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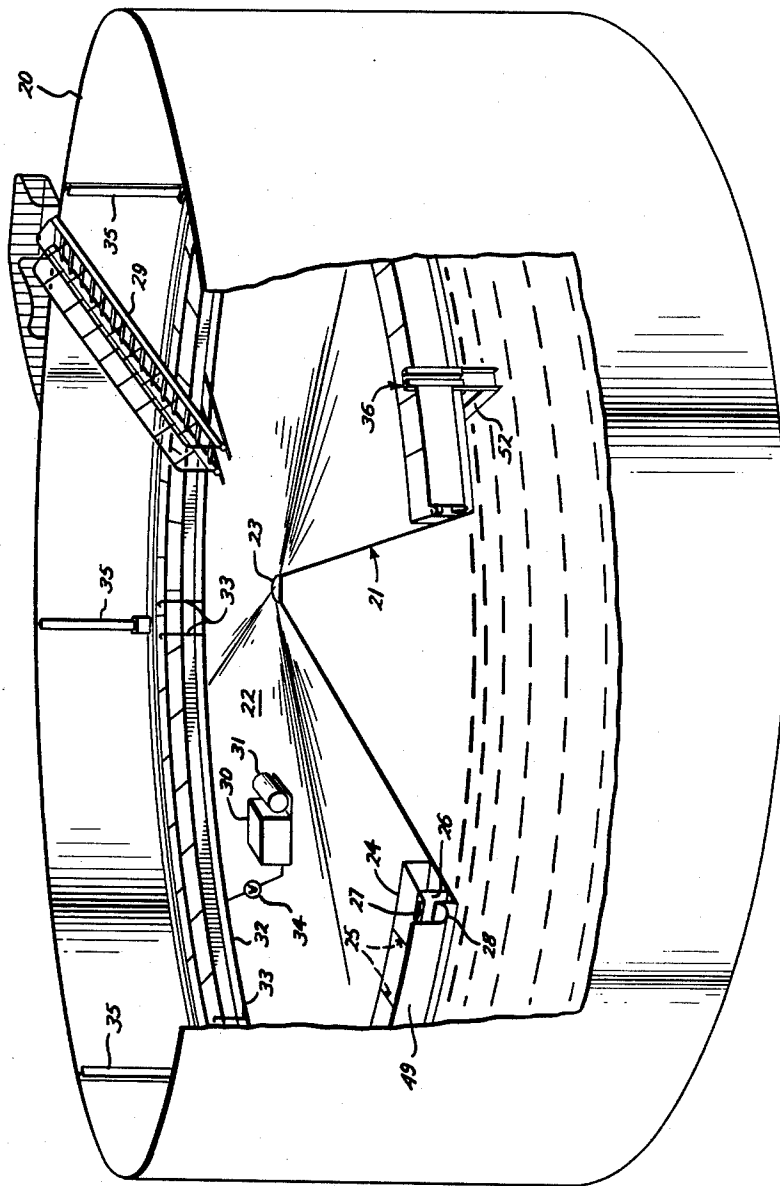
W. E. JOOR, II

3,059,805

SEALING MEANS FOR FLOATING ROOF TANKS

Filed May 25, 1959

6 Sheets-Sheet 1



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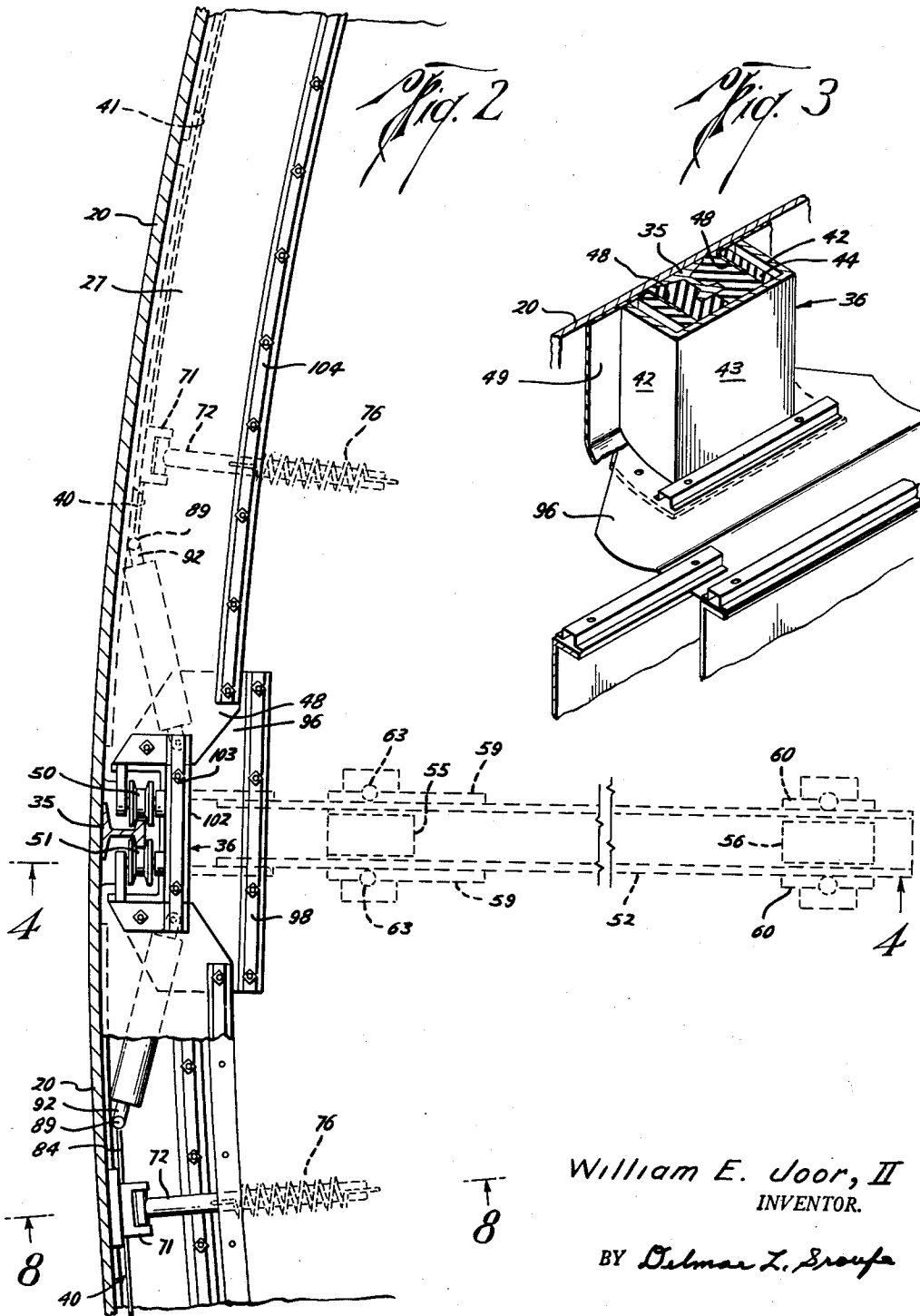
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SEALING MEANS FOR FLOATING ROOF TANKS

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6 Sheets-Sheet 2



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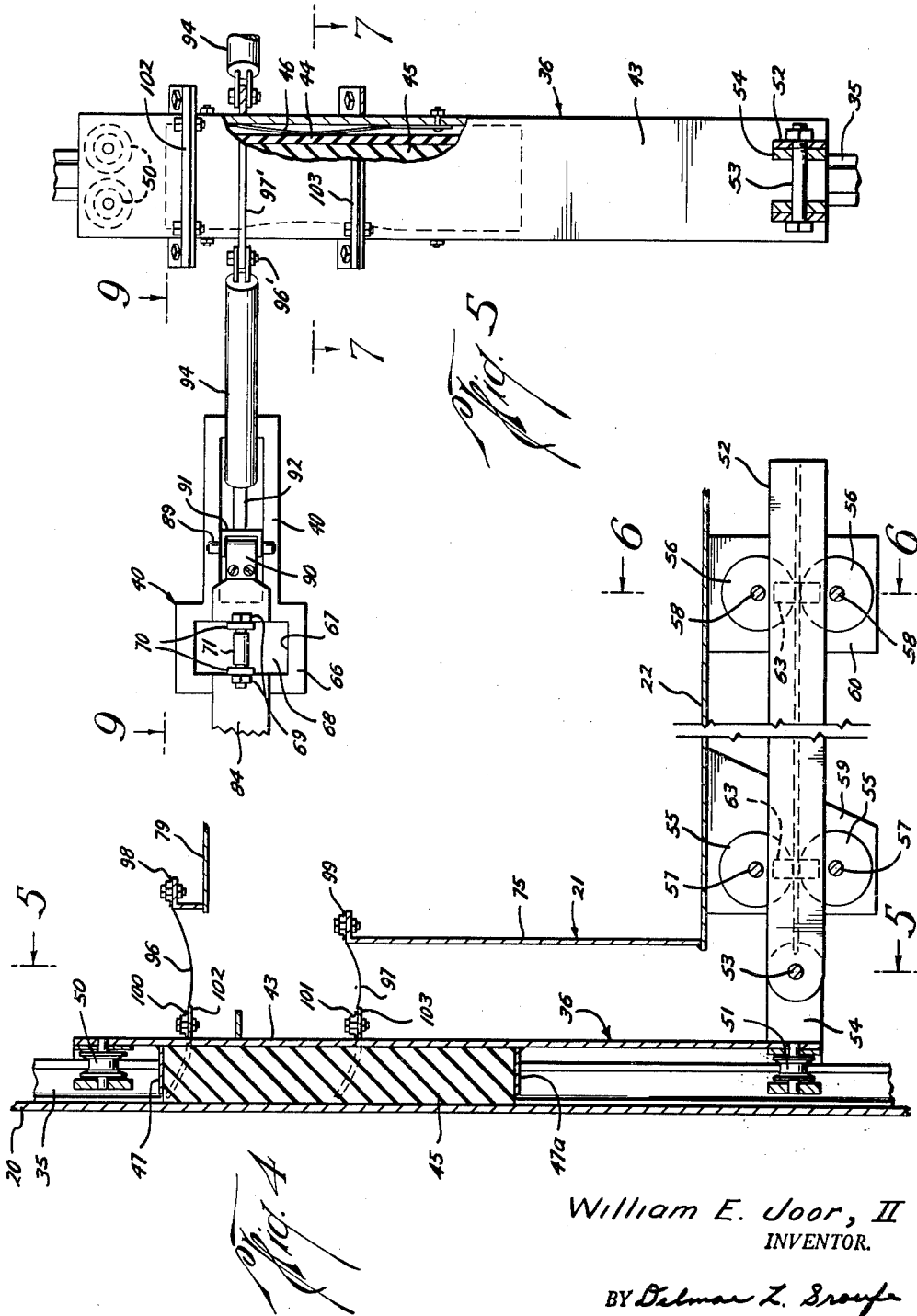
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SEALING MEANS FOR FLOATING ROOF TANKS

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SEALING MEANS FOR FLOATING ROOF TANKS

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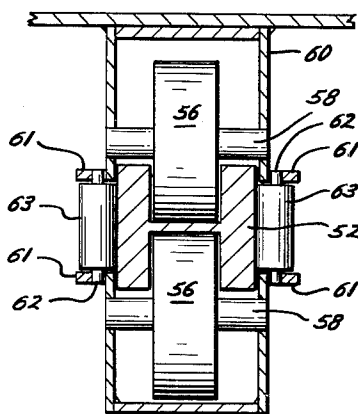
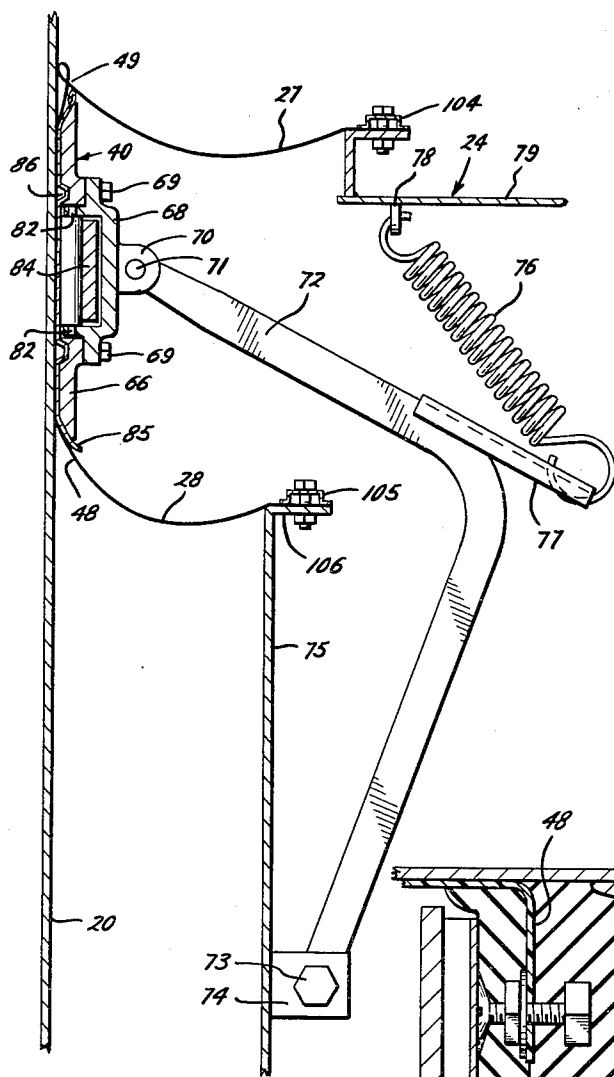


Fig. 6

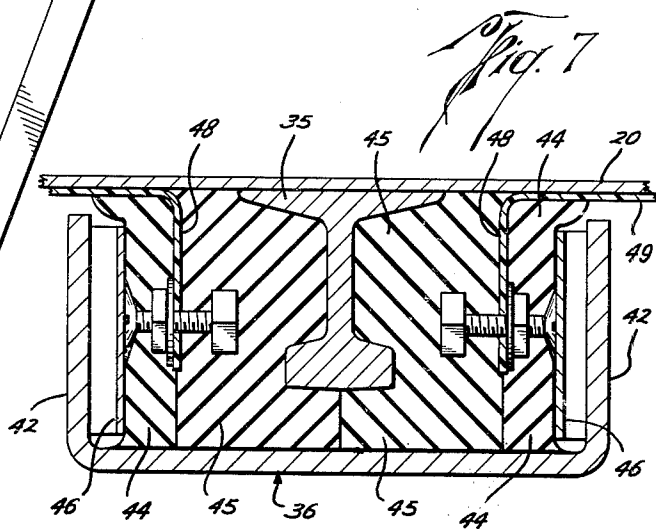


Fig. 7

Fig. 8

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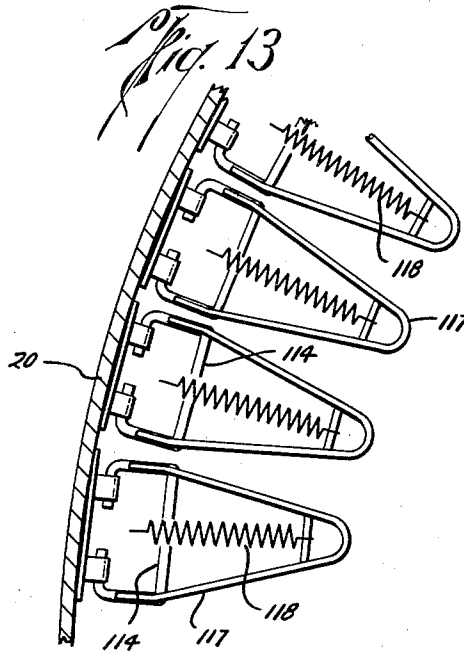
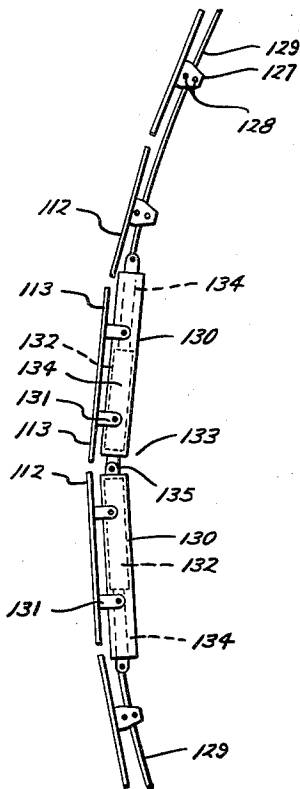
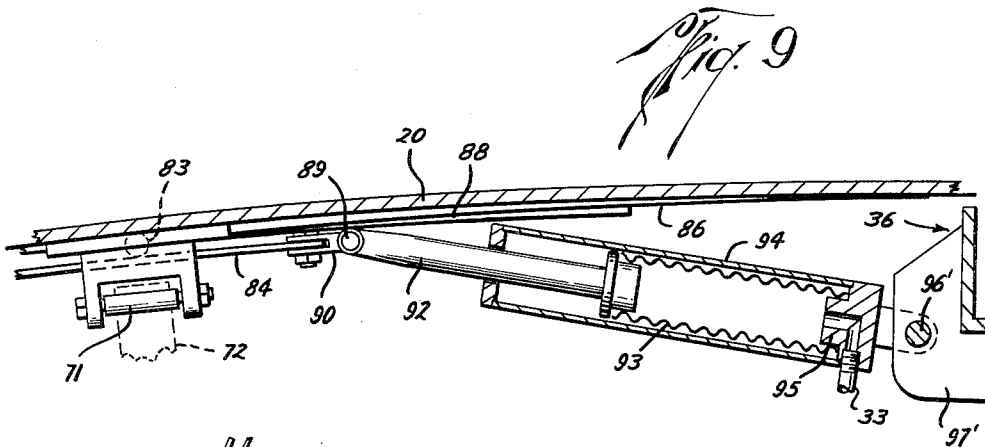
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SEALING MEANS FOR FLOATING ROOF TANKS

Filed May 25, 1959

6 Sheets-Sheet 5



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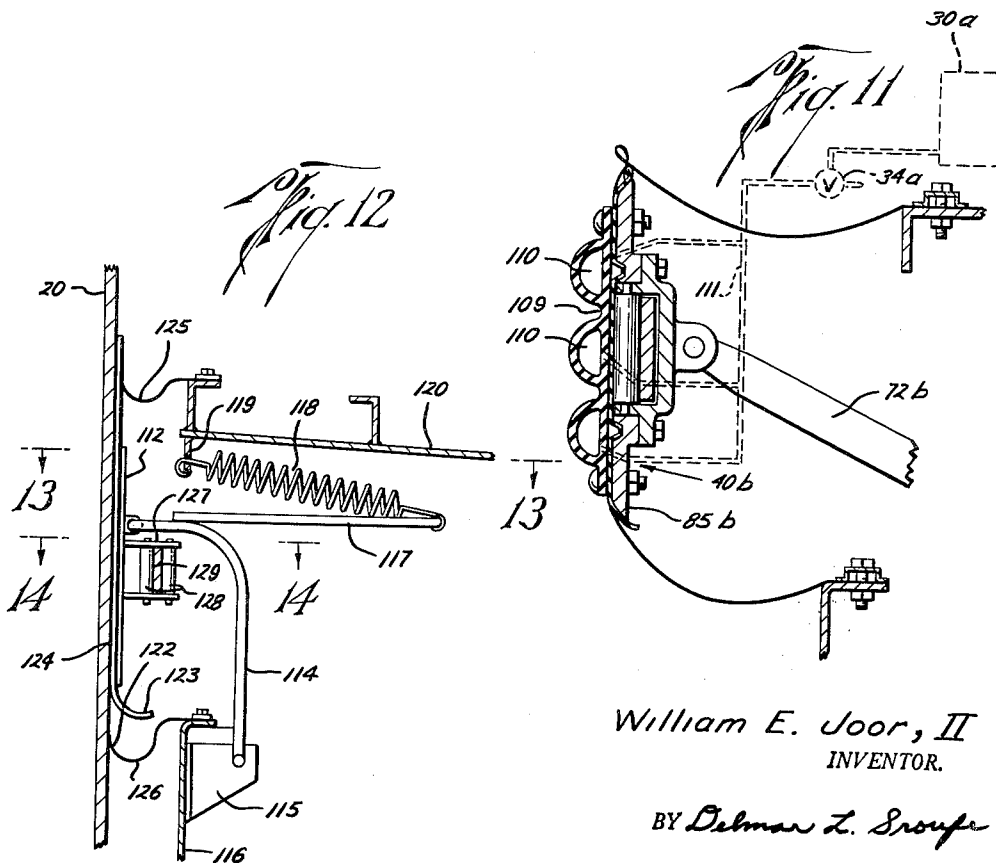
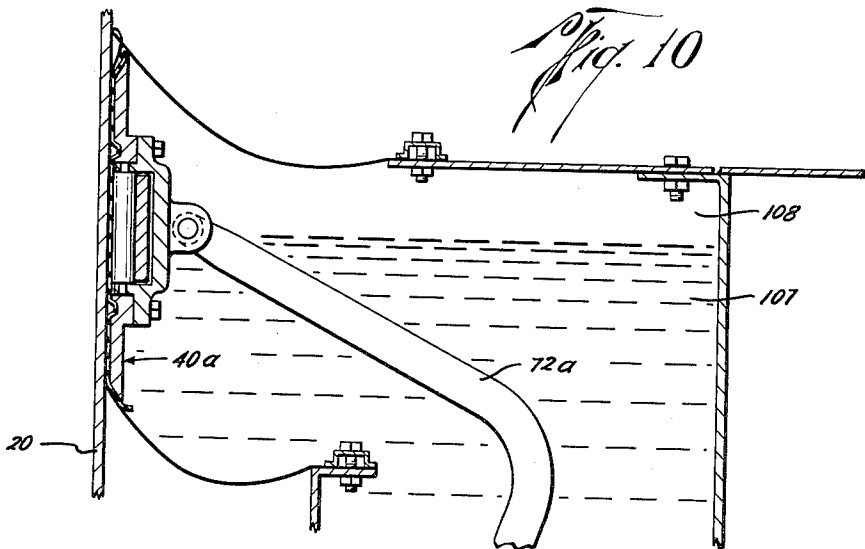
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SEALING MEANS FOR FLOATING ROOF TANKS

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6 Sheets-Sheet 6



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SEALING MEANS FOR FLOATING ROOF TANKS

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Filed May 25, 1959, Ser. No. 815,396
12 Claims. (Cl. 220-26)

This invention relates to pressure seals for floating roof tanks for storing gases and volatile liquids.

Variable volume tanks of the floating roof type for storing gases or volatile liquids must be provided with means for effectively sealing the space between the roof and tank wall. It is also necessary that such sealing means be capable of sliding along the tank wall without unduly affecting the roof movement as the quantity of fluid in the tank varies, and of accommodating itself to irregularities in the tank wall.

This is a continuation-in-part of my co-pending application, Serial No. 528,382, filed August 15, 1955 and now Patent No. 2,987,215. In the latter application there is illustrated and claimed a floating roof tank with novel peripheral sealing means urged against the tank wall by laterally bendable, arcuately biased beams carried by the roof structure. The ends of each beam are yieldingly urged together by the use of spring devices reacting against the roof so as to tend to increase the bowing thereof and, thereby, to bias the sealing means outwardly against the tank wall while permitting the roof and sealing means to slide vertically along the wall as the quantity of fluid in the tank varies.

The main object of the present invention is to provide improved, simplified sealing means for a floating roof tank.

Another object is to provide floating roof sealing means for an expandable tank embodying arcuately biased beams arranged serially around the tank wall and reacting through a novel arrangement of shoes and pliable sealing material to prevent the escape of fluids from the tank.

Another object is to provide improved means for arcuately biasing the shoe pressing beams, including expandable fluid motor devices for urging the ends of the beams toward each other.

Another object is to provide floating roof tank sealing means, including arcuately biased beams and means reacting between adjacent ends of successive beams for urging the ends of each beam toward each other to effect radial biasing of the attached shoes and sealing material.

Another object is to provide floating roof sealing means positioned relative to the tank wall by guide structures carried by the tank between the roof and the tank wall.

Another object is to provide floating roof tank sealing means including sealing guide structures carried by the tank wall and expandable devices carried by the guide structures for urging the ends of the respective beams toward each other to effect radial biasing of the intermediate parts thereof.

Still another object is to provide novel means for causing radial biasing of the shoes and facing material of a floating roof seal which means does not react against, and therefore affect the stability of the floating roof.

Other objects as well as advantages of my invention will appear in the following specification, drawings and appended claims.

According to the present invention, the sealing means between the roof and tank wall includes an annularly disposed sealing part or a sealing assembly and laterally bendable, arcuately-biased beams employed, as in the mentioned co-pending application, for urging outwardly the sealing part. However, according to this invention, expandable fluid actuated motor devices are interposed between adjacent ends of successive beams for applying

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force substantially longitudinally upon each beam to affect the outward biasing of the sealing part. In a presently preferred form of my invention, the fluid motor devices are secured to cage reaction devices which sealingly ride along complementary guide elements.

The sealing part or sealing assembly employed in my invention may be of any suitable or desired type which is adapted to span the space between the roof and the tank wall and slidingly to engage the tank wall. But I presently prefer a sealing assembly having shoes maintained in spaced relationship from the periphery of the roof and a pliable, impervious curtain spanning the space between the roof and the tank wall and passing between the shoes and the tank wall. The pliable curtain may be of any suitable or desired composition, such as rubberized fabric, and in a preferred form for pressurized storage the portion of the curtain serving as facing material between the shoe and tank wall may be provided with an additional yieldable facing element disposed adjacent the tank wall for sealing engagement therewith.

In the accompanying drawings illustrating the invention, FIG. 1 is an isometric view showing a variable volume tank for volatile fluids, partially cut away and with a floating roof structure and the novel sealing means of the present invention.

FIG. 2 is a detail plan showing a portion of the sealing structure partly broken away to illustrate the underlying parts.

FIG. 3 is an enlarged, detailed isometric view and section showing a slide member and a guide rail.

FIG. 4 is a vertical transverse section taken substantially on line 4 of FIG. 2.

FIG. 5 is an inner side elevation showing the parts in FIG. 4 and adjacent structure, and taken substantially on line 5-5 of FIG. 4.

FIG. 6 is a detailed, vertical section taken substantially on line 6-6 of FIG. 4.

FIG. 7 is an enlarged detailed, horizontal section taken substantially on line 7-7 of FIG. 5.

FIG. 8 is a detailed, vertical transverse section taken on line 8-8 of FIG. 2.

FIG. 9 is a detailed plan view taken substantially on line 9-9 of FIG. 5, parts being broken away and sectioned to illustrate the underlying structure.

FIG. 10 is a detailed vertical transverse section similar to FIG. 8, but showing a modification.

FIG. 11 is a similar vertical transverse section showing another modification.

FIG. 12 is a similar vertical transverse section showing a third modification.

FIG. 13 is a detailed horizontal section taken substantially on line 13-13 of FIG. 12.

FIG. 14 is a horizontal section taken on line 14-14 of FIG. 12.

FIG. 1 shows a cylindrical tank or casing for storing gases or volatile fluids having a tank wall 20 and being provided with a vertically movable floating roof structure, generally designated 21. The roof structure consists of a relatively thin body sheet 22 of generally conical shape with a central apex 23 and a peripheral, pontoon-forming portion 244. Portion 24 has radial bulkheads forming portion 24. Portion 24 has radial bulkheads used as ballast spaces. Outwardly of the pontoon-forming portion there is provided a crawl-way 26, to which is directly attached sealing diaphragm portions 27 and 28. An access stairway is shown at 29. Mounted on the roof sheet is a tank 30 for pneumatic fluid under pressure. A compressor 31 may be provided or tank 30 may be replaced from time to time by a charged tank containing nitrogen, helium, carbon dioxide or other suitable gas. Tank 30 is connected to a header 32, extending around the

roof which, in turn, is connected by cross feeds 33 to expansion fluid motor devices in connection with the seal biasing means, to be described hereafter.

In a preferred embodiment of the invention, I employ a pressure regulator 34 between tank 30 and header 32. By varying the pressure in header 32, the force produced by the fluid motor devices is correspondingly varied, so that fine adjustments may be made in the outward bias of the sealing means.

Mounted vertically adjacent the inner surface of tank wall 20 are I-beam guide rails 35, in this instance six of such rails being provided at equally spaced positions around the tank wall. The sealing diaphragms and their biasing structures are secured to cage-like structures, generally designated 36, which are sealingly slidable on rails 35 and which are supported from the roof structure, as will be described hereafter.

As indicated in part in FIG. 2, there are arranged at equal intervals around the inner face of tank wall 20, a series of shoe devices 40 and 41, the former being those located adjacent guide rails 35 and the latter being the intermediate shoes. Slidably received on each rail 35 is box-like guide structure 36, which comprises side walls 42 and inner wall 43 (FIGS. 3 and 7). This box structure, or slide member, extends along a portion of the associated rails 35, substantially co-extensive with the roof structure (FIGS. 4 and 5), and encases, for a portion of its length, resilient blocks 44 and 45 of rubber or rubber-like material between confining end plates 47 and 47a. Inner resilient blocks 45 are formed to fit closely about I-beam rail 35 and are yieldingly urged thereagainst by leaf springs 46 of arcuate shape which are lodged between side walls 42 and outermost rubber blocks 44. Interposed between each pair of blocks 44 and 45 is the end extremity 48 of the rubberized fabric sealing material 49, parts of which also form diaphragms 27 and 28. (See FIGS. 1, 2, 4 and 8.) Springs 46 and rubber blocks 45 are designed so that the blocks will seal around the guide rail, yet will slide along the rail during vertical reciprocations of the roof.

With reference to FIGS. 2, 4 and 5, it will be seen that the boxlike sealing guide structure has grooved guide rollers 50 and 51 mounted on stub shafts and positioned to run along the outer flange of associated I-beam 35 for stabilizing the guide structure against unbalanced side thrust. Projecting radially inwardly from the lower extremity of guide structure 35 is an H-beam 52 which I prefer to secure pivotally by a pin 53 to the bracket 54 which is affixed to the guide structure. Riding on opposite sides of the flange of H-beam 52 are pairs of vertically spaced rollers 55 and 56 rotatable on shafts 57 and 58 transversely received in bracket plates 59 and 60 depending from the roof structure. As shown in sectional detail FIG. 6, plate brackets 60 are provided with outward lips 61 which journal bearing pins 62 at the ends of side thrust guide rollers 63 extending through accommodating windows in bracket plates 60. This support arrangement, coupled with the shoe supports to be described hereafter, causes the guide and sealing elements to reciprocate with the roof structure and stabilizes the roof.

As best shown in FIGS. 5 and 8, each seal biasing shoe 40 has a base casting 66, with a central rectangular opening 67 configured to accommodate a holding casting member 68 which is secured to the base portion by bolts 69. Member 68 has inwardly projecting lugs 70 receiving a pivot pin 71 to which is rotatably secured an angular support rod 72, the lower extremity of which is pinned at 73 to lugs 74 projecting from the side wall 75, the outer rim plate of the roof structure. A coiled tension spring 76 connects a bracket 77 at the bend of rod 72 and an eye 78 depending from upper wall 79 of the crawlway. This spring urges shoes 40 and 41 outwardly from the roof to apply an initial bias thereto, for a purpose to be explained.

Shoe casting 68 also has outward lugs 82 which journal

the reduced extremities of a vertical roller 83 which, in turn, is positioned to rotate free of the adjacent shoe facing sheet 85. Closely but slidably received between the raised central portion of casting 68 and roller 83 is the laterally bendable beam 84, the casting and roller accommodating longitudinal play of beam 84 relative thereto.

Secured to the outer surface of the base portion 66 of shoe 40 is facing sheet 85 formed of thin, relatively flexible material, conveniently sheet metal, longitudinally ridged, as at 86, to fit within cooperating recesses in shoe base portion 66. These ridges are preferably tapered or feathered as they approach the extremities of the shoe to provide throughout the length of the shoe limited lateral flexibility thereof to accommodate any irregularities in the surface of the tank wall. Facing sheets 85, in turn, bear against sheeting elements 49 formed of suitable or desired material, such as rubberized fabric, having pliable and elastic properties and having suitable strength and durability properties. The sheeting elements 49, in the presently preferred embodiment, are formed from mid-portions of a single diaphragm sheet that also forms the sealing diaphragms 27 and 28. The side edges 48 of this sheeting material are gripped by slidable guide structures 36. The portion of the sheeting material which functions as a tank engaging facing is preferably affixed to the shoe by suitable bolting and/or cementing means.

Projecting laterally from one end of shoe base portion 66 is an extension having side rail portions 83 upon which ride the roller-equipped, bearing-forming ends of a pin 89 journaled in a yoke 90 secured to the adjacent end of beam 84. Also rotatably secured to pin 89 is a clevis 91 at the end of a rod 92 which projects from the free end of bellows 93 (FIG. 9) housed within a casing 94. The opposite end of the bellows is secured to the casing about a fitting 95 for attachment to previously mentioned cross piping 33 which supplies the interior of the bellows with pneumatic fluid under pressure from tank 30. The right hand end of casing 94 is pivotally secured by a pin 96 to a rib 97 on slidable sealing structure 36. The arrangement of expansible fluid motor devices 93, 94 and their connections to the adjacent ends of successive beams 84 and to floating slidable guide structure 36 is such that upon the expansion of the motor devices due to the supplying of pneumatic fluid thereto under regulated pressure, forces are applied to the ends of each beam tending to increase the bowing thereof and, thereby, bias shoes 40 and 41 outwardly so as to maintain flexible diaphragm material 49 in sealing, though slidable engagement with the tank wall. Although the slide member 36 can be made to operate satisfactorily with thrust from a motor device on only one side, the fluid motor devices are preferably mounted in opposed pairs so as to intermediately oppose each other through the sidewise thrust each imposes upon member 36.

The primary outward biasing force applied to the shoes and sealing diaphragm is generated through the arcuate beams and fluid motor devices, 93, 94. The springs 76, previously mentioned, are outward biasing means for the seal which, in the preferred embodiment, are provided as a secondary biasing force to insure the generally arcuate contour of the beams irrespective of the expansible fluid motors. Guideways 88 on the shoe base castings cooperate with the bearing rollers on pins 89 to restrain the ends of beams 84 substantially to circumferential movements relative to the tank wall so that compressive forces will be applied to the beam ends by the fluid motor devices, resulting in radial biasing of the beams along their entire lengths and of the multiplicity of sealing shoes 40 and 41 applied at regular intervals along the beams. Thus it is important only that a substantial vector of the expansive forces of fluid motors 93, 94 be applied longitudinally of the beams.

Intermediate shoes 41 are identical with described shoes 40, except for the omission of laterally-extending, guide

rails 88 against which bear rollers 89 for smoothly transmitting expansive forces from the fluid motor devices to the attached shoes.

As shown in FIGS. 2, 3 and 4, additional sealing diaphragms 96 and 97 are provided to seal the space around slidable guide structures 36 and between the ends of sealing diaphragm portions 27 and 28. These connecting diaphragms are secured to the adjacent roof structure by bolted clamping rails 98 and 99 and to the slidable guide structure 36 by clamping bars 100 and 101 bolted to flanges 102 and 103. Main sealing diaphragms 49 are secured to the roof structure by bolted clamping bars 104 and 105.

FIG. 10 shows a modification in which the quantity of ballast liquid 107 is provided in the space 108 which, in the previous form, served as a crawlway. This ballast liquid may be any suitable or desired liquid, such as water, glycol, oil, or the like. Corrosion inhibitors and antifreeze may be added to this stored liquid as desired or needed. Shoe 40a and its supporting angular rod 72a are the same as in the previous form. However, secondary biasing springs 76 are omitted from this form since the ballast liquid contacts the seal assembly and provides an initial bias thereto.

The modification in FIG. 11 includes a shoe structure 40b, angular support link 72b, and shoe facing sheet 85b, as in the first form. However, the pliable sealing material affixed to the shoe between the shoe face and the tank wall in this form includes a yieldable facing element formed of a molded strip of material 109, such as rubber, having hollows 110 which may be charged with a suitable fluid. Material 109 is firmly affixed to the sheeting element 49 by suitable means, preferably by cement and bolts. The material is formed around the hollows to provide yieldable ridges which form a pressure retaining seal by contact with the tank wall. The hollows 110 may be sealed with a permanent fluid content or, as indicated, a manifold system 111 may be used to connect hollows 110 through a pressure regulator 34a to pressure tank 30a containing any suitable or desired gas or liquid. The functioning of the seal is the same as in the first form, and it is adapted to retain higher storage pressures.

FIGS. 12, 13 and 14 show a further modification in which the annularly arranged shoes 112 and 113 are supported by V-shaped brackets 114 secured at their lower extremities to lugs 115 projecting from the outer rim plate 116 of the adjacent roof structure. A V-shaped arm 117 projects horizontally inwardly from the upper portion of each V-bracket 114 and is attached at its inner extremity to the end of a coiled, tension spring 118. Spring 118, at its outer extremity, is secured to a depending flange 119 at the outer edge of upper plate member 120 of the roof structure. Rubberized sealing fabric 122 is received between shoe facing sheets 123 and the inner surface of tank wall 124 and has upper and lower folded over portions 125 and 126 for spanning the space between the roof structure and the tank wall.

As shown in FIG. 14, each of the shoes 112 has a pair of lugs 127 with spaced pins 128 between which is received a laterally bendable arcuate beam 129, similar to beam 84 in the first form. Each shoe 113 mounts a cylinder 130 by means of lugs 131. Each cylinder 130 receives an expansible bellows 132 having pneumatic pressure supply piping 133, as in the first form. The bellows is secured at one end to the cylinder and, at its free end, is secured to an actuated rod 134. Fluid motor devices 130, 132 are arranged oppositely in pairs with their adjacent bellows sealing ends pivotally secured together, as at 135, and their remote, actuator-rod ends pinned to the adjacent ends of successive arcuate beams 129. Thus, the expansive forces of the fluid motor devices are applied substantially longitudinally of the arcuate beams so as to tend to increase the bowing thereof and the consequent outward biasing of the sealing shoes. While in a small tank, a single arcuately biased beam may suffice, in larger

tanks additional beams may be provided with interposed expanding fluid motors between successive beams.

Accordingly, in all forms of the invention, the sealing shoes and pliable facing material are urged into sealing engagement with the tank wall by arcuately biased laterally flexible beams provided with expansible bowing means which react against each other around the circular tank wall, to apply compressive, i.e. opposed forces to the beam ends, thus relieving the roof structure of such reaction forces. The design is substantially simpler and provides a more effective seal than heretofore known sealing devices. The principles of the invention may be applied to other types of floating roofs, for instance, the twin deck or pan type and may be used in connection with any type of service for which expandable, pressure sealing tanks are useful. Moreover, the opposing expansive forces of the fluid motors may be applied to the ends of each beam at any convenient angle tending to urge these ends together provided the beam ends are restrained to movements within the chord between the ends and the inner circumference of the tank wall, i.e., substantially along the tank wall. The invention may be modified in these and other respects, as will occur to those skilled in the art and the exclusive use of all modifications as come within the scope of the appended claims is contemplated.

What is claimed is:

1. In a variable volume tank, a peripheral wall, a vertically movable roof structure therein, sealing means closing the space between said structure and said wall including a part extending around and slidably engaging said wall, a guide rail extending vertically along said wall, a member slidable along said rail and in sealing engagement therewith, flexible, laterally-resilient beam means extending around said wall and bearing against said sealing part, said beam means having ends adjacent said slidable member, and expansible devices reacting between said member and said adjacent ends of said beam means to apply an outwardly flexing bias to said beam means and, thereby, urge said sealing part against said peripheral wall.

2. In a variable volume tank, a peripheral wall, a roof structure spaced radially from said wall and movable vertically therein, sealing diaphragm means spanning the space between said structure and said wall, yielding material extending around and engaging said wall, a plurality of shoes disposed around said wall inside said material, laterally-flexible, arcuate beams extending serially around said wall and bearing against said shoes, said beams having adjacent ends, and expansible means reacting against said ends and applying an outwardly bowing bias thereto for urging said yielding material against said peripheral wall.

3. Variable volume tank construction as described in claim 2 further including a vertical guide rail adjacent the inner wall of said casing and a cage member slidable along said rail and sealingly engaging the same, said expansible means reacting, intermediately, against said cage member and one end of said beam means.

4. In a variable volume tank, a casing including a peripheral wall, a roof structure spaced therefrom and vertically movable therein, a vertical guide rail on said wall, a cage member slidable on and sealingly received about said rail, and means sealing the space between said wall and said roof structure and including a pliable part extending around and engaging said wall, said part being sealingly secured to said cage member, laterally resilient, arcuate beams extending serially around said peripheral wall immediately inwardly of said pliable part, and means for applying longitudinal pressure to at least one of the ends of each of said beams tending to bow said beam intermediate its ends for urging said pliable part in sealing engagement with said wall.

5. In a variable volume tank, a peripheral wall, roof structure spaced from said wall and movable vertically

therein, spaced vertical guides on said wall, sealing means between said roof structure and said wall including devices movable along and sealingly received about said guides, pliable parts extending around and engaging said wall and sealingly secured to and around said devices, backing shoes engaging said pliable parts, means to apply radial pressure to said shoes to cause said pliable parts to sealingly engage said wall, and supports for said sealing means including bearing elements carried by said roof structure and radial projections on said devices supported by and movable along said bearing elements.

6. In a variable volume tank, a peripheral wall, roof structure spaced from said wall and movable vertically therein, vertical guide rails on said wall, cage members constrained for vertical movement along said rails, resilient sealing material lodged between each cage member and the associated guide rail and slidable on said rail, means sealing the space between said roof structure and said wall including pliable parts directly engaging said wall and extending therearound, said parts being sealingly secured to and around said cage members and extending therebetween, means biasing said pliable parts outwardly into sealing engagement with said wall, support rails projecting substantially radially from said cage members, and bearing elements on said roof structure, said support rails being carried by and slidable along said bearing elements whereby said roof structure supports said cage members through said radial rails and said roof structure is stabilized against rotation.

7. Variable volume tank construction as described in claim 6 in which the means biasing said pliable parts outwardly comprises a plurality of flexible, bowed beams disposed serially around the said wall and each extending between adjacent sliding cage members and expansible devices each reacting between one of said cage members and an adjacent beam end whereby opposing forces are applied longitudinally to the ends of each beam tending to increase the bowing thereof and thereby apply resilient outward pressure to said pliable parts.

8. Sealing means for a tank having a peripheral wall and a roof spaced therefrom and movable vertically therein comprising pliable material sealing the space between said wall and said roof, horizontally flexible, arcuate beam means extending around said wall and having adjacent ends, bearing shoes between said beam means and said pliable material, bearing brackets on said shoes extending substantially circumferentially of the tank well, bearing elements on said beam means movable along said shoe surfaces and constrained thereby for circumferential sliding movements to accommodate flexing of said beam means, and means applying opposite forces longitudinally to said ends of said beam means for increasing the bowing

of said beam means and thereby biasing said shoes and said sealing material against said wall.

9. In a variable volume storage tank, a peripheral wall, a roof structure vertically reciprocable therein, and sealing means between said wall and roof structure including a shoe member having a surface confronting said wall, yielding facing material between said surface and said wall, diaphragm means sealingly connecting said material and said roof structure, and means urging said shoe member outwardly for causing said facing material to sealingly engage said wall, said material including at least one fluid charged, hollow rib on said surface and directly engaging said wall for conformance to irregularities therein.

10. A variable volume tank as described in claim 9 in which a plurality of said hollow, fluid charged ribs are formed on said surface extending circumferentially of said wall.

11. In a variable volume tank, a peripheral wall, a roof structure vertically reciprocable therein, sealing means between said wall and said roof structure including an outwardly biased shoe having a generally form-sustaining, laterally resilient sheet for presentation to said wall and conformance with irregularities in the contour thereof, and a force transmitting bracket mounted on said sheet, said sheet having a stiffening corrugation and said bracket having a recessed wall received upon and snugly fitting said corrugation for stably positioning said bracket on said sheet.

12. Variable volume tank construction as defined in claim 11 in which said plate extends substantially beyond said bracket part and said corrugation is reduced in depth as it approaches the outer edge of said plate to permit tank wall conforming flexing of said plate.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,059,805

October 22, 1962

William E. Joor II

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 62, for "244" read -- 24 --; line 63, strike out, "forming portion 24. Portion 24 has radial bulkheads", and insert instead -- 25 forming individual chambers, some of which may be --; column 7, line 49, for "surfaces" read -- brackets --.

Signed and sealed this 2nd day of July 1963.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents