April 22, 1952 — J. Y. COUSTEAU — 2,593,988

DIVING APPARATUS

Filed March 26, 1947 — 2 SHEETS—SHEET 1

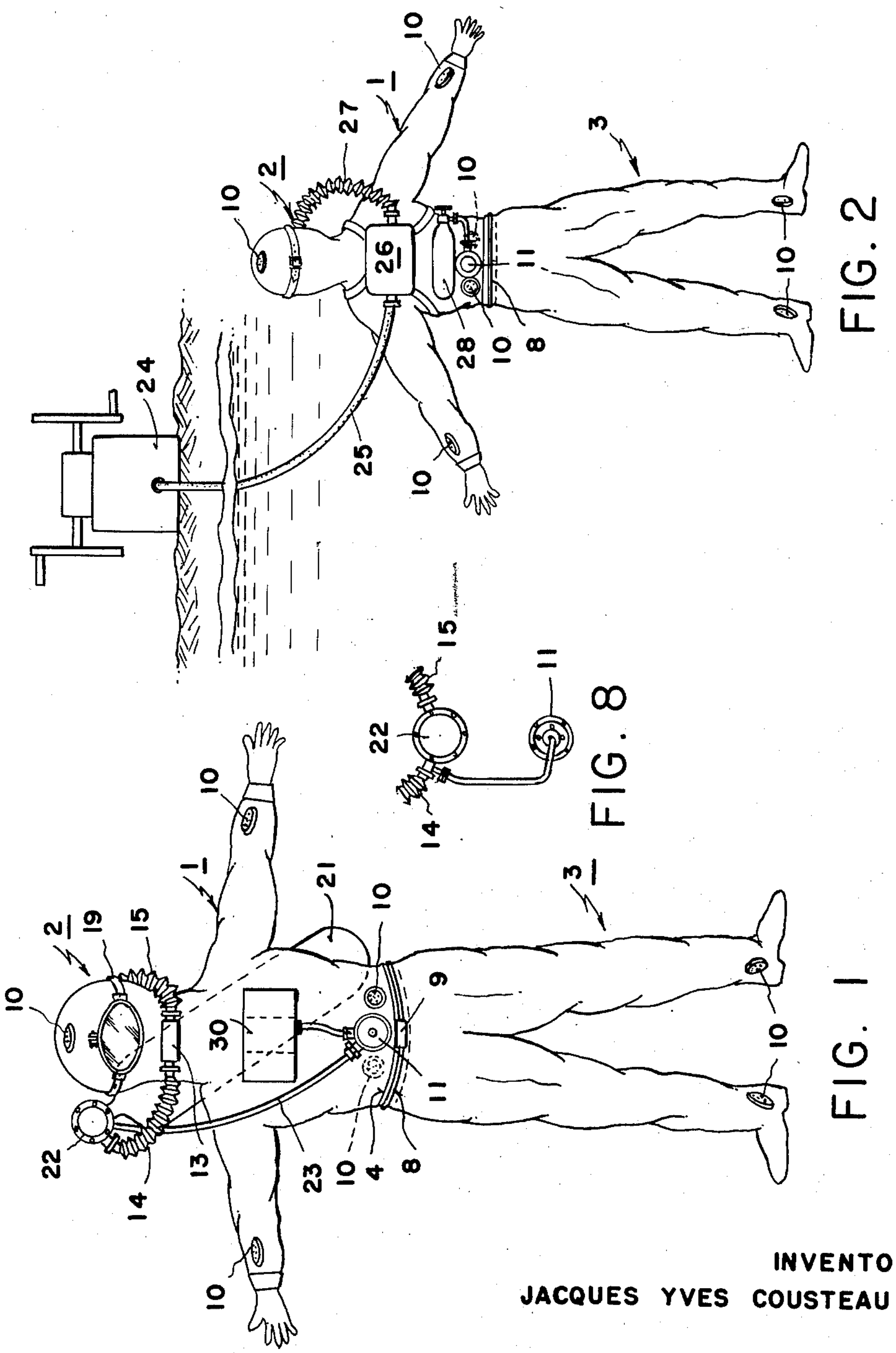

FIG. 2

FIG. 8

FIG. 1

INVENTOR

JACQUES YVES COUSTEAU,

BY Stone, Boyden & Mack

ATTORNEYS

DIVING APPARATUS

Filed March 26, 1947 2 SHEETS—SHEET 2

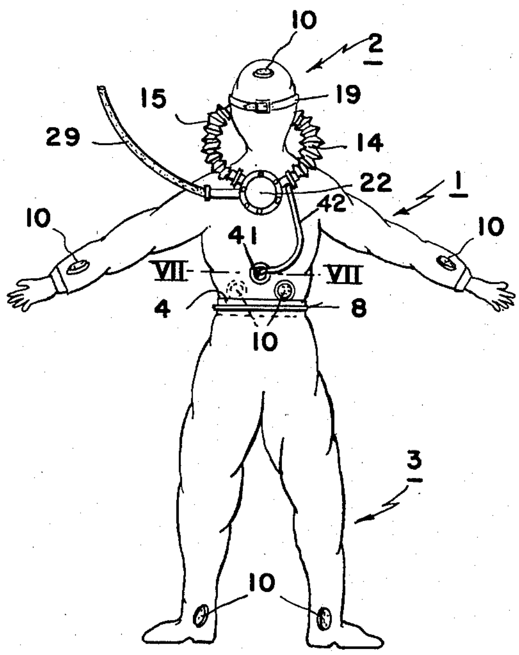

FIG. 3

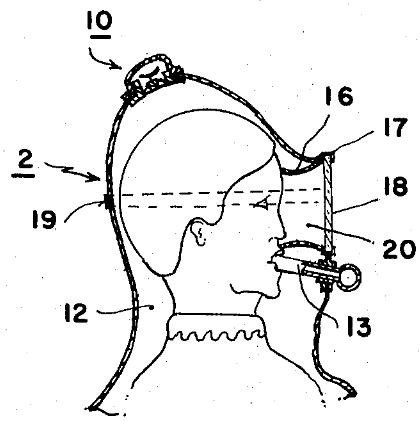

FIG. 4

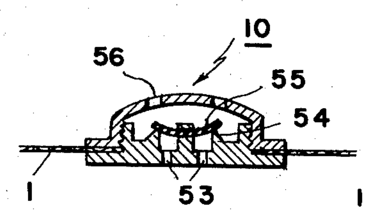

FIG. 5

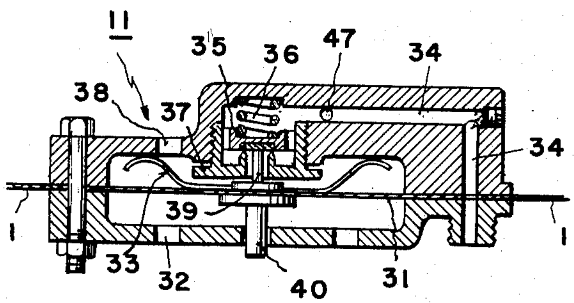

FIG. 6

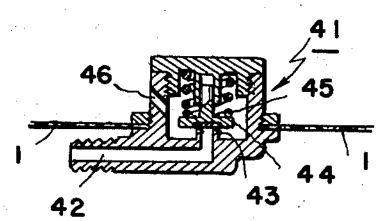

FIG. 7

INVENTOR
JACQUES YVES COUSTEAU,

BY Stone, Boyden & Mack.
ATTORNEYS

Patented Apr. 22, 1952

2,593,988

UNITED STATES PATENT OFFICE

2,593,988

DIVING APPARATUS

Jacques Yves Cousteau, Paris, France

Application March 26, 1947, Serial No. 737,325
In France April 2, 1946

4 Claims. (Cl. 128—144)

1

Existing non-rigid diving-suits present several drawbacks, the chief of which are the following:

1. The differences of pressure between the surrounding medium and the space between the suit and the body of the diver are not automatically adjusted. They may therefore be raised to dangerous figures, especially when an accident occurs, for instance if a pipe breaks or the diver falls.

2. The above mentioned intermediate space is not invariable. This may entail variations in buoyancy which may give rise to grievous casualties such as "blowing-up" etc.

These difficulties limit to a considerable extent the depth which may be reached and are moreover liable to bring about physiological accidents which are often fatal to the diver.

The diving apparatus according to this invention does not present any of the aforesaid drawbacks.

It comprises a breathing apparatus and a non-rigid water-tight suit in which obtains a gas pressure constantly equal to, or slightly lower than, that which obtains in the water at the highest point of that non-rigid part of the suit which is liable to get off the diver's body.

Inasmuch as the gas cushion formed between the suit and the diver's body on account of the under-garments and the unevenness and folds of the suit is everywhere under a pressure at most equal to that obtaining in the water at the highest point of the non-rigid part of the suit, this part is entirely pressed against the diver's body and there never occurs any inflation modifying the buoyancy.

The non-rigid part always comprises the chest, which is therefore, through the medium of the suit pressed against it, subjected to the pressure of the water at its level. Since this pressure is also necessarily substantially that of the breathing circuit, the latter works under a pressure higher than that obtaining inside the suit.

In order to constantly remain near the pressure of the water, the pressure of the atmosphere inside the suit must be increased when the diver sinks. Several means of obtaining this result will be stated hereinafter. On the other hand the pressure of the atmosphere inside the suit must be lowered when the diver rises again. This may be obtained by providing a gas outlet valve near the point of the non-rigid part of the suit which is nearest to the top of the diver's head. At least another valve may also be provided at another place of the non-rigid part in the event this point might happen to become the highest point of the diver when he is in the water. If for instance a valve is provided on the diver's back he may stoop without his suit ceasing to be pressed against him everywhere by the external pressure of the water. Other outlet valves may also be provided on the abdomen and the extremities of the legs and arms of the suit. In that case the diver may assume any position without his suit ceasing to remain entirely pressed against him, whereas in the usual devices of the prior art the diver cannot assume every position, for instance, head downwards.

2

Other features and advantages of the present invention will appear as the following description will proceed and from the accompanying drawing in which a few forms of embodiments of the invention have been shown diagrammatically and by way of example only.

In the drawings in which the same reference numbers designate identical parts:

Fig. 1 is a front elevation view of a self-sufficient diving apparatus designed according to the invention;

Fig. 2 is a back elevation view of an apparatus the breathing circuit of which is supplied from the surface by a pump, the interior atmosphere of the suit being supplied by a separate source carried by the diver;

Fig. 3 is a back elevation view of an apparatus in which a common source of moderate pressure air placed above the surface supplies at the same time the breathing circuit and the interior atmosphere of the suit;

Fig. 4 is a section, on a larger scale, of a hood which may be a part of the suit;

Fig. 5 is an axial cross section of an outlet valve;

Fig. 6 is an axial cross section of a pressure regulator controlling the admission of gas into the suit;

Fig. 7 is a cross section according to line VII—VII of Figure 3 of a valve capable of performing the same function as the regulator;

Fig. 8 is a view of an arrangement which may be substituted for the valve shown in Fig. 7.

In the apparatus shown in Fig. 1, and parts of which are shown in greater detail in Figs. 4, 5 and 6, the non-rigid suit is composed of two parts: an upper part 1, comprising the hood 2 for the head, sleeves and a jacket, and a lower part 3 consisting of the trousers. These two parts are tightly connected over a belt 4 by means of a cord 8 which is itself tightened by means of a clamping device diagrammatically indicated at 9.

Outlet valves 10 are placed at the top of the hood 2, at the ends of the sleeves, at the bottom of the trousers legs and in the middle of the body on the abdomen and the back. The tightness-securing system of each sleeve wristband may perform itself the part of a valve. Should the diver's dressing gear comprise rigid parts, the valves should be placed at the extremities of the non-rigid part of the suit. For instance they should be worn not at the feet, as shown, but near the knees or even higher if the diver wore boots, leggings or tights.

Whatever the diver's position may be, the pressure applied by water to the suit decreases from the lowest to the highest part of said suit. Since the latter is not rigid, it is applied against the diver's body more or less closely according to the vertical distance which separates the part of the suit under consideration from the surface of the water, by forcing the gas closed in the suit towards the highest part of the suit from which the gas is discharged in water through the outlet valve provided at said highest part as long as the gas pressure is greater than the water pressure on said valve. In that manner the suit is substantially applied on the diver's body and its inner capacity remains constant.

Fig. 5 shows in cross-section an outlet valve of a suitable type. It essentially consists of a casing which encloses a flexible sheet **55** for instance of India rubber, and is provided with ports **53** in its portion inside the suit and openings **56** in its portion lying in the water. The sheet is raised off its seat and allows gas to escape from the suit into the water when the pressure within the suit becomes higher than that in the water at the level of the valve.

The suit is provided with a diaphragm pressure regulator **11**, the diaphragm of which is, on its external surface, subjected to the pressure of the water, and which causes the inlet of air into the suit when the differences between this pressure and that which obtains inside the suit becomes slightly greater than the pressure of a water column the height of which is the distance between the diaphragm and the farthermost valve. Thus, when the diver sinks, air is admitted into the suit, but always under such low pressure, that it cannot escape through any valve, whichever position the diver may assume. The difference between the pressure difference for which the regulator works and the pressure of the above defined water column is of course chosen as low as possible so as to reduce to a minimum the value by which the pressure within the suit is smaller than the external pressure. This difference represents the margin for safety which is necessary so that a satisfactory working of the system composed of the regulator and the valves may be safely obtained. It is in practice of the order of a few decimeters of water, for example of 25 to 50 cm.

Fig. 6 shows in cross section a pressure regulator of a suitable type, mounted on the upper part **1** of the suit, a fragment of which only is shown in this figure.

The most essential part of the regulator is its diaphragm **31**, which is in alignment with the suit **1**. This diaphragm is subjected on its outside face (the lower face in the drawing) to the pressure of the water owing to holes **32** provided in the regulator casing. It is further subjected on its inside face, to the action of a spring **33** and, owing to a port **38**, of the pressure obtaining within the suit. It is connected through a spindle **39** with a valve member **35** which is pressed against its seat **37** by another spring **36**. The compressed air coming from a source outside the suit and to be expanded, flows in the regulator through a channel **34**. When the outside water pressure increases with respect to the pressure within the suit, the diaphragm is deflected towards the inside (upwardly in the drawing), the valve member **35** is lifted off its seat **37**, and air is admitted into the suit.

The regulator **11** is placed at substantially equal distances from the farthermost valves, that is, approximately in the middle of the body when the lowermost valves are placed at the feet. The value by which, when the diver sinks, the pressure inside the suit is smaller than the pressure outside is thereby reduced to a minimum.

A compressed air cylinder **21**, which the diver carries on his back and which, in order that it may be seen more easily, has been represented raised and inclined, serves the twofold purpose of supplying the suit and the breathing apparatus. The cylinder **21** carries a pressure regulator **22** the diaphragm of which is also, over its outside face, subjected to the pressure of the water. The pressure regulator **22** preferably is of the type described in the United States Patent No. 2,485,039 which was granted on October 18, 1949. The air expanded in the regulator **22** serves to supply the diver with breathing air. The regulator **11** is directly supplied from the cylinder **21** through a pipe **23**. The breathing circuit diagrammatically shown at **13**, **14** and **15** is that described in the United States Patent No. 2,485,039, but any other breathing circuit might also be used, either, as that shown, of the open cycle type, that is, in which the air breathed out is expelled into the water, or of the closed cycle type, in which the air breathed out is regenerated by being passed over suitable substances, and then breathed in again.

The breathing circuit is separated from the atmosphere within the suit, in which a lower pressure is obtaining. For this purpose (see Fig. 4) a mouthpiece **13** which is of a type well known in the art tightly passes through the hood **2** owing to a joint. The nose is also isolated by a mask which also encloses the eyes and comprises an India rubber or similar substance skirt **16** tightly pressed against the face, and a window **17** bearing a transparent glass **18**. The mask is held well applied on the face by means of thin straps **19**, which are preferably fastened outside the joint-cramping frame of the window glass so that they may be adjusted and tightened after dressing.

The window glass **18** is preferably removable or may at least be opened easily so as to enable the diver to rapidly shift to normal respiration as soon as he is out of the water and also to clean the glass after dressing.

The rod **40** (Figure 6) mounted externally on the diaphragm **31** allows the diver to admit air directly into the suit without passing through the controlling action of the regulator **11**. The diver can thus, when working in certain positions (lying flat for instance) suppress or lower the slight pressure drop which otherwise could obtain within the suit.

By pushing upon the rod **40**, the diver moves the valve member **35** of the regulator off its seat **37**, thus enabling the air to flow through the regulator and penetrate into the suit.

In the form of embodiment shown in Fig. 2. the breathing circuit is supplied by a surface pump **24** by means of a pipe **25** which ends in a breathing bag **26**, which itself is connected to the mouthpiece (not visible in the figure) by a pipe

27. The regulator 11 is supplied by a compressed gas cylinder 28 carried by the diver. It is not necessary that the gas supplying the suit be a breathable one.

In the form of embodiment shown in Fig. 3 the air, which is under a pressure higher, for instance by some kgs./sq. cm., than that to which the diver is subjected, arrives from above the surface through a pipe 29, and supplies the breathing circuit directly and the suit through the breathing circuit, from which air is tapped at a place where it is substantially at the breathing pressure.

For this purpose a valve 41 adjusted to the suitable pressure difference, which with the arrangement shown in the figure lies between 1.50 and 2 m. but with other arrangements could not exceed 0.75 or even 0.50 m. of water, is disposed between the breathing circuit and the inside space of the suit.

Fig. 7 shows the arrangement of the valve on the suit 1, a fragment of which only is shown. The air derived from the breathing circuit enters the valve through a channel 42 lying outside the suit and leaves it through a part 46 lying inside the suit. The valve member 44 is pressed against its seat 43 by a spring 45 of suitable strength. It is lifted off its seat when the difference between the pressure obtaining in the breathing circuit and that obtaining in the suit becomes too high.

Alternatively the regulation valve 41 could be replaced by a regulator 11 as shown in Fig. 8.

In both cases the air or other breathable gas of the breathing circuit may be tapped either above or below the mouthpiece with respect to the direction of the gas flow.

As hereinabove already stated, the pressure obtaining in the breathing circuit is substantially equal to that of the water at the level of the diver's lungs. Therefore, when the suit is supplied from the breathing circuit through a regulation valve, the pressure difference for which the valve is adjusted to work should be such that the valve works only when the difference between the pressure of the breathing circuit and the pressure of the suit is slightly greater than the pressure of a water column the height of which is the distance between the lungs and the outlet valves which are farthest therefrom. The pressure obtaining in the suit when the valve is operating is in that case the same as would obtain if the suit were directly supplied through a regulator which would be placed at the level of the lungs, although this level may not be at substantially equal distance from the farthermost outlet valves, especially when the non close-fitting part of the non-rigid suit reaches down to or nearly down to the diver's feet.

The diver may also cause gas tapped from the breathing circuit to enter the suit without the regulator 11 or the valve being necessary. He will have but to take off his face the device which isolates the breathing circuit from the atmosphere of the suit. Thus, with the arrangement shown in Fig. 4, if the skirt 16 is sufficiently flexible, the diver will have the possibility of allowing gas, which will lift the skirt and flow between the same and his face, to escape through his nose. Again, but less conveniently, the diver could, by parting his lips, allow gas to flow along and outside the mouthpiece 13, which gas would pass into the atmosphere of the suit.

The arrangement shown in Fig. 4 which separates the breathing circuit from the suit may be adopted unchanged in the apparatus according to Figs. 2 and 3.

In the forms of embodiment represented by Figs. 1, 2 and 3 the air may be replaced by any other breathable gas, as already appears from the above description.

I claim:

1. In a diving appliance, in combination, a non-rigid water and gas tight suit, outlet valves provided in a plurality of distinct points of said suit and adapted to discharge in the surrounding water the gas collected inside the highest part of the suit as long as the pressure of said gas is greater than the water pressure on the outlet valve provided at said highest part, a diaphragm pressure regulator having the outer surface of its diaphragm subjected to the water pressure and adapted to allow a gas to flow inside said suit as long as the difference between said water pressure and the pressure of the gas collected in the highest part of the suit exceeds a value corresponding to a water column the height of which is equal to the vertical distance between said diaphragm and the outlet valve which is nearest to the water surface, and a breathing apparatus adapted to allow the diver to breathe in and out.

2. In a diving appliance, in combination, a non-rigid water and gas tight suit, outlet valves provided in a plurality of distinct points of said suit and adapted to discharge in the surrounding water the gas collected inside the highest part of the suit as long as the pressure of said gas is greater than the water pressure on the outlet valve provided of said highest part, a mouth piece for the diver, a breathing apparatus the piping of which is connected to said mouth piece by tightly passing through the suit and adapted to allow the diver to breathe in and out, a first diaphragm pressure regulator adapted to feed a breathable gas to said mouth piece at a pressure substantially equal to the water pressure on the diaphragm of said first regulator, and a second diaphragm pressure regulator adapted to allow the breathable gas to flow inside the suit as long as the difference between the water pressure on the diaphragm of said second regulator and the pressure of the gas collected in the highest part of the suit exceeds a value corresponding to a water column the height of which is equal to the vertical distance between said diaphragm and the outlet valve which is nearest to the water surface.

3. In a diving appliance, in combination, a non-rigid water and gas tight suit, outlet valves provided in a plurality of distinct points of said suit and adapted to discharge in the surrounding water the gas collected inside the highest part of the suit as long as the pressure of said gas is greater than the water pressure on the outlet valve provided at said highest part, a mouth piece for the diver, a breathing apparatus the piping of which is connected to said mouth piece and adapted to allow the diver to breathe in and out, a diaphragm pressure regulator adapted to feed a breathable gas to said mouth piece at a pressure substantially equal to the water pressure on the diaphragm of said regulator, and an inlet valve on the suit adapted to allow breathable gas to enter inside said suit when the difference between the pressure in the breathing apparatus and the pressure inside the suit reaches a predetermined value.

4. In a diving appliance, in combination, a non-rigid water and gas tight suit, outlet valves

provided in a plurality of distinct points of said suit and adapted to discharge in the surrounding water the gas collected inside the highest part of the suit as long as the pressure of said gas is greater than the water pressure on the outlet valve provided at said highest part, a source of gas under pressure adapted to be carried by the diver, a diaphragm pressure regulator adapted to allow the gas of said source to flow into the suit as long as the difference between the water pressure on the diaphragm of said regulator and the pressure inside said suit exceeds a value corresponding to a water column the height of which is equal to the vertical distance between said diaphragm and the outlet valve which is nearest to the water surface, a mask provided in the suit and consisting in a flexible skirt closed at its front part with a window glass and pressed against the diver's face for enclosing his eyes and nose and allowing him

to expire into the suit, and a breathing apparatus adapted to be connected to the diver's mouth and to allow the diver to breathe in and out.

JACQUES YVEYS COUSTEAU.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,131,490	Drager	Mar. 9, 1915
1,226,148	Walters	May 15, 1917
1,689,079	Murakami	Oct. 23, 1928
2,388,674	Browne	Nov. 13, 1945

FOREIGN PATENTS

Number	Country	Date
649,034	Germany	Aug. 13, 1937