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# Cooling Jacket Construction

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July 5, 1938.

R. H. GODDARD

2,122,521

COOLING JACKET CONSTRUCTION

Filed March 10, 1937

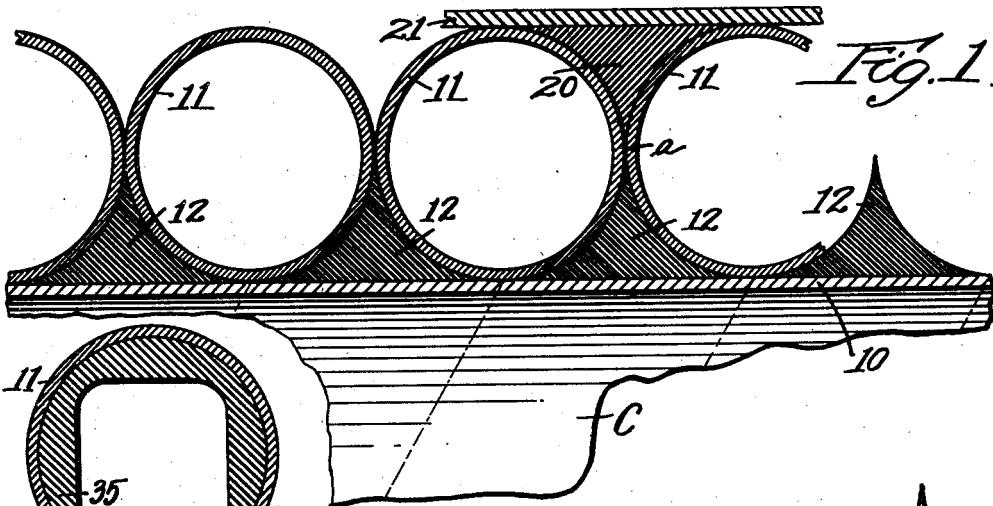


Fig. 1.

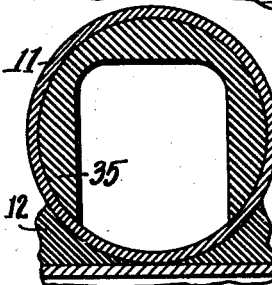


Fig. 7.

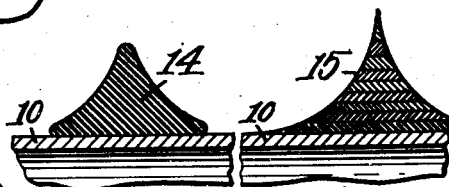


Fig. 2.

Fig. 3.

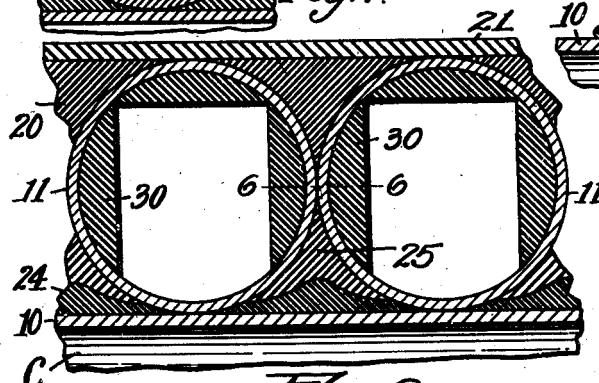


Fig. 6.

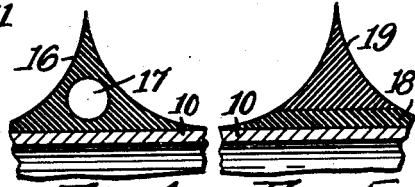


Fig. 4.

Fig. 5.

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# UNITED STATES PATENT OFFICE

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## COOLING JACKET CONSTRUCTION

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Application March 10, 1937, Serial No. 130,144

10 Claims. (Cl. 122—367)

This invention relates to the cooling of the outer wall of a combustion chamber or other highly heated container.

It is the general object of my invention to provide an improved cooling jacket construction by which such chambers or containers may be very effectively cooled by a jacket structure of minimum weight.

To the attainment of this object, I provide a system of conduits or tubes and associated parts, by which a cooling fluid may be circulated about a combustion chamber and by which the transfer of heat thereto may be facilitated.

More specifically, I provide conduits or tubes of such cross section as to present maximum resistance to distortion, together with associated heat transfer elements or filler strips which overcome the disadvantage of line contact only between such a conduit and a combustion chamber wall.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

Preferred forms of the invention are shown in the drawing, in which—

Fig. 1 is a partial sectional elevation showing my improved cooling jacket construction applied to the cylindrical wall of a combustion chamber; Figs. 2, 3, 4 and 5 are sectional elevations of modified forms of filler strips;

Fig. 6 is a view similar to Fig. 1 but showing a modified construction; and

Fig. 7 is a similar view of a further modification. Referring to Fig. 1, I have shown a portion of a combustion chamber C having a side wall 10. A cooling conduit or tube 11 is maintained in contact with the outer surface of the chamber wall 10. The tube 11 is commonly wound in helical formation around the cylindrical chamber but may be placed lengthwise of the chamber if so desired.

I form the conduits or tubes 11 of relatively thin metal, usually copper, and I preferably form the tubes of circular cross section, as tubes of this section have maximum resistance to distortion by either internal or external force.

Any suitable cooling liquid may be circulated through the tubes 11, and this liquid under certain conditions will be at substantial pressure.

Each tube 11 makes line contact only with the wall 10, which is a most unfavorable condition for heat transfer. Accordingly I provide filler strips 12 to improve the thermal conductivity. The strips 12 may be of copper or copper alloy of such composition that it will not be melted by the heat

transferred from the highly heated chamber wall 10.

The strip 12 in Fig. 1 is substantially triangular in cross section, with curved outer faces adapted to closely engage the outer surfaces of adjacent tubes 11. With this construction, heat will be transferred continuously from all portions of the combustion chamber wall, either through direct contact with the tubes 11 or indirectly through the filler strips 12.

In applying my improved jacket construction to a combustion chamber, I find it desirable to first wind a continuous triangular filler strip in helical formation around the combustion chamber and to then wind a continuous tube 11 in the helical recesses formed between adjacent filler strips.

Instead of the sharply triangular filler strip shown in Fig. 1, I may provide a filler strip 14 having rounded edges as indicated in Fig. 2, such a strip being easier to manufacture and easier to manipulate, but being slightly less efficient as to heat transfer, as the air spaces between tubes are not entirely filled.

In Fig. 3 I have shown a filler strip 15 of laminated structure, which may be formed by winding successive layers of decreasing width around the combustion chamber wall. For relatively large chambers and conduits, such a laminated construction has structural advantages.

In Fig. 4 I have indicated a further modified form of filler strip 16 in which a longitudinal passage 17 is provided. With this construction, the strip 16 forms in effect an additional continuous conduit through which also cooling fluid may be circulated.

In Fig. 5 I have shown a form of filler strip comprising an inner band 18 and an outer triangular portion 19. In this construction, the band 18 is preferably of copper to resist the high temperature of the combustion chamber wall, while the portion 19 may be of aluminum. This construction is desirable where lightness is important, as aluminum at high temperature is substantially equal to copper in thermal conductivity, whereas the weight of aluminum is only about one-third that of copper for equal mass.

In order to still further facilitate heat transfer and also to provide increased strength, I may provide additional filler strips 20 (Fig. 1) outside of the conduits or tubes 11 and enclosed by a strong outer casing 21. The filler strips 20, being substantially removed from the combustion chamber wall, are exposed to less intense heat and may be of aluminum, with the advantages previously described. The outer casing 21 may be of strong

steel or of an alloy of high tensile strength, under which conditions the wall 10 of the combustion chamber may be made thinner and lighter and the tubes 11 may also be of less thickness and strength, as the outer casing provides the necessary resistance.

In Fig. 6 I have shown the combustion chamber wall 10, tube 11, outer filler strip 20 and outer casing 21 all as previously described, but I have also indicated a further modified construction for the inner filler strips, in which construction each strip is formed of a copper portion 24 and an aluminum portion 25, somewhat as shown in Fig. 5 but having the copper portion 24 of such varied thickness that its outer surface at all points will be at substantially the same temperature, which temperature is safely below the melting point of aluminum.

The outer filler strips 20 may also be used to advantage without using the outer casing 21 where only moderate pressures will be developed.

It will be noted that where the copper portion is more widely spaced from the cooling tubes 11, the thickness of the copper is increased to offset the decreased cooling effect of the fluid in the tubes.

Where cooling fluid and particularly a liquid is circulated at a fairly rapid rate through the cooling tubes, it is found that the warmer portion of the liquid circulates adjacent the combustion chamber wall 10, while the cooler portion of the liquid is displaced outward away from the wall 10 by centrifugal force. Also if the liquid should become heated to such an extent that it began to boil, the liquid portion would be thrown to the outside of the tube and would of course be a much better heat conductor than the warm vapor. Furthermore, the reduced amount of metal at the point *a* in Fig. 1 greatly reduces the heat transfer to the outer filler strips 20 from which heat could be transferred to the cooler outer portion of the liquid. To overcome these disadvantages, I may utilize one of the constructions shown in Figs. 6 and 7.

In Fig. 6 I have shown the tubes 11 provided with lining strips 30 at the top and both sides of each tube, these strips being preferably continuous and formed of aluminum. The addition of the strips 30 provides a substantial thickness of metal at the line 6-6 (Fig. 6) and facilitates transfer of heat to the outer portion of the jacket structure and to the cooler portion of the liquid in the tubes 11.

In Fig. 7 I have shown a slight modification of this construction, in which a one-piece reinforcing lining member 35 of substantially U-shaped section is provided, this member also being preferably formed of aluminum. This one-piece construction is more readily assembled with the tubes and stiffens and reinforces the tubes to a substantial extent.

It will be understood that the lining strips 30 and lining members 35 may be inserted in any of the tubes 11 and may be used in combination with any of the filler strips shown in any one of Figs. 1 to 7.

A cooling jacket as above described has been found extremely efficient and satisfactory where high temperatures are encountered and where light weight combined with high tensile strength is essential. Such conditions obtain in the construction of rocket motors for aeronautical purposes, where combustion chambers of very thin shell steel must function under extremely high temperature conditions.

My improved cooling jacket construction not only provides effective cooling but also directly reinforces and strengthens the thin combustion chamber walls. Where the outer casing 21 is used, this outer casing, being relatively cool, may be of high tensile strength while the combustion chamber wall may be of a metal which is highly heat conductive but without special strength qualifications.

While my new construction is most efficient when using a liquid cooling medium, many of the advantages will be retained when using a gas or vapor under high pressure, or a mixture of liquid and gas or vapor.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:—

1. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing for said wall a cooling jacket construction comprising abutting circular fluid-conducting tubes directly engaging said wall, and separate heat-conducting metal filling strips engaging said wall and disposed between adjacent tubes and in close contact therewith, said strips having a substantially triangular cross section and being in continuous and substantially complete contact with said wall and tubes but unattached thereto.

2. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing for said wall a cooling jacket construction comprising circular fluid-conducting tubes directly engaging said wall, and separate heat-conducting metal filling strips engaging said wall and disposed between adjacent tubes and in close contact therewith, said strips having a substantially triangular cross section closely filling the spaces between said tubes and said wall and being formed of a plurality of circumferentially superposed laminated layers.

3. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing for said wall a cooling jacket construction comprising circular fluid-conducting tubes directly engaging said wall, and separate heat-conducting metal filling strips engaging said wall and disposed between adjacent tubes and in close contact therewith, said strips having a substantially triangular cross section closely filling the spaces between said tubes and said wall and being formed of an inner wall-engaging portion of copper and a superposed outer portion of aluminum.

4. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing for said wall a cooling jacket construction comprising circular fluid-conducting tubes directly engaging said wall, and separate heat-conducting metal filling strips engaging said wall and disposed between adjacent tubes and in close contact therewith, said strips having a substantially triangular cross section closely filling the spaces between said tubes and said wall and being formed of an inner wall-engaging portion of copper and a superposed outer portion of aluminum and the thickness of the copper portion being proportioned to maintain substantially uniform temperature at all points on its external surface.

5. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, the combination with said wall of a cooling jacket construction comprising thin fluid-conducting tubes engaging said wall, a copper filler strip engaging said wall and disposed between adjacent tubes and in contact therewith, aluminum outer filler strips mounted between the outer portions of adjacent tubes and in contact therewith and with said copper strip, and a steel casing enclosing said tubes and outer filler strips.

6. In combustion apparatus wherein high temperatures are developed within a chamber having a thin metal wall, the combination with said wall of a cooling jacket construction comprising thin fluid-conducting tubes engaging said wall and a substantially triangular metal filler strip disposed between and in continuous contact with said wall and adjacent tubes, said strip having a continuous longitudinal passage therethrough effective to conduct additional cooling fluid about said chamber.

7. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, the combination with said wall of a cooling jacket construction comprising thin fluid-conducting tubes engaging said wall, separate heat-conducting filler strips engaging said wall and disposed between adjacent tubes and in contact therewith, and additional separate heat-conducting filler strips disposed between the outer portions of adjacent tubes.

8. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing a helical tubular cooling coil closely engaging said wall, and a shaped helical metal winding strip interposed between the turns of said coil and contacting said wall and turns and substantially filling the spaces between said wall and turns.

9. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing a helical tubular cooling coil closely engaging said wall, a shaped helical metal winding strip interposed between the turns of said coil and contacting said wall and turns and substantially filling the spaces between said wall and turns, and an aluminum lining for said tube on portions remote from said wall.

10. In combustion apparatus wherein high temperatures are developed within a chamber having a thin sheet metal wall, that improvement which consists in providing a helical tubular cooling coil closely engaging said wall, a shaped helical metal winding strip interposed between the turns of said coil and contacting said wall and turns and substantially filling the spaces between said wall and turns, and a one-piece aluminum lining for said tube which is U-shaped in section and covers the sides thereof and the portion remote from said wall.

ROBERT H. GODDARD.