June 14, 1966 J. J. MEDE 3,255,976

WINDING MACHINE

Filed July 9, 1962 5 Sheets-Sheet 1

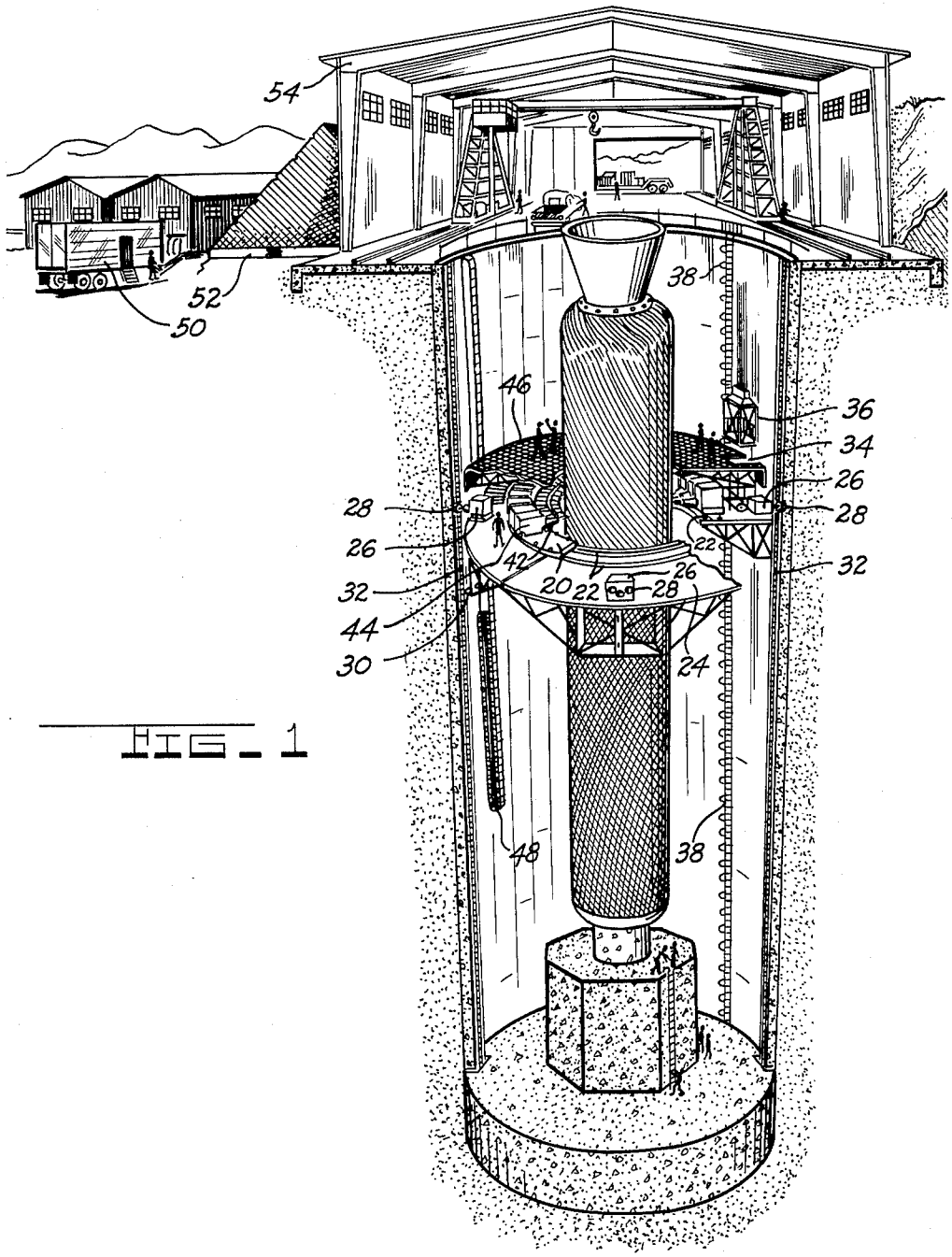


FIG. 1

INVENTOR.
JOHN J. MEDE.
BY Cecil Owens
ATTORNEY.

June 14, 1966 J. J. MEDE 3,255,976

WINDING MACHINE

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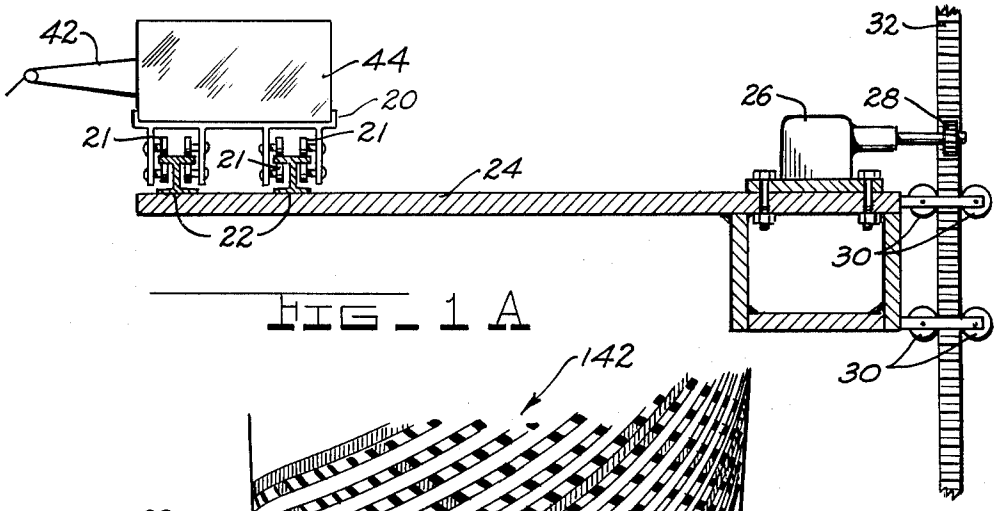


FIG. 1A

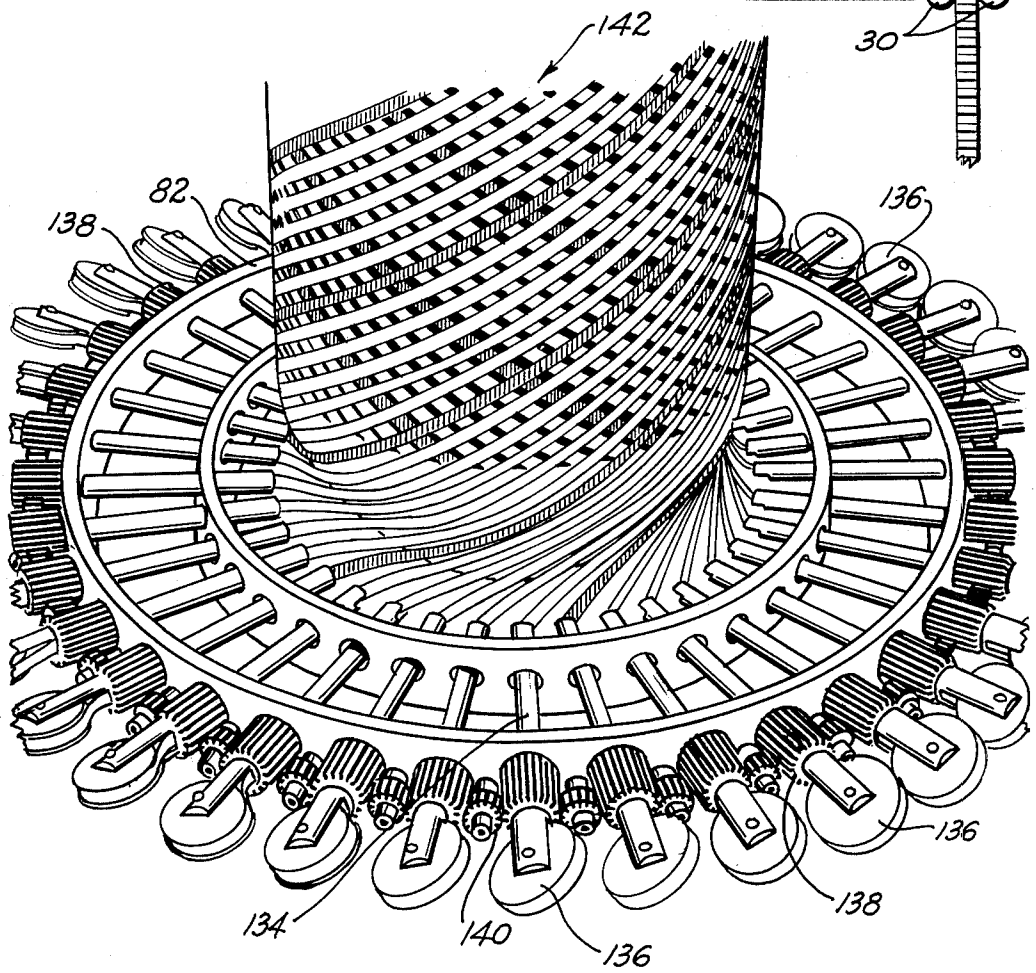


FIG. 3

INVENTOR.
JOHN J. MEDE.
BY Cecil F. Arens
ATTORNEY.

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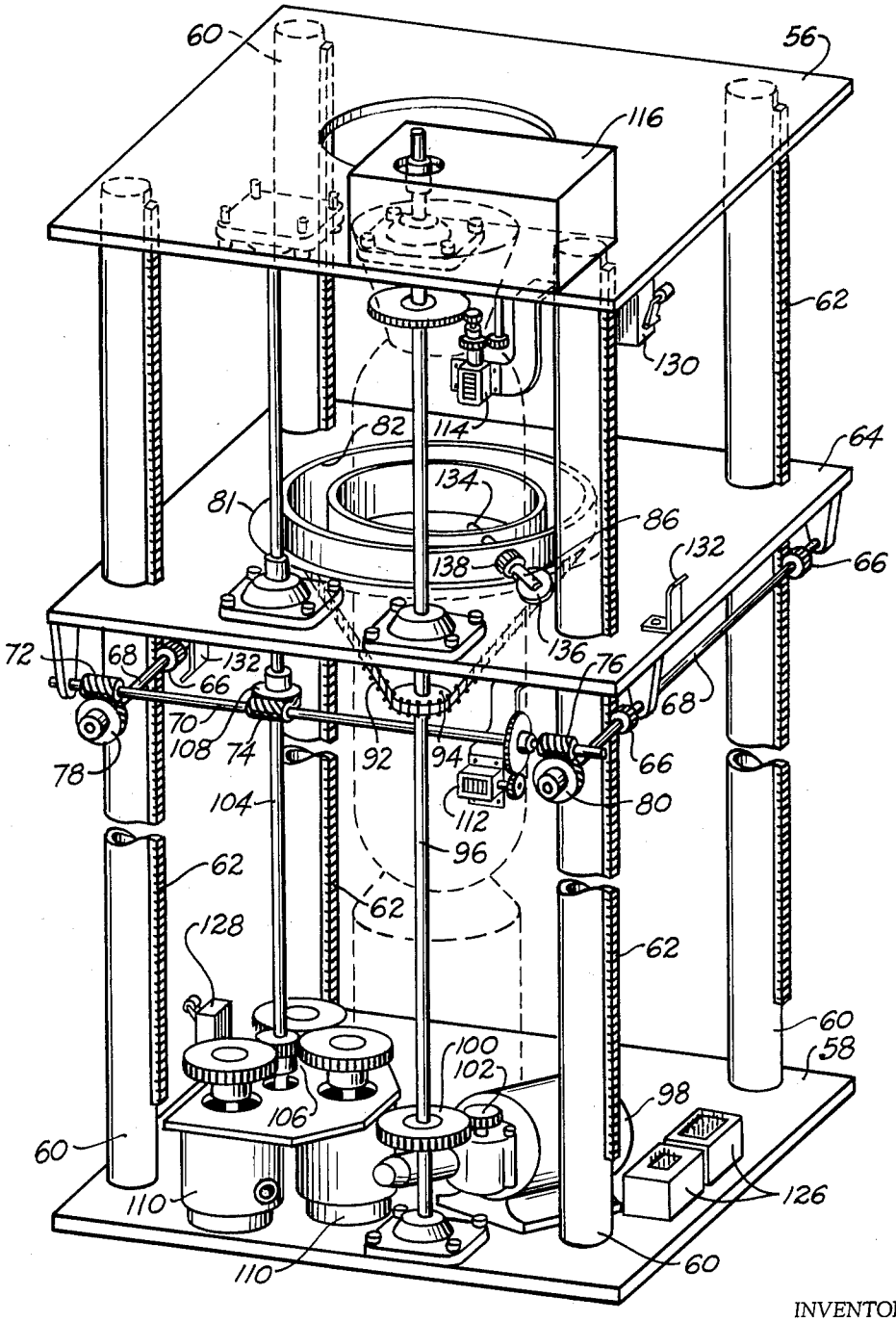


FIG. 2

INVENTOR.
JOHN J. MEDE.
BY Cecil F. Arens
ATTORNEY.

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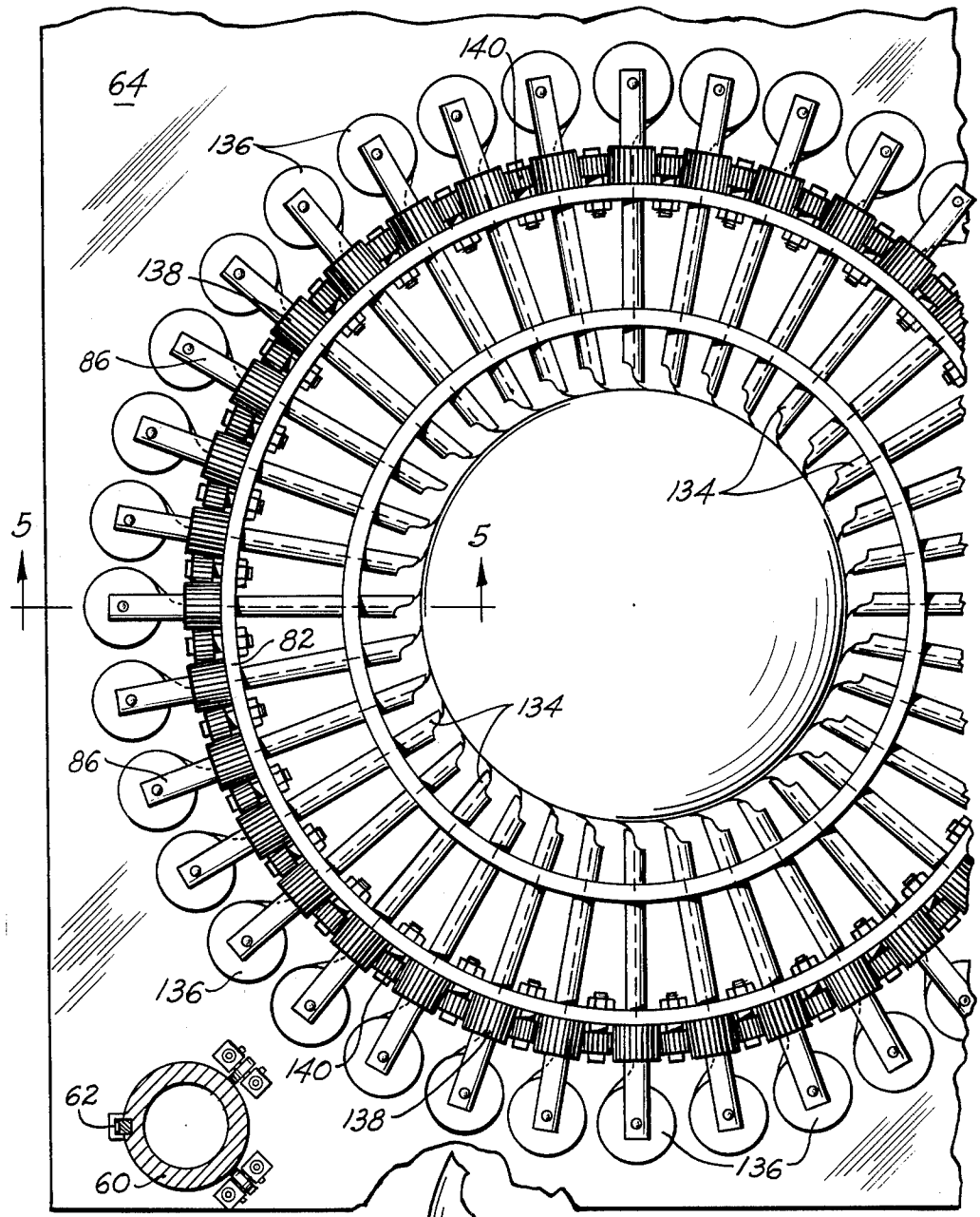


FIG. 4

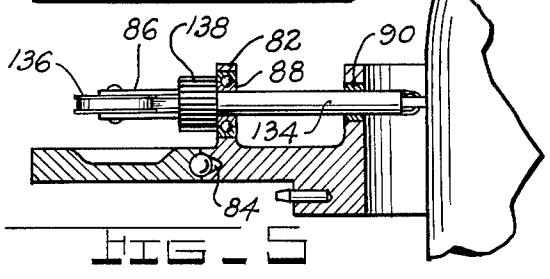


FIG. 5

INVENTOR.
JOHN J. MEDE.
BY Carl F Arens
ATTORNEY.

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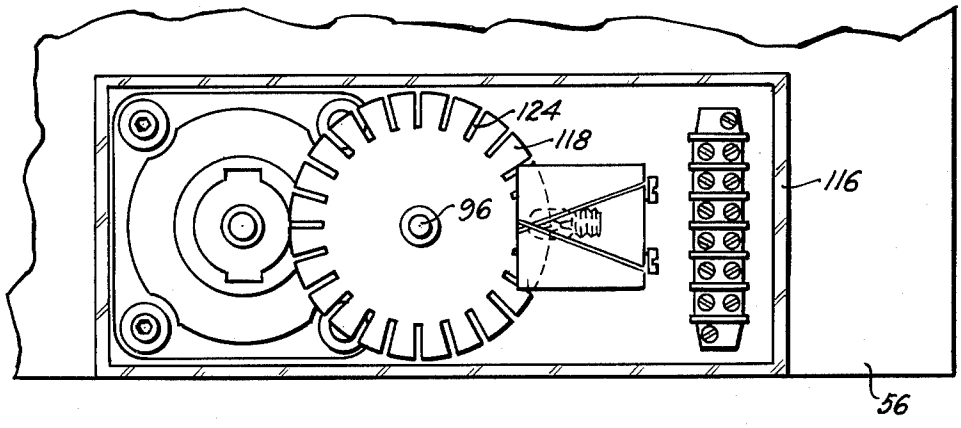


FIG. 7

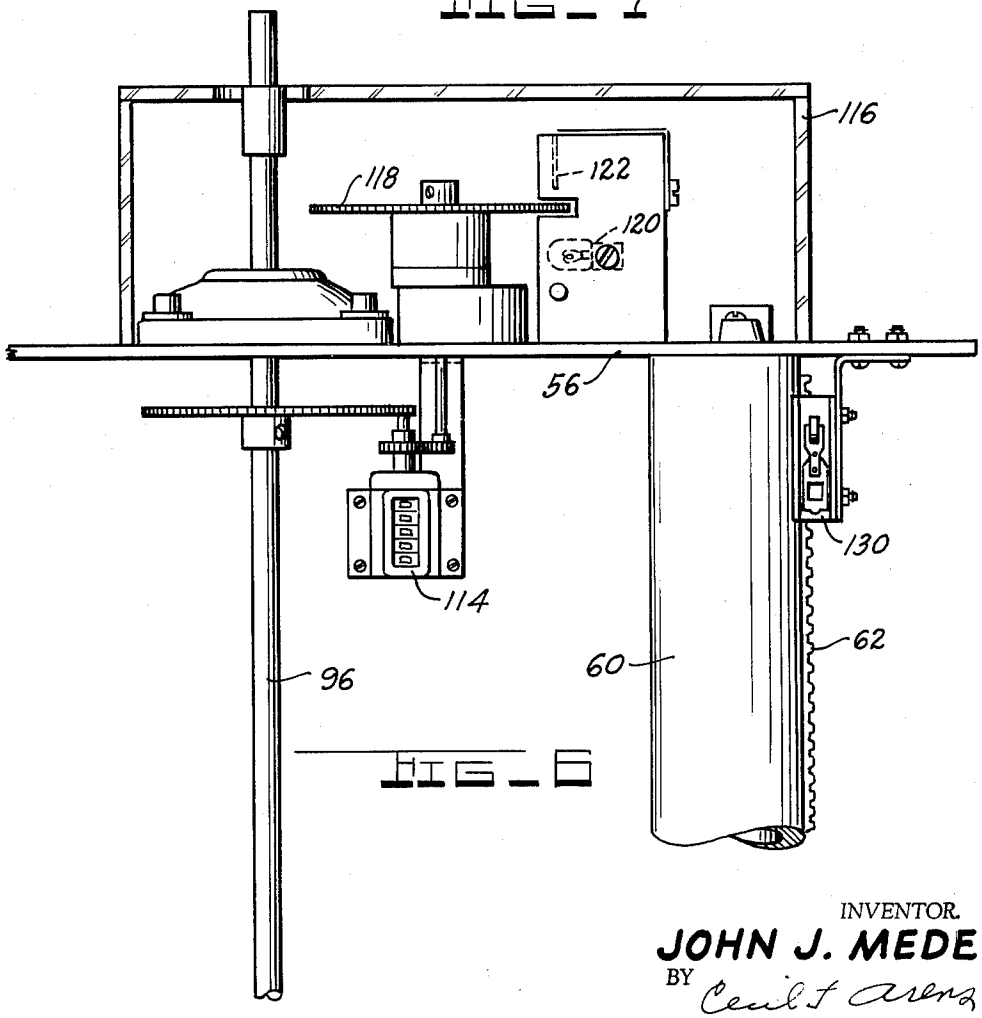


FIG. 6

INVENTOR.
JOHN J. MEDE.
BY Cecil F. Arens
ATTORNEY.

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3,255,976

WINDING MACHINE

John J. Mede, South Bend, Ind., assignor to The Bendix Corporation, South Bend, Ind., a corporation of Delaware

Filed July 9, 1962, Ser. No. 208,501
6 Claims. (Cl. 242—7)

This invention relates to a machine for wrapping pressure vessels. More particularly, it is concerned with a machine having an escending or descending platform with a constantly rotating member thereon supplying winding material centrally thereof such that an appropriate path for the winding material is generated by varying the rate of ascension or descension.

It is the principal intent of this invention to provide a means for wrapping a large solid propellant engine with a filament, tape or filament tape so that the propellant may be stored for lengthy periods of time in a position of mission readiness and to provide a pressure tight vessel to restrain and contain the internal pressure which can be generated therein.

It is also an object of this invention to create a winding path for a wrapping material for a pressure vessel.

Another object of this invention is to wrap a body and in the wrapping attach an end dome and/or an outlet means to said body by the overlapping of said wrapping of the end domes of said body.

An additional object of this invention is to wind or generate a vessel around a suitable mandrel or form using one or more filaments or filament tapes or tapes.

Still another object of this invention is to wrap a solid propellant with a filament, tape or filament tape within a launching silo so that a booster stage for a missile or rocket may be prepared at the launch site.

An advantage of the construction afforded by this invention is that the plurality of wraps aggregates to a high degree of strength suitable for resisting considerable abrasion and shock without allowing fracturing or breaking of a propellant charge. More particularly, an advantage of the construction afforded by this invention is that a plurality of filaments or filament tapes or tape dispensing systems generate a pattern which minimizes the bending and interweaving of the tapes or winding material, whatever it may be, and reduces the stresses of and abrasion in this winding material.

The foregoing and other features of my invention will be better understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a cutaway view showing a wrapping machine in accordance with the present invention wrapping a booster propellant case at a test facility;

FIGURE 1A is a detailed section of a rotating platform support for the wrapping machine;

FIGURE 2 is a schematic view of a simplified machine designed in accordance with the present invention for wrapping booster cases of a similar type as that presented in FIGURE 1;

FIGURE 3 is a view of the tape wrapping head applied to the rotating platform of the machines of FIGURE 2 showing the manner of winding about a form;

FIGURE 4 is a plan view of a winding material supply head of the present invention;

FIGURE 5 is a detailed view of a winding material supply mean through the tape wrapping head of the present invention;

FIGURE 6 is an enlarged schematic showing an indicating and pulsing control mechanism for indicating the azimuth position by generating electrical signals proportional to the rotation and for the control of the vertical

position of the winding head with respect to the azimuth position of the rotating platform; and

FIGURE 7 is a plan view of the coordinating mechanism of FIGURE 6.

As above, this invention defines a machine concept for the purpose of winding pressure vessels which may range in size from ten to forty feet in diameter with a length to diameter ratio of approximately, but not limited to, less than one to over ten with filament or tape members.

As shown in FIGURE 1 and by the phantom outline in FIGURE 2, the propellant segments to be wrapped have their longitudinal centerline in a vertical position.

My machine, as seen in FIGURE 1, consists of a rotating platform **20** which may have a box beam shape in cross section and be in the form of a toroidal ring as shown. Because of filament tension applied at some distance from a neutral axis of this toroidal ring, the rotating platform **20** must have the ability to resist distortion due to rotation and torsional loads plus the mass of equipment mounted on it and the resultant stresses due to accelerations. The rotating platform is guided by rollers **21** (see FIGURE 1A) on rails **22** such that it is constrained to rotate and to resist motion vertically both upward and downward. The rotating platform may also assume a construction whereby it may be readily disassembled with each prefabricated component being of a tranportable size.

The rotatable platform **20** is mounted to an elevating platform **24** which may be composed of multiple segments. Each segment of the elevating platform **24** can be essentially a 90° quadrant, and each segment will carry its own hydraulic power unit **26** having a speed reducer gearing arrangement (not shown) driving pinions **28** which cooperates with a rack **32** in the sides of the test site to raise or lower the platform **24** and its attendant mechanism. In addition, platform **24** is guided along the racks by rollers **30** to either side thereof, as seen in FIGURE 1A. The platform **24** has cutout spaces, one of which is shown as at **34**, to allow passage of a man carrying elevator **36** mounted to rails in the side of the test site and the emergency ladder **38**, as well as a space for a hydraulic and electric power supply leading to platform **24**.

In addition, one or more hydraulic motors (not shown) can be mounted to one of the elevating platform quadrants and geared to the rotating platform **20** to drive said platform at a constant rotational speed.

As seen in FIGURE 1, the elevating platform may be a truss construction or a sandwich construction with cantilevered wings at 90° to each other on a truss structure upon which is located the elevating motors. As each cantilevered wing abuts against the adjacent ones, a thrust component is carried horizontally from one to the other, and the rollers **30** are mounted to guide and position it with respect to the rack, as mentioned above and seen in FIGURE 1A. As may be seen in FIGURE 1, a plurality of winding material dispensing systems are cantilevered from compartments **44** that are mounted to the rotatable platform **20**. If desired, the winding's dispensing heads may be made telescoping by suitable extendible structure, not shown, which is within the skill of the art to provide such that they may be projected for purposes of depositing the winding in an end dome area. In addition to moving in a radial direction, the tip of the winding head **42** can be rotated on its own axis for the proper angle of wrap so that the winding will lay properly on the case. This rotation of the filament head is not in a continuous direction, but is an oscillating angle of about 180°. If necessary, the winding heads may be used for applying circumferential wraps to the case as well as a helical or

other type of winding pattern shown by the schematic line presentation of FIGURES 1 and 3.

In a preferred embodiment, I have found that there can be approximately forty winding compartments 44. Each of these forty compartments may hold one or more spools of winding material, not shown, conventionally arranged as will be understood by those persons skilled in the art. Rather than replace the spools containing the winding material, when each becomes depleted, the empty storage compartment can be replaced with a fully loaded interchangeable unit to reduce the reloading time to a minimum.

In order to protect the equipment and workman from possible falling objects from the ground level at a test site such as depicted in FIGURE 1, a catwalk 46 is mounted above the elevating platform 24, as by the beam structure shown in FIGURE 1, which platform is located to barely clear the rotating platform and the filament storage compartment. It is to be understood that the catwalk 46 will have removable sections to allow the replacement of the filament storage containers as mentioned above.

In order to power the elevating platform, I have found that, in one installation, hydraulic oil pressure and electrical power volts may be utilized. The hydraulic power required is transmitted to the elevating platform through suitable conductors in the mechanical flexible guides 48. The high pressure hydraulic oil is supplied through several relatively small diameter hydraulic flexible hoses within the elevating platform leading to the hydraulic motors thereon. In addition, a return hydraulic line has also been found to be necessary as well as a drain line at atmospheric pressure for the hydraulic motors. The low level electrical signals are also transmitted through this mechanical flexible guide, hereinafter called a Power-Trak 48, which electrical signals are used for actuating several valves on each of the elevating motors and the low level electrical signals required to actuate the servo valves on the hydraulic motor for rotating the platform. As may well be expected by those skilled in the art, other control signals are required such as temperature position indicators.

In an on-site installation such as in FIGURE 1, the electrical and hydraulic lines can be fed from a programming trailer 50 and from electric motor driven hydraulic pumps (not shown) through a concrete tunnel 52 into the test site building 54. Thereafter the lines are then fed in an enclosed wire-way 38 vertically downward along the sides of the launch site to a termination point about midway down. At this point, the flexible hydraulic and electrical lines are guided through the Power-Trak 48 to the elevating platform, which Power-Trak length is approximately equal to the total travel required of the elevating platform.

While the type of control unit within the programming trailer is not considered a part of this invention, it is obvious that a general explanation thereof leads to further understanding of my invention. Therefore, the programming mechanism may be essentially described as a digital tape control mechanism whose control functions are coordinated from a master clock which controls the overall speed of machine operation. Motions of all machine axes are thus dependent variables, the clock being the independent variable. For a two axes system, for example, the command inputs are vertical position, rotational position and feedrate. The provision for feed-rate control introduces a versatility into the system which is difficult to achieve by other techniques. By use of a programmed feed-rate, dynamic forces can be kept within allowable limits during critical portions of the wrap cycle. When dynamic forces are small, higher feed-rates can be programmed to increase operational efficiency of the machine. If a constant feedrate is required for suitable impregnation of the winding material or for other reasons, this can be achieved by so programming the control tape. The digital control mechanism is such that the command signal over discrete path lengths is converted to incremental commands to all axes simultaneously. Thus, a continuous uniform path is generated between the discrete command points. This system should not be confused with the point-to-point system where input commands between discrete points cause traverse of the machine motions between these points resulting in a stepwise output with loss of position control between the control points. Reference is made to U.S. Patent No. 3,128,374, issued April 7, 1964, to Yu Chi Ho et al. and entitled "Control System" and having a common assignee for details of one type of digital tape control mechanism suitable for use as the abovementioned control unit in the programming trailer 50.

The accuracy of the overall winding machine is dependent upon the limiting accuracy of the mechanical winding system, not upon the accuracy of the control system. The accuracy of the mechanical winding machine is a function of the precision of the mechanical drive system, backlash, deflection of structural members under load, and many other factors which must always be taken into account under the usual practices of good machinery design. In addition, the control system can be a closed loop having positive position feedback for each of the machine axes. The input signal and feedback signal are compared in an error register; the result being an error signal which is the command for the axes to move. An error signal of one pulse magnitude is required to initiate axes movement. A maximum of two or three pulse error signal can be experienced under normal operating conditions.

For this winding machine, a tentative pulse value was chosen which is equivalent to 0.010 inch per pulse for both vertical and circumferential travel on the periphery of a twenty foot diameter form. This value is arbitrary and results from anticipated accuracy requirements. Greater accuracy can be made available if desired. With no pulse multiplication, feed-rates of two feet per second can be obtained. If required for control accuracy, pulse values of .001 or .002 could be used in connection with pulse multiplication features.

In order to best meet the requirements of any machine application, the machine control unit is designed and engineered for that particular job, as may be readily appreciated by those skilled in the art. In this sense, there is no standard control system but, instead, standard basic control components or subsystems which are combined in suitable combinations to best meet the requirements imposed in that particular instance.

A winding machine such as I have invented may take on the form as appears in FIGURE 2. This machine consists of a pair of plates 56 and 58 separated by four steel posts 60, one in each corner. On each post is a rack 62 upon which rides an elevating platform 64. The elevating platform is geared to rack 62 by pinions 66 in each corner, and these pinions are interlocked with each other through shafting 68 and a drive shaft 70 having worm gears 72, 74 and 76 thereon. As seen, the worm gears 72 and 76 drive gears 78 and 80 which are pinned to shafts 68 to drive the pinions 66.

In the center of the elevating platform 64 is a rotating carrier 82 in a ball bearing track 84, which ball bearing track 84 may be best seen in FIGURE 5. The rotating carrier 82 supports a plurality of wrapping heads 86 by means of bearings 88 and 90 as seen in FIGURE 5.

The rotating carrier 82 is driven by a ladder chain 92 driven by a sprocket 94, which sprocket 94 is driven by shaft 96. Shaft 96 is connected to a motor 98 through the reduction gearing comprising gears 100 and 102. The elevating platform 64 may be raised and lowered through a vertical shaft drive including shaft 104 and gears 106 and 108. Gear 108 drives the worm 74 to drive shaft 70 and in turn the pinions 66, as aforementioned. Gear 106 of shaft 104 is driven by three "Slo-

Syn" motors 110 which rotate in accordance with a pulse command from a control unit such as aforedescribed. "Slo-Syn" is a trade name of the Superior Electric Co., Bristol, Connecticut and may be found in usual product description literature released by the Superior Electric Co. to the public.

In order to orient the azimuth position of the rotating carrier 82 and the elevating platform 64, counters 112 and 114 are respectively connected to the elevating and azimuth drive mechanisms through an appropriate gear reduction to correlate the counters with the azimuth and elevational position. In addition, an input pulse train is generated within the housing 116 by the drive of the rotating carrier, which pulse mechanism is more particularly outlined by FIGURES 6 and 7. The pulsating mechanism consists of an interruption of a light beam by a slotted wheel 118 which passes between a light source 120 and a light sensitive pickup 122 of familiar type. The slotted wheel 118 is slotted as at 124. The pulse train thus generated is transmitted through suitable electrical leads including connectors 126 and associated plugs, not shown, to the control mechanism in programming trailer 50 where the pulse train provides a signal representing speed and position of the shaft 96. It is to be understood that varying electrical circuitry is to be provided to the machine shown by FIGURE 2 and connected to a control mechanism such as aforedescribed through connectors 126 on the base platform 58. It will be understood that the plugs, not shown, engageable with connectors 126 are wired to electrical leads communicating with the aforementioned control mechanism in trailer 50. With the mechanism of FIGURE 2, switches 128 and 130 are mounted adjacent the lower and upper extremities of the machine and operable by means of fingers 132 to stop the machine at its upper and lower limits and reverse its direction as a safety measure.

The rotating carrier 82, as with the rotating platform of the mechanism of the machine of FIGURE 1, carries a plurality of winding heads 86 which consists of a hollow tube 134, a spool 136 and a geared portion 138. The geared portion of the heads 86 are interconnected with each other through the idlers 140 which idlers are rotatably mounted to the rotating carrier 82. Thus, as one head rotates on its own axis, all of the other heads rotate with it.

In the preferred form of my invention, the winding heads 86 are self-guided, that is the winding material will direct the freely rotating head to the proper angle. However, it is realized that the angular position of the head could be a function of the programming equipment and would be directed from the programming mechanism. In the form of my machine whereby the heads are self-guided, the material feeding from all the tubular portions 134 of the heads are attached about a mandrel at a desired angle and the elevating platform is then set in motion so that a wrap pattern 142 is generated in the traversing of the rotating carrier vertically along the propellant casing. When the rotating carrier reaches an upper or lower limit, which lower limit is seen in FIGURE 3, the heads rotate such that the tape direction is reversed to allow the upward travel of the elevating platform to provide complete coverage for the casing. Partial coverage is shown in FIGURE 3 wherein the blackened areas are corresponding to uncovered or yet to be wrapped portions of the rocket casing.

As may be readily appreciated by those skilled in the art, various changes may be made without departing from the scope of my invention. For example, my machine can readily be adapted to wrap internally of a body. Therefore, I do not propose to be limited by the foregoing description but rather by the appended claims.

I claim:

1. Apparatus for winding a filament tape along a helical path on the surface of a relatively large cylindrical body having an end dome structure, said apparatus comprising:

support means for supporting the body at one end with the axis of the body extending vertically;

vertically extending fixed rack means spaced radially outwardly from the body;

an elevating platform concentric with the body and operatively connected to said rack means for vertical movement therealong;

a rotatable platform rotatably supported by said elevating platform for rotation about the axis of the body;

filament tape supply means including a plurality of spaced apart tape guide means each freely rotatable about an axis normal to the axis of the body operatively connected to said rotatable platform for supplying filament tape to the surface of the body;

means operatively connecting said plurality of spaced apart tape guide means so that all of the same rotate in unison;

means carried by said elevating platform operatively connected to said rack means for actuating said elevating platform vertically relative to said rack means;

first motor means operatively connected to said last named means for driving the same to vertically move said elevating platform;

second motor means operatively connected to said rotatable platform for actuating the same; and

control means operatively connected to said first and second motor means for controlling the same to coordinate the vertical movement of said elevating platform with the rotation of said rotatable platform.

2. Apparatus as claimed in claim 1 wherein said filament tape supply means further includes a reel for storing said filament tape operatively connected to each of said tape guide means and rotatable therewith about the axis thereof.

3. Apparatus as claimed in claim 1 wherein said control means includes:

means responsive to preselected extreme positions of said elevating platform and operative to cause reversal of said first motor means to thereby reverse the direction of travel of said elevating platform.

4. Apparatus as claimed in claim 1 wherein said control means includes:

means for sensing the azimuth position of said rotatable platform.

5. Apparatus as claimed in claim 4 wherein said azimuth sensing means includes:

a slotted disc driven by said second motor means;

a light source;

a light sensitive element; and

said slotted disc, light source and light sensitive element being operatively connected such that rotation of said disc interrupts rays from said light source.

6. Apparatus for winding a filament tape along a helical path on the surface of a relatively large cylindrical body having an end dome structure, said apparatus comprising:

support means for supporting the body at one end with the axis of the body extending vertically;

vertically extending fixed rack means spaced radially outwardly from the body;

an elevating platform concentric with the body and operatively connected to said rack means for vertical movement therealong;

a rotatable platform rotatably supported by said elevating platform for rotation about the axis of the body;

filament tape supply means including a plurality of tape storage reels and associated tape guide means rotatably mounted on said rotatable platform for rotation about an axis normal to the axis of the body;

said plurality of tape storage reels and associated tape guide means being arranged in spaced apart relationship around the body and provided with connection means interconnecting said plurality of tape storage reels and associated tape guide means so that each of said tape storage reel and associated tape guide means is equally rotated about said normal axis simultaneously;

means carried by said elevating platform operatively connected to said rack means for actuating said elevating platform vertically relative to said rack means;

first motor means operatively connected to said last named means for driving the same to vertically move said elevating platform;

second motor means operatively connected to said rotatable platform for actuating the same; and

control means operatively connected to said first and second motor means for controlling the same to coordinate the vertical movement of said elevating platform with the rotation of said rotatable platform.

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MERVIN STEIN, *Primary Examiner.*

HARRISON R. MOSELEY, *Examiner.*

O. M. SIMPSON, B. S. TAYLOR, *Assistant Examiners.*