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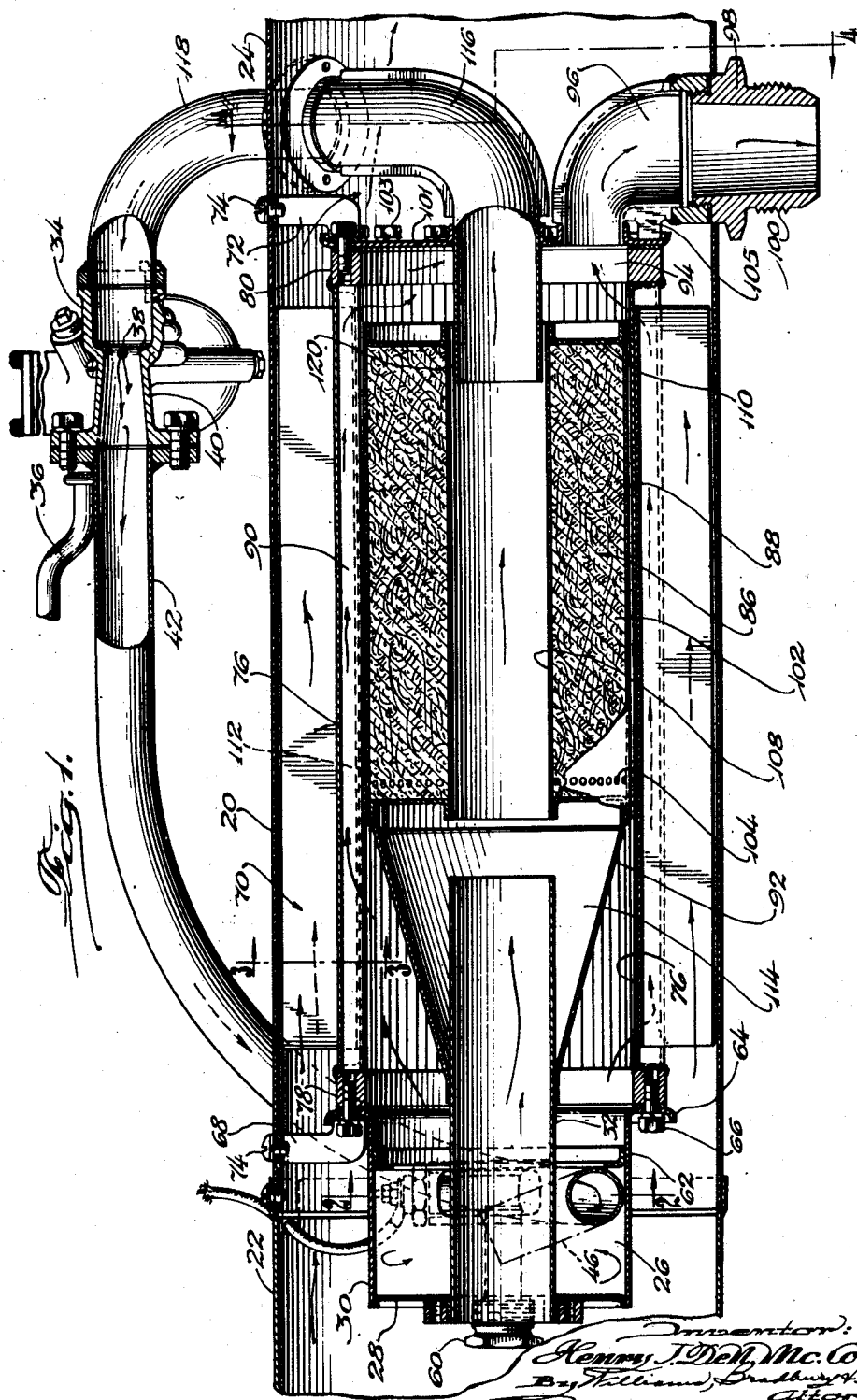
H. J. DE N. McCOLLUM

2,482,987

INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

Filed June 5, 1943

9 Sheets-Sheet 1



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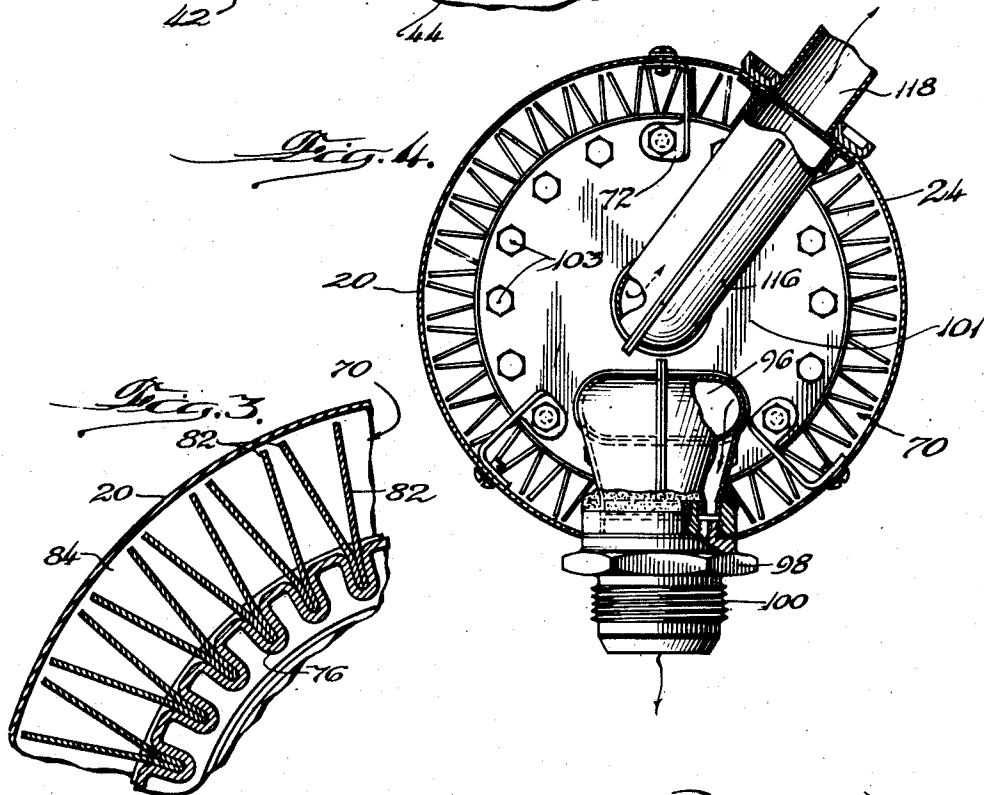
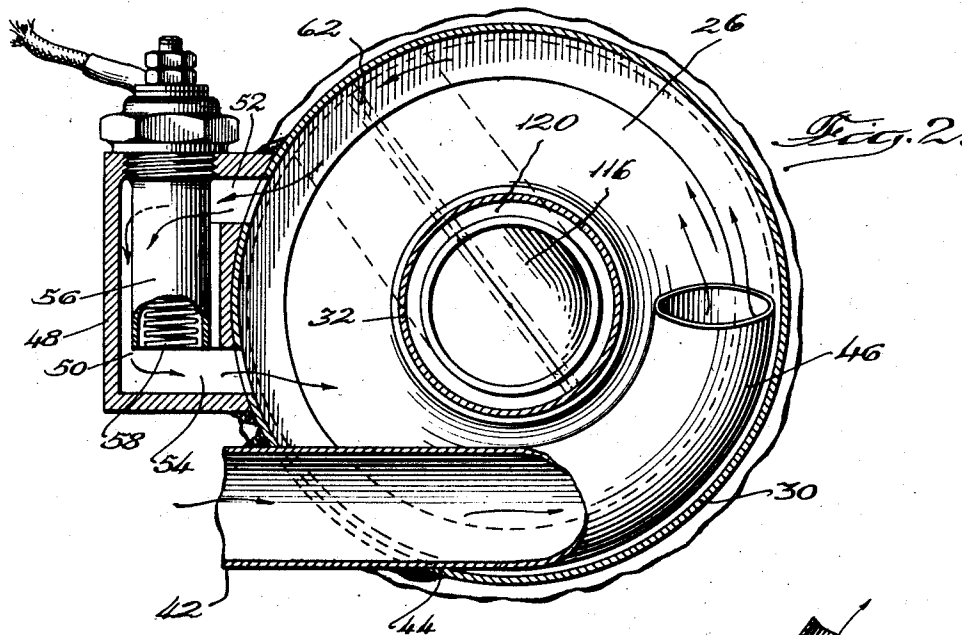
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

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9 Sheets-Sheet 2



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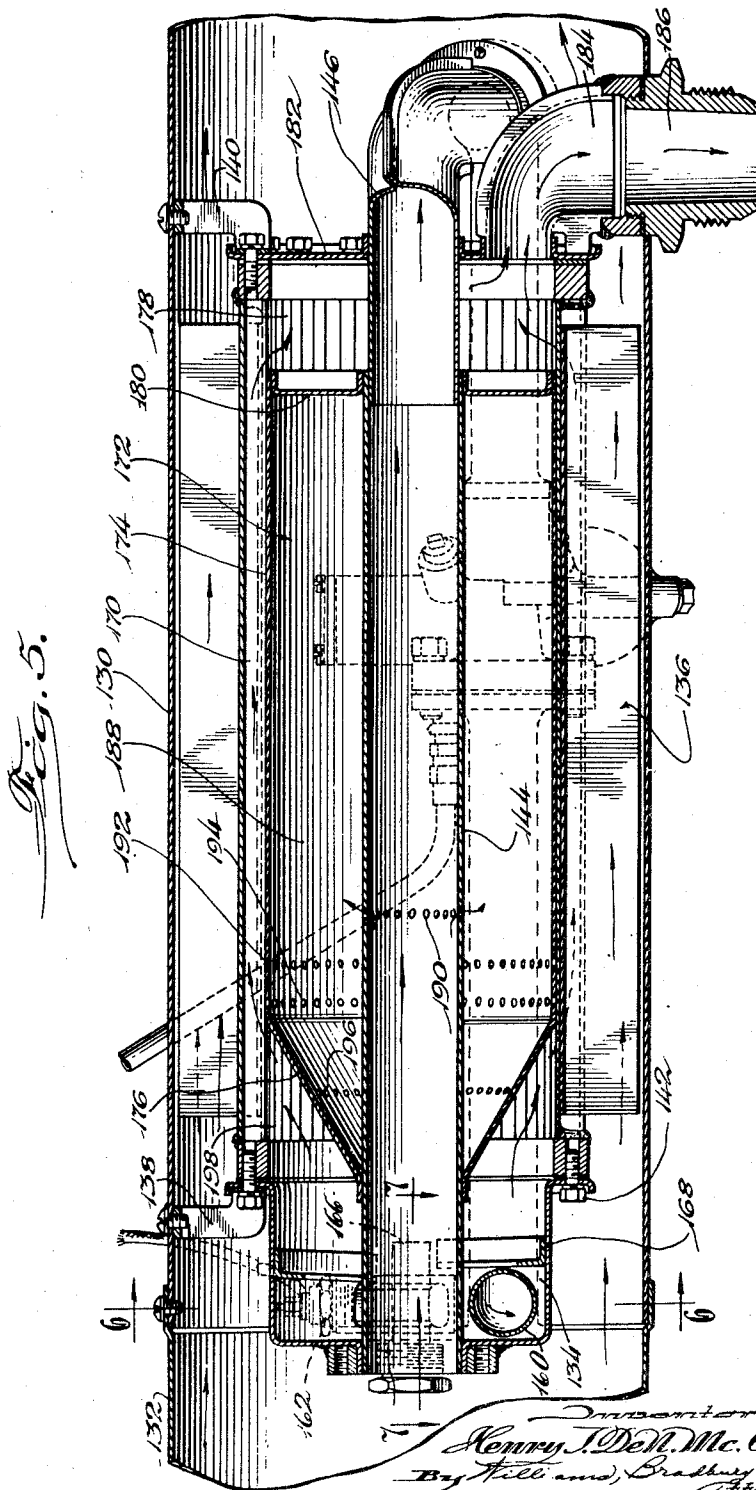
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

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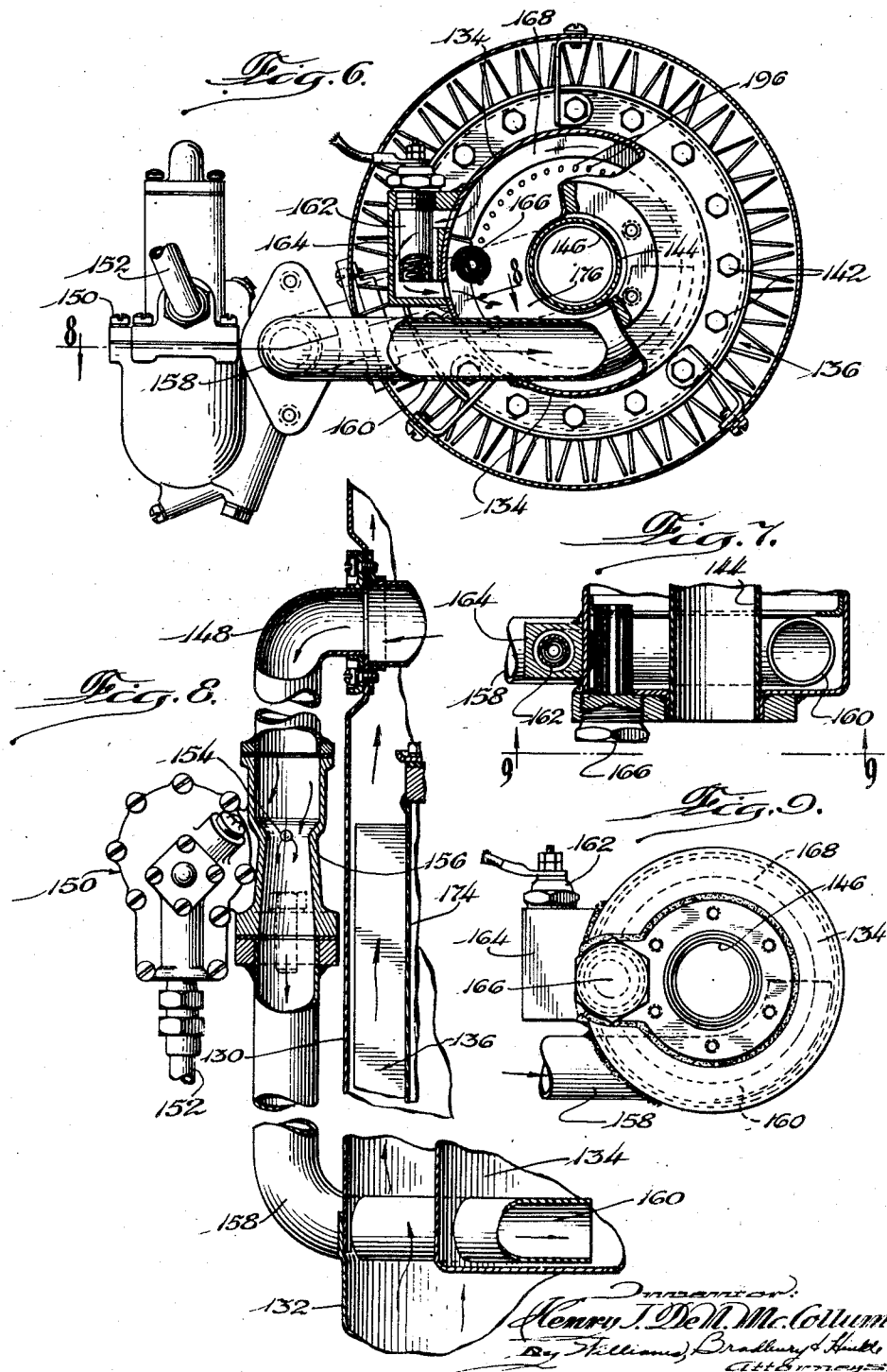
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

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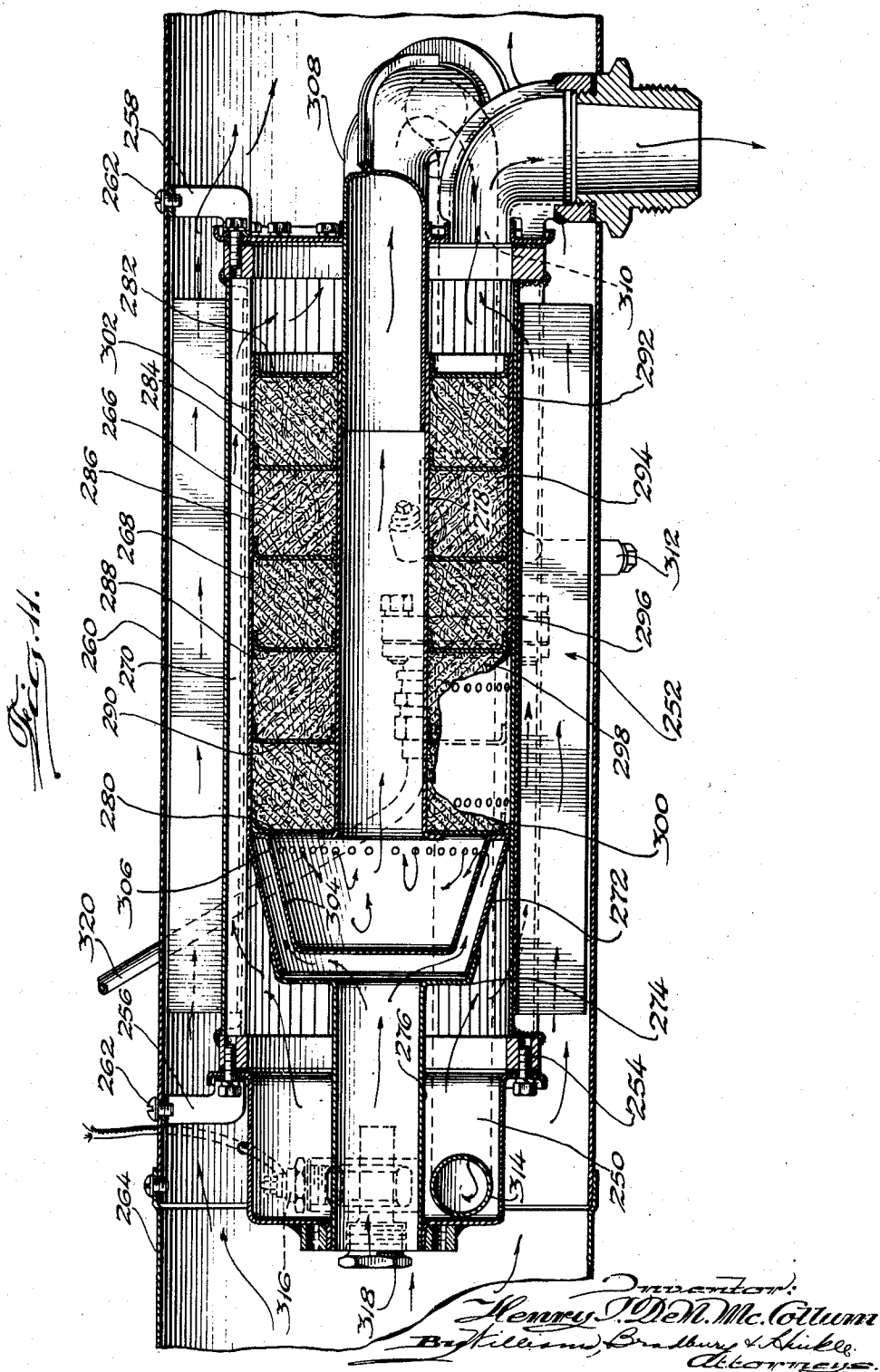
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

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9 Sheets-Sheet 6



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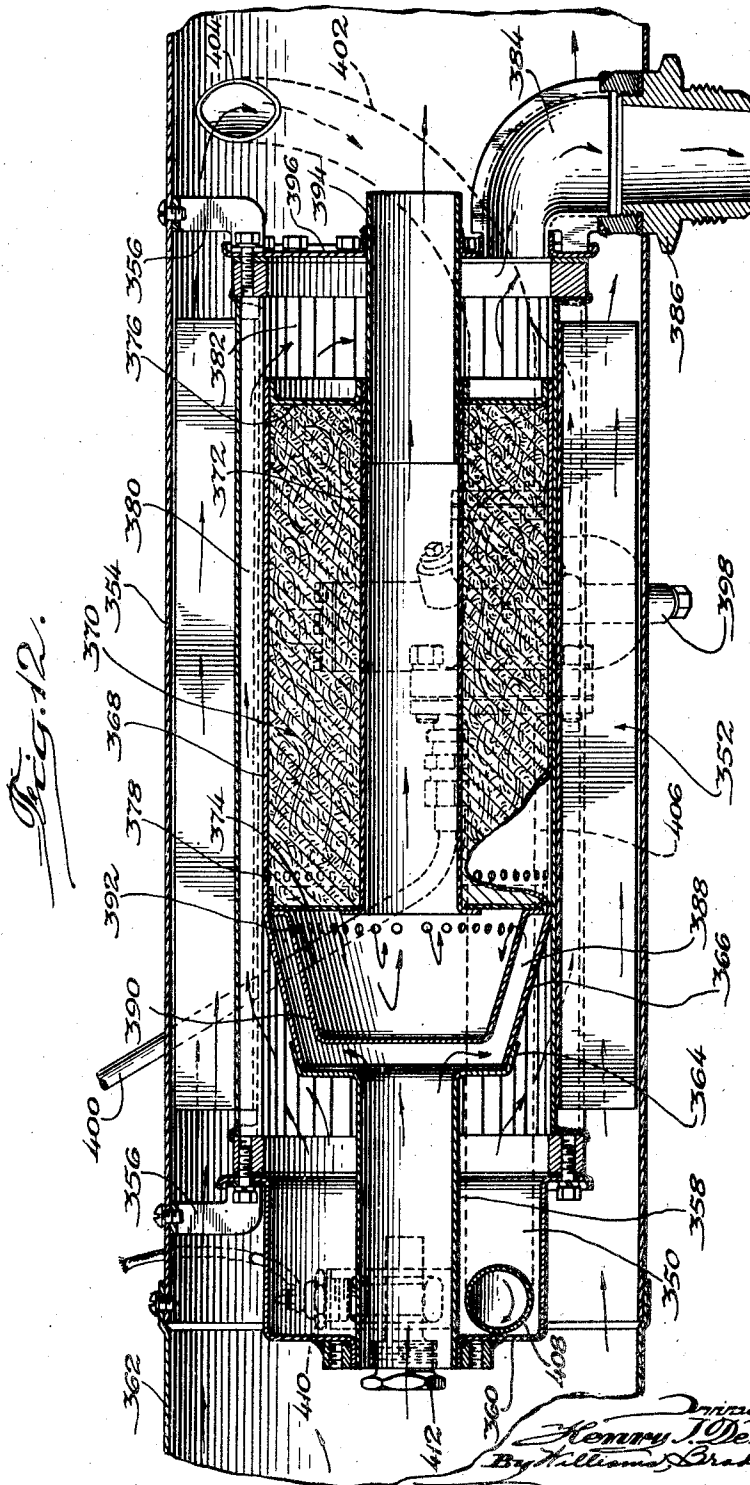
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

Filed June 5, 1943

9 Sheets-Sheet 7



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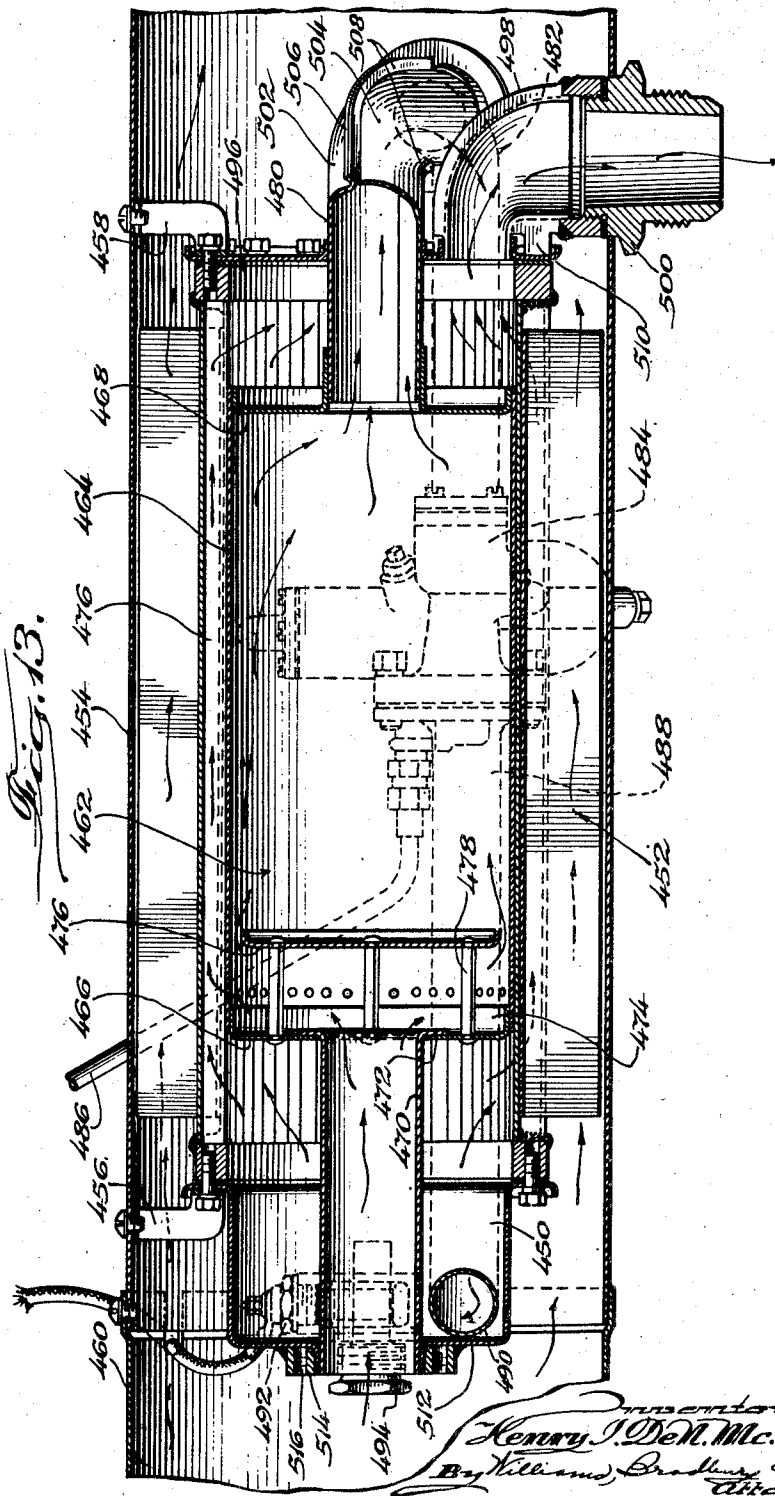
H. J. DE N. McCOLLUM

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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

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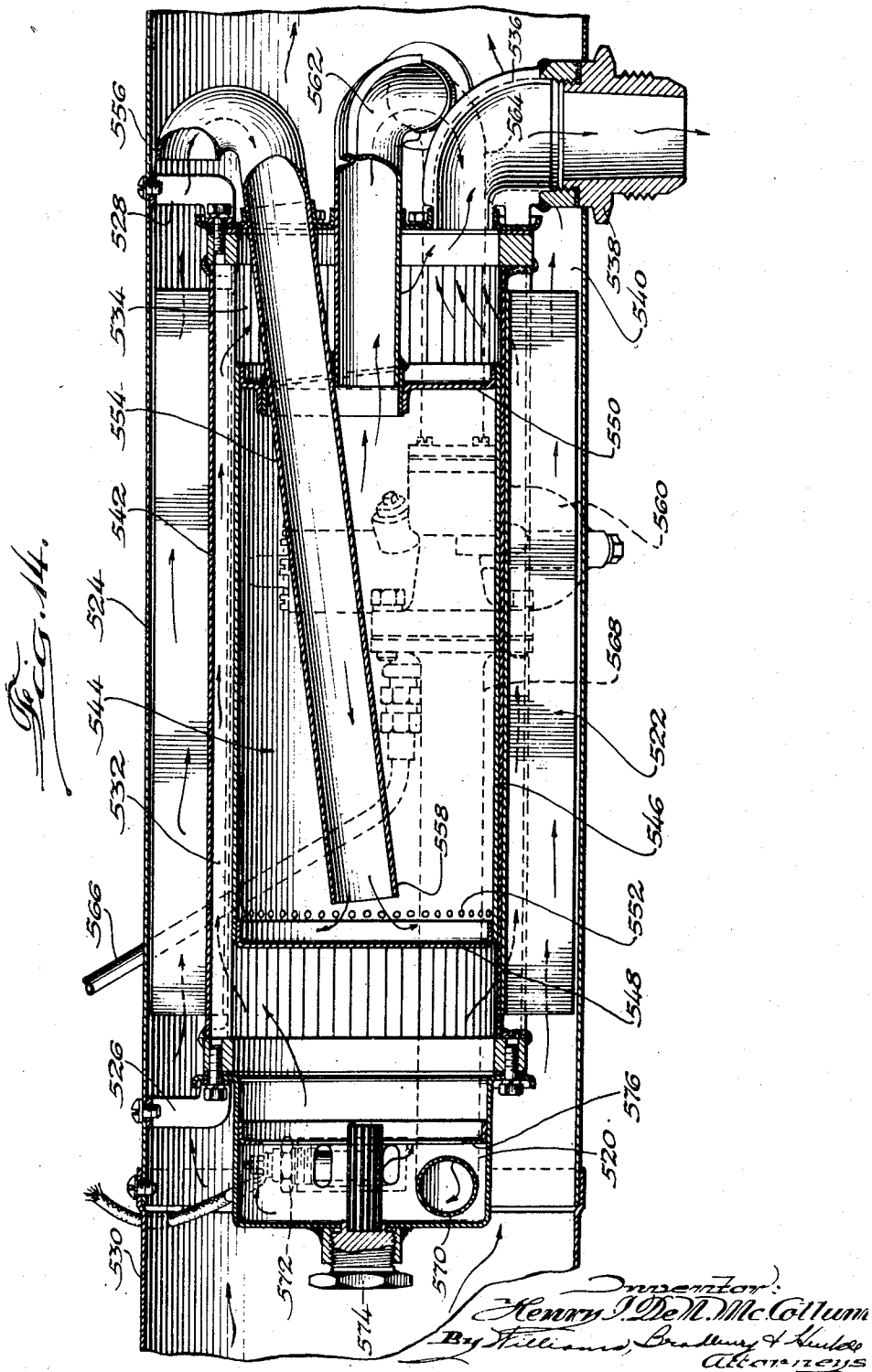
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INTERNAL-COMBUSTION HEATER WITH AIR-COOLED MUFFLER

Filed June 5, 1943

9 Sheets-Sheet 9



UNITED STATES PATENT OFFICE

2,482,987

INTERNAL-COMBUSTION HEATER WITH
AIR-COOLED MUFFLER

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

Application June 5, 1943, Serial No. 489,766

26 Claims. (Cl. 126-116)

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My invention pertains to heaters and more particularly to internal combustion heaters of the type commonly used in aircraft and for similar purposes.

An object of my invention is to provide a new and improved internal combustion heater which is quieter and more efficient than the heaters now in use.

Another object of my invention is to provide an internal combustion heater having a muffler and new and improved means for preventing any part of the muffler from reaching an excessive temperature.

Another object of my invention is to provide a heater having new and improved means for preventing the accumulation of combustible mixture in the muffler.

Another object of my invention is to provide a heater having an improved means for cooling the exhaust gases.

Another object of my invention is to provide a heater having new and improved means for introducing secondary air into the hot products of combustion.

Another object of my invention is to provide a heater having a new and improved arrangement for preheating air utilized for combustion purposes.

Another object of my invention is to provide a heater having new and improved heat exchange means for heating the ventilating air.

Another object of my invention is to provide a heater having a less expensive and lighter weight muffler than those heretofore used.

Another object of my invention is to provide a heater having novel means for introducing secondary air into the products of combustion and for preventing products of combustion from entering the ventilating air.

Another object of my invention is to provide a new and improved heater which offers minimum resistance to gas and air flow therethrough.

Another object of my invention is to provide a new and improved heater which may be easily disassembled and re-assembled for inspection, repair, cleaning, or other similar purposes.

Another object of my invention is to provide a heater having the foregoing advantages and which is inexpensive to manufacture and capable of affording long and trouble-free service.

Other objects and advantages will become apparent as the description proceeds.

In the drawings:

Fig. 1 is a longitudinal, sectional view through a preferred embodiment of my invention;

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Fig. 2 is a transverse, sectional view taken on the line 2-2 of Fig. 1;

Fig. 3 is a partial, transverse, sectional view taken on the line 3-3 of Fig. 1;

Fig. 4 is an irregular, transverse, sectional view taken on the line 4-4 of Fig. 1;

Fig. 5 is a longitudinal, sectional view through a modified form of my invention;

Fig. 6 is a transverse, sectional view taken on the line 6-6 of Fig. 5;

Fig. 7 is a partial, horizontal section taken on the line 7-7 of Fig. 5;

Fig. 8 is an irregular, generally horizontal, sectional view taken on the line 8-8 of Fig. 6;

Fig. 9 is an end view of the combustion chamber and associated parts and is taken in the plane of the line 9-9 of Fig. 7;

Fig. 10 is a longitudinal, sectional view of a further modification;

Fig. 11 is a longitudinal, sectional view of another modification;

Fig. 12 is a longitudinal, sectional view of another modification;

Fig. 13 is a longitudinal, sectional view of another modification; and

Fig. 14 is a longitudinal, sectional view of another modification.

That embodiment of my invention which is shown in Figs. 1 to 5, inclusive, comprises a tubular casing 20, having an inlet end 22 adapted to be supplied with air by a ram, blower, or other suitable means. The outlet end 24 of the casing may discharge directly into an airplane cabin or other space to be heated, or may be connected to a duct system leading to a plurality of outlets arranged at selected locations in the same or different spaces. Any suitable or usual means may be provided for controlling communication between the ram and the casing 20 and between this casing and the space or spaces to be heated.

A combustion chamber 26 is located in the casing 20 adjacent the inlet end 22 and has an end wall 28 and a cylindrical side wall 30. A pipe 32 is attached to the end wall 28 and extends through the center of the combustion chamber in coaxial relationship to the cylindrical wall 30 thereof. The lefthand or inlet end of the pipe 30 is in open communication with the inlet end 22 of the casing 20 so that the combustion chamber 26 is annular.

A carburetor 34 is shown as being provided for the purpose of supplying combustible mixture to the combustion chamber 26. A pipe 36 connects the carburetor 34 with any suitable source of fuel and one or more nozzles 38 deliver this fuel into the throat of a Venturi tube 40 which forms

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a part of the carburetor 34. The lefthand or outlet end of the Venturi tube 40 is connected to one end of an induction pipe 42 which extends through the casing 20 and an opening 44 in the wall 30 of the combustion chamber and has a curved end 46 lying closely adjacent this wall. This end 46 is exposed to the heat of the combustion chamber and serves to preheat to the desired extent the combustible mixture being delivered to this chamber by way of the induction tube 42. As best shown in Fig. 1, this end 46 is inclined toward the end wall 28 of the combustion chamber whereby the combustible mixture is caused to whirl about the axis of this chamber adjacent the rear wall thereof and all fuel is completely consumed within this chamber.

As best shown in Fig. 2, a housing 48 is attached to the cylindrical wall 46 of the combustion chamber and provides a passageway 50 which communicates with the combustion chamber by way of an inlet 52 and an outlet 54. An igniter plug 56 is located in the passage 50 in spaced relation to the walls thereof so that combustible mixture may flow around the plug 56 and be ignited by the electrical coil 58 in the lower end thereof. In ordinary practice, the igniter plug 56 is automatically disconnected from its source of current when the heater attains operating temperature and one or more re-igniters 60 (Fig. 1) may be provided to maintain combustion thereafter.

A ring 62 is attached to the cylindrical wall of the combustion chamber by welding, or in any other suitable manner, and serves to prevent the escape of liquid fuel from this chamber. The righthand end of the cylindrical wall 30 is provided with a flange 64 which is attached by screws 66, or in any other suitable manner, to supporting brackets 68 and also to one end of a heat exchanger, indicated generally by reference numeral 70. Similar brackets 72 attach the other end of the heat exchanger to the casing 20, the brackets 68 and 72 being secured to the casing by screws 74, or in any other suitable manner.

The heat exchanger 70 comprises a sheet metal generally cylindrical shell 76 having its opposite ends welded or otherwise suitably secured to rings 78 and 80. The shell 76 is corrugated, as best shown in Fig. 3, and fins 82 have their bases secured in folds of the corrugated shell 76. The radially outward portions of the fins 82 project into the ventilating air passage 84 formed between the casing 20 and the shell 76.

A muffler indicated generally by a reference character 86 is located in the heat exchanger 70 and has a cylindrical body 88 of sheet metal, or other suitable material, which cooperates with the shell 76 of the heat exchanger to form longitudinally extending passages 90 for the hot products of combustion issuing from the combustion chamber 26. A sheet metal cone 92 connects the lefthand end of muffler body 86 with pipe 32 and serves to direct the hot gases issuing from the combustion chamber into the lefthand ends of the gas passages 90. As the hot products of combustion traverse these gas passages, heat is given up to the shell 76 and fins 82, which transmit this heat to ventilating air flowing through the ventilating air passage 84. The gases then pass into an outlet chamber 94 and are discharged to atmosphere through outlet pipe 96 and fitting 98 and any suitable exhaust pipe attached to the threaded end 100 of this fitting.

The outlet pipe 96 is attached to a plate 101 which closes the righthand end of the heat ex-

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changer 70 and which is attached thereto by bolts 103, some of which also serve to attach this heat exchanger to bracket 72. As best shown in Fig. 1, the outlet pipe 96 is provided with a boss or foot 105 which rests against the plate 101 at a special place provided by omitting one of the bolts 103. The pressure foot 105 forms an extra support for the outlet pipe 96 and gives this pipe and the fitting 98 attached thereto additional stability.

The muffler 86 has an annular sound absorbing chamber 102, which is illustrated as being in communication with the gas passages 90 through a single, annular row of openings 104 forming acoustic couplings between the annular chamber 102 and the gas passages. As clearly shown in Fig. 1, this single annular row of openings 104 is located adjacent the lefthand end of the muffler 86 and serves to conduct sound into the annular chamber 102 where it is absorbed by the glass wool or stainless steel wool 106 located in this chamber.

The inner wall of the annular muffler chamber 102 is formed by a tube 108 supported in end walls 110 and 112. The tube 108 is in axial alignment with the pipe 32 and is shown as being of the same size as this pipe. The lefthand end of the tube 108, however, is spaced from the righthand end of the pipe 32, so that air leaving the righthand end of the pipe 32 must pass through a conical chamber 114 before entering the tube 108. This conical chamber 114 is formed by the cone 92 and end wall 112 of the muffler body and serves to prevent the wool in the lefthand end of the muffler from being overheated by the hot products of combustion issuing from the combustion chamber. The air passing from pipe 32 to tube 108 absorbs heat from the walls of this chamber so that this chamber also serves to increase the preheating of the air entering the tube 108.

Most of the air flowing through the tube 108 enters pipes 116 and 118 leading to the air inlet of the carburetor 34. When the heater is operating normally, the air delivered to the carburetor through these pipes is preheated to the desired temperature, and this preheating materially improves the operation of the heater by aiding in the vaporization of the fuel delivered by the jet 38. A small part of the air flowing through the tube 108, however, passes through the annular space 120 formed between the righthand end of the tube 108 and the lefthand end of pipe 116 and enters the outlet chambers 94 where it mixes with, dilutes and cools the products of combustion discharged to atmosphere by ways of pipe 96 and fitting 100. This arrangement for diluting the exhaust is accomplished with very low pressure drop and without requiring outside connections.

The purpose in diluting the exhaust gases is primarily to prevent explosions when the heater is being started. In other words, the exhaust gases are diluted to such an extent that any mixture of fuel and air entering the exhaust pipe and discharged therefrom will not explode even though combustible mixture delivered to the combustion chamber passes therefrom to the exhaust outlet without being burned in the heater itself. The introduction of secondary air into the exhaust chamber 94 also serves to muffle the exhaust end of the heater and permits the acoustic couplings between the interior of the muffler and the gas passages to be confined to the combustion end of the heater, as clearly shown in Fig. 1.

I wish to call particular attention to the fact

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that I have provided a simple and efficient arrangement whereby the combustion air is preheated in such a way that it cools the muffler and serves to prevent overheating of any part of this muffler by the heat of the combustion chamber and the hot products issuing therefrom. These objects, together with the dilution of the exhaust are accomplished by a simple structure which may be easily assembled and disassembled for inspection, cleaning or repair. This structure also offers minimum resistance to flow of air and gas therethrough and may be constructed of light weight but sturdy parts which are capable of withstanding rough usage and giving long and trouble-free service. This heater is highly efficient and has a high heat output for a given size and weight and so is particularly adapted for use in airplanes wherein these factors are especially important, although it is to be understood that my heater is not limited to such use and is also adapted for other purposes.

In Figs. 5 to 9, inclusive, I have shown a modified form of my invention wherein the heater comprises a casing 130 having its inlet end attached to an air supply pipe 132 leading from a ram, blower, or other suitable air supply means. A combustion chamber 134 and heat exchanger 136 are located in the casing 130 and are supported therefrom by brackets 138 and 140 attached by screws, or other suitable means, to the casing, heat exchanger and combustion chamber. As in the previous embodiment, the screws 142 which attach the brackets 138 to the combustion chamber and heat exchanger also serve to secure the combustion chamber and heat exchanger to each other.

A combustion air tube 144 has its lefthand end secured to the end wall of the combustion chamber and is in open communication with the air inlet pipe 132. The righthand end of the tube 144 is in sealed engagement with the lefthand end of a pipe 146 which connects with an external pipe 148 (Fig. 8) leading to a carburetor 150. A fuel supply pipe 152 connects the carburetor 150 with any suitable source of fuel and this fuel is delivered to a jet 154 located in the restricted throat of the Venturi tube 156 forming part of the carburetor 150. A mixture of fuel and air is formed in the Venturi tube 156 and this mixture is delivered to the combustion chamber 134 by way of induction tube 158, having an end 160 which extends through the casing 130 and side wall of the combustion chamber 134.

The mixture delivered to the combustion chamber 134 by the induction tube 158 is ignited by an electrical igniter 162 located in the bracket provided by a housing 164 attached to the cylindrical wall of the combustion chamber. The combustion chamber is provided with one or more re-igniters 166 to maintain combustion after the igniter 162 has been cut out by the usual thermostatic switch. A ring 168 is welded or otherwise secured to the cylindrical wall of the combustion chamber to prevent escape of liquid fuel therefrom.

The heat exchanger 136 may have the same construction as the heat exchanger of the first embodiment and has gas passages 170 which receive the hot gases discharged from the combustion chamber 134. A muffler 172 is located in the heat exchanger 136 and has an outer cylindrical wall 174 which cooperates with the heat exchanger to form the gas passages 170. The forward end of the muffler is tapered, as indicated at 176, and serves to direct the hot products

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of combustion into the lefthand ends of the gas passages 170. The righthand ends of these gas passages discharge the cooled gases into an outlet chamber 178 formed between the end wall 180 of the muffler and a plate 182, which closes the righthand end of the heat exchanger. These gases are discharged to atmosphere through outlet pipe 184 and fitting 186 and any suitable exhaust pipe attached to the threaded end of this fitting.

In this embodiment of my invention, the muffler 172 has an annular chamber 188 formed between the tube 144 and the outer wall 174, but in this embodiment of my invention this chamber is not filled with glass wool or stainless steel wool, or other sound absorbing material. Instead, the particular arrangement of the muffler and especially the flow of air therethrough are relied upon to absorb sound and prevent rumbling or other noises in the heater. A single row of openings 190 provided in the tube 144 connects the annular chamber 188 of the muffler with the air passageway through the tube 144 and permits a small amount of air to flow from the tube 144 into the annular space 188. Annular rows of openings 192 and 194 connect the annular space 188 with the gas passages 170 and a third annular row of openings 196 connects the annular space 188 with a tapered gas passage 198 which connects the combustion chamber with the inlet ends of the passages 170.

The openings 190, 192, 194 and 196 are preferably of such size as to form acoustic couplings which connect the annular space with the air passage in the tube 144 and also with the gas passages through the heater. A small amount of air flows into the annular space 188 through openings 190 and this air flows slowly through the lefthand end of the muffler chamber 188 and out of the openings 192, 194 and 196 to mix with the hot products of combustion. This air performs several functions. It cools the lefthand end of the muffler and prevents this end from being overheated by the heat of the combustion chamber and the hot gases issuing therefrom. It also absorbs sound entering the muffler through the openings 192, 194 and 196 and eliminates rumbling and other noises. This air flow, together with the large annular space provided by the muffler chamber 188, serves effectively to quiet the heater. This air also functions as secondary air to dilute and slightly reduce the temperature of the gases entering the passages 170 and prevents the lefthand ends of these passages from being overheated by the inflowing gases. The flow of secondary air through the muffler shell also prevents combustible gases from entering the chamber 188 when the heater is first turned on and before combustion occurs in the combustion chamber.

All of the foregoing advantages are obtained with a very small flow of air from the tube 144 through the muffler and into the gas passages of the heater. The operation of this heater is exceedingly efficient and this efficiency is accomplished by a structure of minimum weight since no sound absorbing material need be provided in the muffler chamber. The elimination of this sound absorbing material has a further advantage in that such sound absorbing material is a part of the heater which has the shortest life and which requires the most frequent attention and service.

In Fig. 10, I have shown a form of my invention which is more nearly the embodiment of

Figs. 1 to 4, inclusive. In the embodiment of Fig. 10, the combustion chamber 200 and the heat exchanger 202 are attached to each other and to brackets 204 by screws 206, or in any other suitable manner. The other end of the heat exchanger 202 is separated by brackets 208 and the brackets 204 and 208 are attached to the heater casing 210 by screws 212. The lefthand or inlet end of the casing 210 is connected to an air inlet pipe 214 which may lead from a ram, blower, or other suitable source of air supply. The righthand end of the casing 210, as in the previous embodiments, delivers the hot air to the space or spaces to be heated.

The heat exchanger 202 may be identical with the heat exchangers of the previous embodiments and a muffler 216 is located in this heat exchanger to cooperate therewith in the formation of the gas passages 218. A tube 220 extends through the combustion chamber and muffler and has its lefthand end in open communication with the air inlet pipe 214. The righthand end of this tube 220 is sealed to the lefthand end of a pipe 222 which connects with a second pipe 224 leading to the air inlet of the usual carburetor 226. A fuel supply pipe 228 connects the carburetor with any suitable source of fuel and an induction tube 230 conducts the combustible mixture formed in the carburetor to the combustion chamber 200.

The tube 220 forms the inner wall of an annular muffler chamber 232 which is filled with stainless steel wool or glass wool or other suitable sound absorbing material. A single annular row of openings 234 connects this annular chamber with the gas passages 218 and is clearly shown in the drawing. This annular row of openings is located adjacent the lefthand end of the annular muffler chamber.

The outer cylindrical wall 236 of the muffler has a conical extension 238 which serves to direct the hot products of combustion issuing from the combustion chamber into the lefthand ends of the gas passages 218. This conical extension 238 forms a tapered annular chamber 240 surrounding that portion of the tube 220 which is intermediate the combustion chamber 200 and the muffler 216. Annular rows of openings 242 and 244 connect opposite ends of the chamber 240 with the interior of the tube 220. An annular member 246 is located in the tube 220 between the openings 242 and 244 and serves to restrict the flow of air through this portion of tube 220 sufficiently to cause some of the air entering the lefthand end of this tube to pass through openings 242 into annular chamber 240 and thence through openings 244 back into this tube. This circulation of air through the chamber 240 cools the lefthand end of the muffler 216 and also aids in preheating the combustion air delivered to the carburetor 226. In this form of my invention, no secondary air is introduced into the products of combustion and all air entering the lefthand end of the tube 220 is delivered to the carburetor 226.

The embodiment of Fig. 11 is generally similar to that of Fig. 10, but shows a somewhat different arrangement for cooling the lefthand end of the muffler and for preheating the combustion air. Also in this embodiment of my invention I have utilized a different form of muffler which is divided into a plurality of compartments, each having its own acoustic coupling means forming a communication between such compartment and the gas passages.

The combustion chamber 250 and heat exchanger 252 are secured to each other by screws 254, which also connect these parts to brackets 256. The other end of the heat exchanger 252 is supported by similar brackets 258 and the brackets 256 and 258 are secured to the casing 260 by screws 262. The lefthand end of the casing 260 is connected to an air inlet tube 264 and the righthand end of the casing discharges heated air to one or more spaces to be heated.

A muffler 266 is located in the heat exchanger 252 and has an outer cylindrical wall 268 which cooperates with the heat exchanger 252 to form gas passages 270 therethrough. The wall 268 has a tapered lefthand end 272 connected to the enlarged righthand end 274 of a pipe 276 which extends through the combustion chamber 250 and whose lefthand end is in open communication with the air inlet pipe 264. The inner wall of the annular muffler 266 is formed by a tube 278 in sealing engagement with end walls 280 and 282 and intermediate partitions 284, 286, 288 and 290, which cooperate with the end walls and with each other to form compartments 292, 294, 296, 298 and 300. A single annular row of openings 302 connects each compartment with the gas passages 270 whereby sound may enter the several compartments and be absorbed by the glass wool or stainless steel wool or other sound absorbing material located therein.

A sheet metal cup 304 is located in the tapered end 272 of the wall 268. The open end of this cup is closed by the end wall 280 of the muffler and a single annular row of openings 306 forms the sole means of communication between pipe 276 and tube 278. All air entering pipe 276 flows around the base and side walls of cup 304 and passes through openings 306 into the interior of this cup and thence into tube 278. In passing around the outside of cup 304, this air is preheated and serves to protect the lefthand end of the muffler against the heat of the combustion chamber 250 and the hot gases issuing therefrom. This preheated air then flows through tube 278 and pipes 308 and 310 to carburetor 312, where a combustible mixture is formed which is delivered to the combustion chamber through induction tube 314. The usual igniter plug 316 and re-igniter 318 are provided to initiate and maintain combustion of this mixture. A pipe 320 connects the carburetor with any suitable source of fuel.

In the embodiment of Fig. 11, all air entering the pipe 276 is preheated and delivered to the carburetor as combustion air. There is no provision for introducing secondary air into the products of combustion formed in the combustion chamber. The combustion air is preheated to the desired temperature and this preheating is so accomplished that it serves to protect the muffler against undue heat from the combustion chamber and hot products of combustion issuing therefrom. The muffler in this form of my invention is divided into a plurality of compartments arranged lengthwise of the gas passages and connected thereto at intervals throughout their length.

In the embodiment of Fig. 12, the combustion chamber 350 and heat exchanger 352 are attached to each other and are suspended from the casing 354 by brackets 356, as in the previous embodiments. The heater shown in this figure is similar to that shown in Fig. 11, except that a different type of muffler is used and the air which passes through the combustion chamber and muffler is not directed to the carburetor but is discharged

into the outlet end of the casing 354. The carburetor receives its supply of air from this end of the casing 354, as will be hereinafter described in more detail.

A pipe 358 has its lefthand or inlet end attached to the end wall 360 of the combustion chamber and in open communication with the air inlet pipe 362. The opposite end of the pipe 358 is enlarged, as indicated at 364, and is attached to the conical end 366 of the outer cylindrical sheet metal wall 368 of the muffler 370, which is located within the heat exchanger 352. The inner wall of the annular muffler is formed by a tube 372, which is secured to cylindrical wall 368 by end walls 374 and 376. The elongated annular muffling chamber formed between the cylindrical wall 368 and tube 372 is preferably filled with stainless steel wool or glass wool, as indicated in the drawing. A single annular row of openings 378 forms acoustic couplings between the elongated chamber of the muffler and the gas passages 380 through which the hot products of combustion pass in flowing from the combustion chamber 350 to outlet chamber 382 from which these gases are discharged to atmosphere by way of outlet pipe 384 and fitting 386 and any suitable exhaust pipe which may be connected thereto.

The tapered end 366 of the cylindrical muffler wall 368 forms an air chamber 388 interposed between the combustion chamber 350 and the muffler 370. A sheet metal cup 390 is located in this chamber and has a single annular row of perforations 392 through which air must pass in flowing from the pipe 358 to the tube 372. This air flows around the outside of the cup 390 and then through openings 392 into the interior thereof, absorbing heat from the pipe 358 and tapered end 366 and protecting the adjacent end of the muffler against excessive heat. This heated air then flows through tube 372 and is discharged into the righthand or outlet end of the casing 354.

Most of the air delivered to the heater by the pipe 362 which connects this heater with a ram, blower, or other air supply means, passes between the casing 354 and heat exchanger 352 and absorbs heat from this heat exchanger. This heated air is then discharged from the righthand end of the heat exchanger into the righthand or outlet end of the casing 354, where it mixes with air which has passed through the center of the combustion chamber and the center of the muffler by way of pipes 358, chamber 388, muffler tube 372, and a pipe 394 which forms an extension thereof and which is welded or otherwise maintained in sealing engagement with the closure plate 396 for the righthand end of the heat exchanger.

The carburetor 398 may be of any conventional or suitable type and is supplied with fuel through a fuel supply pipe 400 which connects this carburetor with any suitable source of fuel. This carburetor is supplied with combustion air through a pipe 402 whose inlet end 404 passes through the casing 354 and is located inside this casing adjacent but downstream from the righthand end of the heat exchanger. Air entering this pipe 402 has passed over the heat exchanger or through the passageway passing through the center of the combustion chamber and muffler and when the heater is in operation, has attained a temperature which facilitates vaporization of the fuel mixed therewith in the carburetor 398. An induction tube 406 extends generally parallel to and outside of the casing 354 and has an end

408 which passes through the casing 354 and a wall of the combustion chamber 350 to deliver a combustible mixture to this combustion chamber. This mixture is originally ignited by an electrical igniter 410 and combustion is maintained by one or more re-igniters 412 after the igniter 410 has been cut out by the usual thermostatic switch.

In the heater of Fig. 12, all of the heated air is used either for ventilation or as combustion air delivered to the carburetor 398. None of this heated air is introduced as secondary air into the products of combustion. The arrangement of Fig. 12 is preferable to that of Fig. 11, where the amount of air necessary to cool the muffler is considerably greater than the quantity of combustion air required by the carburetor. The somewhat simpler muffler of Fig. 12 is satisfactory for most purposes, but the more complex and expensive muffler of Fig. 11 can be substituted therefor, if required.

The heater shown in Fig. 13 is similar to Fig. 11 in that most of the air passing through the muffler is directed to the carburetor and used as combustion air. The heater of Fig. 13 differs from Fig. 11, however, in that Fig. 13 shows a different type of muffler and part of the air directed into the muffler is introduced into the products of combustion as secondary air to aid in the reduction of noise.

In Fig. 13, the heater has a combustion chamber 450 attached to one end of a heat exchanger 452 and supported in a casing 454 by means of brackets 456 and 458. The lefthand or inlet end of the casing 454 is attached to an air supply pipe 460 connected with a ram, blower, or other suitable air supply means.

A muffler 462 is located in the heat exchanger 452 and comprises a cylindrical wall 464 and end walls 466 and 468 forming a single chamber therein. The lefthand end of this muffler chamber is in open communication with the air inlet pipe 460 by way of a pipe 470 which passes through the center of the combustion chamber 450. The lefthand end of the pipe 470 is sealed to the end wall of the combustion chamber and the righthand end of this pipe is provided with a flange 472 which is welded or otherwise sealed to the muffler end wall 466. The cylindrical wall 464 of the muffler is provided with an annular series of openings 474 adjacent the end wall 466. These openings form acoustic couplings between the muffler chamber and the gas passages 476 in the heat exchanger 452. These openings 474 also permit secondary air to flow into the passages 476 and mix with the products of combustion passing therethrough to aid in reducing noise.

A sheet metal baffle 476 is located in the muffler chamber and is attached to the end wall 466 by rivets 478, or in any other suitable manner. This baffle 476 causes the air entering the muffler through pipe 470 to flow in close contact with the end walls of this muffler and to prevent these walls from becoming overheated. The presence of the baffle 476 also facilitates flow of air through the openings 472 into the gas passages 476.

Pipes 480 and 482 connect the righthand end of the muffler chamber with the air inlet of a carburetor 484 which is supplied with fuel from any suitable source through a fuel supply pipe 486. An induction tube 488 has its outlet end 490 located in the combustion chamber 450 and delivers a combustible mixture of fuel and air to this chamber. This mixture is initially ignited by an electrical igniter 492 and after this igniter

is cut out by the usual thermostatic switch, combustion is maintained by one or more re-igniters 494.

Only a small proportion of the air delivered to the heater by air supply pipe 460 is required for combustion purposes, or as secondary air. Most of this air is heated by passing between the casing 454 and heat exchanger 482 and is discharged from the righthand end of the casing 454 into one or more spaces to be heated. The products of combustion leave the righthand ends of the gas passages 460 to enter an outlet chamber 490, from which they flow to atmosphere through outlet pipe 498 and outlet fitting 500 and any suitable exhaust pipe connected thereto.

As clearly shown in this figure, the pipe 480 which conducts heated air to the carburetor inlet is preferably formed of two sheet metal sections 502 and 504. The section 502 has a pair of diametrically opposed flanges 506 and the section 504 has a pair of diametrically opposed flanges 508, abutting flanges 506 and 508, being welded together to form the unitary pipe structure. The outlet pipe 498 is preferably of the same construction and the pressure foot 510 constitutes an extension of the inner flanges of two pipe sections.

In this figure, the combustion air is supplied by the same air supply pipe which furnishes the ventilating air to be discharged into the cabin or other space or spaces to be heated. In some installations it may be desirable to provide a separate source for the combustion air and in this figure the end wall 512 of the combustion chamber 450 is provided with a ring 514 welded to this wall and provided with tapped holes 516, so that a separate air inlet pipe for the combustion air may be secured to this end wall in sealed relation to the pipe 470 extending through the combustion chamber. Where a separate source of air is provided for combustion purposes, this separate source may be a ram, blower, or any other suitable means. Certain of the other figures have identical means for attachment of a separate air supply pipe for the combustion air.

The muffler 462 is of simple construction and design and the muffling chamber requires no sound absorbing material, such as stainless steel wool, or glass wool. The sound absorbing qualities of the chamber itself, together with the flow of air therethrough which increases these sound absorbing properties, is adequate to provide a quiet heater where some secondary air is discharged into the gases flowing through the gas passages 476. In this particular embodiment of my invention, the weight and cost of the sound absorbing material are eliminated and since only a very small amount of air is introduced into the products of combustion as secondary air, the heater is highly efficient and has a high heat output for a given size and weight.

The heater of Fig. 14 has a somewhat different arrangement for introducing cooling air into the muffler. In this heater the combustion chamber 520 and heat exchanger 522 are supported in the cylindrical casing 524 by brackets 526 and 528. The lefthand or inlet end of the casing 524 is connected to the usual air supply pipe 530 and the righthand or outlet end of this casing discharges directly or indirectly into the space or spaces requiring heat.

The hot products of combustion flow from the righthand end of the combustion chamber 520 into the lefthand ends of the gas passages 532 in the heat exchanger and give up their heat to the

walls and fins of this heat exchanger. The cooled gases flow from the righthand ends of these gas passages 532 into an outlet chamber 534 and are discharged to atmosphere through outlet pipe 536 and fitting 538, and any suitable exhaust pipe attached to the threaded end of this fitting. In this heater, all of the air supplied by pipe 530 passes around the combustion chamber 520 and through the annular passage 540 between the casing 524 and shell 542 of the heat exchanger. This air absorbs heat from the heat exchanger and passes from the righthand end of the heat exchanger into the outlet end of the casing.

A muffler, indicated generally by reference numeral 544, is located in the heat exchanger 522 and has a cylindrical side wall 546 and end walls 548 and 550 forming a muffling chamber which communicates with the gas passages 532 through a single annular row of openings 552 located in the side wall 546 adjacent the end wall 548. This muffler is exposed to the heat of the combustion chamber and the hot gases issuing therefrom and I have provided means for cooling this muffler by introducing air thereinto. This cooling means comprises a pipe 554, having an inlet end 556 located in the outlet end of the casing 524 and positioned to receive heated air discharged from the righthand end of the heat exchanger. This pipe passes through the rear wall 550 of the muffler and is inclined downwardly so that its outlet end 558 is located closely adjacent to and substantially opposite the center of the end wall 546.

The ventilating air entering the muffler through pipe 554 serves to prevent overheating of any part of the muffler 544 and a small part of this air passes through openings 552 into gas passages 532 and serves as secondary air which mixes with the products of combustion and tends to eliminate noise therefrom. The end wall 548 is the part of the muffler which is most likely to become overheated and the pipe 554 is so positioned and arranged that it discharges air directly against this wall to prevent such overheating. Most of the air entering the muffler through pipe 554 is utilized as combustion air and passes to the carburetor 560 by way of pipes 562 and 564. This air absorbs additional heat from the walls of the muffler so that the combustion air reaching the carburetor is considerably hotter than the ventilating air passing from the righthand end of the heater casing 524 into the airplane cabin or other space or spaces requiring heat.

A fuel supply pipe 566 connects the carburetor 560 with any suitable source of fuel and the mixture of fuel and air formed in this carburetor is delivered to the combustion chamber 520 through an induction pipe 568 having an outlet end 570 located in this chamber. The combustible mixture delivered to the combustion chamber 520 is ignited by the usual electrical igniter 572 and after this igniter is cut out by the usual thermostatic switch, a re-igniter 574 insures continued combustion of the inflowing fuel and air mixture. A ring 576 prevents escape of liquid fuel from the combustion chamber when the heater is first started.

The heater of Fig. 14 is particularly advantageous where it is desirable to have the combustion air supplied to the carburetor at a temperature materially greater than that of the ventilating air leaving the heater. This heater also utilizes a muffler of simple construction which requires no sound absorbing material, such as stainless steel wool or glass wool, and is inexpensive and light in weight.

Each of the embodiments herein shown and described, comprises a simple heater which may be made of lightweight but strong and rugged parts and which has a high heat output for a relatively small, compact and lightweight structure of high efficiency. In each of these embodiments, special air circulating means is provided to prevent any part of the muffler from becoming overheated so that the portion of the muffler which is most exposed to the heat of the combustion chamber and the gases issuing therefrom is protected against burning out and is afforded a life equivalent to that of the other parts of the heater. These advantages are accomplished in a heater which may be easily disassembled and reassembled for purposes of inspection, cleaning and repair and all parts of the heater are so designed that they may be easily manufactured by conventional methods and equipment.

Because the heaters herein shown and described are compact and efficient and have a high heat output for a given weight, these heaters are particularly adapted for heating the cabins and other spaces in an airplane. My novel heaters, however, are equally capable of use for other purposes. The particular heat exchanger shown herein is claimed in my co-pending application, Serial No. 464,451, filed November 4, 1942, now Patent No. 2,380,602 of July 31, 1945, and the various combustion chambers and other features not herein claimed are claimed in other co-pending prior applications. Other forms of heat exchangers and combustion chambers could be used in lieu of those herein shown and described and various other changes could be made without departing from the scope of my invention. In fact my invention may be incorporated in numerous other forms and includes all variations and modifications falling within the scope of the appended claims.

I claim:

1. A heater comprising a casing adapted to be connected with a source of air supply, means forming a combustion chamber in said casing, a tubular heat exchanger in said casing connected to said combustion chamber and receiving products of combustion therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, and means for circulating part of the air supplied to said casing through said muffler to prevent any part of said muffler from becoming overheated.

2. A heater of the class described, comprising a casing having one end adapted to be connected to a ram or other source of air supply, means forming a combustion chamber located in said casing, a heat exchanger of tubular conformation having one end attached to said combustion chamber, a sheet metal muffler located in said heat exchanger and having a wall cooperating therewith to form gas passages for hot products of combustion issuing from said combustion chamber, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means forming an air chamber between said muffler and combustion chamber, and means for creating air flow through said air chamber to protect said muffler against overheating.

3. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a heat exchanger connected to said combustion chamber and receiving hot products of combustion therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means forming an air chamber between said muffler and combustion chamber, means providing a passage for supplying air to said chamber from said source, and an outlet passage for said chamber extending through said muffler.

4. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a heat exchanger connected to said combustion chamber and adapted to receive hot products of combustion therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means forming an air chamber between said muffler and combustion chamber, and a pipe extending through said combustion chamber and connecting said air chamber with said source of air supply.

5. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a heat exchanger connected to said combustion chamber and adapted to receive hot products of combustion therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means forming an air chamber between said muffler and combustion chamber, and means for creating air flow through said air chamber to protect said muffler against overheating, said means comprising a pipe extending through said combustion chamber and a second pipe extending through said muffler.

6. A heater comprising a cylindrical casing having one end adapted to be connected with a source of air supply and a second end connected to one or more spaces requiring heat, means forming a combustion chamber located in said casing in spaced relation to the walls thereof, a tubular heat exchanger in said casing, said heat exchanger having one end connected to said combustion chamber and receiving hot products of combustion therefrom, a cylindrical sheet metal muffler located in said tubular heat exchanger and having one end adjacent said combustion chamber, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, and means for circulating air adjacent said end of the muffler to prevent said end from becoming overheated.

7. A heater comprising a cylindrical casing having one end adapted to be connected with a source of air supply and a second end connected to one or more spaces requiring heat, means forming a combustion chamber located in said casing in spaced relation to the walls thereof, a tubular

heat exchanger in said casing, said heat exchanger having one end connected to said combustion chamber and receiving hot products of combustion therefrom, a cylindrical sheet metal muffler located in said tubular heat exchanger and having one end adjacent said combustion chamber, means for circulating air adjacent said end of the muffler to prevent said end from becoming overheated, a carburetor for supplying combustible mixture to said combustion chamber, and means for conducting said circulated air to said carburetor.

8. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air, means forming a combustion chamber located in said casing, a heat exchanger connected to said combustion chamber and located in said casing and receiving hot products of combustion from said combustion chamber, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means providing a conical air chamber interposed between said combustion chamber and said muffler, and means for creating a circulation of air through said air chamber to prevent overheating of said muffler.

9. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air, means forming a combustion chamber located in said casing, a heat exchanger located in said casing and connected to said combustion chamber, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, said muffler and heat exchanger cooperating to provide passages for hot products of combustion issuing from said combustion chamber, means providing a passageway extending through said combustion chamber and muffler, means for supplying air to said passageway, said passageway being provided with openings for admitting air to said muffler, and means provided by said muffler for discharging said air into said products of combustion adjacent said combustion chamber.

10. A heater of the class described, comprising a casing having an end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger located in said casing and connected to said combustion chamber, a tubular muffler located in said heat exchanger and cooperating therewith to provide passages for hot gases issuing from said combustion chamber, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, means for directing air through the interior of said muffler, and means for directing a small portion of said air through said muffler and into said gas passage.

11. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger having one end connected to said combustion chamber and receiving products of combustion therefrom, a pipe extending through said combustion chamber and heat exchanger,

means for supplying air to said pipe, a shell surrounding said pipe and cooperating therewith to provide a muffling chamber, said shell cooperating with said heat exchanger to form a passage for said products of combustion, means providing openings connecting said pipe with said chamber, and means providing openings connecting said chamber with said gas passage, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, said two last-named means creating air circulation through said muffling chamber.

12. A heater of the class described, comprising a casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger having one end connected to said combustion chamber and receiving products of combustion therefrom, a pipe extending through said combustion chamber and heat exchanger, a shell surrounding said pipe and cooperating therewith to provide a muffling chamber, said shell cooperating with said heat exchanger to form a passage for said products of combustion, means providing openings connecting said pipe with said chamber, means providing openings connecting said chamber with said gas passage, said two last-named means creating air circulation through said muffling chamber, a carburetor for supplying combustible mixture to said combustion chamber, and a connection between said pipe and said carburetor.

13. A heater of the class described, comprising a casing of generally cylindrical cross section and having an end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger having one end connected to said combustion chamber and receiving hot products of combustion therefrom, a muffler shell located in said heat exchanger and cooperating therewith to form a gas passage for said products of combustion, said shell having a tapered end adjacent said combustion chamber, a conduit extending through said combustion chamber and muffler shell and cooperating therewith to form a muffling chamber, a single row of openings connecting said conduit with said muffling chamber, and a row of openings in the tapered portion of said muffler shell connecting said muffling chamber with said gas passageway.

14. A heater of the class described, comprising a casing of generally cylindrical cross section and having an end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger having one end connected to said combustion chamber and receiving hot products of combustion therefrom, a muffler shell located in said heat exchanger and cooperating therewith to form a gas passage for said products of combustion, said shell having a tapered end adjacent said combustion chamber, a conduit extending through said combustion chamber and muffler shell and cooperating therewith to form a muffling chamber, a single row of openings connecting said conduit with said muffling chamber, a row of openings in the tapered portion of said muffler shell connecting said muffling chamber with said gas passageway, and two rows of openings in the cylindrical portion of said muffler shell and connecting said muffling chamber with said gas passageway.

15. A heater of the class described, comprising a generally cylindrical casing having an end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber and receiving hot gases therefrom, means providing a passageway extending through said combustion chamber and heat exchanger, means supplying air to said passageway, a muffler shell surrounding said pipe and cooperating therewith to form a muffling chamber, said muffler shell having a tapered end adjacent said combustion chamber, and sound absorbing material located in said muffling chamber.

16. A heater of the class described, comprising a shell having one end adapted for connection to a source of air supply, means forming a combustion chamber located in said shell and having an end wall, a tubular heat exchanger located in said shell and connected to said combustion chamber, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, and conduit means supplied with air from said source and extending through said muffler, combustion chamber and end wall to pass cooling air therethrough to prevent overheating said muffler.

17. A heater of the class described, comprising a tubular casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger having one end connected to said combustion chamber receiving hot gases therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, a cup interposed between said combustion chamber and muffler, said cup having a bottom located adjacent said combustion chamber and a top abutting a part of said muffler, said muffler having an extension surrounding said cup in spaced relation thereto, said cup having perforations therein, a pipe extending through said combustion chamber and connected to said extension, means for supplying air to said pipe, and a second pipe extending through said muffler and communicating with the interior of said cup.

18. A heater of the class described, comprising a tubular casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber receiving hot gases therefrom, a muffler located in said heat exchanger, a cup interposed between said combustion chamber and muffler, said cup having a bottom located adjacent said combustion chamber and a top abutting a part of said muffler, said muffler having an extension surrounding said cup in spaced relation thereto, said cup having perforations therein, a pipe extending through said combustion chamber and connected to said extension, means for supplying air to said pipe, a second pipe extending through said muffler and communicating with the interior of said cup, said muffler having a muffling chamber, and sound absorbing material located in said chamber.

19. A heater of the class described, comprising

a tubular casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber receiving hot gases therefrom, a muffler located in said heat exchanger, a cup interposed between said combustion chamber and muffler, said cup having a bottom located adjacent said combustion chamber and a top abutting a part of said muffler, said muffler having an extension surrounding said cup in spaced relation thereto, said cup having perforations therein, a pipe extending through said combustion chamber and connected to said extension, means for supplying air to said pipe, a second pipe extending through said muffler and communicating with the interior of said cup, said muffler having a single muffling compartment, and a single row of openings adjacent said cup and connecting said muffling chamber with gas passages between said muffler and said heat exchanger.

20. A heater of the class described, comprising a tubular casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber receiving hot gases therefrom, a muffler located in said heat exchanger, said muffler including a muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, a cup interposed between said combustion chamber and muffler, said cup having a bottom located adjacent said combustion chamber and a top abutting a part of said muffler, said muffler having an extension surrounding said cup in spaced relation thereto, said cup having perforations therein, a pipe extending through said combustion chamber and connected to said extension, means for supplying air to said pipe, and a second pipe extending through said muffler and communicating with the interior of said cup, said last-named pipe discharging into said first-named casing.

21. A heater of the class described, comprising a tubular casing having one end adapted to be connected to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber receiving hot gases therefrom, a muffler located in said heat exchanger, a cup interposed between said combustion chamber and muffler, said cup having a bottom located adjacent said combustion chamber and a top abutting a part of said muffler, said muffler having an extension surrounding said cup in spaced relation thereto, said cup having perforations therein, a pipe extending through said combustion chamber and connected to said extension, means for supplying air to said pipe, a second pipe extending through said muffler and communicating with the interior of said cup, said last-named pipe discharging into said first-named casing, a carburetor for supplying combustible mixture to said combustion chamber, and an inlet pipe for said carburetor, said inlet pipe communicating with said casing adjacent the end of said heat exchanger remote from said combustion chamber.

22. A heater of the class described, comprising a tubular casing having one end adapted for connection to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber, a cylindrical muffler located in said heat exchanger and cooperating therewith

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to form a gas passage for hot products of combustion from said combustion chamber, said muffler having a large muffling chamber, means for introducing air into the end of said muffling chamber which is closest to said combustion chamber, means for discharging air from the other end of said muffling chamber, and acoustic coupling means for discharging a small amount of air from the inlet end of said muffling chamber into said gas passageway and for acoustically coupling said muffling chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves.

23. A heater of the class described, comprising a tubular casing having one end adapted for connection to a source of air supply, means forming a combustion chamber located in said casing, a tubular heat exchanger connected to said combustion chamber, a cylindrical muffler located in said heat exchanger and cooperating therewith to form a gas passage, said muffler having a single large muffling chamber and means acoustically coupling said chamber to said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, said muffler having an end adjacent said combustion chamber, said heat exchanger having an end remote from said combustion chamber, means for conducting air from said remote end of the heat exchanger to said end of the muffling chamber, and means for discharging air from the opposite end of said muffling chamber.

24. A heater of the class described, comprising a tubular casing having an inlet end and an outlet end, means forming a combustion chamber located in said casing adjacent said inlet end, a tubular heat exchanger located in said casing intermediate the ends thereof and connected to said combustion chamber, a muffler located in said heat exchanger and cooperating therewith to form a gas passageway for hot products of combustion from said combustion chamber, said muffler having a sound-absorbing chamber and a sheet metal end located adjacent said combustion chamber, a pipe for conducting air from the outlet end of said casing to a point adjacent said muffler end and discharging said air against said end, and an opening connecting said end of the muffler with said gas passageway, said opening being of such size as to constitute an acoustic coupling between said muffling chamber and said heat exchanger and combustion chamber for damping out incipient sound and pressure waves.

25. A heater of the class described, comprising a casing having an inlet end and an outlet end,

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means forming a combustion chamber located in said casing, a heat exchanger located in said casing and connected to said combustion chamber, a muffler located in said heat exchanger and having an end adjacent said combustion chamber, said muffler providing a single large acoustic chamber, means for conducting air into said muffling chamber and discharging it against the end of said muffler adjacent said combustion chamber, a carburetor for supplying a combustible mixture to said combustion chamber, and means for conducting air from the other end of said combustion chamber to said carburetor.

26. A heater of the class described, comprising a casing having an inlet end and an outlet end, means forming a combustion chamber located in said casing, a tubular heat exchanger located in said casing and connected to said combustion chamber, a muffler having a sound-absorbing chamber and one end adjacent said combustion chamber, and means for cooling said muffler, said means comprising a pipe for conducting air into said muffler, said pipe extending lengthwise of said muffler and discharging adjacent said end thereof, openings adjacent said end of the muffler for connecting the interior thereof with said combustion chamber, said openings being of such size as to constitute an acoustic coupling between said sound-absorbing chamber and said heat exchanger and combustion chamber for damping out incipient sound and pressure waves, and an air outlet for the other end of said muffler.

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