

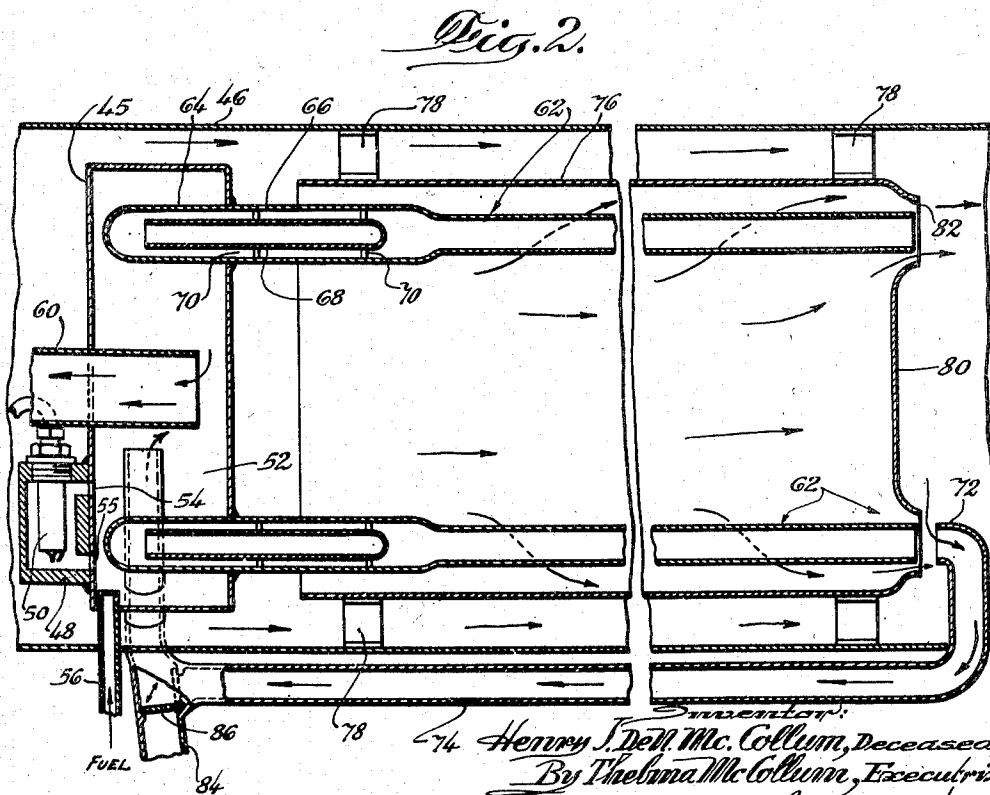
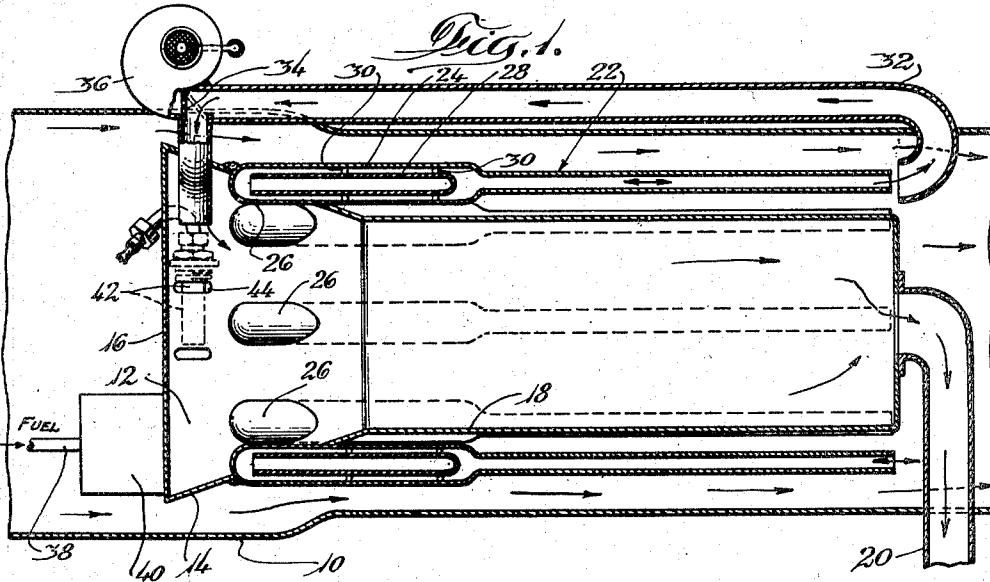
May 31, 1949.

H. J. DE N. McCOLLUM  
INTERNAL-COMBUSTION HEATER WITH  
KNIPP'S SINGING TUBES

2,471,832

Filed March 23, 1945

2 Sheets-Sheet 1



Inventor:  
Henry J. De N. McCollum, Deceased,  
By Thelma McCollum, Executrix,  
By Williams, Bradbury & Hinkley  
Attorneys.

May 31, 1949.

H. J. DE N. McCOLLUM  
INTERNAL-COMBUSTION HEATER WITH  
KNIPP'S SINGING TUBES

2,471,832

Filed March 23, 1945

2 Sheets-Sheet 2

*Fig. 3.*

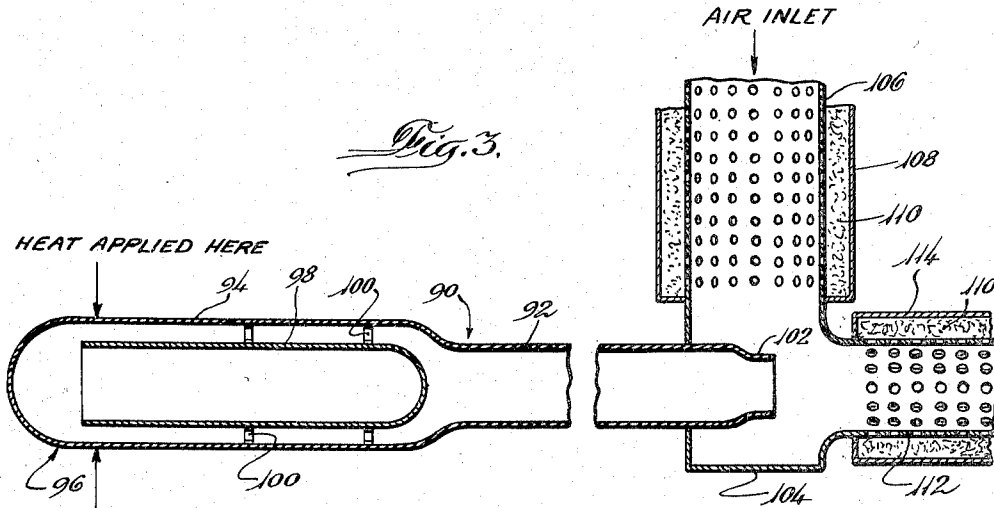
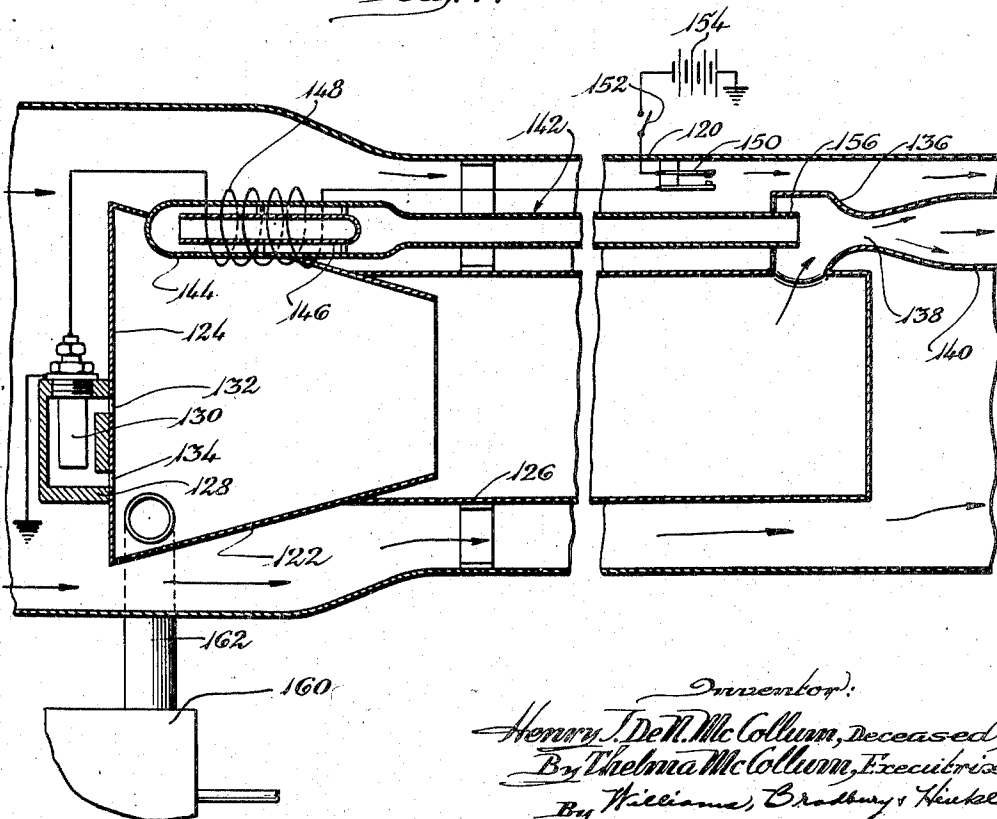


*Fig. 4.*



*Inventor:*  
*Henry J. De N. McCollum, deceased,*  
*By Thelma McCollum, Executrix*  
*By Williams, Bradbury & Henkle*  
*Attorneys.*

## UNITED STATES PATENT OFFICE

2,471,832

INTERNAL-COMBUSTION HEATER WITH  
KNIPP'S SINGING TUBES

Henry J. De N. McCollum, deceased, late of Chicago, Ill., by Thelma McCollum, executrix, Chicago, Ill., assignor to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Application March 23, 1945, Serial No. 584,361

10 Claims. (Cl. 126—116)

1

The invention relates generally to heaters, and more particularly to heaters of the sealed combustion type and to means for inducing flow of combustion and ventilating air through such heaters.

It has been known for some time, as a scientific curiosity, that a relatively long tube having a bulbous enlargement at one end in which is located an open end tube with its open end facing the closed end of the bulb, will, if the bulbous portion is heated, emit a musical tone. This apparatus is generally known as a "Knipp's singing tube."

The fundamental principle of the invention is based upon the discovery that flow of air may readily be induced by such singing tubes, and the tubes thus used in the place of fans or blowers to circulate air. This principle is illustrated herein as applied to sealed combustion type heaters for producing the flow of ventilating air and air for combustion.

It is thus an object of the invention to provide an improved sealed combustion type heater in which the flow of ventilating air and the flow of air for combustion is induced by singing tubes heated by the heater.

A further object is to provide an improved simplified apparatus for converting energy in the form of heat to the kinetic energy of flowing gases.

A further object is to provide an improved heater of the sealed combustion type, which does not require the use of a blower, fan, or other power-operated means to cause the flow of ventilating air through the heater.

Other objects will appear from the following description, reference being had to the accompanying drawings, in which:

Fig. 1 is a central longitudinal sectional view of a heater incorporating the invention;

Fig. 2 is a similar view of a modified form of the invention;

Fig. 3 is a diagrammatic sectional view of a further embodiment of the invention; and

Fig. 4 is a central longitudinal sectional view of a third modification of the invention.

Referring to Fig. 1, the heater is illustrated as comprising a housing 10 having a frusto-conical combustion chamber 12 formed by a generally conical wall 14 and an end wall 16, the small diameter end of the conical wall 14 being continued in a cylindrical shell 18. An exhaust conduit 20 is connected to the other end of the shell 18. If desired, the shell 18 may have fins

2

secured thereto to increase the rate at which heat may be dissipated therefrom.

A plurality of singing tubes 22 are secured to the wall 14 as by welding. Each singing tube has an enlarged diameter bulb-shaped portion 24, the extremity 26 of which projects through a suitable opening formed in the conical wall 14. Within the bulbous portion 24 of each of the tubes there is located a smaller diameter tube 28 having an open end adjacent the portion 26 of the bulb, and having its other end closed. The tube 28 is suitably spaced from the walls of the bulb portion 24 by means of spiders 30. The open end of one of the singing tubes 22 is closely adjacent the open end of a larger diameter combustion air supply tube 32 which leads into the combustion chamber 12, extending inwardly therein in an arcuate direction so as to impart swirling motion to the air in the combustion chamber.

A two-position valve 34 is provided, this valve normally closing the outlet opening of a hand operated blower 36 and moving to its dotted line position when the blower is being operated. Fuel is supplied to the combustion chamber from a suitable source under pressure through a conduit 38, a suitable fuel metering device 40 being provided to cause the fuel to flow into the combustion chamber in a regulated amount and in atomized form. An electrical igniter 42 is suitably secured in a chamber which communicates with the combustion chamber through ports 44.

To cause operation of the heater, the fuel supply is turned on, the electrical igniter is energized, and the blower 36 is operated to introduce combustion air to the combustion chamber. After hand operation in this manner for a sufficient length of time, the bulbs 26 will become heated sufficiently to cause the tubes to "sing," that is, to cause high amplitude oscillations of the air within the tubes. The frequency of such oscillations is determined by the dimensions of the tube. For best results, the singing tube should be designed to oscillate at frequencies of the order of 200 to 600 C. P. S. Tubes which generate frequencies within this range will have overall lengths ranging between 17" and 4".

The end of the singing tube which is in alignment with the opening of the combustion air supply tube 32 causes air to be forced into the latter tube. Apparently the alternate pulsations of the air at the end of the tube 22 imparts sufficient kinetic energy to the air to cause it to enter the tube 32 upon the pressure portion of

3

the pulsations, whereas upon the rarefaction portion of the pulsating cycle, air is drawn from the space surrounding the ends of the tubes 22 and 32. The result is that a substantial quantity of air will enter the tube 32 at sufficient pressure to cause it to flow through this tube and into the combustion chamber of the heater.

To assist the singing tube in producing such flow of air, the exhaust conduit 20 is preferably discharged into a low pressure area along the skin of the airplane (if the heater is utilized for heating an airplane), or discharged into a stack in which natural convection will assist the singing tubes in producing such air flow. The singing tubes 22, other than the one which is in alignment with the end of the combustion air tube 32, produce flow of ventilating air through the housing 10. The flowing ventilating air picks up heat from the shell 12 and from fins which may be secured thereto, as well as from the combustion chamber walls. In flowing past the portions of the singing tube other than the end 26, the ventilating air will cool such portions and thus maintain the temperature differential required to cause the singing tubes to continue to oscillate. Except for the initial use of the blower 36 to start the heater, it operates without any moving parts.

It will be understood that the heater will be provided with the usual temperature responsive controls for cutting off the supply of current to the igniter after combustion has been established. The heater is in effect self-regulating, in that if the normally cooler portions of the singing tubes become excessively heated, the amplitude of air oscillation within them will decrease and hence less air for combustion will be supplied to the combustion chamber, thus causing a reduction in the heat output, with the result that the normally cooler portions of the singing tubes will be cooled sufficiently to induce oscillations of normal amplitude.

In Fig. 2 there is illustrated a modified form of the invention, in which the singing tubes have only the ends of their bulbous portions supplied with heat. In this construction a short cylindrical sheet metal box 43, which may be formed by welding the sheets together, is located within a housing 45 with sufficient clearance to permit the flow of ventilating air between the box 43 and the housing 46. An igniter well 48 is welded or otherwise suitably secured to the forward wall of the box 45 and contains a suitable igniter 50, preferably of the electrically heated resistance wire type. The igniter well communicates with the combustion chamber 52, formed within the box 45, through a plurality of ports 54, 55. Fuel is supplied through a pipe 56 which projects into the combustion chamber 52 and may have a nozzle tip secured thereto to cause partial atomization of the fuel.

The products of combustion are withdrawn from the combustion chamber 52 through an exhaust conduit 60 which projects a substantial distance into the combustion chamber so as to cause the burning fuel and products of combustion to follow a circuitous path within the combustion chamber.

A plurality of singing tubes 62 are arranged in a circle, being suitably spaced from one another, and have the ends 64 of their enlarged diameter portions 66 projecting into the combustion chamber 52. In Fig. 2 only two of the singing tubes are illustrated, but it will be understood that any desired number may be suitably spaced, prefer-

4

ably in a circular pattern, within the dimensional limits of the combustion chamber 52.

Within each of the enlarged portions 66 of the singing tubes there is located the open end, small diameter tube 68 supported so as to lie co-axially with the portions 66 by a pair of spiders 70. The outlet end of one of the tubes 62 is spaced a short distance from the end 72 of a combustion air supply tube 74, the latter extending inwardly to the combustion chamber in a generally tangential direction so as to impart a swirling rotary motion to the mixture in the combustion chamber.

A shell 76 of generally cylindrical contour, is supported within the housing 46, so as to be co-axial therewith, by a plurality of brackets 78. The shell 76 has an end wall 80, provided with a plurality of flared openings 82, one surrounding each of the ends of the singing tubes 62.

The singing tubes 62 operate in the manner described with reference to Fig. 1 to cause the flow of combustion air into the combustion chamber and to cause flow of ventilating air through the openings 82 in the end wall 80 of the shell 76. The air flowing from these openings will induce flow of air through the annular space between the shell 76 and housing 46. The ventilating air will maintain the portions of the singing tubes 62, other than their end portions 64, sufficiently cooler than the portions 64 to maintain oscillation.

To cause the heater to commence operation a supply of air under pressure, or a hand-operated blower, is connected to a T 84 to supply the initial air for combustion. The air pressure from such auxiliary supply will swing a spring-retained flap valve 86 to its dotted line position and thus permit flow of air into the combustion chamber. After the heater has commenced normal operation, the auxiliary air supply may be disconnected from the T 84, whereupon the valve 86 will be spring returned to its full line position and combustion air will be supplied through the tube 74 by virtue of the flow induced by its associated singing tube 62.

Since the oscillations produced by the singing tubes are usually well within the audible range and normally of high amplitude, and since they may not be of exactly the same frequency, it is usually desirable to provide means for muffling or suppressing the sounds produced. In Fig. 3 there is diagrammatically illustrated a suitable means for muffling the sound produced. This means may be incorporated in either of the heaters shown in Figs. 1 or 2, or in the heater shown in Fig. 4, subsequently to be described.

In the apparatus shown in Fig. 3 the singing tube 90 has a reduced diameter portion 92 and a bulbous portion 94, the extremity 96 of which is adapted to be heated. Within the bulbous portion 94, is located the tube 98, having an open end directed toward the extremity 96 of the bulbous portion. The tube 98 is held co-axially in the bulbous portion 94 by any suitable means, such as projecting lugs 100. The open end of the smaller diameter portion 92 of the singing tube is further reduced in diameter, as indicated at 102, and this end projects into an elbow 104. The elbow 104 has a perforated air inlet tube 106 which is surrounded by a casing 108, the space between this casing and the tube 106 being preferably filled with a suitable sound absorptive and damping material 110, such as rock wool, stainless steel wool, or glass wool. An air outlet tube 112, forming part of the elbow 104, is likewise perforated, surrounded by a casing 114, with the

space between these elements filled with one of the named sound damping materials 110. The air outlet tube 112 is co-axial with the singing tube 92 so that the pulsations produced in the latter will cause flow of air from the tube 106 through the elbow 104 and into the outlet tube 112. The perforated tubes 106 and 112 operate as mufflers to reduce the intensity of the sound transmitted to the space surrounding these tubes. Since the singing tube of given dimensions will always operate at substantially the same frequency, the number and size of the perforations in the tubes 106, 112, as well as the dimensions of the casings 108, 114, may be made such as to be most effective in damping the particular frequency which is generated.

In the form of the invention shown in Fig. 4 the heater comprises a housing 120 surrounding a frusto-conical combustion chamber wall 122, which may be welded to an end wall 124, and a generally cylindrical shell 126 welded to the wall 122. Suitably secured to the end wall 124 is an igniter well 128 having an igniter 130 secured therein. The igniter 130 is preferably of the hot resistance wire type. The fuel and air mixture may flow into and out of the igniter well through suitable openings 132 and 134. The products of combustion are exhausted from the shell 120 through a Venturi tube 136 having a throat portion 138. The Venturi tube 136 may be formed as part of an exhaust conduit 140 which preferably discharges into a space of sub-atmospheric pressure.

A singing tube 142 is mounted in the heater so as to have its bulbous end 144 projecting into the combustion chamber. Within the bulbous portion of the singing tube there is located the customary tube 146 having an open end directed toward the closed end of the bulb. An electrical heating element 148 is wound around the bulbous portion of the singing tube for initially heating this portion. The heating element 148 is shown as connected in series with the igniter 130, and in series with a thermostatic igniter switch 150, a manually operable control switch 152, and a suitable source of electrical energy, illustrated as a battery 154.

The outlet end 156 of the singing tube projects into the Venturi tube 136 so as to be positioned in reasonably close proximity to the throat portion 138 thereof.

The form of the invention shown in Fig. 4 is used whenever a suitable source of ventilating air under pressure is available. Under these conditions it is not necessary to supply singing tubes for propelling the ventilating air stream. In installations of this character a suitable fuel mixture from a carbureting means 160 is supplied to the combustion chamber through a tube 162, the outlet end of which is preferably directed tangentially of the combustion chamber.

In operating the heater shown in Fig. 4 the switch 152 is closed, either manually or under the control of a room thermostat, thus completing a circuit through the igniter, the heating element 148, and the thermostatic igniter switch 150. As the bulbous portion of the singing tube 142 becomes heated, the air therein will commence oscillation and, in cooperation with the Venturi tube 136, cause the flow of the products of combustion outwardly through the exhaust pipe 140. The resultant reduction in pressure within the shell 126 and combustion chamber 122 will cause flow of a fuel mixture from the carbureting means 160 to the combustion chamber where it will be ignited by the igniter 130. After a short

interval of operation, the bulbous end portion 144 of the singing tube will be heated by the flame in the combustion chamber and the thermostatic igniter switch will open to deenergize both the heating element 148 and the igniter 130. Thereafter the heater will continue in operation, since the bulbous end portion 144 of the singing tube is continuously heated by the combustion flame, while the remaining portion thereof will be held at a lower temperature by the ventilating air flowing past it. In the event that the heater should become extinguished accidentally, the temperature of the ventilating air flowing past the thermostatic igniter switch 150 will drop and the latter switch will close to reenergize the igniter 130 and the heating element 148, whereupon re-ignition will take place after a short interval.

As used in this specification and in the claims the term "Knipp's singing tube" defines a structure comprising a relatively long tube having a closed bulbous enlargement at one end thereof and, within the bulbous end portion and spaced from the walls thereof, a short closed end tube having its open end directed toward the closed end of the bulbous tube, the structure being such that when heat is applied to the bulbous end of the tube while the remainder of the tube is at a lower temperature, acoustic vibrations occur in the tube. In these tubes the wave length of the acoustic vibrations is four times the sum of the length of the bulbous tube and the length of the short closed end tube which is enclosed in the bulbous portion of the longer tube.

It will be apparent to those skilled in the art that while a number of modifications of the invention are disclosed herein, many additional modifications of the invention may be made without departing from the underlying principles of the invention. It is therefore intended by the following claims to include within the scope of the invention all such modifications and variations by which substantially the results of the invention may be obtained by the use of substantially the same or equivalent means.

The invention claimed is:

1. Means for causing the flow of air, comprising a pipe having an open end, an elongated tube having a bulb at one end and being open at the other end, said latter end being closely adjacent the open end of the pipe and in substantial alignment therewith, a tubular element enclosed within the bulbous end of said tube, said tubular element being open at the end facing the end of said tube and closed at its opposite end, means for supporting said element co-axially with respect to said bulbous end portion, and means for heating the bulbous end portion of said tube.

2. In a sealed combustion type heater having means forming a combustion chamber, means for supplying fuel to said combustion chamber, and means for igniting the fuel mixture in the combustion chamber, and means for causing flow of air for combustion and flow of ventilating air to be heated including passage forming means and a plurality of Knipp's singing tubes having their closed bulbous ends projecting into said combustion chamber, said singing tubes having their open ends communicating with said passages in a direction to induce the flow of air through said passages.

3. The combination set forth in claim 2 in which there is provided means including a manually operated blower for supplying combustion air during the starting period while the singing tubes are ineffective to cause air flow.

4. In an apparatus for causing the flow of a gaseous fluid, the combination of a Knipp's singing tube having an open end, a pipe having an open end adjacent to, but spaced from, the open end of said singing tube and in substantially axial alignment therewith, and means for supplying heat to the closed end portion only of the singing tube.

5. The combination set forth in claim 4, in which said pipe has a Venturi tube form at the open end thereof which is located adjacent to the open end of the singing tube.

6. The combination set forth in claim 4, in which said pipe is provided with a plurality of relatively small perforations, in which the perforated portion of said pipe is surrounded by a casing, and in which the space between said pipe and casing is packed with a heat resistant, sound damping material.

7. In a heater having means forming a combustion chamber, a heat exchanger communicating therewith and a ventilating air duct structure to convey air to be heated past said heat exchanger, and having means for supplying a combustible mixture to the combustion chamber and igniting it, the combination of a Knipp's singing tube having its closed bulbous end portion projecting into the combustion chamber and having a second portion located in the flow path of ventilating air, an exhaust conduit connected to the heat exchanger to provide a passageway for the discharge of the products of combustion from the heat exchanger, the open end of said singing tube projecting into said exhaust conduit in alignment with a portion thereof to induce flow of the products of combustion from the heat exchanger through said exhaust conduit, and an electrical heating element for heating the bulbous portion of said singing tube during starting of the heater.

8. In a heater of the sealed combustion type, including means forming a combustion chamber, a heat exchanger and a ventilating air duct structure to convey air to be heated past said heat exchanger, a plurality of singing tubes, each having its closed end in close proximity to said combustion chamber forming means so as to be heated by the burning gases within the combustion chamber, means for supplying air for combustion to said combustion chamber, said means comprising a pipe having an open end in substantial alignment with and closely adjacent the open end of one of said singing tubes, means for supplying fuel to the combustion chamber and igniting the combustible mixture therein, the

open end of the other singing tubes being in the ventilating air stream and in a direction to propel the ventilating air to a space to be heated.

9. Apparatus for causing the flow of a gas, comprising a Knipp's singing tube having a bulbous end portion and a tubular element within the bulbous end portion, the tubular element having an open end facing the closed end of the bulbous end portion and being closed at its opposite end, means for applying heat to the bulbous end portion to raise its temperature above that of the remaining portion of the singing tube, and an air propulsion pipe having its end in substantial alignment with the open end of the singing tube and spaced therefrom a sufficient distance to cause the vibratory oscillations of the air in the singing tube to inject air into the pipe with substantial kinetic energy.

10. In a sealed combustion type heater having means forming a combustion chamber, a heat exchanger communicating therewith, a ventilating air duct structure to convey air to be heated past said heat exchanger, means for supplying fuel to the combustion chamber, and an igniter, the combination of means for causing the flow of air for combustion including passage forming means and a Knipp's singing tube having its closed bulbous end portion projecting into the combustion chamber and having a second portion located in the flow path of the ventilating air, said singing tube having its open end communicating with said passage in a direction to induce the flow of air therethrough.

THELMA MCCOLLUM.

35 *Executrix of the Last Will and Testament of Henry J. De N. McCollum, Deceased.*

#### REFERENCES CITED

40 The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name    | Date           |
|-----------|---------|----------------|
| 1,729,579 | Hayes   | Sept. 24, 1929 |
| 2,204,226 | Nelson  | June 11, 1940  |
| 2,363,168 | Findley | Nov. 21, 1944  |

#### FOREIGN PATENTS

| Number  | Country | Date         |
|---------|---------|--------------|
| 505,891 | France  | May 17, 1920 |

#### OTHER REFERENCES

55 "A Textbook of Sound," by A. B. Wood, 2nd edition, published by the Macmillan Company in 1941.