April 19, 1927. G. S. McCAA 1,625,419

BREATHING APPARATUS

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FIG. 1.

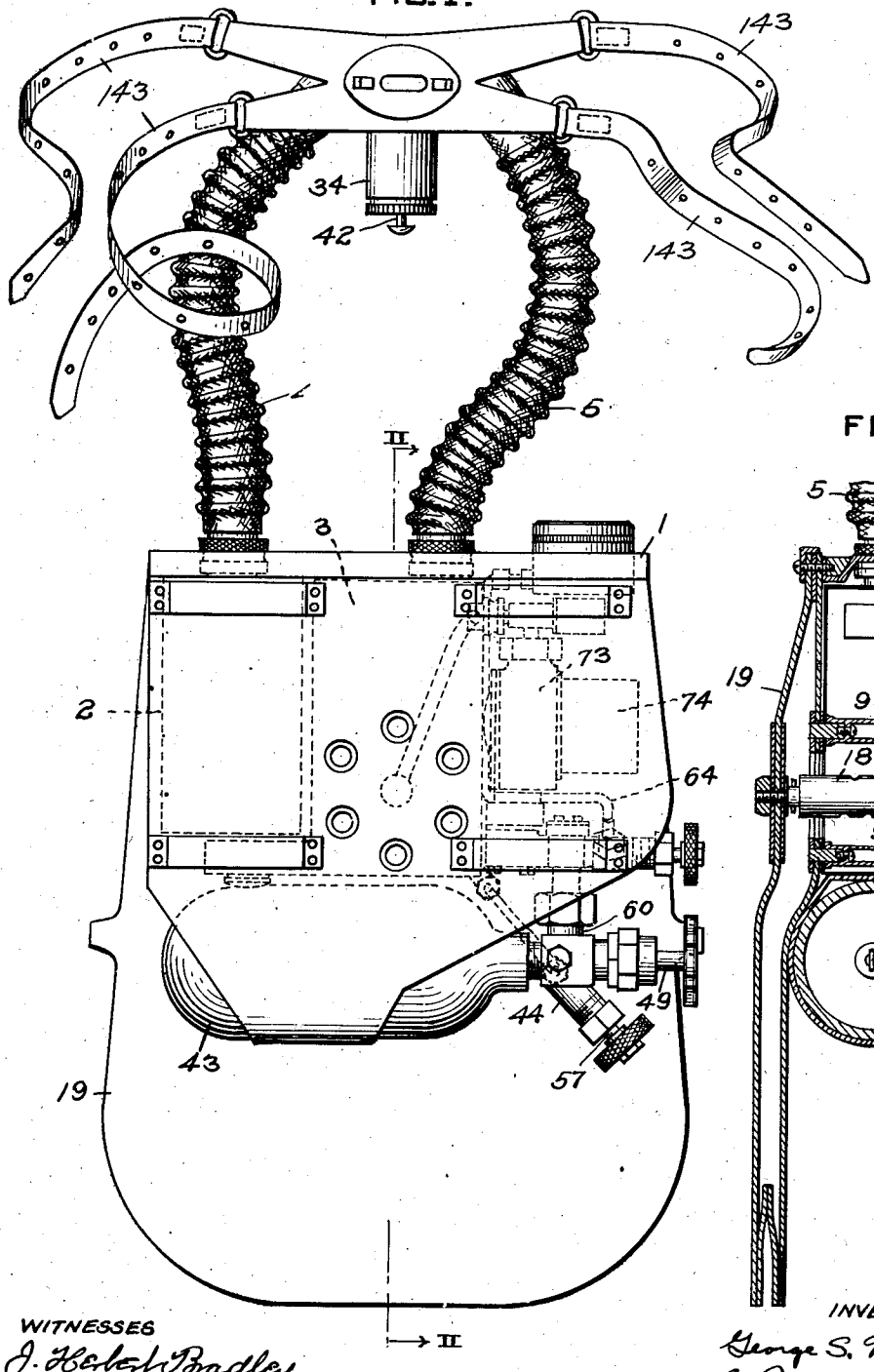

FIG. 2.

WITNESSES

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BREATHING APPARATUS

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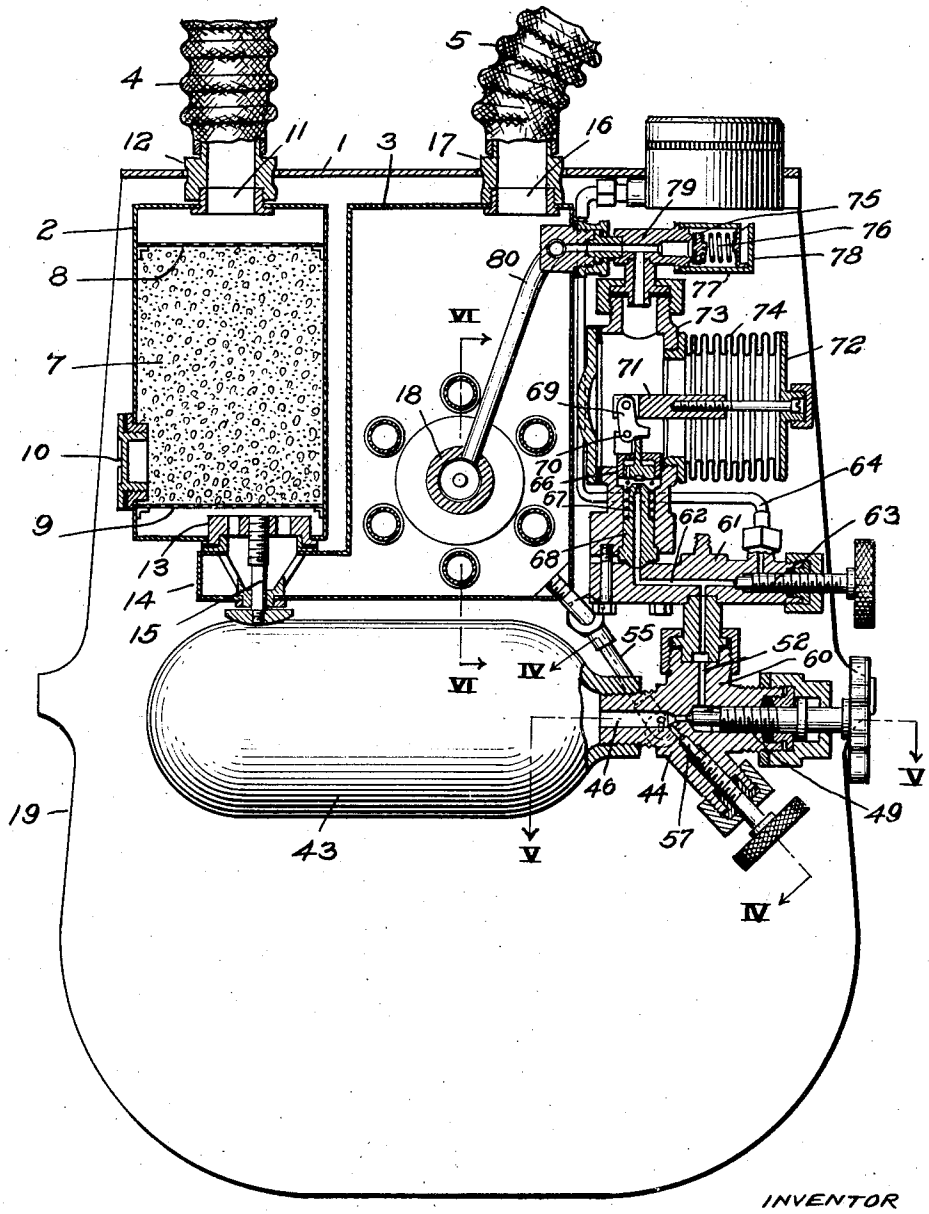
FIG. 3.



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BREATHING APPARATUS

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FIG.6.

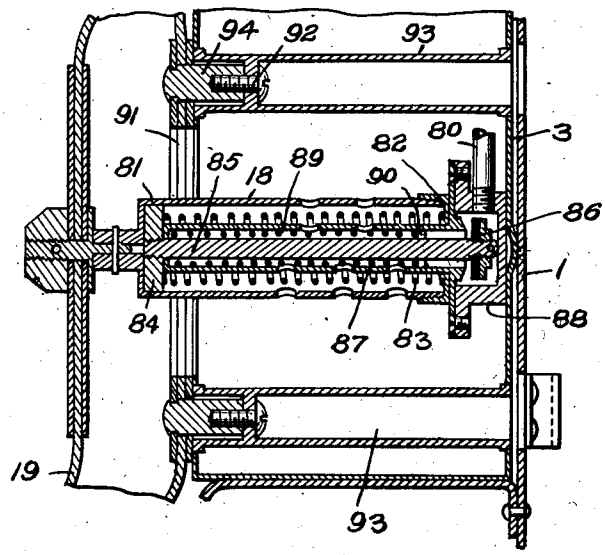


FIG.4.

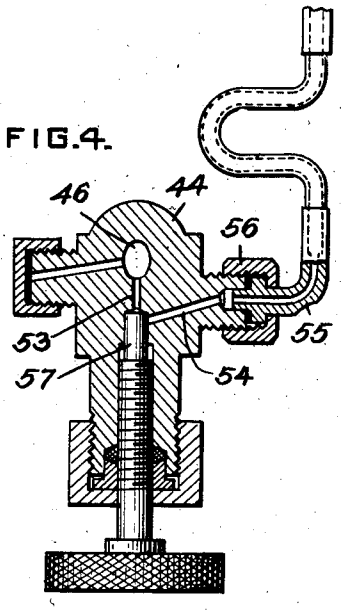
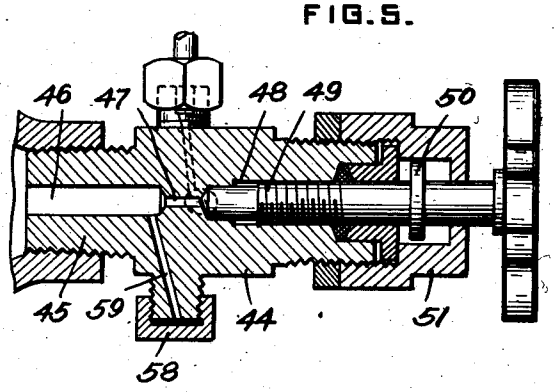


FIG.5.



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BREATHING APPARATUS

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FIG.7.

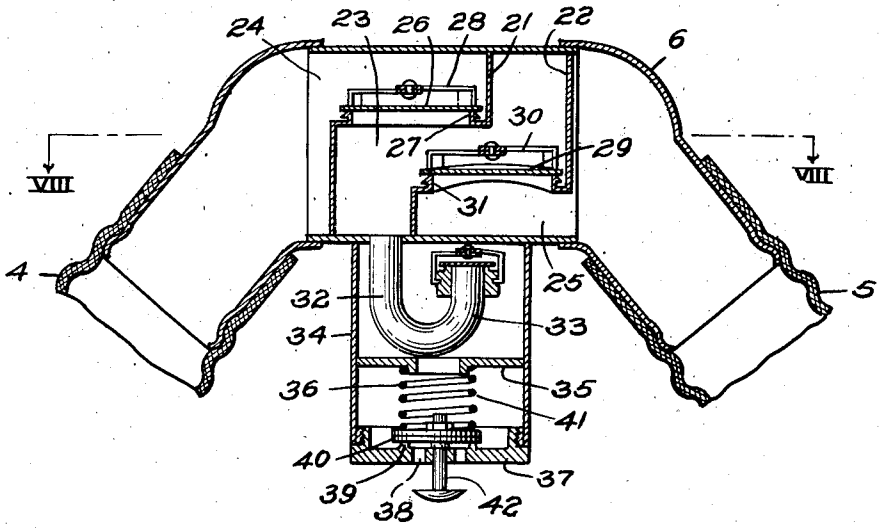


FIG.8.

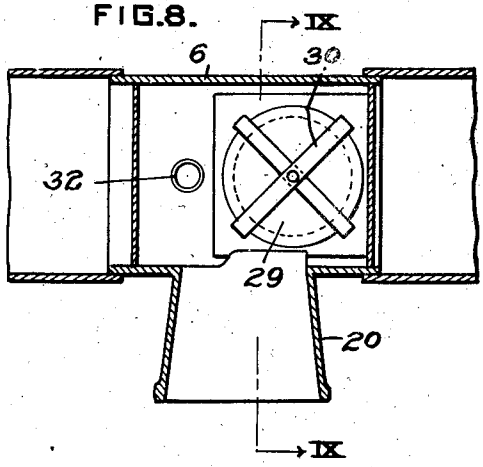
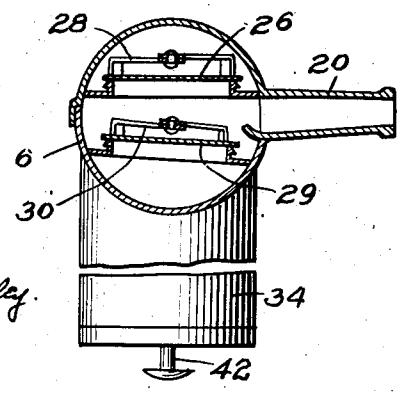


FIG.9.



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UNITED STATES PATENT OFFICE.

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BREATHING APPARATUS.

Application filed August 12, 1922. Serial No. 581,274.

The invention relates to self-contained oxygen breathing apparatus, that is to say, apparatus of the character used by miners, firemen and others when operating in atmospheres containing noxious or poisonous gases.

The general object of the invention is to provide a breathing apparatus which is of simple and practical construction, and which will operate efficiently with a minimum liability of any of its several units failing to properly function. A more specific object is to so construct and arrange the several parts of the apparatus that it will be compact in form and convenient to operate. Further objects will appear from the following description of the apparatus.

The invention is illustrated in the accompanying drawings, of which Fig. 1 is an elevation of a complete apparatus, the view being taken on the side of the apparatus, which, when the apparatus is in operation, is adjacent to the user; Fig. 2 a vertical sectional view of a portion of the apparatus, the plane of view being indicated by the line II—II, Fig. 1; Fig. 3 a vertical sectional view taken substantially at right angles to the plane of view of Fig. 2; Figs. 4, 5 and 6 detail sectional views taken, respectively, on the lines IV—IV, V—V and VI—VI, Fig. 3; Fig. 7 a vertical central sectional view of the mouthpiece and valves for controlling the flow of air through the apparatus, and to and from the user of it; Fig. 8 a sectional view taken on the line VIII—VIII, Fig. 7, and Fig. 9 a sectional view taken on the line IX—IX, Fig. 8.

Throughout the specification and claims the gases exhaled by the user into the apparatus and those inhaled from the apparatus will be designated as air, although neither is strictly atmospheric air.

As is usual in apparatus of the character contemplated herein, the present apparatus includes an air circulatory system comprising a regenerator for removing carbon dioxide and moisture from the exhaled air, a cooler for the air after it has passed through the regenerator, means for automatically supplying regulated quantities of oxygen to the regenerated and cooled air, and valves for controlling the flow of air in the circulatory system. The means for supplying oxygen consists of a second series of elements including an oxygen bottle, pressure reducer and inlet valve. The several units forming the circulatory system will first be explained, and thereafter the oxygen system, or, in other words, the means for supplying oxygen to the circulatory system.

The several units of the entire apparatus are mounted within or upon a frame 1 which for lightness and strength may be made of duralumin, an aluminum base alloy having high physical properties. Within the frame, which is of relatively small width, there is mounted a regenerator 2, and a cooler 3 which are connected, respectively, to the lower ends of the flexible tubes 4 and 5, the upper ends of which are attached to an outlet and inlet of a casing 6 of a mouthpiece.

The regenerator preferably consists of a rectangular metal casing provided interiorly with a body of granular material 7 for removing carbon dioxide and moisture from the exhaled air. The air purifying composition is arranged between screens 8 and 9 placed near the upper and lower ends of the casing, and may be put in and removed from the casing through a suitable side filling opening 10. At the upper end of the regenerator there is an air inlet 11 having an exteriorly threaded nipple to which flexible pipe 4 may be attached by means of a connecting member 12 rotatable with respect to the pipe. At the lower end of the regenerator there is an air outlet across which there extends a bridge member 13 whereby the regenerator may be connected to the inlet of cooler 3.

The cooler is arranged adjacent to the regenerator and within the sides of frame 1. It comprises a relatively narrow metal casing having at its bottom a laterally extending projection 14 which lies beneath the lower end of the regenerator and is provided with an inlet adapted to register with the regenerator outlet. For connecting the regenerator and cooler to each other, a thumb screw 15 extends through the lower wall of cooler projection 14 and engages bridge member 13 of the regenerator. Suitable gaskets are arranged between the meeting faces of the regenerator outlet and cooler inlet as well as beneath the head of the thumb screw to prevent leakage of air. The upper end of the cooler is provided with an outlet 16 adapted to be connected to pipe

5 by a member 17 in the same manner as pipe 4 is connected to inlet 11 of the regenerator. Within the cooler there is a valve 18 adapted to be operated by a bellows-like breathing bag 19 for controlling the supply of oxygen to air in the cooler. The construction of this valve and of the breathing bag and their manner of operation will be explained in connection with the description of the oxygen-supplying system.

Having reference now to the mouthpiece element of the circulatory system, the casing 6 thereof is provided centrally with a laterally-extending oblong tube 20, which in the operation of the apparatus is held in the mouth of the user. Casing 6 is, by offset partitions 21 and 22, divided into three compartments, a compartment 23 which is constantly in communication with tube 20, a compartment 24 which through pipe 4 is in communication with the regenerator, and a compartment 25 which through pipe 5 is in communication with the cooler. In the horizontal portion of partition 21 there is arranged a check valve which permits flow only from chamber 23 to chamber 24. The valve preferably consists of a plate 26 constructed of mica or other suitable light material adapted to rest upon the upper edge of a valve seat 27, and held in operative position by means of a cage consisting of cross strips 28 having their ends bent downwardly and attached to the horizontal portion of partition 21. A similar valve 29 held in position by a cage 30 is arranged to control flow through an opening 31 in the horizontal offset portion of partition 22, the arrangement of valve 29 being such that there may be flow only from chamber 25 into chamber 23. By arranging these inlet and outlet valves in horizontal positions and constructing them in the manner explained, the liability of the valves becoming permanently unseated and of accordingly failing to function is reduced to a minimum, if not entirely eliminated.

Connected to the lower portion of the mouthpiece there is a combined saliva trap and pressure relieving valve. The saliva trap consists of a U-shaped tube 32 attached at one end to casing 6 and communicating with chamber 23 of the mouthpiece. The other end of tube 32 is adapted to be closed by a horizontally disposed valve 33 which may be, and preferably is of the same construction as the valves in mouthpiece partitions 21 and 22. The saliva trap is enclosed within a casing 34 provided with a horizontal partition 35 having a central opening 36. At the lower end of casing 34 there is a closure 37 provided near its center with openings 38. On the inside of closure 37 there is a valve seat 39 for a disc valve 40 which is yieldingly pressed towards closed position by a spring 41, but which may be opened by a stem 42 extending through closure 37. The mouthpiece is further provided with suitable straps 143, preferably arranged to attach it to a special cap (not shown) for the user of the apparatus to wear, this being a convenient way of quickly attaching the mouthpiece to the user's head and of assuring its being firmly and continuously held in proper position.

The operation of the air circulatory system will be explained before describing the oxygen admitting system. Air exhaled by a user passes through tube 20 into compartment 23 of the mouthpiece, and the pressure of the air lifts valve 26 and permits the air to freely flow into chamber 24, and from such chamber into and through tube 4. The pressure of the exhaled air acts upon the top of mouthpiece valve 29, already closed by gravity, and prevents such air from flowing into tube 5. The exhaled air flows from tube 4 downwardly through the air purifying composition 7 in regenerator 2, by which composition carbon dioxide and moisture is removed from the air. The purified air flows from the bottom of the regenerator into the bottom of cooler 3 in which oxygen is supplied to the air in the manner and by the apparatus presently to be explained. When the user inhales, air is drawn through pipe 5 from the cooler and from the breathing bag attached to it. Due to the pressure of this air, which pressure is regulated by the oxygen supply system, and due also to the rarefaction effected by the inhaling operation, valve 29 of the mouthpiece rises to permit air to flow into chamber 23 and from it through tube 20 to the user. The saliva which is almost always emitted by the user of breathing apparatus is trapped in the lower portion of chamber 23 and flows into tube 32. If the tube fills up with saliva, valve 33 will rise and permit the saliva to flow into casing 34 from which it may be intermittently removed by pressing upwardly on valve stem 42. In case the pressure of the air in the apparatus becomes too high, it may be lowered by opening valve 40, but no external air may be drawn into the apparatus through the saliva trap, this being prevented by check valve 33 at the upper end or outlet of tube 32.

Having reference now to the oxygen supplying system, oxygen under a pressure of approximately 150 atmospheres is contained in a bottle 43 supported by the lower portion of frame 1. The oxygen flows to the cooler successively through a main valve, a high pressure fitting, a reducing valve, a safety valve and a control valve, and manually controlled means are provided for permitting the flow of oxygen directly from the bottle to the cooler so that in case any of the units in the oxygen supply sys-

tem should fail to properly function, oxygen may still be supplied to the air.

The construction of the main valve is shown particularly in Figs. 3, 4 and 5. It comprises a casing 44 having a threaded stem 45 adapted to engage the neck of bottle 43, the stem being provided centrally with a bore 46 having a contracted portion 47 near the center of the casing. Beyond this contracted portion the casing is provided with a bore 48 which receives a stem 49 of a needle valve for controlling flow through bore 47 into bore 48. Valve stem 49 is provided with a shoulder 50 arranged in a cap packing-nut 51 so that the valve stem may not accidentally be entirely removed from the valve with consequent liability of entire loss of the oxygen in the bottle. The valve casing is provided with a side opening 52 (Fig. 3) which communicates with bore 48, and through which oxygen flows to the pressure reducing valve and other automatic control mechanism.

A special by-pass is provided between the main valve and cooler 3 so that in case any of the automatic control units fails to properly function oxygen may nevertheless be supplied to the user of the apparatus. For this purpose valve casing 44 is provided with bores 53 and 54, the former of which communicates with bore 46, and the latter of which communicates with a pipe 55, connected at one end to the casing by a union coupling 56, and suitably attached at its other end to the cooler. For controlling flow through bores 53 and 54, valve casing 44 is provided with a second valve 57, the end of which seats against the outer end of bore 53. Thus when it is desirable to supply oxygen directly to the cooler, valve 57 may be opened for a short interval of time, usually not more than a second or two. A further feature of the main valve is a safety cap for relieving the pressure within the oxygen bottle when, for example, the bottle is heated above a predetermined temperature,—a temperature at which the pressure of the oxygen may cause the bottle to burst. The safety cap, which may be of standard construction, is indicated at 58 as closing the outer end of a bore 59 which communicates at its inner end with bore 46.

Bore 52 of the valve casing extends through an exteriorly threaded projection 60 of the valve casing, to which projection a high pressure fitting 61 is attached by a suitable union coupling. This fitting is provided with a bore 62, the right end of which, as viewed in Fig. 3, may be closed by a valve 63. This valve controls flow through a pipe 64 connected at its lower end to fitting 61, and at its upper end to a pressure gage 65, so that the user of the apparatus may, by opening the valve, observe the pressure of the oxygen in the bottle, and thereby determine how nearly at an end the supply of oxygen may be.

Arranged immediately above high pressure fitting 61 is a reducing valve whereby the pressure of oxygen is reduced to about three pounds. The pressure reducer includes a valve member 66, held yieldingly upwardly by a spring 67 arranged between it and a stem 68, which stem is provided with a central bore registering with the outer end of the bore 62 in fitting 61. The upper end of valve 66 presses against one arm of a bell-crank lever 69 having a fixed pivot at 70, and having its other arm pivoted to the inner end of a rod 71, the outer end of which rod is adjustably attached to a plate 72. Between a casing 73 and plate 72 there is an expansible metal bellows diaphragm 74 formed to normally urge plate 72 inwardly so that bell-crank lever 69 normally permits valve 66 to remain in open position.

When the pressure of oxygen within casing 72 and diaphragm 74 exceeds a predetermined amount, say about three pounds, the diaphragm sufficiently expands, against its own resiliency and the pressure of spring 67, to close valve 66. By this simple arrangement the pressure of oxygen beyond valve 66 is automatically maintained substantially constant.

Above the reducing valve, and in the line of flow of oxygen to the cooler, there is a safety valve for permitting the escape of oxygen in case the reducing valve should fail to properly function; and combined with such valve, there is an audible indicator for warning the user of the apparatus that the safety valve has been blown open. The safety valve comprises a disc valve element 75 yieldingly pressed towards its seat by a spring 76 of the required strength to hold the valve seated until a predetermined pressure acts upon its inner face. At the outer end of a casing 77, within which the spring pressed valve is arranged, there is a whistle 78 which responds with a sharp noise when oxygen escapes through the safety valve. The safety valve and whistle are arranged at the outer end of a casing 79 adapted to be attached to the upper end of reducing valve casing 73, and adapted also to be connected to a pipe 80 arranged within cooler 3 and connected to the controlling valve 18 in the cooler.

The last element of the oxygen supplying system is controlling valve 18 which is operated by breathing bag 19. The construction of this valve is shown in detail in Fig. 6. The outer wall of the breathing bag is attached to one end of a cylindrical casing 81 provided with an inwardly flanged sleeve 82 at its other end. Within cylinder 81 there is a spring 83 which at one end

bears against the flange of sleeve 82 and at its other end against a disc 84, which disc is attached to the outer end of a valve stem 85. The inner end of this stem is provided with a disc valve 86 adapted to control flow into the end of a tube 87 arranged within spring 83. This tube is attached to a casing 88 which in turn is fastened to the wall of the cooler. A second spring 89 is arranged within tube 87 and bears at one end against an inwardly turned flange of the tube and at its other end against a shoulder 90 formed on the valve stem. Tube 87 and casing 81 are provided with perforations as indicated to permit flow of oxygen from casing 88 into the cooler when valve 86 is open. The oxygen thus permitted to flow into the cooler mingles with the regenerated air which occupies both the cooler and breathing bag, there being a large opening 91 in the cooler and bag surrounding valve 18 for placing the two into communication with each other. The breathing bag may be conveniently attached to the cooler by means of screws 92 arranged within open ended tubes 93 which traverse the cooler, the screws being adapted to engage studs 94 attached to and projecting laterally from the inner wall of the breathing bag.

In the operation of the oxygen supplying system, valve 49 is opened to permit oxygen to flow through valve casing bores 46, 47, 48 and 52 into bore 62 of fitting 61. The pressure of the oxygen in bore 62, which it will be understood is the same or substantially the same as that in the oxygen bottle, may be observed by opening valve 63 whereby bore 62 is, through pipe 64, placed in communication with pressure gage 65. Oxygen flows through nipple 68, past valve 66 as long as the pressure within the reducing valve is below the maximum for which the valve is set. In case the reducing valve does not close when the pressure in it is materially above the predetermined maximum, safety valve 75 opens and permits oxygen to escape, the escaping oxygen causing whistle 78 to blow and thereby warn the user of the apparatus that it is not properly functioning. From the safety valve the oxygen flows through pipe 80 to casing 88 of valve 18. When the breathing bag is deflated, as indicated in Fig. 6, valve 86 is opened to permit oxygen to flow into the breathing bag and cooler. Gas pressure in the breathing bag, effected both by exhalation and by oxygen admitted through valve 86 when open, causes the bag to expand, its outer wall moving to the left as viewed in Fig. 6. This movement of the outer breathing bag wall carries with it cylinder 81 which causes spring 83 to be compressed. When the compression exerted by spring 83 overcomes that of auxiliary spring 89, valve 86 is closed, by reason of the movement of disc 84 and stem 85 under the pressure of spring 83. By providing a controlling valve having main and auxiliary springs arranged in the manner explained, such valve will not be closed as soon as the breathing bag begins to distend, and the valve will be opened before the breathing bag has returned to the deflated position in which it is indicated in Fig. 6.

It will be observed of the breathing apparatus that its several parts are so arranged that the apparatus as a whole is of small size. In the air circulatory system the air travels a minimum distance,—downwardly through the regenerator and upwardly through the cooler. In the oxygen supplying system practical instrumentalities are provided for effecting efficient operation of the apparatus and for meeting any extraordinary conditions that may be encountered.

According to the provisions of the patent statute, I have described the principle and operation of my invention, together with the construction which I now consider to represent the best embodiment thereof. However, I desire to have it understood that, within the scope of the appended claims, my invention may be practiced by other forms of construction than that specifically shown and described.

I claim:

1. In a breathing apparatus, the combination of a frame, a regenerator attached to the upper portion of the frame and having an air inlet at its top and an air outlet at its bottom, a cooler arranged in said frame adjacent to the regenerator and having a laterally projecting portion extending below the bottom of said regenerator, said projection being provided with an air inlet registering with said regenerator outlet, a screw extending through said projection and detachably connecting said regenerator and cooler to each other, an air outlet at the top of said cooler, and automatic means for supplying oxygen to the cooler.

2. In a breathing apparatus, the combination of an air circulatory system, an oxygen bottle, means intermediate said bottle and system for automatically controlling the flow of oxygen at reduced pressure to said system, a manually operated main valve for controlling flow from the bottle to said flow-controlling means, a direct connection between said bottle and system by-passing said main valve and the entire flow-controlling means, and a manually-operated valve for controlling flow through said direct connection.

3. In a breathing apparatus, the combination of an air circulatory system including a regenerator and a cooler each connected directly to a mouthpiece, an oxygen bottle, a conduit including a manually-operated main valve and automatic pressure reducing and flow controlling valves connecting said bottle with said cooler, an auxiliary conduit directly

connecting said bottle with said cooler and by-passing said entire first named conduit, and a manually operated auxiliary valve for controlling flow through said auxiliary conduit.

4. In a breathing apparatus, the combination of an air circulatory system including a regenerator and a cooler, an oxygen bottle, a valve casing attached to said bottle and provided with two manually controlled valves each communicating directly with said bottle, a conduit extending from one of said valves to said cooler and including a reducing valve and a valve for automatically controlling admission to said cooler, and a conduit extending from the other valve of said casing directly to said cooler whereby oxygen may be supplied to said cooler without flowing through the first-mentioned valve and said reducing and flow controlling valves.

In testimony whereof, I sign my name.

GEORGE S. McCAA.