirements but generally should be kept to a minimum. In tests, offsetting the standing wave arm in this way has been found to have no noticeable detrimental effect on the operation of the system in attenuating a resonant frequency.

[0023] In the arrangement shown in Figure 2, condensate may collect in the region of the arm 15' below the outlet 14 from the boiler. The build up of condensate in the column will alter the effective length of the column of gas and so vary the standing wave. To prevent this problem, a condensate drain 20 is provided in the base of the standing wave arm 15'. A similar drain can also be provided in the base of the standing wave arm 15 in the arrangement shown in Figure 1.

[0024] In an alternative arrangement (not shown) the standing wave arm may be curved or S shaped to enable it to be fitted within a desired casing size.

[0025] The use of a standing wave arm as described above can be combined with other arrangements for reducing resonance. For example, the burner may be a dual port burner in which the flame area is divided into regions of different flame size. This avoids a single common frequency and significantly reduces the intensity of the resonance.

[0026] A Helmholtz resonator can also be used in conjunction with a standing wave arm to attenuate resonant frequencies in a combustion system. A Helmholtz resonator comprises a closed chamber having a narrow opening and can be used to attenuate a resonant frequency by allowing the flue gas to oscillate against the closed chamber, with the volume in the chamber acting like a spring to absorb the energy of resonance. In Figure 2, a Helmholtz resonator 21 is shown mounted to the boiler 9. The resonator 21 comprises a body 22 defining a chamber 23 and having an open neck region 24 which is in fluid connection with the flue gas in the sump 13. The resonator 21 in this case is connected with a side wall of the sump 13 and has the neck region 24 located towards a lower edge of the chamber so that condensate can drain out of the resonator into the sump.

[0027] Where a Helmholtz resonator is used in conjunction with a standing wave arm arrangement as described above, the resonator is typically designed to attenuate one resonant frequency whilst the standing wave arm is configured to attenuate a second and usually a more significant resonant frequency. In the previously discussed example in which the boiler has a dual port burner, a first resonant frequency of about 420hz occurred for a few seconds after ignition and a second frequency of about 320Hz occurred as the boiler modulated towards a maximum rate. In this case, the Helmholtz resonator 21 can be configured to attenuate the 420Hz frequency whilst the standing wave arm 15' is configured to attenuate the 320Hz frequency.

[0028] The use of a Helmholtz resonator may have an impact on the operation of the standing wave arm and may also require the geometry of the standing wave arm to be varied somewhat from its theoretical requirements in order to achieve acceptable levels of attenuation. For example, in the arrangement described above in which the standing wave arm 15' is used to attenuate the 320Hz frequency, a standing wave arm 15' having a length L of about 460mm and a diameter of 55 mm was used.

[0029] Although it is convenient to mount a Helmholtz resonator 21 to the sump, this is not essential. A Helmholtz resonator 21 can be integrated at any point in the flue or exhaust gas system and could be integrated into a standing wave arm 15, 15', for example.

[0030] The attached drawings are diagrammatic only, and the type and nature of the burner and heat exchanger or boiler installation may be any required, and also the disposition of the flue gas outlet may be varied as needs be. The standing wave arm 15, 15' may be in any orientation suitable, such as horizontal. The standing wave arm may also be made to be variable in length, e.g. comprising telescopic sections or movable internal baffles, so that the standing wave can be tuned to the resonant frequency of the installation, which must otherwise be calculated or measured, in advance of installation.

[0031] It will of course be understood that the invention is not intended to be restricted to the details of the above embodiments which are described by way of example only.

Claims

1. A combustion apparatus incorporating a noise reduction arrangement, the apparatus comprising a burner (10) and a standing wave arm (15, 15') for establishing a standing wave connected to a flue gas outlet (14) of the burner, **characterised in that** a flue gas outlet system (17) is connected to the standing wave arm at a mid-point (16) of the standing wave.

2. A combustion apparatus as claimed in claim 1, in which the standing wave arm (15, 15') is configured to generate a standing wave which is or approximates to one half of the wavelength of a resonant frequency to be attenuated.

3. A combustion apparatus as claimed in claim 1 or claim 2, in which the flue gas outlet (14) is fluidly connected with the standing wave arm (15) at one end of the arm.

4. A combustion apparatus as claimed in claim 1 or claim 2, in which the flue gas outlet (14) is fluidly connected with the standing wave arm (15’) at a position between the ends of the arm.

5. A combustion apparatus as claimed in any one of claims 1 to 4, in which the standing wave arm (15, 15’) comprises a column.

6. A combustion apparatus as claimed in claim 5, in which the length the column is adjustable.

7. A combustion apparatus as claimed in claim 5 or claim 6, in which the column is aligned generally upright.

8. A combustion apparatus as claimed in claim 7, in which a condensate drain (22) is provided at a lower end of the column.

9. A combustion apparatus as claimed in any one of the previous claims, in which the flue gas outlet system (17) is orthogonally connected with the standing arm (15, 15’) at the mid-point of the standing wave leading to a flue outlet.

10. A combustion apparatus as claimed in any one of the previous claims, in which the burner (10) is a dual port burner.

11. A combustion apparatus as claimed in any one of the previous claims, in which the apparatus comprises a gas boiler (9) including the burner (10), a heat exchanger (11 and a sump (13).

12. A combustion apparatus as claimed in claim 11, in which the flue gas outlet (14) is taken from the sump (13) of the boiler.

13. A combustion apparatus as claimed in any one of the previous claims, in which the apparatus further comprises a Helmholtz resonator (21).

14. A combustion apparatus as claimed in claim 13 when dependant on claim 11 or claim 12, in which the Helmholtz resonator (21) is mounted to the sump (13) of the boiler.

15. A combustion apparatus as claimed in claim 13 or claim 14, in which the Helmholtz resonator (21) is configured to attenuate a first resonant frequency and the standing wave arm (15, 15’) is configured to generate a standing wave which is or which approximates to one half of the wavelength of second resonant frequency.

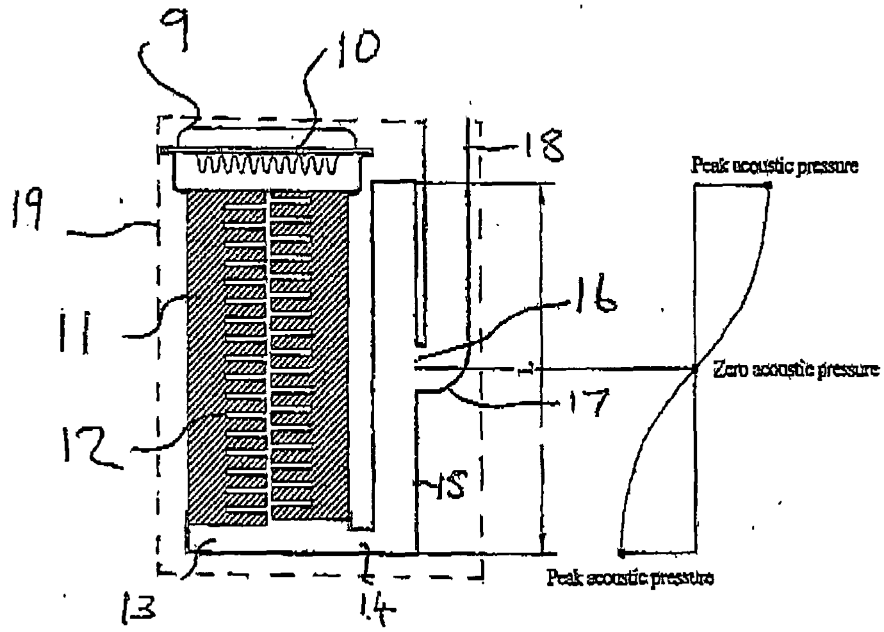
9
10
18
Peak acoustic pressure
19
16
11
Zero acoustic pressure
17
12
15
Peak acoustic pressure
13
14

Fig. 1

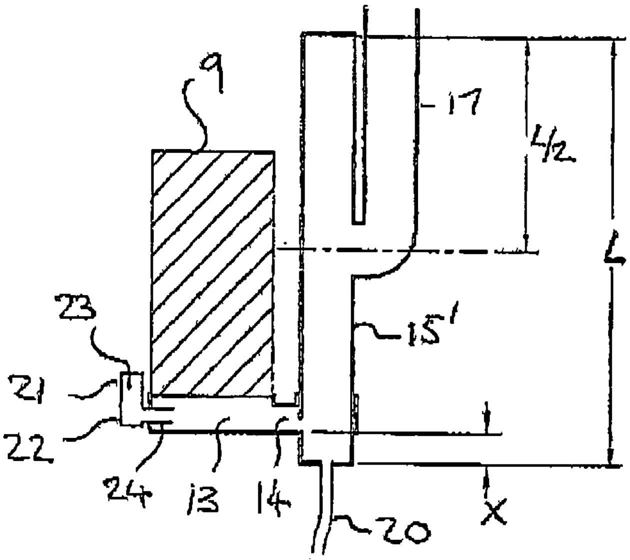

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003166689 B **[0003]**