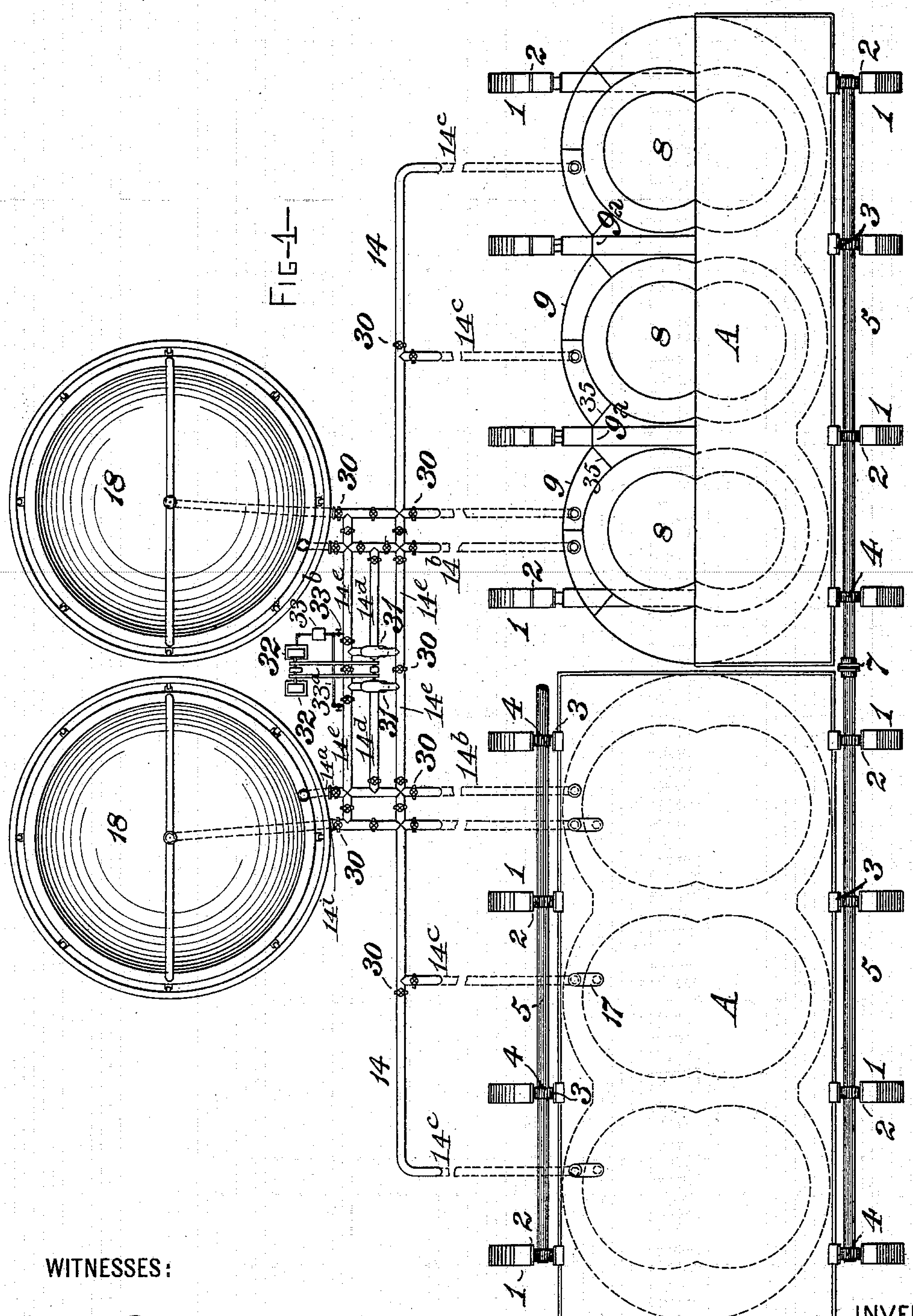
No. 615,440. Patented Dec. 6, 1898.

C. N. DUTTON.

PNEUMATIC DIFFERENTIAL DRY DOCK.

(Application filed Aug. 4, 1897.)

(No Model.) 6 Sheets—Sheet I.



WITNESSES:

Jules P. Metzger

Chas. F. Collyer.

INVENTOR,

Chauncey N. Dutton,

by J. Snowden Bell,

ATTORNEY

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C. N. DUTTON.

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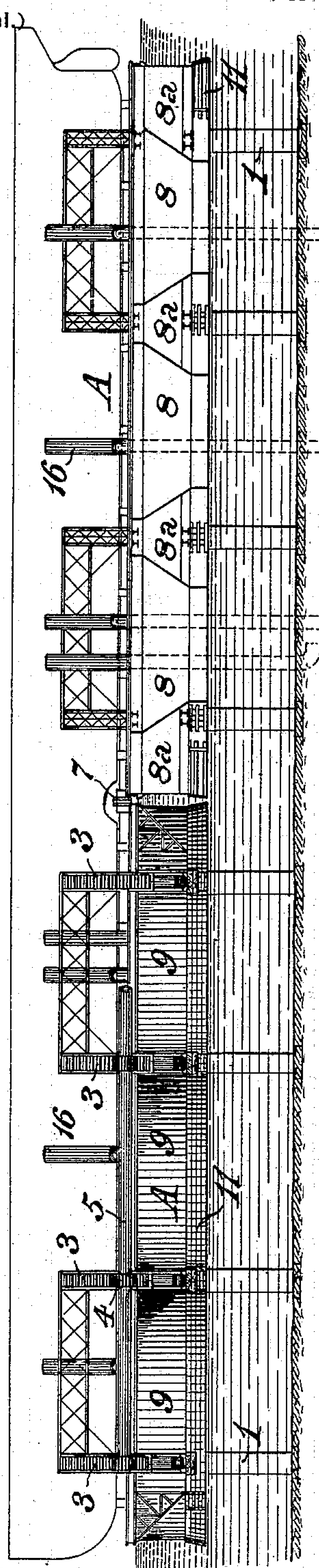


FIG-2—

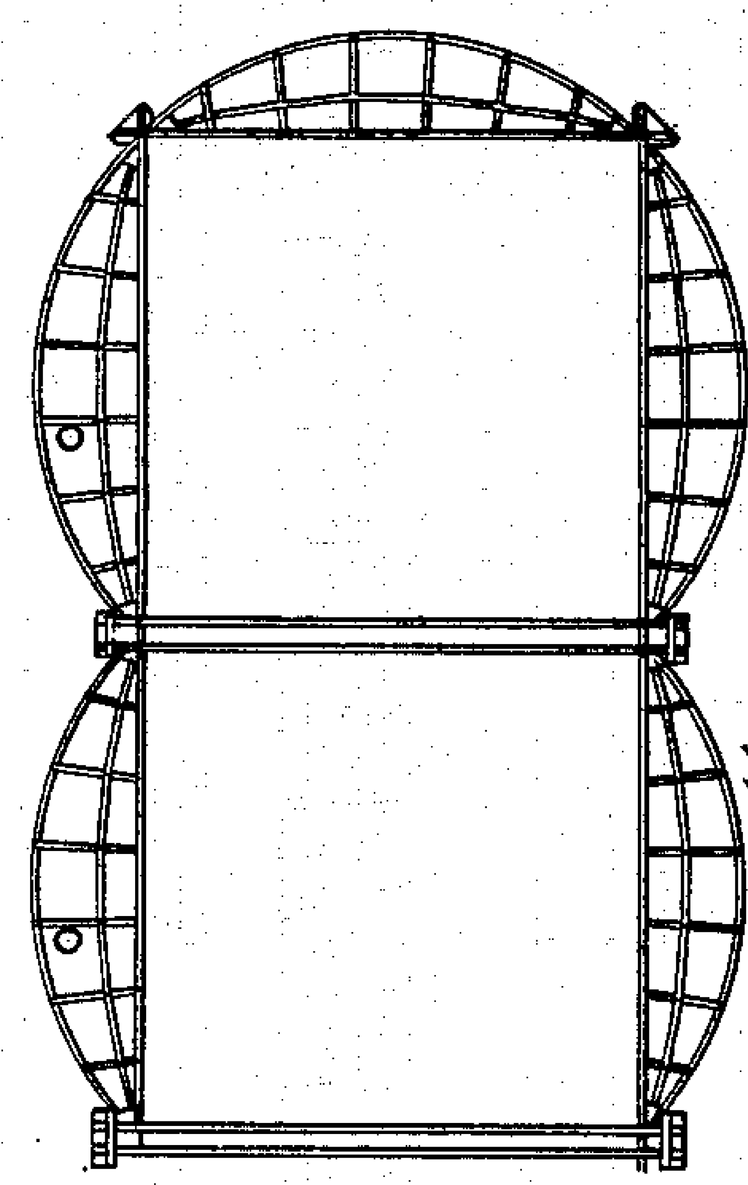


FIG-6—

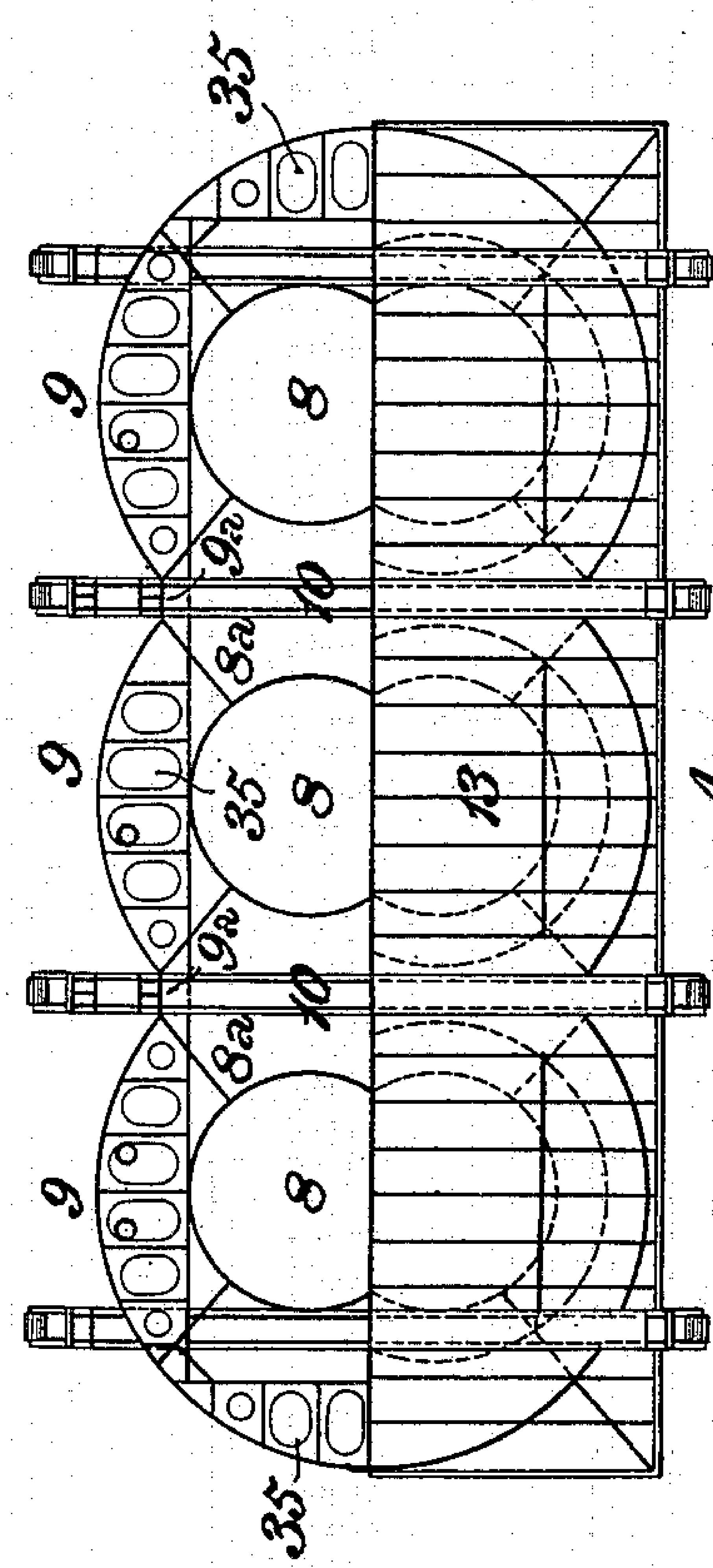


FIG-5—

WITNESSES:

Jules P. Metzger

Chas. F. Collyer

INVENTOR

Chauncey N. Dutton,

by J. Snowden Bell,

ATTORNEY.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

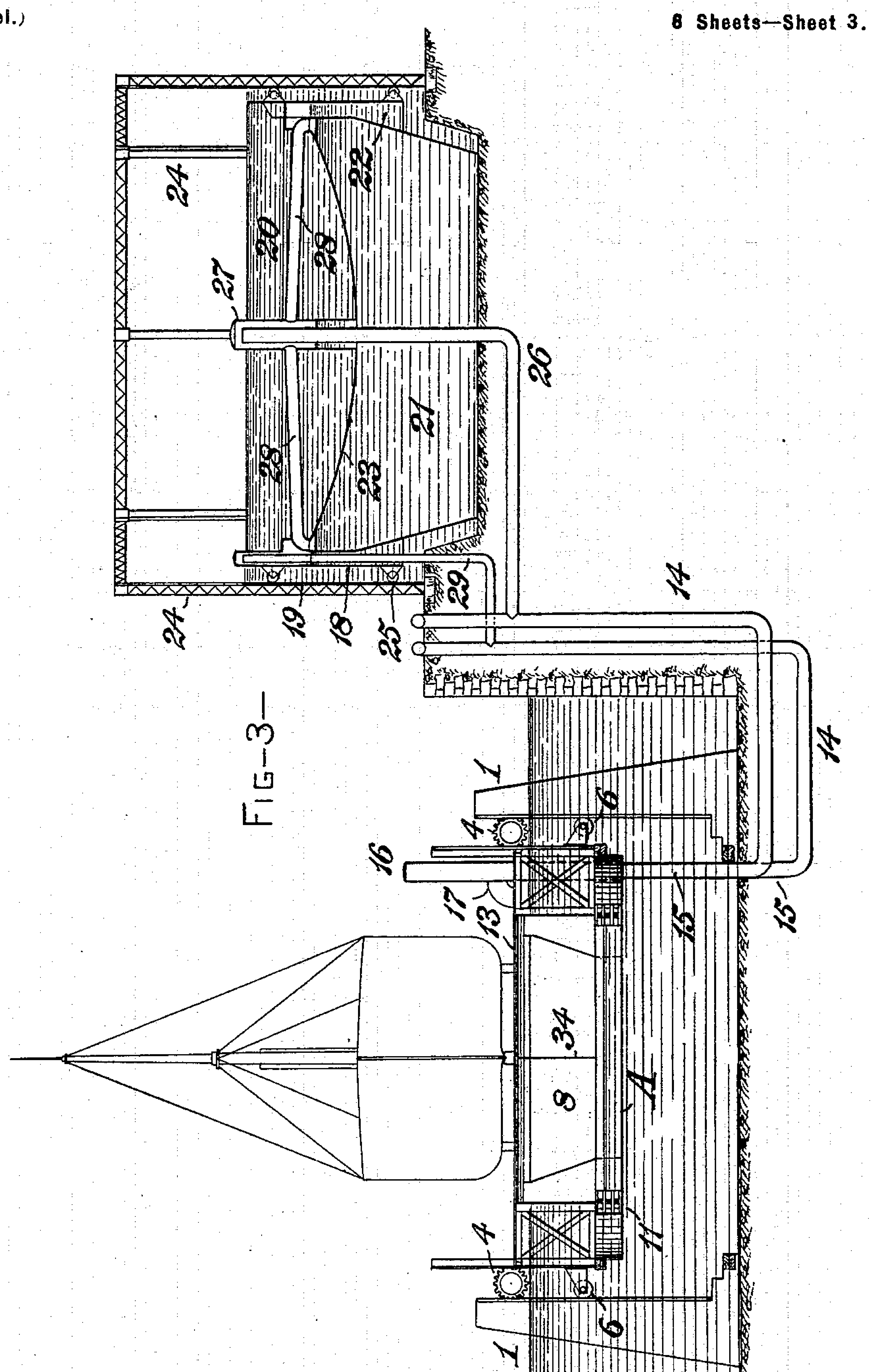
No. 615,440. Patented Dec. 6, 1898.

C. N. DUTTON.

PNEUMATIC DIFFERENTIAL DRY DOCK.

(Application filed Aug. 4, 1897.)

(No Model.) 6 Sheets—Sheet 3.



FIG—3—

WITNESSES:

Jules T. Metzger

Chas. F. Collyer

INVENTOR

Chauncey N. Dutton,

by J. Snowden Bell,

ATTORNEY

No. 615,440. **Patented Dec. 6, 1898.**

C. N. DUTTON.

PNEUMATIC DIFFERENTIAL DRY DOCK.

(Application filed Aug. 4, 1897.)

(No Model.) 6 Sheets—Sheet 4.

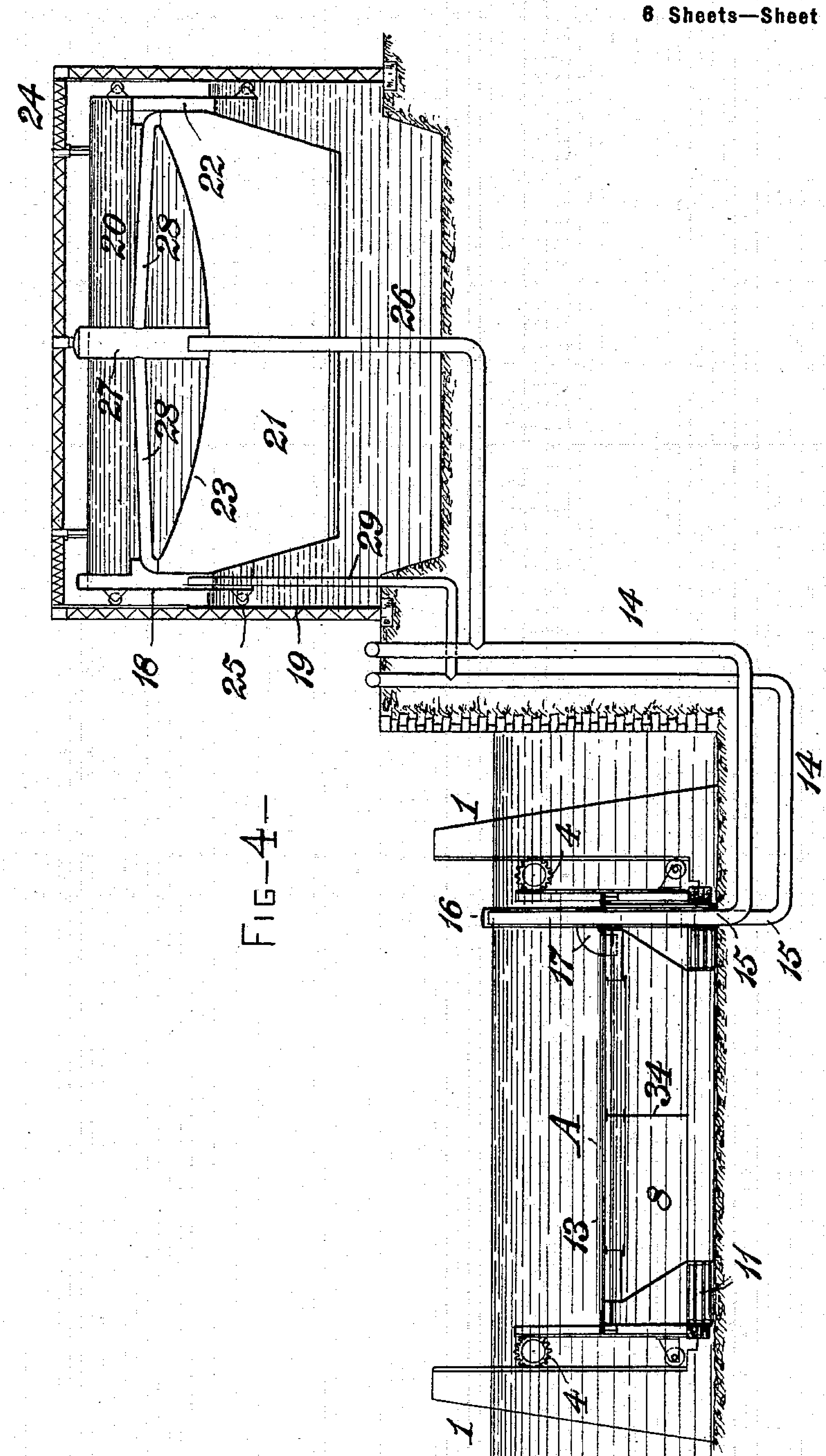


FIG-4-

WITNESSES:

Jules P. Metzger

Chas. H. Collyer

INVENTOR

Chauncey N. Dutton,

by J. Snowden Bell,

ATTORNEY

No. 615,440. Patented Dec. 6, 1898.

C. N. DUTTON.

PNEUMATIC DIFFERENTIAL DRY DOCK.

(Application filed Aug. 4, 1897.)

(No Model.) 6 Sheets—Sheet 5.

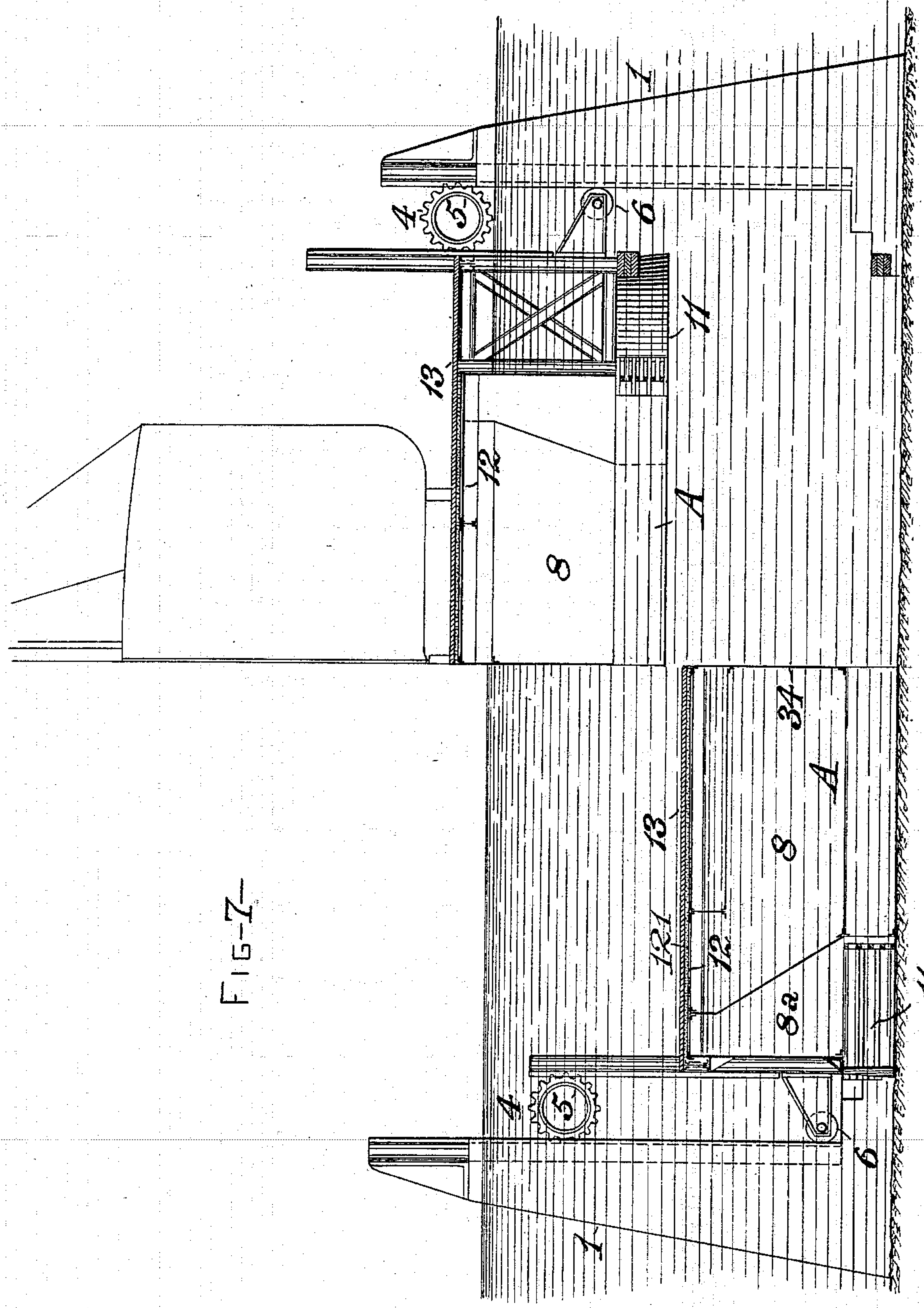


FIG-7

WITNESSES:

Jules T. Metzger

Chas. F. Collyer

INVENTOR

Chauncey N. Dutton

by J. Snowden Bell,

ATTORNEY.

No. 615,440. Patented Dec. 6, 1898.

C. N. DUTTON.

PNEUMATIC DIFFERENTIAL DRY DOCK.

(Application filed Aug. 4, 1897.)

(No Model.) 6 Sheets—Sheet 6.

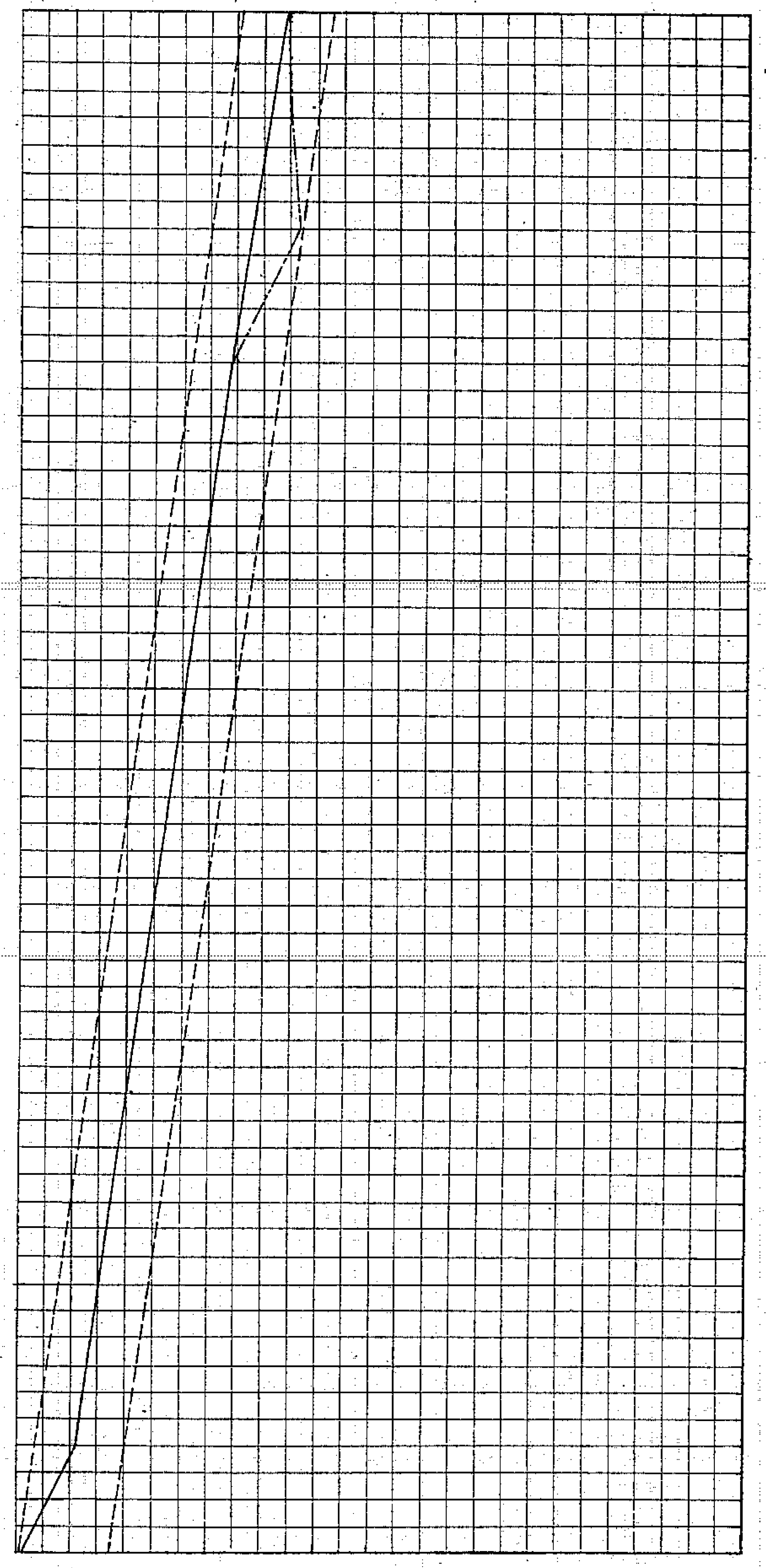


FIG-8-

WITNESSES:

Jules T. Metzger

Chas. F. Collyer

INVENTOR

Chauncey N. Dutton.

by J. Snowden Bell,

ATTORNEY.

UNITED STATES PATENT OFFICE.

CHAUNCEY N. DUTTON, OF NEW YORK, N. Y.

PNEUMATIC DIFFERENTIAL DRY-DOCK.

SPECIFICATION forming part of Letters Patent No. 615,440, dated December 6, 1898.

Application filed August 4, 1897. Serial No. 647,017. (No model.)

To all whom it may concern:

Be it known that I, CHAUNCEY N. DUTTON, of the city, county, and State of New York, have invented a certain new and useful Improvement in Pneumatic Differential Dry-Docks, of which improvement the following is a specification.

The object of my invention is to provide effective and desirable means whereby vessels may be docked for purposes of repair, painting, &c., with the least practicable expenditure of time and power and the greatest degree of safety attainable.

There are two types of dry-docks in common use—namely, ground or graving docks and floating docks. Ground or graving docks consist in excavated water-tight gated chambers. When they are to be used, the keel and bilge blocks on which the vessel is to be supported are placed in proper position, water is admitted to the chamber, the gate is opened connecting the chamber with the water of the harbor in which the dock is located, the vessel is floated in, the gate is closed, and the water is pumped out, the vessel settling upon and being supported by the keel and bilge blocks. A vessel thus supported is firmly and truly held and is of course as wholly free from movement, vibration, or oscillation as any other structure resting upon good foundations. The elements of stability and firmness are highly desirable, as work upon a structure so supported proceeds with greater facility and precision than upon a moving body. The level and plumb can be used freely.

The objections to graving-docks are, primarily, their great cost, the expense of pumping out the great volume of water which they contain, and the loss of time incident thereto; secondarily, the danger of leakage interfering with the workmen and the safety and stability of a vessel upon its supports, and, finally, the close and ill-ventilated quarters in which the workmen must work.

Floating docks as heretofore constructed and operated, while cheaper in first cost than graving-docks, have been more expensive in operation and involve nearly if not quite as great loss of time in docking vessels. They afford free access to the vessels upon them, and the workmen have abundance of room and good ventilation; but no floating dock heretofore constructed has been sufficiently firm and free from movement and oscillation to enable the work of repair upon the vessel docked to proceed under good conditions. The means adopted to keep them level have not been adequate, and consequently the docks and the vessels upon them are in constant motion, and they are, moreover, liable to tip over.

My invention is designed to provide a dry-dock on which the vessel can be docked in the shortest possible time with the least expenditure of power and on which it shall be held with such rigidity and firmness that the level and plumb bob may be used in repairing, as in the graving-dock, and which shall be wholly free from upsetting.

To this end my invention, generally stated, consists in certain novel mechanisms and combinations comprehending a docking member composed of an open-bottomed air-chamber or caisson carrying a working deck or platform on which a vessel may be supported, means for leveling said docking member while being raised and lowered and supporting it in truly level position, and means for raising and lowering the docking member, composed of a pneumatic differentiating-accumulator and valve-controlled pipes connecting the air-chambers of the accumulator and docking member.

The improvement claimed is hereinafter fully set forth.

In the accompanying drawings, Figure 1 is a plan or top view of a pneumatic differential dry-dock, illustrating an application of my invention; Fig. 2, a view, half in side elevation and half in longitudinal central section, of the same; Figs. 3 and 4, transverse sections with the docking member elevated and depressed, respectively; Fig. 5, a plan or top view of one of the duplicate docking members, the lower half showing the framing of the working deck and the upper half showing the air-chambers and framing; Fig. 6, a similar view of the lower timber portion of the docking member; Fig. 7, a transverse section, on an enlarged scale, through the docking member, the left-hand half showing the same as depressed and the right-hand half as elevated; and Fig. 8, a diagram illustrating the relation of pressures in the structure.

As illustrated in the drawings, the principal elements of the dock consist in a docking member composed of open-bottomed air-tanks or caissons carrying a flat working deck and provided with apparatus to synchronize its motion and hold it absolutely true and level, a pneumatic accumulator, air-pipes by which the accumulator may be connected with the dock, and a pumping apparatus for moving or renewing the air by which the dock is operated.

In the operation of the dock air is transferred from the accumulator to the docking member or members to raise it or them as quickly as possible, and when the dock is to be lowered the air is transferred back into the accumulator, so as to save the air and economize the power necessarily employed.

To give the greatest possible economy of power in operating the dock, the dock and the accumulator or either of them is made differential. This differentiation is so designed that when the dock is being raised the pressure in the accumulator varies in such a manner relatively to the varying pressure in the dock as to be uniformly greater than the resistance of the dock, and when the dock is being lowered the pressure in the accumulator is uniformly less than the pressure in the dock.

The drawings show a divided or duplicate dry-dock, the docking member being formed in two independent sections, set end to end, each having its own pneumatic accumulator, connecting-pipe system, and synchronizing-shafts, the shafts of the two sections of the docking member being adapted to be connected, as from time to time desired, by a detachable coupling. Either of the sections of the docking member may be operated independently of the other when small or short vessels are to be docked, and by connecting the synchronizing-shafts the two sections of the docking member are made a single structure, which may receive a large vessel occupying the entire length of the dock, or two or more smaller vessels may be docked independently.

In the practice of my invention, a suitable site having been selected, preferably such that access can be had to both ends of the dock, an excavation is made of sufficient depth to permit vessels to float over the dock when depressed, and guiding structures or piers 1 are built in two parallel lines or series at such distance apart that the docking member A, whether in one or two sections, can be located between them. The piers 1 serve as the foundations and supports of vertical racks 2, each of which stands parallel with a similar rack 3 on the adjacent side of the docking member. The racks 2 3 on each side of the docking member are engaged by intermediate pinions 4, fixed upon synchronizing-shafts 5, which are preferably hollow and built up and roll between the racks 2 3. The shafts and pinions, by their engagement with the racks, accurately level the docking member endwise and synchronize the movements of its ends, any tendency to incorrect alinement, which would cause one end to move faster than the other, being resisted by the torsional strength of the shafts. Tilting sidewise is resisted by the shafts and pinions acting as rollers and also by guide-wheels 6, journaled on the lower part of the docking member and running on rails on the piers 1 parallel to the racks 2. Where, as in the instance shown, the docking member is made in two sections, the shafts 5 of each section are provided with suitable detachable couplings 7, by which they may be connected to or detached from those of the other section, accordingly as it is desired to use both or either section of the dock.

The docking member A consists of an open-bottomed air-tank or caisson, of any suitable material, preferably steel. The drawings show a steel dock, in which the walls 9 of the caisson A are made in segments of cylinders, so as to be in tension and dispense with framing. The segments of the walls do not quite intersect, but are joined by longitudinal plates 9^a, and where the longitudinal plates intersect the curved walls there are transverse tie members 10, framed into stiff transverse members, which afford firm foundations for the racks 3 and the lower guide-wheels 6.

Within the caisson A are formed differential chambers 8, which are preferably conical, so that the pressure therein may be varied with the varying degree of immersion, the pressure in said chambers, due to a constant weight, being greater when the water-surface against which the air therein contained bears is in the lower part of the cone and less when it is in the upper part of the cone; but, as hereinafter explained, this form of said chambers is not an essential feature of my invention, because the docking member gives a differential pressure, even though these chambers be omitted. When they are made of the form shown in the drawings, in order to make them as large as can be contained within the outer chamber and at the same time to make them stiff and strong without framing they are made in two segments symmetrically disposed upon the longitudinal axis of the dock, the ends of the two segments being united by a tie member 34 on said axis, this member being continuous from end to end of the docking member, and in addition to serving as a tie to hold the ends of the segments of the differential chamber also being framed as a longitudinal girder, giving support to the keel-blocks and taking the principal part of the weight of the vessel docked.

The docking member is preferably provided with a lower section 11, formed of timber, so that when it is desired to paint the steel structure the docking member can be raised to such height that the steel portion will be entirely above the water-level and accessible on all sides. The air-chambers are covered by a steel roof 12, which is protected by a layer of asphalt 121, upon which is laid a substantial timber working deck or platform 13, of sufficient thickness to permit the usual ways for the keel and bilge blocks employed to support a vessel to be spiked to it without danger of perforating the metallic air-tight skin of the air-chambers.

A system of ground-pipes 14 14^a 14^b, &c., controlled by valves 30, leads from a source of compressed air, to be presently described, to suitable locations below the docking member, where they connect with vertical stand-pipes 15, open at their upper ends and extending above the water-line into hoods or inclosing pipes 16 16^a on the dock member, the pipes 16 opening into the outer air-chamber 8^a and the pipes 16^a being connected by branches 17 with the differentiating-chambers 8. In the movements of the docking member the hoods thereon telescope the stand-pipes and permit the free ascent and descent of the docking member without escape of air from the connecting-pipes or air-chambers. It will be obvious that, if preferred, air could be led to and from the air-chambers through flexible pipes or by any other suitable means.

The drawings show a valve-controlled piping system, with branches adapted to connect with the several parts or separate air-chambers of the system and so controlled by valves that the passage of air can be controlled and directed from any part or member to any other member. The branches 14^a communicate with the outer annular chamber 22 of each accumulator, and branches 14^i communicate with the inner chamber 21 of each accumulator. Branches 14^b connect with the riser-pipes 16, and branches 14^c connect with the riser-pipes 16^a. Branches 14^d connect with the blowers or pumping-engines 31, and branches 14^e are also connected to said blowers or engines, so that by proper manipulation of the valves in said pipes the blowers or engines can be run in either direction to force air from the dock members into the accumulators or from the accumulators into the dock members or between the two chambers of the accumulators. The high-pressure pump 33 is connected by pipes 33^a 33^b to two of the branches—as, for example, to the branches 14^e on opposite sides of controlling-valves 30 therein—so that air can be pumped by the high-pressure pump 33 in any desired direction. Therefore by manipulating the proper valves it is practicable to make such pipe connections that the flow of air can be directed or forced between any two air-chambers in the entire system.

The docking member could be raised by air delivered at proper pressure from any source, as a power-driven air-compressor or a simple cylindrical air-tank weighted to provide the necessary pressure; but such use of compressed air would be wasteful, as the entire volume of air and the power exerted to compress it would be lost at each operation. In lieu of methods of such crude and extravagant character and in order to realize the greatest attainable economy under my present invention I employ a system of differentiating the air-pressures in the working of the dock and of the accumulator by which it is actuated, whereby the loss of power is as nearly as may be reduced to a minimum, which is merely sufficient to overcome the friction of the apparatus. This economy is effected by the employment of a differentiating chamber or chambers either in the dock or in the accumulator, or in both, as hereinafter to be described.

The accumulator 18, by which air under pressure is provided for the elevation of the docking member, is shown in the drawings as a cylindrical open-bottomed vessel, rising and falling in water contained in a steel tank 19, and having an upper chamber 20 for containing a load of water, an internal open-bottomed differentiating air-chamber 21, substantially in the form of a frustum of an inverted cone, and an annular open-bottomed air-chamber 22, surrounding the differentiating air-chamber. The lower wall of the load-chamber 20 is formed by a suspended diaphragm 23, which is in a curve of equilibrium and is attached at its outer edge to a stiffened part or ring formed at the top of the outer annular air-chamber 22. This form dispenses with the mushroom which is necessary to support the diaphragm when the accumulator is depressed in cases where the diaphragm is convex on its upper side. The accumulator-tank 19 is provided with suitable guide-framing 24, forming ways for guide-wheels 25 on the accumulator, and is in this instance shown as located at a higher elevation than the docking member. It may, however, be placed in any other desired relation thereto, and where it is economical to so locate it the accumulator may work in the same body of water as the docking member.

A branch pipe 26 leads from one of the air connecting-pipes 14 of the docking member A into a central hood 27, which opens into the differentiating air-chamber 21 of the accumulator and passes through the load-chamber 20, and said hood is also connected with the chamber 21 by pipes 28, which extend to the periphery of the diaphragm 23, so as to enable all the air in the differentiating air-chamber to be withdrawn therefrom. A branch pipe 29 extends from another of the air connecting-pipes 14, which leads into the outer air-chamber 8^a of the docking member into an annular air-chamber 22, terminating by an open end above the water-level therein. The system of pipes, as hereinbefore described, is controlled by valves 30, (indicated in Fig. 1,) so that communication may be opened and closed between the air-chambers of the accumulator and all or any one or more of the air-chambers of the docking member.

The operation of the dock may be clearly understood by reference to Figs. 3 and 4. Fig. 4 shows the apparatus ready for docking vessels, and Fig. 3 shows the vessel docked thereby. To lower the dock, air is exhausted from the chambers of the docking member and its buoyancy thereby reduced, so that it will sink and rest upon the bottom in the position shown in Fig. 4. If the air exhausted from the docking member were discharged into the atmosphere, the apparatus would be wasteful of power. To conserve the energy as much as possible, the air is transferred from the docking member to the accumulator, where it enters both the inner chamber 21 and the outer chamber 22 and exerts its pressure and lifting force on the entire upper surface of the accumulator, the constant weight of which is at such time supported by said pressure over its entire area, or, to change the mode of expression, by the displacement of water from both of the chambers of the accumulator. While the accumulator is ascending, therefore, the air-pressure in its chambers is at the desired minimum, and the figure of displacement in equilibrium with the load is of the largest diameter and area and the least depth, and the air-pressure is therefore minimum. After the docking member has descended to the position shown in Fig. 4 the valves controlling the air-pipes are closed, so that no air can pass between the dock and the accumulator. At this time the energy necessarily lost in operating the apparatus is replaced, the accumulator being stored with energy by pumping the air from its outer annular chamber 22 into its inner conical differentiating-chamber 21, as shown in Fig. 4, the operator manipulating the proper valves in the air-conduits, so that the chambers will be connected and air can be pumped, as aforesaid. When ready for docking, as shown in Fig. 4, the main body of the air charge is contained within the chamber 21, and the air in the outer chamber 22 is at, or nearly at, atmospheric pressure and exerts little or no lifting force, and the constant load of the accumulator is supported by the displacement of water by the compressed air from the inner chamber only, the figure of displacement being a truncated cone of relatively small diameter and great height, so that the working air-pressure is maximum, the surface of contact or pressure between the air in said chamber and the water, being in the lower part of the cone, is of minimum area, and the head thereon or the depression of said surface below the free surface of the water without the accumulator in which it floats being a maximum. When it is desired to raise the dock, the valves in the connecting-pipes 14 14^a 14^b 14^c between the differentiating-chamber of the accumulator and the chambers of the docking members are opened and the high pressure is transmitted to the air-chambers of the docking member, acting over the entire transverse area thereof, overcoming the maximum resistance of the docking member, and causing it to rise. As the docking member rises by transferral of air from the accumulator the latter descends, and as it descends the pressure-surface, rising within the conical differentiating-chamber, becomes constantly larger and the air-pressure correspondingly lower, for the reason that it is due to a constant weight imposed upon a continuously-increasing surface, the pressure-surface rising within the cone and its area increasing, and the head thereon consequently decreasing, and, further, because the air confined in the annular outer chamber 22 of the accumulator (which was originally at or near atmospheric pressure) increases in pressure as the accumulator descends, thus supporting a larger portion of the load and correspondingly relieving the pressure in the differentiating-chamber.

In a properly-designed differential accumulator the air-pressure in the outer annular chamber 22 never becomes as great as the pressure in the chambers of the elevated docking member, as hereinafter explained.

Where, as in the instance shown, a differential chamber (one or more) is employed in the docking member, the pressure in said differentiating-chamber increases with the degree or depth of immersion in the water in which the dock member floats, so that as the dock descends the pressure in said chamber rises until it becomes greater than the pressure in the differentiating-chamber in the depressed pneumatic accumulator and air is transferred from the docking member to the accumulator

The variation of pressure in the docking member is due primarily to the fact that when the dock is depressed, so that the working deck is submerged, the water on the deck is carried by the air-pressure in the air-chamber and raises the pressure therein proportionately to the depth of immersion of the dock and the consequent weight of water imposed thereon.

The differentiation of the differentiating-chamber, as shown in the drawings, is opposite in effect to the variation due to the depth of immersion of the dock and is designed to facilitate keeping the desired uniform or nearly uniform difference in pressure between the descending docking member and the ascending accumulator.

To effect the lowering of the docking member and return all of the air from the chambers thereof to the accumulator with the least expenditure in power in readiness for the next upward traverse of the docking member, the operation is the reverse of that above described. When the docking member is to be lowered and is thereby to raise the accumulator, the outer air-chambers of the docking member, as hereinafter set forth, are connected with the annular outer air-chamber 22 of the accumulator, the pressure in which is lower than in the connected chambers 8^a of the dock, as before described, and the differentiating-chamber 21 of the accumulator is connected with the chambers 8 of the docking member by opening the valves controlling the pipes 14^b and 14^a to connect the outer chambers of the docking and accumulator members and those controlling the pipes 14^c and 14^i to connect their inner chambers. The pressure from the docking member being now exerted over the entire area of pressure-surface in the accumulator, the figure of displacement thereof being of the greatest diameter and least depth, the pressure-surface or surface of contact within the accumulator of the compressed air and the water being of maximum area, and the head or depression of said surface below the free level of the water without the accumulator, in which it floats, being minimum, the resulting pressure is less in the accumulator than when the entire weight of the accumulator was supported on the air in its conical differentiating-chamber only. In such case the figure of displacement is of minimum diameter and greatest depth, the unbalanced pressure-surface or surface of contact of the compressed air and water within said chamber being of minimum area, and the "head" or depression of said surface below the free water-surface is a maximum and the pressure consequently a maximum, as above set forth. The docking member descends, and as it descends the pressure in the chambers of the dock connected with the differentiating-chamber of the accumulator increases until it approximates as nearly as may be the original pressure in the accumulator when elevated, the fall of pressure therein being compensated by the higher pressure in the outer annular chamber 22 and representing directly the frictional and other losses necessarily incurred in operating the dock. At every operation of the docking member this loss must be compensated for by the application of power, and the most convenient time for effecting this replacement of loss is when the accumulator is elevated. At such time therefore the valves controlling the pipes 14^c and 14^d are so manipulated that a power-driven pump or blower 31, Fig. 1, connected with the system of pipes 14 may be put into action and the air pumped through said pipes from the outer annular chamber 22 of the accumulator into the differentiating-chamber 21 thereof, thereby restoring the original conditions of pressure and making ready for another operation of the docking member.

As before stated, pressure in the outer annular chamber 22 never equals the pressure in the air-chambers of the elevated docking member. Therefore when the dock is elevated and the accumulator depressed the conditions of equilibrium can be disturbed and motion instituted by connecting one or other of the air-chambers of the dock—say the outer chamber 8^a—with the outer chamber 22 of the accumulator, whereupon air will expand from the connected dock-chamber into the annular accumulator-chamber, the air-pressure in said dock-chamber will be reduced and its buoyancy or lifting power correspondingly diminished, and a greater portion of the weight of the dock and ship will be thrown on the remaining dock-chambers 8, increasing the air-pressure therein. The dock will settle and water, in continually-increasing depth, will cover its top, further increasing the load borne on and the air-pressure in the chambers of the dock, while the air, which expands or passes from the dock-chambers 8^a into the annular chamber 22 of the accumulator, will expel water therefrom, take and bear a corresponding part of the load theretofore borne by the inner chamber 21, cause a corresponding reduction of air-pressure therein, and float the accumulator higher. Thus it will be seen that the pressure in the inner differentiating-chamber 21 of the accumulator is steadily diminished as the accumulator ascends, and as the dock descends the pressure in its chambers 8 is steadily increased until it exceeds the pressure in the inner differentiating-chamber of the accumulator, when air can flow from the dock-chambers to the inner differentiating-chamber of the accumulator if they be connected. It will also be seen that as the dock descends its power to lift the accumulator is cumulative proportionately to its depth of immersion, and that there will be complete transference of air between the two thus rendered possible, and the losses of working compensated for by power applied as above described, while the accumulator is elevated. It will be obvious to those skilled in the art that the power could be applied at other times and that the sequence of operation admits of considerable variation.

While the construction and mode of operation substantially as above described are the preferred ones and will attain the maximum economy, such economy may be approximated without the use of a differentiating-chamber in the docking member by suitably proportioning the chamber 21 of the accumulator or by a continuous operation of the blower while the movement of the docking member is being made, the deficiency in power being thus supplied by a continuous instead of an intermittent run. Differentiating-chambers in the docking members may therefore be omitted without departure from the essential and governing features of my invention, and it will also be obvious that the outer annular chamber of the accumulator might be dispensed with by imposing increased duty on the pump or blower.

The relative pressures are indicated diagrammatically in Fig. 8. When the docking member is at its lowest point and it is desired to raise it, it is evident that the air must be delivered to it at a pressure sufficient to displace water from the air-chambers in sufficient volume to overcome the dead-weight of the docking member and cause it to rise until the keel and bilge blocks of the working deck come in contact with the vessel to be docked. This is illustrated in Fig. 8, in which the full inclined line indicates the working pressures in the docking member. The dotted line above the full inclined line indicates the pressure in the accumulator, which raises the docking member in the descent of the accumulator by the transfer of air from the latter to the former, and the dotted line below the full inclined line indicates the pressure in the accumulator while it is being raised by the descending dock. The lines from right to left indicate the vertical movement of the docking member and accumulator, and the lines from top to bottom the air-pressures in feet of water per unit of area.

It will be observed that the lower timber-section 11 of the docking member sets out of line with the upper steel portion of the structure, as best seen in Fig. 7, and the lower part of the air-chamber within the timber portion is enlarged in horizontal area, so that when the deck of the dock is being raised out of the water the surface of contact between the compressed air and the water within the dock is depressed into such enlarged portion of the air-chamber, and said horizontal enlargement thereof, when filled with air, increases the displacement and the buoyancy without increasing the head, and this compensates for the fall in pressure, which would otherwise occur when the vessel on the docking member is raised out of the water, and later the increase in pressure as the working platform is raised out of the water, giving the smooth line of variation of pressure instead of a ragged line, as indicated by the broken triangle beneath it, as would otherwise be the case.

In Fig. 1 the docking members, accumulators, and pipe connections are shown in duplicate, there being an independent valve connection between the outer chamber of each accumulator and the adjacent docking-member section and between the differentiating-chamber of each accumulator and each of the inner (in this case differentiating) chambers of the adjacent docking-member section. The engines 32, which operate the pumps or blowers 31, are shown in duplicate, and the connecting-pipes are valve-controlled, as indicated, so that communication can be established between any two parts of the system. A small high-pressure pump 33 is provided for replacing leakage, which can be likewise piped to any part. It will be obvious, however, that should it be so desired the operation of the dock can be effected by varying the load of the accumulator, a cock being provided to drain the water out of the load-chamber 20 and a pump to restore the load thereto, the cock and pump not being illustrated.

In docking small or light vessels it will be unnecessary to employ the entire power and only so many of the air-chambers as are requisite need be used, the remaining chambers being idle. When short vessels are to be docked, the central couplings of the synchronizing shafts can be disconnected and the two sections of the docking member used independently.

The parts necessary to insure the proper functioning of the docking member are so disposed as to form elements of the trusses essential to give proper structural strength and rigidity. The shells of the inner and outer air-chambers are combined with the floor-plates and with chord members 35 at their lower edges and act as webs of girders, the floor and bottom members acting as flange members.

The shells of the chambers 8 serve as a stiffening-truss which gathers up the strain on the floor and delivers it to the frames carrying the racks 3 by means of short plate connections 35 comparatively free from movement.

The only further stiffening member necessary or desirable is the longitudinal central truss 34, which takes the weight delivered by the keel of the vessel and transmits it to the members before referred to. The timber portion of the structure is suitably trussed and connected with the steelwork, and the racks 3 are framed together longitudinally, two and two, in bents to stiffen them without incurring temperature strains.

I claim as my invention and desire to secure by Letters Patent—

1. In a dry-dock, the combination of a docking member having a downwardly-decreasing open-bottomed air-chamber, and a working deck adapted to receive a vessel and the supports for the same, a synchronizing apparatus, a movable balance member having an open-bottomed air-chamber, and valve-controlled air-conduits connecting the air-chambers of the docking and balance members.

2. In a dry-dock, the combination of a movable docking member, having an open-bottomed air-chamber and a working deck adapted to receive a vessel and the supports for the same, racks on the docking member, parallel racks on fixed supports, synchronizing-shafts carrying pinions which mesh with the parallel racks, a pneumatic accumulator or balance member, having a weight-chamber, and a downwardly-decreasing open-bottomed air-chamber, air-conduits connecting the air-chambers of the docking and balance members, and valves controlling said air-conduits.

3. In a dry-dock, the combination of sectional movable docking members, each having a working deck adapted to receive a vessel and the supports for the same, parallel racks on each section of said members, similar racks on fixed supports parallel to the racks on the sections of the docking member, sectional shafts corresponding with the sections of the docking member and carrying pinions which mesh with the parallel racks on the docking member, and on the fixed supports, and detachable couplings on the adjacent

ends of the sections of said shafts, whereby the sections of the docking members may be operated either independently for docking two small vessels or as a unit for docking a single large vessel.

4. In a dry-dock, the combination of a docking member composed of one or more open-bottomed air-chambers, and a working deck or platform supported thereon, adapted to receive and support a vessel, a pneumatic accumulator having a differential open-bottomed air-chamber, the horizontal cross-sectional area of said chamber decreasing from its top toward its open bottom, and air-conduits for connecting the air-chambers of the docking member and the accumulator.

5. In a dry-dock, the combination of a docking member provided with one or more open-bottomed air-chambers and a working deck or platform supported thereon and adapted to receive and support a vessel, a pneumatic accumulator having an inner differentiating-chamber central in an outer chamber, and air-conduits for connecting the air-chambers of the docking member and the accumulator.

6. In a dry-dock, the combination of a working deck or platform, and a series of inner differentiating downwardly-opening air-chambers, each nearly concentric with an outer wall of a main air-chamber.

7. In a dry-dock, the combination of a docking member composed of one or more open-bottomed air-chambers, and a working deck or platform supported thereon, a pneumatic accumulator having a differential air-chamber of increasing transverse section from its bottom toward its top, and valve-controlled connections between said differentiating air-chamber and an air-chamber of the docking member.

8. In a dry-dock, the combination of a docking member composed of one or more differentiating air-chambers, each of increasing transverse section from its bottom toward its top, and a working deck or platform supported thereon, a pneumatic accumulator having a differentiating air-chamber of increasing transverse section from its bottom toward its top, and valve-controlled connections between the chambers of the accumulator and docking member.

9. In a dry-dock, the combination of a docking member composed of one or more open-bottomed air-chambers and a working deck or platform supported thereon, a pneumatic accumulator having a differentiating air-chamber of increasing section from its bottom toward its top, valve-controlled connections between said differentiating air-chamber and an air-chamber of the docking member, and an air-compressor adapted to deliver air under pressure to said differentiating air-chamber.

10. In a dry-dock, the combination of a docking member composed of one or more open-bottomed air-chambers, and a working deck or platform supported thereon, a pneumatic accumulator having a differentiating air-chamber of increasing transverse section from its bottom toward its top, and an independent air-chamber, valve-controlled connections between said differentiating air-chamber and an air-chamber of the docking member, and valve-controlled connections between said independent air-chamber and an air-chamber of the docking member.

11. In a dry-dock, the combination of a docking member composed of one or more open-bottomed air-chambers, and a working deck or platform supported thereon, a pneumatic accumulator having a differentiating air-chamber of increasing transverse section from its bottom toward its top, and an independent air-chamber, valve-controlled connections between said differentiating air-chamber and an air-chamber of the docking member, valve-controlled connections between said independent air-chamber and an air-chamber of the docking member and an air-compressor adapted to transfer air between the differentiating and the independent air-chamber of the accumulator.

12. In a dry-dock, the combination of a docking member composed of a plurality of open-bottomed air-chambers, one or more of which is differentiating or of increasing transverse section from its bottom toward its top, and a working deck or platform supported on said air-chambers, a pneumatic accumulator having a differentiating air-chamber of increasing transverse section from its bottom toward its top, and an independent air-chamber, valve-controlled connections between the differentiating air-chamber of the accumulator and a differentiating air-chamber of the docking member, and valve-controlled connections between the independent air-chamber of the accumulator and an air-chamber of the docking member.

13. In a dry-dock, the combination, of two docking members, located end to end, each composed of one or more open-bottomed air-chambers and a working deck or platform supported thereon, two parallel lines of fixed guiding structures or piers between which the docking members may traverse through their entire range of vertical movement, racks fixed to said piers, racks fixed to the docking members, synchronizing-shafts interposed between the racks of the piers and of each docking member, gears fixed upon said shafts and engaging said racks, and detachable couplings by which the synchronizing-shafts of the two docking members may be connected and disconnected, on each side thereof, to admit of the independent operation of said docking members, for docking two small vessels, or their joint operation for docking a single large vessel.

14. In a dry-dock, the combination of a metal docking-member shell in the form of a series of connected segments of cylinders, connected by transverse frame members, chord members connected to the lower portions of the shell, a metal roof connected to the top of

the shell, and a timber deck or platform connected to said roof.

15. In a dry-dock, the combination of a metal docking member, having an open-bottomed air-chamber, a working deck or platform supported thereon and adapted to receive a vessel and the supports for the same, and a lower timber-section, the metal docking member being floatable to a height sufficient to be accessible for painting and repairs.

16. In a dry-dock, the combination of a metal docking-member shell forming a series of open-bottomed air-chambers, transverse frame members connected to said shell, chord members connected to the lower portions of said shell, a metal roof connected to the top of said shell, and a lower timber-section connected to the bottom of said shell and set out of line with or projecting beyond the sides thereof.

17. In a dry-dock, the combination of a movable docking member, having an open-bottomed air-chamber, a longitudinal central frame member therein, and inner differentiating open-bottomed air-chambers, each formed in cylindrical segments disposed symmetrically on opposite sides of, and united to, the longitudinal member.

CHAUNCEY N. DUTTON.

Witnesses:

F. C. NOBLE,

JULES P. METZGER.