Aug. 18, 1964 M. H. SHARPE 3,145,128

APPARATUS FOR CHEMICAL MILLING CONVEXO-CONCAVE BULKHEADS

Filed Jan. 13, 1961

2 Sheets-Sheet 1

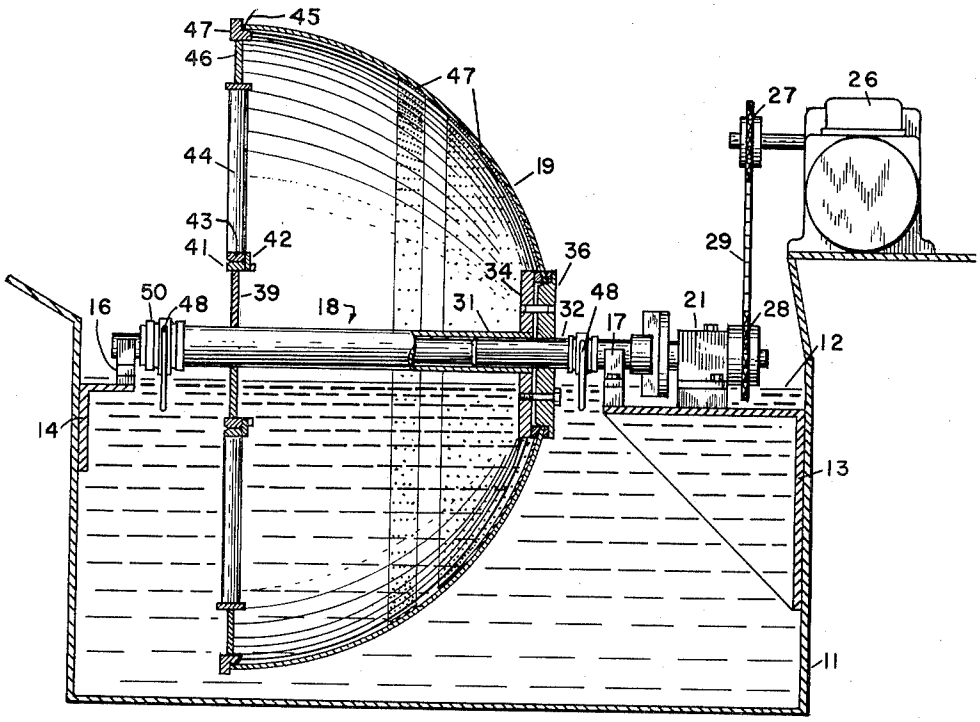


FIG. 1

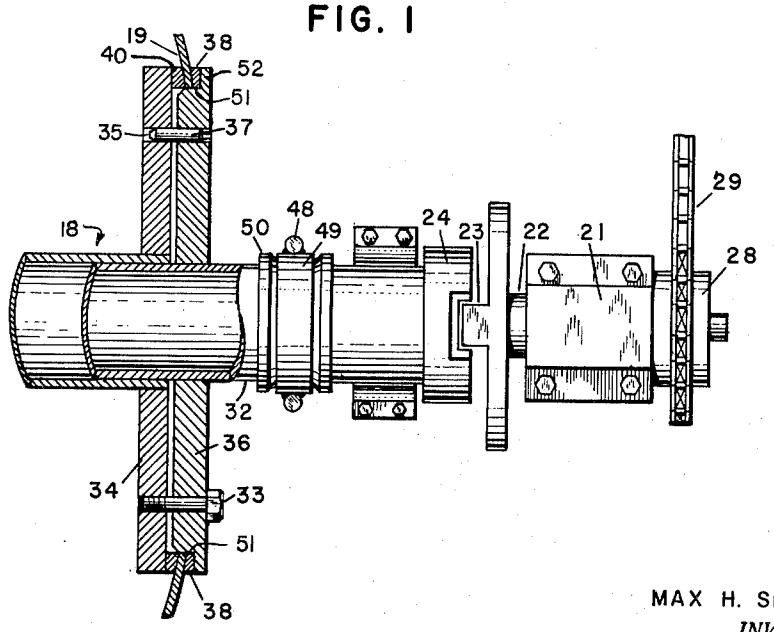


FIG. 2

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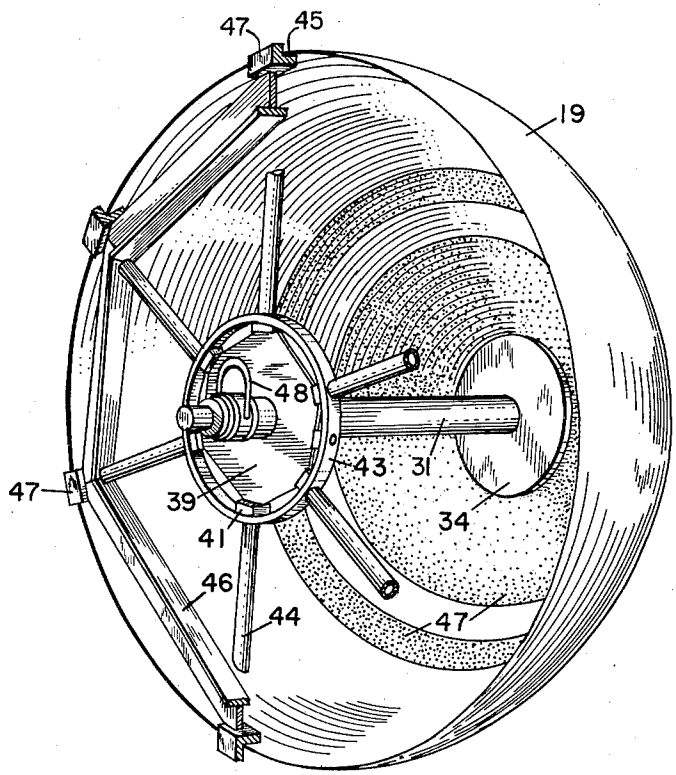


FIG. 3

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APPARATUS FOR CHEMICAL MILLING CONVEXO-CONCAVE BULKHEADS

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(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 invention relates to an apparatus for the chemical milling of large metal hemispherical convexo-concave bulkheads.

The prior method of making large hemispherical convexo-concave domes which consisted of welding metal sheets together, previously cut to pattern, has been proven inadequate for the large bulkheads used on propellant tanks of large rocket boosters. A dome bulkhead made from one piece of metal was needed to obtain consistent uniform high strength characteristics. The convexo-concave shape can be obtained by the conventional method of placing a large metal sheet on a dome shaped die and applying a shear force by a tool which moves in an increasing diameter circular path starting from the apex of the die and gradually moving outwardly from the apex so as to bend and conform the metal sheet to the die. However, the obtaining of the final internal contour desired for the hemispherical bulkhead having a large diameter of approximately six or eight feet by removing select portions of the surface was heretofore unsolved. This invention overcomes these prior difficulties by the use of a novel apparatus which adapts the known method of chemical milling as described in U.S. Patent 2,801,909 to the milling of the surface of a large hemispherical convexo-concave metal bulkhead.

It is, therefore, an object of this invention to provide an apparatus for chemically milling the surface of a convexo-concave bulkhead.

Another object is to provide an apparatus for rotatively supporting a large convexo-concave bulkhead in a chemical etching bath.

Other objects and many attendant advantages of the present invention will be apparent from the following detailed description when taken together with the accompanying drawings in which:

FIGURE 1 is a cross section of the apparatus, shown partly in full for clarity.

FIGURE 2 is an enlarged illustration of the connection between the transmission drive and axle including a sectional view of the axle mount for the bulkhead.

FIGURE 3 is an end view of the bulkhead showing the spider framework.

Referring now to the drawings, there is shown in FIGURE 1 an apparatus having an open top tank 11 with two spaced and opposed sides. The tank 11 is filled with an etching bath 12 of a type disclosed in U.S. Patent 2,801,909. Secured to one side of the tank 11 near its upper edge is a platform 14 which supports a U-shaped bearing 16, and secured to the opposite side of the tank 11 near its upper edge is a second platform 13 which supports another U-shaped bearing 17. Extending between and rotatively supported by the U-shaped bearings 16 and 17 is an axle 18 on which is mounted a hemispherical convexo-concave bulkhead 19 which is to be chemically milled.

A transmission 21 for regulating the speed of rotation of the axle 18 is mounted on the second platform 13. The transmission 21 includes a drive shaft 22 which has a key structure 23 on its distal end inserted into the

slotted end 24 of the axle 18 whereby the torque of the drive shaft 22 may be transmitted thereto. Power is supplied to the transmission 21 by a motor 26 which is supported by a flangelike platform integral with the upper edge portion of the tank 11 side which supports the second platform 13. The motor 26 drives a sprocket 27 and in turn sprocket 28 by a chain 29 which is in mesh with the teeth of each sprocket.

The axle 18 consists of two aligned portions 31 and 32 of different lengths which telescope together for the convenience of mounting the bulkhead 19. A first disc 34 is symmetrically secured to the long axle portion 31 so as to present a face substantially flush with the end of long axle portion 31 which telescopes over a part of the short axle portion 32. A second disc 36 is symmetrically secured to the short axle portion 32 spatially to the end of the short axle portion 32 which is telescoped within the long axle portion 31.

The second disc 36 has an L-shaped edge about its circular periphery defining a shoulder surface 51 and an upstanding stop portion 52. An annular rubber member 38 fits upon the shoulder surface 51 and abuts the stop portion 52 of the L-shaped edge. The annular rubber member 38 is sufficiently thin to have a portion of the shoulder surface 51 exposed.

The first disc 34 also has an annular rubber member 40 which is secured to its face, which confronts the second disc 36, so as to be adjacent its circular periphery. Thus, when the discs 34 and 36 are placed in an abutting relationship, the annular rubber member 40 of the first disc 34 will slip onto the shoulder 51 of the second disc 36 and abut its annular rubber member 38.

The axle 18 and bulkhead 19 are assembled into their cooperative relationship by placing the first disc 34 adjacent an aperture provided in the apex of the bulkhead 19 so that its annular rubber member 40 abuts the inner surface of the bulkhead 19 about the aperture. The short axle portion 32 is then telescoped within the long axle portion 31 until the second disc's annular rubber member 38 abuts the outer surface of the bulkhead 19 about the aperture and the second disc's shoulder surface 51 extends through the aperture and fits snugly against the bulkhead's circumferential edge which defines the aperture.

The two discs 34 and 36 are shifted to aligned holes 35 therein and dowels 37 are inserted through the aligned holes 35 to hold the discs 34 and 36 in an aligned relationship. To grip the bulkhead 19, the two discs 34 and 36 are tightened together by screws 33 which are inserted through bores in the second disc 36 and screwed into threaded bores within the first disc 34. Because the bulkhead's circumferential edge which defines the apex aperture fits snugly on the shoulder surface 51 of the second disc 36, the axle 18 will accurately position itself to correspond to the symmetrical axis of the bulkhead 19 when fastened thereto.

If the convexo-concave bulkhead 19 is sufficiently large as to require a support for its open end, the spider, best illustrated in FIGURE 3, may be fastened to the long axle portion 31. The spider consists of a polygonal plate 39 which is attached to the long axle portion 31 in a symmetrical manner. Secured to each corner of the polygonal plate 39 is a block support 41 having an upper curved surface and an upstanding stop 42. A circular ring 43 is supported on the curved surfaces of the block supports 41 in an abutting relationship with the upstanding stops 42 (see FIGURE 1).

Attached to the circular ring 43 are spaced spokes 44 which extend outwardly in a radial manner and support an outer polygonal ring 46. Fastened to the corners of the polygonal ring are L-shaped block supports 47 having a curved supporting surface 45 adapted to engage

the inner surface of the bulkhead **19** adjacent its large open end.

The circular ring **43** and the polygonal ring **46** with their interconnecting spokes **44** form an assembly which may be slipped onto the block supports **41** of the polygonal plate **39** until the circular ring **43** abuts the upstanding stops **42** and the upstanding portion of the L-shaped supports **47** of the polygonal ring **46** abut the bulkhead **19**.

To aid in lifting the bulkhead **19** an eye bar **48** is fitted on each end of the axle **18**. The eye bar **48** includes a ring **49** rotatively mounted on a race **50** attached to the axle **18**.

The surface areas of the bulkhead **19** which are not to be milled are coated with a suitable protective mask **47** which will not react with the etching bath used. The mask **47** could be an asphaltic or rubber latex type. The entire bulkhead **19** may first be coated with the mask **47** and then the mask removed from those areas of the bulkhead which are to be milled or the mask **47** may be applied initially only to those areas which are not to be milled.

The operation of the apparatus consists in filling the desired etching solution **12** in the tank **11** to a depth which will put its surface at a level approximating the location of the axle **18**, or the symmetrical axis of the bulkhead **19**, whereby those portions of the bulkhead **19** to be etched will enter and leave the etching bath **12** at the same time. In this manner a uniform etch rate will be assured.

The convexo-concave bulkhead **19**, suitably masked, is mounted on the axle **18** in a manner previously noted. After the bulkhead mounting operation has been completed, the axle **18** including the bulkhead **19** is lowered into the U-shaped bearings **16** and **17** with the slotted end **24** of the axle portion **32** receiving the key **23** of the drive shaft **22**. The bulkhead **19** is then rotated at a predetermined rate in the etching bath **12** using the transmission **21** to vary the speed. After the desired milling has taken place, the bulkhead is removed from the tank **11**.

Additional control of the chemical milling rate during rotation can be accomplished by spraying water on the portion of the bulkhead **19** above the surface of the etching bath **12** to prevent the continued etching by the solution clinging to its surfaces when it leaves the etching bath during rotation.

It will be understood by those skilled in the art that the etching solution selected will depend upon the metal used for the dome bulkhead and that the apparatus described herein for rotating the bulkhead in the tank should be selected from materials which will not react with the etching solution.

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 other than as specifically described.

What is claimed is:

1. In an apparatus for chemical milling a convexo-concave bulkhead which converges from a large open end to an apex, the apex of the bulkhead having an aperture:
   (*a*) a tank adapted to hold an etching bath,
   (*b*) said tank having two spaced and opposed sides;
   (*c*) a pair of U-shaped bearings, one of said bearings being supported by one of said sides and the other of said bearings being supported by the other of said sides;
   (*d*) an axle adapted to extend through the apex aperture of said bulkhead;
   (*e*) said axle extending between and supported by said U-shaped bearings;
   (*f*) said axle consisting of a first portion telescoped over a second portion;

   (*g*) a first disc symmetrically secured to said first axle portion and having a face substantially flush with the end thereof telescoped over said second axle portion;
   (*h*) a second disc symmetrically secured to said second axle portion spatially to the end thereof telescoped within said first axle portion;
   (*i*) means for holding said first and second discs together so that they are adapted to abut the surface of said bulkhead about said aperture; and
   (*j*) means for rotating said axle.

2. A combination as defined by claim 1 including:
   (*a*) a spider structure adapted to support the large open end of the bulkhead;
   (*b*) said spider structure consisting of
      (1) a polygonal plate symmetrically secured to said first axle portion,
      (2) a block support secured to each corner of said plate,
      (3) a circular ring having a plurality of outwardly directed spokes supporting an outer polygonal ring, and
      (4) a plurality of L-shaped block supports secured to the corners of said polygonal ring,
      (5) said circular ring being supported upon said block supports of said plate whereby said L-shaped supports of said polygonal ring are adapted to engage the inner surface of said bulkhead about its large open end.

3. In an apparatus for chemical milling a convexo-concave bulkhead which converges from a large open end to an apex, the apex of the bulkhead having an aperture:
   (*a*) a tank adapted to hold an etching bath;
   (*b*) an axle adapted to extend through the apex aperture of said bulkhead;
   (*c*) means including bearings secured to opposite sides of said tank for supporting said axle within said tank for rotative movement;
   (*d*) said axle consisting of a first portion telescoped over a second portion;
   (*e*) a first disc symmetrically secured to said first axle portion and having a face substantially flush with the end thereof telescoped over said second axle portion;
   (*f*) a first annular rubber member secured to said face of said first disc adjacent its circular periphery;
   (*g*) a second disc symmetrically secured to said second axle portion spatially to the end thereof telescoped within said first axle portion;
   (*h*) said second disc having an L-shaped edge about its circular periphery defining a shoulder surface and an upstanding stop portion;
   (*i*) a second annular rubber member situated upon said shoulder surface and abutting said upstanding stop;
   (*j*) means for holding said first and second discs together so that said annular rubber members are adapted to abut the surface of said bulkhead about its apex aperture; and
   (*k*) means for rotating said axle.

4. A combination as defined by claim 3 including:
   (*a*) means attached to said first axle portion for supporting the large open end of said bulkhead.

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