

[54] DIVING EQUIPMENT

[75] Inventors: **Hans Olof Almqvist**, Lidingo, Sweden; **Gösta H. Fahlman**, New Westminster, British Columbia, Canada

[73] Assignee: **AGA Aktiebolag**

[22] Filed: **June 29, 1972**

[21] Appl. No.: **267,472**

[52] U.S. Cl. **128/142.3**
[51] Int. Cl. **A61m 16/00**
[58] Field of Search..... 128/142.3, 142.4, 142.7, 128/142, 141, 145, 145.5, 145.6, 145.8, 146.4, 146.5, 191, 204

[56] **References Cited**
UNITED STATES PATENTS

594,945	12/1897	O'Neill.....	128/142.5
829,274	8/1906	Knoff.....	128/142.3
1,131,490	3/1915	Drager.....	128/142.3
1,561,086	11/1925	Korjibski.....	128/142.3
1,681,029	8/1928	Cooke.....	128/191
3,370,585	2/1968	O'Neill.....	128/142.5
3,481,333	12/1969	Garrison.....	128/142.7

3,524,444 3/1966 Ellard 128/142

FOREIGN PATENTS OR APPLICATIONS

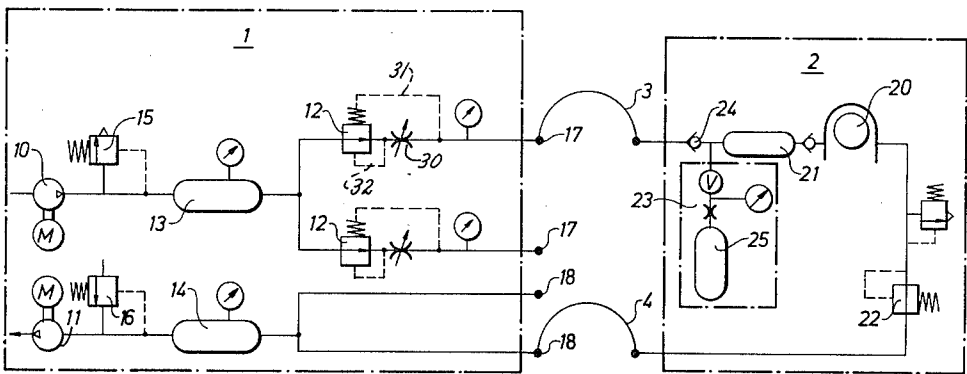
393,650	2/1922	Germany.....	128/142.3
850,356	5/1958	Great Britain.....	128/142.3

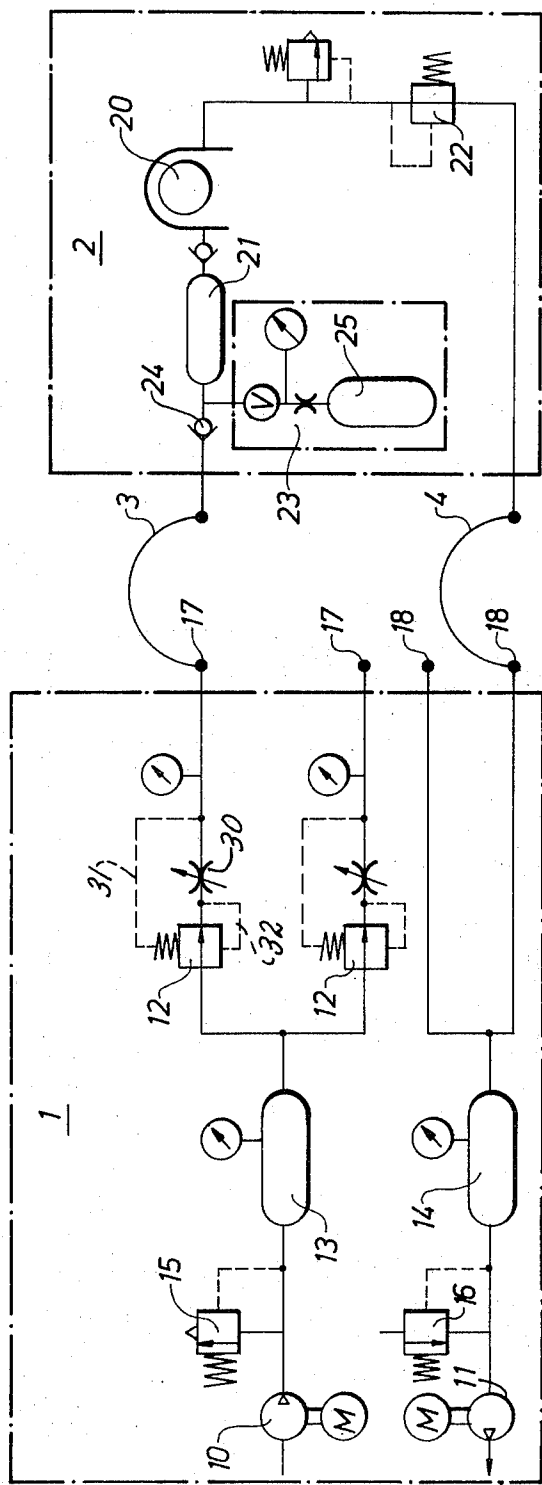
Primary Examiner—Richard A. Gaudet
Assistant Examiner—Henry J. Recla
Attorney, Agent, or Firm—Larson, Taylor and Hinds

[57] **ABSTRACT**

A diving equipment for deep diving and comprising a station including a source of gas for the diver or divers. The station may be disposed either above the water surface or submerged therebelow, and is provided with one or more supply conduits for the helmet-carrying divers who may move both above and beneath the level of the station. From the diver or divers, the exhalation gas is returned to the station through return conduits. The portion of the supply conduit within the station is provided with a pressure regulator for the respective diver. In the return conduit, a predetermined subatmospheric pressure is established.

5 Claims, 1 Drawing Figure





DIVING EQUIPMENT

The present invention relates to a deep-diving equipment. Such equipment, conventionally, comprises a gas supply housed in a station disposed above or below the water surface and from which gas is fed, either by its own pressure or by a compressor, to one or more helmet-carrying divers, from which the spent gas is returned to the station.

For diving to depths of up to 400 meters, the diving equipment, and particularly the ventilation arrangement for the diver, is subject to high demands. In prior-art arrangements, and particularly in association with submerged stations, certain problems have been encountered in connection with the supply of gas from the station to the diver. Thus, the prior-art arrangements have been found to restrict the range of movement of the diver more or less to the occasional level of the submerged station. Consequently, the diver cannot move very far downward beneath the submerged station, and his range of mobility is still more restricted in the ascending direction from the submerged station.

By the measure - as characteristic of the diving equipment according to the present invention - of providing a pressure regulator adapted in response to the diving pressure to meter the gas at a constant absolute rate of flow through the supply conduit for the diver, the diver's range of movement has been essentially increased in both ascending and descending senses relative to the station. Thus, the diver can move without any danger within an extensive range above and beneath the submerged station, irrespective of the depth of submersion of the station. In addition, the inventive arrangement will enable two divers connected to one single diving equipment to be at opposite end levels of the depth range at the same time.

The present invention, in addition, provides for further important advantages in connection with deep diving, such as a reduction of the noise level in the diver's environment. This will enable him to move with less danger of detection in underwater missions than has been possible with previously known arrangements. A further substantial advantage of the diving equipment according to the invention resides in that it will afford fair chances of recovering the exhalation gas, involving satisfactory gas economics.

To enable unrestricted mobility above the station, it is required to connect a vacuum pressure regulator into the return conduit from the diver so as to regulate the pressure in the return conduit in response to the occasionally actual diving depth. In this case, a vacuum pump is suitably connected into the return conduit.

To attain a smooth and reliable gas flow to and away from the diver, surge vessels are suitably arranged in both the supply and the return conduits and are provided with relief valves adapted to limit overpressure and vacuum pressure, respectively, to predetermined values.

The diving equipment, in addition, may suitably include an emergency unit to be carried by the diver and comprising an auxiliary gas container connected to the supply conduit between the diver's helmet and a non-return valve inserted in the supply conduit.

The diving equipment according to the present invention will now be described more in detail with reference to the accompanying drawing showing a basic dia-

gram of a preferred embodiment of the inventive diving equipment.

The diving equipment according to the invention comprises a stationary assembly arranged in a station 1 which may be disposed above the surface of the water or may be submerged therebelow. The stationary assembly, in this case being intended for submerged use, comprises a compressor 10 adapted to pressurize gas drawn from the atmosphere within the underwater station 1 and to supply this gas to a surge tank 13. To prevent the overpressure generated by the compressor 10 from exceeding a predetermined maximum value, a relief valve 15 is connected into the supply conduit on the upstream side of surge tank 13. From the surge tank 13, the gas is passed through a pair of parallel-connected conduits leading to respective outlet connections 17 for supply conduits 3 for two divers 2, respectively. Connected into each conduit between the surge tank 13 and the respective outlet connections 17 is a pressure regulator 12. Through the regulators 12, the pressurized gas is fed to the divers 2 at a constant absolute rate of flow.

The stationary assembly of the diving equipment further comprises a vacuum pump 11 for evacuating exhalation gas flowing from the divers 2 through a return conduit 4 and entering the underwater station 1 through inlet connections 18, there being one such inlet connection for each diver. From these inlet connections 18 the exhalation gas is drawn through a second surge tank 14 at sub-atmospheric pressure through vacuum pump 11 and, optionally, through a gas purifier (not shown) for removing carbon dioxide from the exhalation gas before merging the latter with the atmosphere within the underwater station 1. To prevent the sub-atmospheric pressure generated by the vacuum pump 11 from falling below a predetermined value, the conduit leaving the surge tank 14 is provided with a vacuum limiter 16.

As mentioned hereinbefore, the stationary assembly is intended to supply inhalation gas to two divers 2, only one being illustrated in the drawing. The helmet 20 carried by the diver 2 is connected to the outlet connection 17 through supply conduit 3, the latter being a hose about 50 meters in length and connected to the unit carried by the diver through a non-return valve 24. From the non-return valve the gas is fed at a constant absolute rate of flow to an inhalation bellows 21 from which the diver draws his breathing air when inhaling. During the diver's exhalation, the contaminated breathing gas will flow or be drawn back into the underwater station 1, viz. to its inlet connection 18. The return flow of the contaminated breathing gas is through a pressure regulator 22 and the return conduit 4, the latter being a hose about 50 meters in length. The pressure regulator is adapted to regulate the vacuum pressure within the portion of the return conduit 4 next to the diver's helmet 20 so as to cause the diver's exhalation resistance to be independent of the subatmospheric pressure generated within the return conduit at different depths relative to the station 1.

The portion of the inventive diving equipment carried by the diver 2 further comprises an emergency unit 23. The latter is intended to be used if the normal gas supply should cease, and comprises a gas container 25 which is connected to the supply conduit 3 between the above-mentioned non-return valve 24 and the inhalation bellows 21. The emergency unit 23 is suitably acti-

vated automatically in response to an excessive pressure drop in the normal gas supply through conduit 3.

The diving equipment according to the invention provides a ventilation arrangement for great depths which is well suited for at least two divers, affording free mobility for each diver 2 within a depth range of, for instance, 10 meters above and 30 meters below the underwater station 1, and independently of each other. The regulator 12 is controlled by pressure on both sides of a restriction 30 in the supply conduit via lines 31 and 32 for operating in response to the diving pressure ensures a constant absolute rate of flow of inhalation gas. This rate of flow is preferably selected to be of the order of 50 liters (abs.) per minute. For maintaining said pressure, an overpressure will be required downstream of the surge tank 13 which is 5 to 8 bars higher than the pressure existing within the underwater station, depending on the depth of submersion of the latter. For the surge tank 14 in the return path a sub-atmospheric pressure of 2 to 4 bars will be required.

At the pressure just stated, the maximum pressures within the hoses 3 and 4 will be 3 to 4 bars above and below, respectively, the ambient pressure. Said hoses 3, 4 preferably could be nested, one within the other.

When diving from a surface-based station, it is often sufficient to terminate the return conduit 4 above the water surface, thus allowing the exhalation gas to be freely vented to atmosphere. Alternatively, it is also conceivable, and even necessary in many cases, to recover the exhalation gas from the return conduit at the surface-based station, as well as at the subsurface station, and to purify and repressurize this gas for supplying the same to the diver or divers again.

Further modifications of similar kinds may also be made in the diving equipment thus described within the scope of the invention, and the latter thus should not be considered to be restricted to the details of the present specification and as illustrated in the drawing.

We claim:

1. A diving apparatus for supplying a diver with breathing air to great depths comprising: a main station, a diver's helmet, a gas source means at said station, means including a supply conduit for supplying gas to the diver's helmet, a vacuum pump at the said station, means including a return conduit for connecting the vacuum pump to the said diver's helmet for

evacuating exhalation gases from the helmet, control means in the supply conduit and located at the station downstream from the pressure regulator and operatively connected with the pressure regulator for sensing an increase in pressure as the diver moves downstream with respect to the station and a decrease in pressure in the supply conduit as the diver moves upward with respect to the station resulting in an adjustment at the pressure regulator so as to supply a higher or lower gas pressure, respective of the diver's movement with respect to the station, into the supply conduit, thereby maintaining constant the absolute rate of gas flow of breathing gas through the supply conduit for maintaining constant the absolute rate of gas flow of breathing gas through the supply conduit and a vacuum-pressure regulator means in the return conduit near the helmet for regulating the sub-atmospheric pressure in the return conduit to keep the resistance of the diver to exhalation independent of the sub-atmospheric pressure generated by the said vacuum pump at different depths of the diver relative to the station.

2. A diving apparatus according to claim 1, said control means comprising a restriction in the supply conduit and fluid lines from both sides of the restriction to said pressure regulator to control the latter.

3. A diving apparatus according to claim 2, wherein said apparatus is adapted to supply gas from the station to more than one diver, and including a separate supply and return conduit for each diver.

4. A diving apparatus according to claim 1, including surge tanks located at the station and connected, one to the supply conduit and one to the return conduit, each of said surge tanks comprising a relief valve on the side thereof away from their respective conduits, the relief valve of the surge tank in the supply conduit being openable at a predetermined over pressure, and the relief valve for the surge tank of the return conduit limiting the sub-atmospheric pressure in this return conduit and its associated surge tank to a predetermined value.

5. A diving apparatus according to claim 1, including an emergency gas source including an auxiliary gas container carried by the diver and connected to the supply conduit between the helmet and a non-return valve in the supply conduit near the diver.

* * * * *

50

55

60

65