No. 626,140. Patented May 30, 1899.

W. CARR.

PNEUMATIC PROPULSION OF VESSELS.

(Application filed Nov. 22, 1898.)

(No Model.) 3 Sheets—Sheet 1.

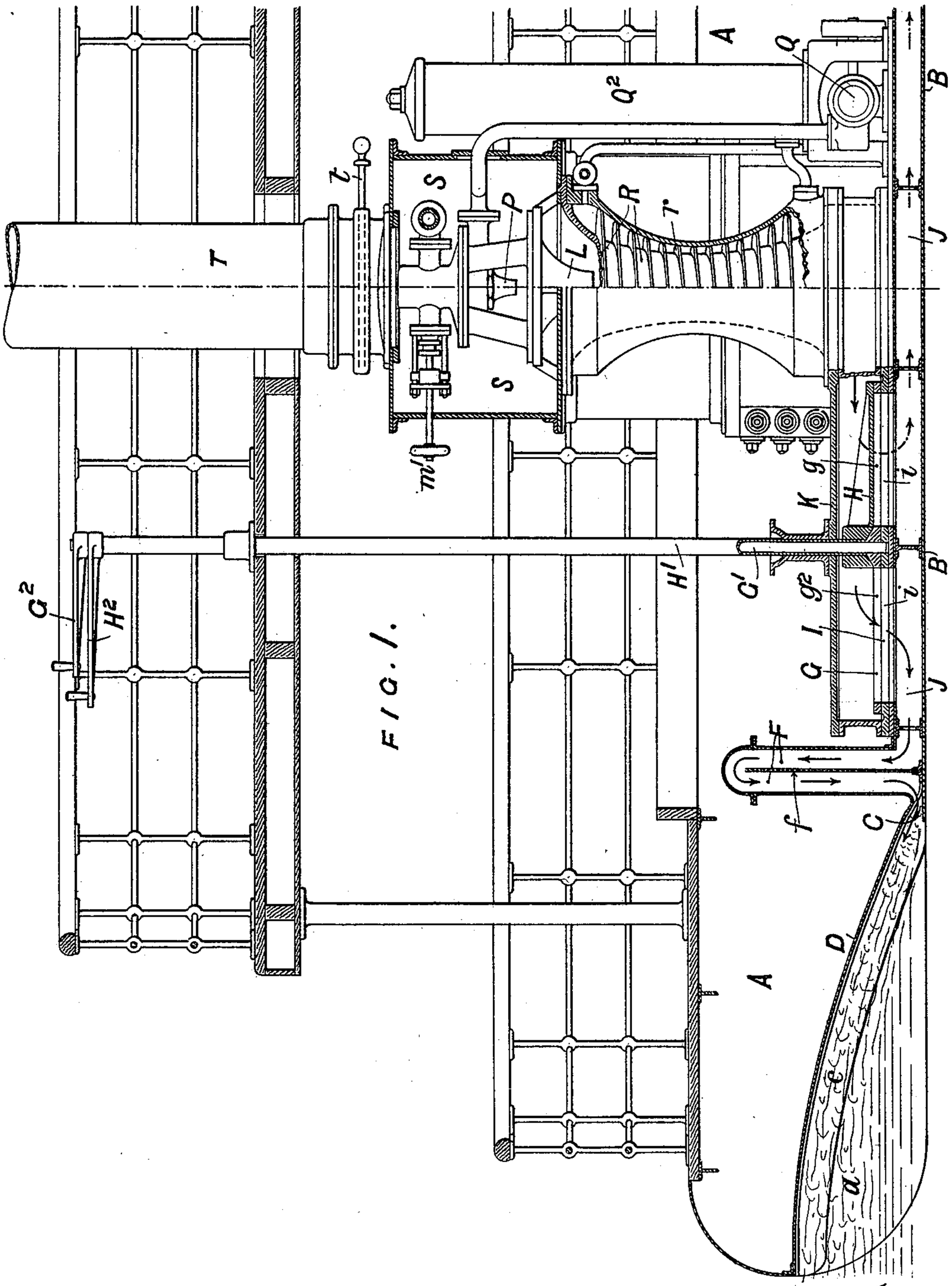

FIG. 1.

Witnesses.
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(No Model.) 3 Sheets—Sheet 2.

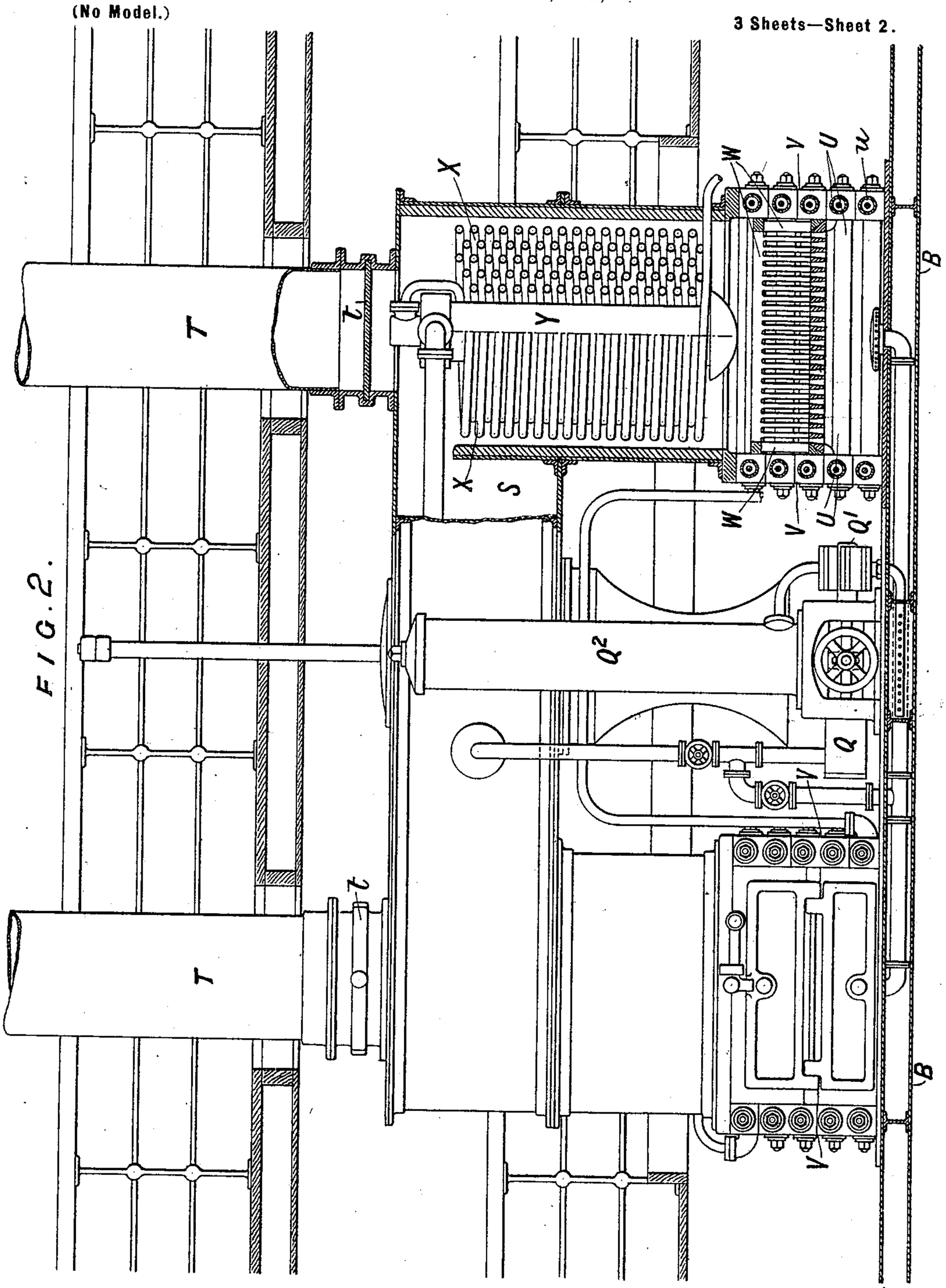

FIG. 2.

Witnesses.
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(Application filed Nov. 22, 1898.)

(No Model.)

3 Sheets—Sheet 3.

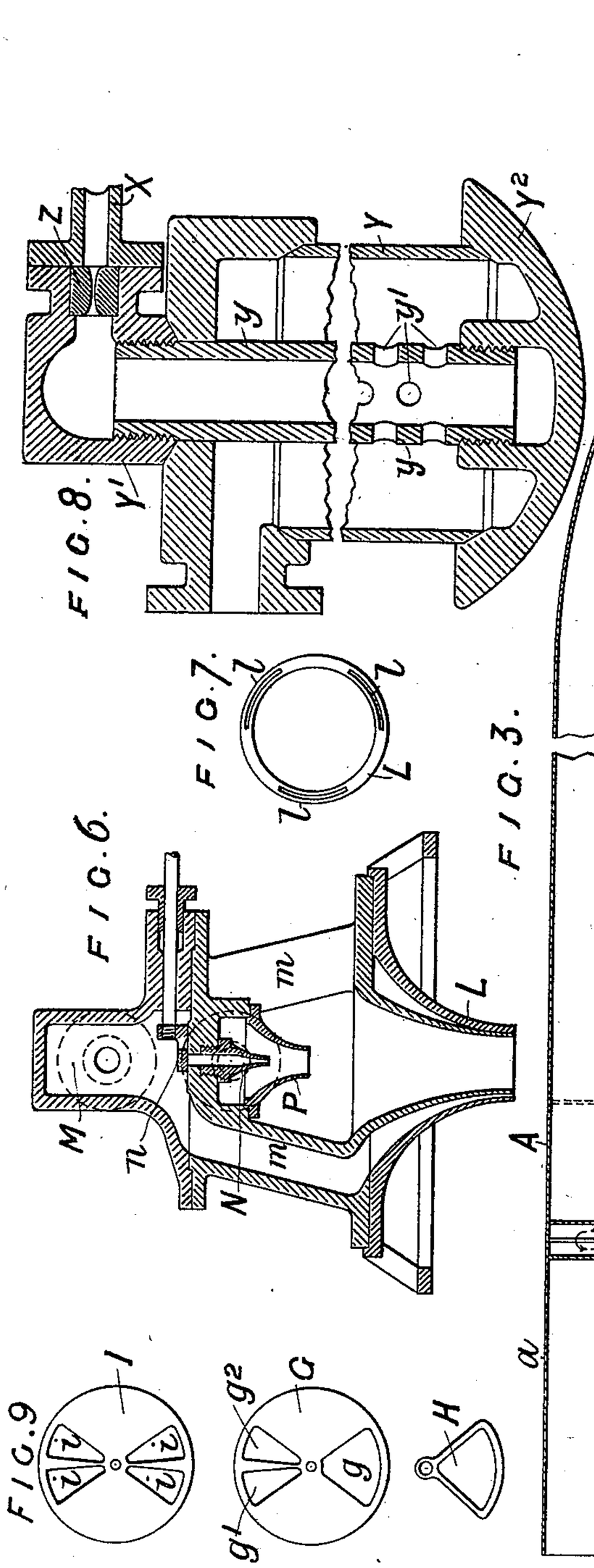

FIG. 8.

FIG. 7.

FIG. 6.

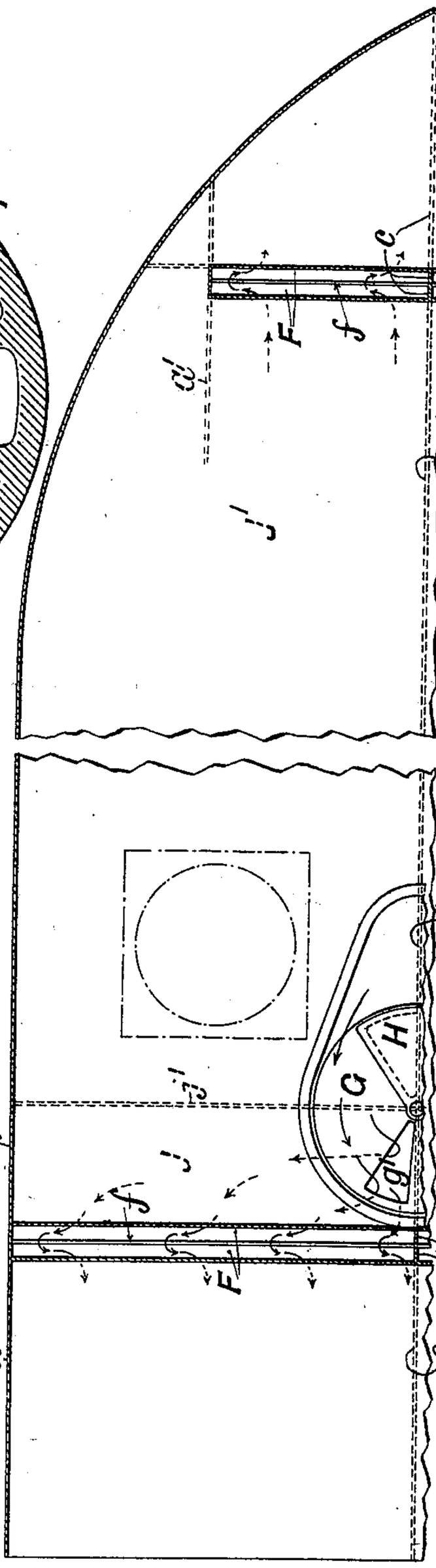

FIG. 3.

FIG. 4.

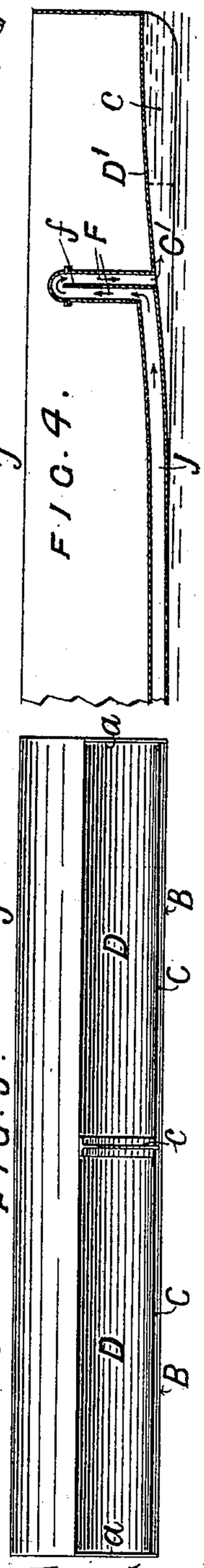

FIG. 5.

FIG. 9.

Witnesses.
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UNITED STATES PATENT OFFICE.

WALTER CARR, OF LONDON, ENGLAND.

PNEUMATIC PROPULSION OF VESSELS.

SPECIFICATION forming part of Letters Patent No. 626,140, dated May 30, 1899.

Application filed November 22, 1898. Serial No. 697,143. (No model.)

To all whom it may concern:

Be it known that I, WALTER CARR, engineer, a resident of 5 Earlham road, Bowes Park, Wood Green, London, N., England, have invented new and useful Improvements in the Pneumatic Propulsion of Vessels, (for which an application for patent has been filed in Great Britain, dated April 27, 1898, No. 9,678,) of which the following is a full, clear, and exact description.

This invention relates to the pneumatic propulsion of vessels generally, and particularly of shallow-draft vessels for the navigation of rivers and canals; and it consists of a combination or system comprising a hull having a bow and stern of special form in transverse and longitudinal section; air-emission passages of peculiar form or arrangement terminating in orifices extending as nearly as possible across the full breadth of the bow and stern, respectively; means of distributing the air uniformly across the full breadth of the propelling-surface and of preserving such uniformity of distribution during its ascending passage along the propelling-surface of the hull; means of conveying the air either to the bow or stern and of controlling the distribution of the air either to the stern or the bow emission-orifice or to a part of the one or of the other orifice for purposes of forward or backward propulsion and steering; induction steam and air jet apparatus comprising jet-nozzles and receiving-cones of special construction and so arranged as to be surrounded by the hot gases of combustion and draw in part the supply of air through the furnace and in part otherwise, whereby to maintain the required rate of combustion and to effect the most economical compression of the air; a steam generator or generators of special construction for the economical production of steam at very high pressure, and means of reducing the steam-pressure at a point between the generator and a superheater, whereby is supplied the heat necessary to maintain the temperature of the steam or even to increase it, notwithstanding loss of sensible heat incidental to the reduction of pressure, and a special construction of internal furnace whereby the fire-grate is extended up the sides of the furnace, which therefore becomes effective as grate area, permitting the access of air to the fuel for supporting combustion, besides preventing contact of the incandescent fuel with the generator-tubes inclosing the furnace.

Reference is to be had to the accompanying drawings, forming part of this specification, which illustrate the preferred form in which my invention may be embodied, and wherein—

Figure 1 shows a longitudinal vertical section of the stern of a shallow-draft vessel and a part sectional elevation of the jet and distributing apparatus. Fig. 2 is a transverse vertical section looking aft, one of the generators (of which it is preferred to use a pair) being represented in section. Fig. 3 is a diagrammatic half-plan view of the bow and stern ends, the middle portion of the hull being broken out. Fig. 4 is a longitudinal vertical section of the bow end. Fig. 5 is a stern-end view. Fig. 6 is a vertical section of the jet apparatus. Fig. 7 is an inverted plan view of interrupted annular jet-nozzle. Fig. 8 is a vertical section of the superheater, showing the device for reducing the pressure of the steam as it passes from the generator to the superheater. Fig. 9 shows the separate parts of the distributing-valve.

The same letters of reference indicate the same parts in all the figures.

In accordance with this invention the hull or body of the vessel would vary in shape with the requirements of the service for which such vessel was intended; but generally, and in particular for extreme shallow draft, where the maximum of displacement is required for given dimensions, the hull would be of rectangular form in transverse section throughout its entire length, the sides A being vertical and parallel and the bottom B flat. For the greater portion of its length the bottom or floor B is flat and horizontal both longitudinally and transversely; but for a short distance at either end it, while remaining flat transversely, rises gradually, either in the form of an inclined plane or curved surface, to some distance above the water-line. The vertical sides A of the hull may, however, be continued of full depth to the stern end of the vessel or even beyond, as shown at *a*, the extreme corners only being rounded off more or less, so that while these downwardly-pro-

jecting continuations may follow, more or less, the configuration of the inclined part of the bottom they will always project so far below it as under all circumstances to prevent the lateral escape of the air.

In the case of a vessel intended to proceed mainly ahead the upward slope of the bottom at the stern or principal propelling end is steeper than that at the bow, the rise preferably taking the form of a compound curve especially adapted to afford space for the propelling stratum of air. This air is emitted from a narrow slot or opening C, extending as nearly as possible wholly across the vessel's bottom B at or about the point where the upward slope D commences. At the opposite or bow end the rise of the inclined part D′ of the bottom is much more gradual and the corresponding emission-aperture C′ is situated at a somewhat higher level than the aperture C, the longitudinal downwardly-projecting webs (corresponding to those marked *c* at the stern) being also considerably modified both as to form and extent, as shown at *a*′, Fig. 3, the object being to obtain arresting (as distinguished from propelling) efficiency. The emission-apertures C C′ at both bow and stern and the air-channels leading thereto are divided into any number of channels and openings by vertical webs *c*, which are continued longitudinally along the under surface of the inclined propelling-surface of the bottom, so as to form, with the side extensions *a*, a series of longitudinal channels, which serve to maintain the position and direction of the streams into which the propelling air stratum is thereby divided and to enable the propulsive effect to be applied toward the one or other side only of the vessel, so as to provide a means of steering and maneuvering generally without the use of rudders. The emission or discharge apertures C C′ open out of an upcast and downcast channel F, of corresponding breadth, the upcast and downcast channels being separated by a vertical diaphragm or plate *f*, rising from the floor or bottom of the hull to some distance above the water-line, so as to exclude the external water from the air mains or conduits when, as is generally the case, such mains or conduits are disposed below the water-line, the dividing-webs *c*, before referred to, dividing the upcast and downcast channels into a number of separate channels. Where the air-supplying apparatus and channels are wholly above the water-line, the downcast portion only of the channel would be employed. The foregoing description applies also to the forward or bow end, with the exception that the deck-plan form of the bow is normal, and, as already explained, the forward emission aperture or apertures would be situated at a somewhat higher level and the upward slope of the inclined bottom is more gradual, as shown.

When the vessel is required to be propelled indifferently in either direction, both ends are similarly formed in all respects, the shape being practically a compromise between that of the bow and stern already described.

Where greater draft is admissible and speed is a consideration, the sides instead of being straight and parallel may be curved, so as to conform more nearly to the form of an ordinary vessel, the portion of the stern which is effective for purposes of propulsion remaining of the rectangular form in cross-section, as above explained.

The distribution of air is controlled by a distributing-valve consisting of a rotary adjustable plate or disk G and a rotary adjustable covering-segment H, superimposed upon the disk G, which is itself seated upon a fixed plate I, having preferably four or more radial openings *i*, communicating with air-trunks J, extending fore and aft between the double skin of the bottom of the hull or otherwise formed. The revolving disk G has openings *g g′ g*², Fig. 9, which, according to their position relatively to those of the fixed plate I and the superimposed covering-segment H, allow the air to pass either to the stern or to the bow, or to both the port side of the stern and the starboard side of the bow, or vice versa, as may be required for the purpose of stopping, reversing, steering, and maneuvering generally. The plates G H I, constituting the distributing-valve, are inclosed in a chamber K and are actuated by any convenient mechanical device. In the example shown the plates G and H are carried by concentric vertical shafts G′ H′ and are adjusted by lever-handles G² H². This valve may also be rectilinear with transverse slots. The air trunks or mains J may be tubes or pipes, as in the example shown, or may be formed structurally between the double skin of the vessel's bottom. There would generally be a pair of longitudinal trunks separated by a longitudinal central web *j* and divided transversely by a cross-web *j*′ into separate pairs J and J′, leading, respectively, to the stern and bow orifices. I do not, however, limit myself to a pair of trunks, as there would generally be as many air-trunks as there are emission orifices and channels, so as to enable the supply of air thereto to be efficiently controlled.

The air is supplied to the chamber K by a special form of steam-jet apparatus. This consists of a main jet-nozzle L, in the form of an annulus, with segmental emission-orifices *l*, separated by intervening corresponding spaces, the object of this form and arrangement being to expose as large as possible a surface of contact of the steam to the air to be set in motion thereby. This annular nozzle L is supplied with steam from a chamber M, connected with the generators and with the nozzle L by tubes *m*, so as to admit air to the interior of the annular nozzle. In connection with said chamber M is an auxiliary steam-jet nozzle N, which discharges through a second larger nozzle P, both of said nozzles

being in axial alinement with the main nozzle L, which acts as a receiving-cone. The nozzle P is in connection with the exhaust-pipe from the feed-pump Q, supplying the generators, and the purpose of the jet of live steam issuing from nozzle N or of exhaust-steam issuing from nozzle P, or of both, if used conjointly, is to set in motion toward the interior of the main nozzle a comparatively large body of air, so as by preliminarily overcoming the inertia of the air to increase the efficiency of the main jet. The emission of steam through nozzle N is controlled by a valve *n*, and the supply of steam from the generator to the chamber M is controlled by the main stop-valve *m'*. The main jet discharges into a receiving-cone R, of the form shown, whose delivery end communicates with the distributing-chamber K, the cone being surrounded by a spirally-divided water-jacket *r*, through which a circulation of the feed-water is maintained by the feed-pump Q'. The jet portion of the apparatus is inclosed within a chamber S, which is an extension of the smoke-box of the generator-furnaces, so that the steam-jet will do its work in a highly-heated medium, mainly hot products of combustion, whereby the requisite draft will be produced and the temperature of the jet will be maintained while it is doing its work. This chamber is surmounted by a funnel or funnels T, controlled by dampers *t*, which would be opened at starting and more or less closed when the jet apparatus is in action.

Steam is supplied preferably by a pair of boilers, (or by a single boiler or more than two,) each of the particular construction hereinafter described, whereby to filter the water and heat it to a sufficient extent to cause the deposit of scale (at the position where it is least injurious and whence it can be easily withdrawn) before the entry of the water into the steam-generating portion proper. Each generator has a forced circulation and comprises a lower series of coils or straight tubes U, of relatively large section, inclosing the furnace at the sides and back, the ends of the straight tubes U being connected with superposed corner chambers or headers V, the said corner chambers or headers, which are situated at the front of the furnace, being adapted to couple together in pairs the front ends of adjacent superposed tubes U, the uppermost tube of a pair so coupled at the one side being the lowermost of a pair at the other side, so that the tubes U form a continuous zigzag coil extending around the three sides of the furnace to and fro from side to side throughout the whole series of tiers of tubes. The corner chambers or headers have hand-holes and cover-plates in alinement with the various tubes to admit of the tubes being packed with porous material and being cleaned out when required. The furnace-front is inclosed by horizontally-hinged doors and the incandescent fuel is kept out of contact with the tubes U by vertical extensions W of the fire-grate extending upward at all four sides of the furnace at a short distance within the coil of tubes and the doors, the vertical grate which is next the door being also hinged for purposes of stoking. The tubes U and the superposed coils X are inclosed in an external casing of iron plates with a refractory lining. The steam-generating part of the boiler consists of concentric series of coils X of small diameter, connected at the lower end with the uppermost tube U and at the upper end with a superheater Y, arranged axially within the coils X, so as to be exposed directly to the heat from the furnace. This superheater consists of a vertical drum Y, traversed in the vertical direction by a central tube *y*, screwed at its ends into the top and bottom castings Y' Y^2 of the drum, for which it also serves as a central stay-rod. It has perforations *y'* near its lower part, opening into the surrounding space within the drum Y, and the steam enters the upper end of this central pipe *y* from the pipe *x* (connected with the upper ends of the generator-coils X) through a reducing-nozzle Z of small bore, so as to enter the superheater at a reduced pressure at the same time that its temperature is maintained or increased by the action of the superheater. The steam passes down the central tube *y* through the perforations *y'* into contact with the walls of the lowermost and hottest part of the drum Y, wherein it rises and passes off through a pipe to the chamber M of the jet apparatus. The feed-water is supplied by the feed-pump Q' through a pressure-equalizing air-vessel Q^2, wherein a pressure is maintained superior to that in the generator, the feed-water then passing through the water-jacket of the receiving-cone R of the jet apparatus, wherein it is heated, then through any suitable known kind of feed-water heater, and enters in a steady stream the lowermost tube *u* of the coil surrounding the furnace, wherein its temperature is still further raised. The feed-water may also be separately supplied to each of the concentric coils X, if required.

I claim—

1. The herein-described system or combination of apparatus for the pneumatic propulsion of vessels, comprising a steam-generator of the continuous-coil type whereof the lower part surrounds at a distance a fire-chamber inclosed by horizontal and vertical fire-grates; a superheater above the furnace and within the steam-generating coils and in connection therewith by a pressure-reducing appliance; steam-jet-induction apparatus comprising an interrupted annular jet-nozzle in connection with the superheater and a receiving-cone the nozzle being inclosed in a chamber in connection with the furnace so as to draw therefrom the products of combustion, whereby an induced draft is produced for maintaining combustion in the furnace and the steam issuing from the nozzle is

maintained at the temperature necessary for its efficiency; means of cooling the receiving-cone for partially condensing the steam and reducing the volume of the air and gases passing through the cone, a valve for controlling the distribution of the air and gases, and trunks for conveying the same to the emission-orifices; a hull having its bottom upwardly inclined at each extremity, flat in transverse section and extending the full width of the hull at that part, with downwardly-projecting lateral and intermediate longitudinal flanges or ribs forming channels along the inclined bottom, an upcast and downcast air-emission passage communicating with the trunks and opening through the inclined bottom by a narrow orifice extending transversely as nearly as possible the full width of the hull, the passage being divided to correspond to the air-trunks and to the channels below the inclined bottom, so as to enable the emission of the air to be controlled and directed as required for steering, substantially as specified.

2. In a pneumatic system of propulsion, a steam-generator of the continuous-coil type, constructed of a lower coil composed of straight tubes of relatively large diameter connected in zigzag order by headers and inclosing at a distance on three sides a fire-chamber constructed of horizontal and vertical grates, the zigzag coil being connected to and surmounted by concentric circular coils of tube of relatively small diameter connected at the upper end through a reducing-nozzle with a superheating-drum placed over the furnace and within the coils substantially as described.

3. In a pneumatic system of propulsion, a steam-jet-induction apparatus comprising a principal nozzle of interrupted annular form, in combination with a receiving-cone, said nozzle being supplied with live steam from a generator, a compound auxiliary nozzle comprising a nozzle connected with the exhaust of the feed-pump and a second smaller nozzle connected with the live-steam supply, for both of which the principal nozzle is adapted to act as receiving-cone, the said principal and auxiliary nozzles being inclosed in a chamber in communication with the generator-furnace so as to produce an induced draft therein, insure the maintenance of the temperature of the steam on issuing from the nozzles, and supply the current of air for purposes of propulsion.

4. In a pneumatic system of propulsion, the construction of the hull with an upwardly-inclined bottom at each extremity, flat in transverse section and extending as nearly as possible the full width of the hull at that part, and with downwardly-projecting lateral and intermediate flanges or ribs forming longitudinal channels below the inclined surface, a narrow air-emission orifice opening through the inclined surface and extending transversely the full width thereof, an upcast and downcast air-passage leading to said orifice and divided transversely to correspond to the longitudinal channels beneath the inclined bottom of the hull, substantially as described.

5. In a pneumatic system of propulsion, the combination with a hull having an upwardly-inclined transversely-flat bottom at each extremity divided into longitudinal channels, and having transverse air-emission orifices and upcast and downcast passages leading thereto and divided to correspond to the said channels, of air trunks or conduits leading to such passages, and a distributing-valve or appliance for controlling the emission of air at the one or the other or at any part of the one or other emission-orifice as may be required for purposes of propulsion, steering, or maneuvering, as described.

Signed by the said WALTER CARR this 11th day of November, 1898.

WALTER CARR.

In presence of—
C. G. CLARK,
T. W. KENNARD.