May 10, 1966 H. ROBINSON 3,249,989

METHOD OF MAKING A SHEET METAL THRUST CHAMBER

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Fig. 7

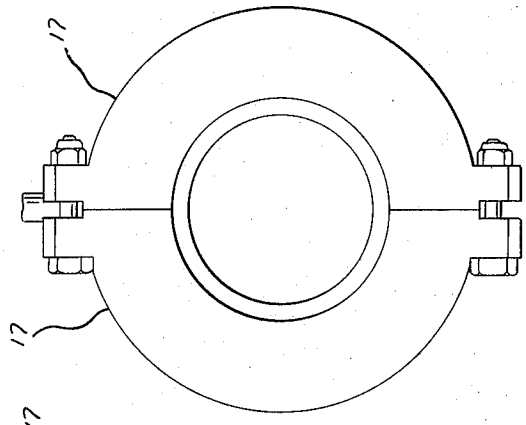



Fig. 1

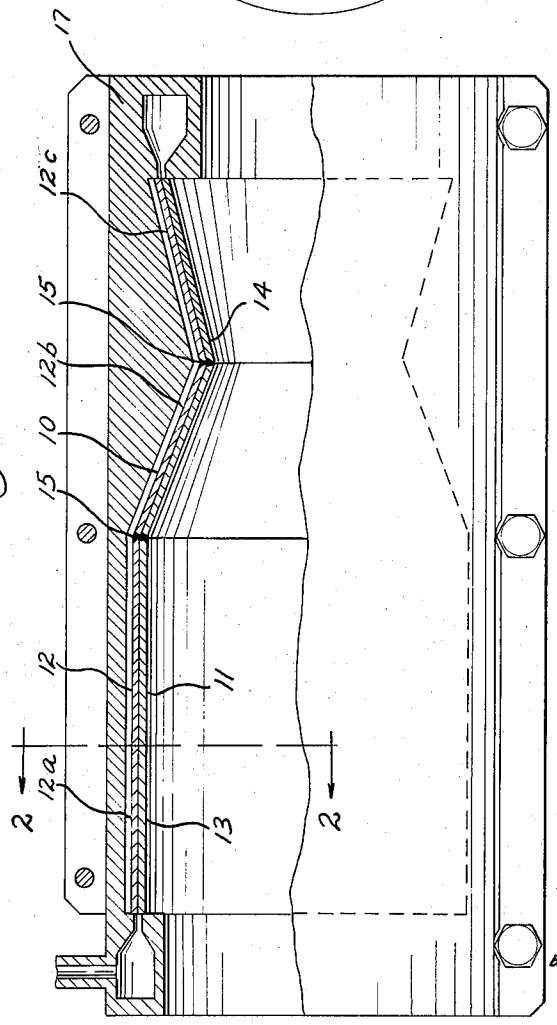
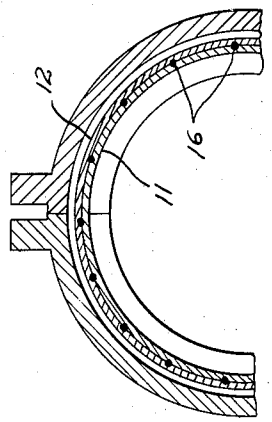



Fig. 2




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Fig. 3

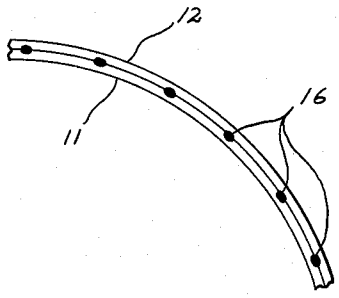



Fig. 4

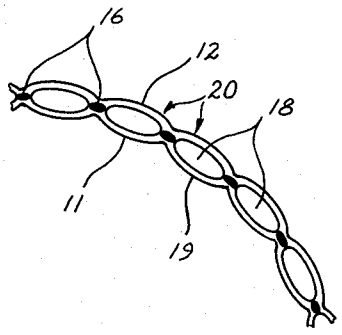



Fig. 5

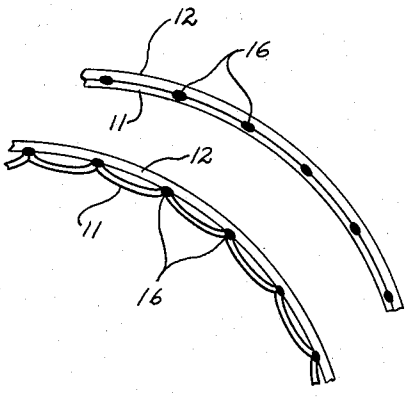
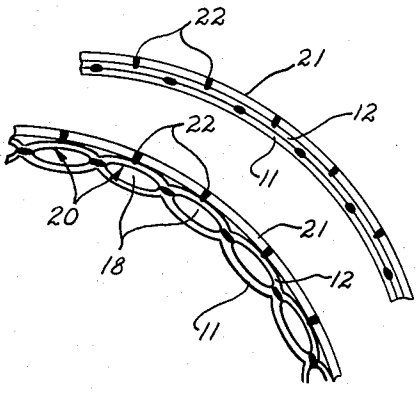



Fig. 6




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3,249,989

# METHOD OF MAKING A SHEET METAL THRUST CHAMBER

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4 Claims. (Cl. 29—157)

The invention relates in general to coolant-jacketed thrust chambers of jet propulsion devices, and has particular reference to a novel thrust chamber of this type wherein the wall is composed of plural sheet metal shells that are united and formed by a special method of fabrication.

An important object of the invention is to provide a simplified sheet metal thrust chamber construction capable of fabrication at low cost and high speed when employing the new method.

Another important object is to provide a sheet metal thrust chamber, particularly one of regenerative cooling type, wherein the coolant passages are formed between inner and outer concentric shells of such construction that the greater proportion of heat transfer will be from the interior of the chamber to the coolant fluid and not to the outer shell, whereby the latter will not be sufficiently heated to impair its strength.

Other objects, advantages and features of the invention will become apparent as the following specific description is read in connection with the accompanying drawings, in which:

FIGURE 1 is a side elevational view, partly in section, of a sheet metal thrust chamber and a hydraulic fixturing device prior to application of expanding fluid; FIGURE 2 is a transverse section on line 2—2 of FIGURE 1; and FIGURE 3 is a similar section without the fixturing device showing the unexpanded condition of the coolant passages prior to the admission of hydraulic fluid under pressure.

FIGURE 4 is a view similar to FIGURE 3, showing the result of hydraulic expansion when the outer and inner shells are of equal thickness.

FIGURE 5 is a view similar to FIGURE 3, showing the result of hydraulic expansion when the outer shell is of greater thickness than the inner shell.

FIGURE 6 is a view similar to FIGURE 3, showing the addition of a third, or outer, shell to take the hoop tension load.

FIGURE 7 is an end view of the fixturing device of FIGURE 1 showing a method of securing the metal shells therein.

Referring now in detail to the drawings, wherein like reference characters designate corresponding parts in the several views, FIGURES 1 to 4, inclusive, illustrate the simplified and presently preferred embodiment of the improved sheet metal thrust chamber and means for producing the same by hydraulic expansion.

In this instance, the body of the thrust chamber **10** comprises an inner shell **11** and a concentric outer shell **12**, both being of equal thickness and initially of cylindrical form. To give thrust chamber **10** its characteristic longitudinal contour, wherein there are a substantially cylindrical upstream combustion chamber **13** and a downstream convergent-divergent nozzle **14**, the inner shell **11** is fabricated by spinning, rolling, or similar process, and the outer shell **12** is wrapped around said inner shell. Outer shell **12** is composed of separate sections **12***a*, **12***b* and **12***c*, respectively, to match the longitudinal contour of inner shell **11**, and these sections are united at meeting edges by welding as at **15** (FIGURE 1).

As shown in FIGURE 2, the opposed surfaces of inner



shell **11** and outer shell **12** are substantially contiguous at the time of initial assembly. While in this initial relationship, both shells are united by a series of circumferentially evenly spaced seam welds **16** extending parallel to the longitudinal axis of chamber **10**. These seam welds can be made readily by resistance welding in which cooperative electrodes are applied to both sides of the sheet metal components to be welded and electrical energy fuses one component to the other by a common method known to any skilled welder.

Thereafter, by the employment of suitable hydraulic fixturing devices **17**, exemplified by the showing of (FIGURE 7), hydraulic fluid under pressure is forced into the clearance spaces intervening between shells **11** and **12** and between adjacent seam welds **16**. The result of this application of hydraulic pressure is to expand the parallel axial weld-line defined portions of shells **11** and **12** radially to form the coolant passageways **18** shown in FIGURE 4.

The practical advantages of this improved sheet metal thrust chamber construction may be explained by reference to FIGURE 4. It will be observed that the inwardly bulging convolutions **19** of the inner shell **11** present large exposed areas of comparatively thin sheet metal for conduction of heat from the combusted gases inside thrust chamber **10** to the coolant fluid in passageway **18**. In a regenerative cooling jacket wherein one of the liquid propellants is circulated, heat absorbed by the coolant fluid is not wasted but actually augments the heat content of the propellant desirably prior to combustion.

Another advantage of the inwardly convex form of convolutions **19** of the inner shell **11** is the effect of strengthening the shell against outward radial pressure while subjected to the softening effect of intense heat. The outwardly bulging convolutions **20** of outer shell are desirably insulated from internal chamber heat by the coolant fluid in passageways **18**. Due to the narrowness of the linear areas of contiguity of inner and outer shells **11** and **12**, respectively, along the seam welds **16**, very little heat will be conducted to outer shell **12**. An important result of this condition is the retention of sufficient strength in outer shell **12** to reinforce inner shell **11** during prolonged combustion.

FIGURE 5 represents the results of expanding a double shell thrust chamber structure generally similar to that disclosed in the preceding figures of the drawings but differing therefrom in that outer shell **12** in this instance is considerably thicker than inner shell **11**. This construction is designed to withstand very high pressure. During fabrication by hydraulic expansion, outer shell **12** will be distorted less than inner shell **11** since most of the energy of expansion goes into distorting the latter.

In FIGURE 6 there is shown a further modification in accordance with which a secondary outer shell **21** is applied to the external periphery of the thrust chamber **10** constituted by what may now be considered "primary" inner shells **11** and **12**. Secondary shell **21** is intended to take the hoop tension load and is united to outer primary shell **12** by an inert gas shielded fusion welding technique (with or without consumable electrodes) at welds **22**. It may be explained that a welding technique such as referred to above is a fusion welding technique in which no back-up electrode pressure is required and in which the piece to be welded serves as an electrode completing the electrical circuit. Hence an additional electrode on the underside of the pieces to be welded is unnecessary. A high heat electric current locally fuses the metal of the uppermost piece to the underneath one. The degree of penetration of the weld is determined by the amount of electrical energy used. Of course, a limitation as to the thickness of metal which can be penetrated effectively is imposed which is approximately one-quarter of an inch.

It should now be apparent that this improved sheet metal thrust chamber construction is highly versatile. It permits different combinations of metals, varying sheet thickness, tempers, and seam weld spacings to control the extent and shape of the expanded areas. The longitudinal seam welds are easily and economically made by automatic welding equipment. Combinations of materials, such as nickel; Inconel, 17–7PH; 300 series stainless, low carbon and alloy steels; and clad materials, can be used to achieve certain desirable heat transfer or strength combinations.

While there have been shown and described and pointed out the fundamental novel features of this invention as applied to only three structural embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. The method of making a thrust chamber of sheet metal which consists in shaping a portion of a cylindrical shell to define a convergent-divergent nozzle; forming an outer shell contiguous therewith by placing concentric, contour matching sections over said cylindrical, convergent, and divergent shell portions; uniting said sections to form a unitary outer shell; uniting said shells integrally at circumferential intervals by a series of continuous axial seam welds; and finally producing plural axial coolant passageways between said primary shells by injecting fluid under sufficiently high pressure into the clearance spaces between shells and adjacent seam welds to expand said spaces.

2. The method defined in claim 1, to which is added the step of surrounding the outer primary shell with a secondary outer hoop tension load sustaining shell of circular cross-section arranged in concentric contiguous relation thereto before expanding said spaces.



3. The method defined in claim 2, to which is added the step of welding the secondary shell to the outer primary shell in areas of mutual contact.

4. The method of making a thrust chamber of sheet metal which consists in assembling a pair of primary shells of circular cross-section in concentric and substantially contiguous relations, uniting said shells integrally at circumferential intervals by a series of continuous axial seam welds; surrounding the outer primary shell with a secondary outer hoop tension load sustaining shell of circular cross-section arranged in concentric contiguous relation thereto, welding the secondary shell to the outer primary shell in areas of mutual contact, and finally producing plural axial coolant passageways between said shells by injecting fluid under sufficiently high pressure into the clearance spaces between shells and adjacent seam welds to expand said spaces.


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