United States Patent [19]

King et al.

[11] **3,922,823**

[45] **Dec. 2, 1975**

[54] **ENCLOSED CONCRETE WATER RESERVOIR SUPPORTING EARTHFILL FOR MULTIPLE LAND USES**

[76] Inventors: **Jimmie D. King,** 8316 Stone Ave. North, Seattle, Wash. 98103; **Harry R. Powell,** 102 Maiden Lane East, Seattle, Wash. 98112

[22] Filed: **Nov. 1, 1973**

[21] Appl. No.: **411,744**

[52] **U.S. Cl.** ..... **52/80;** 52/169 DT; 52/167; 61/1 R

[51] **Int. Cl.²** **E02D 29/00**

[58] **Field of Search** ..... 52/13, 14, 80, 169, 167; 61/1 R

[56] **References Cited**

UNITED STATES PATENTS

981,824	1/1911	Veres	52/167
2,705,929	4/1955	Atkins	52/73
3,283,515	11/1966	Pottorf	52/167
3,510,999	5/1970	Habacher	52/169
3,638,377	2/1972	Caspe	52/167

FOREIGN PATENTS OR APPLICATIONS

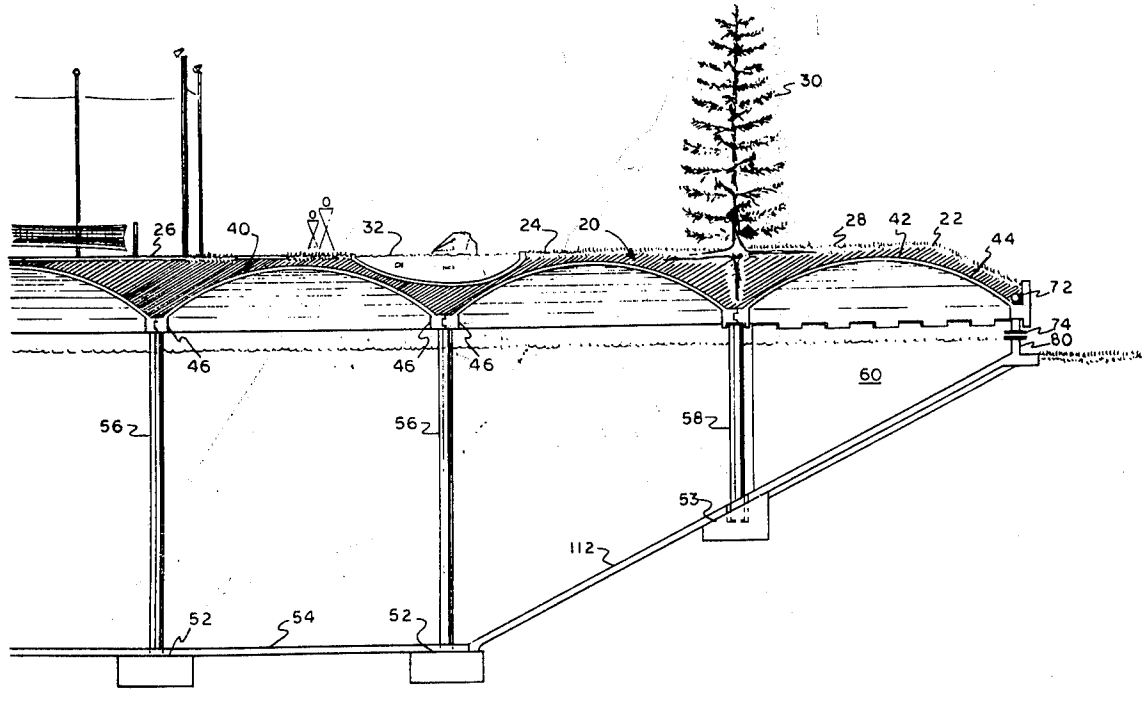
826,887	4/1938	France	52/169
362,473	12/1931	United Kingdom	52/73
1,352,711	1/1964	France	52/73
328,442	10/1923	Germany	52/167
456,060	2/1928	Germany	52/169
380,041	4/1940	Italy	52/169

Primary Examiner—Ernest R. Purser
Assistant Examiner—Henry Raduazo
Attorney, Agent, or Firm—Roy E. Mattern, Jr.

[57] **ABSTRACT**

In one embodiment, the concrete post-tensioned multiple dome and integral beam roof modules, utilizing cable-tendons as they are assembled into a roof, form the roof of a concrete water reservoir. A comparative minimum amount of materials are used in this embodiment which is designed to be substantially completely surrounded by earth. The earth fill above is of sufficient depth for the creation of scenic and recreational park facilities, and other multiple uses and also the soil depths in many locations will support tree growth. In this reservoir embodiment, of the overall roof modules, the concrete water reservoir has a continuous floor, inclusive of footings, surrounding side walls, selectively spaced interior shear walls perpendicular to the side walls, spaced columns, either pre cast or formed in place, post-tensioned valley beams integrally made in modules with integral domes and supported on the spaced columns, horizontal cable tendons used in the post-tensioning of the overall arrangement of the integral valley beam and dome modules, and expansion, cushion, and sealing materials to accommodate expansion and contraction of the concrete reservoir during temperature changes and surrounding earth movements. Each dome consists of four alike integral roof portions, each one curved throughout on a radius first determined in a geometric plane perpendicular to its respective post-tensioned valley beam at the center of the beam, resulting in single rather than compound curvature construction.

12 Claims, 14 Drawing Figures



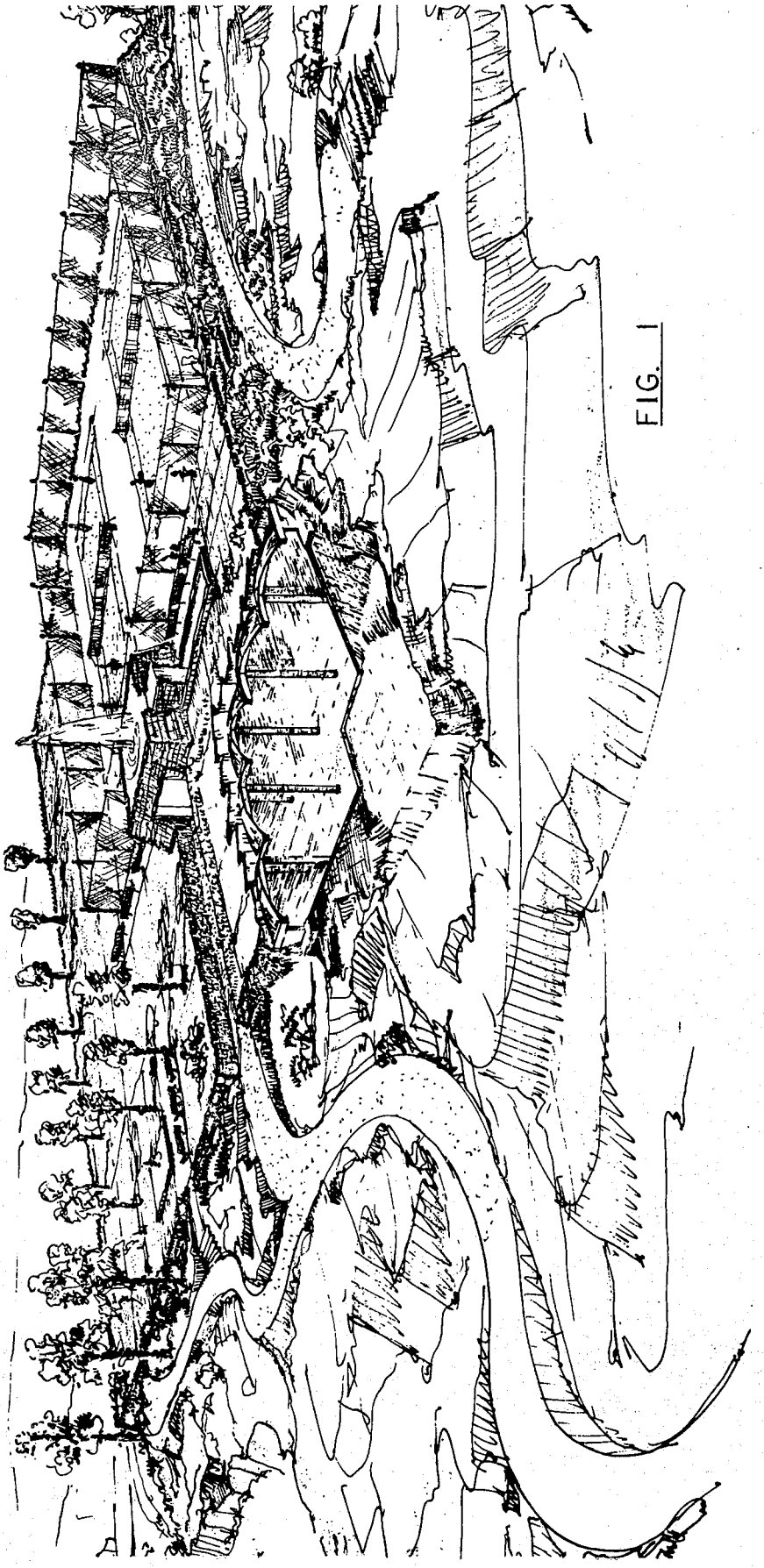


FIG. 1

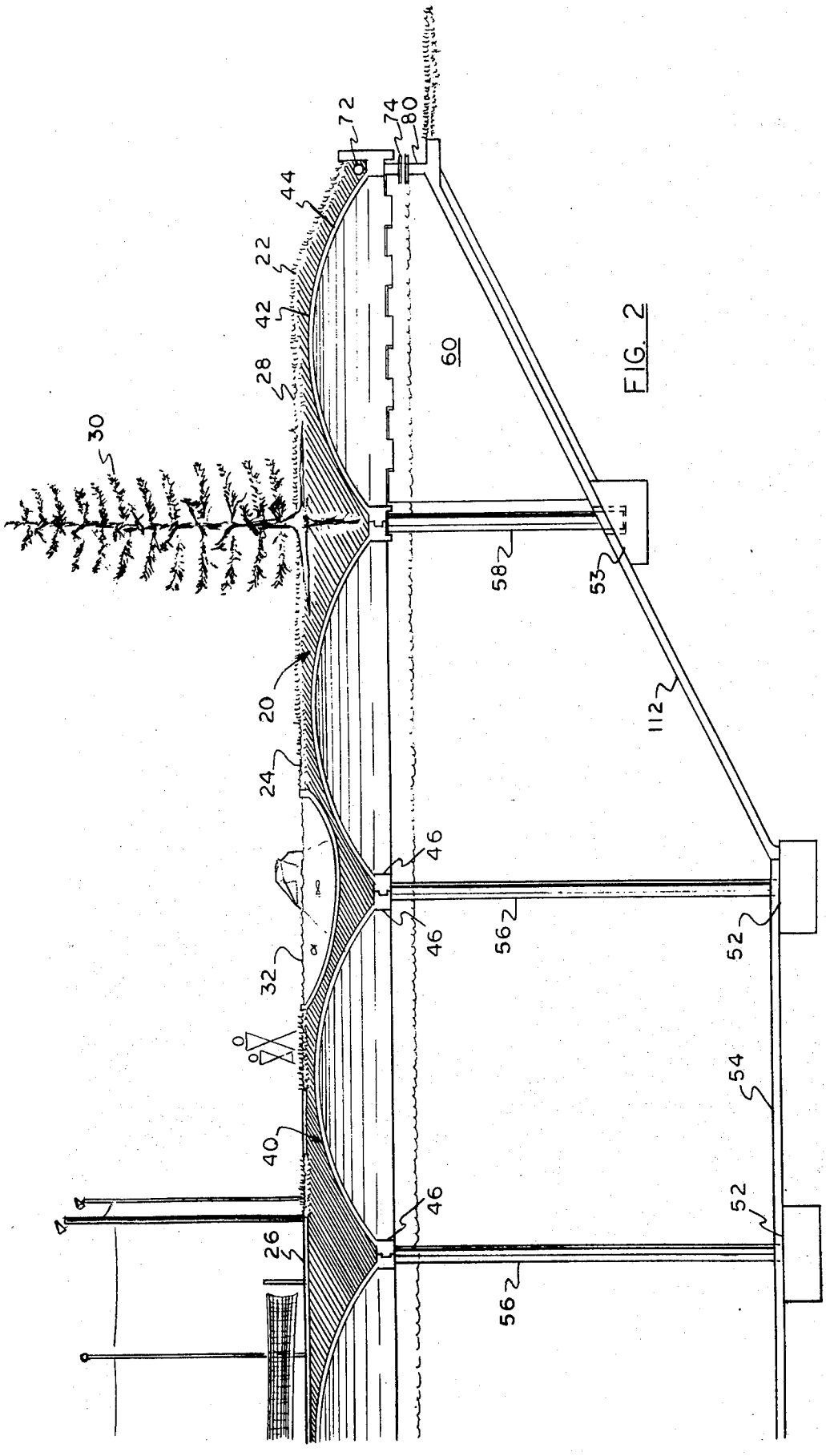

72
74
80
44
22
42
28
30
60
58
53
112
20
24
46
46
46
56
56
52
52
32
54
40
26

FIG. 2

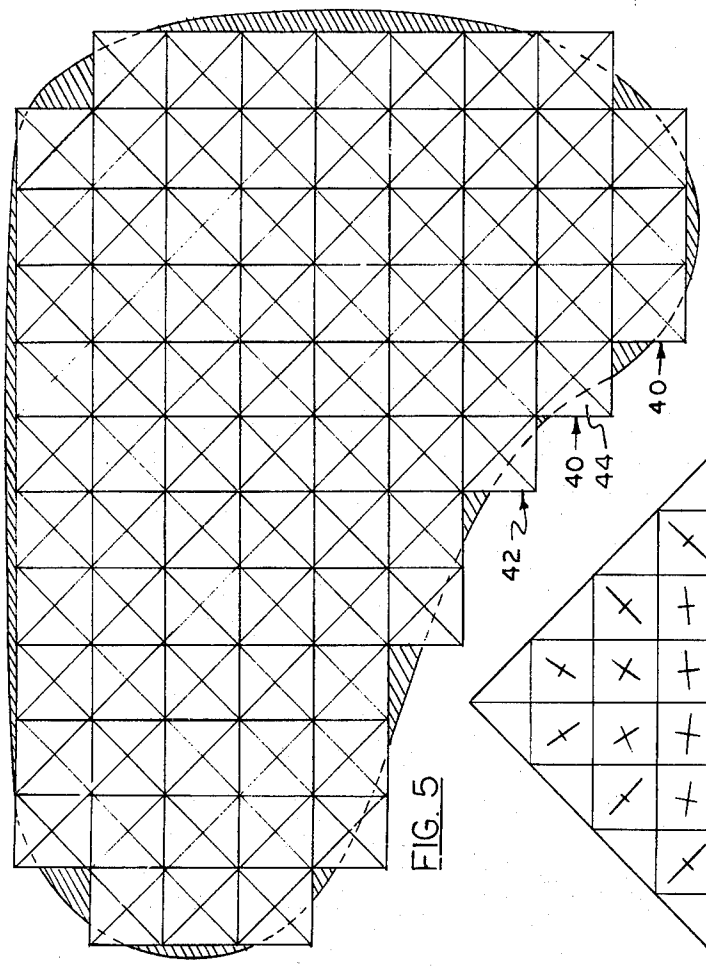


FIG. 5

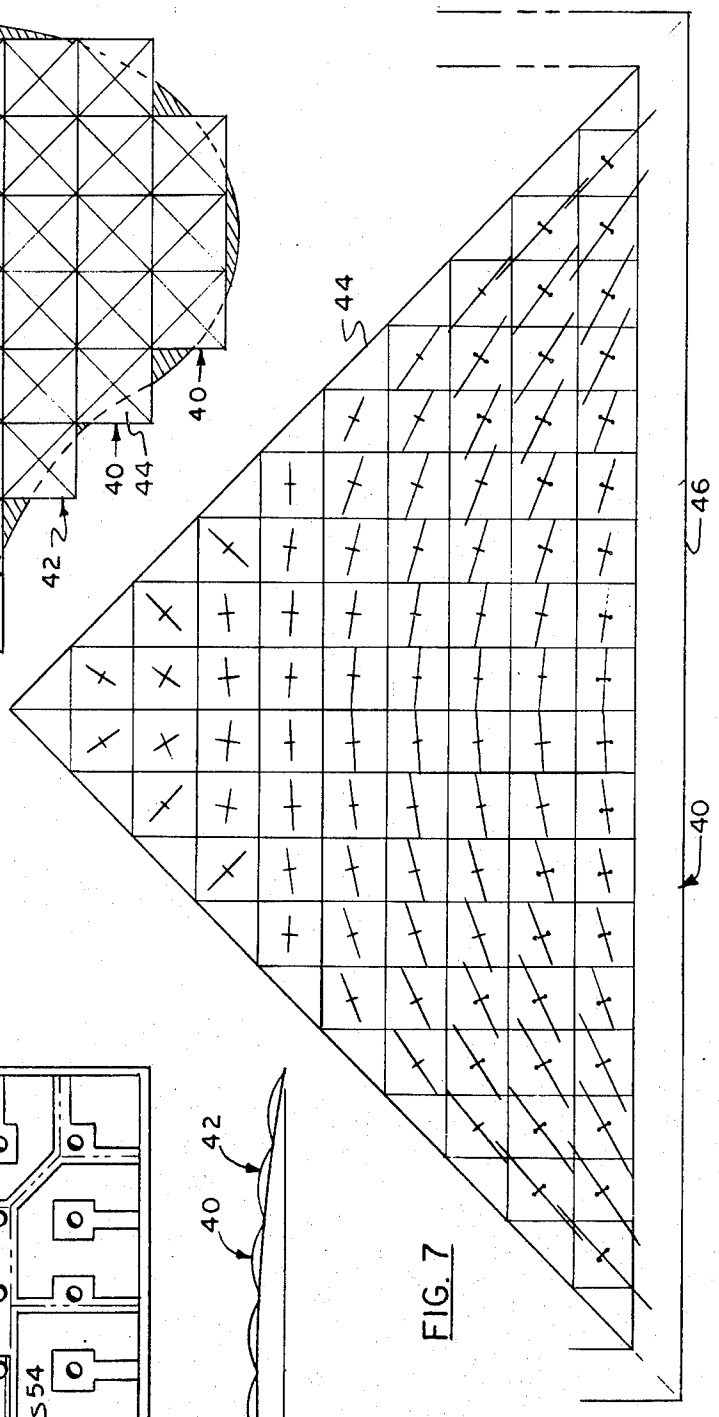


FIG. 7

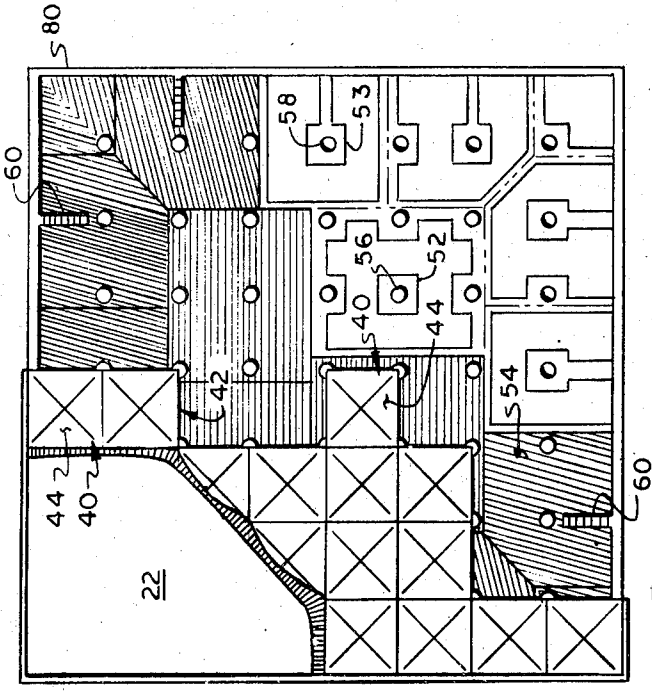


FIG. 3

FIG. 4

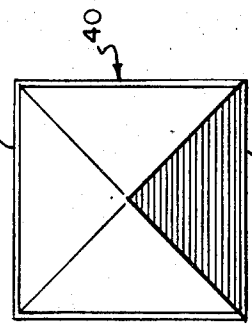
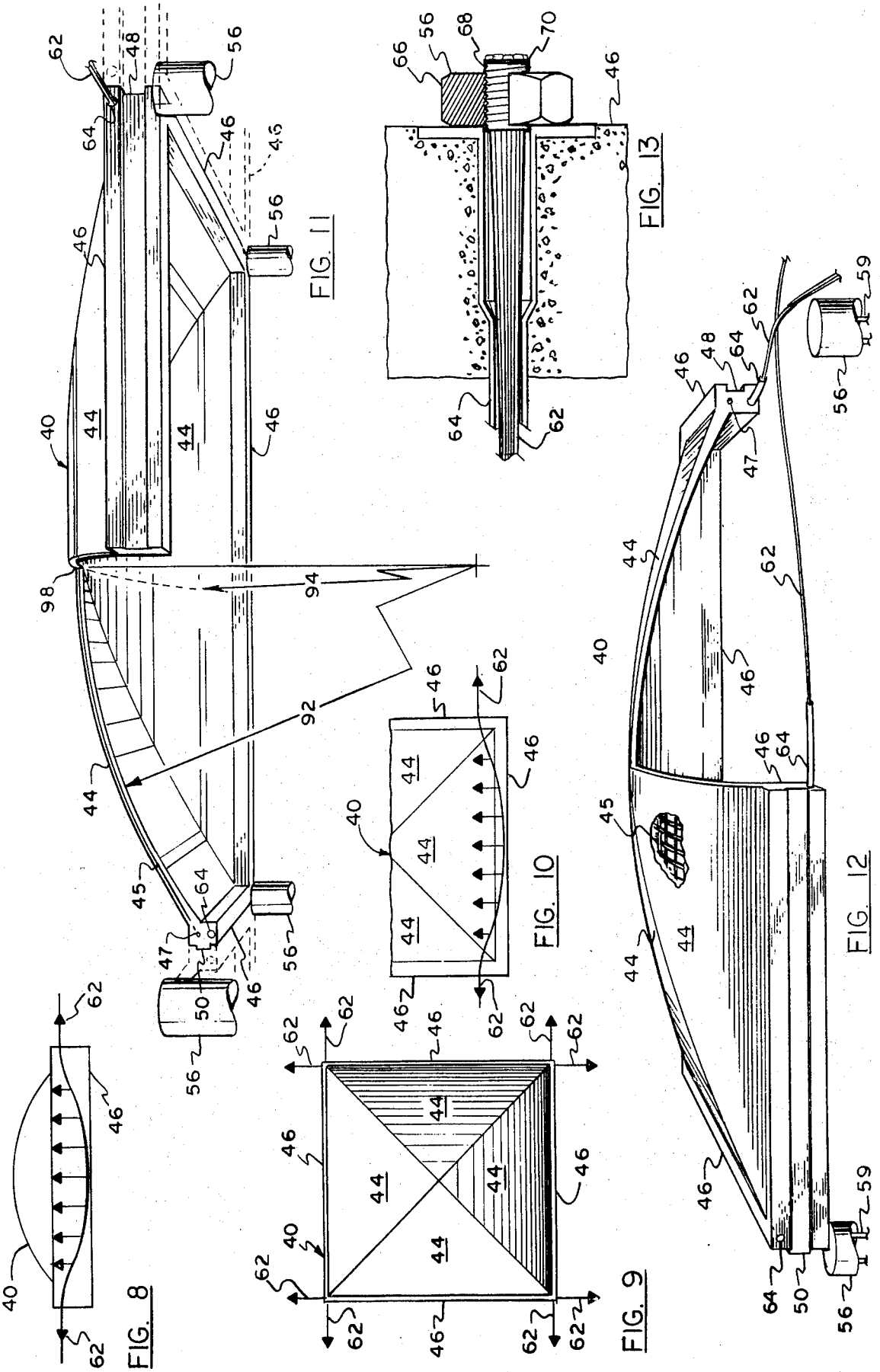


FIG. 6


FIG. 8
FIG. 9
FIG. 10
FIG. 11
FIG. 12
FIG. 13

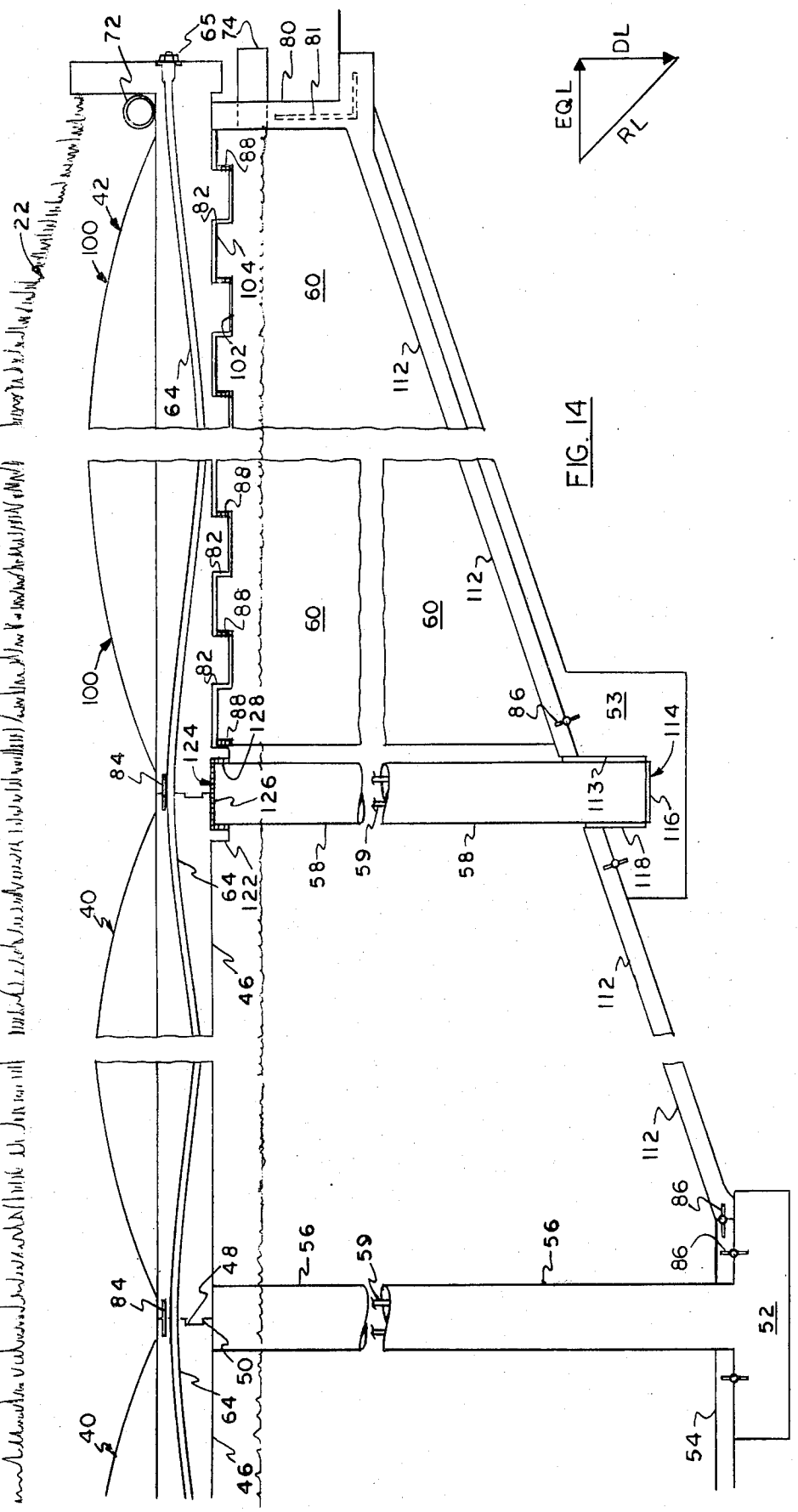

EQL
DL
RL
72
65
74
80
81
88
82
104
102
64
60
112
42
100
22
86
53
114
113
116
118
84
124
126
128
122
58
59
46
40
48
56
50
52
54

FIG. 14

ENCLOSED CONCRETE WATER RESERVOIR SUPPORTING EARTHFILL FOR MULTIPLE LAND USES

BACKGROUND OF THE INVENTION

In particular reference to enclosed water reservoirs, in the past they have been made of wood assemblies of multiple timbers and sheets of plywood; steel assemblies of spaced frames; trusses, and beams; concrete assemblies of prestressed concrete units; hyperbolic paraboloid shells; and/or cast in place concrete slabs; and selective combinations of portions of these assemblies. All of these past construction assemblies have served well in meeting the design objectives of the past. However, current design objectives, especially entering on the requirements of multiple land use and uncontaminated water supplies in urban areas, have indicated the past assemblies of enclosed water reservoirs do not meet the current objectives, such as: insure the quality of immediately available fresh water for domestic human supply against bacterial and chemical contamination, algae growth, and vandalism; construct the enclosed reservoir of permanent materials; construct the enclosed water reservoir at minimum cost; maintain and operate the enclosed water reservoir at minimum expense; and use the area above the enclosed water reservoir of multiple purposes such as for scenic and recreational parks, playgrounds, outdoor theaters, reflecting pools, etc. In reference to other buildings, such as garages, treatment plants, etc. many of the same advantages involving multiple use will be realized when the concrete post-tensioned multiple dome and integral beam roof modules are assembled as a roof utilizing the post-tensioned cable-tendons.

SUMMARY OF THE INVENTION

Concrete post-tensioned multiple dome and integral beam roof modules utilizing cable-tendons, when assembled as an overall roof, may be effectively used as a roof for many multiple use structures. For example, a fully enclosed concrete water reservoir, providing areas above for multiple purposes such as for scenic and recreational parks, is uniquely constructed, especially in respect to using these integral valley beam and dome modules. In each of the valley beams of a dome module, a conduit is formed in a parabolic drape configuration, with the high points of the conduit being located at the ends of each valley beam over its column supports, and the low point of the conduit being located at the midspan of each valley beam. Upon subsequent jacking or pulling of the cable-tendons within their conduits and securing them, all the valley beam and dome modules are post-tensioned in their original pattern. As a consequence, throughout this overall roof, such as the roof of a concrete water reservoir, the compression forces in the concrete are essentially multi-directional, the bending moments in the valley beams are reduced and also the tension stresses in the comparatively thin shell domes are well reduced below the cracking stress of concrete in tension. In this way a lighter overall concrete water reservoir structure and other multiple use structures are efficiently constructed.

The collective contours of the domes, wherein each dome has four alike integral roof portions, each being of a single rather than of a compound curvature construction, reduces costs of manufacture while maintaining high strength capabilities. Also the overall contours

of the domes form the top of the reservoir so the maximum depths of earth fill, used in growing trees, are located over the valley beam and column load transferring locations, and the minimum depths of earth fill, used in growing grass or other small vegetation are located over the central portions of the domes, again maximizing the overall structural efficiency of the multiple land use water reservoir. The effective incorporation of both resilient expansion and sealing materials with the concrete and the effective coating of the concrete surfaces with crystallization type waterproofing, complete the construction of the water confining overall cement reservoir to store water during a long life while at all times protecting the water from bacterial and chemical contamination, algae growth, and/or vandalism.

DRAWINGS OF A PREFERRED EMBODIMENT

A preferred embodiment of assembled concrete post-tensioned multiple dome and integral beam roof modules serving as a roof of a concrete water reservoir, over which earth is filled to create an area above for other uses, such as for a scenic and recreational park, is illustrated in the drawings, wherein:

FIG. **1** is a perspective view, with portions removed for illustration, of this post-tensioned roof on a concrete water reservoir, fully installed and covered with earth fill supporting in turn scenic and recreational park facilities, such as the illustrated tennis courts;

FIG. **2** is a partial sectional view of the concrete water reservoir illustrating the underground water storage and the above ground scenic and recreational park facilities;

FIG. **3** is a top view with portions broken away at different levels to illustrate how the concrete water reservoir is constructed utilizing modules wherever possible and arranging them for orthogonal post-tensioning insuring multi-directional compression in the concrete members providing continuity over multiple spans and thereby increasing their collective overall load carrying capacity;

FIG. **4** is a partial schematic section view indicating on a larger scale the overall curvature of the top of the concrete water reservoir, to provide drainage for the earth fill;

FIG. **5** is a top view, before filling with earth, of a concrete water reservoir, indicating how the modules may be arranged to provide an overall free form water reservoir, in contrast to the square or rectangular water reservoir;

FIG. **6** is an enlarged top view of a dome and valley beam module with one-quarter of the dome being lined for emphasis of the utilization of four alike quarters, each quarter being formed as a single rather than a compound curve structure, and also being lined as a reference key for a computer output;

FIG. **7** is an enlarged top view of one-quarter of a dome and valley beam module on which a tension and compression computer output is plotted;

FIGS. **8, 9** and **10** schematically illustrate, respectively, how the post-tensioning occurs in vertical geometric planes, as shown in FIG. **8,** using the cable-tendons draped through valley beam conduits, around all of four sides of an integral valley beam and dome module, as shown in FIG. **9,** with a modification occurring wherein the post tensioning occurs in a horizontal geometric plane in the valley beams located over the

side walls of the concrete water reservoir, as shown in FIG. 10;

FIGS. 11 and 12 in enlarged sides, with some portions removed for illustrative purposes, show how the integral valley beam and dome modules are formed, how they are positioned on the columns, and how the conduits and the cable-tendons are located;

FIG. 13 is an enlarged partial view, essentially in cross-section, illustrating how an end of a cable-tendon is secured at the terminus of a conduit extending through a valley beam; and

FIG. 14 is an enlarged partial view essentially in cross-section, of portions of the concrete water reservoir to illustrate the transition from the central construction components to the side construction components where shear loads are handled and where expansion and contraction forces are accommodated.

DESCRIPTION OF PREFERRED EMBODIMENT IN A RESERVOIR

Multiple Use of Ground Area Above Reservoir

The preferred embodiment of the concrete water reservoir **20,** illustrated in the drawings, allows the potential multiple ground use area above the reservoir, after filling with earth **22,** for small children play areas **24,** playfields for games **26,** picnic spots, outdoor concert and show theaters, and scenically landscaped parklike surroundings inclusive of lawns **28,** gardens, trees, **30,** ponds **32,** and streams, as particularly shown, in part, in FIGS. **1** and **2.**

Principal Design Criteria for This Water Reservoir

The principal objectives or design criteria for this water reservoir **20** were to arrange for the multiple use of the area above the reservoir, yet do so at minimum cost, constructing the water reservoir **20** of permanently lasting materials, and at all times never deviating from the major objective or purpose of insuring the availability of quality of fresh water, fully protected from bacterial and chemical contamination, algae growth, and attempts of vandalism.

Highlights of the Specific Design Approach

Concrete, reinforced where necessary, is used because it is compatible with water environment, suitable for underground construction, readily conformed to a desired shape, easily waterproofed using a crystallization waterproofing, durable and thereby leading to a long operational life, and purchased, handled, and formed at a comparative moderate cost level. Futhermore, reinforced thin shell concrete technology is followed wherein minimal materials are required to gain the required strengths to withstand the direct compression stresses. Moreover, modular concrete unit construction and assembly is employed. In the modular units cable-tendons are arranged and tightened following orthogonal post tensioning procedures to acquire multi-directional compression in concrete and thereby increase the load carrying capacity of the overall concrete water reservoir structure **20.**

Multiple Integral Valley Beam and Dome Modules Serving as the Integrated Water Reservoir Roof

The selection of concrete, followed by the utilization of thin shell concrete technology, and the adoption of post tensioned modular reinforced concrete unit construction, leads to the unique creation of integral valley beam and dome modules **40** serving together as the integrated water reservoir roof **42** shown in FIGS. **1, 2,** 3, and **14.** They excellently carry direct compression stresses and do so while utilizing a comparative minimal amount of materials. They are compatible with rectangular grid arrangements and yet collectively may be arranged not only in overall square and rectangular roof areas, but also in free form areas, which are subdivided in various grid arrangements, as viewed in FIGS. **3** and **5.** Their overall curved portions are, in effect, made of four curved portions **44,** as shown in FIGS. **9,** 11 and **12,** each one of which is made in a single rather than a compound curvature form, making their forming during their manufacture reasonably easy in conjunction with their integral valley beams **46.** Moreover, the production forms, not shown, into which the concrete is poured may be used many times to produce a large number of integral valley beams and dome modules **40** at or for one job site, and oftentimes the production forms may be utilized at or for another job site where another enclosed concrete water reservoir **20** is to be constructed.

Principal Order of the Overall Production of the Water Reservoir

Following excavation and the arrangement of forms, then as viewed in FIGS. **2, 3** and **14,** the concrete footings **52** are poured; the floor **54** is poured or optionally poured later; the preformed columns **56, 58** with steel reinforcing **59** are positioned; the shear walls **60** are poured; the preformed valley beam and dome modules **40** are positioned using their groove **48** and projection **50** interfitting structures; the cable-tendons **62** are installed in conduits **64,** then post-tensioned, and secured upon tightening an assembly **65** of a nut **66,** threaded clamping sleeve **68** and end plate **70,** as shown in FIGS. **12** and **13;** as necessary, roof drains **72** are installed; water piping including overflow lines **74** are installed; access doors, not shown, are installed; then perimeter walls **80** with steel reenforcement **81** are poured; and timely during this overall construction, expansion spaces **82** are maintained, seals **84** and **86** are installed, elastomer shock pad assemblies **88** are positioned, waterproofing materials are utilized, and necessary connectors and fasteners are tightened. Finally after the concrete has cured sufficiently, earth backfilling and earth top filling **22** is undertaken, followed by creating the improvements above the reservoir **20,** such as landscaped parks and recreational facilities.

Integral Valley Beams and Dome Modules

The integral valley beams and dome modules are produced using thin concrete shell production methods and may be produced almost in place as special forms, not shown, are made to be moved over completed integral valley beams and dome modules **40.** As illustrated in FIG. **11,** the curved quarters **44** of the module **40** are each made of single rather compound curves. Conventional steel reinforcement **45** is utilized as necessary. Their outside surface radius **92** remains constant, and both radii **92, 94** may be taken from the same starting line **96,** which parallels the respective valley beam **46** and passes below the center **98** of the module **40.** Throughout most of the roof **42** of the water reservoir **20,** the integral valley beams and dome modules **40** are made alike in this way. Around the edges of the reservoir **20,** they may be changed.

Changes in Design of Integral Valley Beams and Dome Modules Around the Edges of the Reservoir to Interfit with the Shear Walls

As shown in FIGS. **2, 3, 10** and **14,** the designs of components, previously noted as suitable when used in central portion of the water reservoir **20,** must be modified around the edges of the reservoir **20.** Expansion movements of the reservoir **20** caused by temperature changes, possible earth movements, and general sound structural design, requires the inclusion of shear walls **60,** the provision of expansion spaces **82,** sealing materials **84, 86,** and cushioning materials, such as the elastomer shock pads **88.**

To make the shear walls **60** effective and yet allow for some movement between them and the modified integral valley beam and dome module **100,** located above, each shear wall **60** along its top portion is formed with shear keys leaving spaces **102** and structures **104** inbetween them. Also the bottom portion of the modified valley beam **106** above is formed with complementary interfitting keys with structures **108** and spaces **110.** The overall fit between the shear wall **60** and the modified module **100** allows their independent relative movement through the limited overall spaces **82.** Throughout this spacing, elastomer shock pads **88** are placed to serve: a cushioning effect, and an earthquake load transferring effect, between the shear walls **60** and modified valley beams **106** of the roof **42.**

Elastomer Bearing Cushion Pads Serving as Pocket Bearings in the Mounting of Columns Used Nearer the Edges of the Reservoir

In addition to the shear wall structural accommodations made at selected positions along the edges of the reservoir **20,** other accommodations in regard to the columns **58** are undertaken, so overall movements of the resevoir **20** may be satisfactorily compensated for, without damage occurring to any of the overall components of the reservoir **20.** As illustrated in FIG. **14,** columns **58** are generally shorter than columns **56,** as the bottom of the reservoir has sloped portions **112** at this locale. Below, footing **53** is formed with a hole **113** to receive a bottom pocket bearing assembly **114** having a bottom elastomer pad **116** and a premolded joint filler sleeve **118,** of an elastomeric material which together surround the bottom of the erected column **58.** Above, the valley beams **106** and **46** are formed to create a flange **122** to receive a top pocket bearing assembly **124** having a top elastomer pad **126** and a premolded joint filler ring **128** of an elastomeric material, which together surround the top of the erected column **58.** The longer columns **56** because of their length and also their greater distance from the side walls are able to self compensate for expansive and contractive movements of the overall reservoir **20.** However, if an entire reservoir of another embodiment were to be made of shallower depth, all columns might be cushioned in some way.

Positioning of the Conduits and Cable-Tendons to Create the Most Effective Post-Tensioning of the Reservoir Roof Composed of the Multiple Integral Valley Beams and Dome Modules

As indicated in FIGS. **8, 11, 12** and **14,** conduits **64** are preformed in a parabolic drape configuration with their highest elevation being located over the supporting columns and their lowest points being located at the midspan of each valley beam **46, 106** in which these conduits **64** are permanently embedded upon the curing of surrounding poured in concrete. During assembly of the overall reservoir **20,** cable-tendons **62** are threaded through these conduits **64** in the overall orthogonal pattern. After the pre-assembly of all the reservoir **20,** these cable-tendons **62** are jacked or otherwise tensioned and then secured with the fastening assembly **65,** as illustrated in FIG. **13,** to complete the final structural assembly of the reservoir **20.**

The effectiveness of this post-tensioning is schematically illustrated in FIG. **8** with the force vectors, as it occurs throughout most of the reservoir **20.** Along the sides of the reservoir, this post-tensioning is undertaken in a horizontal geometrical plane, as shown in FIG. **10,** rather than in the vertical geometrical plane, as shown in FIG. **8.**

Plot of Computer Output in the Analysis of the Total Load Condition Of the Reservoir, With Respect to a Quarter of a Dome Structure of An Installed Valley Beams and Dome Module Serving with Others as the Roof of the Reservoir

In FIG. **7,** in reference to the key location set forth in FIG. **6,** a quarter **44** of a dome structure of an installed integral valley beams and dome module **40** is illustrated in a plot of a computer output indicating the analysis, under total load conditions of the overall reservoir **20,** of the distribution of tension and compression stresses. The vectors, both long and short, cross other vectors at right angles to indicate the direction of the stresses. Plain line vectors, both long and short are plotted compression vectors, and lines, both long and short, terminating with dotted ends, are plotted tension vectors. Therefore the desirable overall objective of having the concrete undergoing the most favorable compression and tension is clearly indicated. In some embodiments, tension stresses may be eliminated in the concrete domes.

Other Uses for All or Many of the Components of the Water Reservoir As They Could be Made, Erected, and Used for Other Purpose Structures

Although the illustrated and described preferred embodiment of the post-tensioned assembly of the roof modules has centered on an enclosed water reservoir, the post-tensioned dome roof structure composed of its many unique modules could be supported as a roof for other structures having a different operational purpose. For example, garages, covered marinas, open market places, dwellings, sewage plants, etc. could be constructed using the integral valley-beams and dome modules which are post-tensioned in the orthogonal pattern. Throughout all such structures the efficient utilization of a minimum quantity of long lasting materials will likewise be realized. Throughout all the methods, the most efficient procedures and/or order of steps will be undertaken. For example, the columns may be formed and poured in place using continuous steel reinforcing rods or they may be precast and moved into place using connectors and fasteners for their securement and tie in with their self contained steel reinforcing rods.

Preferably and especially in reference to water reservoirs, the slope of the side walls will be essentially perpendicular to the diagonal resultant vector force deter-

mined by first calculating the horizontal vector of a potential earthquake force in one direction, to be handled at shear walls on one side of the reservoir and then by calculating the vertical vector force determined by the dead load of the roof structure, and thereafter calculating their resultant. It is to be noted the shear walls on the other side of the reservoir will handle the horizontal vector of a potential earthquake force in the other direction.

In addition to standing ready to handle earthquake loads, the shear walls and their shear keys and the complementary shear keys of the valley beams, with other compensating structural arrangements compensate for: movement during temperature changes, elastic shortening due to post-tensioning, movement or creep upon post-tensioning, and the shrinking in concrete upon curing.

As necessary, the multiple use concepts of the overhead areas may be always considered and preferably undertaken. However, the domes may be left exposed for all time or until a suitable multiple use is decided upon.

We claim:

1. An enclosed concrete water reservoir, utilizing a comparative minimum amount of materials, designed to be substantially completely surrounded by earth, the earth above being of sufficient depth for the creation of scenic and recreational park facilities, inclusive of soil supporting tree growth, comprising:

a. a continuous floor inclusive of footings;

b. surrounding side walls;

c. spaced columns positioned over the footings;

d. post-tensioned valley beams integrally made in molules with integral domes and supported on the spaced columns;

e. horizontal cable tendons used in the post-tensioning of the overall arrangement of the integral valley beam and dome molules; and

f. selectively spaced interior shear walls arranged perpendicular to the surrounding side walls having components of shear key structures along their tops, and wherein the post-tensioned valley beams integrally made in modules with the integral domes, where such valley beams are located over the interior shear walls, have components of shear key structures along their bottoms which complementary, with slight spacing, otherwise interfit with the shear key structures of the interior shear walls;

g. compressible sealing materials installed between adjacent concrete components of the reservoir to accommodate expansion and contraction of the enclosed concrete reservoir during both temperature changes and surrounding earth movements, to thereby seal and keep sealed the interfaces between adjacent concrete components.

2. An enclosed concrete water reservoir, as claimed in claim **1**, wherein the bottom of the selectively spaced interior shear walls are sloped to rest on sloped portion of the reservoir bottom which extend upwardly from around the level reservoir bottom portions to the bases of the reservoir side walls and are secured thereto to withstand the resultant force of the possible horizontal earthquake loads and the existing vertical dead weight loads of the overhead modules of post-tensioned valley beams and integral domes and the loads of other possible weights carried by these modules.

3. An enclosed concrete water reservoir, as claimed in claim **2**, wherein slight spacing between the shear key structures is selectively filled in some places with elastomer shock pads, so horizontal earthquake loads occurring in only one selected direction will be transmitted to the shear walls and surrounding sloping portions of the reservoir bottom along one side of the reservoir.

4. An enclosed concrete water reservoir, as claimed in claim **2**, wherein some of the spaced columns ae made shorter to carry loads immediately adjacent the inside termination of the interior shear walls and between the overhead integral roof modules and sloping portions of the reservoir bottom below, and these shorter columns at their top and bottom portions have pocket bearing assemblies.

5. An enclosed concrete water reservoir, as claimed in claim **4**, wherein the pocket bearing assemblies, each in turn, comprise, an end elastomer pad, surrounding sleeve elastomer pad, and an encompassing concrete structure to receive the elastomer pads and the respective column portions.

6. An enclosed concrete water reservoir, as claimed in claim **5**, wherein the encompassing concrete structures at the tops of the shorter columns are integrally formed with the overhead valley beam, and the encompassing concrete structures at the bottoms of the shorter columns are integrally formed with both the sloping portions of the reservoir bottom and the respective footings for these shorter columns.

7. An enclosed concrete water reservoir, utilizing a comparative minimum amount of materials, designed to be substantially completely surrounded by earth, the earth above being of sufficient depth for the creation of scenic and recreational park facilities, inclusive of soil supporting tree growth, comprising:

a. a continuous floor inclusive of footings;

b. surrounding side walls;

c. selectively spaced interior shear walls arranged perpendicular to the surrounding side walls;

d. spaced columns positioned over the footings;

e. roof modules, integrally formed with post-tensioned valley beams along each module side fitting in side by side continuous contact with the valley beams of adjacent roof modules, both laterally and longitudinally, thereby forming a checkerboard like matrix of modules, supported on the spaced columns and a covering and enclosing dome over each module, formed by four identical roof portions each extending from a module side, and formed as a part of a cylindrical structure;

f. horizontal cable tendons, used in the post-tensioning of the overall arrangement of the roof modules, positioned in conduits in the post-tensioned valley beams, and extending through adjacent module valley beams, forming an orthogonal pattern throughout the checkerboard like matrix of modules;

g. crystallization type coating material to waterproof the concrete structure;

h. compressible sealing materials installed between adjacent concrete components of the reservoir to accommodate expansion and contraction of the enclosed concrete reservoir during temperature changes and surrounding earth movements, and to thereby seal the interfaces between adjacent concrete components.

8. An enclosed concrete water reservoir, as claimed in claim 7, wherein the conduits are positioned, before pouring the concrete valley beams, in a parabolic drape configuration, with the high points of the conduit being located at the ends of each valley beam over its column supports, and the low point of the conduit being located at the midspan of each valley beam.

9. An enclosed concrete water reservoir, as claimed in claim 8, having securement fasteners to hold the cable tendons in place after they have been tightened to post tension the valley beam and dome modules in the overall orthogonal pattern.

10. An enclosed concrete water reservoir, as claimed in claim 9, wherein earth is back filled around the reservoir and distributed over the top of the reservoir, and, thereafter, the area above the reservoir may be prepared for a multiple use, and tree planting may be undertaken in the soils over the joining locations of the abutting valley beams.

11. An enclosed concrete water reservoir, as claimed in claim 7, wherein selected spaced columns at their top and bottom portions have pocket bearing assemblies.

12. An enclosed concrete water reservoir, as claimed in claim 11, wherein the pocket bearing assemblies, each in turn, comprise, an end elastomer pad, surrounding sleeve elastomer pad, and an encompassing concrete structure to receive the elastomer pads and the column portions.

* * * * *