Nov. 1, 1938. H. REDON 2,134,890

MEANS FOR MATERIALIZING THE STREAMLINES OF A FLUID

Filed June 15, 1936 2 Sheets-Sheet 1

Fig. 1

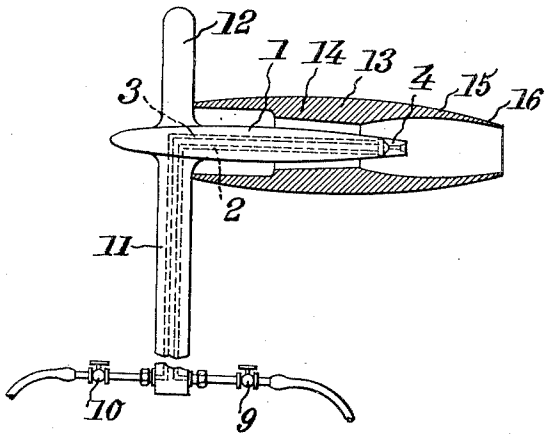


Fig. 2

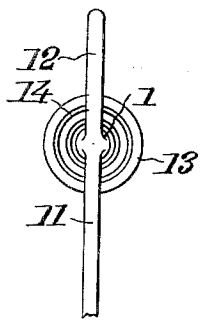


Fig. 3

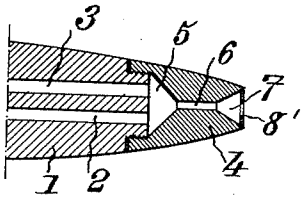


Fig. 4

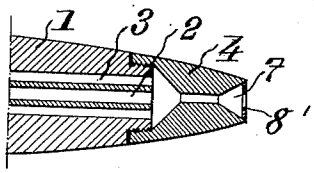
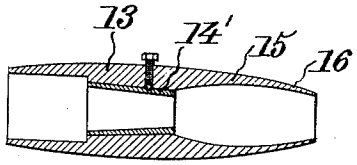


Fig. 5



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Fig. 6

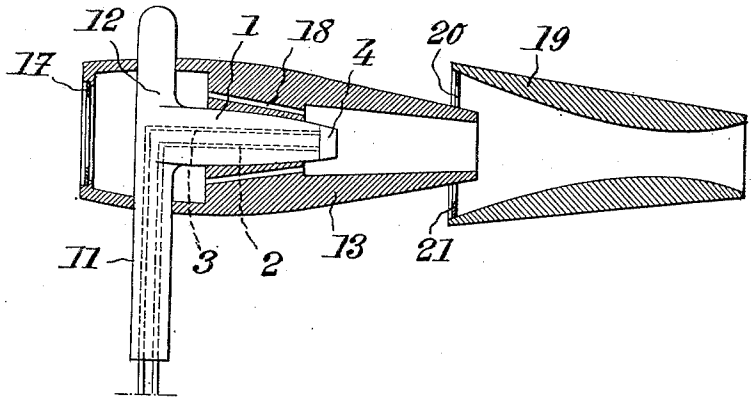
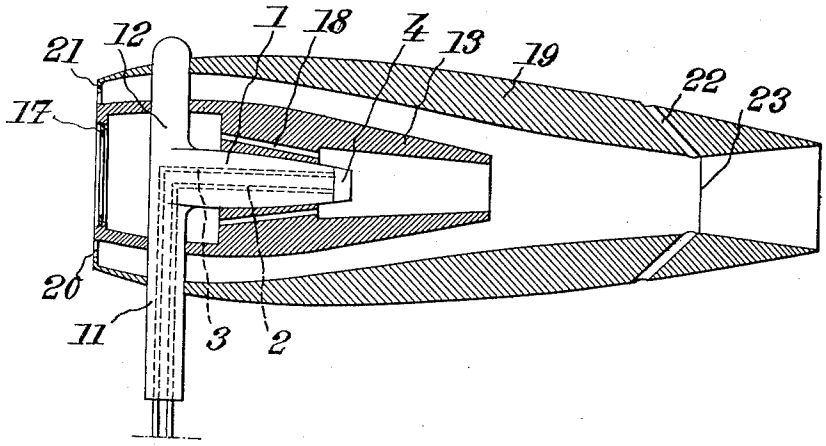


Fig. 7



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MEANS FOR MATERIALIZING THE STREAMLINES OF A FLUID

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18 Claims. (Cl. 73—51)

The present invention relates to means for materializing the streamlines of a fluid, that is to say means for permitting the observation of said lines especially when a light beam is directed thereon. The invention is more especially, although not exclusively, concerned with means for materializing the streamlines corresponding to the flow of air around a solid body.

The object of the present invention is to provide a method and apparatus which are better adapted to meet the requirements of practice and, in particular, which permit a more accurate observation of said streamlines.

The essential feature of the present invention consists in emitting, through suitable means, located ahead of the streamlines to be observed, a succession of elements, and especially soap bubbles or the like, formed in such manner that the resultant of the forces acting on said elements is substantially in the direction of the fluid streamlines, and that the inertia of said elements is as low as possible.

Another feature of the present invention consists in providing apparatus for emitting substances intended to materialize the airstreams of a fluid with means for modifying, and preferably adjusting in a continuous manner, the rate or flow of said fluid about the outlet of said apparatus, especially with a view to keeping said rate of flow substantially uniform.

According to still another feature of the present invention, the apparatus is further provided with means for causing the elements emitted by said apparatus to take up gradually the velocity of the surrounding stream.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:

Fig. 1 is an elevational view, with some parts in section, of an apparatus for emitting bubbles made according to the present invention;

Fig. 2 is an end view corresponding to Fig. 1;

Fig. 3 is a sectional view, on an enlarged scale, of a portion of the apparatus of Fig. 1;

Fig. 4 is a sectional view, similar to Fig. 3, of a modification;

Fig. 5 is a sectional view, on an enlarged scale, of an element of the apparatus, made according to a modification;

Fig. 6 is a sectional view of an apparatus made according to another modification of the invention, embodying certain other features;

Fig. 7 is a view, similar to Fig. 6, corresponding to still another modification.

It will be supposed, in the following description, that it is desired to provide a wind tunnel for studying the coefficients of aerodynamic resistance of different bodies with means for materializing the streamlines of air flowing around said bodies.

Up to the present time, this result was obtained by making use of the differences of refractivity of the airstreams as a function of their temperature.

Another method employed prior to this invention consisted in emitting smoke across the path of the streamlines to be materialized. But this method can be applied only in the case of plane streamlines (curvature of said lines outside of their planes producing a diffusion of smoke and therefore a confusion of the trajectories of the different streamlines), and in the case of relatively low rates of flow of the fluid (too high a velocity of flow dispersing the smoke elements).

In order to obviate this drawback, according to the present invention, there is provided, ahead of the streamlines to be observed, means for emitting a succession of elements of such a nature that the resultant of the forces acting on said elements is in the direction of the flow of the airstream, and that, preferably, they have as little inertia as possible.

These elements may, for instance, consist of bubbles and especially, as it will be hereinafter supposed, small soap bubbles inflated with air or any other gas, coloured or not, laden with smoke, dust, or the like.

Such bubbles have, besides the advantage inherent in their small inertia, the advantage of presenting, by reflection, very bright points when they are illuminated by means of a light beam.

Concerning the frequency of emission of said bubbles, it is advantageously so chosen that, account being taken of the persistency of luminous sensations, the eye does not detect any interruption between the passage of one bubble and that of the next one, the trajectory of said bubbles therefore having the appearance of a luminous ribbon.

As for the apparatus for the emission of said soap bubbles, it is made in such manner that an air stream under pressure acts on soapy water so as to form bubbles which are strong enough for moving through the useful path of tavel without bursting, small enough for permitting the

observation of streamlines close to the body and of inertia sufficiently low for permitting them to adapt themselves to any curve of the trajectory.

In the drawings, I have shown by way of example, an embodiment of such an apparatus.

In this embodiment of the invention, the main part of the apparatus consists of a streamlined body 1 mounted, through any suitable fixation means, in the wind tunnel, coaxially with the streamlines to be observed, and ahead of the body the aerodynamical properties of which are to be studied. In this body 1 there are provided two conduits 2 and 3, fed with air under pressure and soapy water, respectively. Of course this water may contain any suitable matter facilitating the formation of the bubbles.

In an embodiment of the invention, corresponding to Fig. 1, and as shown in a more detailed manner in Fig. 3, the respective air and water conduits are disposed side by side.

According to another embodiment of the invention the respective air and water conduits are arranged coaxially, air being preferably fed through the inner, or central conduit, as shown by Fig. 4.

Of course, the invention is not limited to these specific arrangements of the conduits.

Body 1 is provided, at its end, with a nozzle 4 intended to facilitate the formation and the outflow of the bubbles.

Advantageously, according to the present invention, this nozzle includes the following parts:

a. A conical chamber 5 against the walls of which the soapy water slips with a capillarity effect;

b. A narrow channel or passage 6 (of a diameter of some tenths of millimeter) inside which said water is collected; and,

c. An inverted cone 7 along the walls of which the bubble is formed, said bubble detaching itself from the edge limiting the outlet 8 of said cone.

The apparatus, including the arrangement above described, is further provided with means for adjusting the size and weight of the bubbles.

These means may consist in the provision of valves 9 and 10 on the conduits 2 and 3, respectively, through which water and liquid are fed to body 1, so as to permit of varying the respective pressures of these fluids.

It is also possible, in order to vary the size and weight of the bubbles, to modify the area of the outlet 8 of nozzle 4.

This last mentioned result can be obtained by providing a set of nozzles having different outlets and adapted to be fitted, in a removable manner, upon the end of the streamlined body 1, for instance by screwing them on said end.

It is also possible to arrange said outlet in such manner that its section is adjustable.

Such an adjustment could be obtained by partly filling up the base 8 of cone 7 with a diaphragm 8' of the kind of those used in connection with photographic apparatus.

Alternately, the walls of said cone might be made of an elastic material capable of being compressed or expanded by jaws of suitable shape.

Of course, these indications do not exclude the possibility of making use of other arrangements.

It should be noted that, when the streamlined body 1 is carried by an arm 11 at right angles to said body, the apparatus just above described advantageously should include a dummy arm 12, extending along a certain length symmetrically to arm 11 with reference to streamlined body 1, in order to avoid any lack of symmetry in the flow of air which might interfere with the smooth and rectilinear outflow of the bubbles. Such an arrangement is visible in Figs. 1 and 2.

The working of the apparatus above described is believed to be obvious enough for making it unnecessary to describe it in detail. This way of materializing air streamlines formed about a body has, over the methods used prior to the present invention, the following advantages:

a. It permits the observation of the streamlines of a fluid flowing at very high velocity;

b. It permits of materializing streamlines of very considerable curvature;

c. It ensures a materializing of the streamlines which permits of easily photographing them when said streamlines are illuminated by means of a lightbeam of high intensity.

The device for materializing streamlines is sufficient per se, but its efficiency is increased by making use of the following features, which may, eventually, be employed separately.

According to one of these features, which will be hereinafter supposed to be used in combination with an emitting apparatus such as that just above described, and which is especially advantageous when the flow of air takes place with a high velocity, the apparatus above described further includes means for adjusting, preferably in a continuous manner, the velocity of the flow of fluid in the vicinity of the outlet 8 from which the bubbles are driven along by the streamlines to be materialized. With such an arrangement, it is possible to keep this velocity substantially uniform. Advantageously, means are further provided for causing the bubbles to take on, in a gradual manner, the velocity of the surrounding flow of fluid.

The advantage of such an arrangement results from the fact that, when the rate of flow of the fluid is very high, it is advantageous, in order to permit of increasing the diameter of the bubbles and therefore of reducing their thickness and their mean density, to reduce said rate of flow in the vicinity of outlet 8 and to devise means for keeping said rate of flow at a value corresponding to the formation of bubbles of the optimum diameter and thickness.

For this purpose, concerning the means for adjusting the velocity of the flow of fluid, I advantageously make use of an annular body 13 which is disposed around the streamlined body 1. Said annular body 13 is provided with a part 14 of restricted cross section located ahead of outlet 8, and with an expansion chamber 15 corresponding to said outlet. Advantageously, this chamber is prolonged by a funnel 16 the outlet diameter of which depends upon the size of the bubbles and which guides the bubbles issuing from the emitting apparatus, thus preventing them from taking a pulsatory motion which would produce a dispersion of the streamlines.

It will be readily understood that, by varying the dimensions of the annular part 14 of restricted section, it is possible to modify the rate of flow of the bubbles and therefore their diameter.

In order to obtain this result I may make use of the arrangement disclosed by Fig. 5, in which the walls of the part of restricted cross section consist of a removable element 14' fixed to the annular body 13. Of course, I may provide a whole series of elements similar to 14' but having different respective inner diameters, so as to permit, by substituting an element 14' by an-

other one, of modifying the annular space existing between the inner surfaces of said elements and the streamlined body 1.

I might also provide, in order to adjust the dimensions of this annular space, a continuous system of the kind of those above referred to for modifying the aperture of the inlet cone of the emitting apparatus. For instance, as shown by Figs. 6 and 7, this system consists of a diaphragm 17 adapted to be more or less opened, means, such for instance as regulating conduits 18, being advantageously provided for remedying the perturbations caused, in the flow of the fluid, by said diaphragm and also by arms 11 and 12.

Concerning now the means for causing the bubbles to gradually take on the velocity of the surrounding stream of fluid, they consist of a device which is positioned, at least partly, behind nozzle 4, this device being arranged in such manner that it reduces, or, on the contrary, increases the velocity at which the bubbles are driven along, according as the rate of flow of the air streams at the outlet of said nozzle is higher or lower than the velocity of the surrounding air stream.

In any case, this device advantageously consists of at least one nozzle or tube 19, arranged coaxially to streamlined body 1 and annular envelope 13. Advantageously, this tube 19 is devised in such manner as to leave, between its front inner wall and said envelope 13, an annular orifice 20, preferably adjustable, in which the airstreams of the main flow can enter annular element 19 and modify the velocity with which the soap bubbles flowing through said element are driven along.

I may, for instance, make use, for this purpose, of a diaphragm 21, of the kind of those employed in connection with photographic apparatus.

When applying the device shown in Fig. 6, I may make use of a mechanism permitting of producing an axial displacement of tube 19 and therefore of varying the section of orifice 20.

Concerning now the shape of tubular member 19, it is of course different according as it is desired to slow down or, on the contrary, to accelerate, the movement of the soap bubbles.

In the first case, tubular member 19 must be given a divergent shape, whereby the portions of the air stream that enter said member 19 are caused to slow down. Preferably, the tubular member will be so shaped that the airstreams issuing therefrom have a direction parallel to that of the surrounding stream of air. For this purpose, the rear end of tube 19 is given a substantially cylindrical shape.

In the second case (when it is desired to accelerate the movement of the soap bubbles) which seems to be more frequent than the first one, tubular member 19 is given, as shown by Figs. 6 and 7, a convergent shape over at least a portion of its length. The air streams are then given, in the zone of restricted section, a velocity higher than that of the surrounding stream and they ensure, in an efficient manner, the acceleration of the movement of the soap bubbles. In this case, the rear end of tube 19 may be provided with a slightly divergent portion facilitating the release of the soap bubbles into the main air stream.

I may also, taking into account what has just been explained, provide many alternative constructions of this tubular part 19.

According to an embodiment, shown by Fig. 6, tube 19 is arranged in such manner that it surrounds only the rear end of envelope 13.

According to another embodiment, shown by Fig. 7, said tube 19 is arranged in such manner that it wholly surrounds the remainder of the apparatus, whereby the air entering through annular orifice 20 is taken from a zone in which the flow takes place in a regular manner.

Although an apparatus made as above described is capable of giving very satisfactory results, I have found that it is advantageous to make use of still another feature of the invention consisting, while giving tubular element 19 a convergent divergent shape, in providing, in the walls of said element, channels 22 adapted to place the portion of minimum section, or neck 23, in communication with the surrounding stream of air.

It will be readily understood that there is then produced, through said channels, a certain suction effect which compels the air streams to move along the walls of the emitting apparatus as far as the rear end thereof, whereby the soap bubbles issuing from the apparatus are not surrounded by a mass of air flowing at a reduced velocity, which might render them unstable.

The apparatus according to the present invention has, in addition to the advantages just above stated, the following special advantages:

a. It materializes the air streams in a very sharp and accurate manner over the whole of their length, since the characteristics of soap bubbles correspond to the best possible conditions of observation and they are released only when they have been given the velocity corresponding to the flow of the surrounding air stream;

b. There are no variations in the trajectories or paths of travel of several successive bubbles.

Of course, the invention is not limited merely to the case in which the elements that materialize the air streams are soap bubbles. These elements might be homogeneous particles, such for instance as kind of flakes.

It should also be well understood that the invention could serve to materialize the lines of flow of a liquid.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A method of materializing the streamlines of a fluid flowing around a body which comprises producing and thereafter introducing, ahead of the streamlines to be observed, a succession of soap bubbles arranged on a line of which the cross section thereof is substantially equal to that of a single soap bubble.

2. An apparatus for materializing the streamlines of a fluid flowing around a body, located within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body adapted to be disposed coaxially with the fluid streamlines to be observed, two conduits in said rounded body for the feed of air under pressure and soapy water, respectively, and means, at the rear end of said rounded body for the formation and the release of the bubbles.

3. An apparatus for materializing the stream-

lines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body arranged to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, means for feeding soapy water to said nozzle, and means for feeding air under pressure to said nozzle, so as to transform said soapy water into soap bubbles and to drive them out through said nozzle.

4. An apparatus according to claim 3 in which said nozzle includes a conical chamber at its front end, a narrow channel connected with said chamber, and a conical outlet at the opposite end of said channel for formation of the soap bubbles along its wall.

5. An apparatus for materializing the streamlines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body adapted to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, for formation and delivery of soap bubbles, means for feeding soapy water to said nozzle, means for feeding air under pressure to said nozzle, so as to transform said soapy water into bubbles and to drive them out through said nozzle, and means for adjusting the size and weight of said bubbles.

6. An apparatus for materializing the streamlines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body adapted to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, for formation and delivery of soap bubbles, means for feeding soapy water under pressure to said nozzle, means for feeding air under pressure to said nozzle so as to transform said soapy water into bubbles and to drive them out through said nozzle, and means for varying the feed pressure of at least one of said feeding means.

7. An apparatus according to claim 6 in which the last mentioned means consist of valves adapted to cooperate with the means for feeding air under pressure and the means for feeding soapy water, respectively.

8. An apparatus for materializing the streamlines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body adapted to be arranged in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body for formation of soap bubbles, said nozzle having an outlet aperture through which the soap bubbles are discharged, means for feeding soapy water to said nozzle, means for feeding air under pressure to said nozzle so as to transform said soapy water into bubbles and to drive said bubbles out through said nozzle, and means for adjusting the area of said outlet of the nozzle.

9. An apparatus according to claim 8 in which the last mentioned means consist of a diaphragm of variable opening fitted on said nozzle outlet.

10. An apparatus according to claim 2 further including an arm for supporting said rounded body in said airstream, and another arm, symmetrical with the first one about the axis of said streamlined body, intended merely to avoid disymmetry of the flow of fluid around said rounded body.

11. An apparatus for materializing the streamlines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body arranged to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, means for feeding soapy water to said nozzle, means for feeding air under pressure to said nozzle, so as to transform said soapy water into soap bubbles and to drive them out through said nozzle, said bubble forming means comprising an annular body disposed in coaxial relation with said rounded body, said annular body including a portion of restricted section ahead of the nozzle outlet, and an expansion chamber after said outlet.

12. An apparatus according to claim 11 further including means for varying the size of said portion of restricted section.

13. An apparatus according to claim 11 further including an adjustable diaphragm fitted on said annular body for adjusting the velocity of the stream of fluid around said nozzle, said annular body being provided with channels for eliminating perturbations resulting from the presence of said diaphragm.

14. An apparatus for materializing the streamlines of a fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body arranged to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, means for discharging soap bubbles through said nozzle, said bubble forming means being adapted gradually to impart to said bubbles a velocity equal to that of the stream of fluid the streamlines of which are to be observed.

15. An apparatus for materializing the streamlines of a stream of fluid within means for guiding the flow of a gaseous fluid in predetermined directions and which comprises bubble forming means having a rounded body arranged to be disposed in coaxial relation with the fluid streamlines to be observed, a nozzle at the rear end of said body, means for discharging soap bubbles through said nozzle, said bubble forming means comprising an annular envelope surrounding said body having a portion of restricted section ahead of said nozzle and an expansion chamber at the rear thereof, for regulating the velocity of said fluid around said nozzle, said bubble forming means further comprising a tubular body coaxially surrounding both said streamlined body and said envelope, so as to leave an annular orifice between the inner wall of said tubular body and the outer wall of said envelope, the shape of said tubular body being calculated to gradually impart to said bubbles a velocity equal to that of the surrounding stream of fluid.

16. An apparatus according to claim 15 further including means for varying the area of the annular orifice provided between said tubular body and said envelope.

17. An apparatus according to claim 15 in which said tubular body wholly surrounds the remainder of the apparatus.

18. An apparatus according to claim 15 in which said tubular body has a convergent-divergent shape, said body being provided with channels connecting the inside thereof where the cross section is minimum with the surrounding atmosphere.

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