

Dec. 22, 1970

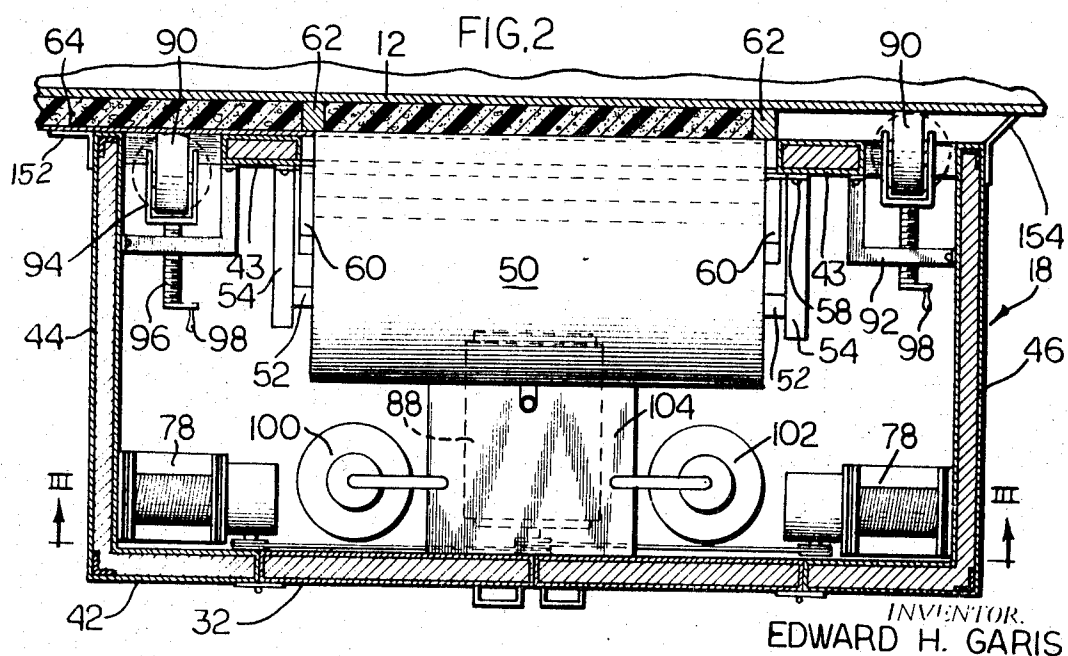
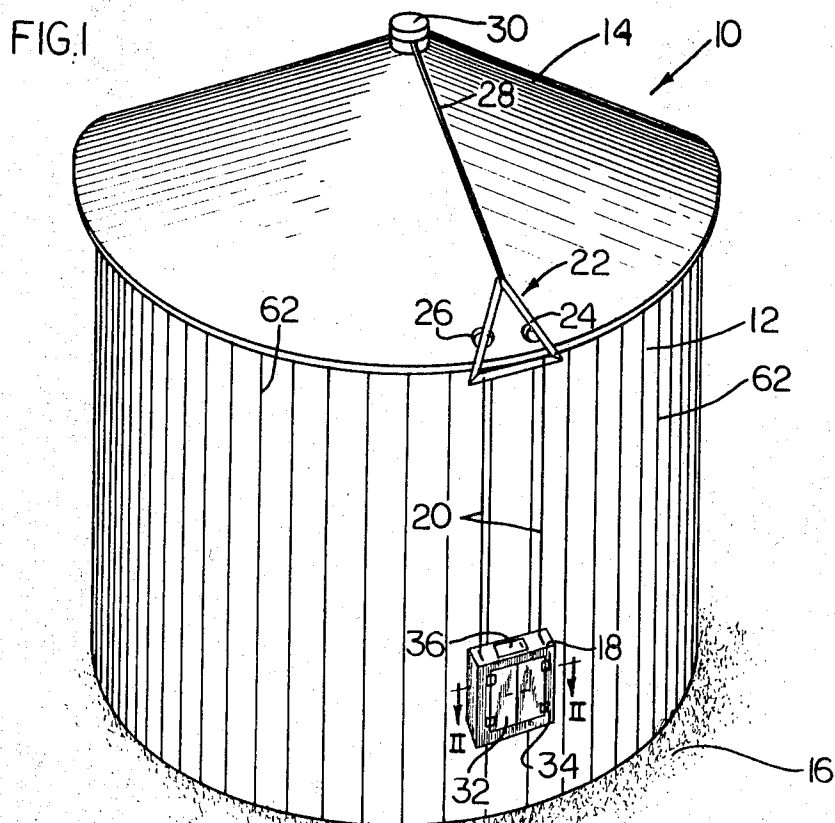
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3,548,453

APPARATUS FOR FOAMED-IN-PLACE INSULATION OF VERTICAL SURFACES

Original Filed March 8, 1966

5 Sheets-Sheet 1



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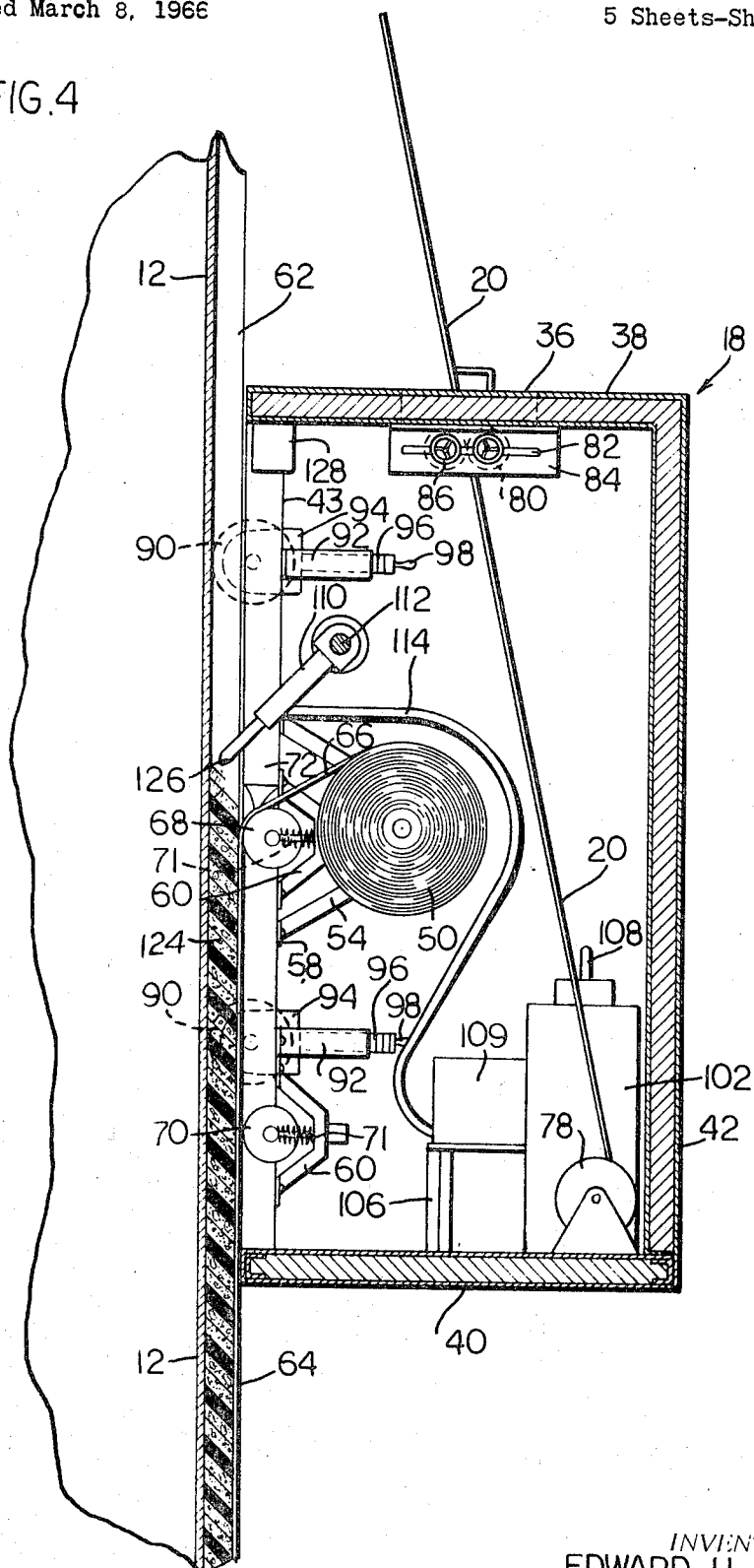
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5 Sheets-Sheet 5

FIG. 4



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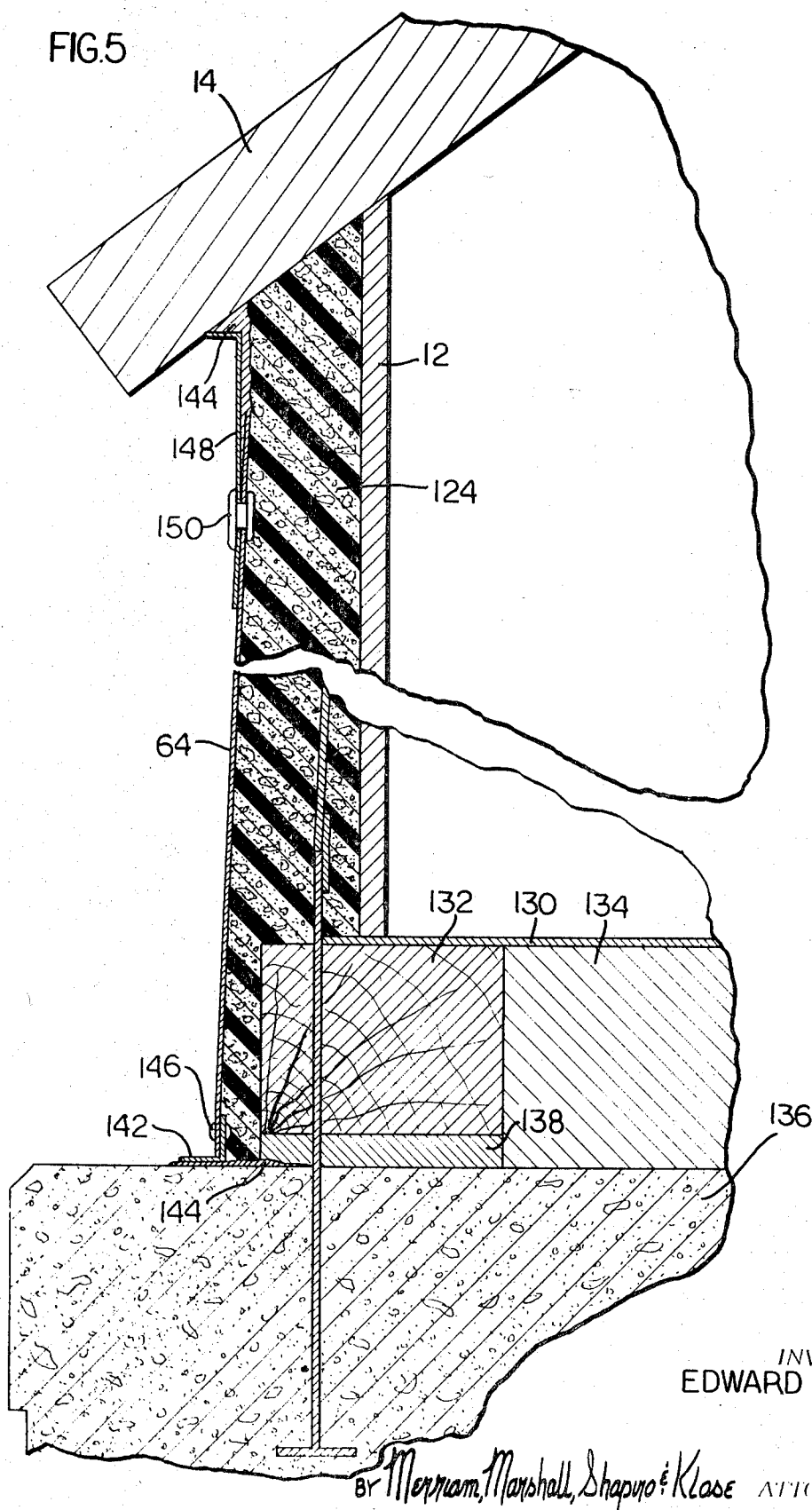
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APPARATUS FOR FOAMED-IN-PLACE INSULATION OF VERTICAL SURFACES

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5 Sheets-Sheet 5

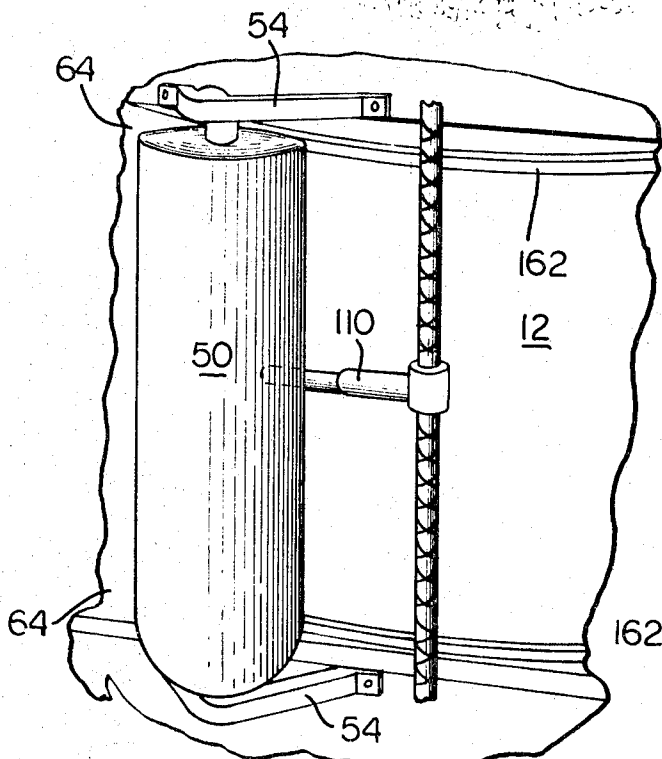
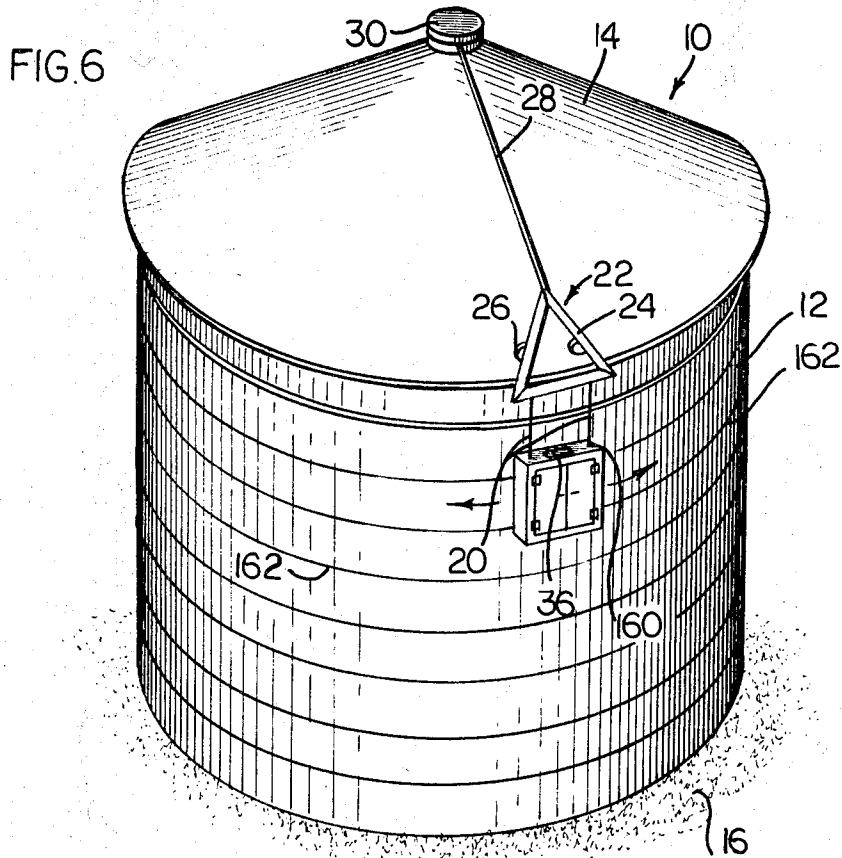


FIG. 7

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APPARATUS FOR FOAMED-IN-PLACE INSULATION OF VERTICAL SURFACES

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Original application Mar. 8, 1966, Ser. No. 532,740.

Divided and this application Oct. 29, 1968, Ser.
No. 786,793

Int. Cl. B29d 27/04

U.S. Cl. 18—5

8 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus and method for insulating the vertical tank surfaces of liquid or gas storage tanks, including a framework structure adapted to move vertically adjacent a vertical surface, means for supporting a roll of sheet material on the structure so that the roll can be unwound as the structure moves upwardly adjacent the surface, means for supporting foam-in-place equipment on the structure for directing foam between the vertical surface and the sheet material as it is unwound, and means associated with the structure for raising and lowering it relative to the vertical surface.

This application is a divisional of my copending application Ser. No. 532,740, filed Mar. 8, 1966.

This invention relates generally to the insulation of vertical surfaces and more particularly to apparatus and a method for applying foamed-in-place insulation to vertical surfaces.

The invention to be more particularly hereinafter described is especially applicable to the insulation of tank structures of the type that are commonly used for storing liquids or gases at desired temperatures. Since such tanks are exposed to an outdoor environment, they sometimes must be properly insulated so as to maintain the stored fluid within a required temperature range. Also, when the contents of the tank are to be stored at a temperature significantly above or below ambient temperature, insulation of the tank retards heat leak in and/or out of the tank.

Both hand labor per se and semi-automated techniques have been utilized to apply insulation to tanks. In one technique, an outer jacket for protecting the insulation is applied in sheets to the tank wall by means of a scaffold movably mounted on the tank structure. Using a separate scaffold, a foaming type insulation, such as a foamable resin composition, is applied under pressure between each full sheet of the outer jacket and the tank wall. This procedure is both time consuming and costly in terms of the use of separate scaffolds and the amount of labor involved for maneuvering the scaffolds. Furthermore, since each sheet of the outer jacket is entirely in place and spaced from the vertical wall when the foam insulation is directed therebetween, an increased amount of foam pressure and particular care must be exercised to insure that large air pockets do not remain between the jacket and the tank wall.

According to the principles of the present invention, there is provided apparatus for, and a method of, insulating a vertical surface by depositing foamed-in-place insulation between the vertical surface and a jacket in a continuous manner as the jacket is applied to the surface. Furthermore, the apparatus includes an enclosed framework structure such that the tank can be insulated even under adverse weather conditions.

More particularly, this invention is directed to the method of insulating vertical surfaces which includes positioning a roll of sheet material adjacent a vertical

2

surface to be insulated with the roll axis substantially horizontal, securing the end of the roll away from and in fixed position relative to the vertical surface, displacing the roll upwardly while unwinding the sheet material and maintaining it spaced from the surface, and depositing foamed-in-place insulation between and in contact with the vertical surface and the unrolled sheet material in proximity thereto at a rate commensurate with the unrolling of the sheet material.

Furthermore, the present invention provides apparatus for insulating vertical surfaces which includes a framework structure adapted to move vertically adjacent a vertical surface, means for supporting a roll of sheet material on the structure so that the roll can be unwound as the structure moves upwardly adjacent the surface, means for supporting foam-in-place equipment on the structure for directing foam between the vertical surface and the sheet material as it is unwound, and means associated with the structure for raising and lowering it relative to the vertical surface.

Another aspect of this invention is directed to the insulation of vertical surfaces by unrolling and applying the sheet material and the foamed-in-place insulation in a continuous manner horizontally across the surface.

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a tank having vertical surfaces, and a movable framework structure mounted thereon containing apparatus for insulating the vertical surface in accordance with the principles of the present invention;

FIG. 2 is a sectional view taken along the section line II—II of FIG. 1 and providing a plan view of the framework structure shown in FIG. 1;

FIG. 3 is a sectional view taken along the section line III—III of FIG. 2 and illustrates a front view of the framework structure and the apparatus mounted therein;

FIG. 4 is a sectional view taken along the section lines IV—IV shown in FIG. 3 and illustrates a side view of the interior of the framework structure of FIG. 1;

FIG. 5 is an enlarged fragmentary sectional view illustrating the top and bottom portions of the jacket as it is applied to the tank structure;

FIG. 6 is a perspective view similar to FIG. 1 illustrating the insulation of the vertical surface in a continuous horizontally traversing manner; and

FIG. 7 is a fragmentary view illustrating the mounting of a roll of sheet material and a foam gun for insulating a vertical surface in accordance with FIG. 6.

For purposes of illustrating a specific embodiment, the present invention will be described in connection with the application of insulation to the vertical surfaces of a tank structure such as has been previously described, although it is to be understood that the invention is not limited to that particular type of vertical surface.

Referring now to FIG. 1, there is illustrated a tank structure 10 having a vertical surface 12 extending from a dome-like roof 14 to the ground 16. Mounted on the tank structure 10 for application of insulation to the vertical surface is a framework structure 18 which is adapted to be raised and lowered along the vertical surface by means of a pair of winch cables 20 attached to a suitable hoisting mechanism 22. The hoisting mechanism includes a support member 24 having a pair of wheels 26 rotatably mounted thereon for rolling the support member on the tank roof so as to move the framework structure 18 to a next succeeding vertical surface which is to be insulated. The support member is maintained in position by suitable means such as a cable 28 fastened to a fixed object as a center post 30 in a known manner.

Two entrances to the interior of the framework struc-

ture 18 have been provided. A front main equipment door 32 mounted by means of hinges 34 enables access to the interior of the framework structure for maintenance and replacement of the apparatus mounted therein. Similarly, a trap door 36 permits access to the framework structure from the top portion thereof.

In FIGS. 2-4, there is illustrated the apparatus provided for applying insulation to the vertical surface 12. The framework structure 18 includes ceiling and floor portions 38 and 40 respectively, a front portion 42, a rear wall 43, and side walls 44 and 46. A roll of aluminum sheet material 50 is wound on mandrel 52 and positioned by a pair of brackets 54 attached to each side of the mandrel, at respective mounting apertures 56 spaced along the rear wall 43. The apertures 56 are threaded such that the roll 50 can be located at the desired position on the rear wall 43 and held in position by means of suitable bolts 58 passing through the brackets and threadably engaging the wall.

On the exterior portion of the vertical surface 12, there has been positioned a number of spacers, such as the studs 62, to limit the lateral displacement of the foam insulation when it is applied to the vertical surface. These studs 62 do not perform a supporting function and can therefore be formed of a rigid type foam insulation and applied to the vertical surface at intervals approximately equal to, but slightly less than, the width of the roll 50 as is illustrated most clearly in FIGS. 2 and 3. Referring to FIG. 4, the roll 50 is positioned closely adjacent the vertical surface 12 such that, as the framework structure 18 is raised along the vertical surface, a jacket 64 is applied to the studs 62 in spaced relation to the vertical surface as a sheet 66 of aluminum is unrolled from the roll 50. Suitable guide means, such as a guide roll 68, guide the sheet 66 behind one or more pressure rollers 70 and/or pressure shoes. A pair of brackets 60 at each end of the guide roll 68 support the roll by means 71, such as a common coil spring and through rod arrangement, so that the guide roll is horizontally spring loaded against the sheet. A similar spring loaded and bracket arrangement is utilized for the pressure roll 70, with the brackets being selectively threadably mounted with appropriate bolts through the apertures 56 to the rear wall 43. To secure the edges of jacket 64 in position against the stud front faces, a pair of adhesive applying means 72 mounted to the rear wall 43 at each end of the sheet 66 applies a suitable strip of adhesive to each inner side edge of the sheet, thus attaching the jacket 64 in an overlapping manner on the studs 62.

Movement of the framework structure 18 along the vertical surface 12 is provided by a pair of motor driven winches 78 mounted on the floor 40 of the framework structure to drive the winch cable or chain 20. To position the framework structure 18 with respect to the vertical surface 12, there is provided two co-acting sheaves 80 at each end of the framework structure. The sheaves 80 are mounted within a slot 82 in suitable angled members 84 secured to the ceiling 38 such that positioning the sheaves 80 in the slot adjusts the angle of the winch cable 20. Locking members 86 are provided to lock the sheaves 80 in the desired position. The winches 78 are driven by a motor 88 which is connected to the winches by appropriate pulley and belt means 89. Thus, actuation of the motor 88 operates the winches 78 so as to move the framework structure 18 vertically along the surface 12.

To assist the framework structure in its vertical or horizontal movement, four wheels 90 are respectively mounted on right angle brackets 92 secured to the rear wall 43 and the respective side walls 44 or 46. Each wheel is rotatably mounted on a yoke 94 which is fixed to a rod 96 threadably engaging the bracket 92. A handle 98 is provided for rotating the rod and thus adjustably locating the wheel. As shown in FIG. 2, one wheel has been adjusted in position for rotation on a portion of a jacket 64 which has been previously applied to the vertical surface. The wheel at the right-hand portion of FIG. 2

is adjusted at a more forward position such that the wheel rotates on the vertical surface 12. All of the wheels 90 exert very slight pressure on the vertical surface due to the angle of support of the framework structure 18 from the hoisting mechanism 22, as determined by the position of the adjustable sheaves 80 operating on the winch cable or chain 20. To assist the framework structure in horizontal movements from one section of the vertical surface to another, the wheels 90 can be turned 90° to the dashed line position shown in FIG. 2. This is provided by turning the handle 98 to align the wheels with the desired direction of movement. It is understood that all four wheels are rotated in this manner, and the framework structure then rolled to the next vertical section on the surface 12. Power driven wheels rotatably mounted to the framework structure can be provided to aid in this horizontal movement, or the structure can simply be hand rolled by exerting a slight pushing force on the surface 12.

Apparatus for dispensing foam-in-place insulation to the vertical surface 12 as the jacket 64 is applied is also mounted on the framework structure. A pair of tanks 100 and 102 is secured to the floor 40 for storing of chemicals utilized in a foaming composition such as one of the commonly used resin foams. The foam composition can be one which results in either rigid or flexible foam insulation, however, a flame retardant foam or a self-extinguishing foam of the rigid type is preferred, particularly of the polyurethane type. A foam mixing chamber 104 is mounted on a platform 106 and interconnected to the tanks by conduit means 108 for mixing of the foam forming reactants within the tanks 100 and 102 to provide the resulting foam insulation. The foam forming reactants are well known in the art and are employed in this invention using techniques conventionally employed in such art.

To direct the foam insulation between the jacket 64 being applied and vertical surface 12, there is provided a foam gun 110 mounted on a traversing head 112 and interconnected to the mixing chamber 104 by a flexible conduit 114. Referring to FIG. 3, there is more clearly shown an arrangement wherein a motor 116 drives a traversing rod 118 through a suitable gear exchanger 120. The other end of the traversing rod 118 is rotatably mounted to a plate 122 secured to the side wall 44. The traversing rod 118 is splined in a well-known manner for a length substantially equal to the length of the roll 50 such that rotation of the traversing rod moves the traversing head 112 and the attached foam gun 110 from one end of the splined section to the other in a reciprocal manner. The mixing chamber 104 also includes suitable controls for proper mixing of the chemical reactants from the tanks 100 and 102 for forming the foam and also controls for regulating the flow of the foam mixture to the gun 110. Thus, as the gun 110 reciprocates between one end of the splined rod section and the other end, a foamed-in-place insulation 124 is directed under pressure from the gun spout 126 to occupy the space between the vertical wall 12 and the jacket 64 being applied.

Depositing the foam-in-place insulation 124 is a continuous process as the aluminum sheet 66 is unrolled from the roll 50 and applied in a spatially separated position from the vertical wall 12 as a jacket 64, while the framework structure 18 traverses the vertical surface 12. In order to facilitate adherence of the applied foam insulation to the vertical surface and to the jacket, the appropriate surfaces can be treated using known means. Normally, it is sufficient to degrease the surface and apply a prime coat thereto. In the present illustrated embodiment wherein the foam insulation is applied to the vertical surface of a tank type structure, such structures are generally formed of steel or aluminum sheets.

In a process well known by those familiar with the foaming art, the foam material is partially foamed in the gun, with the final expansion taking place after the material has been applied between the portion of the jacket immedi-

5

ately precedingly unrolled and the vertical surface. In order to provide for the final expansion of the foam in the cavity between the vertical surface and the jacket when insulating under varied weather conditions, a heater 128 is rigidly attached to the ceiling 38 of the framework structure so as to be in operating position adjacent the vertical surface. The heater 128 can be of the torch type generally available in which a direct flame from the heater contacts the vertical surface; or the heater can be of the radiant heat type such as an electric heater. In any case, the heat directed to the cavity between the vertical surface and the jacket heats up the appropriate surfaces so that a final expansion of the foam material will occur in the cavity to insure good adherence of the foam insulation 124 to both the vertical surface and the jacket.

In FIG. 5, there is illustrated the manner of attaching the jacket 64 at the bottom and top of the tank structure. The floor 130 of the tank is mounted on a wooden block 132 around the perimeter of the tank structure, and suitable insulation 134 extends throughout the remainder of the tank structure below the floor 130. A concrete pile cap 136 forms the main vertical support for the tank structure, and a grout line 138 is placed between the wood block 132 and the pile cap 136. A suitable anchor strap 140 has one end imbedded in the concrete pile cap and another end attached to the tank structure to prevent the tank from rising when a gas is stored in it.

At the bottom of the tank structure an angle member 142 is set in a vapor barrier mastic 144 and firmly anchored to the pile cap and prevents moisture from attacking the applied insulation. The jacket 64 is secured to the angle member by a rivet means such as illustrated by the rivet 146. At the top of the tank structure, a piece of flashing 148 is connected to the jacket 64 by suitable attachment means such as a rivet 150, and a quantity of vapor barrier mastic 144 similar to that as used at the foot of the tank structure is placed between the flashing and the foam insulation 124 to prevent moisture from contacting the foam insulation. As can be seen in FIG. 5, the flashing 148 extends from the jacket 64 to the tank roof 14.

In operating the framework structure and the associated apparatus for insulating the vertical surfaces 12, the hoisting mechanism 22 is initially moved to present the framework structure at the vertical surface which is to be insulated. By controlling the motor 88, which drives the winches 78, the framework structure is lowered to the ground surface. A short length of sheet 66 is unrolled from the roll 50 and attached at the foot of the tank structure to the angle member 142 to provide the beginning of the jacket at the foot of the tank. Assuming that all the appropriate surfaces have been prepared for properly receiving the foam insulation, the heater 128 is then operated to warm the vertical surface, the jacket, and the space therebetween. The foam gun controls are then operated to release foam-in-place insulation which is directed from the gun spout to the formed cavity, the gun traversing the full width of the sheet 66 as previously described. As the winches 78 are operated to raise the framework structure along the vertical surface 12, the aluminum sheet 66 is unwound from the roll and placed in a spaced position from the vertical surface with the framework structure 18 being raised vertically along the vertical surface. The foam-in-place insulation is then deposited in a reciprocal manner throughout the width of the sheet 66 at a rate compatible with the unrolling of the sheet material. To restrict the foam from lateral displacement, the vertical spacer strips or studs 62 are placed on the vertical surface separated by a distance approximately equal to the width of the sheet material. As the sheet material is unwound from the roll, it is glued to the studs 62 and maintained against the studs by means of a light pressure exerted by the guide roll 68 and the pressure roll 70. The foaming continues as the roll un-

6

winds with the foaming partially taking place in the gun and the final foam expansion occurring within the cavity to adhere the foam material tightly to the vertical surface 12 and to the applied jacket 64. At the top of the tank structure, the sheet 66 is cut at a suitable location, and the piece of flashing 148 is secured to the jacket 64 along with the appropriate mastic 144.

As an aid in preventing a heavy wind from disrupting the application of the foam insulation to the vertical surface, a pair of wind deflectors 152 and 154 are mounted to the framework structure sidewalls 44 and 46 respectively and extend at least from the ceiling 38 to the floor 40 of the framework structure.

As an example of the present invention, a framework structure was constructed according to the teachings herein, and in which the roll 50 comprised a 0.024 inch aluminum foil sheet four feet wide wound on a 12 inch diameter mandrel. The spacers or studs 62 were formed of rigid polyurethane foam material and applied to the vertical surface at spacings of approximately four feet between studs. A minimum of at least two and one-half inches of foamed-in-place polyurethane insulation was then applied between the vertical surface and the jacket. The studs 62 were, of course, of the required thickness so as to insure the desired insulation thickness. Although the described embodiment uses studs to restrain the foam against lateral displacement beyond the edges of the sheet as it is unrolled and foaming takes place, it is to be understood that means other than studs can be used to keep the foam in place. For example, slidably mounted shoes can be used for the same purpose, as can a wide endless belt positioned lateral to the vertical surface of the tank.

Referring now to FIG. 6, there is illustrated the tank structure 10 similar to that shown in FIG. 1 having a vertical surface 12 extending from a dome-like roof 14 to the ground 16. A framework structure 160 is suspended by a pair of cables 20 attached to a hoisting mechanism 22 according to the manner of FIG. 1. The framework structure 160 is constructed similar to the structure 18 previously described and is adapted to apply the jacket and the foam-in-place insulation in horizontal rings around the tank by horizontally traversing the surface 12 in one of the directions indicated by the arrows in FIG. 6.

A number of horizontal stud rings 162 are secured to the vertical surface to form sections slightly less than the jacket width. As shown in FIG. 7, the axis of a roll of sheet material 50 is rotatably mounted vertically on the framework structure by means of a pair of brackets 54. A foam gun 110 is also mounted for vertical movement on a traversing rod 118 which is rotated in the manner as previously indicated to traverse the foam gun and deposit insulation between the horizontal stud rings 162. It must be realized, of course, that guide and pressure rolls and adhesive means are also provided according to the description above.

In operation, the framework structure 160 is lowered until the roll 50 is suitably positioned adjacent two separated horizontal stud rings 162. With the wheels 90 aligned in the desired directional movement, power driven wheels or other common drive apparatus drive the structure 160 substantially parallel to the ground so as to horizontally traverse the surface 12. As the framework structure is horizontally moved, the roll 50 is unrolled and applied as a jacket 64, with the foam-in-place insulation being directed to the newly-formed cavity between the applied jacket and the surface. After completion of the first insulating section, the framework structure is raised vertically to the next higher section. The jacket and the foam insulation are then again continuously applied to this section as the framework structure is driven horizontally around the surface 12.

It must be realized that it is within the teachings of this invention to provide other jacket materials. For instance, instead of the aluminum roll described herein, a pre-

7

painted roll of flexible steel can be utilized. Thus, it can be realized that this invention provides apparatus and a method for insulating a vertical surface with a minimum amount of time and cost. Furthermore, since the apparatus herein described is a completely enclosed structure, vertical surfaces which are exposed to the elements can be insulated even under severe weather conditions.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. Apparatus for insulating a vertical surface comprising:

a framework structure adapted to move adjacent a vertical surface;

a plurality of spacer studs substantially equally spaced along and attached to said vertical surface to define adjacently disposed foaming sections;

a roll of sheet material having a width at least equal to the spacing between said spacer studs to cover said foaming section;

roll support means for supporting said roll of sheet material on the structure so that the roll can be unwound and the sheet material applied across at least two of said spacer studs corresponding to a respective foaming section as the structure moves adjacent the surface;

means for supporting foam-in-place equipment on the structure;

foam dispensing means coupled to said foam-in-place equipment for directing foam between the vertical surface, said spacer studs, and the sheet material bounding a respective foaming section as the sheet material is unwound and applied to said spacer studs; and

drive means associated with the structure for moving it relative to the vertical surface.

2. Apparatus according to claim 1, wherein said foam dispensing means includes a foam gun, and traversing means for moving said foam gun reciprocally between said two spacer studs at a rate commensurate with the application of said sheet material to said studs as said structure is moved along said surface.

3. Apparatus according to claim 1, including a heater mounted on said structure for heating said vertical surface before the application of said foam thereto so as to insure the attachment of said foam to the surface, and a pressure device mounted to said structure for applying a restricting force on said sheet material after application to said spacer studs to urge said foam against said vertical surface, sheet material and spacer studs.

4. Apparatus according to claim 1, including means for attaching said plurality of spacer studs vertically on said surface to define a series of adjacently spaced vertical foaming sections on said surface, and wherein said drive means includes raising and lowering means connected to said structure for moving said structure vertically along and adjacent one of said vertical foaming sections on said surface between the uppermost and lowermost portions thereof, so that said roll is unwound to cover said vertical section as the structure moves upwardly adjacent the surface.

5. Apparatus according to claim 4, including means for selectively and consecutively positioning said structure at each of said vertical foaming sections on said surface so as to consecutively apply said insulation to said vertical sections thereby covering said surface.

8

6. Apparatus according to claim 1, including means for attaching said plurality of spacer studs horizontally on said surface to define a series of adjacently spaced horizontal foaming sections on said surface, and wherein said drive means includes means for moving said structure horizontally along and adjacent one of said horizontal foaming sections on said surface, so that said roll is unwound to cover said horizontal foaming section as the structure moves horizontally adjacent the structure.

7. Apparatus according to claim 6, including raising and lowering means for selectively and consecutively positioning said structure at each of said horizontal foaming sections on said surface so as to consecutively apply said insulation to said horizontal foaming sections, thereby covering said surface.

8. Apparatus for insulating the vertical surfaces of large storage tanks for storing liquids and gases, said apparatus comprising:

a substantially enclosed framework structure adapted to move adjacent said vertical surface;

a plurality of rigid foam spacer studs arranged on said vertical tank surface to define adjacently disposed, substantially equally spaced foam insulation sections on said surface;

a roll of sheet material having a width at least equal to or slightly greater than the center to center distance between said rigid foam spacer studs so as to slightly overlap one of said defined foam insulation sections and form an outer jacket for said vertical tank surface;

roll support means on said framework structure for supporting said roll of sheet material on said framework structure and to enable said roll to unwind to apply said sheet material across at least two of said spacer studs;

foam-in-place insulation means supported on said framework structure for supplying a foamable resin insulation to said foam insulation sections so that said foamable resin rapidly completes the final foaming-in-place in said section to form a self-supporting insulation;

foam dispensing means connected to said foam-in-place insulation means for directing said foamable resin insulation to said foam insulation section bounded by said vertical tank surface, said applied sheet material and two respective spacer studs as the sheet material is unwound and applied to said spacer studs; drive means associated with the structure for moving it vertically along a respective foam insulation section; and

means connected to said structure for selectively and consecutively positioning said structure at each of said foam insulation sections so as to consecutively apply said foam-in-place insulation and said outer jacket on said vertical tank surface.

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J. SPENCER OVERHOLSER, Primary Examiner

U.S. Cl. X.R.

264—45

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,548,453

Dated December 22, 1970

Inventor(s) Edward H. Garis

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

┌ In the patent heading, the assignment by Edward H. Garis to Chicago Bridge and Iron Company, Oak Brook, Illinois, a corporation of Illinois, should be inserted.

Signed and sealed this 8th day of June 1971.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

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