March 29, 1966 W. H. POWERS 3,243,012

MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

Original Filed April 2, 1956 8 Sheets-Sheet 1

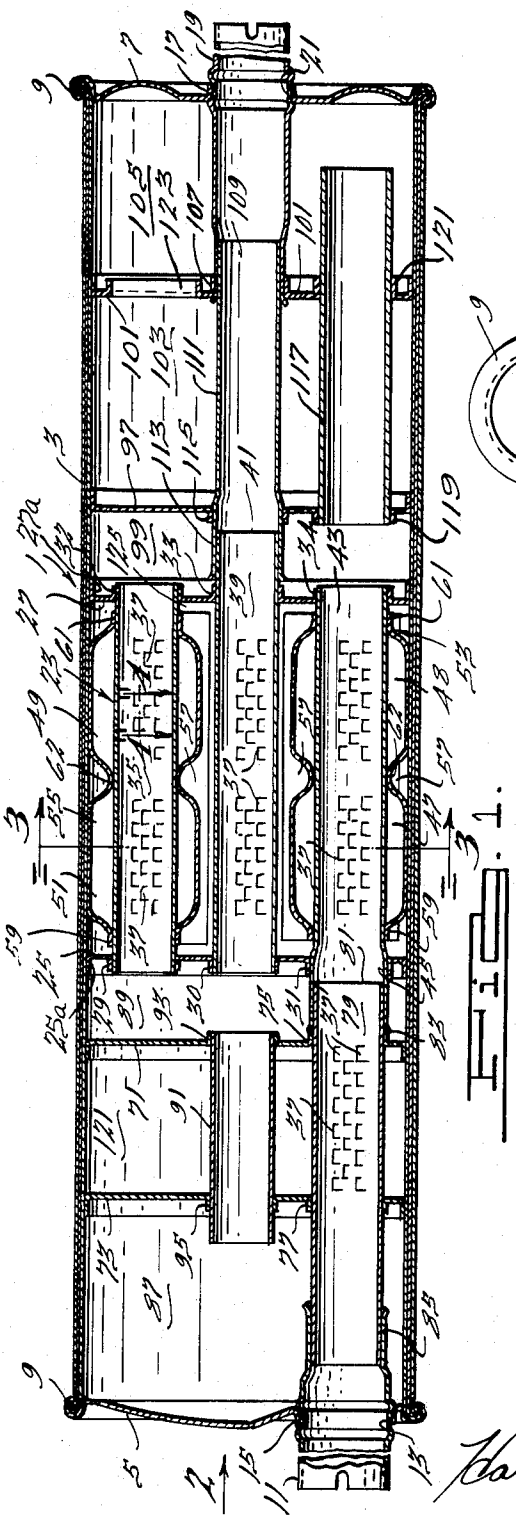


Fig. 1.

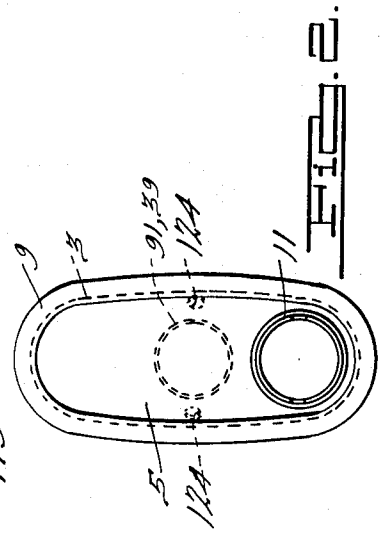


Fig. 2.

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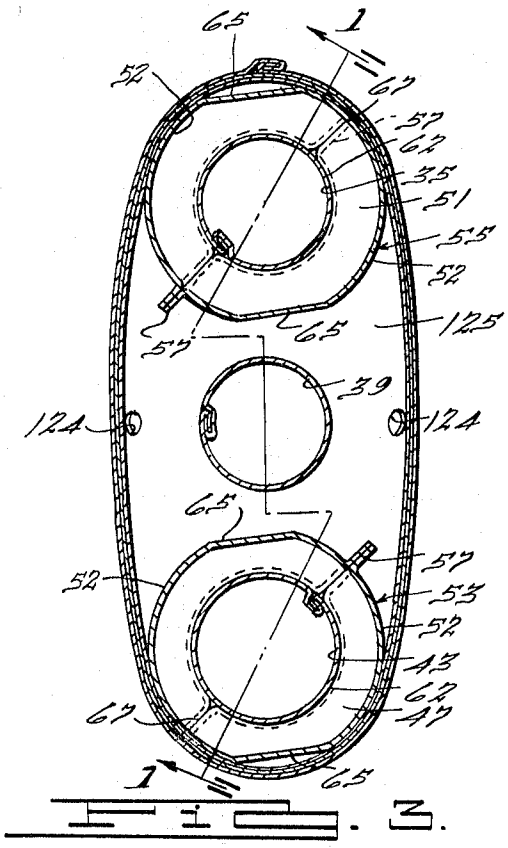


Fig. 3.

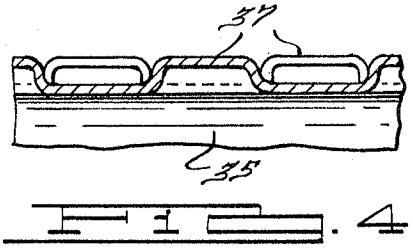


Fig. 4.

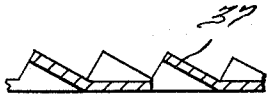


Fig. 5.

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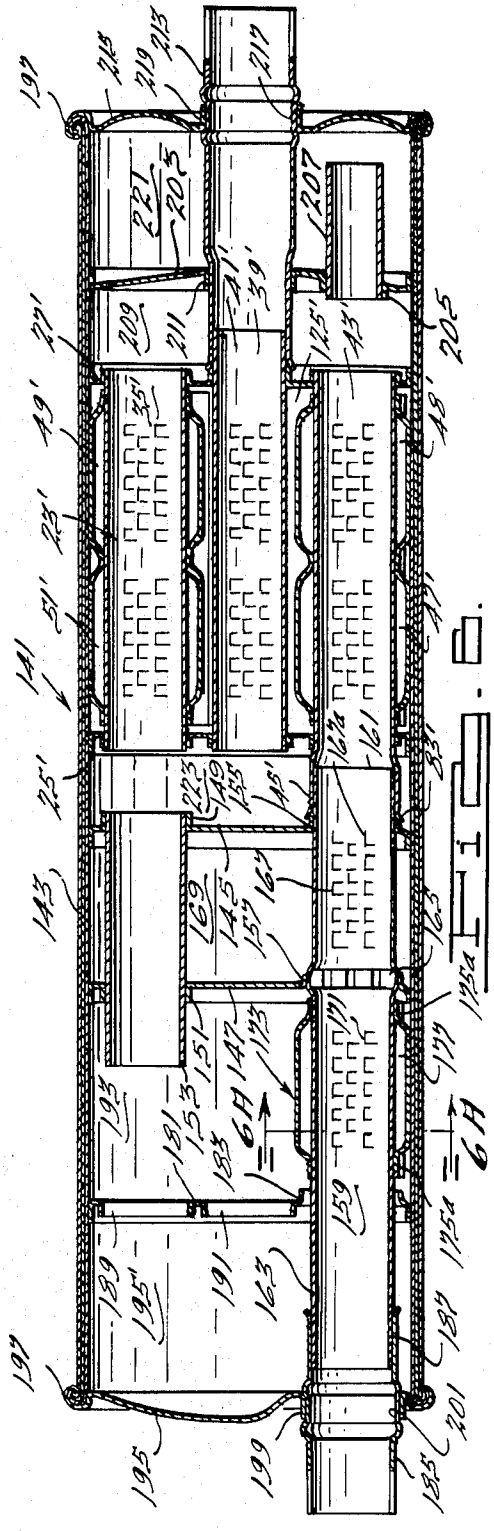


Fig. 6.

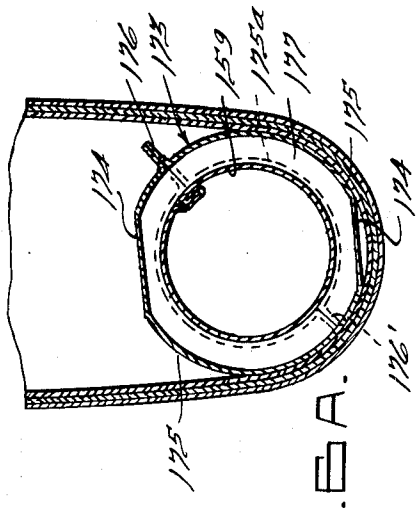


Fig. 6A.

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MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

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Fig. 7.

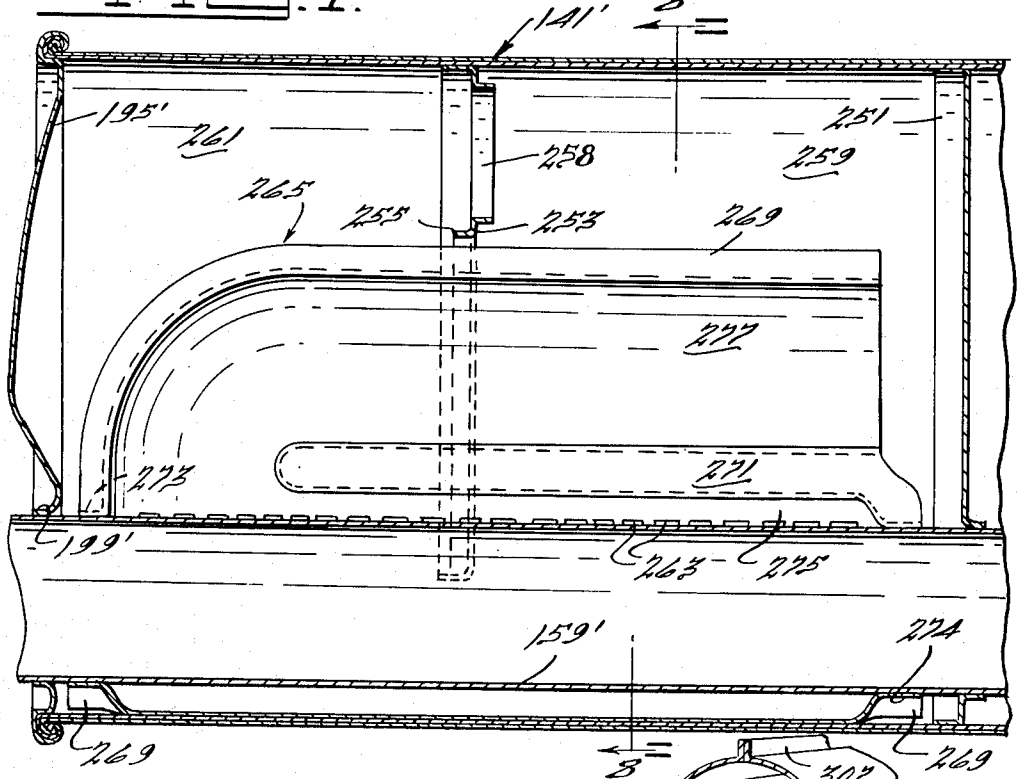


Fig. 9.

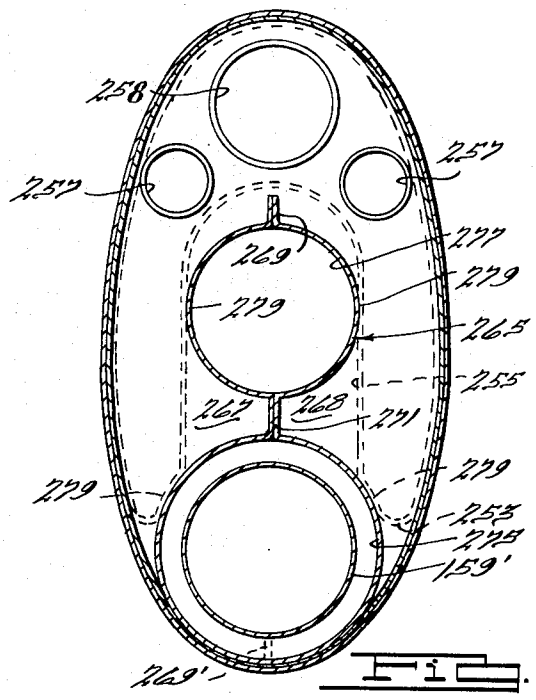


Fig. 8.

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MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

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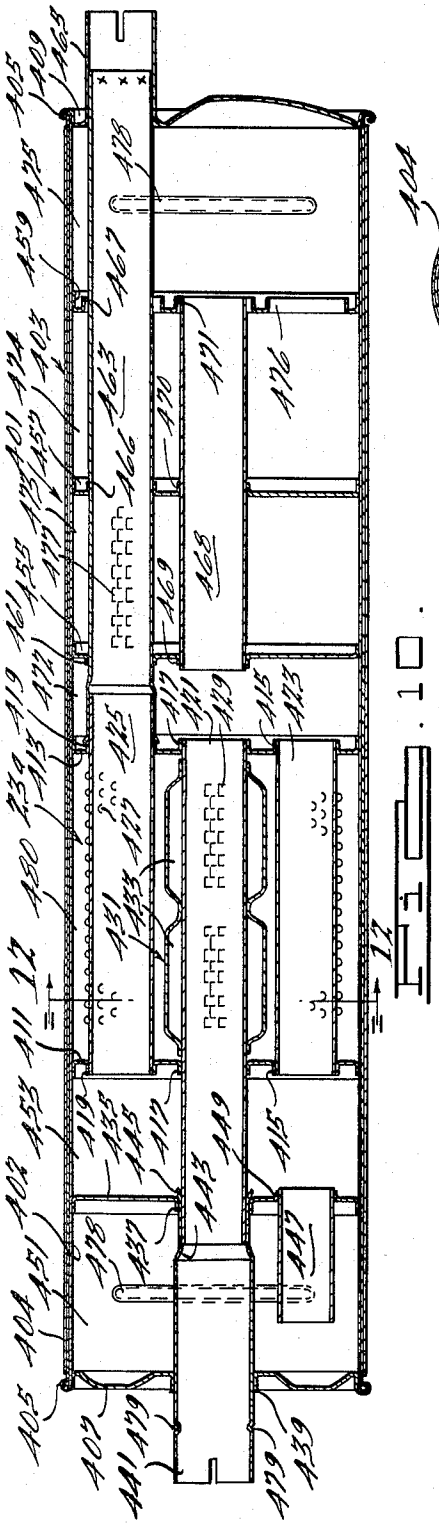


FIG. 10.

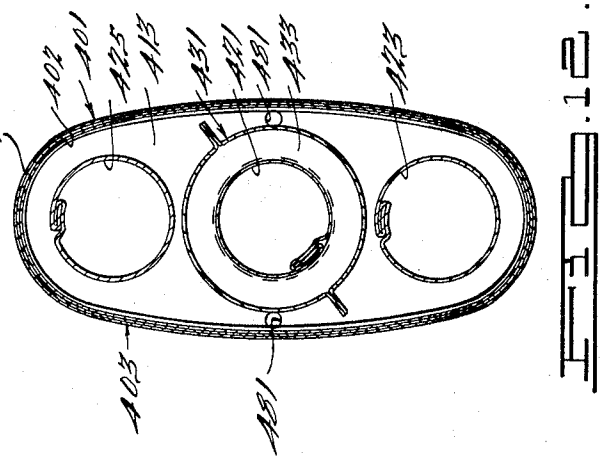


FIG. 12.

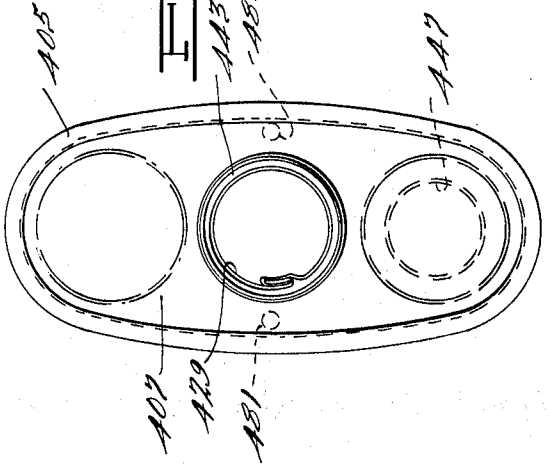


FIG. 11.

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MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

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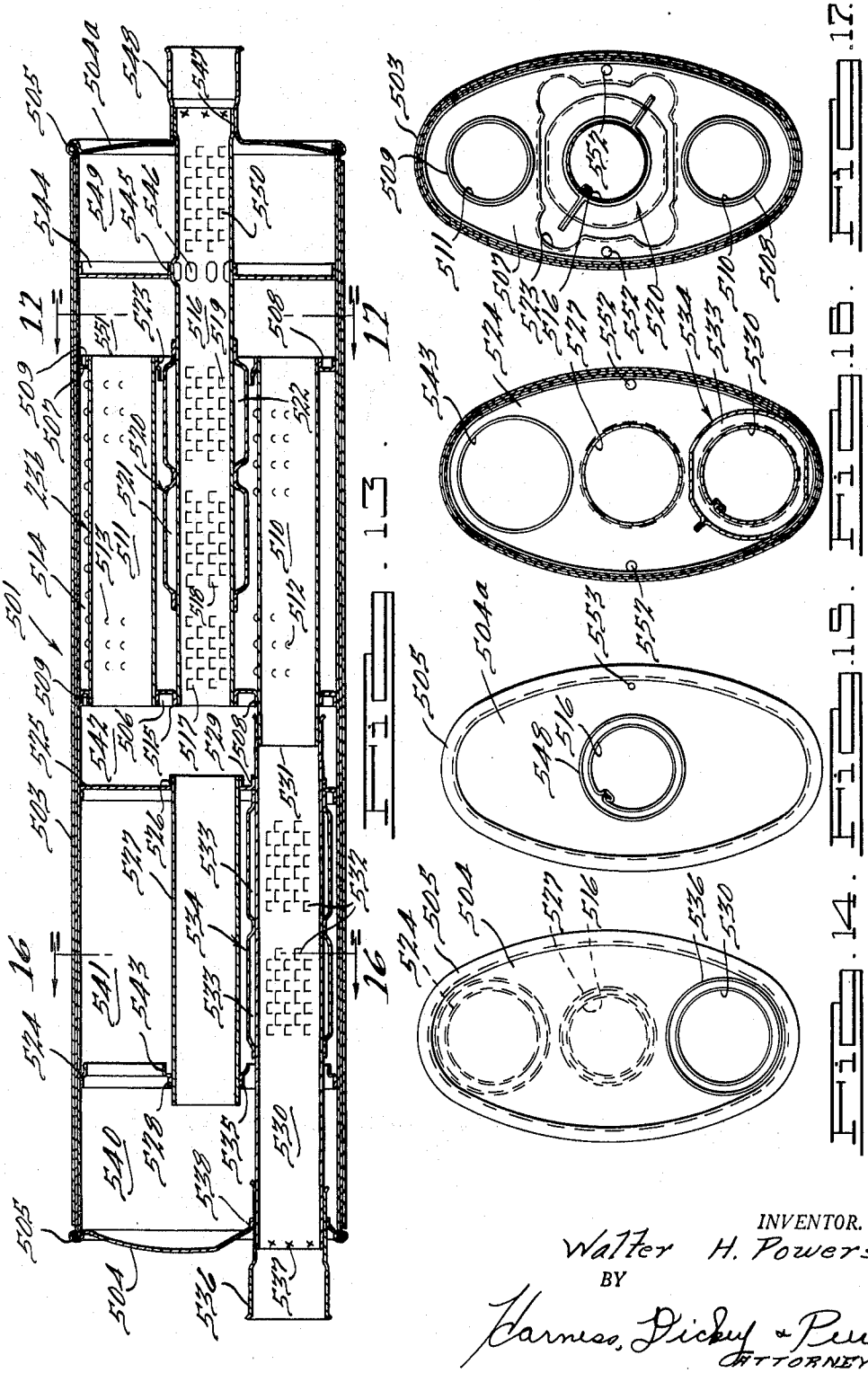


FIG. 13.

FIG. 17.

FIG. 16.

FIG. 15.

FIG. 14.

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MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

Original Filed April 2, 1956 8 Sheets-Sheet 7

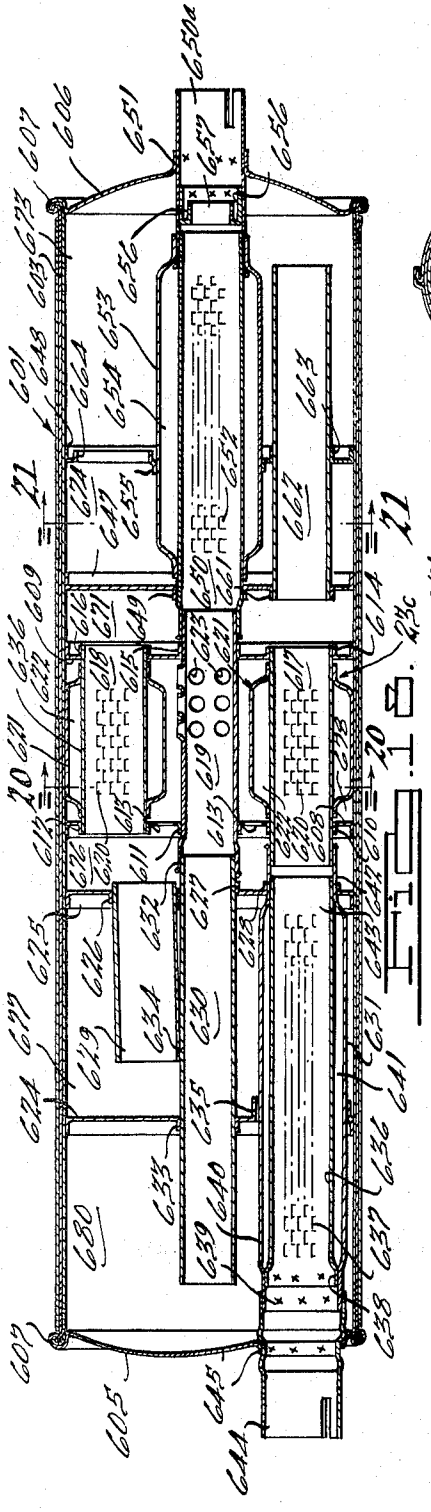


Fig. 18.

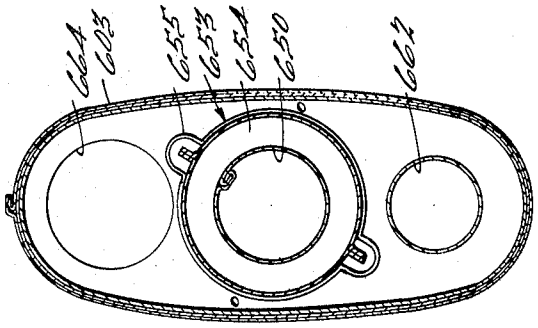


Fig. 21.

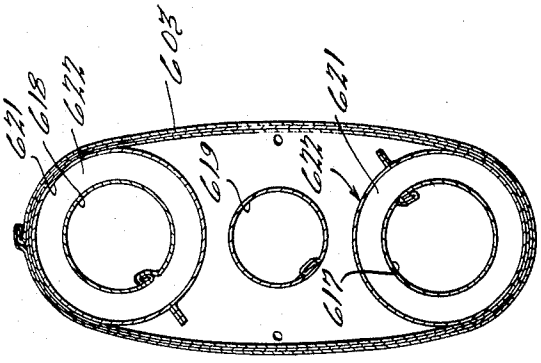


Fig. 20.

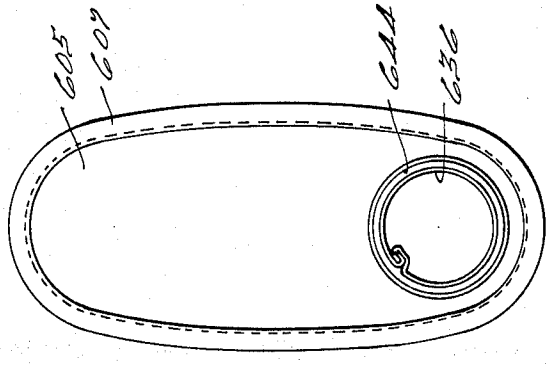


Fig. 19.

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MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

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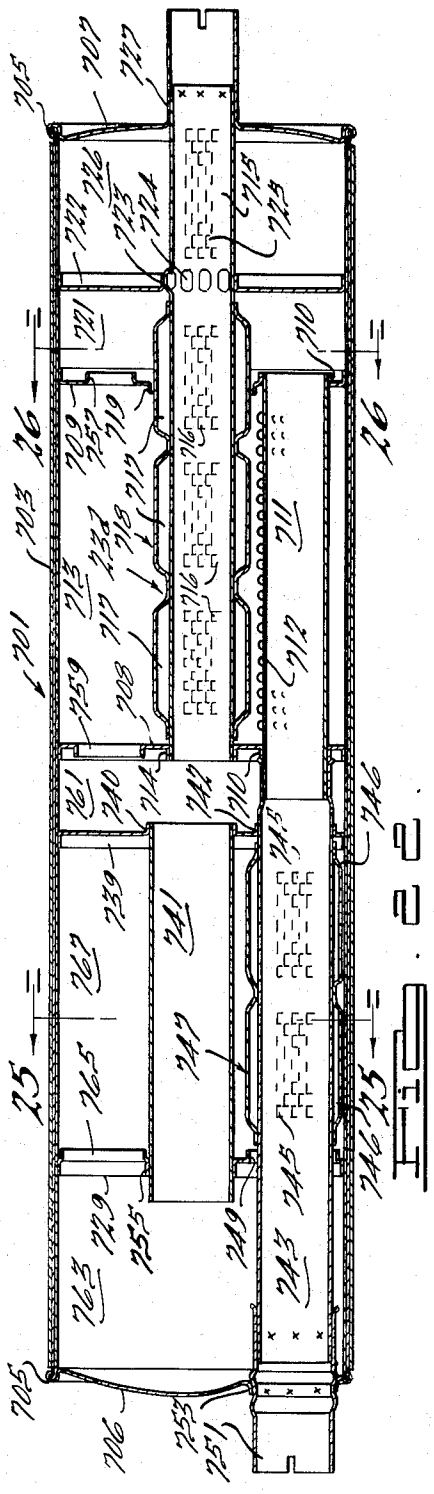


Fig. 22.

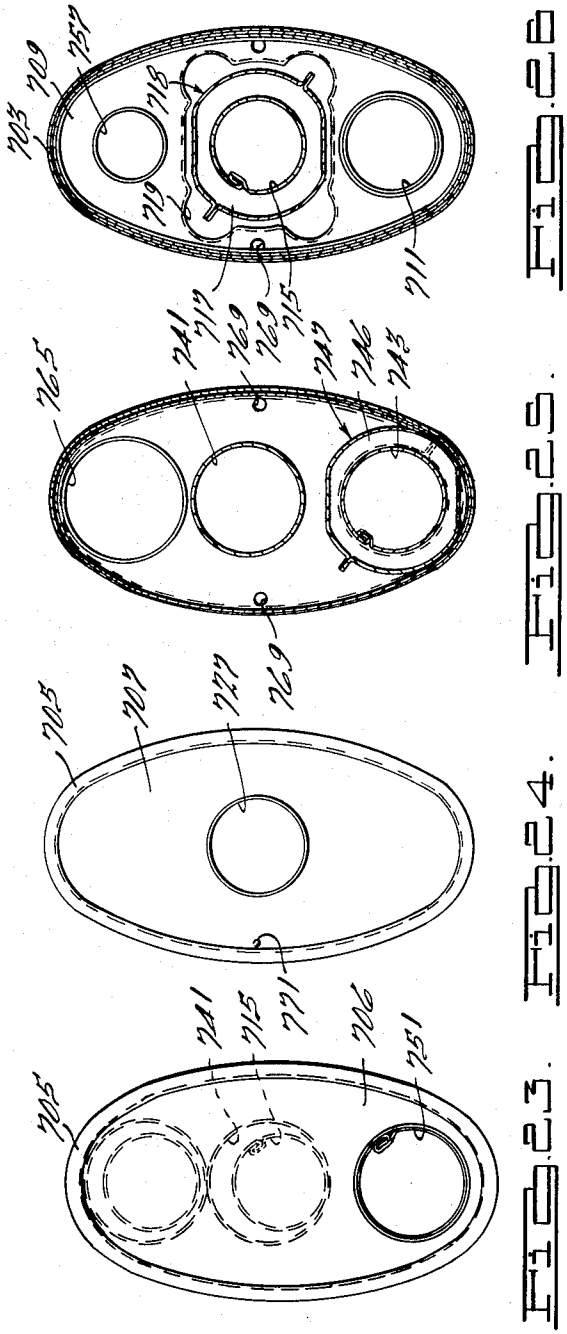


Fig. 26. Fig. 25. Fig. 24. Fig. 23.

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United States Patent Office 3,243,012 Patented Mar. 29, 1966

3,243,012

MUFFLER CONSTRUCTED TO VAPORIZE CONDENSATE FROM INNER CHAMBERS

Walter H. Powers, Racine, Wis., assignor to Walker Manufacturing Company, a corporation of Delaware

Continuation of application Ser. No. 575,404, Apr. 2, 1956. This application Sept. 6, 1961, Ser. No. 136,286
3 Claims. (Cl. 181—72)

This case is a continuation of U. S. Serial No. 575,404, filed April 2, 1956 and now abandoned.

This invention relates to muffler constructions and, in particular, to mufflers of the type adapted to silence the exhaust stream of automotive internal combustion engines.

It is the object of this invention to provide a muffler construction that may be economically manufactured and yet which is rugged and durable in construction and which will efficiently silence the powerful modern day automotive engines, particularly those having automatic transmissions, without appreciable back pressure.

It is an additional object of this invention to provide new and improved condensate disposal means within the muffler, which means is operative to cause vaporization of condensate within the muffler and removal with the exhaust gases flowing through the muffler.

The invention accomplishes these and other objects by means of a construction in which the gas passages within the muffler casing are arranged in a multiple chamber tri-flow pattern and subjected to the action of a number of spit chambers both large and small which will remove the roughness and high frequency sounds. The gases and sounds are also exposed to the action of a number of resonator chambers which will act to remove the lower frequency heavy power notes. The internal tri-flow construction is of such a nature that it can be pre-assembled, that is, prepared as a subassembly and then inserted into the muffler casing. The over-all design is such as to meet the cost and performance requirements of automotive manufacturers, particularly those manufacturing V-8 engines. In order to obtain the desired acoustical characteristics, the muffler is divided into a plurality of chambers some of which are connected directly in the gas flow path through the muffler and some indirectly in various manners. The acoustic arrangement of the internal silencing structure of the muffler is such as to result in substantial temperature differentials within the muffler during operation. Consequently, some parts of the muffler will be operated hot at temperatures sufficiently high to cause vaporization of condensate in the muffler while other parts of the muffler will be operated at relatively cold temperatures at which the condensate is not readily vaporized or not vaporized at all. As a result, therefore, some of the chambers in the muffler are hot chambers and other are cold chambers. It has been found that accumulation of condensate in the cold chambers will greatly decrease muffler life. Therefore, this invention contemplates drainage means provided within the muffler to connect the cold chambers to the hot chambers so that condensate in the cold chambers can flow to the hot chambers and be vaporized therein for removal with the exhaust gases.

The invention is illustrated in modified forms in the accompanying drawings in which:

FIGURE 1 is a longitudinal section of a preferred form of the invention as taken on line **1—1** of FIG. 3;

FIG. 2 is an end view taken from the left of FIG. 1;

FIG. 3 is a cross section taken along the line **3—3** of FIG. 1, the louvers being omitted for simplification;

FIG. 4 is an enlarged side elevation of one of the gas conduits with parts broken away to show the structure of the louvers in the tube;

FIG. 5 is a cross section through the louvers shown in FIG. 4 and laid out straight rather than on the curved contour of the tube;

FIG. 6 is a longitudinal cross section through a slightly modified type of muffler, the end view and sectional view being the same for this muffler as FIGS. 2 and 3;

FIG. 6A is a section on line **6A—6A** of FIG. 6;

FIG. 7 is an enlarged view, with portions broken away, of the front end of a muffler somewhat similar to the muffler shown in FIG. 6, the structure in FIG. 7 revealing a pancake inlet arrangement;

FIG. 8 is a section on line **8—8** of FIG. 7;

FIG. 9 is a perspective view showing a modified arrangement for forming the tri-flow passages in the muffler, this constituting a pancake arrangement consisting of complemental stampings which when fitted together will define the spit chambers around the outermost passages and define the inner passage itself;

FIG. 10 is a longitudinal cross section of a modified form of muffler;

FIG. 11 is an end view taken from the inlet side of the muffler of FIG. 10;

FIG. 12 is a cross section taken along the line **12—12** of FIG. 10;

FIG. 13 is a longitudinal section through another muffler embodying the invention;

FIG. 14 is an end elevation taken from the inlet end of the muffler of FIG. 13;

FIG. 15 is an end elevation taken from the outlet side of the muffler of FIG. 13;

FIGS. 16 and 17 are cross sections taken along the lines **16—16** and **17—17** respectively of FIG. 13;

FIG. 18 is a longitudinal section through another form of muffler embodying the invention;

FIG. 19 is an end view from the inlet end of the muffler of FIG. 18;

FIGS. 20 and 21 are cross sections taken along the lines **20—20** and **21—21** of FIG. 18;

FIG. 22 is a longitudinal section through another muffler embodying the invention;

FIG. 23 is an end elevation taken at the inlet end of the muffler;

FIG. 24 is an end elevation taken at the outlet side of the muffler; and

FIGS. 25 and 26 are cross sections taken along the lines **25—25** and **26—26** of FIG. 22.

Considering first the muffler **1** that is shown in FIGS. 1–5, there is a casing **3** of oval cross sectional form constructed in accordance with known practice so that internal baffles or partitions can be spot welded to it. It is provided with a head **5** at the inlet end and a head **7** at the outlet end, both heads being interlocked as shown at **9** with the ends of the casing **3**. An inlet bushing **11** is expanded as shown at **13** into a tight contact with the outwardly turned flange or neck **15** on the head **5** so that the bushing **11** can be properly spot welded to the neck after the head and internal parts have been assembled with the casing **3**. The head **7** has an outwardly turned neck or flange **17** in which is fitted an outlet bushing **19** that is expanded diametrically into contact with the neck **17** as shown at **21** so that the bushing **19** can be spot welded to the flange **17** after the head and internal parts have been assembled to the casing **3**. Gas to be silenced flows from the engine through a suitable exhaust line into the inlet bushing **11** and passes through the various gas silencing apparatus within the casing **3** and out through the bushing **19** to the tail pipe of the exhaust system.

The central part of the apparatus within the muffler **1** is a subassembly **23** which can be manufactured as a unit and inserted in the muffler, the various other parts being

assembled later on from both ends of the muffler and then the heads 5 and 7 attached by interlocking at 9 to the casing after which the bushings 11 and 19 are expanded at 13 and 21, respectively, into contact with the necks 15 and 17 and spot welded in place. The subassembly 23 is supported by the parallel transverse partitions 25 and 27. These have flanges 25*a* and 27*a* that run parallel to the inside surface of the casing 3 and which are turned outwardly so that they can be spot-welded to the casing 3 by suitable spot welding apparatus including inner and outer electrodes that are radially aligned inside and outside of the casing, the outwardly turned flanges permitting such apparatus to be inserted inside the casing in proper position. The partition 25 has three outwardly turned flanges or necks 29, 30, and 31 which are aligned, respectively, with the outwardly turned flanges or necks on partition 27 that are designated by reference numbers 32, 33, and 34 respectively. Spot-welded in position to the necks 29 and 32 is an intermediate tube 35 having louvers 37 formed therein along the surface which are of the type shown in FIGS. 4 and 5 so that they can direct gas circumferentially around the outside of the tube 35. Mounted in and spot welded to the necks 30 and 33 is an outlet tube 39 and this projects some distance beyond the end of the partition 27 as shown at 41. Mounted in and spot welded to the necks 31 and 34 is the inlet tube 43 and this tube has a somewhat enlarged end projecting toward the inlet end from the partition 25 as will be seen at 45. The tubes 39 and 43 each have louvers 37 of the type already mentioned. The inlet tube 43 has a pair of spit chambers 47 and 48 formed around it and the intermediate pass tube 35 has spit chambers 49 and 51 formed around it.

The chambers 47 and 48 as well as the chambers 49 and 51 are formed by pancake assemblies 53 and 55 respectively. The pancake assemblies 53 and 55 are substantially identical so that the description of one will suffice. Each assembly consists of a pair of identical stampings or halves 52 which are provided with flanges 57 that lie in the plane of the original sheet metal from which the pancake halves were originally formed, the chamber portions being pressed or "bowled" out of the flat pieces. The flanges 57 are joined together face to face as clearly seen in FIG. 3 and spot welded together so that the two halves form a shell around the tube. The ends 59 and 61 of the halves of the pancake are formed to snugly fit the periphery or semi-periphery of the tube as is the center portion 62. These can be spot welded to the tubes if desired. Angularly spaced from the flanges 57, the halves of the pancake assemblies 53 and 55 are formed with flats as shown at 65 and one edge of the pancake assembly is trimmed so that the flange 57 is removed beyond the diameter of the spit chambers as will be seen at 67 in FIG. 3. By removing the flange 57 at the point 67 and forming the flats 65 it is possible to fit the pancakes 53 closely to the contour of the casing 3 and to get a good deal of additional space adjacent the center outlet tube 39 as is evident from FIG. 3. The pancake assembly halves are so formed that they can be considered standard parts to be used in muffler 1 or in various other mufflers having different over-all dimensions and internal spacings. The flats 65 and the cut off outer flanges increase the flexibility in this respect because they reduce the space taken up by the pancakes, enabling them to be used in mufflers where quarters are more cramped than in muffler 1.

It will be seen that the partitions 25 and 27 with the tubes 35, 39 and 43 spot welded in the respective necks and in turn carrying pancake assemblies 53 and 55 can all be assembled as a subassembly into a spot welded integral unit. This unit 23 can then be inserted into the center portion of the casing 3 whereupon the partitions 25 and 27 can be spot welded in place to the casing and, after this, the elements to the left and to the right of the subassembly 23 can be inserted into the muffler as a part of the final assembly operation. When inserting assembly 23 I prefer to put the casing 3 in a fixture that will hold the casing in its proper shape and I also prefer to outwardly flare the ends of the casing so that the assembly 23 will in effect be funneled into it. These steps will eliminate difficulties caused by having the outwardly turned flange on partitions 25 or 27 as the leading edge during insertion.

Adjacent to but spaced longitudinally toward the inlet end 5 of the muffler is a transverse partition 71 and spaced between it and the header 5 is another transverse partition 73. The partitions 71 and 73 have inwardly and outwardly turned flanges or necks 75 and 77, respectively, through which extends a connecting inlet pipe 79, with louvers 37 therein, that slidably fits within the enlarged end 45 (flared at 83) of the tube 43 (which is a part of the subassembly 23) as will be seen at the point 81. The outermost end of the tube 79 is spot welded at 85 to the inner end of the inlet bushing 11. It will be seen that this arrangement provides a reinforcement for the head 5 since the bushing 11 is spot welded to the head and then to the tube 79 which in turn is spot welded to the partitions 73 and 71 by way of necks 77 and 75.

The chamber between the head 5 and the partition 73 constitutes a resonator chamber 87. The chamber 89 between the partition 71 and the partition 25 is a cross-over chamber. Connecting the cross-over chamber 89 with the resonator chamber 87 is a tuning tube 91 that is spot welded in and to inwardly and outwardly turned flanges or necks 93 and 95, respectively, in the partitions 71 and 73.

At the outlet end of the casing 3 there is a transverse partition 97 that is spaced from the partition 27 to define therewith a cross-over chamber 99. Between the partition 97 and the head 7 is a partition 101 which like the partition 97, and the other partitions herein, has an outwardly extending flange running around it by means of which it is seated in position on the inside of the casing 3 and then spot welded to the casing by radial electrodes on the inside and outside of the casing. The space between partition 97 and partition 101 constitutes a resonator chamber 103 while the space between the partition 101 and the end header 7 constitutes another resonator chamber 105. The outlet bushing 19 fits in an outwardly turned flange or neck 107 in the partition 101 and is spot welded to it, thus typing the head 7 to the partition 101 to reinforce the head 7. As shown at 109, fitting inside of the end of the bushing 19 and spot welded to it is a connecting tube 111 that is enlarged at its end as shown at 113 and flared so that it slip fits over the end 41 of the outlet passage tube 39, the tube 111 extending through the inwardly flanged neck 115 of the partition 97 and being spot welded to it. A tuning tube 117 is spot welded to inwardly and outwardly turned flanges 119 and 121 on partitions 97 and 101 and is preferably aligned with tube 43. Flanged opening 123 connects chambers 103 and 105 to form a compound resonator.

In assembly, after unit 23 has been inserted and spot welded in place, the partitions 71 and 97 with tubes 91, 111, and 117 already spot welded to flanges 93, 115, and 119 are inserted and the outwardly turned partition flanges spot welded to the casing by spot welding apparatus inserted through the ends of the casing. Partition 73 with tube 79 spot welded to flange 77 (and bushing 11 spot welded to tube 79) and partition 101 with bushing 19 spot welded to flange 107 are then inserted, the outwardly turned flange 95 slipping readily over tube 91 and the flared end of bushing 19 slipping over the end of tube 111. Then, from the inside of the casing, the outwardly turned partition flanges are spot welded to the casing, the tubes 91 and 117 are spot welded to outwardly turned flanges 95 and 121, and the end 109 of tube 111 is spot welded to bushing 19. It may be noted that end louvers 37′ will engage partition 71 to limit the slipping of tube 79 into tube 43 and that flange 75 will catch under flare

83 to control insertion of partition 71. It may also be noted that the tubes 79 and 43 may be connected together, if desired, in the same sort of joint as bushing 19 and tube 111, i.e., the tube 43 slipping inside and spot welded to the tube 79 which in turn was spot welded to flange 75. After the partitions and members have been inserted and spot welded in place, as described, the end headers 5 and 7 may be interlocked at 9 and the bushings 11 and 19 expanded and spot welded to flanges 15 and 17.

In operation, gas enters the inlet bushing 11 and flows through the tube 79 into the tube 43. Some of the gas passes through the louvers 37 of tube 79 into the large spit chamber 121 between partitions 71 and 73. Other gas passes through louvers 37 of the tube 43 into the spit chambers 47 and 48, these various spit chambers acting to eliminate roughness and relatively high frequency sounds. Gas leaving the tube 43 enters the cross-over chamber 99 and passes upwardly to the intermediate flow-back tube 35. Heavy notes may pass through the imperforate tube 117 into the resonator chamber 105 and this action is compounded by means of the flanged tuning neck or opening 123 in partition 101 which connects the resonator chamber 105 in a compound relationship with the resonator chamber 103. The gas that is flowing through the tube 35 is subjected by means of its louvers 37 to the high frequency spit chamber control of chambers 49 and 51 and flows into the cross-over chamber 89. Heavy notes still in the gas may pass through the imperforate connecting tuning neck 91 into the resonator or tuning chamber 87. The gas flows toward the outlet through the tube 39 and from louvers 37 into the spit chamber of relatively large size 125 which lies between the partitions 25 and 27. The gas flows through tube 39 into the tube 111 and thence into the outlet bushing 19 from which it goes to the tail pipe and to the exhaust.

It may be noted that aligned apertures 124 in the headers and partitions are drain holes and may be formed at the bottom of all six internal partitions and preferably, for standardization, also at the tops thereof as shown. Thus, the condensate sump means in the muffler, defined by the end headers 5, 7, the partitions 25, 27, 71, 73, 97, 101, and the bottom wall of the muffler casing, are connected by the condensate drainage holes. When all the internal partitions are provided with the drain openings 124, which are preferably about ¼" diameter, water within the muffler will flow back and forth lengthwise of the muffler from the cool to the hot chambers as the muffler rocks back and forth slightly due to movement of the vehicle in which it is mounted. This water will be vaporized by the hot exhaust gases and carried out by them without the need for any external drainage openings. The end chambers 87, 121, 103, and 105 tend to run cooler than the other central chambers and act as natural "condensers" but due to the connection of these chambers with the hotter central chambers by way of openings 124 the condensate will move to the central chambers and be evaporated, thus markedly reducing corrosion of the muffler. These features are of particular importance in dual muffler systems as the mufflers therein tend to be cooler and thus more likely to corrode.

Turning now to the form of muffler shown in FIG. 6, this muffler being designated by the reference number 141, it will be seen that there is found within the casing 143 of the muffler a subassembly which is identical to the subassembly 23 and which will therefore be identified by the reference number 23', no further details of structure being mentioned since it is interchangeable with the unit 23 that has already been described. At the inlet end of the muffler 141 are a pair of transverse partitions 145 and 147. The partitions have inwardly and outwardly turned necks 149 and 151, respectively, through which extends an imperforate tuning neck or tube 153 which is spot welded to both of the necks 149 and 151, being spot welded to neck 149 outside of the casing and to neck 151 inside the casing in accordance with assembly techniques discussed above. The partitions 147 and 145 also have flanged openings or necks 155 and 157 and through these extends a long inlet tube 159. The tube 159 is spot welded to the neck 157 and projects beyond the partition 145 as shown at 161. It also projects a very substantial distance beyond the partition 147 toward the inlet of the muffler as shown at 163. The tube 159 may be of a lock seam construction and provided with spaced embossments 165 whereby it is readily turned into a tubular section from a flat section and spot welded to the neck 157 on the embossments prior to being inserted in the casing. The tube 159 is provided with a set of louver openings similar to those previously described and shown in FIGS. 4 and 5, these being identified by reference number 167 and omitted from FIG. 6A for simplicity. The louvers 167 are located between the partitions 145 and 147 and open into the chamber defined by these partitions, this constituting a large spit chamber 169 and louvers 167*a* abut partition 145. Outwardly of the embossment 165 area, the tube 159 is provided with another set of similar louvers 171. Around the tube and around the set of louvers 171 is a pancake construction 173 of the same type as previously described pancakes 55 and consisting of complemental halves 175, as shown in FIG. 6A. The halves are flat sheet metal pieces bowled out and spot welded together around their flanges 176 to provide a spit chamber 177. The closely fitting ends 175*a* of the pancakes are spot welded to the tube 159. One flange 176' is cut off flush with the periphery, as before, so that it fits snug against the casing. The halves are provided with flats 174 to decrease over-all size as indicated in connection with pancakes 55.

A flanged partition 181 at the inlet end has a flanged tuning neck or opening 183 that is larger than the tube 159 and the inlet bushing 185 which is spot welded to the tube 159 at 187.

The partition 181 also has flanged openings 189 and 191. The space between the partitions 181 and 147 constitutes a resonator chamber 193 and the space between the partition 181 and the inlet end header 195 constitutes another resonator chamber 195' which, being in series with the chamber 193, the two chambers act as a compound resonator construction. The header 195 is assembled to the casing 143 after the parts already described have been inserted in accordance with principles outlined above and is interlocked as shown at 197 with the ends of the casing. The header 195 has an outwardly flanged neck 199 that is larger than the inlet bushing 185 so after assembly the bushing 185 is expanded as shown at 201 into tight engagement with the neck 199 and then it can be spot welded to the flange or neck 199.

At the outlet end of muffler 141 there is a dished partition 203 which has a flanged neck or opening 205 in which is spot welded imperforate tuning tube 207 prior to insertion in the casing. The space between the partition 203 and the partition 27' constitutes a cross-over chamber 209. Also spot welded to a neck 211 in the partition 203, prior to insertion in the casing, is the inlet bushing 213 and it will be seen that it slip fits over the projecting end 41' of the outlet passage tube 39'. The outlet end header 215 can be placed over the bushing 213 and the periphery thereof interlocked at 197 with the end of the casing. The bushing 213 can then be expanded at 217 into tight contact with the neck 219 of the header 215 and spot welded to it. It will be seen that from this arrangement the inlet bushing 185 and the outlet bushing 213 both act to tie their respective headers 195 and 215 to the internal parts of the muffler and thus serve to reinforce the heads against strain or blowout.

In operation, inlet gas enters the bushing 185 from the exhaust line of the engine and passes along tube 159 into the tube 43'. As the gas passes the spit chamber 177 (in resonator chamber 193) certain of the high frequency sounds and roughness are removed. When

it passes the larger spit chamber 169 some of the lower frequency roughness and noise is removed by passage through the louvers 167. In the tube 43' the gas is subjected to the action of spit chambers 47' and 48'. Gas leaving the tube 43' enters the cross-over chamber 209 and some of the lower notes may pass through the imperforate tuning neck 207 which is in alignment with the intermediate tube 43' and be subjected to the action of the resonator chamber 221 which lies between the partition 203 and the end header 215. Gas passing through the intermediate passage 35' is subjected to the action of the spit chambers 49' and 51' and then passes into the cross-over chamber 223 between the partition 25' and the partition 145. Gas in the cross-over chamber 223 is subjected to the action of the compound resonator chamber construction 193 and 195, the gas or sound waves passing through the tube 153 into the chamber 193 and from thence it can pass through the openings 183, 191, or 189 into the chamber 195, it of course being obvious that anything entering these chambers must be reflected back to the cross-over chamber 223 through the tuning tube 153. In order to leave the cross-over chamber 223 for the exhaust line, the gases must pass through the outlet pipe 39' and in doing so they will be subjected to the action of the large spit chamber 125'. Gas then enters the outlet bushing 213 and passes onto the tail pipe and thence to atmosphere.

FIGS. 7 and 8 show a modified form of inlet end construction for a muffler 141', similar to muffler 141 as shown in FIG. 6, in which tuning occurs off the inlet tube 159'. In this arrangement there is an imperforate transverse partition 251 and a transverse partition 253 having a flanged opening or slot 255, a necked large opening 258, and smaller openings 257 which communicate the chamber 259 between the partitions with the chamber 261 between the inlet header 195' and the partition 253. The partition 253 is of the particular shape that is seen best in FIG. 8. The inlet tube section 159' has a long series of louvers 263 preferably similar to those shown in FIGS. 4 and 5, these being omitted from FIG. 8 for simplicity. Supported on and around the inlet tube 159' is a pancake construction 265 which consists of the stamped identical halves 267 and 268 formed from initially flat sheet metal. The flanges and intermediate web 269 and 271, respectively, of the halves are spot welded together to form a unitary section and the end necks 273 and 274 are spot welded to the tube in the manner that has already been discussed above in connection with the pancakes used to provide the spit chambers. The halves are formed to provide a long spit chamber 275 around the openings 263. Communicating with the spit chamber 275 is a fairly long tuning passage 277 (constituting with chamber 275 a long reverse bend passage) which leads gases from the spit chamber into the resonator chamber 259 where the gases are subjected to the tuning action of chambers 259 and 261. The construction will serve in some applications to replace tuning from the cross-over chamber 223 in the muffler of FIG. 6. The flange 269 is cut off on one side as shown at 269' to provide a snug fit to the side of the casing. The pancake 265 is supported by spot welding of the necks 273 and 274 on the tube 159' and also by spot welding of flanged slot 255 thereto at points of contact 279. Partitions 251 and 253, tube 159', and pancake 265 may be put together as a subassembly and inserted into the casing prior to interlocking of head 195'. Obviously the structure shown in FIGS. 7 and 8 could be modified to include an inlet bushing expanded onto neck 199' and spot welded to tube 159' just as in FIG. 6, if desired.

FIG. 9 shows a modified pancake construction 301 for the subassembly 23 or 23'. In this arrangement the outlet passage 39'' as well as the spit chambers 47'', 48'', 49'', and 51'' are all formed in the two complemental pancake stampings 303 and 305 which are spot welded together in the contacting flanges and webs 307 and 309. The spit chambers are necked down in the same manner as before to contact and be spot welded to tubes 35'' and 43''. The outlet passage 39'' formerly provided by tubes 39 or 39' is, in this case, formed right in the halves 303 and 305. Louvers 37'' for passage 39'' are formed in the halves 303 and 305. It is obvious that pancake 301' can be combined with partitions 25 and 27 (or 25' and 27') to form a spot welded subsassembly 23 having the advantages and functions already described.

FIGS. 10–12 show another muffler 401 embodying the principles of this invention. This muffler has an outer shell or casing 403 consisting of a spirally wrapped double ply inner shell 402 which is interlocked at 405 to the inlet and outlet end headers 407 and 409 and around which is disposed a single layer 404 of sound deadening metal which is attached in place after the partitions have been spot welded to the double wrapped shell 402, the friction between the two layers dissipating sound energy. Disposed within the casing 403 is a tri-flow subassembly 23*a* which corresponds to the unit 23 that has already been described, the principal difference being that pancake spit chambers are provided around only one of the three tubes. The subassembly 23*a* comprises inlet and outlet side partitions 411 and 413 having three sets of aligned openings all of which are provided with outwardly extending flanges 415, 417, and 419. Spot welded in the sets of flanges are the inlet tube 421, the intermediate tube 423, and the outlet tube 425. Each of the tubes is provided with louvers, the tubes 423 and 425 having louvers 427 which are more or less tubular shaped while the tube 421 has louvers 429 that are shaped like the louvers 37 of FIGS. 4 and 5. Mounted on the tube 421 around the louvers 429 is a double pancake assembly 431 identical to those already described in connection with the other modifications and which provides a pair of spit chambers 433 communicating with the inlet tube 421.

Between the subassembly 23*a* and the inlet header 407 is a transverse partition 435 having an outwardly turned flange whereby it may be spot welded to the casing after insertion of the subassembly 23*a*. The partition 435 has a central opening provided with an outwardly extending flange 437 and this is aligned with the flange 439 around the inlet in the header 407. An inlet bushing 441 extends through the outwardly extending flange 439 and is spot welded to it. The inlet bushing is necked down at 443 and flared at its inner end as shown at 445 so that it slidably receives the outer end of the inlet tube 421 which is spot welded at assembly to it, the flange 437 and the bushing 441 also being spot welded together at a pre-assembly operation (i.e. before the parts are inserted in casing 403). The partition 435 also has a tuning tube 447 spot welded to the flange 449 of an opening therein which is aligned with tube 423, this being done prior to insertion of the partition 435 in the muffler casing. The partition 435 divides the space between partition 411 and header 407 into a resonator chamber 451 and a cross-over chamber 453.

On the outlet side of the subassembly 23*a* are three partitions 455, 457, and 459, all provided with outwardly extending flanges so that they may be spot welded to the casing after insertion therein. The partition 455 has an opening aligned with the outlet tube 425 and provided with an inwardly extending flange 461 to which is spot welded the outlet tube 463. The outlet tube 463 is also spot welded in a neck 465 formed in the outlet header 409 and it slidably fits in a flanged opening 466 in partition 457 and extends through an enlarged opening 467 in the partition 459. The tube 463 is enlarged at its inner end and flared to slidably fit over the end of the tube 425 at assembly, the outwardly flared end engaging the flange 419 to control the location and insertion of the tube 463.

Aligned with the inlet tube 421 is a tuning tube 468 that is spot welded at a pre-assembly operation to the flange 469 in partition 455 and after assembly to the outwardly turned flange 470 of partition 457, the outer end of the tube 468 terminating in but being spaced from the flanged edges of an opening 471 in the partition 459. The partitions 455, 457, and 459 define with the partition 413 and the outlet header 409, a series of chambers which in FIGURE 10 are from left to right as follows: a cross-over chamber 472, a large spit chamber 473, a resonator chamber 474, and a resonator chamber 475 which is compounded with the resonator chamber 474 through the openings 467 and 471 in the partition 459 as well as by a flanged opening 476 in partition 459 (the flanged openings in the partition 459 acting as tuning necks). Louvers 477, similar to louvers 37, in the tube 463 open into the spit chamber 473.

The opposite sides of the muffler casing 403 may, in the region of chambers 451 and 475, be provided with inwardly extending embossments or beads 478 to prevent flutter of the side walls and the inlet bushing 441 may have a pair of indentations 479 formed therein on opposite sides as stops for the pipes to be inserted therein.

In operation of the muffler 401, gases enter the inlet bushing 441 and pass through the tube 421 where some of the high frequency sounds are silenced in spit chambers 433. Some of the gas passes through the tube 468 where lower notes are silenced in the resonator chambers 474 and 475 but this gas must return through the tube 468 and with gas from the outlet of tube 421, enter cross-over chamber 472 and reverse its direction to pass through tube 423 wherein additional silencing is accomplished by communication through louvers 427 with the large spit chamber 480 between the partitions 411 and 413, some back pressure reducing cross bleeding occurring from tube 423 to outlet tube 425 through chamber 480. Gas leaving the tube 423 enters cross-over chamber 453 and communicates through tuning tube 447 with a resonator chamber 451 where further low notes may be removed. From cross-over chamber 443 gas passes rearwardly through tube 425 and out of the muffler through the bushing 465 after additional silencing in spit chambers 480 and 473 takes place through communication with these chambers by way of louvers 427 and 477.

To permit condensed water to flow to the relatively hot chambers 472, 453, and 480, the six partitions in the muffler 401 are provided with small (¼" diameter) drain holes at their midplane at the top and bottom thereof as seen at 481 in FIG. 12, the inlet and outlet headers 407 and 409, however, being imperforate. This arrangement provides for internal drainage of water that accumulates inside the casing 403 so that the hot gases passing through the muffler will evaporate the water and pick up the resulting vapor and carry it out of the muffler.

FIGS. 13–17 show another modified form of muffler 501 using a tri-flow subassembly 23*b* similar to the assemblies already described. This muffler has a casing 503 to the opposite ends of which are interlocked, after insertion of all the inner parts, the inlet and outlet headers 504 and 505, respectively. This subassembly 23*b* comprises the inlet side partition 506 and the outlet side partition 507 each of which have outwardly turned peripheral flanges whereby they may be spot welded in place in the casing 503 after insertion. The partitions 506 and 507 have sets of aligned holes provided with outwardly extending flanges as shown at 508 and 509 to which are spot welded the inlet tube 510 and the return flow tube 511, respectively. The tubes 510 and 511 have rows of louvers 512, 513 formed therein opening into the chamber 514 between partitions 506 and 507. The partition 506 has a central opening provided with an outwardly turned flange 515 to which is spot welded the end of an outlet tube 516. The outlet tube 516 has three sets of louvers 517, 518, and 519 all of which are similar to louvers 37. The louvers 518 and 519 are encased by a pancake subassembly 520 of the type already described in detail which forms small volume spit chambers 521 and 522 around the outlet tube, the louvers 517 opening directly into the relatively large volume chamber 514. The pancake 520 projects through the double diameter neck 523 formed in partition 507 and which has a shape best seen in FIG. 17, the flat sides of the pancake being parallel to flat sides of the opening.

On the inlet side of the subassembly 23*b* are two partitions 524 and 525 each of which has an outwardly turned flange so that it may be spot welded to the casing 503 after it has been inserted therein. The partition 525 has an inwardly extending flange 526 around an opening that is aligned with the outlet tube 516 and to which is spot welded the inner end of a tuning tube 527 prior to insertion of the partition 525 in the casing. The outer end of the tube 527 is supported on and spot welded at assembly to the flange 528 in the partition 524. The partition 525 also has an inwardly turned flange 529 around an opening that is aligned with the inlet tube 510 and to this flange is spot welded, prior to assembly, an inlet tube 530. The tube 530 is necked down at 531 and flared at its inner end so that it can readily slide over the projecting end of the tube 510. The tube 530 is provided with two sets of louvers 532, similar to louvers 37, and these open into spit chambers 533 provided around the tube 530 by the pancake assembly 534 of the type already described. The outer end of the tube 530 extends through a tuning neck 535 of larger diameter than the tube and over its outer end is slipped the end of the inlet bushing 536 which is spot welded to the tube 530 on the outside of the header 504 as indicated at 537, the bushing 536 having been spot welded to an inwardly flanged neck 538 on the head 504 at a pre-assembly operation. The partitions 524 and 525 act with the inlet header 504 and the partition 506 to define the chambers 540 and 541 which act as a compound resonator chamber connected by tube 527 with the cross-over chamber 542. Another tuning neck 543 is formed in partition 524 to act with the neck 535 to intercommunicate the chambers 540 and 541.

At the outlet side of the subassembly 23*b* is a partition 544 with an outwardly turned flange so that it may be spot welded to the casing after insertion therein. This has an opening aligned with the outlet tube provided with an outwardly extending flange 545 in which are seated the embossments 546 formed on the outlet tube 516 and which embossments are spot welded to the flange 545 at assembly. The outer end of the outlet tube 516 is enlarged as seen at 547 and spot welded to the outlet neck 548 formed integrally in the outlet header 505. The partition 544 acts with the outlet header 505 to provide a spit chamber 549 that communicates with the outlet tube 516 through louvers 550, similar to louvers 37, in the outlet tube. It acts with the partition 507 to define a cross-over chamber 551 connecting the inlet tube 510 and the intermediate tube 511.

In operation, exhaust gas enters the inlet bushing 536 and passes through the inlet tube 530 wherein certain high frequency noises and roughness are removed by the spit chambers 533. In passing through the inlet tube 510 additional noise is removed in the large spit chamber 514 by passage through louvers 512. The gas leaving tube 510 enters cross-over chamber 551 and reverses direction to pass through tube 511 back toward the inlet of the muffler. During passage through tube 511 certain noise and roughness is removed in chamber 514 by communication therewith through louvers 513. Gas leaving the tube 511 enters the cross-over chamber 542 and reverses direction to enter the outlet tube 516. The gas in the cross-over chamber 542 and the outlet tube communicates with the compound resonator provided by chambers 540 and 541 through the tube 527, which is aligned with the outlet tube 516, so that heavy notes

or low frequencies will be removed. Gas passing through the tube **516** passes by the louvers **517** which connects the gas with chamber **514**. High frequencies and roughness still remaining in the gas are removed in spit chambers **521** and **522** and finally in spit chamber **549**.

It will be noted that the gas in cross-over chamber **551** can communicate through a tuning neck **523** with the chamber **514** so that this chamber acts to some extent as a tuning chamber to remove tones or notes by virtue of this connection and as a spit chamber to remove roughness and noise by virtue of communication with the three tubes through louvers **512**, **513**, and **517**. It will also be seen that cross bleeding from tubes **510** and **511** and chamber **551** to louvers **517** in outlet tube **516** will lower back pressure.

Drain holes on opposite sides of each of the five interior partitions are provided as shown at **552** and these will give internal or inter-chamber drainage via the hot gases as already explained. Additionally a very small hole **553** (1/16–1/8" diameter, preferably 3/32" diameter) may be provided in the outlet header on the bottom side of the muffler to provide for external drainage, this hole being so small that it does not affect the acoustic characteristics of the chambers within the muffler, especially the chamber **549** (i.e. acoustically the muffler shell is substantially imperforate) but at the same time being large enough to permit water to leak out of the muffler when the muffler is cold and there are no hot gases to evaporate the water.

Another modified form of muffler **601** is shown in FIGS. 18–21 in which a tri-flow type subassembly is preassembled and inserted as a unit into the casing **603** prior to closing of the ends of the casing by interlocking the inlet and outlet headers **605** and **606** to the ends of the casing as shown at **607**. The subassembly **23***c* includes an inlet side partition **608** and an outlet side partition **609**. The partition **608** has three openings formed therein for the support of tubes, the flanges around these openings being designated by the reference numerals **610**, **611**, and **612**, respectively. The partition **608** also has a series of relatively large and non-restrictive openings **613** formed therein. The partition **609** has three flanged openings to support tubes which are aligned respectively with the flanges **610**, **611**, and **612**, these annular flanges being designated by the reference numerals **614**, **615**, and **616**, respectively. Supported in and spot welded to the flanges **610** and **614** prior to insertion of the subassembly **23***c* is an inlet tube section **617**; spot welded to flanges **612** and **616** is an intermediate tube **618**; and spot welded to the flanges **611** and **615** is a combination tuning tube and outlet tube **619**. The tubes **617** and **618** have louvers **620**, similar to louvers **37**, formed therein and these are covered by pancake units **621** similar to those already described but which provide single spit chambers **622** around the tubes. The tube **619** has relatively large and unrestricted openings **623** formed in the rear portion thereof, the front portion being imperforate.

On the inlet side of the subassembly **23***c* are the partitions **624** and **625** each of which have outwardly extending peripheral flanges so that it may be spot welded to the casing after insertion therein. The partition **625** has three openings formed therein defined by the flanges **626**, **627**, and **628**. Spot welded to these flanges prior to insertion of the partition **625** into the casing **603** are the short tuning tube **629**, the long tuning tube **630**, and an expanded tube **631**, all of these tubes projecting to some extent beyond the outlet side of the partition **625** and the tube **630** being adapted to slide within the flared enlarged end **632** of the tube **619** and the tube **631** being flared and adapted to slide over the end of the tube **617** when the partition **625** is inserted in place in the housing **603**. The partition **624** has an outwardly extending flange **633** around an opening that slips over the tube **630** when the partition **624** is inserted in the casing after which the flange **633** is spot welded to the tube **630**. Prior to such insertion the tube **629** is spot welded adjacent its outer end as shown at **634** to the tube **630**. The partition **624** also has a necked opening **635** which slips over tube **631** when the partition is put into the casing **603**.

Within the tube **631** is an inlet tube **636** which is illustrated as being of the same diameter as the tube **617** and aligned with it. It will be observed that the tube **636** has louvers **637** formed in it and these may be similar to louvers **37** already described. However, the outer diameter across the louvers **637** is no greater and preferably slightly less than the enlarged outer end section **638** of the tube **636** which slides within a portion **639** of tube **631** and is spot welded to such portion. The tube **631** is expanded at **640** opposite the louver **637** to provide a spit chamber **641** surrounding the tube **363** and coextensive with the louver **637**. The inner end of the tube **631** is necked down at **642** to fit in the annular flange **628** and be spot welded thereto in a pre-assembly operation as previously indicated. The inner end **643** of the tube **636** has a slide fit in the portion **642** and it will be apparent that the tube **636** can be inserted at assembly through the outer end of tube **631** and spot welded to the portion **639**. The portion **639** may be spot welded to the inner end of the inlet bushing **644**, the outer portion of which is radially expanded on both sides of the flanged opening **645** in the inlet header **605** and spot welded thereto. It will be noted that the use of the expanded outer tube **631** in conjunction with the inner tube **636** provides an inexpensive method of forming a split chamber of substantial length around the inner tube and one which takes up somewhat less space than the pancake assemblies illustrated hereinbefore. It is also capable of standardization so that it can be used in various muffler designs.

At the outlet end of the muffler **601** are the partitions **647** and **648** each with outwardly turned flanges so that they may be spot welded in place to the casing after insertion. The partition **647** has an inwardly extending flange **649** defining an opening in alignment with the tube **619** and spot welded at a pre-assembly operation to the flange **649** is an outlet tube section **650** which is necked down and flared at its inner end to slip over the end of tube **619**. Over the outer end of tube **650** is slipped the inner end of a bushing **650***a* which is spot welded to the flanged outlet neck **651** on the outlet header **606**. The tube **650** has a series of louvers **652**, similar to louvers **37**, formed therein and mounted on the tube and bushing a pancake assembly **653** which provides a spit chamber **654** around the louvers. The pancake assembly **653** is similar to those already described and extends through and is supported by a flanged opening **655** in the partition **648**, the shape of the opening **655** being best seen in FIG. 21. On the outlet side of the louvers **652** is mounted a restrictor member **656** in bushing **650***a* which consists of a reversely bent tube section, the outer portion of which is spot welded to the tube **650** at a pre-assembly operation and the inner portion **657** of which reduces the effective area of the outlet tube to serve with the tuning of resonator chambers to help silence pulses and beats.

The partition **647** has an inwardly flanged opening **661** formed therein to which is spot welded a tuning tube **662**. The tube **662** extends through the outwardly extending flange **663** of an opening in the partition **648**. Partition **648** also has a tuning neck **664** formed therein.

In operation of the muffler **601**, gas enters the inlet bushing **644** and passes through tube **636** where roughness and high frequency noises are removed in the split chamber **641**. They are further removed during passage through tube section **617** in the spit chamber **622**. On leaving the inlet tube **617** the gases enter the cross-over chamber **671** between partitions **609** and **647**. In this chamber they communicate through tuning tube **662** with a resonator chamber **673** between the outlet header **606** and the partition **648** and also through tuning neck **664** with a resonator chamber **674** between partitions **647** and **648**, the chambers **674** and **673** thus acting as a com-

pound resonator. Gases in cross-over chamber **671** reverse direction and pass through tube **618** wherein they are subjected to the action of the spit chamber **622**. On leaving tube **618** they enter a cross-over chamber **676** between the partitions **625** and **608**. Gases in the cross-over chamber **676** are subjected to the action of a resonator chamber **677** between partitions **624** and **625** through the tuning neck **629** which is offset from the axis of the tube **618**. The gases in cross-over chamber **676** pass through the non-restrictive openings **613** into the chamber **678** between partitions **608** and **609** and from there through non-restrictive openings **623** into the tube **619** from which they can flow through tube **650** and restrictor **657** to the outside of the muffler, being subjected to the action of spit chamber **654** on the way through the tube **650**. Gases in the tube **623** are also subjected to the action of the resonator chamber **680** between the inlet header **605** and the partition **624** by means of the tube **630** and the front portion of the tube **619**. It will be observed that by providing openings **613** in the partition **608** to get flow into the outlet tube through the volume of chamber **678**, it is possible to make the tuning tube, provided by a section of tube **619** added to the tube **630**, of unusually long length. This enables low frequencies to be removed in a relatively short muffler.

FIGS. 22–26 show another form of muffler **701** having a casing **703** with the ends interlocked at **705** with the inlet header **706** and the outlet header **707**. Within the casing **703** is a subassembly **23***d* corresponding in most respects to the subassemblies of this type previously described. This subassembly includes an inlet side partition **708** and an outlet side partition **709**, both having outwardly turned flanges whereby they can be spot welded to the casing after insertion. The partitions **708** and **709** have aligned openings defined by flanges **710** in which is mounted an inlet tube section **711** which is spot welded in the subassembly to the flanges **710**. The tube **711** is provided with louvers **712** opening into the chamber **713** between the partitions **708** and **709**. The partition **708** has an intermediate opening defined by a flange **714** in which is supported and spot welded the end of an outlet tube **715**. The outlet tube **715** has three sets of louvers **716**, similar to louvers **37**, each of which opens into a spit chamber **717** formed by the pancake assembly **718** which is similar to the pancake assemblies already described. The third unit of the pancake assembly extends through the inwardly turned neck **719** of an opening in the partition **709**, the shape of the neck **719** being best seen in FIG. 26. The outer end of the pancake assembly **718** extends into a cross-over chamber **721** formed between the partition **709** and an imperforate partition **722** which has an outwardly turned flange whereby it can be spot welded to the shell after insertion. Partition **722** has an annular flange **723** in which are seated the embossments **724** that are formed on the tube **715** and which are spot welded to the flange at assembly. The tube **715** has a set of louvers **725**, similar to louvers **37**, opening into the chamber **726** between the partition **722** and the outlet header **707**, the chamber **726** thus being a spit chamber. The end of the tube **715** is spot welded to the inside of the drawn outlet nipple **727** on the outlet header **707**.

On the inlet side of the subassembly **23***d* are partitions **729** and **739** each having outwardly turned flanges so that they can be spot welded to the shell after insertion. The partition **739** has a central opening defined by a flange **740** in which is spot welded a tuning tube **741** that is somewhat larger than the outlet passage **715** but generally aligned with it, though the axes are offset from each other. The partition **739** also has an opening defined by the flange **742** in which is spot welded at preassembly the inlet tube section **743**, the end of the section **743** being necked down and flared to fit over the end of the tube **711** and abut the flange **710** as seen in FIG. 22. The tube **743** has two sets of louvers **745** which open into the two spit chambers **746** formed by a pancake assembly **747** of the type already described. The tube **743** extends with substantial clearance through a tuning neck **749** in the partition **729** and its outer end is supported in and spot welded to the end of an inlet bushing **751** which is expanded and spot welded to the outwardly turned flange **753** of the inlet header **706**. The partition **729** has an outwardly turned flange **755** which at assembly fits over the end of the tube **741** and is spot welded to it.

In operation of the muffler **701**, gases enter the inlet bushing **751** and pass through the tube section **743** wherein high frequencies, noises, and roughness are removed in the spit chamber **746**. Additional silencing is accomplished in chamber **713** as the gases go through tube section **711** and pass through louvers **712** into the chamber. Gases leaving the tube **711** enter the cross-over chamber **721** and can pass through the neck **719** or through an opening formed by an outwardly turned flange **757** into the chamber **713**. Aligned with the opening **757** is a somewhat larger opening provided by an outwardly turned neck **759** in the partition **708** so that it will be seen that the return passage is provided by the volume of chamber **713** rather than by a tube as in the previous embodiments. Gas leaving the chamber **713** through opening **759** enters a cross-over chamber **761** between partitions **739** and **708** and can then enter the outlet tube **715** and be subjected therein to the action of the spit chambers **717** and **726**. Low notes in the chamber **761** are subjected to the action of the tuning tube **741** which connects them to the compound resonator formed by the chamber **763** between header **706** and partition **729** which in turn is connected through tuning neck **765** and **749** to the chamber **767** between partitions **729** and **739**. It will be noted that cross bleeding to opening **759** is provided through louvers **712** and opening **719** thus enabling opening **757** to be reduced in size over opening **759** and providing noise elimination without an increase in back pressure. The volume passage gas flow between **757** and **759** in combination with the resonators **763** and **767** and the large size (high energy absorbing) tuning tube **741** will be especially effective in eliminating the otherwise exceptionally loud torque convertor power note.

Each of the five partitions is provided with drain holes **769** at the top and bottom thereof adjacent the casing **703** so that water can slosh from the ends of the casing to the middle as the muffler is rocked back and forth by movement of the automobile. The water within the cooler chambers **763**, **767**, and **726** can thus flow to the chambers **761**, **713**, and **721**, which are hotter due to the circulation of gases therethrough, and be vaporized to pass out of the muffler through tube **715**. Direct liquid drainage to atmosphere can also be accommodated by a small hole **771** at the bottom of the outlet header which is of such a small size as not to permit gas leakage, cause spitting or hissing, or adversely affect the acoustic characteristics of the muffler. The hole **771** is intended only to let the water leak out when the muffler is cold, e.g., when the auto is stopped or just started and should preferably be no longer than ⅛" diameter. It could be put in the casing wall **703** on the bottom side of the muffler.

It will now be recognized that the invention provides many important improvements in the muffler field. Costs of manufacture are reduced by the arrangement of structure which permit subassemblies to be made up outside of the casing and then inserted as units into the casing. The various pancake designs reduce cost over presently used methods and the combination of tubes **631** and **636** (FIG. 18) is an important innovation from the standpoint of cost reduction and standardization of parts. A very important feature which should be of great interest to the motoring public, as it will double or triple the life of a muffler, is the provision for inter-chamber drainage whereby the cold water collecting chambers are connected through drain holes in the partitions to the hot

gas circulating chambers with the result that the water is vaporized as it sloshes back and forth during motion of the car and does not have an opportunity to eat out the muffler shell or the interior parts. This action can be enhanced by use of a layer of asbestos sheet in the shell construction, such as disclosed in U.S. Patent No. 7,761,-525 and assigned to the assignee hereof, as the asbestos wrapping will cause the muffler to run at a higher temperature thereby facilitating vaporization. Also very important is the way the various parts are tied together and to the end headers of the mufflers to provide great strength that will resist blow-outs and backfires. For example, three different methods of rigidly supporting the end headers by spot welding at a considerable distance lengthwise of the muffler away from the plane of the vibration (plane through interlocked joint, e.g., 9) are shown, these methods giving a very high resisting moment to bending at the head neck radius and eliminating fatigue failures due to repeated bending. Among other illustrations, FIG. 1 shows the expanded bushing method; FIG. 10 outlet header shows the drawn head method; and FIG. 13 inlet header shows the inner flanged header and bushing method. A further feature adding strength to the muffler is the use of several spot welded transverse partitions, some of which may be contoured, which not only form acoustic chambers but brace the oval casings against drumming. The embossments 478 also help to prevent drumming.

From the operational standpoint, it will be noted that back pressure is at a minimum due to the relatively large gas tubes and cross-over chambers along with arrangements permitting cross-bleeding, especially cross-bleeding to the outlet tube. The constructions are such as to provide complete sound elimination for any given application. Several spit or filter chambers of different volumes are provided to eliminate noise and roughness over a frequency range from low to high and the harsh bark of modern high compression engines. The resonator chamber and tuning tube arrangements eliminate power notes, second harmonic beat frequencies, road load harmonics, run down noises, etc. Various features provide for high energy absorption, e.g., the large tuning tubes or the restrictor of FIG. 18 and effective sound cancellation will be obtained in the non-turbulent tri-flow chambers over wide speed ranges.

It will be recognized that modifications may be made in the specific structures shown herein by way of illustration without departing from the spirit and scope of the invention.

I claim:

1. A muffler adapted to be connected in the exhaust system of an internal combustion engine or the like to muffle high temperature exhaust gases carrying corrosive vapors which tend to condense and form corrosive condensate in the muffler, comprising: an elongated tubular casing having oppositely located end portions spaced along a central longitudinal axis, and header means extending transversely to the longitudinal axis of said tubular casing and closing the end portions of said tubular casing, gas inlet passage means extending through one of said end header means at one end of said tubular casing, gas outlet passage means extending through the other one of said end header means at the other end of said tubular casing, a partition means extending transversely to the longitudinal axis of said tubular casing and defining multiple chambers in said tubular casing between the end header means, internal gas passage means defining a gas flow path between said gas inlet passage means and said gas outlet passage means, mounting means at opposite ends of said muffler for mounting said muffler in a horizontal attitude with the central longitudinal axis of said tubular casing extending horizontally, said casing having a bottom wall portion and extending the length of said tubular casing through each of said chambers, said end header means having upwardly extending end wall portions intersecting said bottom wall portion at the ends of said tubular casing, said gas inlet passage means and said gas outlet passage means being spaced upwardly above and being discontinuous with said bottom wall portion, condensate sump means defined by said bottom wall portion and said end wall portions and said partition means in said tubular casing whereby condensate in said muffler collects on and is supported by said bottom wall portion below said gas inlet passage means and said gas outlet passage means and is confined within said tubular casing, said sump means being connected to said gas outlet passage means only by said internal gas passage means along said gas flow path within said tubular casing, a portion of said internal gas passage means connecting at least one of said chambers directly to said gas inlet means whereby said one of said chambers is connected in said gas flow path to provide a continuous flow of exhaust gases therethrough and operates at a temperature high enough to vaporize condensate on the bottom wall portion in said sump means in the one of said chambers, additional portions of said internal gas passage means indirectly connecting at least one other of said chambers to said gas inlet passage means and providing a reduced flow of exhaust gases through said other of said chambers relative to said one of said chambers whereby said other of said chambers operates at a temperature too low to effectively vaporize condensate on the bottom wall portion of said sump means in said other of said chambers, and condensate passage means defined in part by said bottom wall portion and extending between said one of said chambers and said other of said chambers only along said bottom wall portion whereby condensate in said sump means on the bottom wall portion in said other of said chambers flows only along the bottom wall portion to said one of said chambers, said condensate in said one of said chambers being vaporized therein in said sump means on said bottom wall portion and being mixed therein with the exhaust gases flowing through said one of said chambers and being removed with the exhaust gases flowing from said one of said chambers along said gas flow path to and through said gas outlet passage means.

2. A muffler adapted to be connected in a horizontal attitude in an exhaust system for an internal combustion engine or the like to muffle high temperature exhaust gases discharged from the engine and carrying corrosive vapors which tend to condense and form corrosive condensate in the muffler, comprising: an elongated tubular casing having a central longitudinal axis, end header means closing opposite ends of said tubular casing, a plurality of partition means extending transversely to said longitudinal axis mounted within said tubular casing and dividing said tubular casing into a plurality of chambers, gas inlet tube means extending through one of said end header means at one end of said tubular casing and extending into said tubular casing through at least one of said partition means and terminating in a first centrally located chamber spaced on each side from both end header means by at least one chamber, gas outlet tube means extending through the other of said end header means at the other end of said tubular casing and extending into said tubular casing through at least one of said partition means and terminating in a second centrally located chamber spaced on each side from both end header means by at least one chamber, at least one centrally located chamber positioned between said first centrally located chamber and said second centrally located chamber, gas passage means connecting said gas inlet tube means and said gas outlet tube means and defining a continuous gas flow path between said gas inlet tube means and said gas outlet tube means, an end chamber defined by one of said end header means and one of said partition means, additional passage means connecting said continuous gas flow path to said end chamber, said first centrally located chamber having a continuous flow of exhaust gases therethrough and operating at a temperature high enough to vaporize condensate therein, at least

one other chamber including said end chamber having a reduced flow of exhaust gases therethrough relative to the flow of exhaust gases through said first centrally located chamber and operating at a temperature too low to effectively vaporize condensate in said other chamber, mounting bushing means provided on opposite ends of said muffler and connected to said gas inlet tube means and said gas outlet tube means for mounting said muffler in a horizontal attitude with the central longitudinal axis of said tubular casing extending horizontally, said tubular casing having a bottom wall portion when said muffler is mounted in the horizontal attitude, said bottom wall portion extending the length of said tubular casing through each of said chambers, said end header means comprising end wall portions extending transversely upwardly from said bottom wall portion to form condensate sump means whereat condensate in said muffler collects on and is supported by said bottom wall portion between said end wall portions, said gas inlet tube means and said gas outlet tube means being spaced upwardly above and being discontinuous from said bottom wall portion, said sump means being connected to said gas outlet tube means only by said gas passage means, and condensate passage means extending between said end chamber and said first centrally located chamber only parallel to and being defined in part by said bottom wall portion whereby condensate on the bottom wall portion can flow from said end chamber to said first centrally located chamber for vaporization therein on said bottom wall portion and mixing with the exhaust gases flowing through said first centrally located chamber when vaporized and removal with the exhaust gases flowing through said gas passage means to and through said gas outlet tube means.

3. A muffler for receiving hot exhaust gases of an internal combustion engine carrying corrosive vapors which tend to condense and form corrosive condensate in the muffler, said muffler being of the type having a casing and internal silencing structure dividing the casing into a plurality of chambers, comprising inlet and outlet gas passages in said muffler, a bottom wall portion formed by said casing and being located below said outlet gas passage and extending through said chambers, transverse wall portions intersecting said bottom wall portion, condensate sump means for collecting and holding condensate along said bottom wall portion between said transverse wall portions, internal gas passage means connecting said inlet and outlet gas passages and being positioned and arranged to provide a gas flow path through the said chambers resulting in substantial temperature variations in different ones of said chambers during at least some substantial periods of use of said muffler, the temperature of at least one of said chambers being above the vaporization point of corrosive condensate collected in said sump means in said muffler and the temperature of at least one other of said chambers being below the vaporization point of corrosive condensate collected in said sump means in said muffler, said sump means in said chambers being connected to said outlet gas passage only by said internal gas passage means, and corrosive condensate drainage means extending only along the bottom wall portion and connecting all of the chambers at a temperature below the vaporization point of the corrosive condensate to chambers at a temperature above the vaporization point of the corrosive condensate whereby corrosive condensate in said muffler can flow to the chambers at the temperature above the vaporization point for vaporization therein and removal with the exhaust gases passing therethrough.

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