Jan. 12, 1960 H. COANDA 2,920,448

APPARATUS FOR IMPARTING RAPID SPEED TO A MASS OF FLUID

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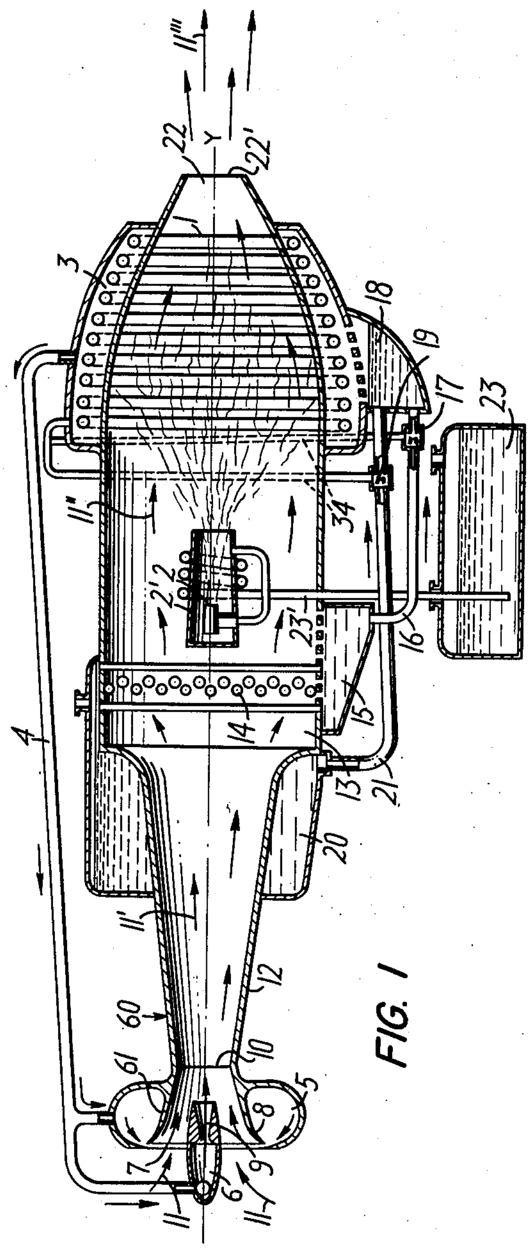

FIG. 1

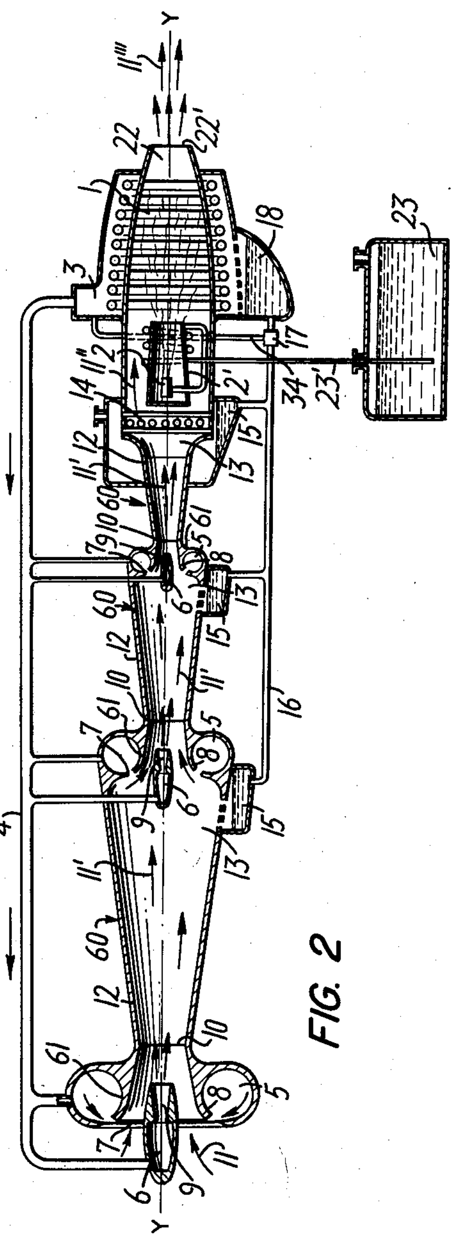

FIG. 2

APPARATUS FOR IMPARTING RAPID SPEED TO A MASS OF FLUID

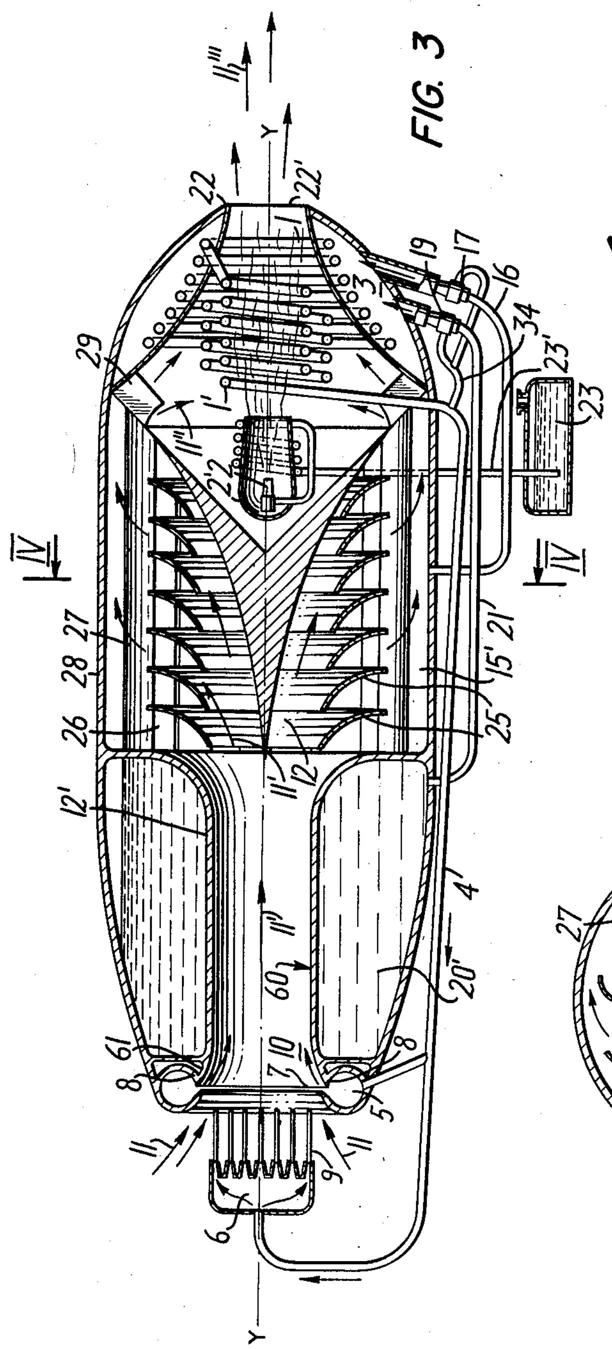

FIG. 3

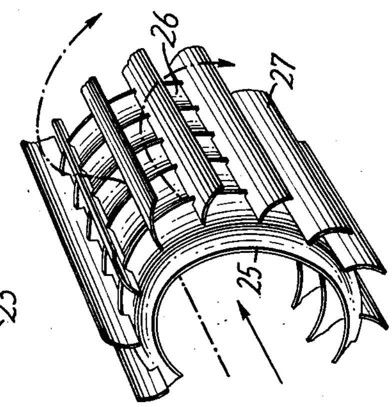

FIG. 5

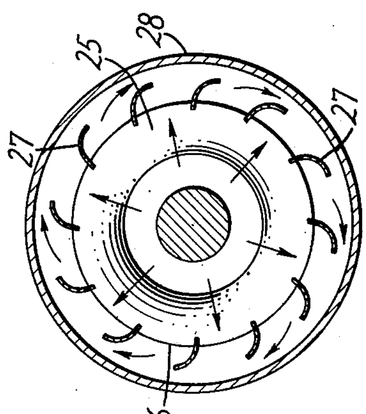

FIG. 4

APPARATUS FOR IMPARTING RAPID SPEED TO A MASS OF FLUID

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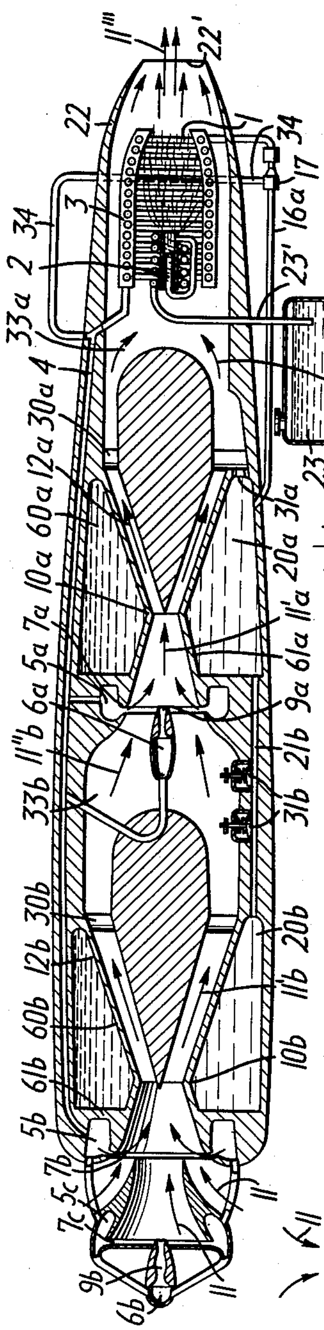

FIG. 6

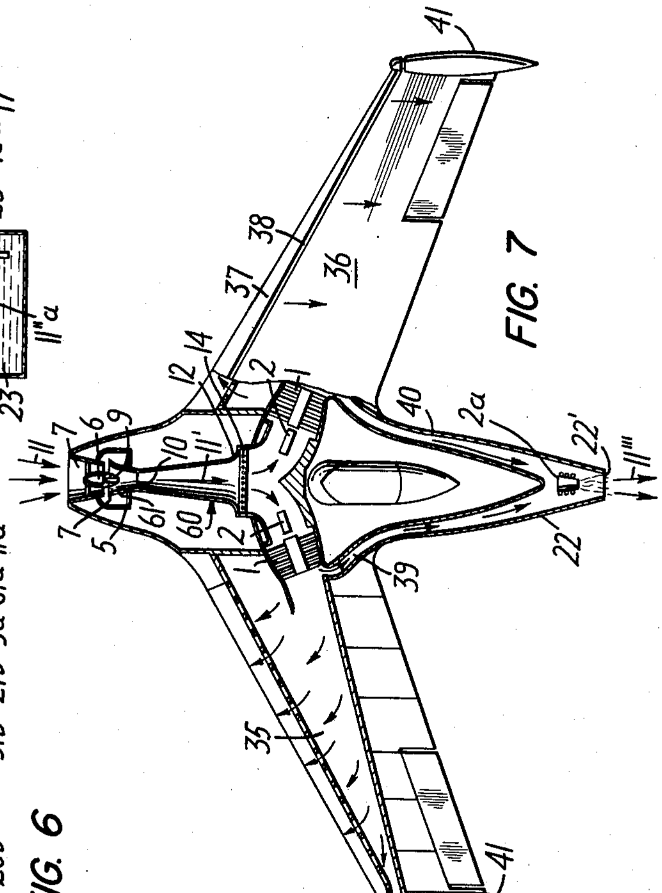

FIG. 7

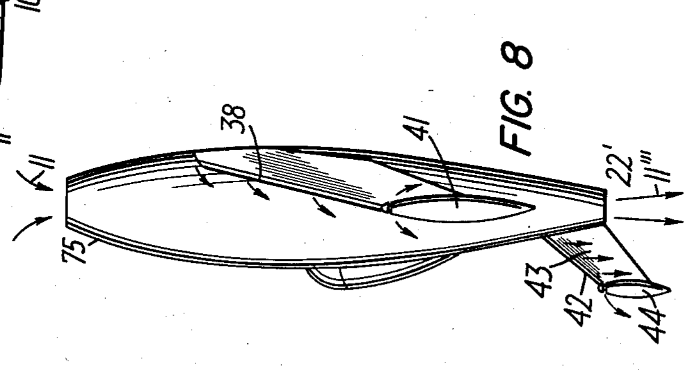

FIG. 8

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FIG. 9

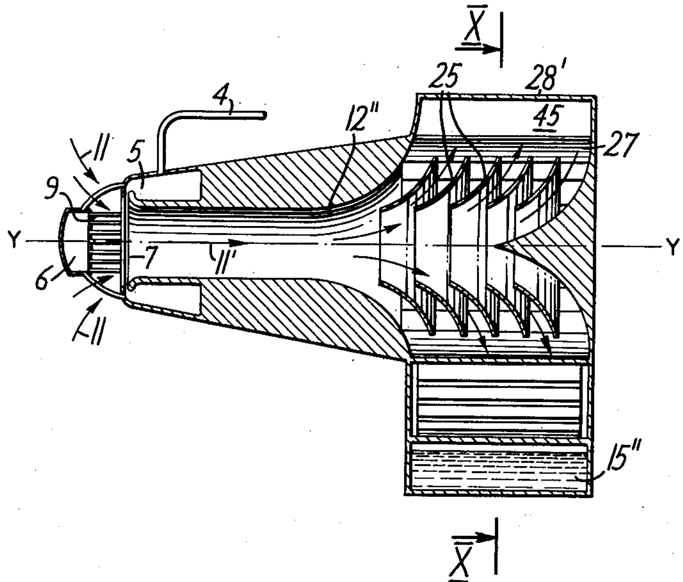
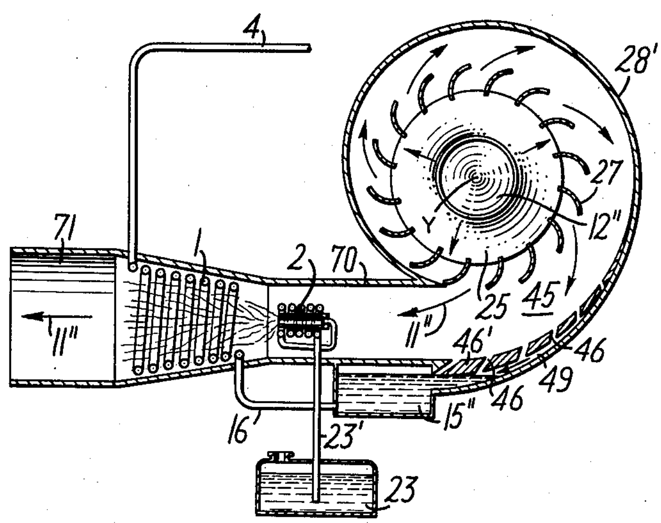


FIG. 10



APPARATUS FOR IMPARTING RAPID SPEED TO A MASS OF FLUID

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FIG. 12

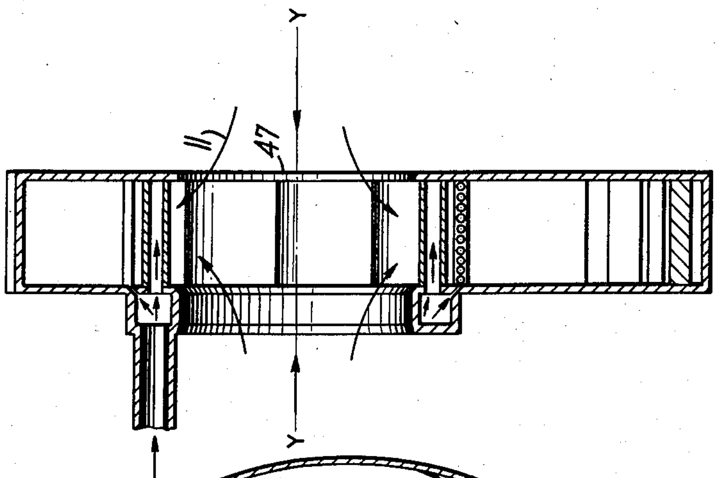
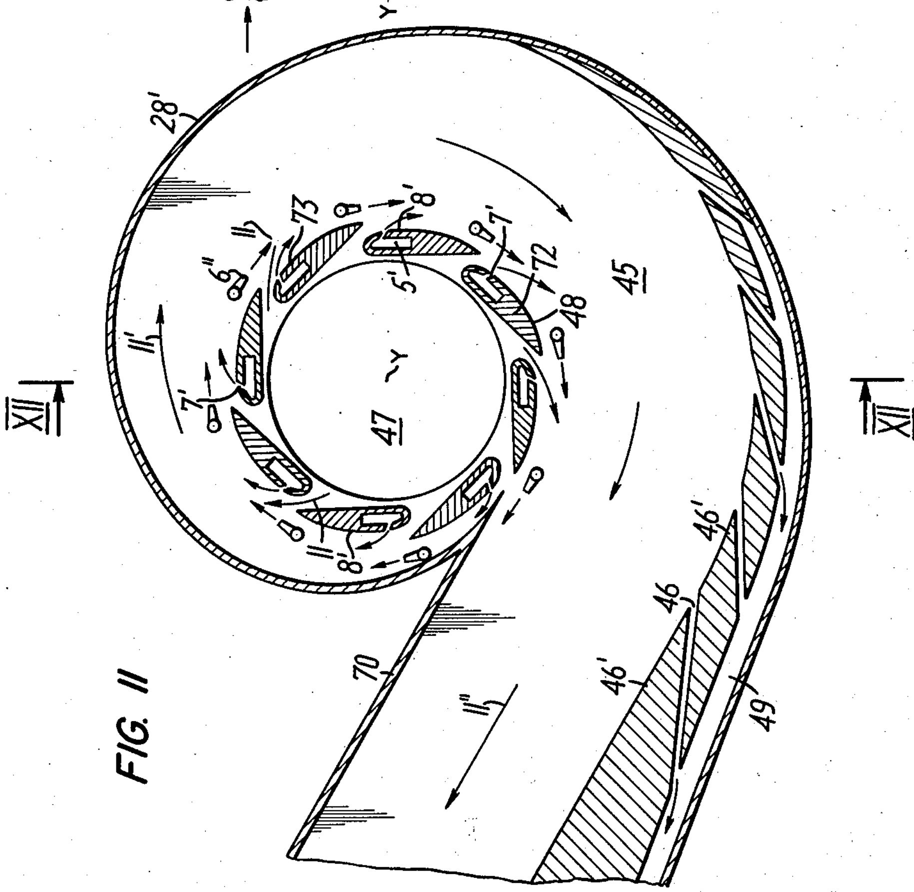


FIG. 11



United States Patent Office

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APPARATUS FOR IMPARTING RAPID SPEED TO A MASS OF FLUID

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Application July 17, 1956, Serial No. 598,441

Claims priority, application France July 29, 1955

12 Claims. (Cl. 60—39.49)

This invention relates to an apparatus for imparting rapid speed to a mass of fluid. In said apparatus, hereinafter called a thermo-blower in which high speed is imparted to a fluid mass, particularly a gas, without the use of any rotating parts, but simply by the use of a source of heat as, for example, one or more heating burners.

The thermo-blower according to the invention uses the reciprocal action of two fluid masses acting one against the other, the said two fluid masses being motivated solely by an application of heat which is applied essentially to the first mass functioning in a primary circuit, which is generally closed and in which the first fluid mass passes through the successive phases of liquid, vapour and liquid phase.

In a thermo-blower according to the invention, a mass of fluid, more particularly a gas such as air, is set in motion by using two fluid masses, namely a first or driving mass which passes successively through the liquid, vapour and liquid phases, and a second or driven mass, namely that which is to be set in motion. The first fluid mass, which is initially in the liquid phase, is vaporised and the vapour under pressure escapes through appropriate apertures in at least one chamber in which it is under pressure in such a manner as to entrain the second fluid mass to which it imparts a certain speed by heating it; that, conversely, the second fluid mass, set in motion by the escape of the first mass, absorbs in being heated the greater part of the heat of vaporisation of the first mass, which is condensed, passing from the vapour state to the liquid state; that the second fluid mass set in motion and heated by the first mass passes through a nozzle; that, where appropriate, the condensed liquid is wholly or partly separated and the liquid separated is re-cycled with a view to a fresh vaporisation operation; that, where appropriate, the second fluid mass is superheated (the condensed liquid thereof being eventually wholly or partially removed); finally, that the said second mass, with or without a part or the whole of the first mass, is allowed to issue at high speed through apertures of appropriate form and dimension.

The thermo-blower of the invention comprises a preferably tubular boiler for vaporising a first or driving fluid mass and bringing the obtained vapour to an over-atmospheric pressure; a device, such as at least one burner, intended for heating the boiler; at least one conduit for leading the said vapour under pressure into at least one chamber, from which the said vapour can escape under pressure through at least one slot having a lip which diverges from the axis of the slot, and/or into at least one injector from which the said vapour issues under pressure, the said slot(s) and injector(s) opening in the vicinity of the inlet end open to the ambient fluid (for example the open air), constituting the second or driven fluid mass, of at least one nozzle preferably of the convergent-divergent type, the vapour entraining the second fluid mass and leading it through said nozzle; where appropriate, means for effecting the total or partial separation of the liquid particles—resulting from the condensation of the aforesaid

vapour—from the second mass of entrained fluid; where appropriate, means for re-cycling the separated liquid towards the boiler; where appropriate, means for superheating the second fluid mass with or without a part or the whole of the first fluid mass, the said superheating means possibly being constituted by the device which heats the boiler; finally, at least one aperture through which the said secondary fluid mass, with or without a part or the whole of the first fluid mass, issues at a high speed.

In one embodiment, the liquid particles are separated by means of a series of tubes through which circulates a cooling fluid, for example a fluid constituting the first fluid mass.

In another embodiment, the liquid particles of the second mass are separated by centrifugal force.

The thermo-blower according to the invention is particularly suitable for use as a propulsion unit, for example for driving aircraft through the air and for moving ships and boats of all kinds over the water and under the water, and also for the propulsion of land vehicles.

A number of exemplary embodiments of the invention will now be described in detail, with reference to the accompanying diagrammatic drawings wherein:

Figure 1 is a longitudinal sectional view through a thermo-blower of the single-stage type, according to a first embodiment of the invention;

Figure 2 is a longitudinal sectional view through a three-stage thermo-blower of the same type as that illustrated in Figure 1;

Figure 3 is a longitudinal sectional view through a thermo-blower of a further embodiment wherein the liquid is separated by centrifugal force;

Figure 4 is a sectional view taken on the line IV—IV of Figure 3;

Figure 5 is a perspective view of the central portion of the thermo-blower shown in Figure 3;

Figure 6 is a longitudinal sectional view of yet a further embodiment of a multi-stage thermo-blower;

Figure 7 shows the application of a thermo-blower substantially of the type shown in Figure 1, to the propulsion of an aircraft;

Figure 8 is a side view of the aircraft of Figure 7;

Figure 9 is a longitudinal sectional view of a further embodiment of the thermo-blower;

Figure 10 is a section taken on the line X—X of Figure 9;

Figure 11 illustrates in cross-section another embodiment of a thermo-blower; and

Figure 12 is a sectional view taken on the line XII—XII of Figure 11.

Referring to Figure 1, it will be seen that a thermo-blower, according to the invention, comprises essentially a tubular boiler **1** heated by a burner **2**. A primary fluid, for example water, is heated to vaporisation in the tubular boiler **1** and the vapour is collected under pressure in the space **3** whence it passes via conduit **4**, and branches to pass on the one hand, to an annular chamber or compartment **5** and, on the other hand, to a chamber **6**. The vapour under pressure escapes from chamber **5** through an annular slot **7**, to pass to the convergent mouthpiece **61** of a nozzle **60**. The lip **8** of the slot **7** diverges (in a half plane limited by the axis YY of the chamber **5** and substantially of the thermo-blower) of the emergence axis (not shown) of the slot and ensures therefore the production of the physical effect known as "the Coanda effect" (described in the U.S. Patent No. 2,052,869). Hence a mass of air **11** constituting the second fluid mass is entrained in the first fluid mass. Likewise, vapour issues under pressure from the chamber **6** through an injector **9** and also entrains air **11**. The injector **9** and slot **7** are situated in the vicinity of the inlet end of the nozzle **60** which comprises the convergent portion **61**, a neck **10** and a divergent portion **12**.

The speed of movement of the mass of air **11** entrained by the vapour issuing under pressure through the injector **9** and the slot **7** is increased at the neck **10** and then diminished in the divergent portion **12**, whilst its pressure is increased.

In the nozzle **60**, the temperatures of the vapour particles and the air particles are substantially equalised, the air particles increasing their temperature, as they cool the vapour particles and cause a partial or complete condensation of said vapour particles. This condensation is facilitated on the one hand by the presence of cooling water in a reservoir **20** and on the other hand by the increased pressure which is produced in the divergent portion **12**.

A mass of air **11''**, charged with liquid particles, passes to the chamber **13** at the end of the divergent portion **12**.

Provided in the said chamber **13** are obstacles or baffles, which, as shown by way of example, are tubes **14** through which water from the reservoir **20** circulates, so that the liquid entrained by the mass of air arriving in the chamber **13** is deposited on the said tubes. The deposited water flows along the tubes **14** and is collected in a reservoir **15** arranged at the lower part of the chamber **13**. Liquid which collects in the reservoir **15** is passed to a reservoir **18** (which feeds the boiler **1**) by way of a conduit **16** and an injector **17** of the "Giffard" type.

Since part of the water entrained practically always remains in suspension in the air stream **11''** leaving the chamber **13** (and even, in certain cases, it is deliberately arranged that a part of the water in the form of liquid or in the form of vapour should remain in the said air mass), a second injector **19** draws a quantity of water through a conduit **21** from the reservoir **20** and passes it to the reservoir **18**. Water in the tubes **14** may discharge into the reservoir **15**. Conduits **34** bring the vapour from the space **3** to the injectors **17** and **19**.

If desired the mass of air **11''** leaving chamber **13**, can be superheated by placing the burner within chamber **13**. The air **11''** passes through the tubular boiler **1** to issue at high speed in the direction of the arrow **11'''** through an orifice **22'** formed in the end **22** of the thermo-blower.

The burner **2** is fed by fuel from the reservoir **23** through the conduit **23'**, a part of which may surround the burner **2** with a view of preheating the fuel, thus providing a better thermal efficiency of the means heating the boiler **1**.

The thermo-blower of Figure 2 is identical to the thermo-blower of Figure 1 except that it comprises three stages for ensuring the entrainment of the ambient air **11** by the water vapour arriving through the conduit **4**, and the transfer of heat from the vapour to the air.

In Figure 2 the same reference numerals have been used to designate those elements which correspond to elements of Figure 1. More particularly, it will be seen that there are three annular chambers **5** supplied with vapour under pressure from the conduit **4**, the vapor escaping from each chamber through an annular slot **7**, and that there are three chambers **6** each of which terminates in an injector **9**.

Each of the assemblies constituted by injector **9** and slot **7** delivers into the convergent portion **61** of the convergent-divergent or venturi nozzle **60**.

In a third embodiment of the invention illustrated in Figures 3 to 5, it is proposed to separate the liquid particles from the air mass by centrifugal force.

In the tubular boiler **1**, the water constituting the first fluid mass is vaporised by burner **2**. The vapor constituting the first fluid mass is collected in the space **3** whence it passes, via a superheater **1'** and conduit **4**, to be distributed into annular chamber **5** and chamber **6**. The vapour issues from chamber **5** through slot **7** similar to those of Figures 1 and 2.

The vapour issuing under pressure from slot **7** introduces the aforesaid Coanda effect and sucks in air **11** which constitutes the second fluid mass. Moreover, vapour issuing from injector **9** of chamber **6** wherein it is under pressure, also entrains air **11**. The injectors **9** and the annular slot **7** are arranged at the inlet of nozzle **60** comprising a convergent portion **61**, a neck **10** and a substantially cylindrical portion **12'**.

The vapour and air passing through the nozzle **60** reach a temperature equilibrium (by heating of the air and cooling of the vapour). The portion **12'** is followed by a divergent portion **12** in which are arranged a series of rings in the form of perforated dished members **25** (which can be seen particularly well in Figure 5), the dished members **25** having a well-defined configuration such as to deflect the air and vapour mass (which has already partially or wholly condensed) toward the periphery **26** of the said dished members. The mass of air and vapour **11'** then encounters blades **27** (see more particularly Figures 4 and 5) which impart rotational movement to the said mass. As a result, the liquid particles are projected by centrifugal force against the wall **28** of the thermo-blower; they are collected in the lower portion **15'** corresponding to the reservoir **15** of Figures 1 and 2. The water then passes through the conduit **16** and injector **17** of the "Giffard" type which directs it into the boiler **1**. The injector **17** receives vapour through the conduit **34** from the boiler **1**.

It is possible to provide a second injector **19**, also of the "Giffard" type, also receiving vapour through the conduit **34** from the boiler **1**, the said injector being intended to aspirate, through the conduit **21**, water from the reservoir **20'** surrounding the substantially cylindrical portion **12'** of the nozzle **60**, the water contained in the reservoir **20'** having a strong cooling action on the air and vapour mass **11'** in the portion **12'** of the nozzle **60**, thus effecting an improved condensation of the vapour contained in the said mass.

The air **11''**, wholly or partially freed of liquid particles, after passing between the straightening blades **29**, is heated by the burner **2** or, more accurately, by passing over the casing **2'** of the burner, and then passes along the tubular boiler **1** to issue through the aperture **22'** formed in the end **22** of the thermo-blower.

In the embodiment according to Figure 6, showing a multi-stage thermo-blower, divergent portions of annular cross-section are used instead of divergent portions of circular cross-section as in the embodiment of Figures 1 and 2, in order to reduce the length of the divergent portions.

In this embodiment, as in the other embodiments, there is provided a tubular boiler **1**, heated by a burner **2** receiving its fuel from reservoir **23** through a conduit **23'**. The vapour produced by the boiler **1** is collected in the space **3** from which it passes via the conduit **4**, to the annular chambers **5***a*, **5***b* and **5***c* and the chambers **6***a* and **6***b*. From the annular chambers the vapour issues under pressure through the annular slots **7***a*, **7***b* and **7***c* which are arranged in the same manner as the slots **7** in the forms of embodiment of Figures 1 and 2. Moreover, the vapour issues under pressure from the spaces **6***a* and **6***b* through the injectors **9***a* and **9***b* respectively.

The vapour issuing from the slots **7***b* and **7***c* and through the injector **9***b* entrains the ambient air **11** and causes it to pass into the nozzle **60***b* which comprises a convergent portion **61***b*, a neck **10***b* and a divergent portion **12***b*, the said divergent portion being annular instead of circular as in the embodiment of Figures 1 and 2.

In the divergent portion **12***b*, the vapour is wholly or partly condensed under the cooling effect to which it is subjected upon contact with the air **11**, which is colder than the vapour issuing from the slots 7b and 7c and the injector 9b. Furthermore, condensation is facilitated by the compression which takes place in the divergent portion 12b.

The mass 11'b of air and more or less condensed water is freed from at least a proportion of its liquid particles on the obstacles 30b. The liquid mass deposited is collected by the walls and, by way of the valves 31b, it reaches the conduit 21b which is arranged between the reservoir 20b and the reservoir 20a.

The air 11''b, thus freed of water particles, enters the chamber 33b in which it is once more accelerated by the vapour under pressure which issues from the injector 9a, which is similar to the injector 9b, and through the annular slot 7a which is similar to the annular slots 7b and 7c.

The slot 7a and the injector 9a open into the convergent portion 61a of a convergent-divergent or venturi nozzle 60a.

The mass of air and vapour 11'a increases its speed in the convergent portion 61a, then, after passing through the neck 10a, decreases its speed, whilst its pressure is increased, in the divergent portion 12a.

Under the cooling effect of the colder air and under the effect of the cooling effected by the water contained in the reservoir 20a, the vapour condenses in the divergent portion 12a and liquid drops are deposited on the obstacles 30a. The air 11''a, freed of liquid particles, arrives in a chamber 33a and thence, after being heated by the walls of the burner 2 and passing through the tubular boiler 1, issues through the orifice 22' at the end 22 of the thermo-blower, in the form of a gaseous jet 11'''. The water which has collected along the walls of the chamber 33a and the obstacles 30a passes through the valve 31a to pass into the pipe 16a with the water in the reservoir 20a. An injector 17 of the "Giffard" type, supplied by vapour through the conduit 34, directs the water in the conduit 16a into the tubular boiler 1.

In Figures 7 and 8, there has been illustrated as an example the application of a thermo-blower according to the invention to an aeroplane. Figure 7 illustrates very schematically, a thermo-blower of the type illustrated in Figure 1, except for the fact that it comprises two tubular boilers 1 each being fed by a burner 2. The two boilers 1 feed the annular chamber 5 and the chamber 6 with vapour under pressure. The vapour issues from the chamber 6 through an injector 9 and from the annular chamber 5 through an annular slot 7 of the same type as the slot bearing the same reference numeral in Figure 1, thus enabling the Coanda effect to be used. These two discharges of vapour entrain the air 11 from the forward portion 75 of the aircraft (the said air intake being of course facilitated by the movement of the aircraft).

The mixture of air and vapour is effected in the convergent portion 61 of the venturi nozzle 60 and after passing into the neck 10, the pressure of the mixture 11' of air and vapour is increased in the divergent portion 12 of the venturi nozzle 60.

Obstacles, constituted for example by tubes 14, arrest the water contained in the mass 11' and the air 11'', freed of its liquid particles, is then heated by the walls of the burners 2. It passes through the tubular boilers 1 to arrive in the spaces 35 formed in the wings 36 of the aircraft. This mass of hot air issues from the spaces 35 through slots 38 formed along the leading edges 37 of the wings. It is possible to arrange that the slots 38 are so formed as to use the Coanda effect, one of the lips of the slot diverging from the axis of emergence of said slot and following the configuration of the upper surface of the wing.

The air, issuing through the slots 38 creates an underpressure in front of the wings 36 and on the back of the said wings, thus increasing the supporting effect and reducing the drag on the aircraft.

A proportion of the hot compressed air passes through

the conduit 39 to arrive at the rear 40 of the fuselage; this air may be pre-heated by a burner 2a before issuing as a propulsive jet 11''' through the aperture 22' which is arranged at the rear end 22 of the fuselage.

It is also possible to provide slots 42 of the same type as the slots 38, at the fins 43, which are preferably arranged in V-formation to act as elevator and rudder planes (Figure 8).

The drawings also show the lateral nacelles 41 of the wings 36, and the lateral nacelles 44 of the fins 43.

The burners 2 and 2a are fed with fuel, which may for example be butane, which is advantageously stored in the lateral nacelles 41.

In the embodiments illustrated respectively in Figures 9 and 10 on the one hand and Figures 11 and 12 on the other hand, use is made of centrifugal force to separate the liquid droplets from the air in a snail-shaped member.

In the embodiment of Figures 9 and 10, a burner 2, which is supplied with fuel through a conduit 23' from a reservoir 23, heats a tubular boiler 1. Vapour under pressure arrives through a conduit 4 into the annular chamber 5 and into the chamber 6. The steam under pressure issues from the chamber 5 through a slot 7 of the type described hereinbefore, and from the chamber 6 through injectors 9. This vapour mass entrains air 11, and the air-stream mass 11' passes into a nozzle 12''. The steam is cooled by means (not shown) which may be of the type described and illustrated in the above-mentioned embodiment, and is condensed either wholly or partially. The mass of air and water arrives at a high speed in front of the annular deflecting blades 25 which direct the said mass towards the blades 27, which impart to the said mass a gyratory movement about the axis Y—Y.

Under the effect of centrifugal force, the liquid particles (resulting from the condensation of the vapour) are projected towards the periphery 28' of a snail-shaped collector 45; the liquid arrives, through apertures 46 formed between the elements 46', to a collecting space or conduit 49 and therefrom into a reservoir 15'' from which, through the conduit 16, it is re-cycled towards the boiler 1. The air 11'' issuing from the snail-shaped member 45 arrives under pressure into the conduit 70, is heated by the burner 2 and issues under pressure through the nozzle 71.

In the embodiment, which is given by way of example and is illustrated in Figures 11 and 12, the vapour produced in a boiler (not shown) arrives in the chambers 5' formed in a series of profiled members 72 of aerofoil cross-section, which are arranged substantially in a circular ring. The vapour under pressure issues from each chamber 5' through a slot 7', the rear lip 73 of which deviates continuously from the direction of outlet of the said slot (and establishes the line of the upper surface 48 of the aerofoil profiled members 72) in such a way as to use the Coanda effect. The vapour issuing through the slots 7' entrains the air 11 which arrives through the centre 47. Moreover, each member 6'' which also receives vapour under pressure from the boiler 1, increases the rotational movement of the air 11' which is charged with vapour.

Under the effect of this arrival of cold air 11, the vapour is condensed. The air, which is lighter, tends to remain in the vicinity of the profiled members 72, more particularly owing to the physical effect which is known as the "Coanda effect" which tends to make the gaseous stream adhere to the extrados surfaces 48; on the contrary, the liquid particles, which are heavier, tend to travel towards the periphery 28' of the snail-shaped member 45. The water droplets which accumulate on the periphery 28' pass through ducts 46 which are formed between the elements 46' and terminate in the conduit 49 which re-cycles them towards the boiler 1.

The air 11'', freed of liquid particles, and where appropriate after superheating, issues through the conduit 70 to be used to form a jet for propulsion, for example, of an aircraft, or any other vehicle, such as a land vehicle or a maritime craft.

Although the invention has been described with reference to certain specific embodiments thereof, it is to be distinctly understood that various modifications and adaptations of the arrangements herein disclosed may be made, as may readily occur to persons skilled in the art, without constituting a departure from the spirit and scope of the invention as defined in preamble and in the appended claims.

For example, the second fluid mass (namely the entrained fluid 11) may be constituted by a liquid, such as sea water (more particularly in the case of propulsion of a ship travelling over the surface of the water or of a submarine), the fluid constituting the first or driving mass and passing successively through the liquid, vapour and liquid phases (preferably in a closed cycle) being a fluid which is immiscible in its liquid state with the fluid constituting the second or driven mass, in such a manner as to make it possible to separate the said two fluids in the liquid state, for example by decantation, the condensed liquid (constituting the first fluid) being sent into the boiler with a view to later vaporisation, whilst the liquid constituting the second fluid mass is evacuated in the form of a jet under pressure and at high speed.

In the particular case where the first mass of fluid does not operate in a closed circuit, it is not necessary for the two fluids to be immiscible, for the final jet is constituted by the mixture of the two liquids. For example, in the case of the propulsion of a ship, sea-water, may, if necessary, be distilled in a boiler and transformed into steam, the said steam under pressure issuing through injectors and/or slots (slots of the type of those carrying the reference numeral 7 in the embodiment of Figure 1), in such a manner as to carry along supplementary sea-water, becoming condensed therein, the mass formed of condensed steam and sea-water issuing in the form of a jet under pressure in order to propel the ship.

I claim:

1. Apparatus for imparting a high speed to a driven mass of ambient fluid, comprising a boiler, heating means for said boiler, a liquid tank, means for feeding a driving fluid in the liquid state from said tank to said boiler, at least one chamber, conducting means for delivering vapors, under supra-atmospheric pressure, of said driving fluid, vaporized in said boiler, to said chamber, a mixing nozzle having an upstream converging portion starting with an entrance end open to said ambient fluid and a downstream diverging portion ending in an exit end, a discharge circular slot provided in said chamber, said slot having one lip thereof diverging in each radial plane from the axis of said slot and delivering said vapors in said converging portion of said nozzle, thereby inducing a driven mass of said ambient fluid through said entrance end, a tubular chamber having an upstream portion connected to said exit end of said nozzle, thereby receiving the mixture of said vapors and said induced ambient fluid, and a downstream portion ending in a discharge orifice, cooling means disposed in at least one portion of the zone consisting of said diverging portion of said nozzle, said upstream portion of said tubular chamber and the space surrounding immediately both last-mentioned portions, and liquid separating means disposed in said upstream portion of said tubular portion downstream of said cooling means, said liquid tank receiving the liquid separated from said mixture when cooled.

2. Apparatus as claimed in claim 1, wherein said boiler is disposed in said downstream portion of said tubular chamber and wherein said heating means are disposed in said tubular chamber downstream of said liquid separating means and upstream of said boiler.

3. Apparatus for imparting a high speed to a driven mass of ambient fluid comprising a boiler, heating means for said boiler, a liquid tank, means for feeding a driving non-combustible cheaply available fluid in the liquid state from said tank to said boiler, at least one chamber, at least one injector, conducting means for delivering vapors, under supra-atmospheric pressure, of said driving fluid, vaporized in said boiler, to said chamber and to said ejector, a mixing nozzle having an upstream converging portion starting with an entrance end open to said ambient fluid and a downstream diverging portion ending in an exit end, a discharge circular slot provided in the walls of said slot having one lip thereof diverging in each radial plane from the axis of said slot, said slot and said ejector delivering said vapors in said converging portion of said nozzle, thereby inducing a driven mass of said ambient fluid through said entrance end, a tubular chamber having an upstream portion connected to said exit end of said nozzle, thereby receiving the mixture of said vapors and said induced ambient fluid, and a downstream portion ending in a discharge orifice, cooling means disposed in at least one portion of the zone consisting of said diverging portion of said nozzle, said upstream portion of said tubular chamber and the space immediately surrounding both last-mentioned portions, and liquid separating means disposed in said upstream portion of said tubular portion downstream of said cooling means, said liquid tank receiving the liquid separated from said mixture when cooled.

4. Apparatus as claimed in claim 3, wherein said boiler is disposed in said downstream portion of said tubular chamber and wherein said heating means comprises a burner fed in fuel from a fuel reservoir and disposed in said tubular chamber downstream of said liquid separating means and upstream of said boiler.

5. Apparatus as claimed in claim 3, wherein said driving fluid is water and said ambient fluid is air.

6. Apparatus as claimed in claim 3, wherein said driving fluid is water and said ambient fluid is water.

7. Apparatus for imparting a high speed to a driven mass of ambient fluid comprising a nozzle having an upstream convergent portion open to said ambient fluid and a downstream divergent portion delivering in a tubular chamber ended by a discharge orifice, cooling means disposed in at least one substantial portion of the zone consisting of said divergent portion of said nozzle, the upstream portion of said tubular chamber and the space surrounding immediately both last-mentioned portions, liquid separating means in said tubular chamber downstream of said cooling means, a burner disposed in said tubular chamber downstream of said liquid separating means, a fuel reservoir, means for delivering fuel from said reservoir to said burner, a boiler in the downstream portion of said tubular chamber, means for collecting liquid separated by said separating means, a liquid tank receiving liquid from said collecting means and feeding liquid to said boiler, an annular chamber disposed around said convergent portion of said nozzle, conducting means for feeding a vaporized liquid from said boiler to said annular chamber, and a circular slot connecting said annular chamber to said convergent portion of said nozzle, said slot having one lip which diverges in each radial plane from the axis of said slot.

8. Apparatus as claimed in claim 7, wherein said ambient fluid is air.

9. Apparatus for imparting to an induced mass of driven fluid a high speed comprising a nozzle having a convergent upstream portion open to the ambient fluid, a cylindrical central portion and a divergent downstream portion, a snail-like centrifuge chamber communicating at the upstream end thereof with said divergent downstream portion of said nozzle, arcuate guide vanes in

said centrifuge chamber, a perforated baffle in the downstream portion of said centrifuge chamber, at a certain distance from the external partition thereof, a heating chamber communicating at the upstream end thereof with said downstream portion of said centrifuge chamber, said centrifuge chamber and said heating chamber forming a continuous tubular chamber, a burner in said heating chamber, a boiler in said heating chamber downstream of said burner, a fuel reservoir, means for feeding fuel from said reservoir to said burner, a liquid tank receiving the liquid collected by centrifugation in said centrifuge chamber through the orifices of said perforated baffle, means for feeding liquid from said tank to said boiler, an annular chamber disposed around said nozzle and communicating with said convergent portion thereof by a circular slot having one lip which diverges in each radial plane, from the axis of said slot, at least one injector delivering in said convergent portion, and conducting means for feeding said annular chamber and said one injector with vapors produced in said boiler by the vaporization of said liquid.

10. Apparatus as claimed in claim 9, wherein said ambient fluid is air and said liquid fluid is water.

11. A propulsion apparatus comprising, means defining a plurality of venturi nozzles arranged in tandem to discharge downstream into one another, means defining a chamber downstream of the nozzles, a boiler in said chamber downstream of said nozzles for vaporizing a liquid therein, means for providing a vaporizable liquid to the boiler, for each venturi nozzle an injector disposed coaxially therewith substantially at the beginning of each nozzle, for each nozzle means for imparting velocity to a relatively large volume of air with a substantially smaller volume of fluid under pressure comprising means defining an annular slot disposed coaxially with said injector and opening into its corresponding nozzle, means to provide vapor under pressure from said boiler to said injectors and through said slot to cause an airstream to flow through said nozzles at increased speed and thereby converting the kinetic energy of the airstream to pressure rise in the nozzles, means comprising cooling tubes disposed downstream of said nozzles and upstream of said boiler for removing liquid particles carried by the airstream, means to return the liquid removed from the airstream to said boiler, and means defining an outlet orifice for said airstream downstream of said boiler.

12. A propulsion apparatus comprising, means defining a venturi nozzle, means defining a first chamber downstream of the nozzle, a boiler in said chamber for vaporizing a liquid therein, means for providing a vaporizable liquid to the boiler, means for imparting velocity to a relatively large volume of air with a relatively smaller volume of fluid under pressure to convey the air through said nozzle to convert the kinetic energy thereof to pressure rise comprising, an injector disposed coaxially with said nozzle substantially at the entrance thereof and positioned to discharge in a direction downstream through said nozzle, means defining a second chamber provided with an annular slot disposed coaxially with said injector and arranged to open into said nozzle, means to convey the vaporized fluid under pressure from said boiler to said second chamber and to said injector, means to impart rotational velocity to the airstream adjacent the nozzle to remove liquid particles carried by said airstream, means to return the liquid removed from the airstream to said boiler, and means defining an outlet orifice for said airstream.

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