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3,235,947

METHOD FOR MAKING A COMBUSTION CHAMBER

Filed Jan. 30, 1962

2 Sheets-Sheet 1

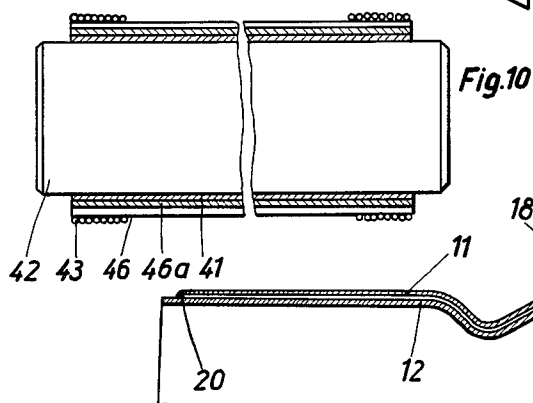
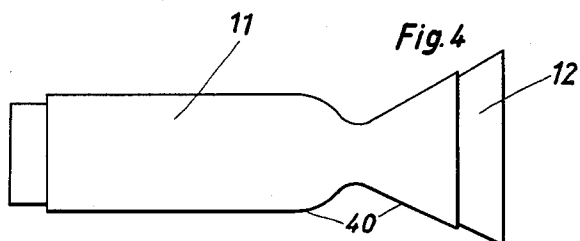
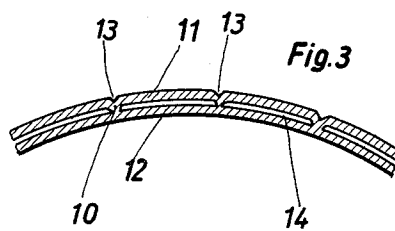
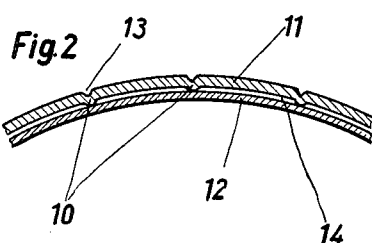
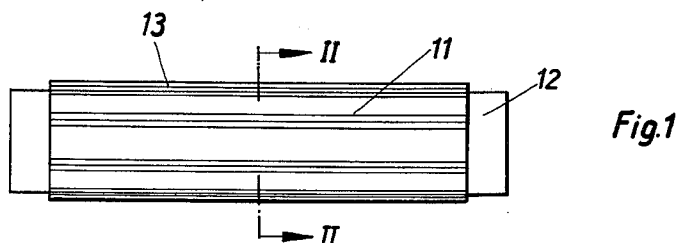


Fig. 10

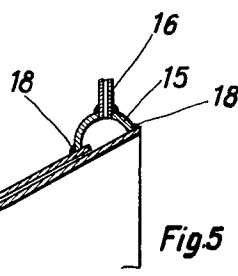


Fig. 5

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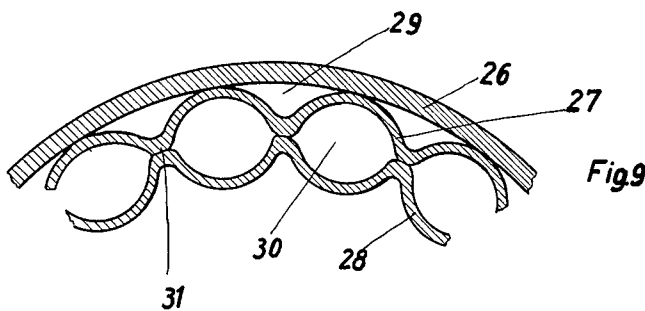
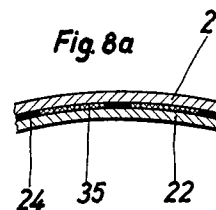
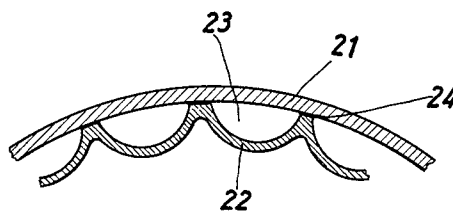
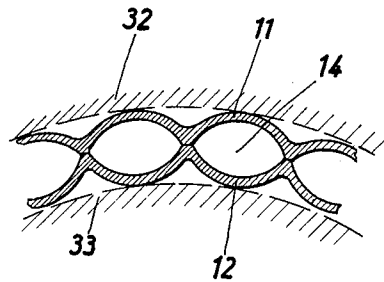
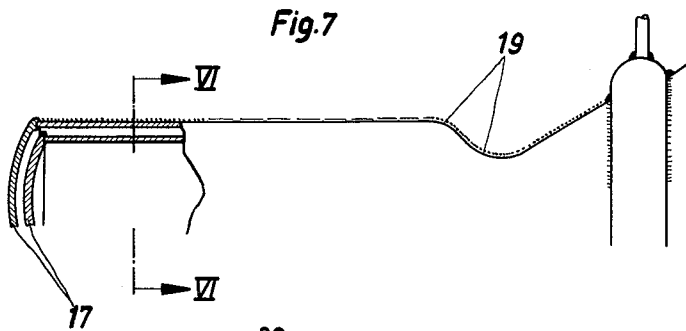
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2 Sheets-Sheet 2



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METHOD FOR MAKING A COMBUSTION CHAMBER

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This invention relates in general to the manufacture of combustion chambers, and in particular to a new and useful process for the manufacture of double-wall combustion chambers which include channels defined between the walls for the passage of cooling fluids.

The present invention has particular application for the production of rocket or thrust-type engines, such as those which operate with liquid or solid fuels. Combustion chambers for liquid fuels are known wherein one of the fuel components is utilized for cooling the combustion chamber wall. For this purpose, such combustion chambers are usually of double-wall construction with cooling channels between the combustion chamber walls which are advantageously arranged to extend in a substantially axial direction. It is usual to make at least the inner walls of such combustion chamber constructions of a material having a high heat transfer coefficient. In some instances, combustion chambers of this type include cooling channels defined between the walls which are separated by ribs which extend either partially or completely between the double-wall construction. With all of these combustion chamber constructions, great difficulty is encountered in the manufacture thereof because of the technical problems encountered in accurately forming the double walls and the cooling channels in a manner to ensure a very strong combustion chamber construction and sufficient cooling liquid flow over all areas.

In accordance with the present invention, combustion chambers of the aforementioned type are manufactured in a relatively simple manner by fabricating the chambers from two tubular elements, one of which is located within the other to form the double-wall combustion chamber construction. One of the tubular elements, either the inner or the outer one, is formed with corrugations or ribs which are bent in a direction toward the other tubular element and extend axially along the length of the elements forming the combustion chamber. The corrugations are advantageously made to an amount which will ensure that the projecting portion will contact the wall of the opposite cylindrical element.

In accordance with the method, the tubular elements forming the double-wall combustion chamber are then joined together along the corrugations, such as by welding. Thereafter, the channels which are formed between the corrugations and between the walls of the two cylindrical elements are widened by the introduction of a fluid medium under pressure into these spaces. In order to facilitate the introduction of this fluid medium, in accordance with the invention, the outer cylindrical element is welded to the inner cylindrical element at one end, a collecting ring is secured between the elements at the opposite end, and fluid under pressure is directed into this collecting ring.

The fluid under pressure will thereupon enter each of the cooling channels and cause the widening thereof into a desirable fluid flow channel configuration in accordance with the amount of pressure which is applied.

In some embodiments, it is preferable to make the inner and outer wall tubular elements of different thickness or of different materials to achieve desirable heat transfer and structural results. Where the materials are made of the same thickness, the channels are widened in a uniform manner and result in a somewhat elliptical cool-

ing channel formation when they are widened under pressure. In those instances where one of the wall elements is made of a materially thicker and structurally stronger material, then only one of the elements will bend under the force of the fluid pressure and the other will maintain its normal configuration.

A further step in the formation of the combustion chamber is the shaping of the tubular elements to form the desired nozzle configuration at the combustion gas discharge end of the combustion chamber.

In some instances, instead of employing a tubular element with corrugations or ribs, insulating materials are placed between the tubular elements at areas where it is desired to have no welding take place and conductive strips are located where the connecting ribs are to be formed and the elements are annealed to form the cooling channels.

A feature of the method of the invention is that the cross sectional shape of the cooling channels may be controlled during the widening process by the choice of the wall thicknesses of the elements employed. For example, the inner pipe can be produced of a material which has good heat transfer properties, while the outer pipe may be made of a very strong or stable material. In order to obtain better weldability of the two tubular elements, it is also possible to use materials having these characteristics and which fulfill both of the previously mentioned conditions.

In accordance with another feature of the invention, more than two tubular elements are employed which are placed over each other in a telescopic manner and welded together along corrugations which project toward the next adjacent pipe element. In a construction of this nature, it is advantageous to offset the corrugations so that the welded connections may be offset between adjacent tubular elements.

In accordance with another feature of the invention, the tubular elements are separated at the corrugation contact areas by intermediate silver strips. The combustion chamber which is formed is annealed and a rigid connection of the pipes at the contact places with the silver strips is thus produced.

Accordingly, it is an object of this invention to provide an improved method of making a combustion chamber.

A further object of the invention is to provide a method of making a combustion chamber which includes arranging two tubular elements in telescopic fashion, one around the other, and wherein at least one of the tubular elements includes ribs or corrugations which extend toward the other tubular element, welding the tubular elements together at locations adjacent the corrugations to form channels between the walls of said tubular elements and between adjacent corrugations, and thereafter widening the channels by directing fluid under pressure there-through.

A further object of the invention is to provide a method of manufacturing combustion chambers which includes arranging a tubular element having corrugations in telescopic arrangement with another tubular element in a manner that the corrugations extend from one tubular element toward the other tubular element in contact therewith and welding the tubular elements together along the corrugations to form cooling channels between corrugations and located between the walls of the tubular elements, thereafter forming the structure into a combustion chamber by forming a nozzle portion and adding end covers and widening the channels formed between the corrugations by introducing fluid under pressure.

A further object of the invention is to provide a method of forming a combustion chamber which is simple in concept, economical to perform and produces a very highly desirable product.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

In the drawings:

FIG. 1 is a side elevation indicating two tubular elements arranged in telescopic fashion in an initial step of the process of the present invention;

FIG. 2 is a fragmentary transverse section taken on the line II—II of FIG. 1;

FIG. 3 is a view similar to FIG. 2 but indicating the parts after they have been welded along the corrugations;

FIG. 4 is a side elevation indicating the tubular elements of FIG. 1 after they are formed to provide a discharge nozzle;

FIG. 5 is a fragmentary longitudinal section of the tubular elements indicated in FIG. 4 prior to widening of the cooling channels;

FIG. 6 is a fragmentary transverse section taken on the line VI—VI of FIG. 7 indicating the widened cooling channels;

FIG. 7 is a fragmentary partly elevational and sectional view of the combustion chamber with the end covers installed;

FIG. 8 is a partial transverse section of the combustion chamber produced, using tubular elements of different wall thickness;

FIG. 8a is a fragmentary transverse section of another embodiment of combustion chamber;

FIG. 9 is a fragmentary transverse section of still another embodiment of combustion chamber construction; and

FIG. 10 is a transverse section indicating still another embodiment of the invention.

Referring to the drawings in particular, the invention embodied therein provides a method for forming two pipes or tubular elements 11 or 12 into a combustion chamber. In the embodiment illustrated, the tubular element 12 is substantially cylindrical and the tubular element 11 is cylindrical but provided with longitudinally extending ribs or corrugations 13 formed along the length thereof. In this particular embodiment the corrugations 13 extend inwardly from the exterior face of the tubular element 11 into contact with the exterior face of the tubular element 12, to form ribs 10 which define cooling channels therebetween. As indicated, the ribs 10 engage the inner pipe or tubular element 12 without play. In some instances, it is desirable to form the corrugations on the inner tubular element 12 which would extend outwardly to engage the inner wall of the outer tubular element 11.

The number of corrugations 13 which are defined on the pipe 11 or the pipe 12, as desired, is chosen in such a manner that the distance between two corrugations is equal to half the circumference of the cooling channels to be produced.

After the pipes have been pushed together in telescopic fashion, they are homogeneously connected to each other at the contacting areas of the corrugations 13 by welding or soldering. In FIG. 3 there is indicated in partial section how the tubular elements 11 and 12 appear after being welded together.

As shown in FIG. 3, the spaces formed between the ribs 10 form very narrow or flat channels 14. Thereafter, the two tubular elements 11 and 12 are formed or shaped without cutting in order to form a thrust nozzle configuration 40 at one end.

Thereafter, as indicated in FIG. 5, an inlet collecting ring 15 is placed in a position to span the ends of tubular elements 11 and 12 and welded to each element by welding applied at 18. The collecting ring 15 includes a filling

pipe 16 and fluid under pressure directed through the pipe for direction via the collecting ring 15 along the cooling channels after the front end of the tubular elements 11 and 12 are welded along a front welding seam 20. All of the welding is done in a gas-tight manner to ensure that there will be no leakage when the fluid under pressure is directed through the cooling channels 14.

After the welding of the cylinder walls 11 and 12, the channels 14 are subjected to pressure by introducing a medium, for example a liquid under pressure, through the filling pipe 16 and collecting ring 15. The pressure of the fluid medium is increased to such an extent that the channels will widen to the form indicated in FIG. 6.

By introducing a core 33 at a position within the inner tubular element 12 and an outer mold 32 arranged at a position spaced from the exterior of the outer tubular element 11, the widening of the channels 14 can be limited to a size in which the tubular element walls press against the core and the outer mold 33 and 32, respectively. By choosing the wall thicknesses and the materials of the inner and outer tubular elements 11 and 12, the channel form of the cooling channels 14 can be varied in any desired manner. Both the forming of the nozzle and also the widening of the channels 14 are preferably accomplished by cold shaping.

Thereafter, the front welding seam 20 is removed and combustion chamber bottoms 17 are connected to the associated tubular elements 11 and 12 in a gas- and pressure-tight fit as indicated in FIG. 7.

For the purpose of increasing the inner pressure stability, the combustion chamber is surrounded or embraced by a strong metal strip or profiled wire 19. This latter strengthening is of particular advantage in those instances in which the combustion chamber is to be built within an additional casing which absorbs the combustion chamber pressure. By winding the combustion chamber with the metal wire or strip 19, difficulties with regard to fitting due to the form or shape of the combustion chamber are prevented.

In the embodiment indicated in FIG. 8, a combustion chamber is formed from two substantially cylindrical elements 21 and 22 which are made of different wall thickness and of different materials. In the production of this combustion chamber, instead of providing corrugations, longitudinally extending silver strips 24 are inserted at circumferentially spaced intervals between the tubular elements. In the spaces between the silver elements or strips 24, insulating strips 35 are inserted as indicated in particular in FIG. 8a. Thus, contact between the pipes through the silver only occurs at the spaced locations indicated. Upon subsequent annealing, an intimate fusing of the pipes or elements 21 and 22 is obtained in the areas of the silver strips.

Thereafter, the channels between the strips are widened by directing a fluid under pressure between the tubular elements. Since the inner tubular pipe 22 is of smaller wall thickness and of softer material only this pipe will be shaped by the introduction of the fluid under pressure. In this manner, the circular outline of the outer tubular element 21 is maintained and the inner pressure in the cooling conduits 23 is absorbed by the outer tubular element 21 without it being necessary to provide reinforcements therearound.

In FIG. 9 another embodiment of the method of the invention is indicated in which inner and outer tubular elements 28 and 27 are employed as in the embodiment of FIG. 6 but, in addition, an additional tubular element or jacket 26 is telescoped over each of these elements 27 and 28. When the channel 30 formed between the tubular elements 27 and 28 are widened in the same manner as in the embodiment of FIG. 6, the outer surfaces of the tubular element 27 connects to the tubular element 26 to form additional cooling channels 29. In this embodiment, the inner cooling channels 30 serve for direct cooling while the outer ones 29 serve for additional cooling of

the welded seam 31 between the combustion chamber wall 27 and 28.

In FIG. 10, a modified method for forming the combustion chamber is illustrated which is followed in order to insure that the longitudinal corrugations 46a of an outer tube 46 fit tightly to the outer circumference of an inner tube 41 during the welding or soldering of the two tubes together. In this embodiment, a mandrel 42 is positioned within the inner tube 41 and is of a size to fit tightly therein. Thereafter, the outer tube is covered with an encircling band 43 such as another tubular element or a belt or continuous coil of tubing or other means.

The mandrel 42 is advantageously made of a material having a higher coefficient of thermal expansion than the material used for the continuous coil 43. For example, the mandrel advantageously may include a coefficient of thermal expansion of 19×10^{-6} while the material used for the continuous coil has a coefficient of thermal expansion of only 15×10^{-6} . The whole arrangement is thereafter heated to accomplish diffusion welding, for example, and during the process the mandrel 42 expands more than the tube 43 so that the tube parts 46 and 41 are firmly pressed against each other at the contact points of the corrugations 46a.

A three wall combustion chamber can also be produced in a manner so that the three pipes are telescoped one over the other and are welded to each along correspondingly aligned or offset arranged corrugations. Thereafter, the formation of the nozzles and the pressure widening on all the cooling channels is accomplished in the same manner as in the previous embodiments.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the invention principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A method for producing liquid cooled rocket combustion chambers employing at least an outer and an inner combustion jacket comprising the steps in succession of arranging two tubular elements together in telescopic fashion one over the other with the inner one extending outwardly from the outer one on at least one end thereof, welding said tubular elements together at spaced circumferential locations extending along the complete longitudinal length thereof to connect said tubular elements together and to form cooling channels between connections, applying a front welding seam to connect said channels around a circumference at one end, applying a collecting ring member to an opposite end at a location so that one of the ring legs overlies one of the tubular elements and the other overlies the end of the other tubular element, welding the collecting ring to the respective tubular elements, and widening the cooling channels by directing a fluid under pressure through the collecting ring and thereafter through said cooling channels.

2. A method for producing a liquid cooled combustion chamber using tubular elements comprising the steps in succession of arranging two tubular elements together in telescopic fashion one over the other and welding the two tubular elements together at circumferentially spaced locations along their lengths so that the space between the tubular elements and between the connections form longitudinally extending cooling channels, forming a nozzle of the tubular elements by bending them adjacent their one ends and thereafter widening the channels by directing fluid through the channels under pressure.

3. A method for producing a liquid cooled combustion chamber using tubular elements, comprising the steps in succession of arranging the tubular elements together in telescopic fashion one over the other, connecting the two tubular elements together at circumferentially spaced locations along the lengths such as by welding so that the space between the tubular elements and between the connections form longitudinally extending cooling channels, forming the connected tubular elements into a nozzle configuration, and thereafter widening the cooling channels by directing fluid through the channels under pressure.

4. A method for producing a liquid cooled combustion chamber using tubular elements comprising the steps in succession of arranging two tubular elements together in telescopic fashion one over the other one of said tubular elements having longitudinal extending projecting portions which contact the other tubular element, inserting a mandrel into the innermost tubular element in tight contact therewith, applying an encircling band around the outer tubular element, welding the tubular elements together by diffusion welding wherein the mandrel expands at a greater rate than the encircling band so that the tubular elements are connected together tightly at the contacting points, said tubular elements being welded together at circumferentially spaced locations along their lengths so that the space between the tubular elements and between the connections form longitudinally extending cooling channels, and thereafter widening the cooling channels by directing fluid through the cooling channels under pressure.

5. A method for producing a liquid cooled combustion chamber using tubular elements, the outer one of which includes corrugations directed inwardly into contact with the opposite inner tubular element comprising the steps in succession of arranging the tubular elements together with the corrugations of the outermost element directed inwardly into contact with the innermost tubular element, arranging a mandrel with the innermost tubular element in tight contact therewith, arranging an encircling band having a lower coefficient of thermal expansion than the mandrel around the exterior of the outer tubular element in contact therewith, and thereafter heating the tubular elements to join them together along their contacting points.

6. A method according to claim 5, wherein said tubular elements are connected together by diffusion welding.

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