United States Patent [19]

Garrahan

[11] **3,845,768**

[45] **Nov. 5, 1974**

[54] **FORM FIT VERTICAL FLOW DIVING HEAD GEAR**

[76] Inventor: **Richard Garrahan,** 2664 Russmar Dr., San Diego, Calif. 92123

[22] Filed: **Feb. 12, 1973**

[21] Appl. No.: **332,046**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 274,150, July 24, 1974, abandoned, which is a continuation of Ser. No. 99,945, Dec. 21, 1970, abandoned.

[52] **U.S. Cl.** ..... **128/142.7,** 2/2.1 R

[51] **Int. Cl.** **A62d 7/00**

[58] **Field of Search** 128/142.7, 142.5, 142, 128/141, 142.2, 142.3, 142.4, 142.6; 2/2, 2.1, 3, 5, 6, 7, 8

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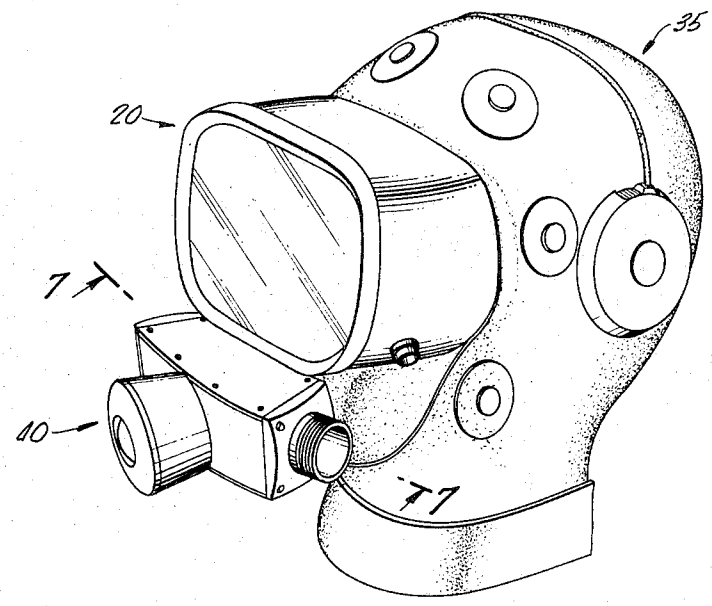
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[57] **ABSTRACT**

A diving head gear includes a form fit mask assembly, a hood assembly, and a breathing block assembly. Custom fitting a mask assembly to a diver's facial contours as defined by the forehead, temples, and lower jawbone, seals its interior from the surrounding water and allows the comfortable wearing of the mask for prolonged periods of time. Securing the mask assembly onto a wearer's head by an elastic, custom fitted hood assembly firmly seats the mask assembly in a sealed relationship as well as providing an armor-like protective covering. Mounting a breathing block assembly on an oral compartment of the mask assembly ensures an effortless inhalation and exhalation of gas and, by its unique configuration, the breathing block assembly blocks and purges any leaked water from the breathing system. Thusly provided, the head gear is ideally adaptable to semiclosed and closed underwater breathing systems to prevent the introduction and transfer of leaked water which would eventually reach the CO_2 absorption unit and inhibit its functioning. Because each head gear is individually tailored to seat on the nonfleshy, bony portions of the head and face, and only a slight force is required to seal the mask assembly's interior and no facial pain is suffered. Thus the head gear is ideally suitable for use during saturation diving or military undersea operations where it must be worn for long periods of time. Most of the inherent advantages of the head gear are attributed to the fitting of the mask assembly and its method of construction. Molding a ductile transparent sheet over a negative mold shaped to represent a diver's head having a builtup template conforming to the internal dimensions of the form fit mask assembly and along a surface representing the bony facial contours of the diver, as defined by his forehead, his temples, and his jawbone, ensures comfortable seating of the mask and prolonged sealing of the interior from the surrounding water.

8 Claims, 23 Drawing Figures



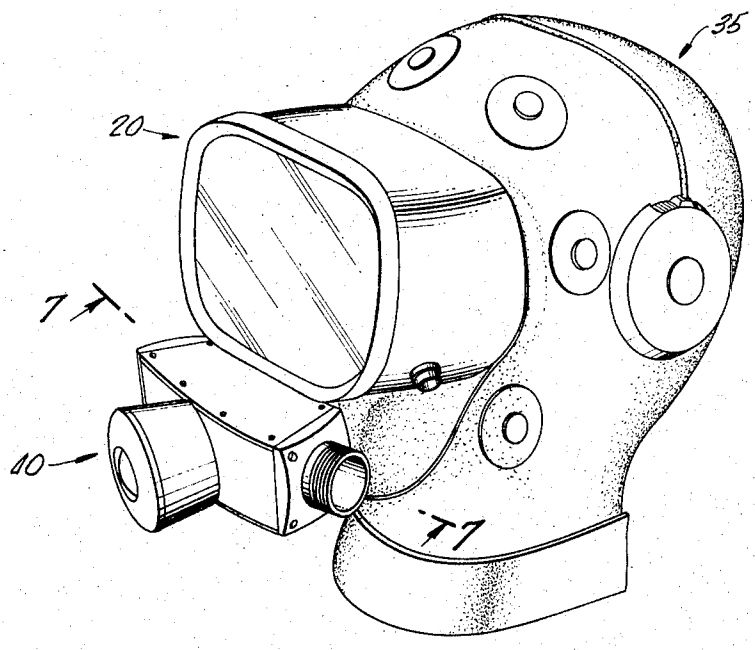


FIG. 1.

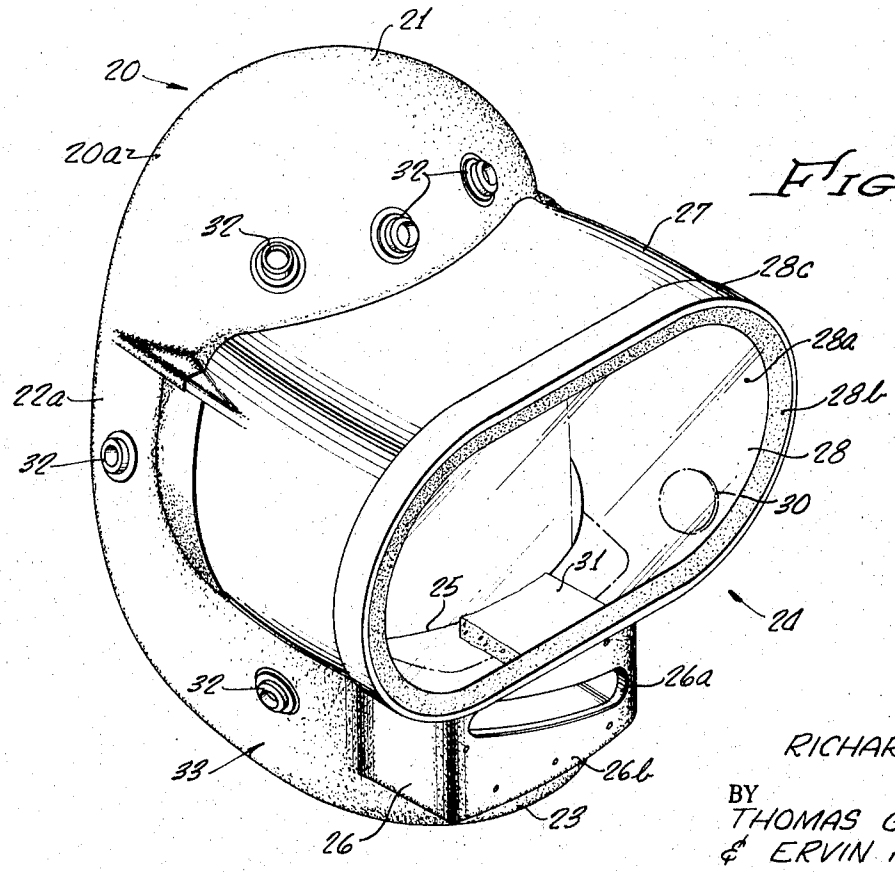
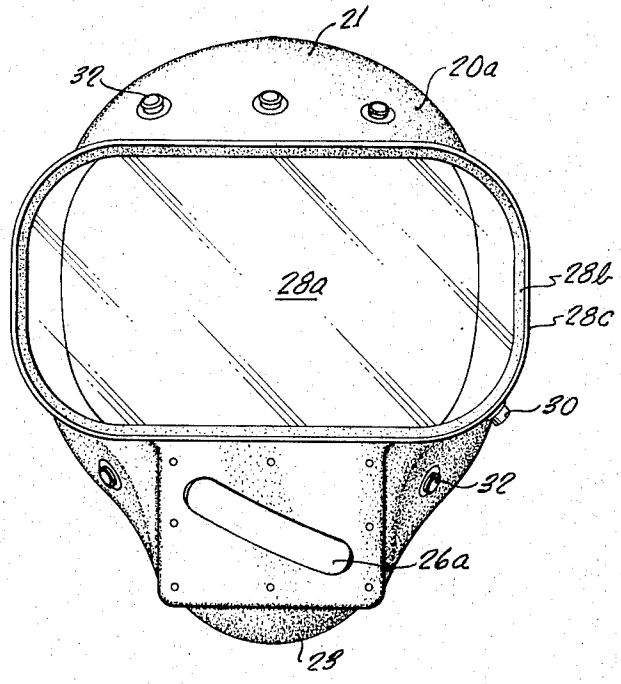


FIG. 2.

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FIG. 3a.



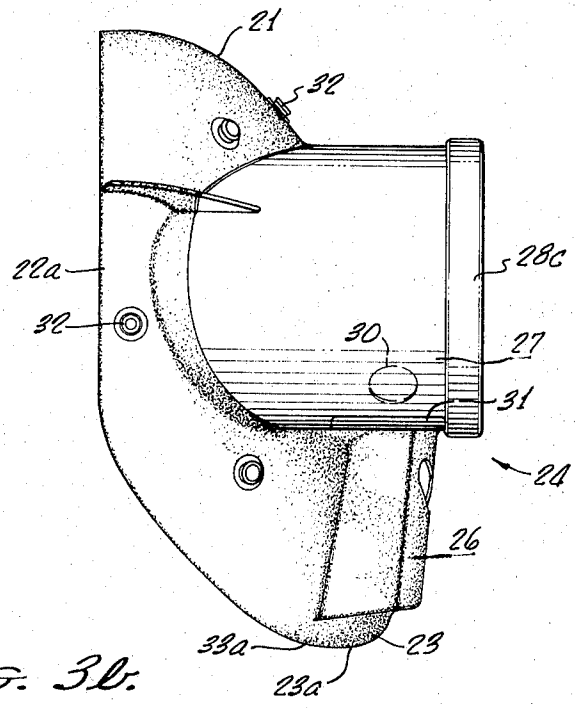


FIG. 3b.

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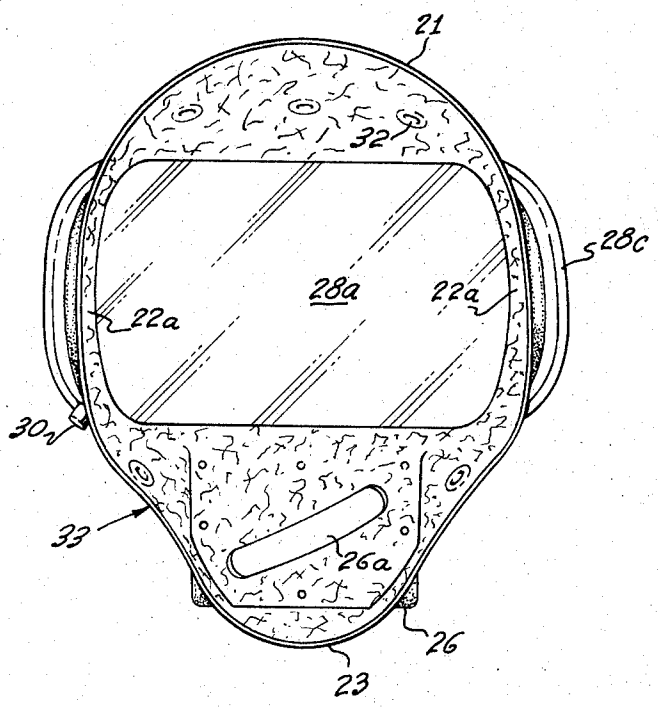
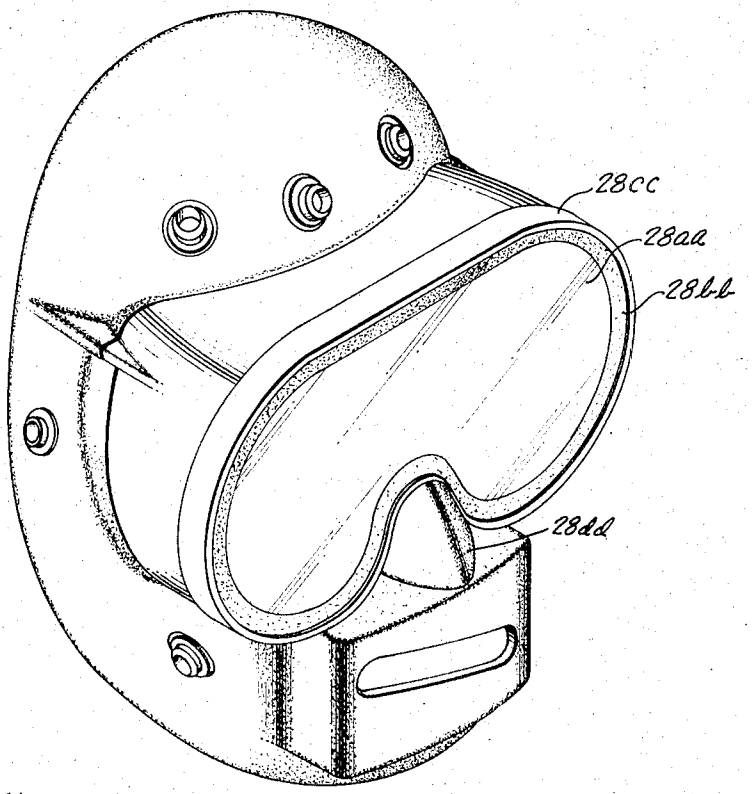


FIG. 3c.

FIG. 4



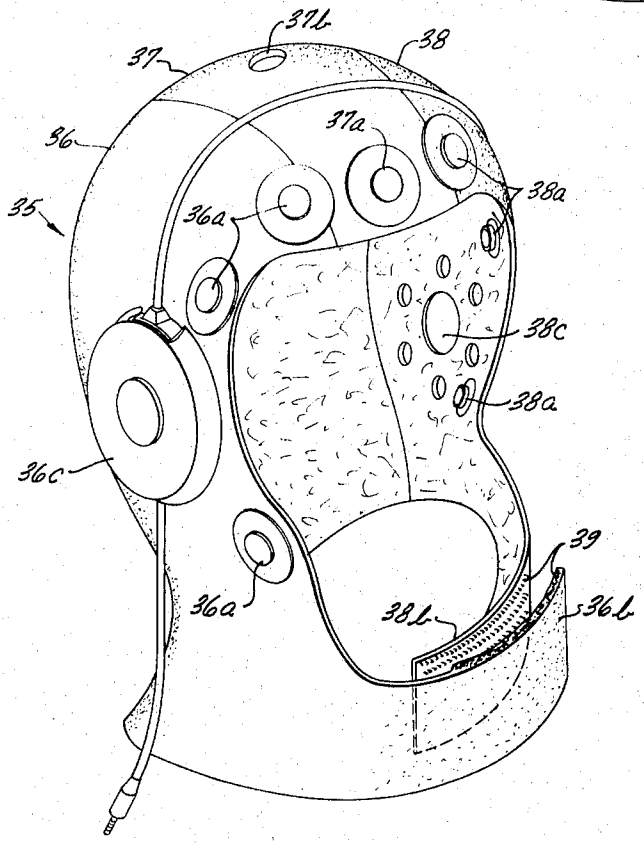


FIG. 5.

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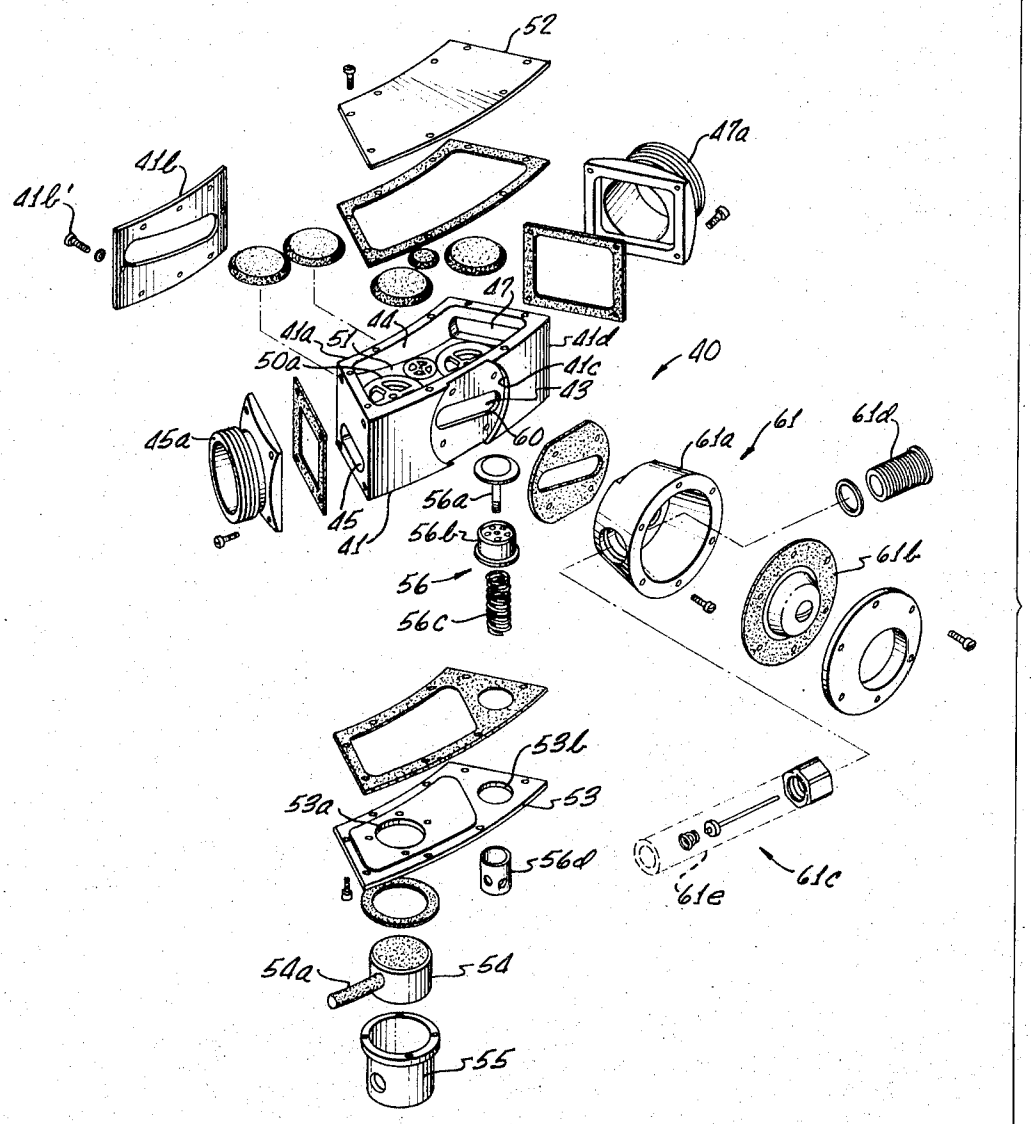


FIG. 6.

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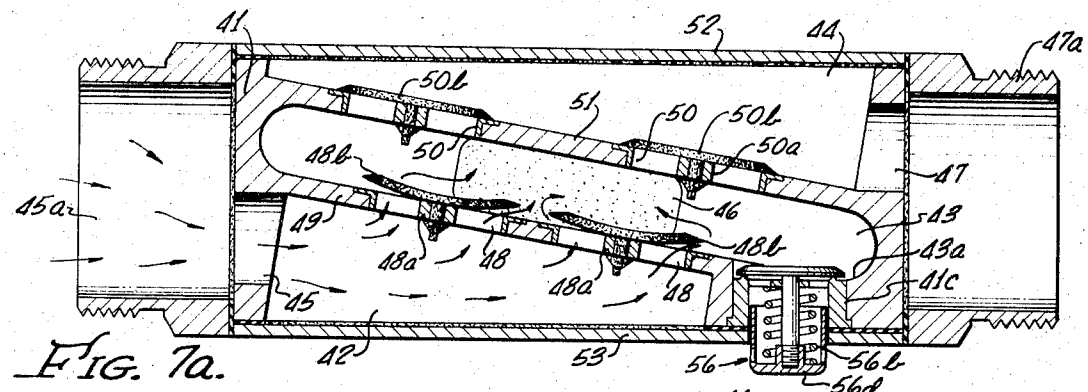


FIG. 7a.

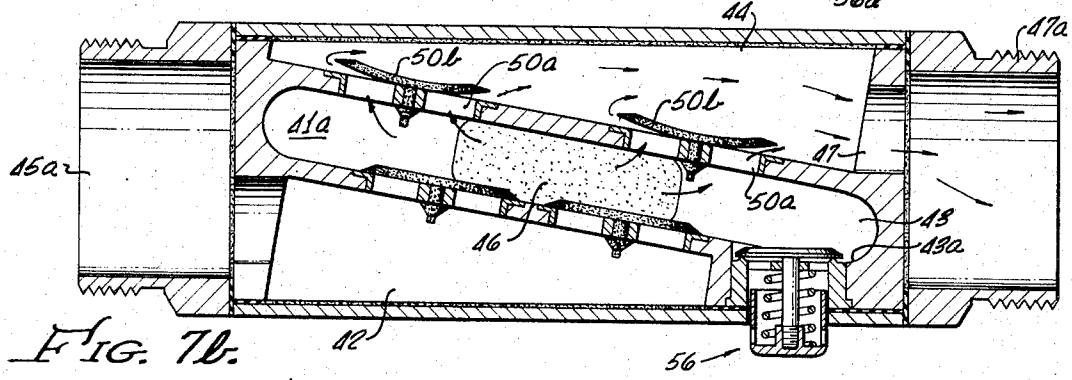


FIG. 7b.

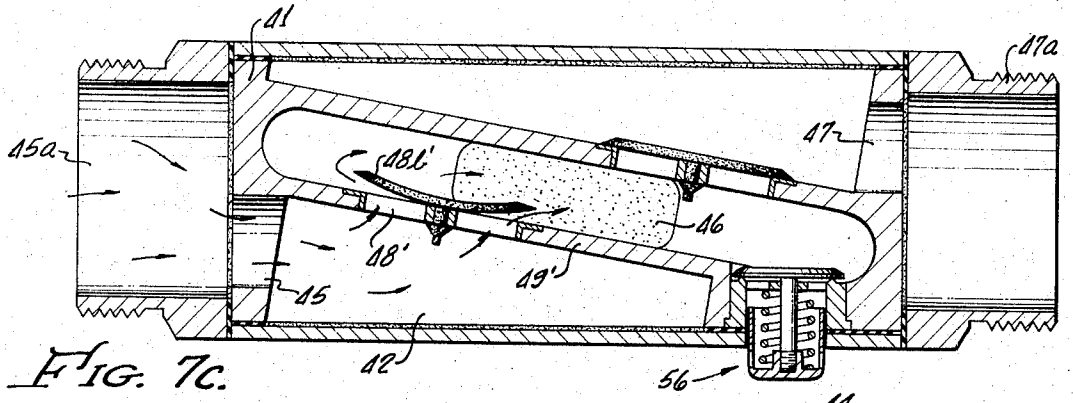


FIG. 7c.

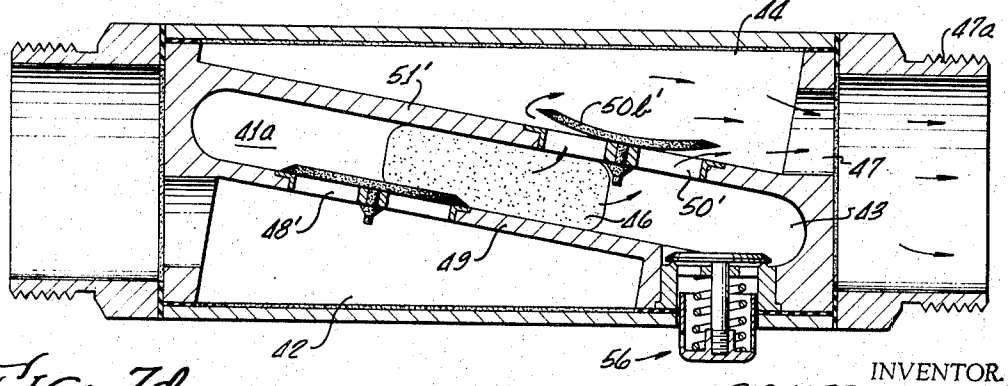


FIG. 7d.

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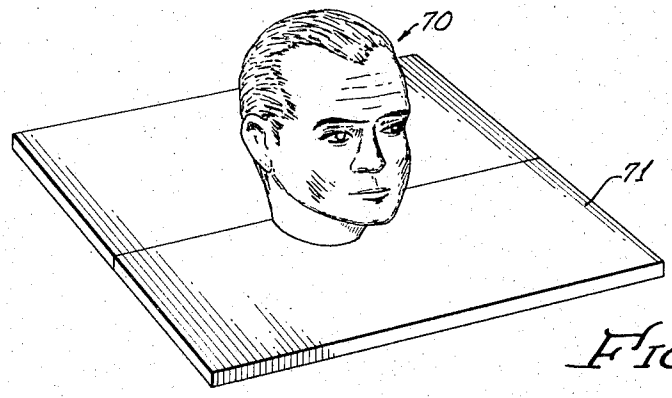


FIG. 8.

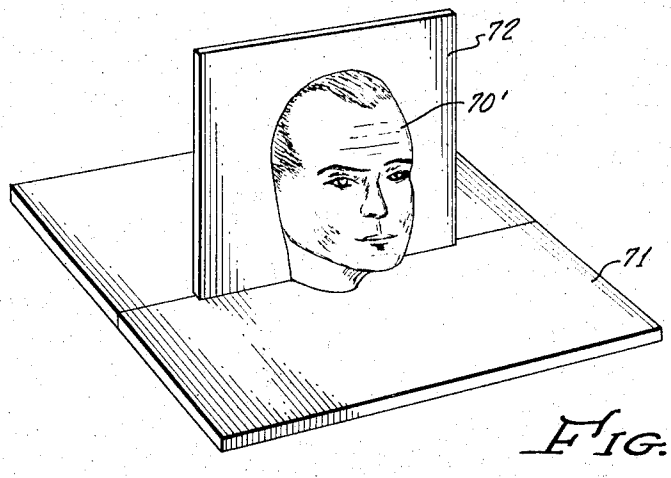


FIG. 9.

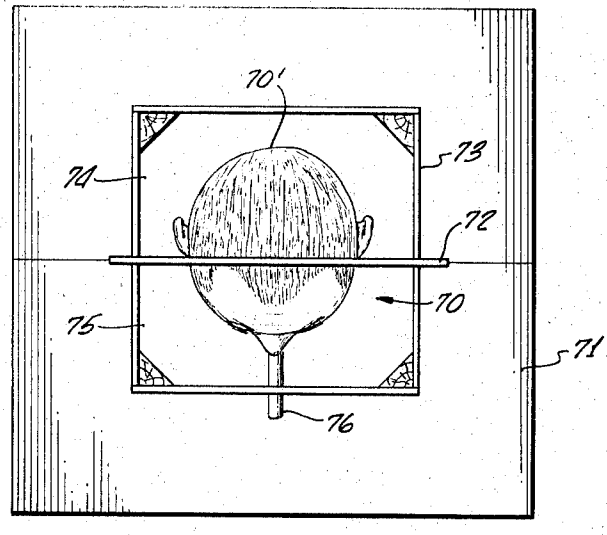


FIG. 10.

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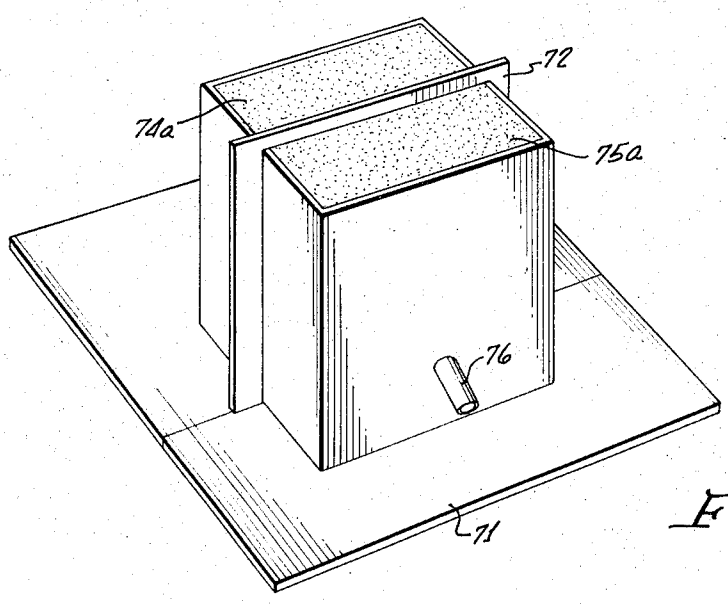


FIG. 11.

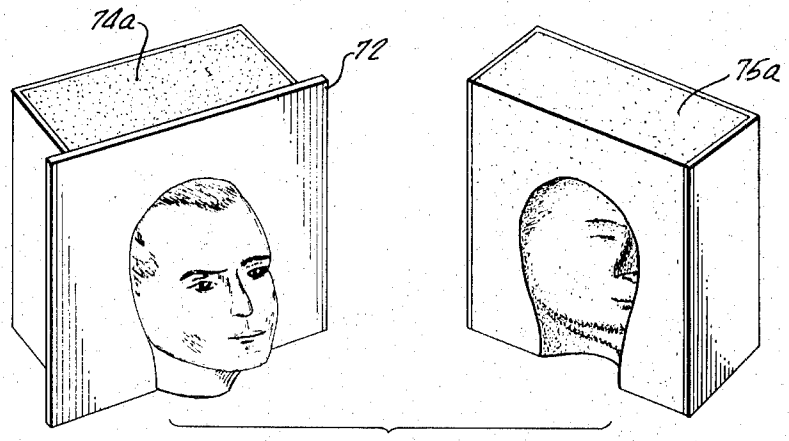


FIG. 12.

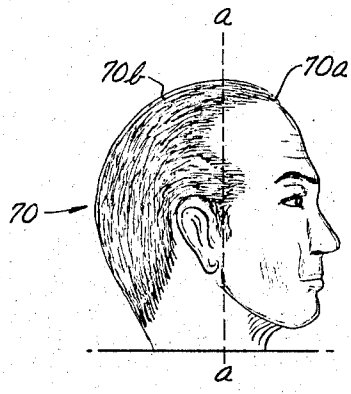


FIG. 13.

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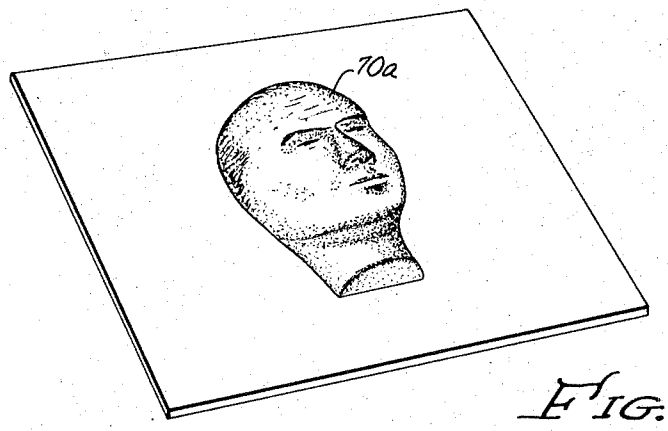


FIG. 14a.

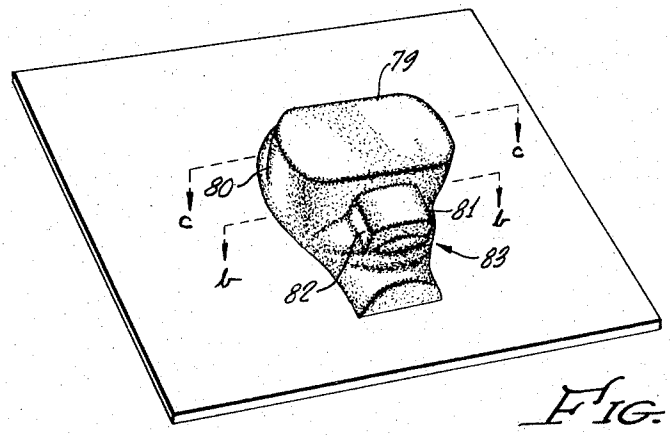


FIG. 14b.

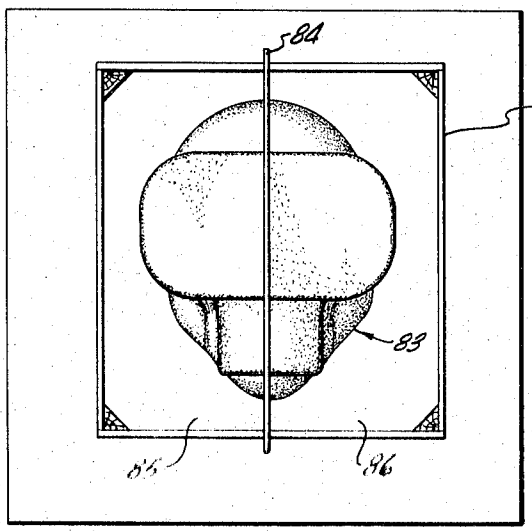


FIG. 15.

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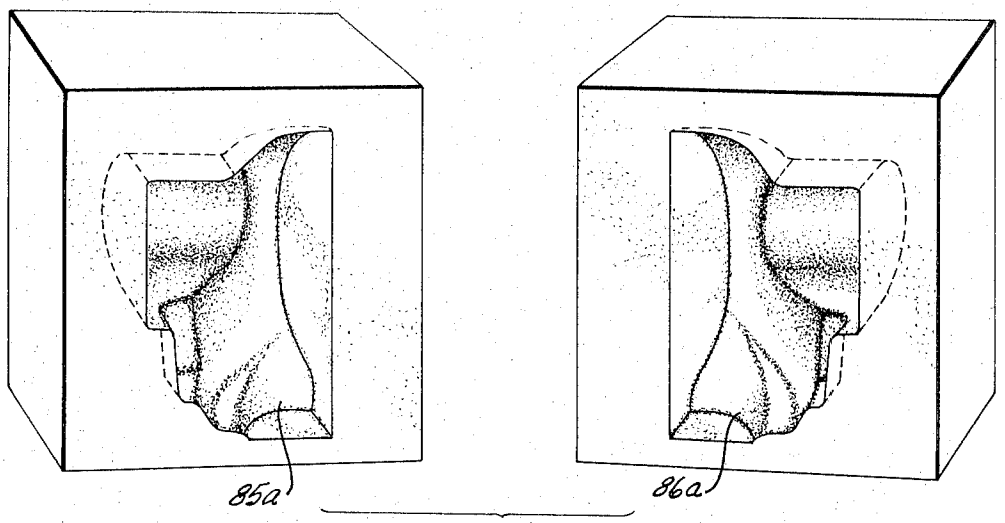


FIG. 16.

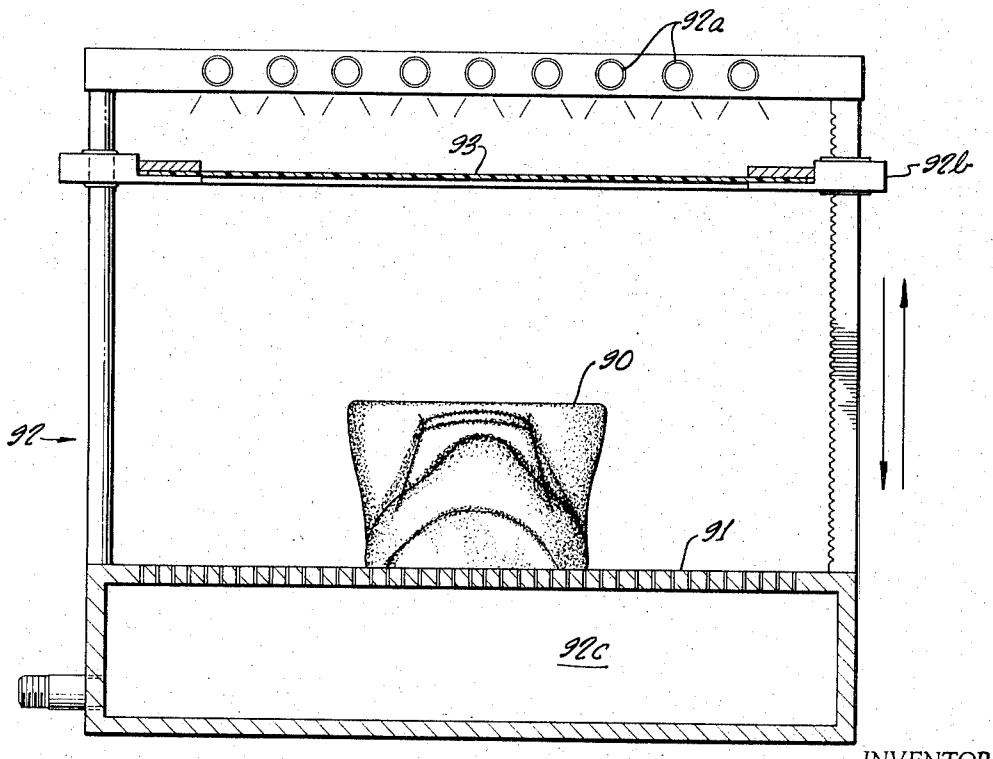


FIG. 17.

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FORM FIT VERTICAL FLOW DIVING HEAD GEAR

CROSS-REFERENCE TO A RELATED APPLICATION

This application is a continuation-in-part of U.S. Pat. application Ser. No. 274,150 filed July 24, 1974, now abandoned, which, in turn, is a continuation of U. S. Pat. application Ser. No. 99,945 filed Dec. 21, 1970, now abandoned.

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

With the continuing interest in the development of an undersea technology, the development of reliable, life sustaining systems is of prime importance. When the performance of tasks and conducting observations required a diver's being under water for prolonged periods of time, or at great depths where surface-supplied air was not practical, self-contained underwater breathing systems of the semiclosed or closed types were produced. Generally speaking, these systems operate to recirculate a diver's exhaled breath through a CO_2 absorption unit which purges the CO_2 from the exhaled breath, and indirectly feed the CO_2 scrubbed gas back to the diver. An immediate inherent hazard of using these systems is that the CO_2 absorbing material becomes nonfunctional upon getting wet. Unless the exhaled CO_2 is scrubbed from the semiclosed or closed systems, the diver is exposed to CO_2 excess, leading to unconsciousness and suffocation. In contemporary systems, water and saliva from the diver's mouthpiece can and do leak into the CO_2 absorption cannister located to receive exhaled breath. One-way valves provided at opposite sides of the mouthpiece allow the inhalation of gas from a breathing bag and the exhalation of gas to the CO_2 absorption cannister. In addition, divers using the present closed and semiclosed systems usually wear a conventional face mask having a resilient, opaque, tunnel-like sleeve. These masks become uncomfortable when worn for prolonged periods of time since they are supported, in part, on a fleshy portion of the face reaching between the cheekbones and the frontal portion of the upper jaw. To seal a mask which rests on these fleshy areas requires elastic straps which pull the tunnel-like sleeve into them. Sufficient tensioning effects a force fitting of the mask with resulting discomfort, especially when the mask is worn for long periods of time. Attempts have been made to obviate this attendant discomfort and water leakage by constructing a helmet-like arrangement that, in one instance, encloses the diver's head entirely. With closed or semiclosed systems, this approach is inherently defective since dangerous CO_2 buildup is likely. The popular "Jack Brown"-type face mask, usually employed where a source of surface-supplied air is available, has been modified for closed and semiclosed circuit adaptations. But, here again, dangerous CO_2 buildup is an ever-present possibility and facial discomfort, where the mask seats, is felt. None of the available head gears permits the full realization of the advantages of self-contained underwater breathing apparatuses since they all are either inherently dangerous, highly confining, or manifestly uncomfortable.

SUMMARY OF THE INVENTION

The present invention is directed to providing a diving head gear worn to seal its interior from the surrounding water medium and includes a mask assembly having a rigid, peripheral portion configured to continuously conform to the facial contours defined by the contours of the forehead, regions of the temples, and the jawbone. A transparent shell portion integrally extends from and reaches across the peripheral portion to define a face mask interior. A breathing block assembly is carried on the portion of the shell adjacent the mouth and directs life-supporting gas vertically as it is inhaled and exhaled to trap liquids and to purge them from the system. A custom fitted hood also is included that elastically seats the peripheral portion to ensure the sealed relationship and to protect the diver. A positive sealed mask interior is guaranteed by the method of forming the mask assembly which includes casting a replica of each diver's head and molding, by a pressure differential method, a ductile sheet over a contour preestablished by a builtup template representative of a face mask interior and the peripheral portion.

A prime object of the invention is to provide a superior diver's head gear.

A further object is to provide a diving head gear affording protection to a diver while blocking any water transfer to the breathing system.

Still another object is to provide a diving head gear overcoming problems of face seal deterioration attendent contemporary masks.

Another object is to provide a diving head gear enclosing a minimal space preventing dangerous CO_2 buildup therein.

Another object is to provide a diving head gear defining a reduced enclosed volume to minimize its entrained mass.

Still another object is to provide a diving head gear free of protuberances.

Another object is to provide a face mask assembly conforming to the bony contour lying outside of the facial area ensuring a sealed relationship.

Another object of the invention is to provide a face mask assembly ensuring comfort when worn for prolonged periods.

Still another object is to provide a face mask assembly separated into a nasal-visual compartment and an oral compartment to minimize the possibility of dangerous CO_2 buildup.

Still another object is to provide a face mask assembly having a compartmented interior with means for purging each interior independent of the other.

Yet another object is to provide a face mask assembly enabling unrestricted forward and peripheral vision.

A further object is to provide a face mask assembly having a dipped rubber liner easily installed and removed.

Still another object is to provide a hood assembly tailored to an individual diver for comfortably seating a face mask assembly.

Another object is to provide a hood assembly having overlapping, connecting strips blocking an excessive transfer of water when the bulk of the diving suit is changed.

Still another object is to provide a breathing block assembly for blocking and purging leaked water making it ideal for semiclosed and closed breathing systems.

Still another object is to provide a breathing block assembly channeling the inhaled and exhaled gas in a vertical flow for setting-out moisture droplets entrained in the gas flow.

Still another object is to provide a breathing block assembly incorporating a slanted chamber in communication with a purge valve to ensure the drainage and expulsion of leaked water.

A further object is to provide a breathing block assembly ensuring a reduced inhalation and exhalation resistance to breathing.

Still another object is to provide a breathing block assembly having a backup-gas system capability.

Yet another object is to provide a breathing block assembly having a diver communications capability.

Yet another object is to provide a method for making a superior face mask.

Another object is to provide a technique of face mask construction ensuring its conformity to a wearer's facial contours.

These and other objects of the invention will become readily apparent from the following description when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric depiction of the head gear.

FIG. **2** is an isometric view of the face mask assembly.

FIG. **3***a* is a frontal view of the face mask assembly of FIG. **2.**

FIG. **3***b* is a side view of the face mask assembly of FIG. **2.**

FIG. **3***c* is a rear view of the face mask assembly showing the relative thickness of the face mask assembly.

FIG. **4** is an isometric view of a modified face mask assembly.

FIG. **5** is an isometric view of the hood assembly.

FIG. **6** is an exploded view of the breathing block assembly.

FIG. **7***a* is a sectional view of the breathing block assembly generally taken along lines 7—7 in FIG. **1** showing gas flow during the inhale portion of the breathing cycle.

FIG. **7***b* is a sectional view of the breathing block assembly generally taken along lines 7—7 in FIG. **1** showing gas flow during the exhale portion of the breathing cycle.

FIG. **7***c* is a sectional view of a modified breathing block assembly generally taken along lines 7—7 in FIG. **1** showing exhaled gas flow.

FIGS. **8** through **17** set forth, graphically, the steps of molding the face mask assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. **1** shows the head gear consisting of three main assemblies, those being a face mask assembly **20,** a hood assembly **35,** and a breathing block assembly **40.** Taking them in order, the face mask assembly is, in its preferred form, a sheet of molded material, for example, a material possessing the characteristics of strength, transparency, and ductility, when heated, as the material commercially available under the trademark, "Lexan **500.**"

The manner by which the face mask assembly is constructed will be elaborated on below, but leave it suffice to say at the present, that it is shaped with a peripheral strip or peripheral portion **20***a*, continuously extending around and resting on the bony contours rimming the face. The peripheral portion extends along the forehead area **21,** the regions of the temples **22***a* and **22***b*, and a lower jawbone area **23,** generally described as lying adjacent the lateral surface of the lower jawbone, i.e., the mandible. Extending the lower jawbone area of the peripheral portion to form a cup-shaped chin recess **23***a*, positions and maintains the face mask assembly on the diver's face should he accidentally bump it while swimming or working. At this time, it is emphasized that the peripheral portion is formed to rest on areas defined by the head's bony, hard surfaces and does not rely, for sealing or support, upon any fleshy areas which either collapse to allow water leakage into the interior of the mask, or which are painful when pressure is brought to bear against them. In addition from a visual inspection of the drawings it is apparent that the peripheral portion has a width resting on the bony contours in excess of a plural integral multiple of its thickness to further ensure comfortable seating of the mask.

Within the confines of the peripheral portion, a shell portion **24** reaches across to define the dimensions of the interior of the face mask assembly, as near to the face as is practicable reducing the entrained air mass enclosed by the mask. Such reduction of entrained air mass is desirable to minimize the possibility of any dangerous CO_2 buildup within the mask, and, to provide a more maneuverable diver head gear that will not restrict a diver's motions.

The shell portion, enclosing the facial area, is separated by an inwardly extending bridge **25** into an oral compartment **26** and a nasal-visual compartment **27.** The bridge is integrally formed with the peripheral portion and shell portion or it, optionally, is a glued-in section of a pliable material conforming to the contour of the outer surface of the upper jawbone, i.e., the maxillae. Isolating the two compartments from each other further reduces the possibility of dangerous CO_2 buildup and its inhalation by the diver.

The nasal-visual compartment extends forwardly of the facial area a distance beyond the nose and terminates, preferably, in a planar wall **28** in front of the eyes and nose, although, the forward wall optionally is curved having a proper radius of curvature to allow, substantially, distortion-free peripheral, as well as, forward visibility.

Molding the planar wall out of the transparent "Lexan **500**" material allowed adequate forward vision; however, slight distortion and vulnerability to damage dictated modification of the planar area by substituting a tempered lens **28***a* sealed in the shell portion by annular seal **28***b* and held in place and protected by a stainless steel rim **28***c*. A more positive protection is provided by optionally using a metal band which automatically, self locks when it is circumferentially squeezed onto the annular seal. The walls of the nasal-visual compartment permitted tolerable, slightly distorted peripheral vision which was found to be adequate to warn a diver of impending danger approaching from the side, and the tempered lens enabled close ob-

servation of the smallest detail when the situation so demanded.

A manual or pressure operated, commercially available purge valve unit **30** is disposed in the lower left-hand portion of the nasal-visual compartment to allow clearing of the compartment should leakage occur. Also, a resilient pad **31** is bonded onto the lower portion of the nasal-visual compartment immediately adjacent and in-line with the nostrils to allow pressure equalization: With the pad in place the diver slightly, upwardly displaces the face mask assembly to seal the end of the nostrils and forcibly blows outward through his nostrils to achieve pressure equalization.

The forward wall of the oral compartment is provided with a diagonally slanted oral compartment aperture **26***a* permitting the exchange of gas from the diver through breathing block assembly **40.** Since the oral compartment is separated from the nasal-visual compartment by bridge **25,** water that inadvertently leaks into the oral compartment requires a separate purging element. It was found unnecessary to include a water purging unit directly in communication with the oral compartment because a purge valve capability is incorporated in the breathing block assembly. Thus, leaked water and saliva gathering in the oral compartment are vented to the breathing block assembly through the oral compartment aperture. At this point may it be emphasized that manually operated purge valve unit **30,** carried on the nasal-visual compartment, and purge valve unit **56** provided on the breathing block assembly, preferably are both located on the left hand side of the head gear to simplify and standardize the procedure for mask clearing (raising the left hand to the head gear to clear either compartment).

An outer surface **26***b* is configured to accommodate mounting of the breathing block assembly and is slightly removed from the lips to allow the intelligible formation of words since a communications capability is also provided for in the breathing block assembly and will be discussed below.

Thusly described, the face mask assembly seals out surrounding water and, by providing a plurality of snap fasteners **32** molded with or bonded onto peripheral portion **20***a*, connection to a resilient member, exerting a slight tensile force, seats the face mask assembly. Because of the width of the strip or peripheral portion, the face mask is seated comfortably on the bony contours.

The seal created by the peripheral portion, as it snugly fits onto the facial bony contours, is enhanced by coating the inside of the peripheral portion with a rubber liner **33.** Earlier attempts to aid sealing of conventional type mask assemblies called for mounting rubber lips around their peripheral extremes or including neoprene padding strips; however, these were prone to failure and leakage occurred.

A preferred manner of mounting the liner calls for dipping the face mask assembly into a liquid latex compound and allowing the adhered coating to dry. Repeated dippings build up a layered resilient liner to enhance the seating and sealing of the mask as well as providing a more comfortable surface contacting the head. Having the liner so disposed on inner surface of peripheral portion liner so disposed on inner surface of peripheral portion **20***a* eliminates the problem of face seal deterioration, a common problem of rubber-lip-sealed, conventional face masks.

A more secure fitting between the hood assembly and the face mask assembly is aided by coating the outer surfaces, along with the inner surfaces, of areas **21,** **22***a*, **22***b*, and **23** with the layered rubber liner. Additional coating of the inner surfaces of the oral compartment with the liner serves to cushion the cheekbone and cheek area and reduces to possibility of facial rawness.

Outer surface **26***b* of the oral compartment is coated with the layered liner, particularly around diagonally slanted oral compartment aperture **26***a*, and provides a resilient gasket for mounting the breathing block assembly. Sandwiching the layered liner between the outer surface of the oral compartment and the breathing block assembly blocks water that may otherwise leak into the head gear.

Coating the face mask assembly is simplified by dipping the entire assembly into the liquid latex compound. Layers of latex overlapping onto the nasal-visual compartment are trimmed by a sharp knife and peeled away so as not to interfere with forward or peripheral vision. A further benefit of repeatedly dipping the entire assembly to form the liner is the formation of a lower liner portion **33***a*, reaching across the underside of the chin backward towards the throat. This liner aids in sealing the mask assembly's interior as well as providing warmth and flexibility during chin movement, see FIG. **3***b*.

A liner, formed as described above possesses the capability to be peeled from the face mask assembly and later replaced. In addition, modifying the face mask assembly by carving away cup-shaped chin recess **23***a* allows greater freedom of chin motion and speech intelligibility. The liner is replaced and lower liner portion **33***a* reaches across the chin and resiliently accommodates the jaw to allow its unrestricted motion while ensuring protection and warmth to the diver.

When wearing a hood assembly is not mandatory, elastic straps having mating snap portions reach around the head and are fastened onto snap fasteners **32.** However, the full advantages of the disclosed head gear are realized when the face mask assembly, hood assembly, and breathing block assembly functionally cooperate as a unit.

A further modification of the shell portion greatly reduced the entrained air mass by adopting a "goggle-shaped" tempered lens **28***aa*, in place of lens **28***a*, see FIG. **4.** Mounting the lens in a resilient ring **28***bb* protected by a similarly shaped metal strap **28***cc*, allowed the lens to be brought closer to the eyes. Provision for the nose was made in the shell portion by outwardly bulging a nose portion **28***dd* configured to conform to a surface slightly removed from the nose's outer surface. All the other teachings, with respect to the face mask assembly using a tempered lens **28***a*, are applicable to this modified version of the face mask assembly.

Noting FIG. **5,** the sealing and seating of the face mask assembly is ensured by hood assembly **35** due to its unique configuration and to its being fabricated from a sheet of elastic neoprene rubber. In addition to holding the face mask assembly in place, the hood assembly provides an armor-like protection for the diver's head and neck areas.

A replica **70** is cast of the diver's head, in a manner to be set forth below, and three neoprene panels **36, 37,** and **38** are cut and trimmed to conform to the contours

of the head. Gluing and sewing the panels along their adjacent boundaries forms a chamber shaped to accommodate a diver's head, leaving open the facial area, through which the face mask assembly protrudes.

A plurality of reinforced panel snaps **36***a*, **37***a*, *and* **38***a* are peripherally disposed about the facial opening to engage similarly disposed mating snaps, snap fasteners **32**, carried on peripheral portion **20***a*, and, via the joined snaps, a gentle pulling force is exerted by the elastic neoprene to seat the face mask assembly.

The lower section of panels **36** and **38** reaches around the front of the neck area and defines a pair of overlapping panel strips **36***b* and **38***b*. Mounted on the panel strips, in an opposed relationship, are the male and female mating portions of a fastener **39**, for example, a fastener having the characteristics of the fastener commercially marketed and known under the trademark of "Velcro."

An immediate advantage of the above-described configuration becomes apparent when donning and removing the diving head gear. The hood assembly is joined to the face mask assembly by snapping together the snaps carried on the forehead area. The diver simply places the face mask assembly on his face and pulls the hood assembly over his head. Connection of the two mating snap fasteners carried on the hood to those carried on the peripheral portion at the lower side of the face, resiliently seats the face mask assembly against his face. By simply wrapping the overlapping panel strips on top of one another, the mating portions of the Velcro fastener are engaged forming a secure closure. In addition, by mounting the Velcro fasteners along the reaches of the overlapping panel strips, the hood is adjustable to block out an excessive water transfer to the interior of the hood irrespective of the bulk of the dive suit. That is to say, the portion of the dive suit reaching up along the neck area may be thicker or thinner according to changing temperature or working conditions. The overlapping strips, by decreasing or increasing their overlapping relationship, accommodate the thicker or thinner suits without any structural modifications.

More reliable communications are aided by including a pair of earphone pockets **36***c* and **38***c* each shaped to provide a mounting and to retain an acoustic earphone which interfaces with existing communications equipment. An opening is optionally provided in each panel adjacent the ear to facilitate the transfer of sound.

The apex of panel **37** is provided with a vent **37***b* for passing a gas bubble trapped in the hood assembly's interior to eliminate an instabilizing buoyant effect. Undue transfer of water through a vent **37***b* does not occur since the tailor-made hood assembly, snugly fitting about the wearer's head, does not lend itself to flexure and pulling from the head.

Breathing block **40** is a significant advance in the art of gas exchange valve mechanisms and, when employed with the face mask assembly, markedly increases diver safety and lessens diver fatigue.

Looking to FIGS. **6**, **7***a*, and **7***b*, showing a detailed arrangement of the breathing block assembly, an integral housing block **41** is machined, or molded, from a strong, lightweight material such as teflon or aluminum; if the latter is chosen, the housing block and all of its associated subcomponents are coated with a hard black anodized finish for protection from the corrosive effects of a marine environment.

Three longitudinally extending chambers, an inhale chamber **42**, a common inhale-exhale center chamber **43**, and an exhale chamber **44** are formed within the block and occupy a substantial portion of its interior. An inhale port **45**, reaches from the inhale chamber to the outside of the housing block, an exhale port **47** reaches from the exhale chamber to the housing block's exterior, and an inhale-exhale opening **46** is formed in an inner wall **41***a* of the housing block to provide passageways for the inhalation and exhalation of gas.

The dimensions and orientation of the inhale-exhale opening coincide with diagonally slanted, oral compartment aperture **26***a* and, when the breathing block assembly is screwed onto the face mask assembly, via a mounting plate **41***b*, the aperture and the opening are aligned. To ensure a sealed fitting between the breathing block assembly and the face mask assembly, the outwardly facing configuration of inner wall **41***a* is complementary to outer surface **26***b* of the oral compartment. Mounting screws **41***b'*, peripherally disposed about the inhale-exhale opening, are fitted through correspondingly disposed holes reaching through outer surface **26***b* to compress layered rubber liner **33**, when the screws are tightened, drawing the two assemblies together.

A source of gas and a CO_2 absorption unit, not shown for the sake of simplicity in the drawings, are joined to the breathing block assembly by an adapter hose fitting **45***a* and **47***a*, respectively. The fittings are provided with appropriate gaskets and, optionally, are of several different sizes to interface with available closed and semiclosed systems.

Looking to FIGS. **7***a* and **7***b*, further fashioning of the housing block calls for shaping a plurality of laterally extending passageways **48** in a partitioning wall **49** separating the inhale chamber from the common inhale-exhale chamber. A spider-shaped valve holder **48***a* is fitted into each of the passageways and provides a support for a releasable mushroom check valve **48***b* allowing a one-way passage of gas from the inhale chamber to the common inhale-exhale chamber. Similarly disposed, a plurality of laterally extending passageways **50** extends through a partitioning wall **51** separating the common inhale-exhale chamber from the exhale chamber. Again, spider-shaped valve holders **50***a* are fitted into each passageway and releasably supported mushroom check valves **50***b* ensure the one-way travel of gas from the common inhale-exhale chamber to the exhale chamber. After the block's interior has been shaped, milled or molded according to the manufacturing technique employed and the valve holders and valves are in place, the exhale chamber is isolated from the surroundings by a top cover plate **52**, provided with an appropriately shaped gasket, screwed onto the housing block.

A modification appears in FIGS. **7***c* and **7***d* and substitutes a single valve **48***b'* in a single passageway **48'** in partitioning wall **49'** and a single valve **50***b'* carried in a single passage **50'** provided in partitioning wall **51'**.

A bottom cover plate **53** and a suitable gasket separate the lower chamber from the surroundings, but the plate is additionally configured with a mike opening **53***a*. The mike opening establishes an audio communication path from the housing block's interior to an intercom microphone **54**, protected and sealed from the

surroundings by a cup-shaped intercom cover **55**. A lead **54***a* extends from the intercom microphone through a gland packing, disposed in the wall of the cup-shaped intercom cover, to relay signals to remotely located communication equipment. Thusly disposed, a speech path, from the diver, through the common inhale-exhale chamber, through check valves **48***b*, the inhale chamber, and, finally, to the intercom mike, is established. Although the check valves are closed while the diver is speaking, they do not dampen or render unintelligible his words.

The bottom cover plate is further provided with a purge valve opening **53***b* axially aligned with a purge valve duct **41***c*. The opening and duct reach in from the housing's exterior and create a purging conduit from the lowest portion, a sump portion **43***a*, of the common inhale-exhale chamber.

A conventional, spring-biased purge valve unit **56** is selected which consists of a check valve element **56***a* supported by a valve holder **56***b* and biased to block the passage of fluid by a biasing spring element **56***c*. This valve unit is fitted in the purge valve duct and by upwardly displacing the check valve element by a manually actuated plunger lever **56***d* the selective purging conduit serves as a passageway between the inhale-exhale chamber and the surrounding medium.

Particularly shaping the common inhale-exhale chamber to lie with, approximately, a 10 percent diagonal slant, ensures the drainage and collection any leaked water and saliva to sump portion **43***a* and minimizes the possibility of the water's reaching the exhale chamber and the following CO_2 absorption unit. As soon as it collects, water is evacuated from the breathing block assembly by first pushing in on plunger lever **56***d*, to raise the check valve **56***a* from its seat, and then exhaling gas into the common inhale-exhale chamber. If excessive amounts of leaked water accumulate in the common inhale-exhale chamber and it starts to become filled presenting a danger of passing the water to the CO_2 absorption unit, the hose, joining adapter hose fitting **47***a* to the CO_2 absorption unit, is pinched closed. Continued forceful exhaling of gas purges the leaked water with little risk of spraying it into the exhale chamber and onto the CO_2 absorption unit.

Most leaked water enters semiclosed and closed breathing systems through the interface connecting the systems to a diver's mouth, usually a mouthpiece, or a conventional type mask assembly. It naturally follows that leaked water should be blocked, or accumulated and expelled at this interface. Actuating the purge valve unit, in a manner above-described, dead-ends leaked water before it gains access to the closed or semiclosed systems. Since CO_2 absorption units directly receive the exhaled breath in most systems, and the absorption material deteriorates as moisture permeates it, the presently configured housing block, having a longitudinally extending, diagonally slanted common inhale-exhale chamber ensuring the collection of leaked fluids, substantially contributes to system reliability and effectiveness.

A further contributing factor to system effectiveness depends from the relative size and disposition of longitudinally extending partitioning walls **49** and **51**. The walls, by containing a plurality of laterally extending passageways, greatly increase the areas through which the inhaled gases and exhaled gases flow with respect to the areas of the inhale port and exhale port. Since the volume of gas passing through the breathing block assembly is constant, upon a given demand by a diver, the velocity of transferred gas is significantly reduced as the gas reaches the common inhale-exhale chamber. While this reduced velocity diminishes the inhalation and exhalation resistance and, therefore, tends to lessen diver fatigue, the reduction of the gas flow velocity causes gas entrained droplets of moisture to settle out within the common inhale-exhale chamber. These settled droplets run down the slanted chamber and drain into sump portion **43***a* (assuming that such droplets find their way into the system "upwind" of the breathing block). Therefore, by reducing the flow velocity through the breathing block assembly, moisture coming into the breathing block assembly via the inhale port is blocked from progressing to the exhale port and is collected and purged from the system.

Furthermore, on the inhale portion of the breathing cycle, the inhaled gas is directed vertically, upwardly through through laterally extending passageways **48** and, combined with the reduced velocity, any gas-carried leaked droplets, being heavier than the gas, tend more readily to settle out and drain to the sump portion. Exhaled gas entering the center inhale-exhale chamber, similarly, is vertically directed and saliva and leaked water coming from the interior of the face mask assembly fall from the gas flow into the sump portion, noting the gas flow arrows in FIGS. **7***a* and **7***c* showing the inhale portion of the breathing cycle, and FIGS. **7***b* and **7***d* showing the exhale portion of the breathing cycle.

An additional modification of the breathing block assembly greatly increases diver safety by allowing an immediate, automatic drawing of gas from a backup system should the primary breathing system fail. An emergency port **60**, laterally aligned with inhale-exhale opening **46**, is formed in forward wall **41***d* of the housing block and the forward facing surface of the forward wall is appropriately shaped to provide a mounting surface **41***e* for receiving a demand regulator unit **61**.

The regulator unit incorporates the known features of a conventional second-stage portion of a widely adopted two-stage demand regulator. Its principal parts are: a regulator body housing **61***a*, a diaphragm member **61***b*, a tilt lever element **61***c*, and a fitting **61***d* joined to a hose **61***e* extending to a source of backup gas. If the primary source of gas fails, the diver squeezes shut the hose carried on fitting **45***a* and inhales. The inhalation pulls in diaphragm member **61***b* unseating the tilt valve to pass gas to the diver. Optionally, the diaphragm is manually depressed when greatly increased amounts of gas are required or if rapid purging of the common inhale-exhale chamber is needed.

Reversing the locations of the demand regulator unit and the intercom microphone, from that shown in FIG. **6**, further improves the functional nature of the breathing block assembly. Of course, suitable adapters are provided to fit the demand regulator unit on the bottom of the housing block through mike opening and to mount the intercom microphone on the emergency port. With this arrangement, speech intelligibility rises since the mike is in direct communication with the diver's mouth and the blind spot blocking lower, forward vision is reduced since the forward protrusion of the cup-shaped intercom cover is less than that presented by the demand regulator unit.

The preferred embodiment of the breathing block assembly is a rectangularly shaped, curved block designed to closely fit on the face mask assembly with a minimum of protuberances, which could become entangled in cables or marine plant life. Where no communications capability is required, the microphone is omitted and the mike opening is sealed shut. When a backup gas supply is not practical, the demand regulator unit is dispensed. Without the mike and regulator unit, the essential features of the breathing assembly are retained and its outline is considerably streamlined.

All the gaskets, screws, fittings, valves, etc. are standard items and are subject to routine modification to interface with existing breathing systems. Because all the elements are subjected to a harsh, corrosive marine environment they are selected from materials either impervious to or resistant to its effects. The precise manner of connecting the component elements of the breathing block assembly has not been elaborated on to avoid belaboring the obvious.

Realization of the interrelated, functional superiority of the head gear is dependent directly on its being custom fitted to each diver according to the novel methods of individually tailoring the subassemblies, viz., the hood assembly and the face mask assembly.

First, there must be cast a replica **70** of a diver's head on which the mask assembly and hood assembly are formed. FIGS. **8** through **17** depict the process of fashioning the face mask assembly.

After a diver is positioned to remain perfectly motionless to allow a setting of a casting material, a support base **71** is fitted about his neck. The support base is cut into two pieces and an appropriately sized neck hole allows its snug placement about his neck to retain the flow of a viscous casting material.

When so placed, the head is coated with a release agent **70'**. Grease is suitable, but a silicon-wax composition, commercially available under the trademark "Plastico Moulage" has been found to be more satisfactory since it is readily mixed to the proper consistency for coating the head a uniform thickness, approximately one-eighth of an inch. Since the release agent tends to be relatively messy, a tight fitting bathing cap worn over the hair reduces the clean-up job.

Prior to casting a female mold whose interior define the outer contours of the head, provision must be made for splitting this mold to enable its removal from the head after the casting material has set. A dividing head template **72**, FIG. **9**, having internal dimensions conforming to a lateral cross-sectional outline of the head, taken generally along line *a—a* in FIG. **13**, is placed about the diver's head. Each dividing template is thin walled serving to act as a nondimensional boundary for the two cast portions to be molded.

In FIG. **10**, a casting box **73** encloses the head and, together with dividing head template **72**, forms a pair of casting chambers **74** and **75**. A tube **76** reaching from the mouth or nostrils extends through a forward wall of the casting box to provide a breathing duct for the diver as the casting operation proceeds.

Plaster of paris, mixed to a viscosity allowing its pouring without difficulty, is poured simultaneously in casting chambers **74** and **75** around and covering the head. After a setting period, approximately 10 minutes, the casting box is carefully and slowly removed leaving a set cube of plaster of paris, consisting of portions **74***a* and **75***a*, enclosing the head with the breathing tube protruding through portion **75***a*, see FIG. **11**.

FIG. **12** shows that the two portions are easily separated along template **72** by gently pulling portion **75***a* forward. Upon removal of portion **75***a* from the facial area, portion **74***a* is withdrawn to he rear and the head is freed from the two portions. The two portions are placed together, minus dividing template **72**, to create a female casting mold having internal dimensions conforming to the external configuration of the head.

Readying the female casting mold for casting a replica **70** calls for separating its portions and coating their interiors with a release agent. Upon completion of the coating operation and after a sufficient drying period, casting of the replica follows.

A compound similar to plaster of paris, commercially available under the trademark "Hydrocal," is mixed to the proper viscosity and poured within the cavity defined by the female casting mold. Hydrocal has a setting time of approximately 6 hours and is harder and resists chipping and cracking, making it preferable to plaster of paris. After the replica has hardened, it is removed from the female casting mold which is reusable for casting additional head replicas, is so desired. The head replica is finished, smoothed, and painted with a primer to protect it during subsequent operations.

At this stage, fabrication of the hood assembly is undertaken using the complete replica of the head, and the fitting, gluing and sewing proceeds as outlined above. Molding the face mask assembly necessitates sawing the head replica along a lateral plane generally depicted by lines *a—a*, to define a facial half **70***a* and a skull half **70***b* of the replica, noting FIG. **13**. The facial half of the replica, containing the bony, peripheral contour outlining the facial features as defined by the forehead, the areas of the temples, and the lower jawbone, is placed face up on a work surface (FIG. **14***a*).

Building up a male negative mold **83** on the facial half provides a molding surface from which the dimensions of the face mask assembly are determined. A face mask lens template **79** is positioned a predetermined distance forward of the facial half, a distance sufficient to enclose the nose, and is arranged to be perpendicular to the line of forward vision. Moldable clay or putty is built up in volume **80** reaching between the facial area and the face mask lens template and within the bony, peripheral contour to define the confines of nasal-visual compartment **27**. In like manner, immediately outwardly and forwardly of the mouth, a breathing block template **81**, configured to shape the face mask assembly for receiving a breathing block assembly, is placed in loose contact with the replica's lips. Similarly, moldable clay or putty builds up volume **82**, lying between the breathing block template and the facial replica and within the bony, peripheral contour, to define the confines of oral compartment **26**.

Face mask lens template **79**, taken with its builtup volume **80**, and breathing block template **81**, taken with its builtup volume **82**, define a male negative mold **83** within the forward facial projection contained within the bony, peripheral contour.

Molding the face mask assembly, described in detail below, optionally progresses at this point. However, irregularities on the male negative mold's surface, attributed to the building up processes, call for further sculpting to provide a suitable molding surface on

which a ductile sheet is shaped. A further reason for not using builtup negative mold 83 becomes apparent, observing that, see FIG. 14*b*, the cross-sectional area near the facial area, cross lines *b*—*b*, is smaller than the cross-sectional area near the lens template along lines *c*—*c*. A face mask assembly molded over a male negative mold defining such a "back draft" volume, would require destruction of the mold to free the face mask assembly. If a later inspection revealed flaws in the molded face mask assembly, another replica would have to be cast, split, and built up before another molding operation is attempted.

These limitations are avoided by mounting a divider 84, having an inner silhouette complying with the longitudinal peripheral configuration of male negative mold 83, noting FIG. 15. A framing box 84a encloses the male negative mold and, when separated by divider 84, a pair of casting chambers 85 and 86 are created. The chambers are filled with a suitable casting material forming a left and a right section 85*a* and 86*a* of a female negative mold 87. After the sections of the female negative mold have hardened, they are separated and the template and the male negative mold are removed. Their interior surfaces are sculpted to render them smooth for formation of a modified negative casting 90.

After having coated the interior of sections 85*a* and 86*a* with a releasing agent, the female negative mold is reassembled and readied for casting the modified negative casting. The casting material fills the mold, it hardens, and the female casting mold is split and removed. The modified negative casting is sanded, if needed, to provide a continuous smooth surface for the molding operation.

The face mask assembly is formed over the modified, negative casting according to a pressure differential method. A transparent sheet of a plastic compound 93 is heated to a specific temprature, the above referred to Lexan 500 was heated to a temperature of 400° to attain a workable degree of ductibility. The modified, negative casting is placed on the lower base 91 of a conventional vacuum forming machine 92. The plastic sheet is placed into the upper portion of a conventional vacuum forming machine and lowered over the modified, male negative mold casting and adjacent the lens area. Applying a vacuum on the base side of the plastic sheet pulls it down and around the modified negative casting, molding it to conform to its outer contours which define the nasal-visual compartment, oral compartment, and the contours of the peripheral portion of the replica. Any type of pressure differential method alternately is used to force the heated plastic sheet over the modified, male negative mold to achieve its molding, be it by pressure or vacuum, or a combination of both.

Fabrication of a face mask assembly on the modified negative casting by building up layered fiber glass and resin is an alternate method of shell construction. This method creates a shell that is as strong as the molded plastic but compromises on transparency.

After the mask assembly has been molded and the modified negative casting has been chipped out and removed, the excess is trimmed away. The lens area may be cut away and a tempered lens with annular seal and protective rim is substituted to minimize distortion and to give the face mask assembly greater rigidity. A bridge 25, separating the oral compartment and nasal-visual compartment, is included and further provisions call for adding the snap fasteners, nasal-visual purge valve, the pressure equalization pad, and other modifications enumerated above.

Reliable seating and sealing of the face mask assembly is ensured when the foregoing method of face mask assembly construction is followed. When a lower entrained mass is desirable to offset the additional effort in construction, a goggle-shaped lens template is substituted for the conventional face mask lens template with attention being given to accompanying modifications, e.g., providing an outwardly bulging nose portion, etc.

By the unique configuration of the face mask assembly, the breathing block assembly, and the hood assembly, diver safety and comfort have risen to a new standard and the limitations imposed by conventional head gear are overcome.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A custom fitted head gear worn to seal its interior from an ambient medium comprising:

a mask assembly having a rigid peripheral strip configured to continuously conform to the bony contours outlining the facial area and including a first curved portion adapted to conform to an area of the contours of the forehead, second and third curved portions interconnected to said first curved portion adapted to conform to areas of the contours of the regions of the temples, and a fourth curved portion interconnected to said second and third curved portions adapted to conform to an area of the outwardly facing contours of the mandible, all the curved portions are shaped having a width in excess of a plural integral multiple of the thickness of said rigid peripheral strip to present conforming areas of sufficient breadth to ensure the comfortable wearing of said face mask for prolonged periods of time, and a shell portion integrally extending from and reaching across said peripheral strip to define said interior and including a section permitting vision therethrough;

means for allowing a selective exchange of gas to and from said interior mounted on said mask assembly; and

means for elastically pulling said peripheral strip against said bony contours to seat said peripheral strip thereon, sealing said interior from said medium and ensuring said comfortable wearing of said face mask for prolonged periods of time.

2. A head gear according to claim 1 in which said mask assembly further includes,

a lateral portion reaching between said second and third curved portions of said peripheral strip configured and adapted to conform to contours defined by the cheekbones and the outwardly facing contour of the maxillae, said lateral portion is joined to said shell portion dividing said interior into an oral compartment and a nasal-visual compartment.

3. A head gear according to claim 2 in which said shell portion is adapted to snugly accommodate the

cheeks and is shaped with a section bulged outwardly from the area immediately forward of the lips, defining the limits of said oral compartment, the minimal distance for enabling intelligible speech while virtually eliminating dead air space.

4. A head gear according to claim 3 in which said mask assembly further includes,

a resilient, nonporous liner disposed on the interior and exterior of said peripheral strip and said shell portion, except for the vision section and the inhale-exhale opening, to further ensure said sealing of said interior and to seal the mounting of the allowing means on said oral compartment.

5. A head gear according to claim 4 in which said resilient, nonporous liner consists of mutually bonded layers of a latex compound thereby removably mounted on said face mask assembly.

6. A head gear according to claim 4 in which said nasal-visual compartment includes a flat transparent lens plate carried forward of the eye-nose area for ensuring more distortion-free forward vision and curved side walls having a radius of curvature for ensuring wide angle peripheral vision.

7. A head gear according to claim 2 in which said mask assembly further includes,

a plurality of snaps mounted on said peripheral strip to ensure said sealing of said interior when mechanically cooperating with correspondingly disposed mating snaps carried on the elastic seating means.

8. A head gear according to claim 6 in which said transparent lens plate is goggle-shaped and said nasal-visual compartment is formed with a bulged-out nose portion enabling positioning of the goggle-shaped plate closer to the eye area to reduce the lateral water plane and entrained mass defined by said mask assembly.

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