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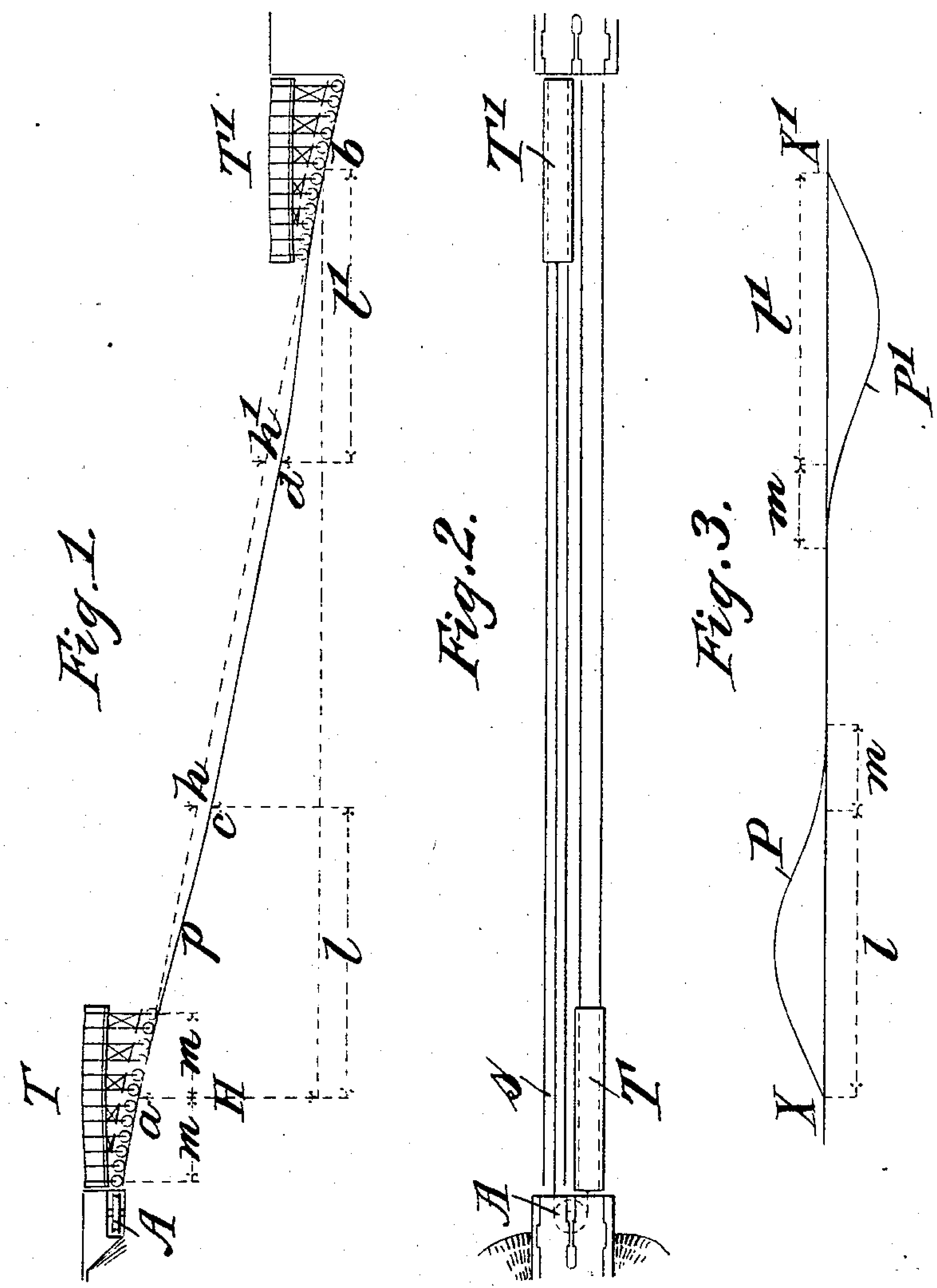
J. GRÖGER.

INCLINED PLANE FOR CONVEYING SHIPS AND THE APPERTAINING SHIP CHAMBERS.

No. 539,866. Patented May 28, 1895.



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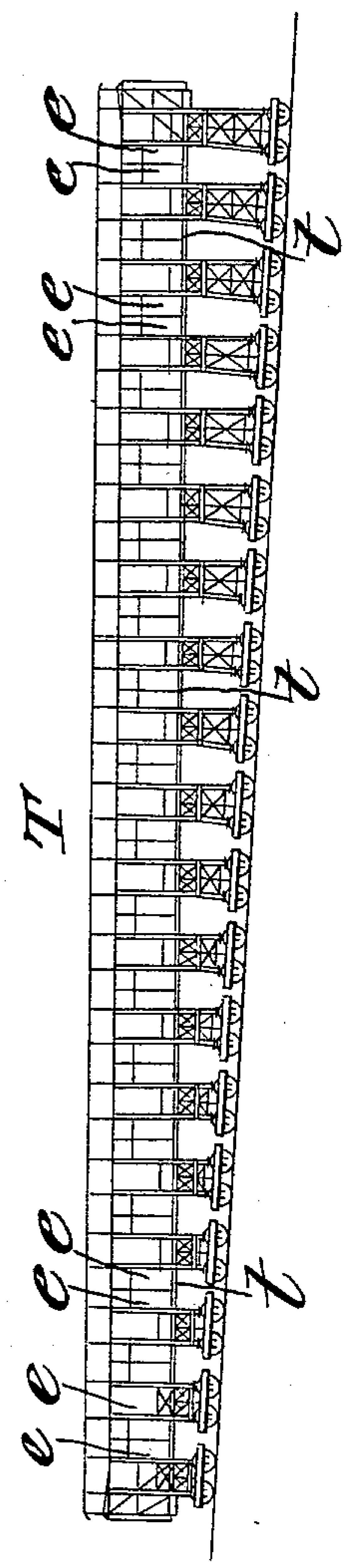

Fig. 4.

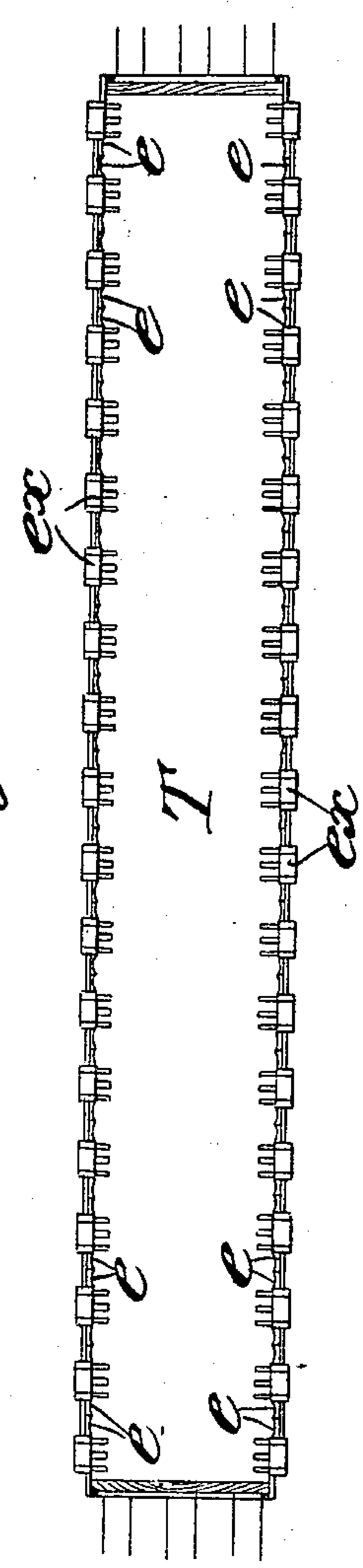

Fig. 5.

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Fig. 7.

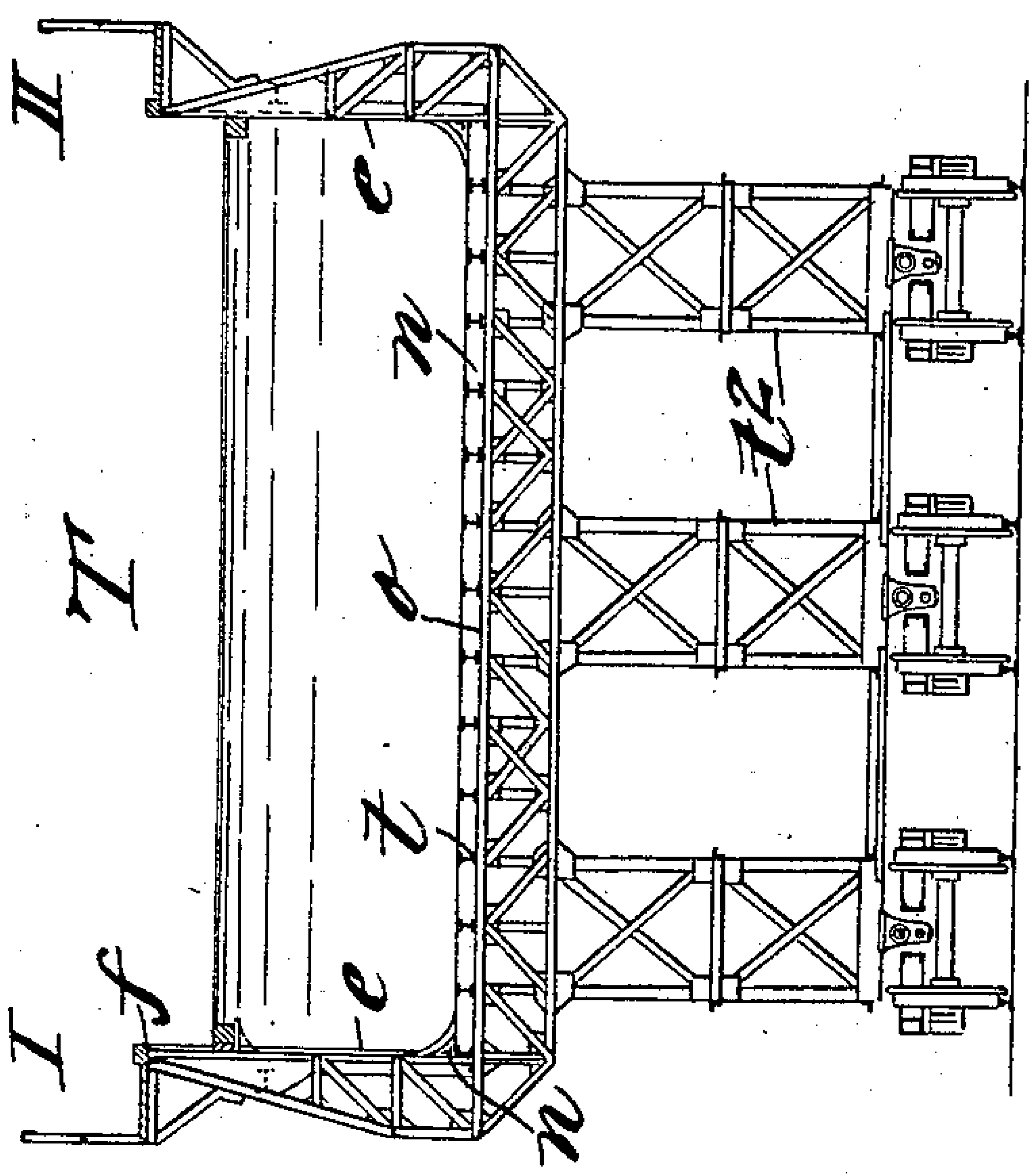


Fig. 6.

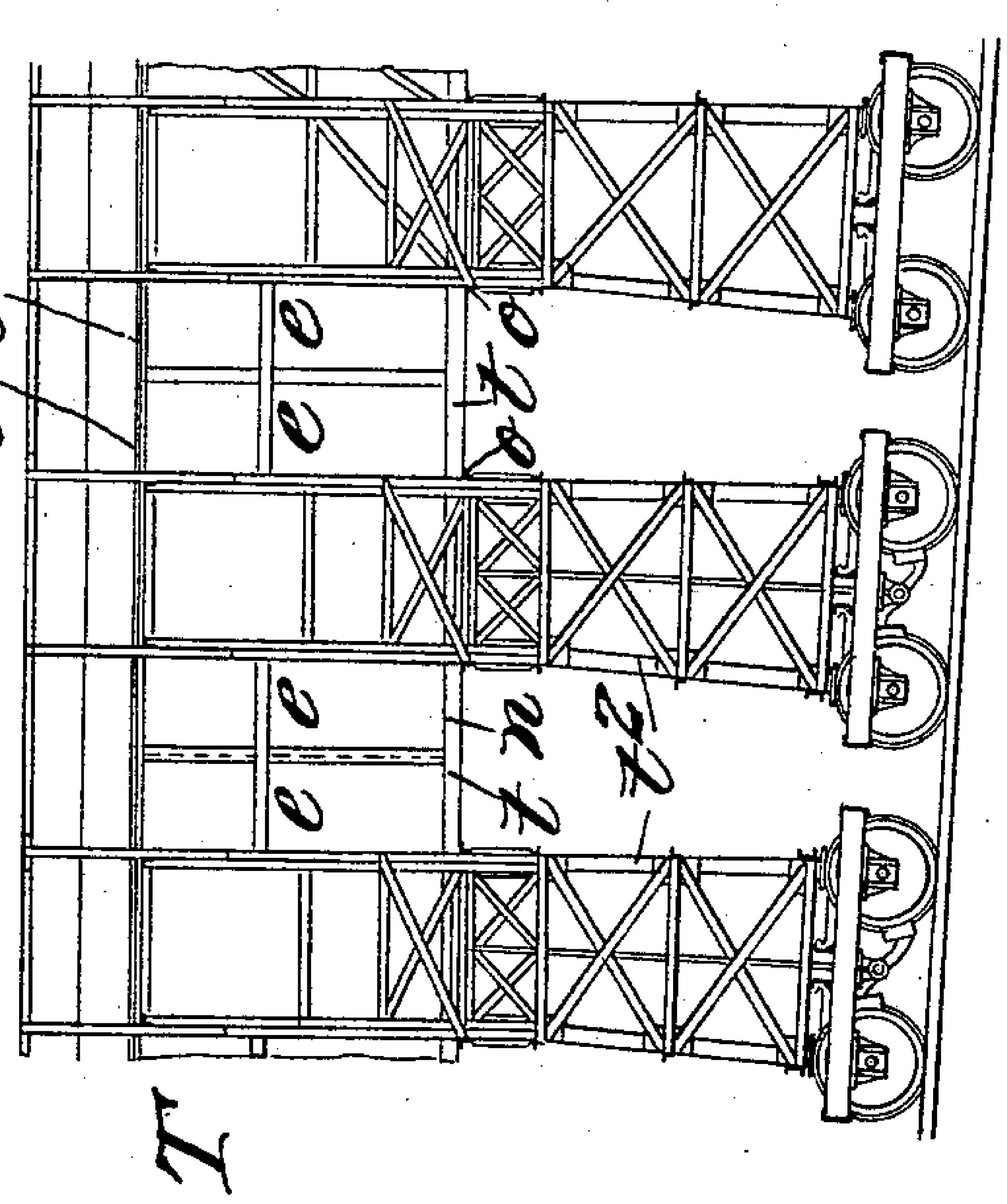
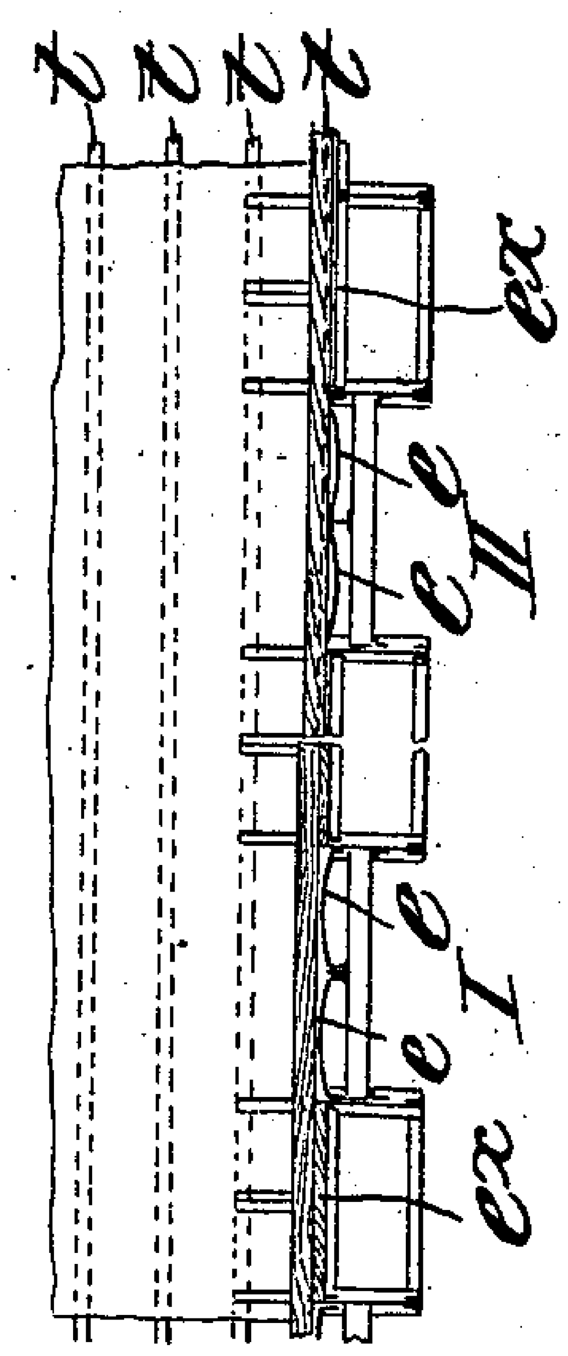


Fig. 8.



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UNITED STATES PATENT OFFICE.

JAROSLAV GRÖGER, OF PRAGUE, AUSTRIA-HUNGARY.

INCLINED PLANE FOR CONVEYING SHIPS AND THE APPERTAINING SHIP-CHAMBERS.

SPECIFICATION forming part of Letters Patent No. 539,866, dated May 28, 1895.

Application filed June 7, 1894. Serial No. 513,750. (No model.)

To all whom it may concern:

Be it known that I, JAROSLAV GRÖGER, a subject of the Emperor of Austria-Hungary, residing at Prague, in the Province of Bohemia, in the Empire of Austria-Hungary, have invented certain new and useful Improvements in Inclined Planes for Conveying Ships and the Appertaining Ship-Chambers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

My invention has relation to ship railways in which the craft to be shipped is floated in a wheeled tank.

In railways of the class referred to as heretofore constructed and operated for the transportation of small craft serious difficulties have presented themselves that constantly endanger the safety of the carrier as well as of the craft, even when said carrier is moved at a low rate of speed, so that the transportation of large vessels from one point to another, or from one level to another, has been found impracticable with the appliances hitherto available.

The difficulties referred to are due essentially to the impossibility of maintaining the body of water in the carrier in a state of rest.

It is well known that the variations in the level of a body of water confined in a moving open vessel or tank is due to the inertia of the water and to variations in the motion of the tank. Hence, whenever the motion of the tank in the direction of its length is accelerated the water will pile or bank up against the rear wall of the tank, the reverse taking place whenever the speed of the tank is decreased, the water then piling or banking up against the front wall of said tank, the extent or degree and violence of this banking up depending of course upon the rate of increase or decrease in the speed of the tank. The power required to move the water along with the tank is derived chiefly through its tendency to piling or banking up, there being but little power derived from its cohesion or adhesion to the tank walls. Furthermore, the tendency of the water to pile or bank up against one of the walls of the tank whenever a variation in the speed of the tank takes place, gives rise to a surface wave motion, the volume of which is proportioned to the rise of the water at one end of the tank, *i. e.*, to the degree or extent of banking up. Hence the greater the recurrence of the banking up, the more pronounced or violent will be the surface undulations or waves. Were it possible to so regulate the motive power as to absolutely avoid involuntary variations, those resulting from the starting and stopping still remain, since the tank in starting must be set in motion from a state of rest, and the speed of travel increased until its maximum speed has been attained, and this again decreased in stopping until the tank is brought back to a state of rest. The craft floating in the body of water in the tank naturally follows the movements of the water level or surface, which movements, irrespective of the liability of loss of a considerable volume of water, is frequently of such violence as to endanger the safety of both craft and tank. These dangers are present even in ship railways such as have heretofore been proposed for the transportation of small craft at a very low rate of speed, so that these railways would be impracticable for the transportation of large vessels, particularly for the translation of the latter from one level to another at anything like a reasonable rate of speed.

My invention has for its object a construction of ship railway for transporting vessels, and particularly for translating the same from one level to another, whereby these dangers are avoided. This I attain by so constructing the inclined ship railway and the tank that the water in the latter will remain practically motionless or stationary relatively to the tank walls during the movement of the tank from one level to another, and this I accomplish by imparting to the water an independent movement, synchronous or corresponding with the direction and speed of motion of the tank, so that the water will in fact be stationary relatively to the tank walls. This independent or separate motion of the water is due to a peculiar construction of the track whereby during the motion of the tank the level of the water therein is inclined relatively to a horizontal plane, that forms the normal water level when the tank is at rest. The required inclination of the water level is brought about by a suitable displacement of the tank floor, which displacement is due to the configuration of the track surface. To this end, the track surface instead of being composed of straight lines, as has heretofore been the practice, is composed of compound curves of opposite curvature, or such compound curves having a straight or slightly concave intermediate connecting line. It is therefore essential that the tank should be of such construction as to adapt itself accurately to its track without endangering its safety either from flexure or expansion and contraction, and it follows that a tank constructed with rigid walls would not be available for a track surface such as described, as the destruction of such a tank would be inevitable.

In order that a carrier of the nature referred to may be safely translated from one level to another along an inclined track, suitable means must be provided to move the carrier at a substantially uniform speed, for obvious reasons, and this invention comprehends such means, and consists, therefore, in the construction of the track and tank, as will now be fully described, reference being had to the accompanying drawings, in which—

Figures 1 and 2 are a schematic elevation and a plan view, respectively, of an inclined ship-railway embodying my invention. Fig. 3 is a diagram illustrative of the forces that accelerate the movements of the tank and the water therein during the travel of the tank over the compound curves of the track. Fig. 4 is a side elevation, and Fig. 5 a horizontal section, of a ship-railway tank constructed according to my invention, said tank being shown as composed longitudinally of nineteen fields or sections supported from two hundred and twenty-eight (228) wheels. Fig. 6 is a fragmentary side elevation of the tank and track. Fig. 7 is a cross-section thereof; and Fig. 8 is a fragmentary horizontal section of one of the longitudinal walls of the tank, drawn to an enlarged scale.

Similar symbols of reference are employed to indicate like parts wherever such may occur in the figures of drawings above described.

The dotted inclined line, Fig. 1, represents the general inclination or level of the track, as heretofore constructed, or proposed, the level of which is a very flat curve, a and b indicating the extremes of the track, relatively to the longitudinal center of the tank in moving on and off such track, or vice versa, H indicating the total difference between the two levels, a and b.

In accordance with my invention, the track level undergoes such changes as to form curves of transition at both ends of the track, whereby the level of the central portion thereof is lowered without altering its geometric direction. These curves of transition of a length l or l' and a relative depression h or h' are composed of two flat curves of opposite curvatures, the general or geometric inclined plane of the track being tangent to the convex end curves at the points a and b respectively, while the concave portions of the curves merge into the middle or central portion c, d, of the inclined plane or track. The oppositely curved end sections of the track may be directly connected at p, Fig. 1, or the said curved portions of the end sections at one or both ends of the track may be joined to an intermediate straight section. On the other hand, the curves of transition or end sections may be composed of segments of circles, or of parabolic or other curves, they may be of equal or of different length, but must have the same relative depression, so that h will equal h', while the corresponding curves of transition of the two parallel tracks traversed simultaneously in opposite directions by two tanks must be exactly alike, and symmetrically arranged relatively to the intermediate portion of the track. In practice it will be found best to make the end sections of the inclined track, *i. e.*, the curves of transition alike, so that the tracks for both tanks will have the same surface.

If it is assumed that the bottom of the tanks will accommodate itself to the surface of the tracks, the behavior of the water in said tanks will be as follows: As long as the tank is at rest the level of the water therein will be horizontal, but as soon as said tank moves downwardly from a to c it will at certain points incline more or less forwardly, the tank floor undergoing at the same time displacements corresponding with the track surface, whereby a mean inclination is imparted to the level of the water at every moment of its motion which induces the water to flow in the direction of motion of the tank, and will therefore not pile or bank up against its rear wall, so long as the downward speed of the tank is not greater than that of the water therein, while a piling or banking up of the water at the forward end of the tank is also avoided so long as it moves at the same speed as the water therein. The automatic motion of the water with undisturbed level parallel with the bottom of the tank ensues therefore, whenever the tank is moving at the same rate of speed as the water therein, and the conditions necessary to this result will be described hereinafter.

Inasmuch as the motive power of the water, and consequently the acceleration of motion of the water itself varies in proportion to the inclination of its level, such acceleration of motion will constantly increase with the increasing inclination of the tank traveling upon the concave portions of the track to the point *p* thereof, and from thence the inclination of the tank will continually decrease as said tank travels over the constantly decreasing inclination of the concave portion of such track until the inclination becomes *nil* at *c*. During the travel of the tank over the compound curve from *a* to *p* the speed of motion of the water will increase more rapidly than farther on, and will have attained its maximum speed as soon as the last set of tank wheels has cleared the point *c* of said curve, when the tank, and consequently the level of the water therein, again assume their normal position of parallelism relatively to the track. These relations are maintained during the travel of the tank from *c* to *d*, during which time both tank and water will move at the same rate of speed in the same direction. As soon as the forewheels of the tank enter upon the lower compound curve of the track, the forward end of the tank rises, thereby retarding the movement of the water in the direction of travel of the tank, the same phenomena presenting themselves in a reverse order as those described in reference to the travel of the tank over the upper or initial compound curve, so that when the tank has reached the end of the inclined track the speed of motion of the water will be zero, that is to say, the level of the water will again be horizontal, or at rest.

In Fig. 3 I have illustrated the increase and decrease of the relative inclination of the track, and hence that of the water level, by curves P and P′. The ordinates X, X′ of these curves P, P′ pertain to the center of the tank on its track. They are proportionate with the sine of the relative angle of inclination of the curves of transition, that is to say, of the angle that is formed by the general level of the track and a chord of a length of two meters, equal to the length of the tank, drawn at any point to said curves of transition, and consequently proportionate to the motive force of the water in the tank. The accelerating forces I have indicated in Fig. 3, above the axes X, X′, and the retarding forces below the same.

During the ascent of the tank T′, Fig. 1, the described causes will produce the same results. The water in the ascending or descending tank will therefore be induced to move with it without piling or banking up at the end walls or being lashed into waves. On the contrary, the motion of the water along the track will be more uniform than if it were flowing along a similar open channel, for the reason that it moves synchronously with the tank, and that its motion is therefore not influenced by friction with the tank walls.

Of course the described results can be attained only by means of a tank that will adapt itself to the track surface, that is to say, that is capable of sufficient flexure and corresponding expansion or contraction. Tanks of comparatively great length having rigid side walls have been found impracticable, even on tracks of uniform inclination, owing to the unavoidable unevenness of the track, which is sufficient to act injuriously upon the tank walls in at least loosening the rivets. To avoid this, various more or less complicated constructions have been proposed, but so far as I am aware the tank walls proper have been constructed exclusively of flat metal plates that are incapable of expansion or contraction.

My invention relates in part to improvements in the construction of the tank walls, in that I employ segmental plates in contradistinction to the flat metal plates heretofore employed.

Referring to Figs. 5 to 8, in which I have shown a practical construction of ships tank whose vertical walls are preferably built up by assembling the segmental plates *e e* in pairs and interposing a straight or flat plate or plates $e^{\times}$ between each pair, while the segmental plates may be arranged with their convex surfaces facing either inside or outside, as shown at I and II, Fig. 8. The cross section of the plates may be an arc of a circle, or a parabolic or other curve, or they may have an undulatory form, their faces being formed by a generatrix extending in a straight line from the bottom to the upper edge of the tank, so as to form warped surfaces, whose expansion and contraction may take place in the direction of the length of the tank without affecting the stability of the structure or injury to the material.

If, for example, the longitudinal girts *t* of one of the tank fields or sections, Fig. 6, are flexed upwardly on their bearers *o o*, the longitudinal upper edges *f* of the plates *e* in such field or section stretch or expand, while they contract when the flexure of the girts takes place in a downward direction, in that the normal curvature of the plates *e* is either decreased or increased according to the direction of flexure.

In view of the fact that the curves of transition in railways adapted for the translation of large vessels have very large radii of curvature, say from ten thousand to forty thousand meters, but a slight curvature of the longitudinal wall plate will no doubt suffice for imparting to said side walls the required resiliency without injury to joints or material.

The longitudinal girts *t* need not be of greater vertical diameter than those of the ordinary railway carriages, and perhaps less, so that they possess the necessary flexibility or pliability to adapt themselves to the track surface, yet if an extraordinary degree of pliability in the tank floor were required, these girts could be dispensed with and the strength of the floor plates suitably increased. At all events, the desired results can be attained by the construction of tank shown in Figs. 4 to 8.

The described construction of tank has the further advantage, in view of its adaptability to the track surface, in that it may be used on railway tracks of usual construction, thereby reducing the cost of track laying very materially. Furthermore, the weight and cost of constructing a wheeled tank in accordance with my invention is considerably less than the weight and cost of like tanks as heretofore constructed, for the reason that much thinner wall plates can be used without thereby reducing the stability of the structure, while the tank can be moved over a track much more readily than a rigid tank by reason of its adaptability to such track.

The locomotion of the tanks T and T′ in my system over their tracks *a c d b*, Fig. 1, is effected chiefly by the force of gravity exerted by the bodies to be moved, which force is greatly to be preferred over any other, by reason of its uniformity, so that such other motive power, as steam or hydraulic, which may be required, may be reduced to a minimum or dispensed with altogether.

Motion is imparted to the water in the tanks exclusively through the inclination of the latter on its track, while those moving forces due to or resulting from the weight of the tanks themselves during their transit over the tracks and its curves of transition are utilized to move or propel said tanks, which, under normal conditions and relative position on their respective tracks or the curves of transition thereof, balance each other. These forces would be ample to impart to the tanks the same speed as that of the water therein, so long as their motion is not antagonized by forces other than those exerted by the weight of their masses, as in the case of flowing water. It is obvious that a tank traveling along a sinuous track, and not antagonized by extraneous forces, as friction, atmospheric resistance, &c., would at every moment of its travel move at the same rate of speed, as water would in flowing over a correspondingly sinuous surface, the surface of the water corresponding with the sinuosities of the surface over which it flows, because the speed in both cases is the result of the weight of the masses exclusively. Hence, those forces necessary to synchronize the movements of the tanks and the water therein will be reduced to forces sufficient to overcome the resistances to the motion of the masses.

The constant resistances to the motion of the tanks may be overcome as in ordinary cable gravity roads, by suitably overcharging one of the tanks with water, while those resistances which may vary in accordance to fixed laws with the distance traveled over by the tanks, may be overcome by means substantially such as employed in ordinary rope transmission, so that the powerful motors that would otherwise become necessary are dispensed with.

By means of the described construction of track and tank the translation of vessels of high tonnage from one level to another can be effected with the utmost safety and at rates of speed heretofore deemed impossible, and this in view of the fact that the speed of travel of the tank has no influence upon the water therein, which is quiescent relatively to the tank since it moves with it and at the same rate of speed.

From the description it will be readily understood that in practice my invention may be variously modified without departing from the principles involved, which are also applicable to the translation of vessels or like ponderous bodies from one level to another in repair or other harbor docks, or to the transportation of liquids in open tank cars on railways.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. In an inclined ship railway, a track composed of compound curves of transition and intermediate straight or substantially straight portions, for the purpose set forth.

2. In an inclined ship railway, a track beginning and ending with a compound curve of transition.

3. In an inclined ship railway, a track beginning and ending with convex curves of transition and intermediate concave curves and straight portions, for the purpose set forth.

4. In an inclined ship railway, a wheeled tank adapted to contain a body of water and a vessel afloat therein and to expand and contract longitudinally, for the purpose set forth.

5. In an inclined ship railway, a wheeled tank adapted to contain a body of water and a vessel afloat therein, and to bend and expand and contract longitudinally, for the purpose set forth.

6. In an inclined ship railway, a wheeled tank adapted to contain a body of water and a vessel afloat therein, said tank having more or less resilient side walls, for the purpose set forth.

7. In an inclined ship railway, a wheeled tank adapted to contain a body of water and a vessel afloat therein, said tank walls composed of sections or fields adapted to expand and contract by bending and flattening out, respectively, for the purpose set forth.

8. In an inclined ship railway, a tank adapted to contain a body of water and a vessel afloat therein, said tank having more or less resilient side walls, and more or less flexible longitudinal girts, in combination with wheeled trucks from which said girts are supported, for the purpose set forth.

9. In an inclined ship railway, the combination with a track or track section having a sinuous surface, of a wheeled tank adapted to contain a body of water and a vessel afloat therein, said tank constructed to adapt itself to the sinuosities of such track, for the purpose set forth.

10. In an inclined ship railway, the combi-

nation with a track or track section having a sinuous surface, of a wheeled tank adapted to contain a body of water and a vessel afloat therein, said tank constructed to adapt itself to the sinuosities of the track and to expand and contract longitudinally in accordance therewith, for the purpose set forth.

In testimony whereof I affix my signature in presence of two witnesses.

JAROSLAV GRÖGER.

Witnesses:
ADOLPH FISCHER,
FRANS. KRÜZIN.