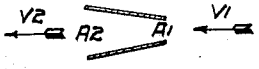
June 7, 1932. H. F. SCHMIDT 1,862,282

CONDENSER SCOOP

Filed Dec. 28, 1931 4 Sheets-Sheet 1

FIG. 2.



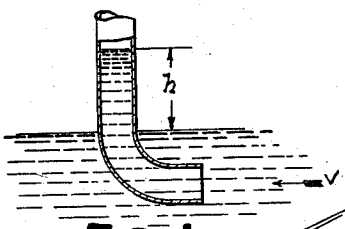


FIG. 1.

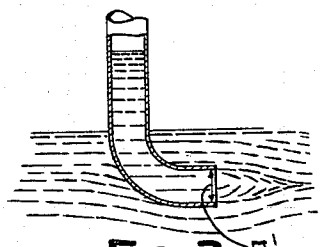


FIG. 3.

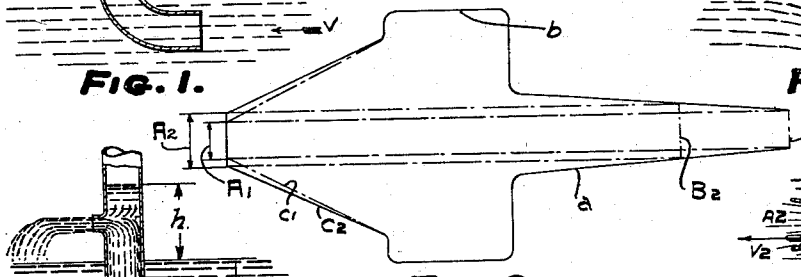


FIG. 9.

FIG. 4.

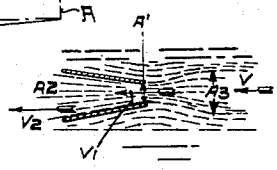
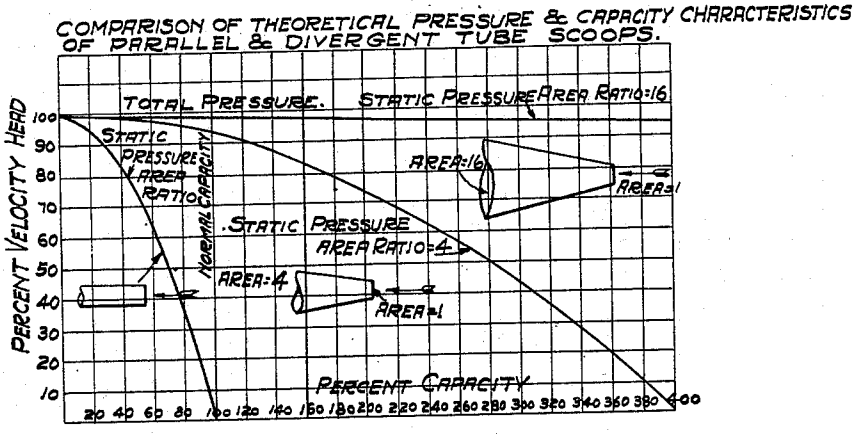


FIG. 6.

FIG. 5.



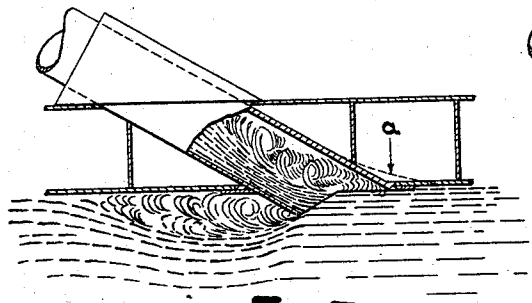


FIG. 7.

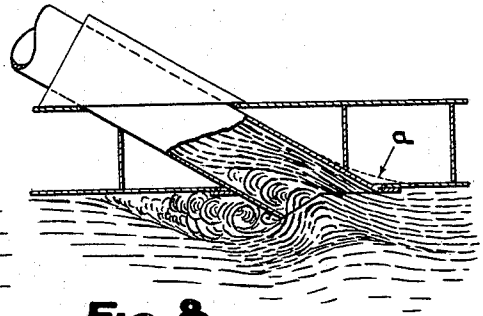


FIG. 8.

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June 7, 1932. H. F. SCHMIDT 1,862,282

CONDENSER SCOOP

Filed Dec. 28, 1931 4 Sheets-Sheet 2

FIG. 10.

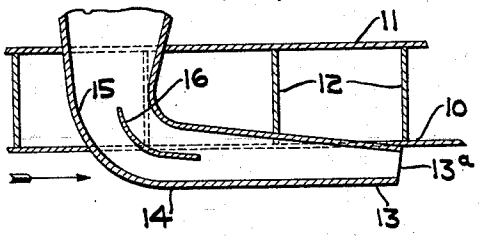
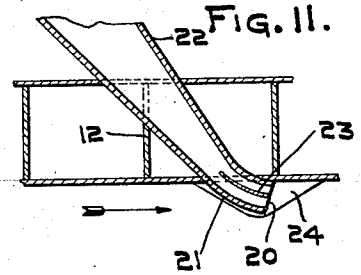


FIG. 11.



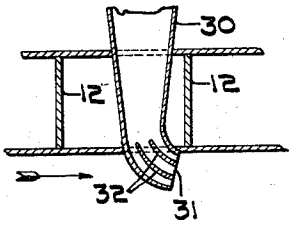
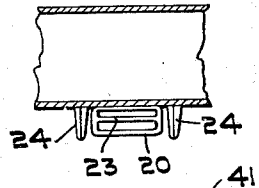


FIG. 14.



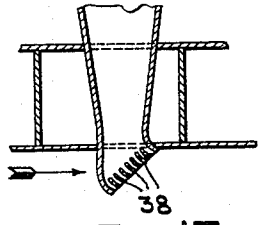


FIG. 12.

FIG. 13.

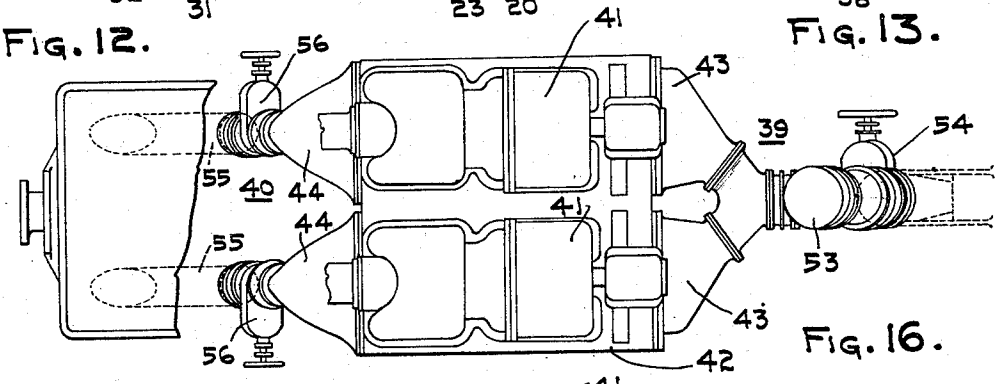


FIG. 16.

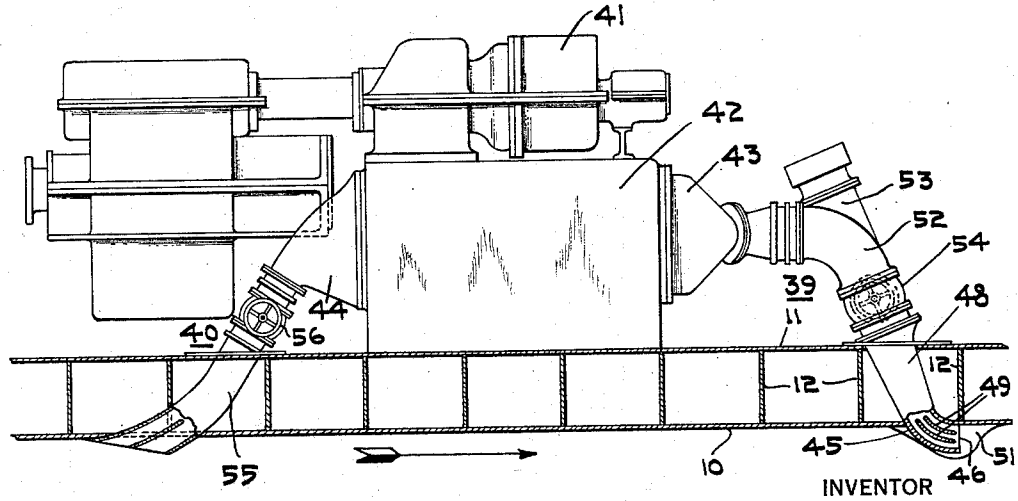


FIG. 15.

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June 7, 1932. H. F. SCHMIDT 1,862,282

CONDENSER SCOOP

Filed Dec. 28, 1931 4 Sheets-Sheet 3

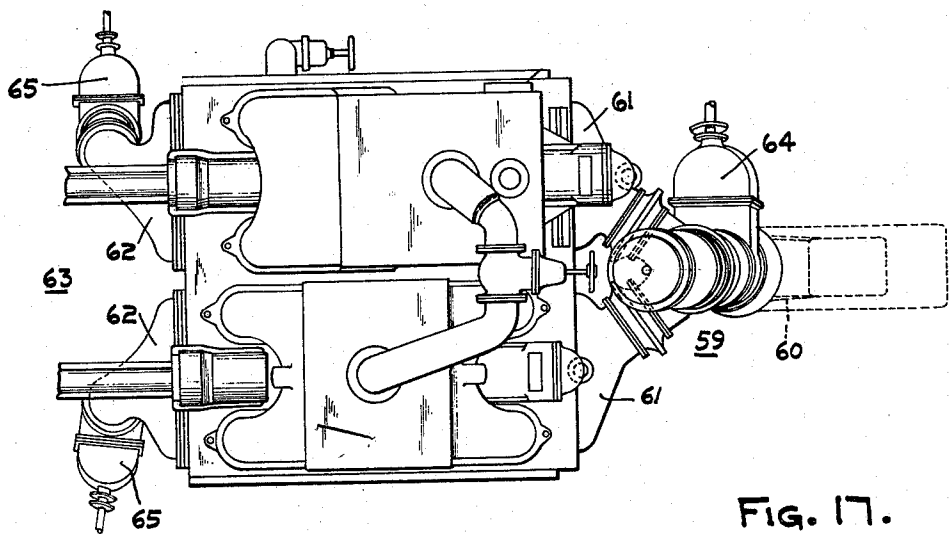


FIG. 17.

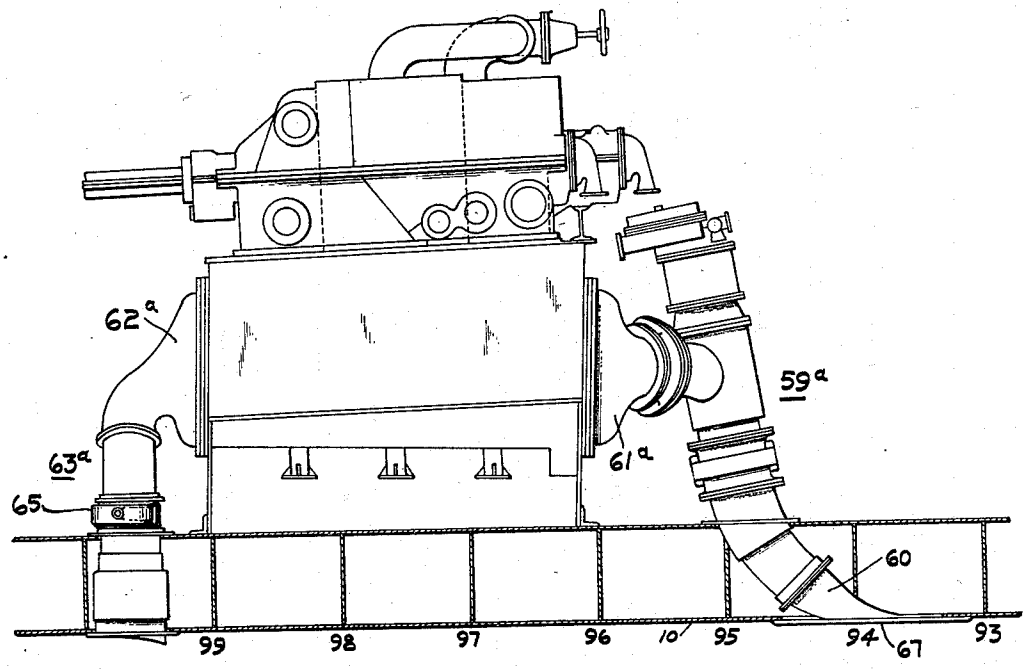


FIG. 18.

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CONDENSER SCOOP

Filed Dec. 28, 1931 4 Sheets-Sheet 4

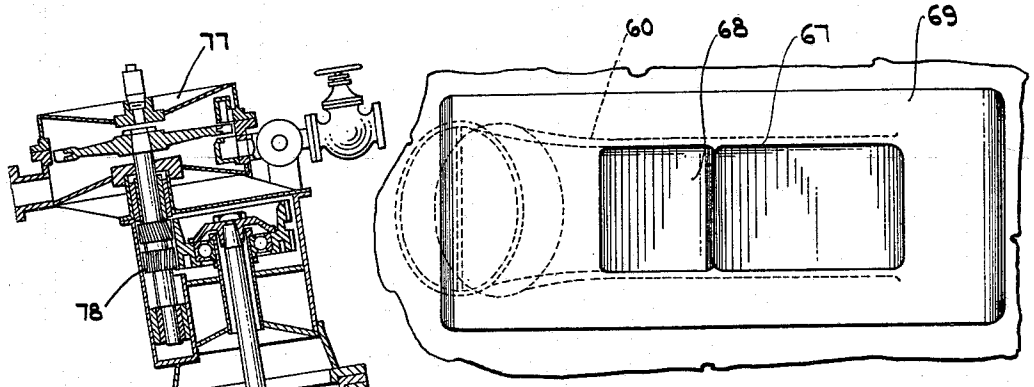


FIG. 20.

FIG. 19.

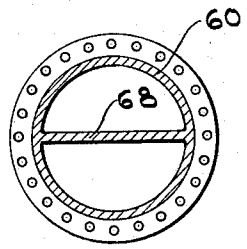


FIG. 21.

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Patented June 7, 1932

1,862,282

UNITED STATES PATENT OFFICE

HENRY F. SCHMIDT, OF LANDSDOWNE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

CONDENSER SCOOP

Application filed December 28, 1931. Serial No. 583,525.

My invention relates to marine heat exchange apparatus, for example, steam condensers, and it has for an object to provide an improved system for circulating condensing water in consequence of movement of the ship so that an installation may be more effective in operation and reduction in weight and space requirements may be effected.

A further object of my invention is to provide heat exchange apparatus, such as condensers, having water circulating systems wherein circulation of water is effected by movement of the ship and it has for an object to provide a system of such design and character that it converts velocity energy of entering water into pressure energy for overcoming resistance to flow in the apparatus.

More particularly, it is an object of my invention to provide a system having an inlet conduit provided with a passage which diverges in the direction of flow to effect velocity-pressure conversion of water flowing through the passage and to provide an overboard discharge whose exit area is larger than the entrant area of the inlet conduit so as to render static head resulting from velocity-pressure conversion available for overcoming resistance to flow.

A further object of my invention is to provide a system having the entrant end of its conduit arranged substantially flush with the ship's hull surface so as to avoid the requirement for a lip projecting beyond the hull surface.

It is a further object of my invention to provide a water circulating system for a marine condenser wherein the inlet conduit is provided with a divergent entrant end portion having guide vanes extending in the direction of flow.

These and other objects are effected by my invention, as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Figs. 1 to 9, inclusive, are diagrammatic views illustrative of scoop and inlet conduit principles;

Figs. 10, 11, 12 and 13 are detail sectional views showing inlet conduit divergent portions constructed in accordance with my invention;

Fig. 14 is an end view of the apparatus shown in Fig. 11;

Fig. 15 is a side elevation of apparatus embodying my invention and showing ship's structure in longitudinal section;

Fig. 16 is a plan view of apparatus shown in Fig. 15;

Fig. 17 is a plan view, somewhat similar to Fig. 16, but showing a modified form of water circulating apparatus;

Fig. 18 is a side elevation of apparatus somewhat similar to that shown in Fig. 17;

Fig. 19 is a detail view of the condenser inlet conduit employed with Figs. 17 and 18 and shown partly in section;

Fig. 20 is an elevational view of the inlet conduit divergent entrant portion as it appears viewed from a point outside the ship; and,

Fig. 21 is a sectional view taken along the line XXI—XXI of Fig. 19.

This application is a continuation in part of my application, Serial No. 382,456, filed July 31, 1929 and assigned to the Westinghouse Electric and Manufacturing Company.

Scoop systems have for years been utilized for circulating water through marine condensers; however, such systems, as have heretofore been employed, are not as effective as they might be and they are unduly large and frequently necessitate an undue amount of modification or alteration of the ship's structure.

The ordinary scoop system depends upon the creation of static head in an impact manner due to the relative velocity of the ship with respect to the water at the entrant end in order to effect flow through the system, and the most efficient condition occurs when the velocity of water through the entrant end is very much less than the velocity of approach, it being understood that substantially zero static head would occur if the velocity of flow equaled the velocity of approach. On the other hand, my improved water circulating system does not depend on impact or ordinary scoop operation, as is evidenced by the fact that the water velocity

through the entrant end may be equal to or greater than the velocity of approach, but rather upon making at least a part of the inlet portion divergent and having the exit area of the overboard discharge portion larger than the entrant area of the divergent portion so that velocity of water entering the divergent portion is converted into pressure or static head which is available for overcoming resistance to flow in the system.

Before describing my improved water circulating system in detail, a theoretical discussion is presented in order to bring out more clearly the reasons for and the advantages of providing an inlet conduit having a divergent portion. As a result of examining the designs of scoops employed in marine practice, more particularly, naval vessels, it occurred to me that such scoops were not as effective as they might be as the passages were not formed for converting the velocity of approach into static pressure, they being arranged to operate more on the impact principle, that is, the static head to overcome resistance was created at the inlet.

Ordinary scoops depend for their operation upon a well-known principle of hydraulics, illustrated by a bent glass tube inserted in a moving stream of water, as in Fig. 1. It will be found, as shown in all works on physics, that the water will rise in the tube to a height of h feet as explained by the relationship:

$$h=\frac{V^2}{2g}$$

in which V is the velocity of the stream in feet per second and g is the acceleration of gravity in feet per second per second.

Even neglecting friction, it is obvious that, if some of the water were permitted to escape from the tube, the height to which it rises would be reduced because the force of impact on the end of the tube would be less than that indicated by the above formula. Before taking up in detail the point last referred to, it is well to consider certain mathematical aspects of a divergent tube. A Venturi meter is a familiar piece of apparatus and the conversion of velocity into pressure therein takes place by the slowing up of the stream in the diverging portion of the tube. If V_1 is the velocity at the entrance to a diverging tube as in Fig. 2, and the inlet area is A_1, and the area at the enlarged section is A_2, then, for continuity of flow, the velocity at the section A_2 will be

$$\frac{A_1 V_1}{V_2}$$

The head built up due to the slowing up of the liquid in a diverging tube is generally represented by the formula:

$$h=\frac{V_1^2}{2g}-\frac{V_2^2}{2g}$$

in which V_2 is the velocity at the enlarged section. Hence, for the section A_2, the head becomes:

$$h=\frac{V_1^2}{2g}-\frac{V_1^2}{2g}\left(\frac{A_1}{A_2}\right)^2$$

Now the quantity of fluid entering the small end of the diverging tube will be V_1A_1, and its kinetic energy will be

$$A_1 V_1 w \frac{V_1^2}{2g}$$

where w is the weight per cubic foot. Hence, the efficiency, as a fraction of the available velocity head at the inlet which is converted into static pressure at the enlarged end of the tube will be:

$$E=\frac{wA_1V_1\left[\frac{V_1^2}{2g}-\frac{V_1^2}{2g}\left(\frac{A_1}{A_2}\right)^2\right]}{wA_1V_1\frac{V_1^2}{2g}}=1-\left(\frac{A_1}{A_2}\right)^2$$

That is, the static efficiency is dependent only upon the ratio of the areas of the diverging tube. In the above theory of the diverging tube, it is assumed that the flow through the tube is such that the velocity through the inlet, or small end, is equal to the velocity of approach of the stream. As already pointed out, it is necessary to slow up the stream gradually in order to convert velocity head into pressure head. In the case of a parallel tube, such as shown in Fig. 1, with no flow through the inlet of the tube, the method by which this slowing up and conversion of velocity head into pressure head takes place is illustrated in Fig. 3. The approaching stream is divided and deflected around the end of the tube, leaving a cone-shape mass of fluid ahead of the tube entrance. This conical mass of fluid is really in effect a diverging tube, the entrance area of which is zero and the other end, the area A_1. As the ratio of areas is infinity, the velocity at the large end of the zone will be zero, and the equation for the diverging tube reduces to:

$$h=\frac{V_1^2}{2g}$$

Now, if, instead of the bent tube of Fig. 1, we had a condition where some of the water were permitted to escape from the tube, the height to which the water would rise in the tube, would of course, be decreased, and, under these conditions, we can conceive of the flow around the inlet as being illustrated in Fig. 4, in which the central column of the approaching water is of such an area that it will pass just the amount of water at the velocity of approach as is being taken out of the tube. The area of this column now becomes A_1 in the general formula and the entrance area of the tube, A_2. Thus we see that for any condition of flow through the parallel

tube, the static head available is still represented by the formula:

$$h=\frac{V_1^2}{2g}-\frac{V_1^2}{2g}\left(\frac{A_1}{A_2}\right)^2$$

It is obvious that, if the flow through the tube were such that the velocity through the inlet were equal to the velocity of approach, the static head available would become zero, and also for any other flow condition, neglecting friction, the static head available is equal to the head corresponding to the velocity of approach minus the velocity head in the tube. From what has been said, it is now quite obvious that the parallel tube is simply a special case of a diverging tube where the area ratio

$$\frac{A_1}{A_2}$$

is unity at normal capacity.

In Fig. 5, is shown a comparison of diverging tubes of various area ratios. In this figure and throughout this specification, what is termed the "normal capacity" of the tube or scoop is the volume corresponding to the inlet area of the tube multiplied by the velocity of approach, that is, the velocity of water past the ship. In the case of the parallel tube, the static head decreases as the quantity passed increases, until, as previously seen from the formula, the static head becomes zero when the velocity through the tube is equal to the velocity of approach, that is, at normal capacity.

In Fig. 5, is shown a diverging tube with an area ratio of four, in which the velocity head at the enlarged end is $\frac{1}{16}$ that of the parallel tube for any given inlet velocity. Consequently, the static head available with this tube, neglecting friction, at normal capacity is practically 94 per cent of the velocity of approach, and the static head does not fall to zero until four times the normal volume is reached. In the case of the diverging tube with an area ratio of sixteen, the static head does not become zero until sixteen times the normal volume is passing. If the area ratio were made infinity, neglecting friction and assuming that the tube were immersed in a liquid at infinite pressure, the capacity of any diverging tube would become infinite. Of course, owing to friction, this is impossible. I have found, however, by tests that diverging tubes do pass more than the normal capacity when the back pressure is reduced.

At first thought, it would appear that it is impossible to have more than the normal capacity, that is, that corresponding to the velocity of approach, since apparently, if this were so, it would necessitate an efficiency of over 100 per cent, which is impossible. This is not true, however, as the action which takes place is illustrated in Fig. 6, as verified by observing the stream lines around the inlet of diverging scoops.

As the diverging tube must necessarily convert the velocity head into static pressure due to the slowing-up of the liquid, if the pressure at the discharge end, or large end, of the tube is reduced below that corresponding to the static pressure resulting from the slowing-up of the liquid, it is obvious that the static pressure at the inlet of the tube must decrease an amount sufficient to maintain this difference of pressure. Consequently, as the pressure at the inlet decreases below that of the surrounding medium, there is a convergent flow to the inlet, as indicated in Fig. 6, and an increase in the velocity through the inlet, with a further increase in static head avaliable, resulting in a further decrease of pressure at the inlet and so on, until the friction losses establish equilibrium. Under these conditions, the energy available is no longer represented by the tube inlet area, but rather by an area which is larger than the tube inlet, in the ratio of the actual volume to the normal volume and consequently, the efficiency under this condition is the actual volume times the static head at the tube discharge divided by the actual volume times the velocity head of approach. This again must necessarily be so because it is observed that the mathematical relation for the static efficiency of the diverging tube depends only upon the ratio of the area. In the case of a straight diverging tube without an elbow at the inlet end, the actual volume passed with zero back pressure at the delivery end of the tube has been found to exceed twice the normal capacity.

When an ordinary scoop or my improved system is employed for supplying water to condensers, it is necessary to have sufficient static pressure to overcome the resistance of the condenser tubes, the losses in the water boxes, and pipe friction. Consequently, what we are interseted in is to obtain the highest product of static head times volume of water delivered; in other words, the maximum useful work which the system is capable of performing. In the case of the parallel-tube scoop, we can find the volume corresponding to the maximum work by differentiating the equation for useful work with respect to velocity through the tube and equating this to zero and solving for the value of V_2 in terms of V_1. Thus:

$$W\frac{wA_1V_2(V_1^2-V_2^2)}{2g}$$

and

$$\frac{dW}{dV_2}-V_1^2-3V_2^2=0$$

or

$$V_2=\frac{V_1}{\sqrt{3}}$$

and the maximum work becomes

$$Wmax=\frac{wA_1V_1^3}{2g\sqrt{3}}\left(1-\left(\frac{1}{\sqrt{3}}\right)^2\right)$$

In other words, the maximum efficiency which is possible with a parallel or ordinary scoop, neglecting friction and other losses, is 38.6 per cent and the quantity of water is roughly 58 per cent of the normal.

Since the maximum efficiency of the diverging type inlet conduit occurs at normal capacity, it is obvious that the exposed or entrant area thereof external to the hull may be much less than that of a parallel-tube type scoop. As commonly constructed, the parallel-tube type or ordinary scoops which have been employed in the past cannot, of course, approach the theoretical maximum static efficiency, owing to the fact that there is friction, and also the scoops are cut off at an angle, necessitating a turning of the stream in order to enter the scoop.

It would seem quite natural that water passing the ship at velocities of thirty to forty feet per second would not be able to make a sudden twenty or thirty-degree change of direction, with the result that the water would enter the scoop more or less as shown in Fig. 7. One would expect, as in Fig. 7, that violent eddies would be set up in the forward entrance area of the scoop and that only the exposed area of the lip would be effective in "picking up" the water. However, while this is what would ordinarily be expected, the actual case is quite different, as experiments have shown.

What actually happens is illustrated in Fig. 8, which represents the stream lines as disclosed by experiment. The water enters the forward edge of the parallel-tube type scoop, and, contrary to all expectations, the lip, instead of "picking up" the water, actually has water coming out of it. The amount of flow out of and around the lip of the scoop depends upon the resistance to flow which the scoop is called upon to overcome. However, the surprising fact is that even with the discharge of the scoop open the full bore of the pipe, there is still a small amount of outflow around the edge of the lip.

As already pointed out, it is necessary that the overboard discharge exit area shall be larger than the inlet area if any advantage is to be gained from providing a diverging inlet conduit passage. Referring to Fig. 9, assume a diverging tube a having its discharge end connected by a portion b of indefinite cross section, which, in turn, is connected to either of the converging tubes c_1, c_2. The convergency of c_1 is such that the discharge area A_1 is equal to the inlet area A of the diverging tube a, in which case, it will be apparent that the entrance and discharge velocities must be equal to obtain flow and that velocity-pressure conversion taking place in the tube a is neutralized by pressure-velocity conversion in the tube c_1. Therefore, where the discharge area A_1 is equal to the inlet area A, no advantage is gained by the divergency and a more efficient arrangement would be to have a tube of uniform flow area, A or A_1, from the inlet to the discharge. Instead of having a converging tube c_1, which has a discharge area equal to the inlet area, assume that a converging tube c_2 is used having a discharge area A_2 which is larger than the inlet area A. If the area A_2 is projected on the diverging tube, it will be at the position B_2, that is, the portion of the diverging tube a which is effective to provide static head available for overcoming resistance is that portion between the inlet area A and the area B_2, which is equal to the discharge area A_2. Hence, it will be seen that divergency of the inlet tube a is of no advantage unless the discharge area of the discharge tube is greater than the inlet area and that irrespective of the extent of divergency of the inlet conduit only that portion between the inlet and a point where the area is equal to the discharge area is effective for producing static head which is available in overcoming resistance. It is to be understood that Fig. 9 is merely diagrammatic. In practice, the area A^2 may be relatively much larger than shown.

From the foregoing theoretical discussion, it will be apparent that the maximum efficiency of the parallel-tube type or ordinary scoop occurs when the velocity in the pipe is very substantially less than the velocity of approach, whereas the maximum efficiency of the system having an inlet conduit provided with a divergent passage constructed and arranged to convert velocity into pressure and to render at least a portion of such pressure available for overcoming flow resistance occurs when the inlet or entrant velocity is equal to the velocity of approach and the inlet or entrant velocity may exceed the velocity of approach; and, for equal volumes of water, the divergent type inlet conduit need also have only a fraction of the inlet area of the parallel tube or ordinary scoop type and it consequently offers proportionately less resistance to propulsion of the ship and even less resistance where it does not protrude beyond the ship's hull. Further, because of the higher static head available for overcoming resistance, the inlet and discharge pipes may be made smaller, reducing the weight of contained water, as well as that of the pipes and valves. Also, because of the higher possible water velocity through the condenser tubes, the condensing surface may be reduced giving a further reduction in weight and space. For example, the savings in weight in the case of a light cruiser of 110,000 shaft horsepower would be in the neighborhood of fifty-two tons. Aside from these advantages in reduction of space and weight, my improved circulating system also has the advantage of minimizing

the alteration or modification of the ship's structure to provide for the system.

Referring now to improved circulating systems more in detail, I show, in Fig. 10, an inlet conduit having a divergent portion which is formed in accordance with my invention. As shown, 10 represents the shell or skin of a ship and 11 the inner bottom, the several ship's frames extending transversely between the inner bottom and the shell being indicated at 12. The inlet conduit has an entrant portion 13 shown arranged parallel to the ship's hull and having an entrant or inlet end 13*a*, a body portion 14 and a curved portion 15 extending inwardly through the ship's hull and arranged to be connected to the condenser. In order to minimize eddying of the water in passing through the curved portion 15, a suitable curved guide vane or splitter 16 is disposed in the curved portion 15.

It will, therefore, be apparent that the form of passage shown in Fig. 10 increases in flow area from the inlet or entrant end 13*a* in the direction of the curved portion 15 so as to provide for conversion of velocity into pressure, the direction of motion of the ship being indicated by the arrow. While the form of inlet conduit shown in Fig. 10 is effective it is not so desirable because of the large amount of structure which is exposed beyond the ship's hull, and, furthermore, because of excessive modification or cutting of ship's frames 12, it being obvious, of course, that weakening of the ship's structure is to be avoided if possible.

In Figs. 11 to 14, inclusive, I show forms of inlet conduits which may be more readily embodied in a ship's structure than the form shown in Fig. 10. Referring specifically to Fig. 11, I show a modified form of inlet conduit of the divergent type having less of its structure exposed outside of the ship's hull. As shown, the entrance or inlet 20 is disposed contiguous to the hull structure while the curved portion 21 is located closer to the inlet than is the curved portion of Fig. 10. The remaining or body portion 22 of the inlet conduit is inclined rearwardly, the arrow indicating the direction of passage of the ship. As before, the flow area increases from the inlet 20 toward the condenser. This form of inlet conduit is more practical than that shown in Fig. 10 in that less alteration of the framing 12 is necessary and the entrant end portion does not protrude so far beyond the ship's hull.

To avoid eddies, the curved portion 21 is preferably provided with a guide vane or splitter 23. In this embodiment some of the ship's frame 12, one for example, are necessarily modified to accommodate the installation of the inlet conduit. In order to protect the entrant end portion from obstructions in the water, guards 24 are preferably secured to the hull on each side of the entrant end portion, which guards project in a forward direction beyond the entrance 20 and are faired into the hull structure, in order that obstructions may be fended off.

In Fig. 12, I show a further form of inlet conduit of the divergent type wherein a diverging body portion 30 is arranged almost normal with respect to the ship's hull. The entrant portion 31 is slanted outwardly and rearwardly and guide vanes, or splitters, 32, are provided so as to turn the water almost 90° without substantial eddy or shock losses. This construction is more desirable than any of the others so far described in that the least alteration of ship's structure is required, none of the frames 12 being cut or modified.

In Fig. 13, I show a construction which is quite similar to that shown in Fig. 12. However, in this embodiment, a plurality of corner blades or splitters 38 are provided to give the water the required degree of curvature at the bevelled entrance, the corner blades 38 being located at the inlet or entrant end of the divergent passage and the inlet entrant end being inclined substantially at 45° with respect to the hull's surface.

It will, therefore, be apparent that the several forms of divergent inlet conduits shown in Figs. 10 to 14, inclusive, as well as other forms hereinafter more fully described, all embody the basic idea of providing for increased flow area between the inlet and the condenser so as to convert velocity into pressure to provide static head for overcoming resistance to flow. Also, as heretofore pointed out, particularly in connection with Fig. 9, it is necessary that the discharge area of the overboard discharge conduit, associated with any of these forms of inlet passages, must be larger than the entrant area in order that divergency may be usefully employed to obtain static head available for overcoming resistance.

Referring now to Figs. 15 and 16, I show the complete assembly of a condenser in a ship's structure together with means for supplying circulating water to the condenser which includes inlet conduit means, at 39, constructed in accordance with my invention, and outlet conduit means, at 40, related to the inlet conduit means, as hereinafter pointed out. In these figures, turbine elements 41 are shown mounted upon and exhausting to an underneath condenser 42. The condenser 42 is provided with inlet water box or boxes 43, forming a part of the inlet conduit means, at 39, and an outlet water box or boxes 44, forming a part of the outlet conduit means, at 40. The direction of movement of the ship is indicated by the arrow, in Fig. 15.

Due to movement of the ship relative to water, water enters the divergent entrant portion 45 of the inlet conduit means, at 39, having an inlet or entrant end 46, the di-

vergent portion increasing in flow area toward the condenser. The inlet conduit means is also constructed and arranged so that only a very small portion thereof extends beyond the hull shell 10 so as to offer a minimum amount of resistance. In addition, the body portion 48 of the divergent portion 45 is so inclined with respect to the inner bottom 11 and the shell 10 that it may be located between adjacent ship's frames 12, no modification or cutting away of any of the ship's frames being required. With the body portion 48 arranged at such an angle of inclination as to permit of its passage through the hull between adjacent frames, the entrant or inlet portion of the divergent conduit member 45 is curved forwardly and it is provided with suitable guide vanes or splitters 49 so as to give the water the required degree of turning with a minimum of shock and eddy losses. Preferably, guards 51 are arranged relatively to the inlet 46 in a manner similar to those shown in Figs. 11 and 14.

The inlet conduit means, at 39, also includes a conduit section 52 connecting the divergent element 45 and the inlet water boxes 43, the section 52 being provided with a propeller pump 53 and a shut-off valve 54, the pump being of relatively small capacity for standby or auxiliary purposes, that is, for supplying water to the condenser when the ship is not moving or moving at low speed. Then again, the pump finds utility as an auxiliary making the divergent inlet conduit and pump useful for low-speed ships, with the result that the pumping capacity is reduced to the extent of the head provided by the divergent portion. Furthermore, this combined arrangement is useful in meeting different temperature conditions. For example, in northern waters, with the combined divergent portion and pump, the portion may be sufficient to provide a head giving flow adequate to effect condensation; and, in tropical waters, where a greater flow of circulating water would be necessary to effect condensation, the greater flow is provided for by operating the pump and the scoop together.

As hereinafter pointed out, the pump is preferably of the propeller type in that such a pump is peculiarly adaptable to the present invention and the propeller may be arranged in the inlet conduit without any substantial modification of the conduit. Also, while some energy loss is necessarily encountered in passing water through a pump when the latter is idling, this loss is not a serious detriment where a pump of the propeller type is used, particularly as the propeller leaves substantial flow area and the blades may be efficiently designed to act as turbine elements to be operated by the stream.

The discharge conduit means, at 40, in addition to the outlet box 44, includes the overboard discharge conduit or conduits 55 having stop valve or valves 56, the conduit or conduits 55 passing through the inner bottom 11 and the shell 10. As heretofore pointed out, it is necessary that the exit or discharge area of the overboard discharge conduit shall be greater than the inlet or entrant area of the divergent portion of the inlet conduit means, if any advantage is to be had from divergency so far as providing static head to overcome flow resistance is concerned. In Figs. 15 and 16, the relation of larger exit area than inlet or entrant area is provided for by using, with a single divergent portion 45, two discharge conduits 55. If one overboard discharge conduit is provided, this larger discharge area is taken care of by making the discharge or exit end larger.

In Fig. 17, I show an installation somewhat similar to Fig. 16 in that single inlet conduit means, at 59, is employed having a divergent portion and inlet water boxes 61, water passing from the latter through tubes in the usual way and discharging into the outlet water boxes 62 of the overboard discharge conduit means, at 63. The inlet and overboard discharge conduit means are provided, respectively, with shut-off valves 64 and 65. As heretofore pointed out, the increase in overboard discharge area, with an arrangement such as shown in Fig. 17, is taken care of by the provision of the plurality of overboard discharge conduits.

In Fig. 18, I show an embodiment of my invention wherein the condenser is provided with inlet conduit means, at 59*a*, and outlet conduit means, at 63*a*, which may have, respectively, a single inlet or entrant area and a single exit or discharge area, the discharge area of the overboard discharge conduit means, at 63*a*, being sufficiently larger than the inlet or entrant area of the diverging conduit means 60 to provide, due to velocity-pressure conversion, static head available for overcoming flow resistance.

The inlet conduit means 59 and 59*a*, shown in Figs. 17 and 18, is shown more in detail in Figs. 19 and 20, such conduit means including a forward divergent portion 60 connected by a rearward portion 66 to the water box or water boxes. The divergent portion 60 has a diverging passage whose flow area increases from area D plus E at the inlet or entrant end 67 in the direction of flow and toward the condenser. It will be seen that the divergent portion 60 is curved outwardly and forwardly, the rearward portion 66 being also similarly curved, and the curvature of these portions providing for installation of the inlet conduit means with minimum alteration of the ship's structure, while providing for the normal flow area at the inlet having its axis extending with a substantial component of direction parallel to the hull surface. As

shown in Figs. 18 and 19, the inlet end 67 of the divergent portion is substantially flush with the outer plating or shell 10 of the ship's structure. In order to minimize losses due to eddying in consequence of the stream passing through the curved portion of the inlet conduit means, the diverging or entrant portion 60 is preferably provided with a curved vane 68 extending in the direction of flow.

Referring to Fig. 19, it will be seen that the rearward portion 66 of the inlet conduit means extends through the inner bottom 11 and is connected to the divergent portion 60 by means of a suitable joint 70. The divergent portion preferably has a flange 69 connected to the outer plating 10, the body portion of the section 60 passing through a suitable opening provided in the outer shell structure. The inner section at 66 is shown as being provided with a flange 72 fitting against the inner bottom 11.

The joint 70 between the forward diverging portion 60 and the rearward conduit section 66 provides adjustment to suit variations in spacing that may exist for any reason between the inner and outer plating of the ship or possible variation in lengths and relative positions of the forward section 60 and the rearward conduit section 66.

The discharge end portion of the rearward conduit section 66 is curved to provide for any easy turn of water and to facilitate connection thereof with respect to the condenser inlet water box. In addition, this curvature facilitates accommodation of a propeller pump, the propeller pump including a propeller 75 arranged in the conduit 66 and connected to a drive shaft 76 fitting a bearing provided by the central sleeve 77 carried by the conduit section 66 and extending outwardly through the conduit wall at the top of the curved or elbow section thereof. A turbine 77 and reduction gearing 78 connecting the turbine to the shaft 76 are housed and supported by suitable structure forming a part of the inlet conduit so that the inlet conduit and the pump, as well as the prime mover for driving the latter, constitute a unitary type of construction wherein the pump and its driving means are supported by the conduit.

As already pointed out, the divergent portion 60 of Figs. 17, 18, 19 and 20 is not provided with a projection or lip protruding beyond the outer plating of the ship and heretofore regarded as necessary, and necessary with scoops of the usual type. I find, from experience, that a projection or lip is not necessary with my improved circulating system, for I do not depend upon impact or the development of static head at the entrance, as with the usual scoop, but I depend upon divergence to bring about velocity-pressure conversion to provide the necessary static head. As pointed out, the maximum efficiency of my improved diverging inlet portion, so far as providing static head is concerned, occurs when the velocity through the inlet is equal to the velocity of approach. This condition corresponds to the condition where the static head is zero when a scoop of the parallel tube type, which is dependent upon impact, is employed. Therefore, I do not depend upon a pressure at the inlet end of my inlet conduit means sufficient to overcome resistance, but upon a pressure condition created in the diverging passage due to conversion of velocity into pressure; and it is only necessary that the water shall enter at a suitable velocity. As a matter of fact, it may enter at a pressure at the inlet area less than the water pressure in the adjacent sea at the same depth.

As heretofore pointed out, with my improved form of apparatus, as soon as flow is initiated, the divergency takes care of velocity-pressure conversion and tends to maintain predetermined pressure differences between the inlet and the effective discharge area of the divergent portion, the velocity through the inlet of the scoop increasing until, due largely to friction, an equilibrium condition is brought about. Therefore, as velocity of water entering the inlet or entrant area is important, and not pressure, the required pressure being later provided by velocity-pressure conversion brought about by the divergency of the passage, the provision of an impact or catcher element is unnecessary and is, of course, to be omitted if possible. The pressure or static head at the normal inlet area required to overcome flow resistance not being essential with my improved inlet conduit means, such pressure may be lower than the surrounding pressure, and there is a tendency for flow of water to be initiated through the inlet conduit means when the ship starts in motion, as there is not only friction of the outside water against water at the inlet end, but also a tendency for the water to adhere to the forward wall. Hence, when the ship starts, flow is initiated through the inlet conduit means and the characteristic of divergency brings about pressure-velocity conversion, which, depending upon the overboard discharge being larger than the inlet area, is capable of providing the available static head for overcoming condenser, water box and piping resistance to flow.

With respect to divergency of the inlet conduit means, the optimum angle of divergence of the divergent portion is preferably approximately 10° for a circular cross-section, while, for a passage of square or rectangular cross-section, the optimum angle of divergence is preferably approximately 8°. It will, therefore, be apparent that, with the embodiments shown in Figs. 18, 19 and 20, wherein the cross-section changes from a rectangle to a circle, very effective conversion

of velocity into pressure can be obtained by using an angle of divergence between 8° and 10°. Greater or lesser angles of divergence may be employed. However, as the angle of divergence is increased, the apparatus becomes less effective until, with a divergence of about 30°, the effect thereof, is practically nil. Below 8°, conversion of velocity into pressure can be had, but, as the divergence becomes smaller, the divergent portion of the inlet conduit means must be increased in length. Increase in length may be impracticable because of structural limitations of the ship, and, in addition, is objectionable on account of increased friction loss.

From the foregoing, it will be apparent that I have devised a condensing water circulating system for a marine condenser wherein a scoop of the ordinary type is not employed and wherein the inlet conduit means has a divergent portion and the overboard discharge conduit means has its exit area sufficiently larger than the inlet or entrant area of the inlet conduit means so that conversion of velocity of water into pressure in the divergent passage provides static head available for overcoming resistance to flow. As my inlet conduit means does not depend upon impact or the building up of static head at the inlet, as is the case with the ordinary scoop, such head being secured by conversion of velocity into pressure in the diverging passage, it is unnecessary to provide a protruding lip or protrusion beyond the skin of the ship. Furthermore, as the diverging type of inlet conduit means constitutes an efficient means for securing the necessary static head and as such head may be provided with water entering the scoop inlet at the velocity of approach, or in excess thereof, it will be apparent that the piping or conduits may be made relatively smaller than heretofore and may be arranged to fit better existing ship structure, whereby alteration of the ship's structure may be minimized. Also, as the circulating system is more efficient in securing circulation, the system as a whole may be made relatively smaller and lighter, or the condenser may be made smaller and lighter as a higher head may be provided to secure higher water velocity in the condenser tubes.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. The combination with a ship's condenser, of means for circulating water through the condenser by movement of the ship relative to water and including inlet and discharge conduit means, said inlet conduit means having its after end portion connecting with the condenser and including the inlet water box of the latter and having its forward end portion communicating with the exterior of the ship's hull, said forward end portion providing an entrance for water and said inlet conduit means so increasing in flow area in the direction of flow of the water as to effect velocity-pressure conversion of the water passing through the inlet conduit, said discharge conduit having its entrant end portion connecting with the condenser and its exit end portion communicating with the exterior of the ship's hull and the exit area of said discharge conduit means being larger than the entrant area of said inlet conduit means to provide the static head, resulting from velocity-pressure conversion in the inlet conduit means, available for overcoming resistance to flow.

2. The combination with a ship's condenser, of means for circulating water through the condenser by movement of the ship relative to water and including inlet and discharge conduit means, said inlet conduit means having its after end portion connecting with the condenser and including the inlet water box of the latter and having its forward end portion communicating with the exterior of the ship's hull, said forward end portion providing an entrance for water and said inlet conduit means having at least a portion diverging in the direction of flow of the water so as to effect velocity-pressure conversion of the water passing through the inlet conduit means, said discharge conduit means having its entrant end portion connecting with the condenser and its exit end communicating with the exterior of the ship's hull and the exit area of the discharge conduit means being larger than the entrant area of the divergent portion of the inlet conduit means to provide static head, resulting from velocity-pressure conversion in the divergent portion of the inlet conduit means, available for overcoming resistance to flow.

3. The combination as claimed in claim 2 wherein the entrant end of the inlet conduit means is arranged substantially flush with the external surface of the ship's hull.

4. The combination as claimed in claim 2 wherein the angle of divergence of the divergent portion is approximately 9°.

5. The combination as claimed in claim 2 wherein the entrant end of the inlet conduit means protrudes externally of the outer surface of the ship's hull.

6. The combination as claimed in claim 2 wherein the entrant end portion of the inlet conduit means is provided with guide vane means extending in the direction of flow.

7. The combination as claimed in claim 2 wherein the entrant end portion is curved outwardly and forwardly and is provided

with guide vane means extending in the direction of flow.

8. The combination with a ship's condenser, of means for circulating water through the condenser and comprising an inlet conduit communicating with the condenser and having its inlet end opening externally of the ship's hull to provide a water entrance, the inlet end portion of said conduit diverging in a down-stream direction to provide for velocity-pressure conversion of entering water, and guide vane means arranged in the inlet end portion of said conduit.

9. The combination with a condenser for a ship having a hull structure which includes an inner bottom and a shell together with a plurality of longitudinally spaced frame members extending transversely of the hull structure between the inner bottom and the shell, of means for circulating water through the condenser including inlet conduit means having an entrant portion opening externally of the hull structure and the axis of the entrant area having substantial extent in the direction of motion of the ship, the inlet conduit means being curved so as to extend from the outer shell to the inner bottom through the single space defined by a pair of adjacent frame members, and means for guiding the water through the curved portion.

10. The combination with a condenser for a ship having a hull structure which includes an inner bottom and a shell together with a plurality of longitudinally spaced frame members extending transversely of the hull structure between the inner bottom and the shell, of means for circulating water through the condenser including inlet conduit means having an entrant portion opening externally of the hull structure and the axis of the entrant area having substantial extent in the direction of motion of the ship, the inlet conduit means being curved so as to extend from the shell to the inner bottom through the single space defined by a pair of adjacent frame members, and means for guiding the water through the curved portion, said conduit means increasing in flow-area in a direction from the entrance toward the condenser to provide for velocity-pressure conversion of entering water.

11. A water-circulating system for ships' condensers embodying inlet conduit means having a curved inlet portion, the flow-area of the inlet conduit means increasing in the direction of flow so as to effect a velocity-pressure conversion of the water passing through the system, and guide vane means arranged in the curved portion.

12. The combination with a condenser for a ship having a hull structure which includes a shell and a series of equi-distantly spaced, transversely-extending frame members disposed contiguous to the interior of the shell, of means for circulating water through the condenser including inlet conduit means having its entrant portion opening exteriorly of the shell and the axis of the entrant area having a substantial extent in the direction of the motion of the ship, the inlet conduit means being curved so as to extend from the shell inwardly through the single space defined by a pair of adjacent frame members, said conduit means increasing in flow area in a direction from the entrant end towards the condenser to provide for velocity-pressure conversion of entering water.

In testimony whereof, I have hereunto subscribed my name this 22nd day of Dec., 1931.

HENRY F. SCHMIDT.