Nov. 28, 1961 W. E. LANFORD 3,010,372

FOLDING APPARATUS

Filed Feb. 11, 1960 2 Sheets-Sheet 1

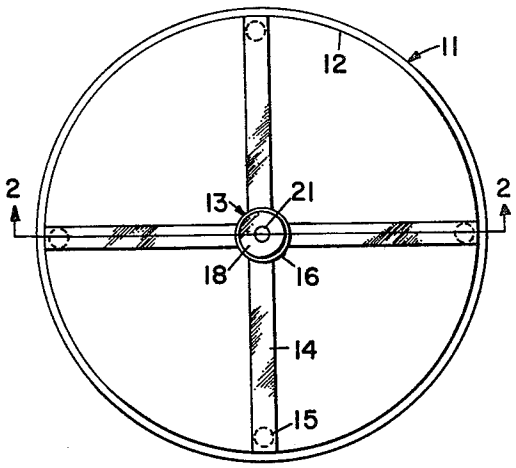


FIG. 1

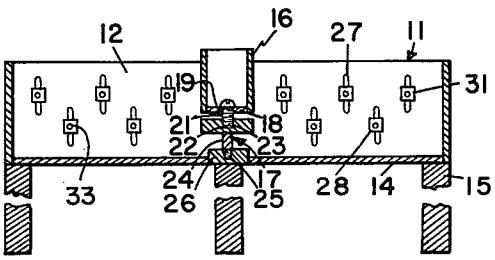


FIG. 2

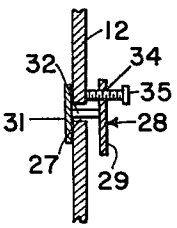


FIG. 3

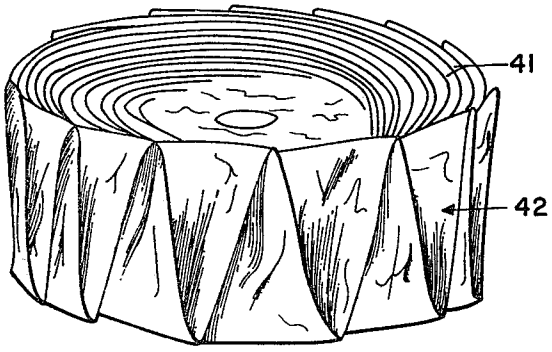


FIG. 6

BY

INVENTOR
WADE E. LANFORD

J. A. Tressanoks
ATTORNEYS

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FOLDING APPARATUS

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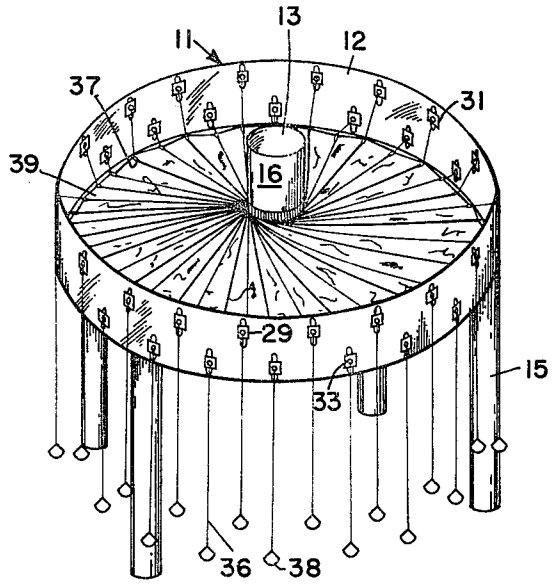


FIG. 4

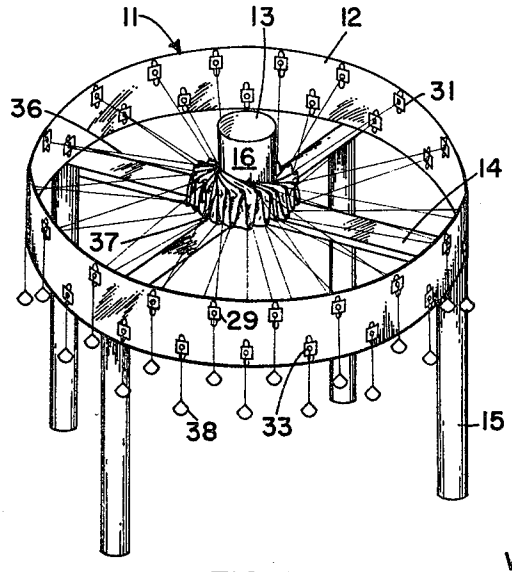


FIG. 5

INVENTOR
WADE E. LANFORD

BY

J. O. Tresansky
ATTORNEYS

United States Patent Office 3,010,372 Patented Nov. 28, 1961

3,010,372
FOLDING APPARATUS

Wade E. Lanford, Newport News, Va., assignor to the United States of America as represented by the Administrator of National Aeronautics and Space Administration

Filed Feb. 11, 1960, Ser. No. 8,203
7 Claims. (Cl. 93—1)
(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 generally to a folding apparatus and, more particularly, to a device and method for folding thin flexible sheets helically and vertically simultaneously to form a compact packaged configuration.

It has been found that space satellites can be folded in a specified manner such as disclosed in applicant's copending patent application, Serial Number 8,204, filed February 11, 1960, N.A.S.A. Case Number 138, to form a compact package configuration capable of being readily extended, or expanded, by centrifugal force on being ejected in the upper regions of the earth's atmosphere. In order to accomplish this result, the packaged configuration may be folded both helically and vertically about the center of the satellite to form a specific folded pattern.

Heretofore, several methods and devices have been proposed for folding flexible materials. Examples of such prior art devices are paper folding machines which fold paper strips, or sheets, horizontally, vertically, or in combinations thereof, such as ticket folding machines, magazine folding machines, napkin folding machines and the like. Other prior art folding machines have been devised to form overlapping pleats along a single plane to produce a folded article having a sawtooth edge such, for example, as an oil filter cartridge. Although these prior art devices have performed satisfactorily for their intended purposes none of them have been found entirely suitable for folding planar flexible material helically and vertically to form a compact folded configuration.

Accordingly, an object of the present invention is to provide a new and improved folding device.

Another object of this invention is to provide a new and improved machine for folding flexible sheets helically and vertically simultaneously.

A further object of the instant invention is to provide a new and improved apparatus for forming a circular flexible sheet into a folded article having a sawtooth outer folded edge.

A still further object of this invention is to provide a new and improved spirally folded compact packaged configuration.

A still another object of the present invention is to provide a new and improved device for folding a flexible disc into a packaged configuration capable of being extended by centrifugal force.

Another and still further object of this invention is to provide a simplified folding appliance which is adaptable to readily vary the frequency and amplitude of helical folds formed in the article during folding.

One still further object of the present invention is to provide a new and improved method of compactly folding a flexible planar sheet of material.

Generally speaking, the foregoing objects, as well as others, are accomplished in accordance with this invention by providing a peripheral outer frame member, a workpiece tensioning means positioned in an alternative sequence in a plurality of diverse parallel planes about

the frame member, and means mounted in the center of the frame for rotating the workpiece.

A more complete understanding of the invention and many of the attendant advantages thereof 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 a top view of the folding apparatus;

FIG. 2 is a cross sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is an enlarged top view of the tension directing means;

FIGS. 4 and 5 are perspective views of the folding device illustrating the sequence of steps during the folding operation; and

FIG. 6 is a folded article produced by the device of the present invention.

Referring now to the drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 whereon the folding apparatus, generally indicated by the reference numeral 11, is shown as consisting essentially of an annular outer frame member 12 and a workpiece securing center section 13 rotatably mounted within the annular member. Center section 13 is rotatably mounted on cross members 14 which mutually intersect each other perpendicularly, and have their end portions securely attached as, for example, by welding or the like to the lower portion of annular member 12. Member 12 can be supported horizontally relative to the floor by affixing to the lower portion thereof legs 15.

As shown on FIG. 2, center section 13 consists of an upper piece 16 and a lower platform 17. Upper piece 16 is preferably a cylindrical body having one end closed by means of a plate 18. Plate 18 has an aperture 19 formed centrally therein capable of receiving a bolt 21. The outer surface edge, or underside, of plate 18 assumes a superposed relationship with the top surface of rotatable platform 17. Rotatable platform 17 consists of a cylindrical member 22 having a substantially smooth planar top surface and a tap hole 23 formed centrally therein. Bolt 21 passes through aperture 19 and threadedly engages tap hole 23 and securely attaches upper piece 16 to lower platform 17. A stem, or connecting rod, 24 is securely attached at one end to the underside of cylindrical member 22. The other end 25 of stem 24 is tapered and rotatably supported by a socket member 26. Socket member 26 is of a cylindrical configuration having an aperture formed on its top face for receiving tapered end member 25. The socket member 26 is securely positioned atop cross members 14 by any conventional means such, for example, as welding. It is to be understood that any conventional rotating means may be used in place of the tapered pin and socket means disclosed in the present invention.

Slits, or slots, 27 are equidistantly formed in two parallel planes in an alternative sequence about annular member 12. Each slit 27 has a slidably adjustable member 28 positioned therein. As more clearly shown on FIG. 3, member 28 consists of a front plate 29 and a back plate 31 joined at the center thereof by a cylindrical connecting element 32 having a bore extending therethrough. Apertures 33 are formed in the front and back plates coincident with the bore of element 32 to form a continuous passageway through member 28. A tap hole 34 is formed in the front plate for receiving a set screw 35. Member 28 may be selectively raised or lowered in slit 27 and securely positioned within the slit at predetermined positions by means of screw 35 for a purpose to be explained more fully hereinafter.

A string, or filament, 36 is slidably disposed through

bore 33, as shown on FIG. 4. String 36 has attached at one end thereof a clamp 37, such, for example, as an alligator clamp and at the other end a weight 38. It is to be understood that any conventional string or like tension transferring means may be used in the present invention. The string should be strong enough to withstand the tension applied to the flexible sheet workpiece 39 during folding. String 36 should be at least as long as the radius of annular member 12 to provide tension to the workpiece 39 during the entire folding operation. It is also pointed out that weights 38 must not rest on an object such, for example, as the floor, but must hang free if they are to provide tension to workpiece 39. For this reason the maximum length of the string may be determined by the relative position of the folding device to the floor. Tension supplied to workpiece 39 by clamps 37 from the tension supplying means forms radial pleats 41 in the workpiece 39 which during the folding operation are wound spirally about center section 13. It is also to be understood that any conventional tension producing means such, for example, as springs, rubber or elastic filaments and the like may be used in place of the string and weights herein specifically described.

In operation, bolt 21 is extracted from tap hole 22 and upper piece 16 is removed from rotatable platform 17. A workpiece of flexible sheet material 39, preferably having the configuration of member 12, is placed on rotatable platform 17. Upper piece 16 is then placed on and secured to lower rotatable platform 17 by means of bolt 21. Bolt 21 is passed through aperture 19 in upper piece 16, perforating the center of the workpiece 39 and is threadedly secured in tap hole 23.

Clamps 37 are connected at equidistant points along the peripheral edge of sheet 39. Clamps 37 are attached in an alternative sequence with the tension forming means of the upper and lower rows of slidably adjustable members 28 positioned in slits 27. It is to be noted that the frequency, amplitude and pattern of pleats 41 formed in the folded article 42 may be selectively varied by raising and lowering slidable members 28 prior to folding.

As shown in FIG. 5, center section 13 is rotated either manually or by means of a drive and during rotation forms spiral folds, or pleats, 41 of increasing amplitudes in the sheet 39 about the centerpiece 13. Rotation of center section 13 is terminated when sheet 39 has been completely wound thereabout. Folded article 42 is then removed from machine 11 by removing clamps 37 from the peripheral edge of the satellite 42 and bolt 21 extracted from tap hole 23 enabling center section 16 to be removed from lower rotatable platform 17 and releasing satellite 42 from the folding apparatus 11.

Folded article 42 as shown on FIG. 6 is an article having a substantially planar center portion with helically wrapped pleats 41 of increasing magnitude towards the peripheral edge thereof which are wrapped about the center portion.

Obviously numerous 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 as new and desired to be secured by Letters Patent of the United States is:

1. A folding apparatus comprising, in combination, a peripheral outer frame member, apertures formed in said frame member in an alternative sequence and in a plurality of diverse horizontal planes, inwardly extending support means secured to the lower portion of said frame member, a center section rotatably mounted on said inwardly extending support means within said frame member adapted to retain a flexible sheet within said frame member, a tension producing element associated with each of said apertures, and means joining each of said tension producing elements to the periprheral edge of the sheet thereby forming pleats therein.

2. A folding apparatus according to claim 1 wherein said center section comprises a cylindrical upper piece, a rotatable platform mounted on said inwardly extending support means, and a fastening means for connecting said upper piece to said rotatable platform.

3. A folding apparatus comprising, in combination, an outer frame member, a plurality of slits formed in an alternative sequence in a plurality of horizontal planes on said frame member, slidably adjustable means having an aperture formed therein disposed in each of said slits, tension producing means cooperating with said apertures, a plurality of mutually intersecting braces secured to the lower portion of said frame member, and a center section rotatably mounted on said braces within said frame member.

4. A folding apparatus according to claim 3 wherein said tension producing means comprises a string slidably disposed in said aperture, a weight affixed at one end of said string, and a clamp secured to the other end of said string.

5. A folding apparatus comprising, in combination, an annular outer frame member, a plurality of mutually intersecting braces secured to the lower extremity of said annular member, a center section rotatably mounted on said braces adapted to retain a flexible sheet within said frame member, tension producing means positioned about said annular member in an alternative sequence and in a plurality of diverse horizontal planes, and clamps joining said tension means to the peripheral edge of the sheet thereby forming pleats therein.

6. A folding apparatus according to claim 7 wherein said tension producing means comprises a string, and a weight attached to the lower end of said string.

7. A folding apparatus comprising, an outer frame member having an annular configuration, a plurality of vertical slits formed in said frame member at equidistant intervals and in a pair of parallel planes, a slidably apertured member disposed in each of said slits, a plurality of intersecting members affixed to the underside of said frame member, means rotatably mounted on said intersecting members centrally of said frame member adapted to clamp the center portion of a sheet of flexible material within said frame member, tensioning means slidably disposed in each apertured member adapted to be attached to the periphery of the sheet thereby to form a plurality of radial pleats in the sheet which spirally wrap around said rotatable means upon rotation thereof.

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