

(No Model.)

G. DE LAVAL.

REDUCING FRICTION OF VESSELS IN WATER.

No. 280,913.

Patented July 10, 1883.

Fig. 1.

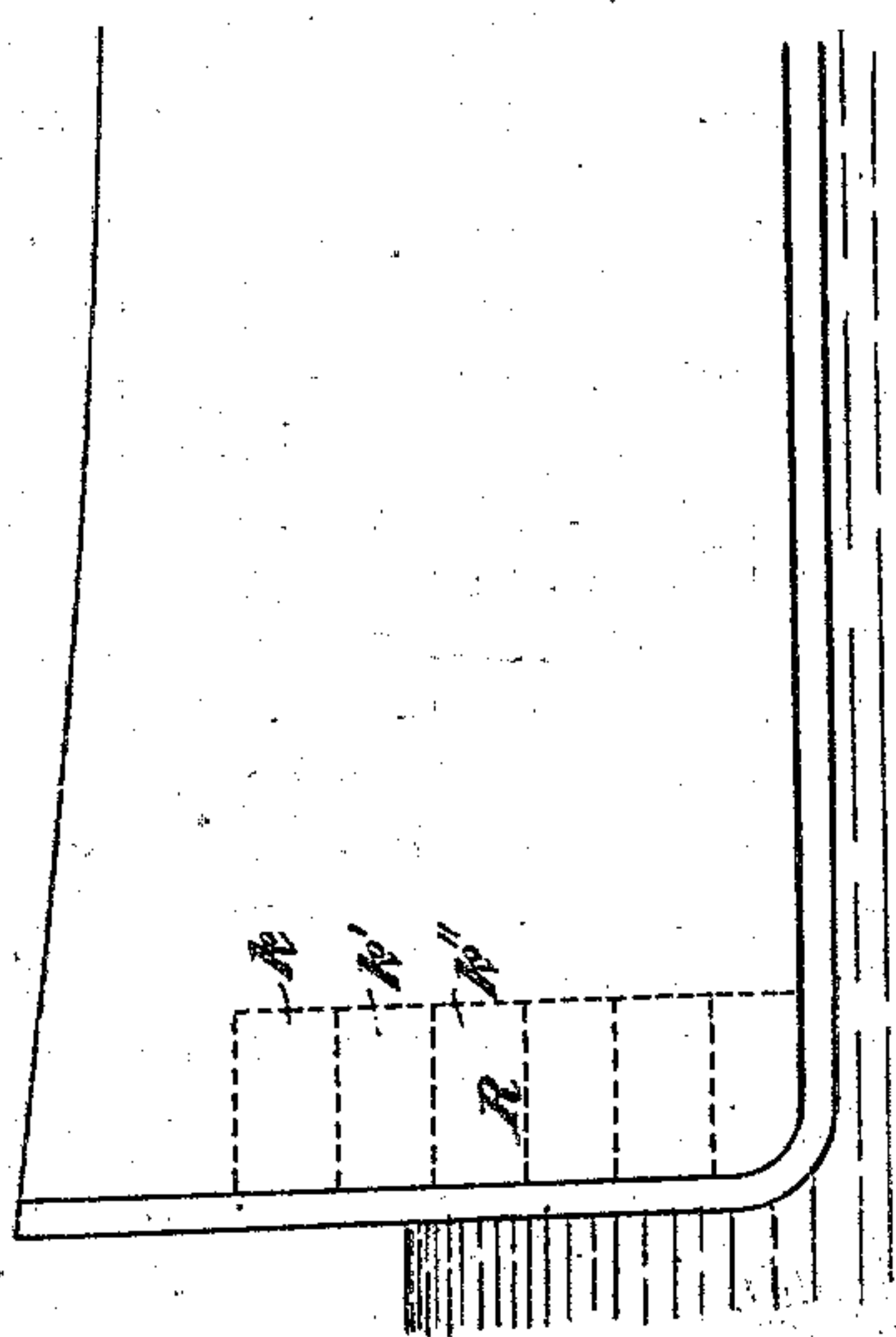


Fig. 2.

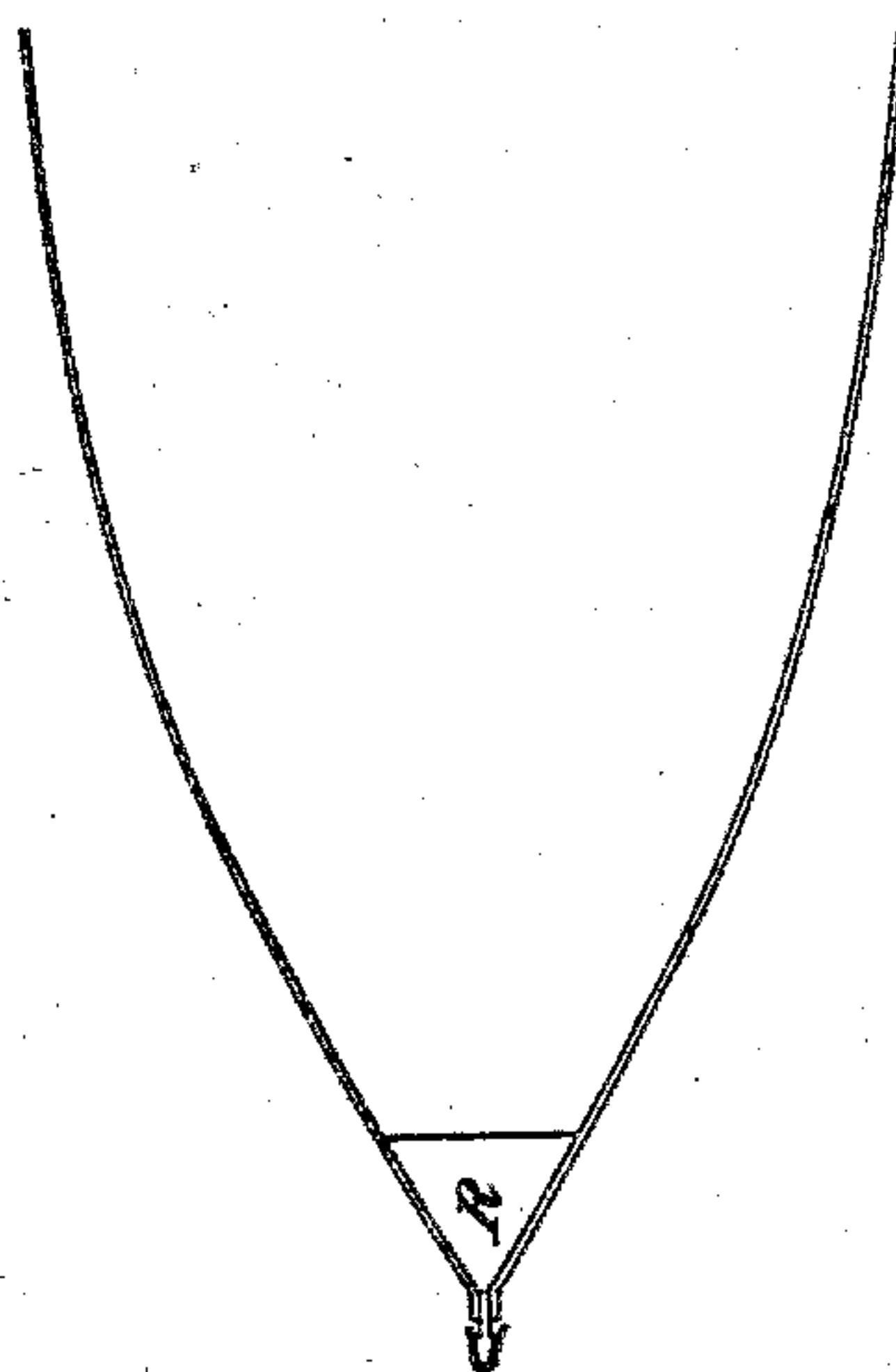


Fig. 3.

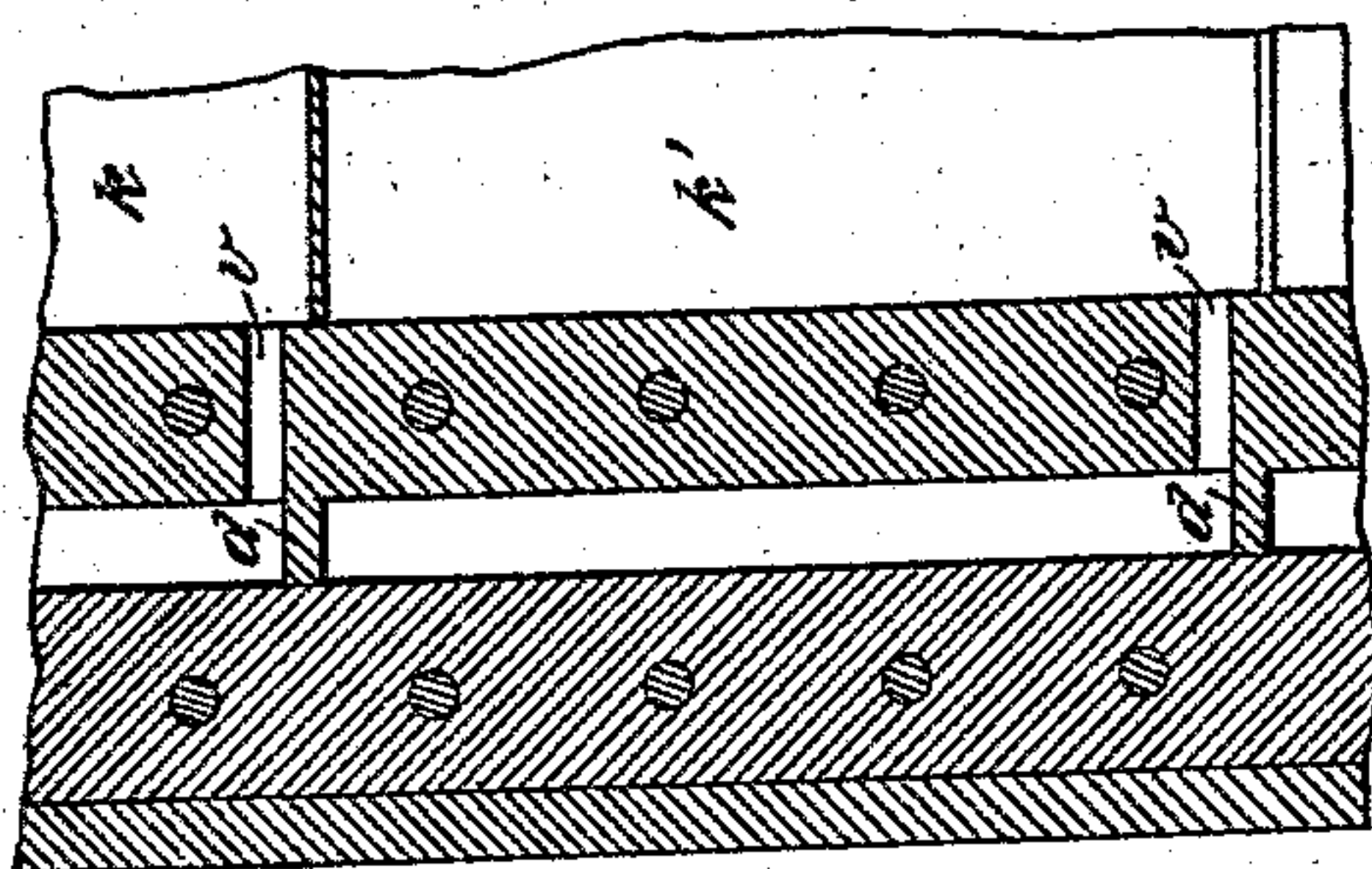
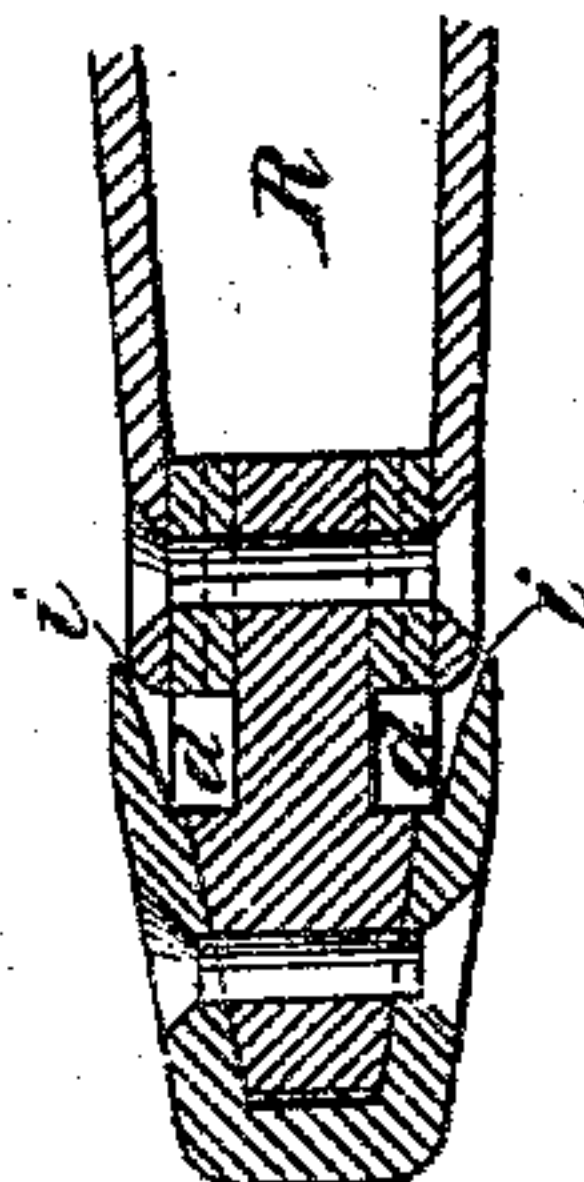


Fig. 4.



Witnesses:  
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# UNITED STATES PATENT OFFICE.

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## REDUCING FRICTION OF VESSELS IN WATER.

SPECIFICATION forming part of Letters Patent No. 280,913, dated July 10, 1883.

Application filed April 27, 1883. (No model.)

*To all whom it may concern:*

Be it known that I, GUSTAF DE LAVAL, of Stockholm, in the Kingdom of Sweden, have invented a new and Improved Method and Means of Reducing the Friction of Vessels on Water, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to the class of apparatus which is employed to lessen the friction between the exterior surfaces of vessels and the water through which they are propelled by discharging a fluid at the exterior skin or surface of the vessel. For this purpose I employ air; and my invention consists in the novel combination, with the walls of a vessel, of a series of separate and independent air-compartments arranged one above another, with outlets to the exterior of the vessel for the purpose of containing and discharging air of different pressures, which are greater in proportion to the depth of the outlet-openings under the surface of the water.

The invention also consists in novel details in the construction of the aforesaid air-compartments and their outlets, as hereinafter particularly described.

The resistance caused by friction increases with the speed of the vessel, according to formula  $R = c a v^2$ , where  $c$  signifies the coefficient of friction,  $a$  the submerged surface, and  $v$  speed of vessel; and the loss of working-power resulting from this is  $A = R = c a v^3$ .

In the accompanying drawings, Figure 1 is a side view of the bow of a vessel embodying my invention. Fig. 2 is a plan thereof; and Figs. 3 and 4 are respectively a vertical section and a horizontal section corresponding to Figs. 1 and 2, but on a much larger scale.

Similar letters of reference designate corresponding parts in all the figures.

In the bow of the vessel I construct an air-chamber, R, which I divide by partitions into a number of separate and distinct compart-

ments designated by the letters  $k$   $k'$   $k^2$ , &c., and arranged one above another. Into the several compartments just described I force air by means of different force-pumps or other mechanical means, and the pressure of air maintained in the several compartments is in proportion to their depth below the surface of the water. For example, the lower compartment is stored with air of the greatest pressure, and the pressure in the several compartments decreases in an upward direction, the least pressure being in the uppermost compartment,  $k$ . The outlets  $i$  in the sides of the bow are divided by partitions  $d$ , which are nearly coincident with the partitions separating the compartments, and each portion of the outlet between two of the partitions  $d$  communicates by a passage or duct,  $v$ , with one of the compartments,  $k$ ,  $k'$ , or  $k^2$ , of the air-chamber R. By this construction I proportion the pressure of air discharged at any part of the outlet  $i$  to the depth of that part of the outlet below the surface of the water.

This improvement is particularly adapted for vessels of great depth.

What I claim as my invention is—

1. The combination, with the walls of a vessel, of a series of separate air-compartments arranged one above another, with outlets to the exterior of the vessel for the purpose of containing and discharging air of different pressures, which are greater in proportion to the depth of the openings under the water.

2. The bow of a vessel, provided with an air-chamber, R, having compartments  $k$   $k'$  at different elevations, outlets  $i$ , and dividing-partitions  $d$ , and channels  $v$  between said outlets and compartments, substantially as described, and as illustrated in the accompanying sheet of drawings.

GUSTAF DE LAVAL.

Witnesses:

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