

May 3, 1966

W. H. POWERS
METHOD OF MANUFACTURING A MUFFLER INCLUDING
COATING WITH CERAMIC

3,248,791

Original Filed Oct. 28, 1960

3 Sheets-Sheet 1

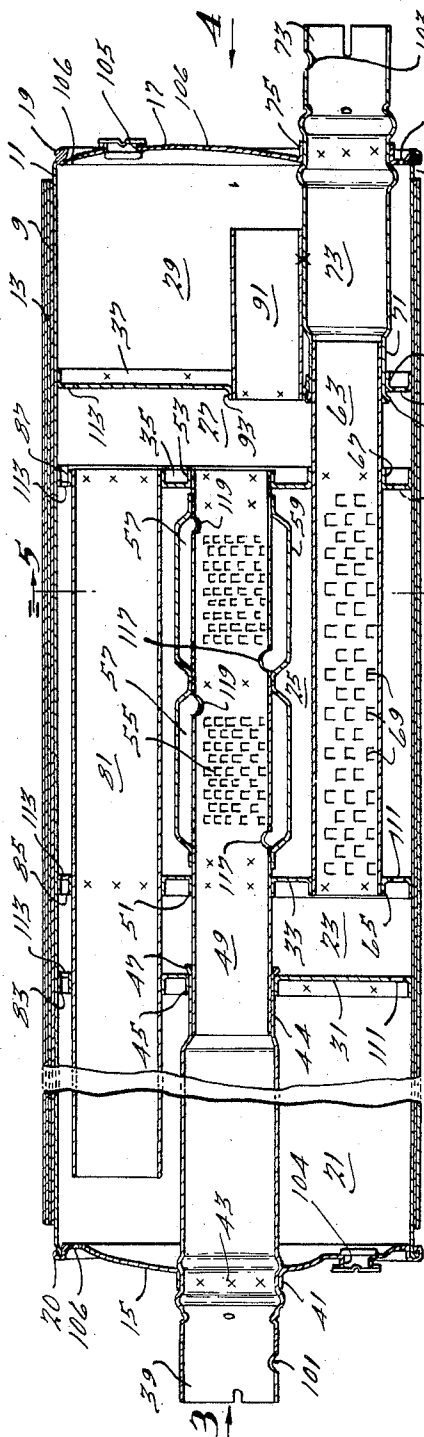


FIG. 2.

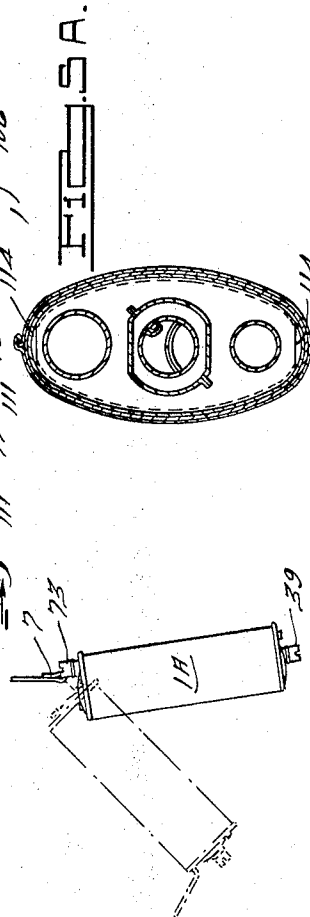


FIG. 3A.

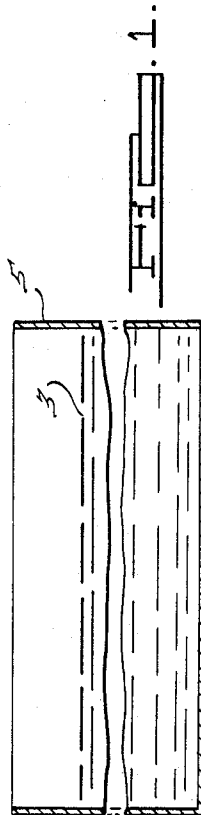


FIG. 1.

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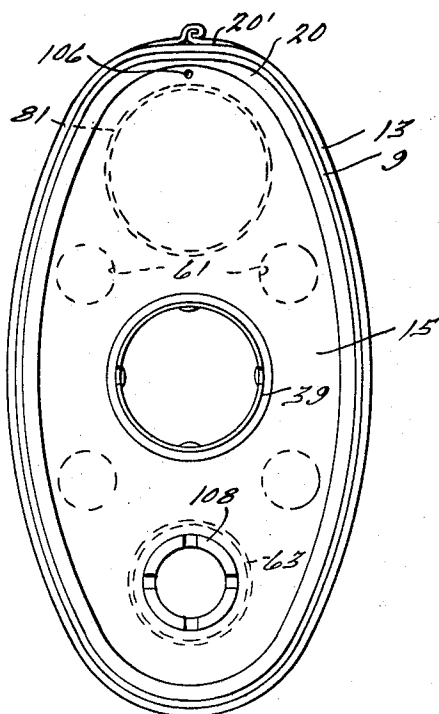


FIG. 3.

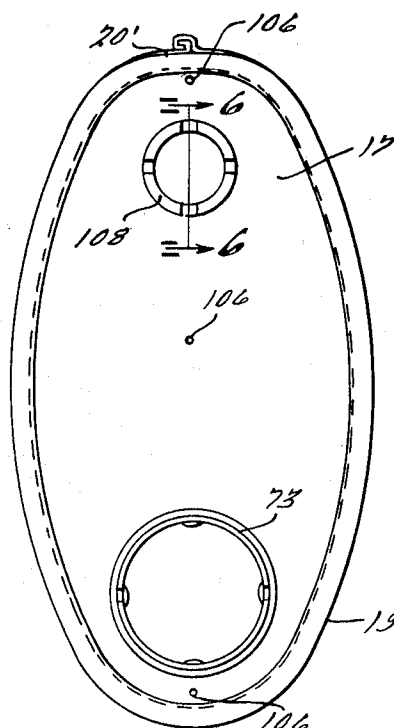


FIG. 4.

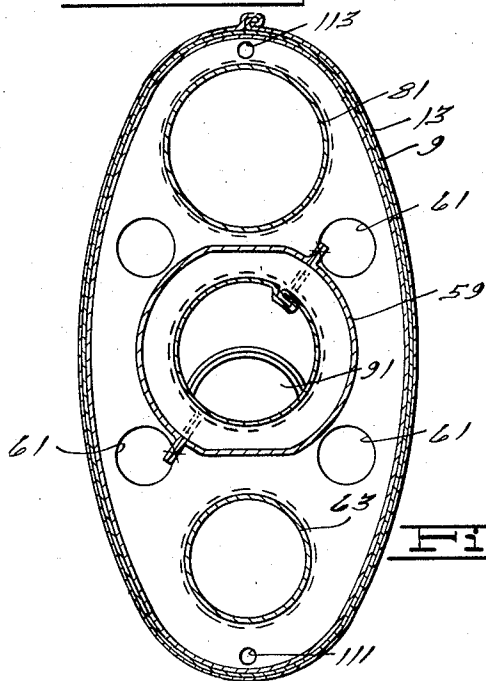


FIG. 5.

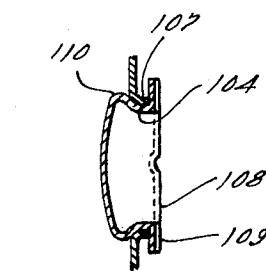


FIG. 6.

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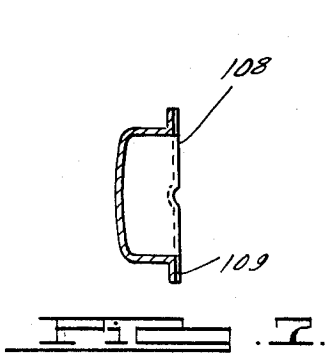
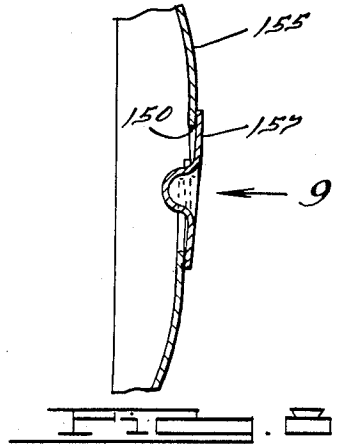
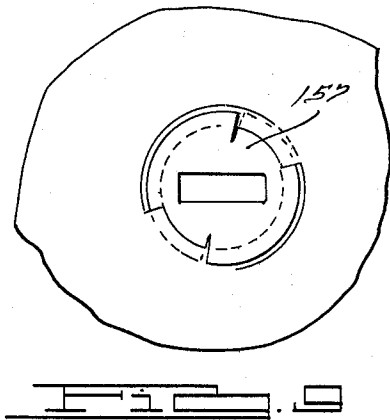
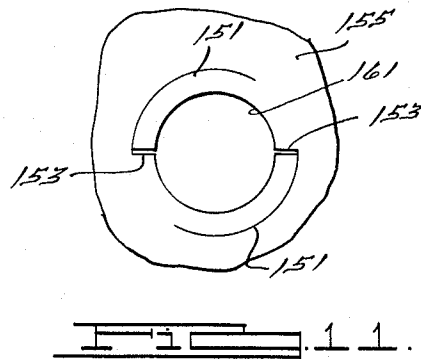
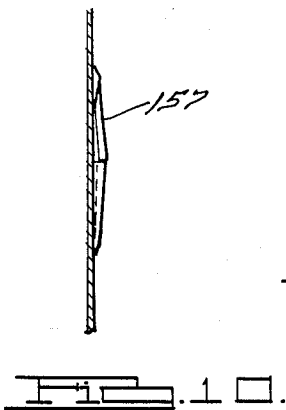
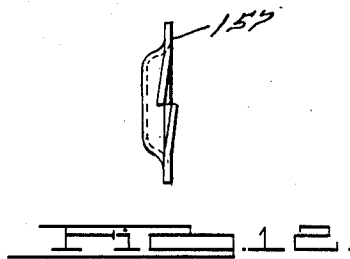
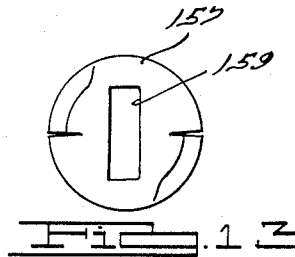
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METHOD OF MANUFACTURING A MUFFLER INCLUDING COATING WITH CERAMIC

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Original application Oct. 28, 1960, Ser. No. 65,767, now Patent No. 3,082,841, dated Mar. 26, 1963. Divided and this application Dec. 4, 1962, Ser. No. 242,270
8 Claims. (Cl. 29-460)

This application is a division of my copending application Serial No. 65,767, filed October 28, 1960, now Patent No. 3,082,841, issued March 26, 1963.

My invention relates to mufflers of the type used to silence the exhaust of internal combustion engines.

It is the object of my invention to greatly reduce or eliminate the corrosion of exhaust mufflers.

In accomplishing the object of my invention I coat the surfaces of the muffler with an anti-corrosive ceramic material of a type available on the open market and which can be applied to a steel surface. I have found that it is best to coat the muffler surfaces after assembly rather than to try to coat the surfaces of individual parts or subassemblies. Thus, I contemplate the dip coating of the muffler in an anti-corrosive ceramic slip. My invention provides a muffler construction that can be successfully coated with ceramic by the dipping process or by other processes if desired.

The conventional muffler contains a series of internal chambers within an outer shell. These form many internal pockets that interfere with the proper drainage of liquids and gases during the coating process. Improper drainage at various stages of the ceramic coating process is very likely to result in incomplete surface coverage and probably in subsequent rust-out at the uncovered areas.

Thus, a further object of my invention is to provide a muffler construction with means for external and internal drainage so that it can be properly ceramic coated.

The invention provides for proper drainage by means of holes located at the correct positions in the various internal chambers. These are located and sized so that they do not have an adverse acoustic effect.

My invention is illustrated in the accompanying drawings in which:

FIGURE 1 is a side elevation, somewhat diagrammatic, showing the muffler 1 in position for dipping in a bath of suitable corrosion resisting ceramic;

FIG. 2 is a longitudinal cross-section through a typical muffler that may be dip coated in accordance with the principles of this invention;

FIG. 3 is an enlarged end elevation taken from the left of FIG. 2;

FIG. 4 is an enlarged end elevation taken from the right of FIG. 2;

FIG. 5 is an enlarged cross-section taken along the line 5-5 of FIG. 2;

FIG. 5a is a cross-section showing a modified form of partition that is cut off to provide air and liquid escape holes;

FIG. 6 is a cross-section taken along the line 6-6 of FIG. 4;

FIG. 7 is a cross-section through the plug of FIG. 6 prior to insertion;

FIG. 8 is a section similar to that of FIG. 6 showing a modified form of plug;

FIG. 9 is a view taken from the right of FIG. 8;

FIG. 10 is a section similar to that of FIG. 8 with still another form of plug;

FIG. 11 is a view similar to that of FIG. 9 taken from the right of FIG. 10;

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FIG. 12 is a side elevation of the plug of FIGS. 10 and 11; and

FIG. 13 is a side elevation of the plug of FIGS. 10-12.

FIG. 1 illustrates dip ceramic coating of a carbon steel muffler 1A. The ceramic is in the form of a suitable slip or bath 3 contained in a suitable tank 5. The muffler 1 may be suspended by a hook 7 which provides the means for lowering the muffler down into the bath and after all surfaces, internal and external, have been coated, for removing the muffler from the bath 3.

FIG. 2 is a longitudinal cross-section through a typical muffler 1. It differs slightly from the muffler 1A illustrated in FIG. 1 in that it shows a layer of asbestos 9 wrapped around the muffler casing 11 and held in place by an external layer of sheet metal 13. In the coating process I prefer to omit the asbestos layer 9 and the sheet metal 13 since the asbestos 9 will tend to soak up the various liquids involved and the material so absorbed may create difficulties in the subsequent coating and firing of the ceramic dipped muffler.

The muffler 1 has a casing 11 which is formed of sheet steel (as are the internal parts) that is rolled into an oval shape and the overlapping edges spot-welded together or lock-seamed in accordance with standard practice. In the form shown in FIG. 2, the lock-seams would be along the bottom edge of the shell 11. The opposite ends of the casing 11 are closed by the headers 15 and 17. The outer peripheries of the headers are tightly connected to the end of the casing 11 in interlocked joints 19 and 20 and in accordance with the invention the top sides of the joints 19 and 20 (opposite the shell joint) are bent inwardly or downwardly so that the outer surface of the casing 11 is exposed at each end, thus enabling the outer shell 13 to be formed as a sheet and wrapped around the layer of asbestos 9 and then lock-seamed by lock-seaming equipment which passes over the flat bent-in portions 20' after the muffler 1A has been coated and fired.

The silencing structure within the muffler shell 11 is typical of various types that can be used and will illustrate how such structure should be adapted for the application of protective coatings presenting the same problems as a dip ceramic coating. Thus, the interior of the casing 11 is divided into a series of longitudinally separated chambers 21, 23, 25, 27, and 29 by a series of transverse sheet steel partitions 31, 33, 35, and 37. Each of the transverse partitions has, in accordance with the usual practice, an annular flange around its outer periphery and this is spot-welded to the casing 11. Gas enters the casing 11 through an inlet bushing 39 which is supported in and spot-welded to a neck 41 formed in the inlet header 15. The inner end of the bushing 39 is necked-down or reduced in diameter at 44 and is supported in and spot-welded to a neck 45 in the partition 31. The extreme inner end of the bushing 39 has a slit or slotted flare 47 to facilitate the insertion of the end of an inlet conduit 49, such conduit being slipped inside of the reduced end 44 of the bushing 39 at assembly when it and the associated parts to be described are inserted inside of the shell 11. The conduit 49 is supported in and spot-welded to flanged necks 51 and 53 of the partitions 33 and 35, respectively. A pair of sets of louvers 55 within the walls of the conduit 49 permit sound waves to enter spit chambers 57 that are formed around the conduit by means of a pancake-type chamber-forming construction 59 consisting of complementary stamped halves that have flanges that are spot-welded together and necks which are spot-welded to the conduit 49.

Gases leaving the inlet conduit 49 enter the chamber 27 and reverse the direction of flow to go back toward the inlet end of the muffler. In doing this, the gases flow back

through the volume of the chamber 25 between the partitions 33 and 35. These partitions have a series of relatively large openings 61 formed in them so that the gases can flow freely and without restriction from the chamber 27 to the chamber 23. Gases in the chamber 23 flow toward the outlet header 17 through an outlet conduit 63 which is supported in and spot-welded to necks 65 and 67 formed respectively in the partitions 33 and 35. The section of the tube 63 within chamber 25 may be provided with louvers 69 opening into the chamber 25. The outer end of the outlet tube 63 is slidably fitted in and supported in the inner reduced end 71 of the outlet bushing 73 which is expanded and spot-welded to the neck 75 in the outlet header 17. The inner end 71 of the bushing 73 is slit and flared slightly at 77 to enable it to be slipped over the end of the tube 63 and is also spot-welded to the neck 79 in the partition 37. The slits in flares 77 and 47 facilitate ceramic drainage as will be self-evident hereinafter.

An unusually long tuning tube 81 is supported in and spot-welded to flanged necks 83, 85, and 87 of the partitions 31, 33, and 35, being spot-welded to the latter two partitions only. The tube 81 is imperforate and connects the crossover chamber 27 to the chamber 21 and since it provides the only inlet and outlet to such chamber it is apparent that this constitutes a resonator chamber for notes of low frequency. The chamber 29 at the outlet end of the muffler is arranged to act as a resonator chamber by means of a relatively short tuning tube 91 which is spot-welded in a flanged neck 93 of the partition 37 and one end thereof is preferably spot-welded to the bushing 73.

Coating an assembled muffler, such as the one just described, with a ceramic material involves a series of processing steps or operations such as the following. First, the muffler is heated to about 1300° F. and held for 5 minutes or so to burn off grease, soap, oil, etc. After cooling, the muffler is detergent washed by dipping for about 10-20 minutes in either or both alkali and acid baths, depending upon the materials to be removed, and water rinsed after each wash. Next it is held in a pickling bath, or acid bath, to roughen the surface so as to promote a bond with the ceramic. After this, it is rinsed and dipped in a neutralizing bath and rinsed again. Next it is dipped in a nickle bath to give it a "primer" coating that promotes the bond with the ceramic. Then it is rinsed and neutralized if necessary. After any or all of the various liquid dipping operations of the type just described have been completed (the order may be varied), the muffler may be held in a tank in which hot dry air is blowing so that it can be dried out.

After the foregoing or equivalent preparatory steps are completed and the muffler surfaces are clean and prepared for ceramic, the muffler is dipped in a bath 3 of anti-corrosive ceramic slip, drained, dried in hot air, and fired in a furnace at about 1500° F.

It will be recognized that the success of most of the above steps is dependent upon the admission of a fluid to the interior of the muffler so that it contacts all of the muffler surface and then the drainage of all of such fluid from the interior of the muffler so that the next fluid can contact all of the muffler surfaces. In the steps involving liquids (such as detergent washes, rinses, pickling, neutralizing, and nickel coating) the muffler is preferably suspended from one end, lowered into a bath containing the liquid, raised out of the bath, and drained by gravity flow of the liquid out of the muffler and back into the bath. In mass production of ceramic coated automobile mufflers it is not only necessary that these various operations be performed well but they must also be performed quickly and automatically without the need for individual attention and inspection. The effectiveness with which the surfaces are contacted by the various fluid and the completeness of subsequent drainage as well as the speed with which the fluid enter and leave the muffler all depend upon

the use of the proper suspension means and drainage means in the muffler itself. The drainage means, however, must not adversely affect the acoustic characteristics of the muffler.

Referring first to the suspension means, this comprises holes 101 and 103 respectively, in the inlet and outlet bushings 39 and 73. These holes receive the end of a hook 7 or other suitable suspending device. A vertical line from the hole 101 or 103 through the center of gravity of the muffler when suspended determines the angle of inclination of the muffler, especially the angle the various transverse partitions, headers, and walls will make to the horizontal. It is evident that in no case can the muffler be suspended by holes 101 and 103 so that the transverse walls will be perfectly horizontal. Thus, whether the muffler is suspended from the inlet or the outlet end, each chamber will have a low point toward which liquid in the chamber will flow. In the case of the flat interior partitions 31, 33, 35, and 37 these low points will be at the corners between the small diameter ends of the partitions and the shell. At these corners I provide internal drainage means in the form of small openings 111 and 113, respectively, which are preferably about $\frac{5}{16}$ inch in diameter and as close as possible to the shell wall. Alternatively, the ends of the partitions could be sliced off as shown at 114 in FIG. 5a to provide drainage openings. It will be noted that when an opening 111 is on the low side the corresponding opening 113 will be on the high side of the adjacent chamber. Thus, as liquid escapes, air can enter to prevent a vacuum lock in the muffler during drainage.

The end headers 15 and 17 of the muffler are provided with external drainage means in the form of large (preferably 1 inch diameter) openings 104 and 105, respectively, each of which has an outwardly extending neck 107. These openings are closed after the coating operation is completed by flanged, cup-shaped caps 108 as will be described hereinafter. Additionally, end header 15 may be provided with a $\frac{1}{16}$ inch drain hole 106 and header 17 with three such drain holes located as shown in FIGS. 3 and 4. More of these holes may be used if desired since they are small enough to plug up with ceramic during the coating operation and therefore do not cause adverse acoustic effects.

The spit chambers 57 are provided with internal drainage means in the form of holes 117 and 119 located in diagonally opposite corners, the holes 117 being on the inlet and plug 104 sides of the chambers. The holes 117 are preferably about $\frac{1}{4}$ inch in diameter and as close as possible to the end walls of the chambers 57 so as to eliminate any pockets that might retain liquid during draining.

The coating operation is carried out with the muffler just described, that is, the muffler of FIG. 2 but before the plugs 108 have been inserted or the outer layers 9 and 13 added to the shell 11. During the preparatory steps, wherein the muffler is dipped in various free flowing liquids as outlined above, the muffler is preferably suspended from the suspension hole 101 in the inlet bushing 39. The muffler will hang at an angle defined by a line through the hole 101 and the center of gravity. When this is done the holes 104 and 105, respectively, will be very close to, if not actually the high and low points of the space inside the shell 11. When the muffler is suspended from the bushing 39 and lowered into a liquid bath, the liquid will enter hole 105 and bushing 73 and flow upwardly toward the inlet header 15. The air replaced by this liquid can escape externally through openings 104 and 106 in the header 15 as well as through inlet tube 49 and bushing 39. Air in the internal chambers can escape through the uppermost of the various internal drainage openings, in this case, the openings 111 and 117. Liquid can enter the internal chambers through the various tubes as well as through the lower openings 113. After the muffler is completely submerged and held

for the desired period of time it will be raised out of the bath and suspended over it so that the liquid will drain out—principally through opening 105. Internally the liquid will drain from one chamber to the next through the lower opening 111 and air can enter from the top to replace it through the same openings as it flowed through to leave the muffler. Liquid in spit chambers 57 will drain into tube 49 through low openings 119. The centrally located hole 106 in header 17 will provide an outlet for any liquid tending to form a puddle in the concave portion of the header. The foregoing arrangement of suspending means and drainage means will enable free flowing liquid to enter and completely leave the muffler without any shaking or agitation, thus facilitating mass dipping of the mufflers without individual attention by an operator.

The ceramic slip 3 is considerably thicker and more viscous than the liquids used in the various preparatory steps and thus flows more slowly than the other liquids. In order to decrease the time required to coat the muffler 1 with ceramic slip, I prefer to suspend it from the outlet bushing hole 103 so that it is oriented more or less as shown in FIG. 1. When this is done the chamber 21 instead of the smaller chamber 29 will be on the bottom. Thus, slip can enter and leave the chamber through large opening 104 instead of openings 111 and 113 and the time required to fill and drain the muffler with slip is reduced substantially. After dipping in the bath of slip 3, a hook (not shown) is used to engage bead 20 and pivot the muffler up about 45° to the left in FIG. 1, thus putting the various drainage holes at the low points in their respective chambers. After dipping in slip 3, the mufflers are shaken somewhat by the operators so that the slip is agitated sufficiently to drain out. This contrasts with the drainage during the preliminary steps which is accomplished without shaking of the muffler.

After the muffler has been lifted from tank 3 and drained over it, it is dried to remove as many fluids as possible before firing. The drying may include a step of subjecting the muffler to circulating hot air (as is done after the preparatory steps) and it will be noted that the location of hole 104 on a side opposite tube 81 will prevent short-circuiting such as might occur if the hole were located on the other side of header 15. During firing of the muffler at an appropriate temperature, normally about 1500° F., it is preferably suspended by hole 101 as this will tend to minimize distortion that might occur due to the heat.

After firing the ceramic is cleaned off the butt ends of necks 107 to expose metal and plugs 108 are inserted in holes 104 and 105. The plugs are hat-shaped and preferably formed of a non-corrosive, high chrome muffler steel. The flanges 109 on the plugs have projections or ribs formed on them to engage the cleaned edges of necks 107. Both plugs are projection-welded to the necks in one cycle by simultaneous engagement of both plugs with welding electrodes, the welding current flowing from the plug at one end of the muffler through the muffler shell, which acts as a conductor, to ground or the low potential side by way of the plug at the opposite end of the shell. After this the interiors of the plugs are expanded radially as seen at 110 to engage behind the header material surrounding the holes 104 and 105 and provide a positive engagement against blow-out.

The ceramic layer will build up on the edges of and tend to bridge the various holes and reduce them in size. In order to obtain the desired results, I prefer to make the various louvers, such as louvers 55 and 69, of rectangular shape and about .030-.040" oversize to avoid clogging or bridging.

In FIGS. 8-13 I have illustrated a different method of plugging the opening in the header. In this form the opening 150, as shown in FIG. 11, is not flanged and would be preferably about 1 inch in diameter and arcs 151 extending through approximately a quarter-circle

would be slit in the material surrounding the opening to form partly annular tabs which would be slit diametrically along line 153 and then lifted up from the plane of the header 155 as seen in FIG. 10. The plug 157 will comprise a flat plate having a rectangular dished T portion 159 which will receive some type of instrument, such as a screw driver, so that the plug can be twisted into place. Sections of the periphery of the plug are slit and deformed from the plane of the plug surface in a manner complementary to the ears 151 so that, as seen in FIGS. 8-9, the plug can be inserted in the openings 150 and then twisted so that these sections will lie over and under the ears 151 and the plug will interlock with the header 155. The plug is coated with ceramic before insertion so that upon firing a gas-tight seal is obtained.

While, as illustrated, the principles of my invention are shown in connection with ceramic coating, it is possible for these features to be used in the coating of mufflers or other sheet metal devices by other means, such as painting or gaseous diffusion, wherever ventilation of the interior of the muffler may be required during the process.

I claim:

1. The method of making mufflers comprising the steps of forming the component parts of a muffler including a shell, end headers, and internal silencing structure, interlocking the end headers with the ends of the shell after the internal silencing structure has been inserted and assembled within the shell, forming the interlocked joint between the end of the shell and one of the headers so a portion thereof is no larger in diameter than the shell whereby lock-seaming equipment can move over said end of the shell, immersing the assembled muffler in a ceramic slip, draining the slip from the muffler, firing the coated muffler to harden as a coating on all surfaces of the muffler, and applying a non-coated layer to the outer surface of the shell over said interlocked joint, and lock-seaming said non-coated layer.

2. The method of making a corrosion resisting muffler comprising the steps of forming a muffler shell and end headers having gas inlet and outlet openings, forming tubes for insertion in the shell to form gas passage means, forming partitions for insertion in the shell to divide the shell into a series of compartments, forming said partitions so that upon insertion in the shell said partitions will provide small openings on opposite transverse sides of the shell connecting adjacent compartments and providing for the interflow of liquid and air between said adjacent compartments during a coating operation, immersing the assembled muffler in a liquid coating bath of anti-corrosive ceramic, removing said muffler from said bath after all surfaces of the muffler have been coated including the edges of said openings, and firing said muffler to harden said ceramic on all said surfaces and partially or completely close said openings.

3. The method of making a corrosion resisting muffler having spit chambers comprising the steps of forming the component parts of a muffler including a tube having a shell around it to form a spit chamber, forming openings in said tube at opposite ends of said chamber and in opposite sides of the tube, inserting the component parts in a muffler shell to form an assembled muffler, immersing the assembled muffler in a bath of anti-corrosive hardenable material, removing the muffler from the bath and draining the material from the muffler, and hardening said material.

4. The method of ceramic coating a pre-assembled muffler having a casing with a central longitudinal axis and closed at each end by header means and divided internally into a plurality of chambers by internal silencing structure having portions extending at substantially right angles to the longitudinal axis and passage means extending through said muffler and opening through said header means; comprising, in sequence, the steps of:

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- (1) providing at least two small drainage openings in said internal silencing structure adjacent said casing to provide for flow of coating liquid therethrough;
- (2) assembling the muffler parts;
- (3) cleaning all exterior and interior surfaces of the assembled muffler;
- (4) roughening all exterior and interior surfaces of the assembled muffler;
- (5) prime coating all exterior and interior surfaces of the assembled muffler; and
- (6) ceramic coating all exterior and interior surfaces of the assembled muffler.

5. The method of ceramic coating a pre-assembled muffler having a casing with a central longitudinal axis and closed at each end by header means and divided internally into a plurality of chambers by internal silencing structure having portions extending at substantially right angles to the longitudinal axis and passage means extending through said muffler and opening through said header means; comprising, in sequence, the steps of:

- (1) heating the assembled muffler to burn off contaminants on the exterior and interior surfaces thereof;
- (2) cleaning all exterior and interior surfaces of the assembled muffler by dipping the muffler into a bath means of cleaning solution;
- (3) roughening all exterior and interior surfaces of the assembled muffler by dipping the muffler into bath means of roughening solution;
- (4) prime coating all exterior and interior surfaces of the assembled muffler by dipping the muffler into bath means of coating solution;
- (5) dipping the preconditioned assembled muffler in bath means of ceramic material to enable ceramic solution to fill each of the internal chambers;
- (6) tilting the assembled muffler in the bath of ceramic material to enable each of the internal chambers and all interior surfaces to be coated;
- (7) removing the assembled muffler from the bath of ceramic material and draining said muffler by gravity flow through the passage means substantially parallel to the longitudinal axis from end to end of said casing and at right angles to the longitudinal axis within said casing along the portions of the internal silencing structure extending at right angles to the longitudinal axis;
- (8) drying exterior and interior surfaces of said muffler by hot air; and
- (9) hardening the ceramic coating by firing the coated muffler in a furnace at elevated temperatures.

6. A method of making mufflers comprising the steps of forming the component parts of a muffler including a muffler shell, end headers, internal silencing structure forming gas passage means extending longitudinally through the muffler, and gas inlet and outlet openings in the end headers to convey a gas to be muffled from the inlet opening through the internal silencing structure via

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the gas passage means to the outlet opening; forming additional openings in the end headers of the muffler for the in and out flow of air and liquid only during a coating operation; assembling the parts into a complete muffler having said additional openings at opposite ends; immersing the muffler in an anti-corrosive hardenable liquid to form a coating thereof on all surfaces of the muffler parts; removing the muffler from said liquid; draining said liquid out of the muffler through one of said additional openings; hardening said coating; and closing at least one of said openings by means of positioning a plug in the opening with a portion of the plug extending in overlapping relationship along an interior surface of the wall of the muffler adjacent the opening so that the plug will tend to be held in place by internal pressure of the muffler during the use thereof.

7. The method of closing drainage openings in end headers of ceramically coated metallic muffler after a coating operation comprising exposing a surface of the metallic muffler adjacent each of the openings after the coating operation, inserting metallic plugs in the openings with the plugs in surface to surface engagement with the exposed surfaces, simultaneously engaging spaced ones of said plugs with welding electrodes and causing current to flow through the electrodes from one plug to another plug via the coated metallic muffler to projection weld the plugs to the muffler in the openings.

8. The invention as defined in claim 7 and subsequently expanding the plugs into engagement with interior surfaces of the muffler outwardly adjacent the openings behind the end headers to provide a positive engagement against blowout under gas pressure in use.

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LEO SMILOW, *Primary Examiner*.