N70-41818

May 22, 1962 E. F. BAEHR 3,035,333

METHOD OF MAKING A REGENERATIVELY COOLED COMBUSTION CHAMBER

Original Filed Jan. 9, 1959 2 Sheets-Sheet 1

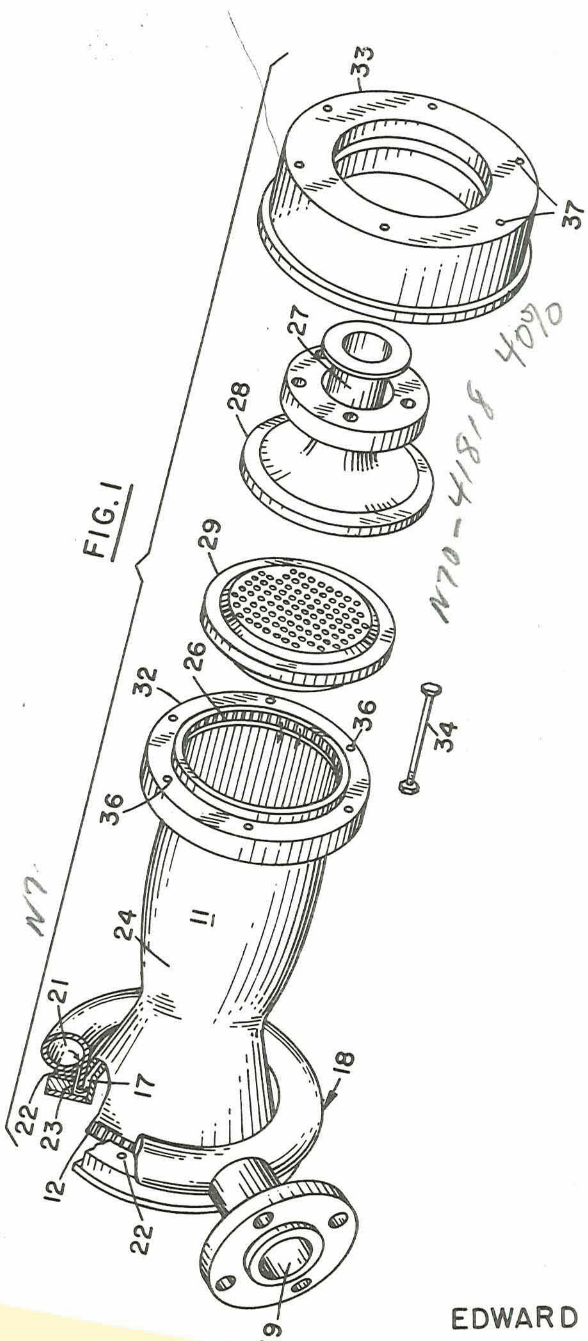

FIG. 1

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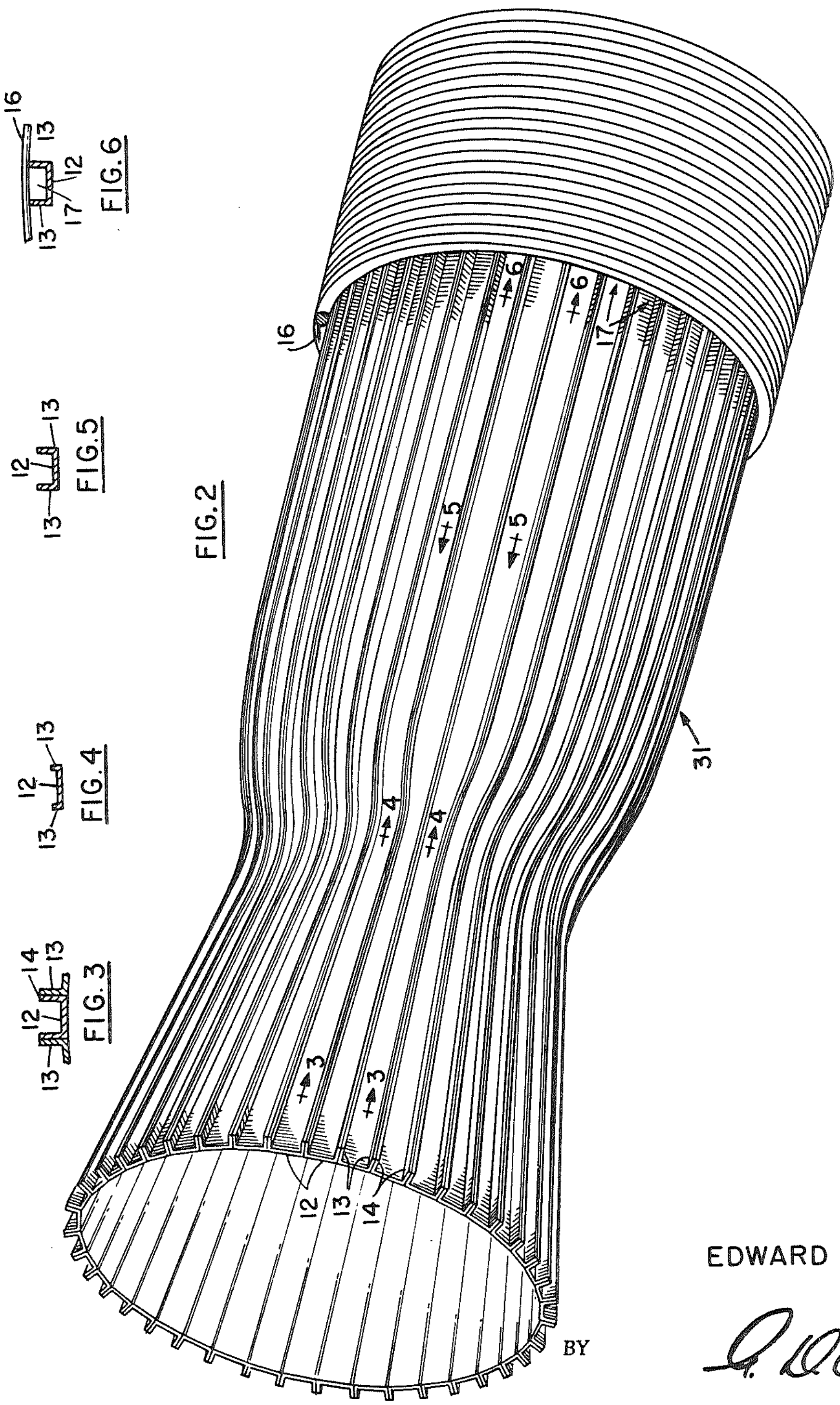

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United States Patent Office

3,035,333

Patented May 22, 1962

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3,035,333
METHOD OF MAKING A REGENERATIVELY COOLED COMBUSTION CHAMBER

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Original application Jan. 9, 1959, Ser. No. 785,990, now Patent No. 2,943,442, dated July 5, 1960. Divided and this application Sept. 15, 1959, Ser. No. 843,032
6 Claims. (Cl. 29—157.3)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This application is a division of copending application Serial No. 785,990 filed January 9, 1959 and now U.S. Patent No. 2,943,442.

This invention relates to combustion chambers requiring high heat flux of the general type commonly used in rockets, gas generators and arc jet chambers.

It is essential that the wall of such a combustion chamber be made thin in order to save weight, but at the same time provision must be made to enable this wall to withstand very high combustion temperatures. Among the means already employed in the art to solve this problem is that of providing a jacket around the combustion chamber spaced a fixed distance therefrom and passing fluid coolant through the resulting annular passage. In this manner the temperature of thin combustion chamber walls can be kept low enough to permit continuous operation over extended periods of time.

Attempts to utilize a spearate coolant, that is one having the sole function of cooling, have indicated that the weight added to the rocket motor by the coolant itself, the means provided for its storage and the necessary valves, pumps and conduits provides a distinct disadvantage. Further, in such an arrangement the heat absorbed by the coolant is entirely wasted.

Currently, the practice is to utilize regenerative cooling of such combustion chambers wherein fluid propellant is employed as the cooling medium in addition to its primary function as a propellant.

The most successful existing light-weight construction employs the tube bundle type construction. In this type of construction the wall of the combustion chamber is composed of tubes contiguously arranged. These tubes serve as the coolant passages as well as serving to function as the structural elements of the chamber wall.

This type of construction has the distinct disadvantage, however, that should any variation in the cross-sectional area of the coolant passage be desired such variation must be achieved by the use of very complicated forming operations.

It is, therefore, one object of this invention to provide a regeneratively cooled combustion chamber of channel construction as a means of making extremely light gage inner walls capable of withstanding very high heat flux rates and yet able to withstand high coolant pressures.

It is another object of this invention to provide a type of combustion chamber construction which furnishes variations in the velocity of the cooling agent at various longitudinal stations along the chamber whereby greater or less cooling is produced at different longitudinal portions of the chamber wall.

It is still another object of the present invention to provide a simple method of fabrication of a light-weight regeneratively cooled combustion chamber of channel construction furnishing differential cooling of the chamber wall.

Thus, in contrast to the prior art tube bundle construction the present invention provides a lighter-weight unit during the fabrication of which the coolant passages can be tailored to the exact cooling requirements of the unit. By employing light-gage channel construction this weight advantage can be gained without sacrifice of the ability of the chamber walls to withstand the pressure loading by the coolant.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is an exploded view in isometric of a rocket thrust chamber of channel construction showing the path taken by the coolant and the order of assembly of parts;

FIG. 2 is an isometric view of the chamber showing the assembly at that fabrication stage preparatory to forming the outer closure of the coolant; and

FIGS. 3, 4, 5 and 6 are sections taken on lines 3—3, 4—4, 5—5, and 6—6 of FIG. 2 showing variations in the height of the channel ribs along the length of the chamber.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIG. 1 (which illustrates a preferred embodiment) a rocket thrust chamber **11** fabricated from a plurality of channels **12** formed from a material capable of withstanding the operating temperatures as well as the corrosive action of the propellants. As seen in FIG. 2 these channels **12** have ribs **13** of varying length at the longitudinal stations indicated. These channels are joined together by braze material **14** during the fabrication process to be described below. In high temperature installations, high strength wire **16** is wrapped about the assembled channels **12** to form a nonporous outer skin and is brazed to ribs **13** at the points of contact therewith. By this expedient the channels **12** are readily converted into rectangular conduits, the coolant passages **17**.

These passages **17** vary in cross-section since the height of the channel ribs **13** is varied as shown in FIG. 2. In this manner the propellant coolant is provided with the proper design velocity to accomplish the required cooling rates.

For moderate temperature conditions, glass fiber may be used as a wrapping instead of the high strength wire. In such case the glass fiber is resin bonded to ribs **13** forming thereby the outer skin of coolant passages **17** and also serving as binding means for the channels **12**.

The rocket thrust chamber **11** formed by the wire-wrapped channels **12** is provided with annular supply manifold unit **18** through which the propellant coolant (such as liquid hydrogen) is admitted (shown by arrows in FIG. 1) to the coolant passages **17** through pipe **19**, conduit **21**, holes **22** and plenum chamber **23**. This supply of coolant enters coolant passages **17** at the exhaust end of chamber **11** and passes through coolant passages **17** counter to the flow of combustibles within the combustion chamber **24**. At the far end of the coolant passages the propellant coolant enters the combustion chamber **24** from coolant passages **17** through openings **26**. Also at this far end of chamber **11** the propellant oxidant (such as liquid fluorine) enters through pipe **27**, manifold **28** and injector **29** to combine with the propellant coolant to initiate combustion.

The fabrication process currently employed consists of the following steps: forming the channels **12** each consisting of one piece running the length of the chamber, bundling of the proper number of properly formed channels around a brazing mandrel, spot-welding the channels together, brazing the channels together into an assembly **31**, grinding the channel ribs **13** to yield the proper uniformly varying coolant passage heights, wire-wrapping channel assembly **31**, brazing the wrapped wire to ribs **13** and to the adjacent turns, installing manifold 18 and flange 32. The incidental steps of installing the injector 29 and manifold 28 (with pipe 27) and holding these components in place by the use of collar 33 bolted to flange 32 with bolts 34 passing through holes 36 and 37 are deemed obvious and form no part of this invention.

As an alternative, the channels 12 can be formed and then sized in an operation resulting in ribs of the proper height as desired for the finished product. These properly sized channels can then be bundled around a brazing mandrel, followed by the wire wrapping step, brazing of the assembly and installing of manifold 18 and flange 32.

The type of wire used in wrapping can be either round or square in cross-section. When round wire is preferably used, a helical groove is ground in the ribs to provide a large area of contact between the wire and the ribs. The lead of this groove is chosen to provide braze clearance between adjacent wires. If square wire is preferably used, the ribs are ground smooth, but the wire is fed through a set of rollers prior to wrapping on assembly 31 whereby a fin is raised on the side of the wire to provide the proper braze clearance.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A method for the fabrication of regeneratively cooled combustion chambers comprising the steps of arranging preformed elongated channels contiguous to one another to form a hollow elongated chamber of desired contour with the ribs of each channel extending radially outwardly substantially parallel to each other, securing adjacent channels to each other, wrapping wire around the channels so arranged to bind said channels together with the loops of said wire being contiguously placed and securing said adjacent loops of wire to one another and to said channel ribs forming thereby a non-porous skin structure effectively closing the open side of each channel and producing a plurality of coolant passages surrounding said elongated chamber and extending longitudinally thereof.

2. A method for the fabrication of regeneratively cooled combustion chambers comprising the steps of forming elongated channels, each channel having substantially parallel ribs, arranging said channels contigous to one another to form a hollow elongated chamber, securing adjacent channels to one another, grinding the ribs of said channels to desired height variations, wrapping wire around the channels so arranged with the loops of wire being contiguously placed and securing said adjacent loops of wire to one another and to said channel ribs forming thereby a non-porous skin structure effectively closing the open side of each channel and producing a plurality of coolant passages surrounding said elongated chamber and extending longitudinally thereof.

3. A method of fabrication of regeneratively cooled combustion chambers comprising the steps of arranging preformed elongated channels contiguous to one another to form a hollow elongated chamber of desired contour with the ribs of each channel extending radially outwardly substantially parallel to each other, securing adjacent channels together, grinding a helical groove longitudinally on said hollow elongated chamber, wrapping round wire in said groove around the channels so as to bind said

channels together with loops of said wire, and securing said adjacent loops of wire to one another and to said channel ribs forming thereby a nonporous skin structure effectively closing the open side of each channel and producing a plurality of cooling passages surrounding said elongated chamber and extending longitudinally thereof.

4. A method for the fabrication of regeneratively cooled combustion chambers comprising the steps of arranging preformed elongated channels contiguous to one another to form a hollow elongated chamber of desired contour with the ribs of each channel extending radially outwardly substantially parallel to each other, securing adjacent channels to each other, grinding smooth said rib surfaces, passing square wire through a set of rollers whereby a fin is raised on one side of said wire, wrapping said wire around the channels so arranged as to bind said channels together with the loops of said wire whereby the fin of said wire provides the proper braze clearance and brazing said adjacent loops of wire to one another and to said channel ribs forming thereby a nonporous skin structure effectively closing the open side of each channel and producing a plurality of cooling passages surrounding said elongated chamber and extending longitudinally thereof.

5. A method for the fabrication of regeneratively cooled combustion chambers comprising the steps of forming elongated channels, each channel having substantially parallel ribs, arranging said channels contiguous to one another to form a hollow elogated chamber, securing adjacent channels to one another, grinding the ribs of said channels to desired height variation, grinding a helical groove longitudinally on said elongated chamber, wrapping round wire in said groove around the channels and securing adjacent loops to one another and to said channel ribs forming thereby a nonporous skin structure effectively closing the open side of each channel and producing a plurality of coolant passages surrounding said elongated chamber and extending longitudinally thereof.

6. A method for the fabrication of regeneratively cooled combustion chambers comprising the steps of forming elongated channels, each channel having substantially parallel ribs, arranging said channels contiguous to one another to form a hollow elongated chamber, securing adjacent channels to one another, grinding the ribs of said channels to desired height variations, passing square wire through a set of rollers whereby a fin is raised on one side of said wire, wrapping said wire around the channels so arranged to bind said channels together with the loops of said wire, whereby the fin of said wire provides the proper braze clearance and brazing said adjacent loops of wire to one another and to said channel ribs, forming thereby a nonporous skin structure effectively closing the open side of each channel and producing a plurality of coolant passages surrounding said elongated chamber and extending longitudinally thereof.

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