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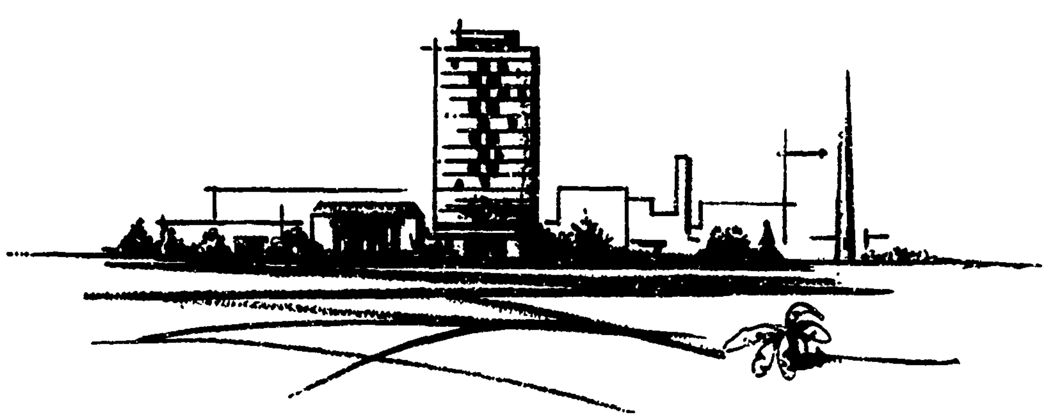
RESEARCH REPORT

PORTABLE RECOMPRESSION CHAMBER ENVIRONMENTAL
CONTROL SYSTEM STUDY

to

SUPERVISOR OF DIVING
UNITED STATES NAVY



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FINAL REPORT

on

PORTABLE RECOMPRESSION CHAMBER ENVIRONMENTAL CONTROL SYSTEM STUDY

to

SUPERVISOR OF DIVING
UNITED STATES NAVY

July 31, 1970

CONTRACT NO. N00014-70-C-0072

by

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BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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INTRODUCTION

Naval divers often dive under hazardous circumstances in areas far remote from recompression facilities. As a result, prior to 1968, SUPSALV had approximately 150 inquiries for a portable recompression chamber from combat EOD and SEAL units in Southeast Asia and other activities involved in diving from a wide variety of small surface craft where space is at a premium.[(1)*] Full-size chambers are located aboard repair ships and some shore activities, usually at some distance from diving operations. Even where SAR Helicopters are available, one or more hours could easily elapse between notification, pick-up, and delivery of a patient to a large chamber. Therefore, the concept of a relatively lightweight, collapsible, and easily transportable recompression chamber evolved.

At the request of the Navy Experimental Diving Unit on March 28, 1968, the Pacific Missile Range at Point Mugu, California was given the task to design and develop a portable collapsible recompression chamber that could be stowed

* References are given on page 19.

aboard small surface craft.[2] This chamber is to provide divers with immediate on-the-spot treatment of bends and air embolism, and is designed such that it can be used to transport the diver to a large double-lock recompression chamber, where he could receive additional treatment under a doctor's care.

The prototype chamber was designed to be supplied with pressurized air from twin-90 scuba bottles. Each set of bottles would sustain the chamber for 40 minutes if the diver is consious and able to use the inhaler. This system of breathing gas supply is satisfactory for short duration (2 hours or less) use where the diver is conscious. However, for accident cases where the inhaler cannot be used, or where the diver must remain in the chamber for several hours, the use of twin-90's for air supply becomes impractical.

Because of the feeling that the chamber should have an adequate gas supply for at least eight hours treatment on the U.S. Navy Diving Manual treatment Table IV,[3] a brief study was authorized to compare various types of gas supply systems for the portable chamber that could be used to supply breathing gas to the patient for extended lengths of time.

SUMMARY AND CONCLUSIONS

The major emphasis of the study has been to determine the feasibility of a reliable, portable, lightweight environmental control system for use with the chamber. This report presents the results of the study and recommendations for system development.

A tank-supplied open-circuit system for breathing-gas supply to the portable recompression chamber is the simplest, easiest to operate, and most reliable system. However, except for instances where a large supply of compressed air is available, it is impractical. Semiclosed-circuit and compressor-supplied open-circuit systems appear to offer excellent alternatives to the tank-supplied system without an unreasonable increase in complexity. A closed-circuit system does not appear to offer any major advantages for this application which would offset its decreased reliability and increased cost.

RECOMMENDATIONS

Prototypes of a compressor-supplied open-circuit system and a semi-closed-circuit system should be developed for evaluation by possible users. A reliable communications system should be a part of any collapsible recompression chamber.

RESEARCH ACTIVITY

The study began with a determination of system requirements followed by the identification of several feasible system approaches and was completed with a brief comparison of these approaches. The results of the study are described in the following report sections: (1) System Requirements, (2) System Descriptions, and (3) System Comparison.

System Requirements

To objectively evaluate any type of system, a set of requirements which the systems must meet is needed. No complete set of requirements specific to a gas-supply system for the portable recompression chamber are presently available. As a result the different types of systems considered during this program were designed and evaluated using requirements which the authors consider reasonable.

The following requirements that each system must be capable of meeting or bettering were established.

(1) The system must be capable of continuously supplying the patient with two cubic feet per minute of air[3] containing approximately 21 percent O_2 at depths to 165 feet of seawater.

(2) The system must be capable of supplying breathing gas with a CO_2 concentration of less than 0.5 percent surface equivalent.[4, 5]

(3) The system must be capable of supplying sufficient quantities of O_2 and removing sufficient quantities of CO_2 to maintain the above requirements for eight hours while treating a patient on Table IV of the U.S. Navy Diving Manual.

(4) The patient consumes a maximum of 0.6 SLPM O_2 and produces a maximum of 0.5 SLPM CO_2[6] while under treatment.

(5) The temperature of the inlet air should remain below 95 F.

No consideration was given to the control of CO, H_2O, or hydrocarbons. Although weight, size, and complexity limitations were not specified, the systems were to be as reliable, simple to operate, lightweight, and easily transportable as possible. These requirements are very subjective and will be discussed further under the system comparison section.

System Descriptions

Four types of environmental control systems---two open systems (one tank supplied and the other compressor supplied), a semiclosed system, and a closed system---were considered. During the design of these systems it became apparent that a few items would be needed on any system ultimately designed for use with the chamber. The system should contain a reliable communications system such as that recently designed for use with the Jack Brown mask.[7] The inlet and exhaust air noise must be muffled such that it does not interfer with communications and is not uncomfortable to the patient. The system must have a rugged and dependable depth gage. An inhaler which could be used for O_2 treatment of conscious patients should be included. The chamber pressure should be easily controllable, possibly with an automatic pressure relief exhaust valve that can be set to the desired chamber depth. The system should be failsafe in design with a free-flow backup system in event of failure. Although not essential, a design in which the fresh air flows from the head to the foot of the chamber would be best.

Tank-Supplied Open-Circuit System

The tank-supplied open-circuit system is shown schematically in Figure 1. Where an adequate air supply is available, this sytem is the cheapest, simplest and most reliable of those considered. The system shown schematically has all the necessary items mentioned above and, with a large enough air supply, is capable of meeting all of the requirements. The system consists basically of an air supply tank, control valve, exhaust valve, and flow meter. Operation of the system consists of adjusting the exhaust valve to the desired depth and

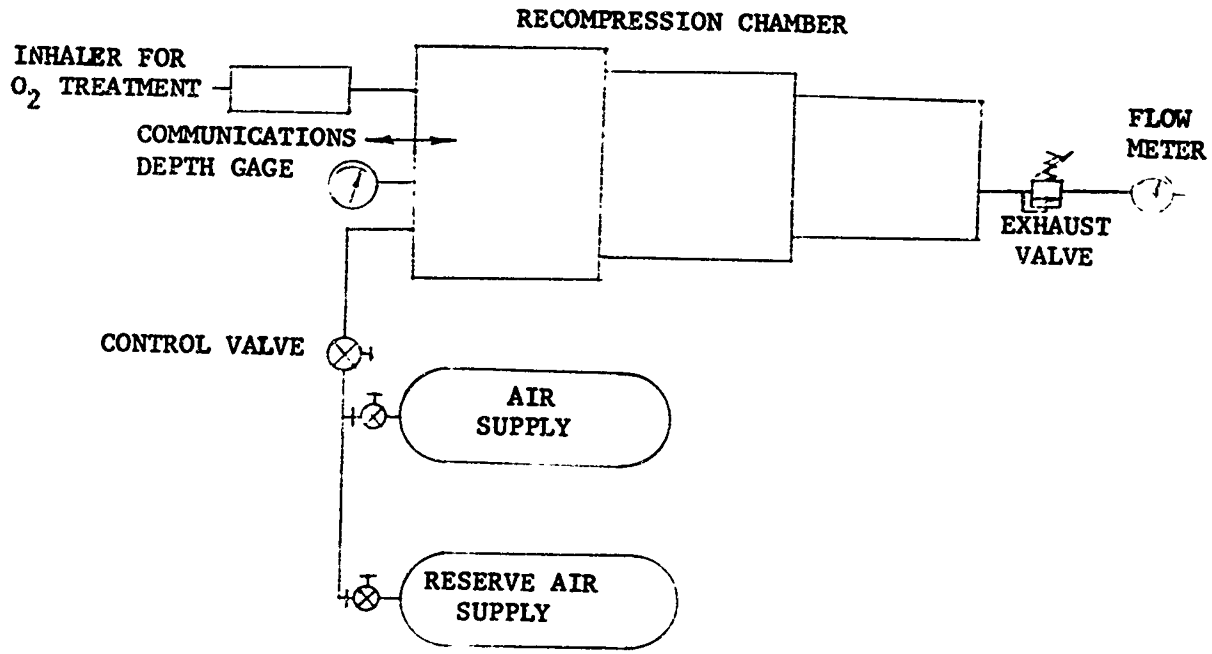


FIGURE 1. TANK-SUPPLIED OPEN-CIRCUIT SYSTEM

pressurizing the chamber by opening the control valve to attain the proper rate of descent. Once the desired depth is reached, the control value is then adjusted until the flow meter reads the proper continuous flow. The flow meter would have a dial calibrated from 0 to 165 feet (rather than 2 to 12 scfm) and would be placed on the exit side of the exhaust valve.

The tank supplied system could be supplied by any available air supply and would require 12 scfm of air at 75 psig. Unless the chamber is used where a large quantity of compressed air is available, this system requires an unreasonable supply of compressed air. If twin-90 scuba bottles were used for the air supply, over four full sets per hour would be required.

Compressor-Supplied Open-Circuit System

The compressor-supplied open-circuit system is shown schematically in Figure 2. This system is identical to the tank-supplied system except that a compressor and a filter system serve as the main air supply in place of the tanks. Compressors for this type of system are commercially available and have been used for years to supply air to hooka rigs. An example of such a compressor is the Bell & Gossett oil-less air compressor shown in Appendix A. Although the compressor cited is capable of continuously supplying sufficient air for breathing, an additional air supply would be required for emergency use and to increase the rate of descen (The compressor cited is capable of descent rate of only eleven feet per minute without a supplemental air supply).

Operation of the compressor-supplied system would consist of adjusting the exhaust valve to the desired depth and pressurizing the chamber using both the compressor and the emergency air supply to achieve the desired rate of descent. During normal operation the compressor would run continuously, pumping its full volume through the chamber, and the flow meter would be used only

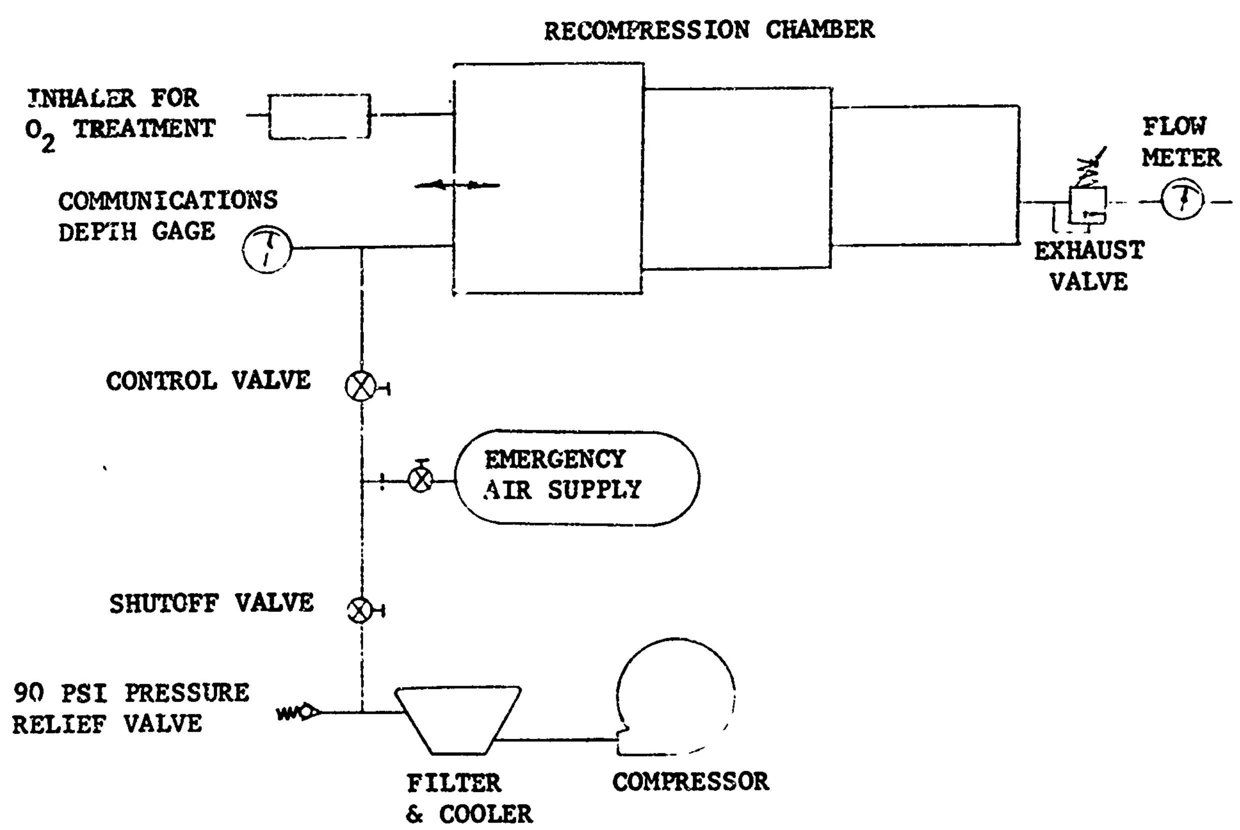


FIGURE 2. COMPRESSOR-SUPPLIED OPEN-CIRCUIT SYSTEM

to assure that the compressor is operating satisfactorily. In the advent of an emergency the flow meter would be used to control the air flow in a free-flow mode, and again would simply be calibrated for proper flow at 0 to 165 feet.

Semiclosed-Circuit System

The semiclosed-circuit system is shown schematically in Figure 3. This is very similar to a semiclosed underwater breathing apparatus except that there are no breathing bags and a recirculation pump circulates the breathing gas. The major components of such a system include a fixed orifice, a pressure regulator, a CO_2 scrubber, and a recirculator pump. The pressure regulator is set at a pressure which maintains choked and therefore constant flow across the orifice regardless of chamber pressure. The recirculation pump may be hand or electrically operated---a hand-operated pump probably being the better for general use. Adequate flow is assured by the use of a flow meter. To reduce system complexity and cost, no CO_2 monitor would be used. The CO_2 scrubber would be designed such that it could be replaced during use after every 8 to 16 hours. The variable-pressure exhaust valve vents the excess air continuously.

Operation of the chamber consists of adjusting the exhaust valve to the desired depth and then opening the free-flow control valve enough to achieve the desired rate of descent. Once at depth, the metering control valve is opened completely, supplying a constant input of about 1/2 liter per minute of air. The recirculator pump would supply 2 cubic feet per minute of scrubbed air at the operating depth. In case of failure of any part of the semiclosed system, the chamber may be operated in a free-flow mode using the flow meter to control the flow.

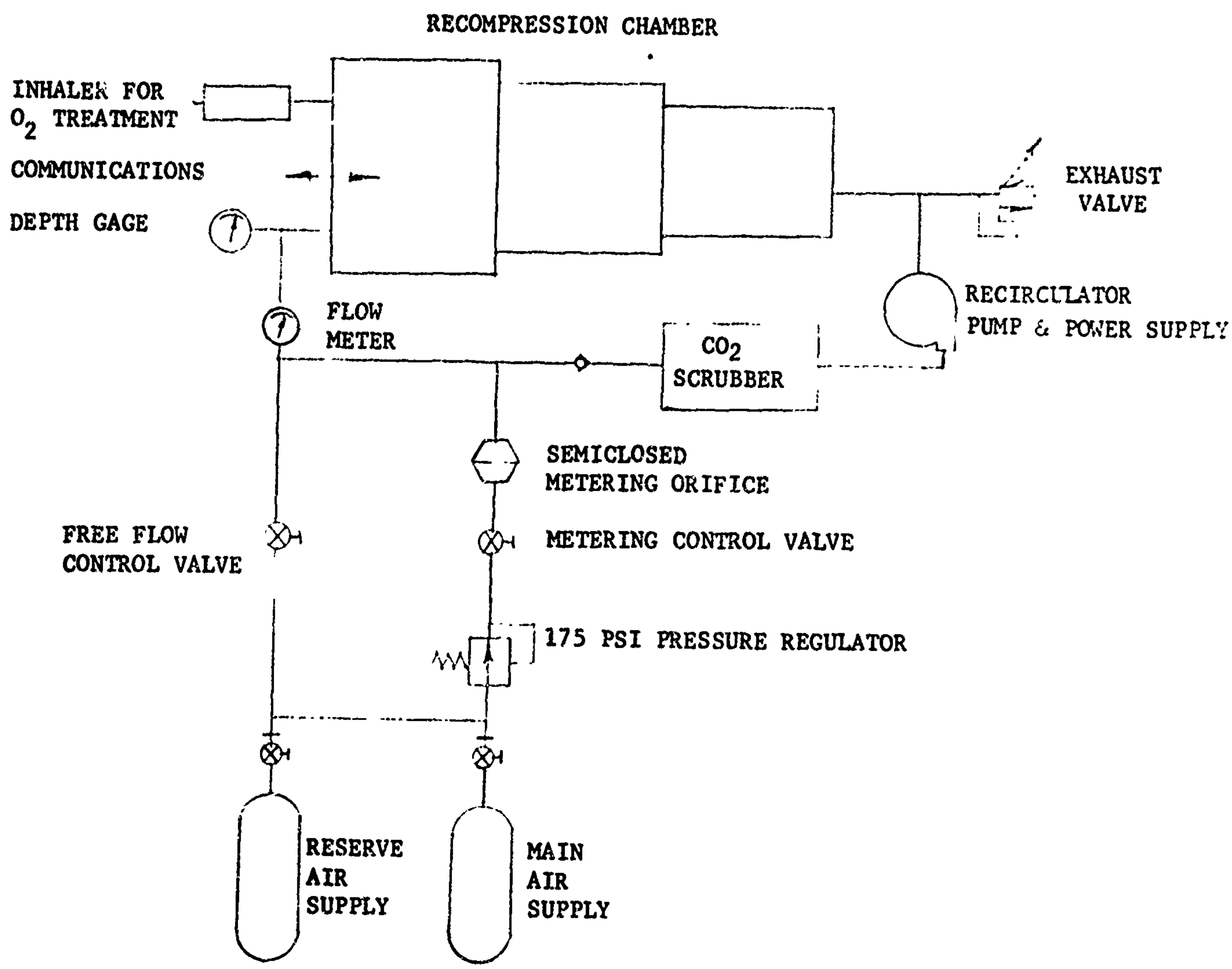


FIGURE 3. SEMICLOSED-CIRCUIT SYSTEM

Closed-Circuit System

The closed-circuit system is shown schematically in Figure 4. Schematically the system is very similar to the semiclosed one, with an oxygen sensor and control valve replacing the regulator and metering orifice. Operation of the system consists of setting the exhaust valve and pressurizing the chamber to the desired depth on air, using the free-flow control valve. Once at depth air is used only to make up any leakage losses. The PO_2 of the chamber is controlled by metering in additional oxygen when the sensor indicates a need. Although conceptually simple, in practice this type of system is fairly complicated and requires the use of sophisticated equipment. However, all equipment is within state of the art and literature on two of the commercial O_2 sensors has been included in Appendix A. As with the other systems, this unit may be operated in a free-flow mode.

System Comparison

As mentioned in the previous section, each system considered meets the basic minimum requirements established during the program for a portable life support system, and each system considered is within state-of-the-art design. To compare the relative merits of each of the systems and make a recommendation for continued development, a group of comparison criteria were formulated. These criteria are given in Table 1. Some of the criteria are subjective in nature while others may be calculated fairly accurately. In each case an effort was made to be as unbiased as possible in rating the systems. Other, possibly better, criteria could have been used to evaluate the systems, but these were considered sufficient for this study.

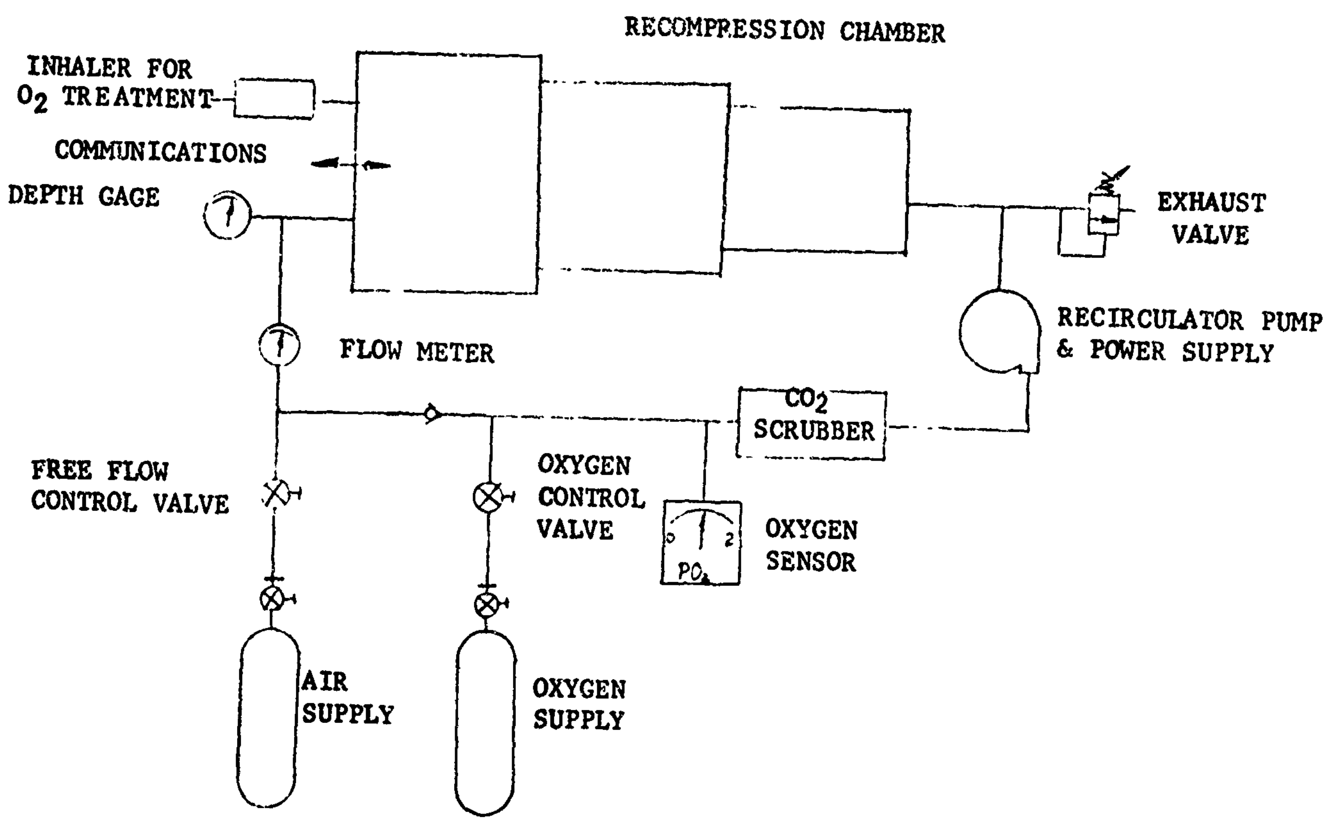


FIGURE 4. CLOSED-CIRCUIT SYSTEM

TABLE 1. PORTABLE RECOMPRESSION CHAMBER ENVIRONMENTAL CONTROL SYSTEM COMPARISON

System Comparison Criteria	Type of System: Tank-Supplied Open Circuit	Compressor-Supplied Open Circuit	Semiclosed Circuit	Closed Circuit
Reliability	Excellent	Good	Excellent	Fair
Simplicity of operation	Very little training required	Little training required	Little training required	Training required
Maintenance requirement other than periodic inspection of hoses, seals, and gages	None	Periodic inspection of compressor and filter required	Periodic canister and battery inspection required	Periodic inspection of battery, canister, and PO_2 sensor required
Air requirement, 8 hours operation, Table 4[a]	23 Twin-90's	None	Less than one Twin-90	58 ft^3 air, 10 ft^3 O_2
Estimated life support system cost; less air bottles	$200	$400	$750	$1050
Estimated life support system weight; less air bottles	15 pounds	125 pounds	70 pounds[b]	71 pounds[b] (74 pounds including O_2 bottle)
Main chamber weight including stretcher and blankets	265 pounds	265 pounds	265 pounds	265 pounds
Estimated total system weight less air required	280 pounds	390 pounds	335 pounds[b]	339 pounds[b] including O_2
Estimated total weight including air required for 8 hours operation using Twin-90 scuba tanks for air supply	1890 pounds	390 pounds	405 pounds[b]	374 pounds[b]

(a) P 173 U.S. Navy Diving Manual.
(b) Subtract 25 pounds for hand-operated recirculation pump.

Reliability

No attempt was made to place numerical values on the reliability criteria. The systems were simply rated as fair, good, or excellent. A rating of "excellent" indicates confidence that such a system would operate flawlessly each time it was used. A rating of "good" indicates no reservations about using the system as the only means of emergency aid if it is properly maintained. A rating of "fair" indicates that the system must be very carefully checked out each time it is to be depended on as the only means of emergency aid.

If an adequate supply of air tanks is available, then the tank-supplied system is inherently the most reliable of the systems considered. There is virtually nothing to go wrong. Even if the flow meter should fail the average chamber operator would have some idea of how much air should be flowing from the exhaust valve. For the purposes of this study, it has been assumed that if the tank-supplied system is to be used, an adequate supply of air exists and therefore the reliability rating is "excellent".

The semiclosed-system reliability has also been rated "excellent". This rating is based on the assumption that if the chamber is the only source of emergency aid the canister, batteries if used, and recirculation pump will be checked periodically to determine if they are operational, and on experience with existing semiclosed breathing apparatus which have proved highly reliable.

The compressor-supplied system reliability has been rated "good" only because of an inherent wariness about the dependability of small gasoline engines. However, gasoline-engine driven compressors have been used very successfully for several years to supply open-circuit underwater breathing gear, and have proven to be very reliable. With careful maintenance the compressor system could prove to be extremely dependable.

The closed-circuit system reliability has been rated "fair". This rating is based on the apparent dependability of PO_2 sensors (they are usually used in groups of three) and the serious consequences that can quickly result from a malfunction in the O_2 supply. If a closed-circuit system is carefully maintained, it could prove to be very dependable, but for general use the reliability as currently envisioned may not be adequate.

Simplicity of Operation

Simplicity of operation is very important for emergency systems. Simple tasks are often difficult under the strains of an emergency situation. As a result, any portable life support system must be straightforward and easy to operate. The tank-supplied system would be very simple to operate and require a minimum of operator training. In fact, most Navy divers should be able to operate such a system with no previous experience. Likewise, both the compressor-supplied system and the semiclosed systems would require a minimum of operator training. With a few well-placed instructions fastened permanently to the components the systems could be operated and maintained by most divers. The closed system is more difficult to maintain. Despite manufacturers' brochures to the contrary, today's PO_2 sensors require careful handling and maintenance, and may have an uncertain shelf life. As a result, even a well-designed closed-circuit system wo ld require some operator training before use.

Maintenance Requirement

Since systems which are not frequently used have a way of falling into disrepair, the maintenance requirement is a very important consideration for systems which sit idle for long periods of time but must perform flawlessly when used. For most systems, the maintenance requirement is roughly proportional to the complexity. For instance, the free-flow system is very simple and should be essentially maintenance-free. Of course, as with each of the other systems considered, there should be a periodic inspection of the hoses, seals, and gages. The compressor unit is more complicated and also requires periodic inspection of the filter and of the compressor unit. Likewise, periodic inspection and replacement of the CO_2 scrubber canister and batteries and testing of the pressure regulator and recirculation pump would be required for the semi-closed system. Regular inspection and testing of the PO_2 sensor would be required for the closed system as well as maintenance of the CO_2 scrubber, batteries, and recirculation pump. On the semiclosed and closed-circuit systems, a hand-operated recirculation pump would eliminate battery maintenance and provide a simpler, lighter-weight system.

Air Requirement and System Weight

A category in which the tank-supplied free-flow system falls short is its unreasonably high air requirement. To operate the chamber eight hours on Treatment Table IV of the U.S. Navy Diving Manual would require 23 sets (1610 pounds) of twin-90 scuba bottles. The initial set of twin-90 bottles would pressurize the chamber to 165 feet and maintain it at that depth for 9 minutes. Each set thereafter would last about 14 minutes at 165 feet equivalent pressure. An eight hour operation on Table IV would require a total system weight, including chamber, of 1890 pounds. This excessive logistic requirement prompted this study.

The compressor-supplied free-flow system could be used without additional tanks of a descent rate of 25 ft /min were not required. For instance, the Bell and Gossett compressor shown in Appendix A would take the patient down at about 11 ft./min. With such a system, total life-support system weight including fuel for eight hours' operation is estimated to be 125 pounds. Therefore the estimated total system weight for eight hours operation is 390 pounds.

A semiclosed-circuit breathing-gas supply system is estimated to weigh 70 pounds without air bottles. Eight hours' operation of the recirculation system would require about 25 pounds of batteries. One set of twin-90 canister has a design operating time of 16 hours requiring 14 pounds of baralyme. Therefore eight hours' operation of the chamber would require an estimated total system weight of 405 pounds.

The closed-circuit breathing-gas supply system is estimated to weigh 74 pounds including the oxygen required for 8 hours' operation and one bottle of air from a twin-90 set for initial pressurization. Therefore eight hours operation would require an estimated total system weight of 374 pounds.

The major emphasis of this study has been to determine the feasibility of a reliable, portable, lightweight environmental control system. It is interesting to note that all three systems designed to replace the tank-supplied free-flow system have nearly the same total system weight (374-405 pounds). Weight alone does not appear to eliminate any of the three.

Cost

If large numbers of chambers are to be used, the cost of the life support system may be important. The cost estimates shown in the table are based on currently available equipment and should reflect the ultimate production cost of the life support system in quantities of 100 to 200. Again, if one system is significantly better than another, cost should not be the determining factor. However, due to better reliability, greater simplicity and lower maintenance requirements, it appears that the compressor-supplied free-flow system and the semiclosed circuits should receive further study. The compressor-supplied systems would require less development effort and be of lower cost, but could be unuseable in areas where excess noise would be dangerous. The semiclosed system at a slight increase in cost and after some development could have excellent reliability at a slightly less weight.

As a result it is recommended that prototypes of both the compressor system and the semiclosed system be developed for evaluation by the possible chamber users.

REFERENCES

(1) NAVSHIPSYSCOM Memorandum No. 3260/CY of August 11, 1969.

(2) Prototype Collapsible Recompression Chamber, Engineering Recommendation and Modification, PMR Serial 4105 of December 15, 1969.

(3) U.S. Navy Diving Manual, March 1970, p 177.

(4) Vorosmarti, "Problems Related to Providing and Maintaining Pure Breathing Gas", Proceedings: Purity Standards For Divers' Breathing Gas Symposium, July 1970, p 15-7.

(5) Handbook of Compressed Gases, Compressed Gas Association, 1966, p 57.

(6) U.S. Navy Diving Manual, March 1970, pp 60 and 173.

(7) "The Development of an Underwater Communications System for the Jack Brown Shallow-Water Diving Mask" to U.S. Navy, Supervisor of Diving, Naval Ships Systems Command by Battelle Memorial Institute, June 30, 1969.

APPENDIX A

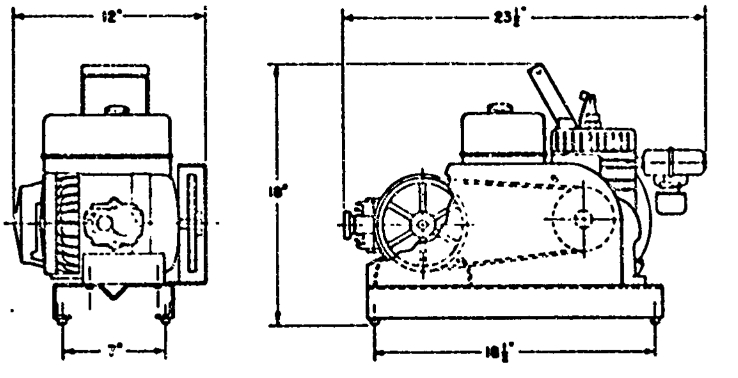
MANUFACTURERS LITERATURE ON AVAILABLE O_2 SENSORS,
CO_2 SCRUBBERS, PORTABLE COMPRESSORS

BELL & GOSSETT, MORTON GROVE, ILLINOIS

GASOLINE ENGINE DRIVEN OIL-LESS AIR COMPRESSOR

The B&G gas engine driven compressor outfit delivers Oil Free air up to 90 PSIG continuously. Its lightweight and compact dimensions make it extremely portable. When lifted by the handle, balance is perfect. The belt guard assures safe operation. An accessory kit for wheel mounting, is available.

The outfit includes a belt-driven B&G Oil-less Air Compressor with the same unique features incorporated in B&G motor-compressors. The engine is oversized to provide ample power at reduced RPM for longer engine life.



SPECIFICATIONS

MODEL EDCO
B & G OIL-LESS AIR COMPRESSOR

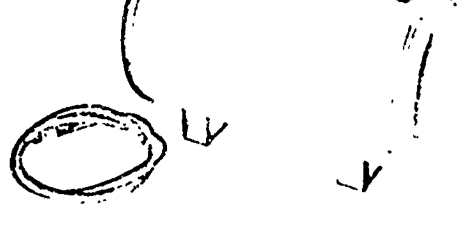
Twin cylinder—single stage—6.57 CFM displacement at 1725 RPM. Integral after-cooler—pulsation chamber—moisture drain. Complete with intake filters and ¼" NPS discharge connection. Safety valve set to open at 95 PSIG. Free air delivery at 35 PSIG = 4.3 CFM, at 80 PSIG = 3.3 CFM.

BRIGGS and STRATTON ENGINE

4 cycle, air cooled, 2700 RPM governed speed. Float feed carburetion. 3 quart fuel tank. Recoil starter. Exhaust valve rotator. Oil bath air cleaner.

ACTUAL WEIGHT 56 LBS.

$195.20 (11/1/68)



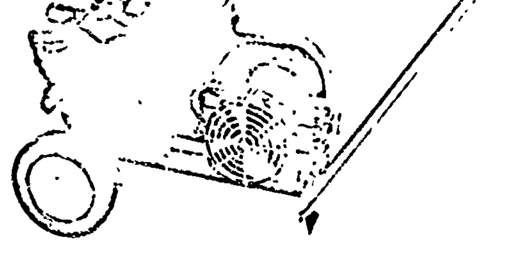
EDCAR PORTABLE AIR TANK

The lightweight and mobile B&G Portable Air Tank is the answer for those applications requiring an air receiver as well as means to carry emergency air to the job. A 6 foot length of hose is attached to the compressor discharge while a quick disconnect coupling is attached to the tank inlet. When disconnected, this coupling serves as a check valve preventing escape of air from the tank under pressure.

The coupling is easily disconnected for no load starting of compressor and engine.

SPECIFICATIONS:

10 gallon capacity, 13" dia. x 24" length. Tested to 150 PSIG. Complete with carrying handle—6 ft. high pressure hose with fittings and quick disconnect coupling—pressure gauge—discharge shut off valve safety valve set at 100 PSIG.



EDCC WHEEL AND HANDLE KIT

Complete with 8" x 1¾" wheels—Semi-pneumatic tires—handle—Axle and necessary hardware.

ACTUAL WEIGHT, 10 lbs.

BMI Series OA200 Gaseous Oxygen Analyzers

oxygen concentration too low for life?
too high for safety?

you can now measure oxygen instantly—continuously—accurately—with Series OA200 Oxygen Analyzers from BMI

- displaying continuous % O_2 readout
- without batteries, line connections or amplifiers
- for hand-held or remote operation

Series OA200 Oxygen Analyzers from BMI are coming into wide use wherever oxygen content of air can drop low enough to impair physical or psychological function. Worn on the belt, held in the hand, or placed conveniently, these small, light weight instruments can detect dangerously low oxygen concentrations before the effects of hypoxia become noticeable.

Because direct-reading Series OA200 Analyzers from BMI are extremely accurate even over the lower range of the scale, they can also indicate the *dangerous presence* of oxygen—i.e., possible inerting system failure, risk of fire or of explosion.

Stable Series OA200 Oxygen Analyzers from BMI are always "on," never need any warm-up or "recharging." When necessary, calibration is carried out in an instant with room air. Automatically temperature-compensated between 32° and 104° F., insensitive to CO_2 and humidity to 100%, OA200 Analyzers can be employed by public utilities, breweries, pharmaceutical and chemical plants, oil refineries, laboratories and shops of all types. Their rugged construction enables them to be taken out into the worst weather.

Signals from BMI oxygen sensors can be transmitted without amplification over cable runs as long as 1000 feet or more. Series OA200 Analyzers may thus be used either with the self-contained sensor or a separate remote sensor. Because outside power is not required, the units are suited for use in ships' holds, tank farms, mines, tunnels and other locations where possibility of the slightest spark or arcing poses unacceptable hazards.

turn the page for specifications . . .

BioMarine Industries™

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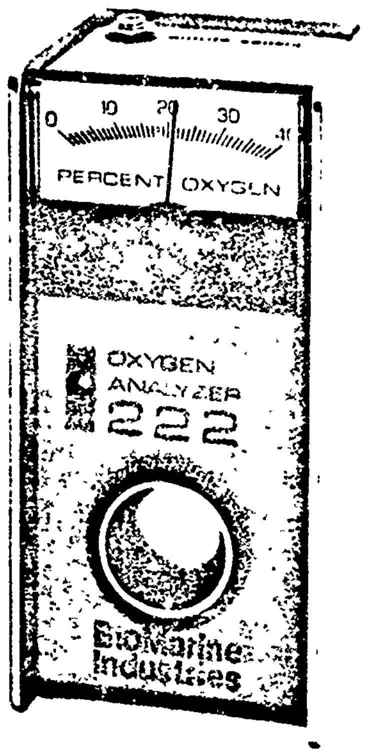
Series OA200 Oxygen Analyzers are as easy and quick to use as a flashlight



Principle of Operation

Oxygen is sensed directly by a BMI galvanic cell* containing a gold cathode and a lead anode in a basic electrolyte. The entire cell is encapsulated in inert plastic. The sensor face is a fluorocarbon polymer. Oxygen diffusing through the cell face initiates redox reactions which generate a minute current proportional to the oxygen partial pressure. A temperature-compensated circuit converts the current to a proportional voltage which is displayed directly on the meter face of the Analyzer as oxygen concentration.

*Patent pending The BMI oxygen sensor is intrinsically safe per ISA S.P 12 2 Factory Mutual approval applied for

Accessories

A flow-through adapter is available from BMI for analyzing gases in lines and bottles.

Notable Features

1 Series OA200 Oxygen Analyzers may be single-point calibrated with oxygen of any known concentration within meter range (e.g., normal room air).* There is never any need for "recharging."

2 OA200 Analyzers are ready for instant use. No warm-up period is needed.

3 Sensor cells of Series OA200 Oxygen Analyzers function accurately at any relative humidity up to 100%.

4 Every Series OA200 Oxygen Analyzer is provided with a connector for remote sensor use. Remote sensors are available as options.

5 Stable, long-lived sensor cells can be replaced simply in a few moments.

6 Use of an adapter on the face of the sensor permits Series OA200 Analyzers to be used for sample stream monitoring.

7 The unique construction of the sensor face minimizes the possibility of mechanical deformation, and eliminates error due to cyclic pressure variations.

8 Series OA200 Oxygen Analyzers are shipped in nitrogen to maintain undiminished cell life prior to use.

9 Model OA202 reads 0-100% O_2, Model OA222 reads 0-40%, and Model OA233 reads 0-2 atmospheres. All have self-contained sensors and accept remote sensors as well. Models OA202R, OA222R and OA233R have the same respective scales, but are designed for use only with remote sensors.

*For use above 3000 feet above mean sea level, specify high altitude sensor

Specifications

	OA202 OA202R	OA222 OA222R	OA233 OA233R
Dimensions:	2" x 2½" x 5" (5.1 cm x 6.4 cm x 12.7 cm)		
Net weight:	14½ oz. (410 g)		
Scale reading.	0-100%	0-40%	0-2 atmospheres
Response, 90% in less than:	20 secs.	10 secs.	20 secs.
Calibration linearity:	±1% of full scale at constant temperature		
Accuracy.	±1% of full scale		
Temperature compensation error:	maximum ±5% in range. 32°-104° F. (0°-40° C.)	45°-104° F (7°-40° C.)	32°-104° F. (0°-40° C)
Pressure:	500 psi maximum		
Decompression rate.	50 psi/minute maximum		

Sensor warranty. 120,000 %-hours, or one year

For full information, prices and delivery schedules, contact:

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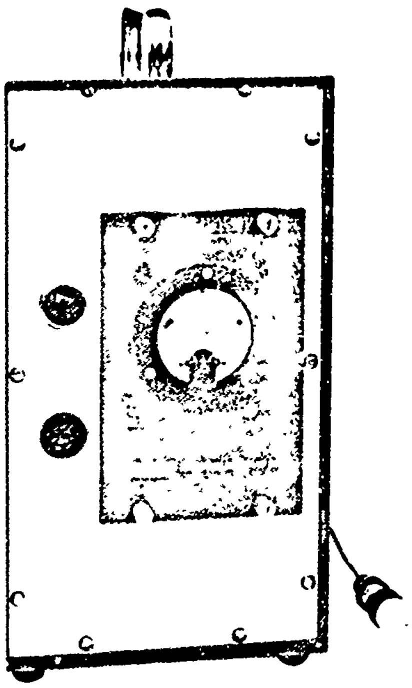
ANALYZERS	
Oxygen Analyzer Models	$285.00
OA202	
OA222	
OA232	
Remote Sensor with 10 ft. extension cord...	$110.00
Replacement Sensor	$110.00
MONITORS/CONTROLLERS	
OMC400 Oxygen Monitor and Controller..........	$790.00
Replacement Sensor	$110.00
Gas Line Adaptor	$ 10.00
OMC 100	2800 00
OMC 104	3400.00
CCR 1000	6445.00 ← closed circuit scuba

* Suggested Retail Price

Oxygen Monitor For Hyperbaric Chambers



SPECIFICATIONS

OPERATING RANGE:	0 to 1000 mm Hg, P_{O_2}; second scale 0 to 1.3 absolute atmospheres.
ACCURACY:	±5% of reading, 0-500 mm Hg: ±10% of reading, 500 to 1000 mm Hg
STABILITY:	±1%, 24 hours; ±5%, 500 hours.
ABSOLUTE PRESSURE RANGE:	0.5 to 35 absolute atmospheres.
RESPONSE TIME:	90% response to a step function change in sample partial pressure within 15 seconds.
TEMPERATURE RANGE:	39° to 122°F.
RELATIVE HUMIDITY:	To 100%.
ALARMS:	Flashing red light and audible Sonalert, high set point: 50 to 95% of full scale (500 to 350 mm Hg, or 0.65 to 1.25 abs atm), low and dual alarms available on request.
OTHER OUTPUTS:	0 to 5 Vdc with 50K minimum load; 0 to 50 mVdc at 500Ω; 0 to 100 μA; all outputs double ended.
POWER REQUIRED:	12 to 32 Vdc external power and/or internal batteries (Mallory type E146X mercury cell, or type MN 1604 alkaline cell), and 2 Eveready 732, 12-V lantern cells (NEDA 926)
SIZE:	8 x 8 x 14 inches.
WEIGHT:	14 pounds.

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

MINOS™ AOM ALARM SYSTEM

Monitoring atmospheric gases is extremely important in any closed environment. Of the gases present in a breathing atmosphere, oxygen is of chief concern. Although contaminants -- such as carbon dioxide — must also be monitored to prevent a build-up of undesirable atmosphere constituents, human life depends upon the availability of a safe level of oxygen.

The MINOS™ AOM (Atmospheric Oxygen Monitor) Alarm System is designed to monitor the oxygen level in hyperbaric chambers. The instrument includes battery-operated audible and visual alarms; the instrument is placed outside the chamber, with the sensor inside. A 15-foot cable permits checking oxygen levels over considerable chamber volume.

For air decompression, a 40-foot level is equivalent to approximately 2.2 absolute atmospheres (360 mm of mercury, oxygen partial pressure). However, divers customarily also use a mask for intermittent breathing of pure oxygen. Exhalation by the diver will, therefore, continuously add oxygen to the chamber — and raise oxygen concentration by an unknown amount. Also, exchanging chamber air through ventilation may not reduce the oxygen content satisfactorily. In addition to the possibility of oxygen reaching a level of toxicity, the risk of combustion becomes a serious threat. The MINOS AOM Alarm System will sound and flash alarms before chamber oxygen reaches a dangerous level.

The instrument monitors oxygen from 0 to 1000 mm of mercury (0 to 1.3 absolute atmospheres). The high-oxygen alarm can be set from 50 to 95 percent of full scale — 0.65 to 1.25 absolute atmospheres (500 to 950 mm of mercury). An alarm condition will trigger the audible Sonalert, and flash a red lamp — immediately notifying all attending personnel. In the absence of alarm levels, this system will display — at all times — the exact chamber oxygen content.

The MINOS AOM Alarm System can be supplied to monitor high or low oxygen, or both. This precision instrument is an excellent safeguard for personnel, protecting them against the threats of fire, toxicity, or hypoxia.

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OCEANIC EQUIPMENT ACTIVITY
2500 Harbor Boulevard, Fullerton, California 92634
(714) 871 4848

A 70112 470-2C

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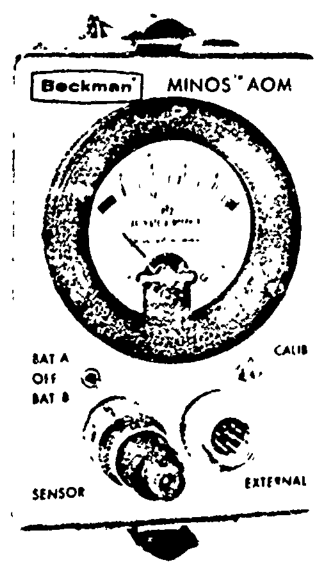
MINOS™ ATMOSPHERIC OXYGEN MONITOR

Oxygen Monitor Ideal For Hyperbaric Chambers



Monitoring atmospheric gases is extremely important in any closed environment. Of the gases present in a breathing atmosphere, oxygen is of chief concern. Although contaminants—such as carbon dioxide—must also be monitored to prevent a build-up of undesirable atmosphere constituents, human life depends upon the availability of a safe level of oxygen.

The MINOS AOM (Atmospheric Oxygen Monitor) — one of a line of specialized Beckman monitoring instruments — is designed to monitor breathing gas in a closed system. Small and completely self-contained, MINOS AOM mounts readily on the wall of any chamber — spacecraft simulator, undersea chamber, or clinical hyperbaric chamber. It is particularly useful for diving decompression chambers and clinical hyperbaric chambers used in therapy for diseases caused by anaerobic bacteria. For additional flexibility, an optional extension cable may be ordered to permit using the sensor away from the signal conditioner and meter.

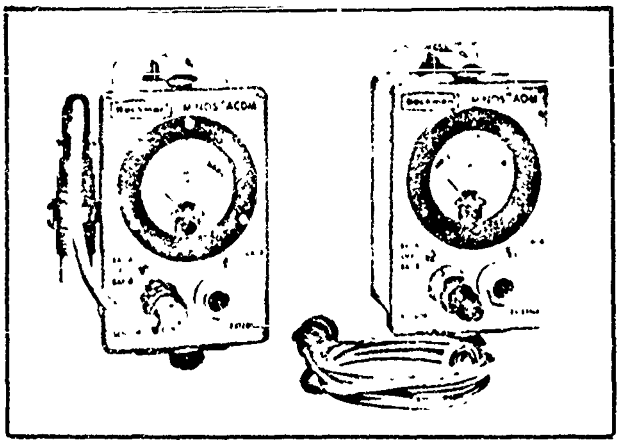
MINOS Oxygen Monitors are based on the Beckman Polarographic Oxygen Sensor.* The tiny sensor — only ½- by ¾-inch — contains a gold cathode and silver anode immersed in a gel electrolyte. A small potential is applied between the electrodes, and the opening to the sensor sealed with a Teflon membrane which is permeable to oxygen. Oxygen diffusing through the membrane passes through a very thin layer of electrolyte and is reduced electrochemically at the cathode, thus producing a small current. The sensor is insensitive to other gases, and the output current is directly proportional to the partial pressure of oxygen.

Sensor current is amplified to provide continuous direct reading from 0 to 1,000 millimeters of mercury, oxygen partial pressure. A second meter scale is calibrated in absolute atmospheres. This solid-state instrument is stable to within ±1 percent of full scale for 24 hours, and within ±5 percent of full scale for 500 hours. The dependable miniaturized sensor is inexpensive and expendable. Designed to operate on either alkaline or mercury batteries, the MINOS AOM may also be operated from 12 to 32 Vdc external power. In addition to displaying oxygen level on the meter, external outputs are available to operate an alarm, remote meters, recorders, or an analog-to-digital converter. Standard external outputs are 0 to 5 Vdc, 0 to 50 mVdc, and 0 to 100 μA. The MINOS AOM will monitor oxygen levels safely in the rugged environment of 100 percent humidity and atmospheric pressures to 35 atmospheres.

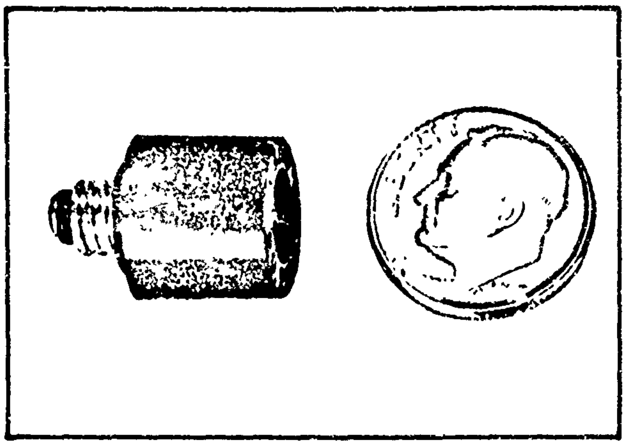
The AOM is just one of a line of atmosphere monitors. For example, you can add a MINOS ACDM (Atmospheric Carbon Dioxide Monitor) and create a complete air-monitoring package.

Whatever your atmospheric monitoring and control needs—space, undersea or earthbound—MINOS atmospheric monitors are available from Beckman now. For 33 years we have been providing advanced instruments for industry and research. Today — at Beckman — science is shaping your future.

*U.S Patent No 2,913,386



COMPANION MINOS UNITS MONITOR OXYGEN AND CARBON DIOXIDE



COMPLETE OXYGEN SENSOR IS DWARFED BY DIME

SPECIFICATIONS

OPERATING RANGE:	0 to 1000 mm Hg, P_{O_2}; second scale 0 to 1.3 absolute atmospheres.
ACCURACY:	±5% of reading, 0-500 mm Hg; ±10% of reading, 500 to 1000 mm Hg.
STABILITY:	±1%, 24 hours; ±5%, 500 hours.
ABSOLUTE PRESSURE RANGE:	0.5 to 35 absolute atmospheres.
RESPONSE TIME:	90% response to a step function change in sample partial pressure within 15 seconds.
TEMPERATURE RANGE:	39° to 122°F.
RELATIVE HUMIDITY:	To 100%.
OUTPUTS:	0 to 5 Vdc with 50K minimum load; 0 to 50 mVdc at 500Ω; 0 to 100 μA; all outputs double-ended.
POWER REQUIRED:	12 to 32 Vdc external power and/or internal batteries (Mallory type E146X mercury cell, or type MN 1604 alkaline cell).
SIZE:	6¼ x 4¼ x 3½ inches.
WEIGHT:	5½ pounds.

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

Beckman INSTRUMENTS, INC.
ADVANCED TECHNOLOGY OPERATIONS
2500 HARBOR BOULEVARD FULLERTON, CALIFORNIA • 92634
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INTERNATIONAL SUBSIDIARIES Amsterdam, Capetown, Geneva, Glenrothes, Scotland, London, Mexico City, Munich, Paris, Stockholm, Tokyo, Vienna

ATO 69122-569-2C

PRINTED IN USA

JANUARY 1970

Beckman® ADVANCED TECHNOLOGY OPERATIONS

MINOS™ ATMOSPHERIC OXYGEN MONITOR

PRICE LIST
FOR BULLETIN 2008A

Part No.	Description	Unit Price
	MINOS Atmospheric Oxygen Monitor (AOM) complete with Sensor, Receptacle, Batteries, Mating Power Connector, and Desiccant. Three models available:	
145400	AOM - Range 0-1000 mm Hg	$950.00
148000	AOM - Range 0-1520 mm Hg	950.00
148900	AOM - Range 0-250 mm Hg	950.00
145204	Meter, Oxygen (Remote readout) 0-1000 mm Hg	50.00
148297	Meter, Oxygen (Remote readout) 0-1520 mm Hg	50.00
148295	Meter, Oxygen (Remote readout) 0-250 mm Hg	50.00
145405	Gasket, Housing	2.50
145416	Battery Bracket Assembly	28.00
145659	Sensor, Oxygen	85.00
146009	Cable, Extension, Sensor*	80.00
146011	Sensor Receptacle	95.00
147451	Battery Pad	7.00
148147	Desiccant Container Assembly	13.00
148193	Cable, Power/Remote Readout *	62.00
11160	Desiccant, five 1-ounce bags	2.40
79618	Desiccant, Indicator Package	1.30
70-094-01	Desiccant, 1-pound package	3.30
45-042-12	Tubing, Tygon (1-foot length)	2.00
MN 1604	Battery, Alkaline	2.00

* Standard 10-foot length unless otherwise specified.
Add $0.50 for each additional foot over 10 feet.

MINIMUM BILLING PER ORDER IS $10.00

(All prices are in U.S. funds and are subject to change without notice)

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ATO 70107-170-2C

PRINTED IN USA

Beckman ATO MARKETING MEMO

No. 1 1 December 1969

NEW IMPROVED OXYGEN SENSOR AVAILABLE FOR MINOS™ AOM

To meet requirements for increased long-term stability and extended useful life, we've developed a new sensor for the AOM. Using a companion receptacle, the new sensor is directly interchangeable with the standard AOM Sensor in all existing MINOS AOM installations. It will be offered as an option on new orders for this popular instrument.

Slightly larger than the existing miniature sensor, this new one is only 1 inch in diameter, and 1-1/4 inches long. The new receptacle is also 1 inch in diameter, and fits the AOM connector--making it completely interchangeable.

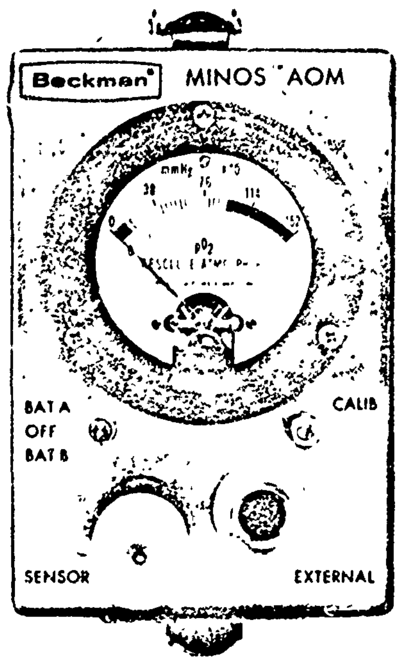
The new sensor features increased electrolyte volume and an elastic bellows surrounding the electrolyte chamber. The increased volume significantly extends sensor life. The theoretical minimum useful life is 1-1/2 million mmHg hours of oxygen exposure--more than a year in normal use. Extended life tests on prototype sensors indicate they will meet the theoretical life.

The elastic silicon rubber bellows provides pressure equalization without venting the sensor. The sensor may be mounted in any orientation, and failure from dry-out through the vent is not possible. Installation of the sensor requires only inserting the receptacle into the AOM connector. There is no vent to open to prevent sensor damage. Pressure tests of the sensor include hydrostatic cycling to 10,000 psi and repeated exposure to helium-oxygen mixtures up to 500 psi. Hyperbaric atmospheric tests include saturation in a helium-oxygen mixture (60 hours at 500 psig helium with 4160 mm Hg P_{O_2}) and rapid decompression (500 psig to 50 psig in 35 minutes). The sensor exhibits a well-established pressure response which results in a decrease in output of about one percent per hundred pounds. This effect is characteristic of all membrane-type sensors and varies only depending on the choice of membrane used.

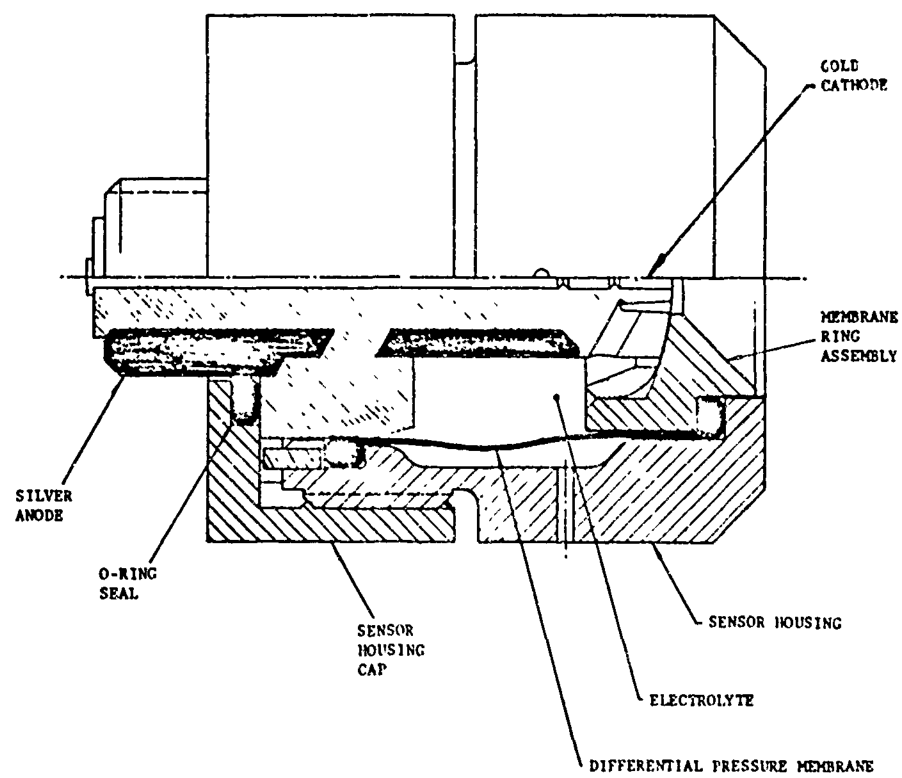
On the following page, the new sensor and receptacle are shown on an AOM. The cutaway drawing shows the pressure-equalizing bellows.

Sensors and receptacles can be shipped from stock in thirty days. The price of the sensor is $200, and the receptacle is $125. Order Part No. 147725 Hyperbaric Oxygen Sensor, and Part No. 148290 Receptacle. New orders for AOM's can be shipped with the new sensor and receptacle. The price of the AOM equipped this way is $1,090.

Incidentally, your new price lists show AOM's available in three full-scale ranges (0 to 250, 0 to 760, and 0 to 1520 mm Hg). All three types are in stock in Fullerton. As you will note on the photo, the absolute atmosphere values have been emphasized on the new meter faces.



New Sensor and Receptacle fit easily on MINOS™ AOM

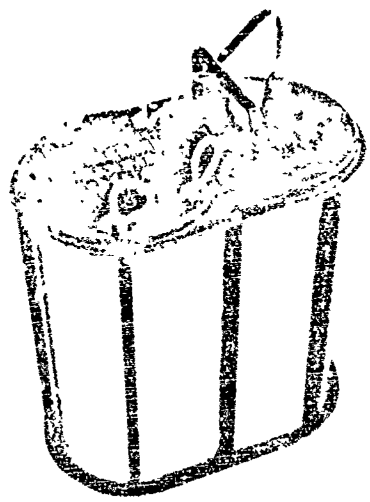


Cutaway shows pressure equalizing bellows and other details

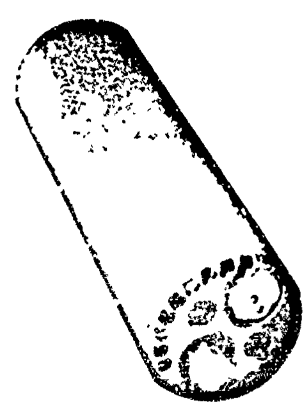
Beckman ADVANCED TECHNOLOGY OPERATIONS

EXPLOSION-PROOF CARBON-DIOXIDE SCRUBBERS

Carbon-Dioxide Removal Systems For Hyperbaric Environments



PURA 787-M9 CO_2 Scrubber



PURA 707-M7 CO_2 Scrubber

Two new carbon dioxide removal systems are now available for completely safe operation in hyperbaric environments. Manufactured by Lindbergh-Hammar Associates, Inc these systems are being offered through Beckman Oceanic Equipment Activity representatives.

Model PURA 787-M9 is a compact and portable unit that can be installed in any hyperbaric chamber. For use in fire-hazardous areas — such as high-pressure oxygen environments — the unit is readily adaptable to any working pressure range from 1 to 100 atmospheres, in pure oxygen or oxygen-helium breathing mixtures. The 787-M9 will process gas at rates up to 10 cfm at 24 volts. It can be operated from either ac or dc power sources, from 24 to 60 V.

The 787-M9 has a 9-pound dessicant canister, and will satisfy almost any hyperbaric application. A high-torque, magnetic interlock connects a sealed, environmentally isolated motor to a twin turbine. The system is inherently safe; all dynamic seals have been eliminated.

Three variations of Model 787-M9 are available — lightweight, anodized-aluminum construction, heavy-duty, corrosion-resistant bronze, and chrome-plated bronze for medical applications. Similar units are also available in the 787-M7 Series; these units have several additional features, including explosion-proof, integral magnetic switches, and special fuse-access housings which can be opened for fuse replacement under operating pressures as high as 1500 psig.

In response to a demand for a smaller and lower-cost version of the 787 system, a new series — the PURA 707-M7 — is now available. These units are specifically designed for the low-volume compartments of submersibles, decompression chambers, experimental test chambers, and medical hyperbaric applications. The 707 is rated for a minimum gas exchange of 7 cfm at 24 volts. This system, also, will operate from ac or dc power, over a range from 24 to 60 volts. The dessicant chamber has a volume of 100 cubic inches, and is rated for a load-life of up to 6 hours. The working pressure range is the same as that of the Model 787 — from 1 to 100 atmospheres.

Explosion-proof and totally fire safe in oxygen environments, the small, compact 707 measures only 6 inches in diameter and 15 inches in length Four versions of the Model 707-M7 are available: anodized aluminum; bronze; heavy-duty bronze; and a medical unit in chrome-plated bronze. Three additional varieties are available — the PURA 707-M77 Series — which include explosion-proof integral magnetic switches and fuse-access housings which can be opened for fuse replacement under operating pressures as high as 1500 psig.

Whatever your needs for carbon-dioxide removal in hyperbaric environments, one of the thirteen variations of these two basic scrubber systems should offer a ready solution to safe carbon-dioxide removal.

SPECIFICATIONS

PURA 787-M9/M70 SERIES

SAFETY	Explosion/fire-proof in high-pressure oxygen and mixed breathing gases.
ABSORBENT TYPE	Any approved CO_2 absorbent, bulk or prepack.
ABSORBENT CAPACITY	298 cu. in. (9 lbs.); yields up to 8-hour load-life at 2 liters/min CO_2 input, depending upon absorbent.
FLOW PROCESSING	10 cfm at 24 V.
SERVICE LIFE	1000 hours, continuous.
PRESSURE RANGE	1 to 100 atmospheres.
POWER REQUIRED	24 to 60 V, ac or dc.
SIZE	Approximately 15 x 15 x 9 inches.
WEIGHT	
787-M9A	Anodized aluminum, corrosion-resistant epoxy interior — 37 lbs.
787-M70A	As above, with magnetic switch and fuse-access housing — 43 lbs.
787-M9B	Heavy-duty corrosion-resistant bronze — 55 lbs.
787-M70B	As above, with magnetic switch and fuse-access housing — 61 lbs.
787-M9D	Chrome-plated bronze (Medical Unit) — 60 lbs.
787-M70D	As above, with magnetic switch and fuse-access housing — 67 lbs.

PURA 707-M7/M77 SERIES

SAFETY	Explosion/fire-proof in high-pressure oxygen and mixed breathing gases.
ABSORBENT TYPE	Approved CO_2 absorbent, bulk or prepack.
ABSORBENT CAPACITY	100 cu. in.; yields up to 6-hour load-life at 7 cfm, depending upon absorbent.
PRESSURE RANGE	1 to 100 atmospheres.
POWER REQUIREMENTS	24 to 60 V, ac or dc.
SIZE	15 in. long x 6 in. dia.
CONSTRUCTION	
707-M7A	Anodized aluminum, stainless-steel cylinder, without exterior frame.
707-M77A	As above, with magnetic switch and fuse-access housing.
707-M7A2	Bronze, stainless-steel cylinder, without exterior frame
707-M7B	Heavy-duty bronze, with exterior frame.
707-M77B	As above, with magnetic switch and fuse-access housing.
707-M7D	Chrome-plated bronze (Medical Unit), with exterior frame
707-M77D	As above with magnetic switch and fuse-access housing

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

Beckman

INSTRUMENTS, INC.

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UNDERSEA COMPONENTS

PRICE LIST

FOR BULLETINS 2012, 2013 AND 2014

Model/Part No.	Description	Unit Price
787-M9A	Explosion-proof CO_2 Scrubber, light-weight anodized aluminum.	$1,433.00
787-M70A	As above, with magnetic switch and fuse-access housing.	1,643.00
787-M9B	As 787-M9A, in heavy-duty bronze.	1,705.00
787-M70B	As above, with magnetic switch and fuse-access housing.	1,915.00
787-M9D	As 787-M9A, in chrome-plated bronze.	1,989.00
787-M70D	As above, with magnetic switch and fuse-access housing.	2,225.00
787-M9-300	Spare canister for 787-M9 Series.	67.50
707-M7A	Explosion-proof CO_2 Scrubber, light-weight anodized aluminum, without exterior frame.	623.00
707-M77A	As above, with magnetic switch and fuse-access housing.	825.00
707-M7A2	As 707-M7A, in bronze.	735.00
707-M7B	As 707-M7A, in heavy-duty bronze with exterior frame.	800.00
707-M77B	As above, with magnetic switch and fuse-access housing.	945.00
707-M7D	As 707-M7A, in chrome-plated bronze with exterior frame.	1,100.00
707-M77D	As above, with magnetic switch and fuse-access housing.	1,335.00

(Continued on reverse side)

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(714) 8?1-4848

Model/Part No.	Description	Unit Price
787-S3	Rotary Magnetic Switch for 3 circuits. (Ask for quotation for additional switch positions.)	$ 395.00
787-V50	24/48 V dc Power Supply (less batteries)	525.00
P-7000-1	Bulkhead Penetrator, single terminal, for 200 A max., at 50 V.	12.00
P-7000-2	Bulkhead Penetrator, 2-terminal, for 100 A max., at 50 V.	12.00
P-7000-2C	Retaining collar for penetrators, for mounting in limited space; uses 2, 1/4-20 cap screws.	3.50
P-7000-6C	Standard retaining collar for penetrators; uses 6, 1/4-20 cap screws.	4.50
500-M5A	Pollution Control Device, 300 cu. in. capacity, anodized aluminum.*	650.00
500-M5B	As above, in bronze.*	850.00
500-M5D	As 500-M5A, in chrome-plated bronze.*	1,000.00
500-M2A	Pollution Control Device, 150 cu. in. capacity, anodized aluminum.*	350.00
500-M2B	As above, in bronze.*	450.00
500-M2D	As 500-M2A, in chrome-plated bronze.*	600.00

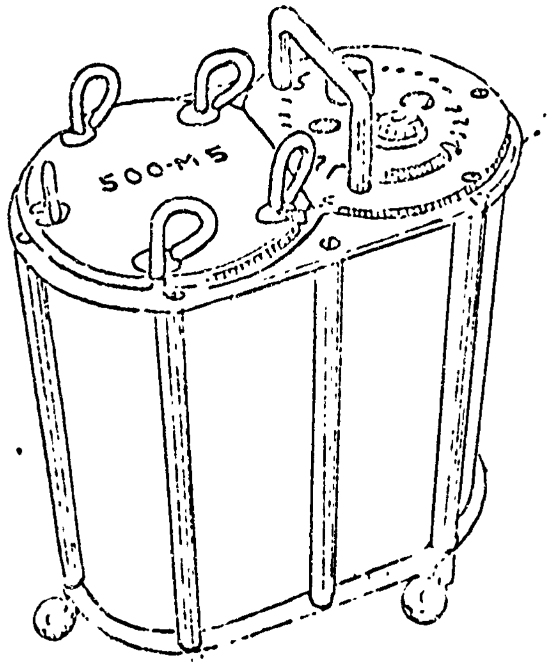
*Specify 110 V ac or dc, or 12 to 60 V ac or dc.

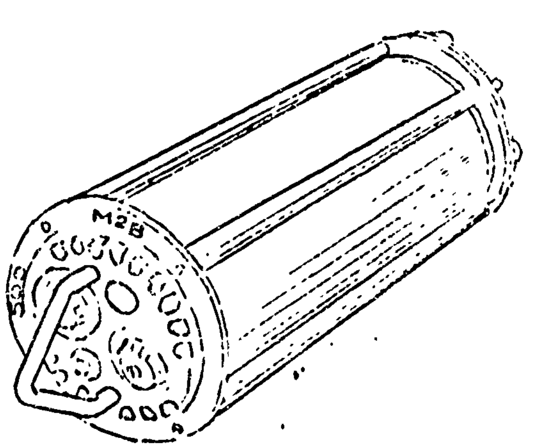
MINIMUM BILLING PER ORDER IS $10.00

(All prices are in U.S. funds and are subject to change without notice.)

PRODUCT BULLETIN 70-500

Pollution Control Devices





pcd 500-M2

PURA pcd 500-M5

LHA Inc. offers a complete line of PCD's in the 500 series to fit every requirement in closed environment air filtration. Devices in the 500 series are designed FOR USE AT ATMOSPHERIC PRESSURE ONLY, such as clean rooms, submarine chambers, hospital rooms, observation diving bells, operating rooms, or any closed area where ventilation is not possible. The M5's have a 300 cubic inch refillable stainless steel canister, and the M2's will hold 150 cubic inches of media. These units can be loaded with activated charcoal granules for odor absorption, silica gel crystals for moisture reduction, granular soda-lime for carbon dioxide removal, or layered combinations of these and other substances. Dust particles are filtered as the air is cycled. Models are available for use in two voltage ranges: 110 volts AC or DC or 12 to 60 volts AC or DC.

For Scrubbing Devices for use in high pressure breathing atmospheres or for use in fire-hazardous environments, send for product bulletins 67-787 and 70-707.

Lindbergh - Hammar Associates Inc., 550 Maple Avenue
Carpinteria, Ca., U.S.A. 93013 Tel. 805-684-421[illegible]

LINDBERGH-HAMMAR ASSOCIATES
550 Maple Avenue, Carpinteria, California 93013
Telephone: (805) 684-4214

JON M. LINDBERGH
Consultant
JAMES H. HAMMAR
Development & Engineering
ROBERT A. BAKER
Administrative

PRICE SCHEDULE

PURA 500-M5 and 500-M2 Pollution Control Devices

MODEL (Catalog No.)	Unit Price
PURA 500-M5A Aluminum construction Anodized finish	$650.00
PURA 500-M5B Bronze Construction	850.00
PURA 500-M5D Chrome Plated Bronze	1,000.00
PURA 500-M2A Anodized aluminum	350.00
PURA 500-M2B Bronze framing	450.00
PURA 500-M2D Chrome plated bronze	600.00

Specify for 110 volt AC or DC power, or 12 to 60 volt AC or DC.

All prices F.O.B. Santa Barbara, California

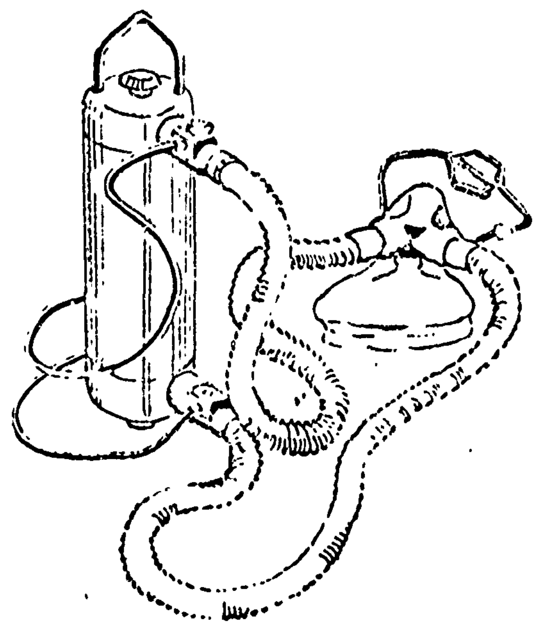
Sales Tax added where applicable

Quantity Discount Schedule available

PRODUCT BULLETIN 70-800

OXYGEN DECOMPRESSION REBREATHER

- TOTALLY FIRE-SAFE
- METERED OXYGEN FLOW
- LOW BREATHING RESISTANCE
- 24 - 60 VOLTS AC or DC
- CERTIFIED TO 2000 PSIG
- 100 CU. IN. DESSICANT CHAMBER
- MINIMUM 6 HOUR LOAD LIFE
- CORROSION-RESISTANT MATERIALS
- MEDICAL ADAPTATIONS



PURA 808-M8

The 808-M8 Decompression Rebreather is designed specifically for decompressing divers on oxygen tables in hyperbaric chambers. Breathing effort is reduced to a comfortably low level; recirculation through the carbon dioxide scrubber is accomplished electrically and oxygen is admitted through a metering jet. A high-torque magnetic interlock connects motor to turbine, environmentally isolating all electrical components in a pressure chamber. The M8 can be easily adapted to a variety of medical hoods for CO_2 removal and O_2 administration to patients at atmospheric pressure or in hyperbaric facilities.

Two models available, specials fabricated to customer specification.

Scrubber available separately for adaptation to customer equipment.

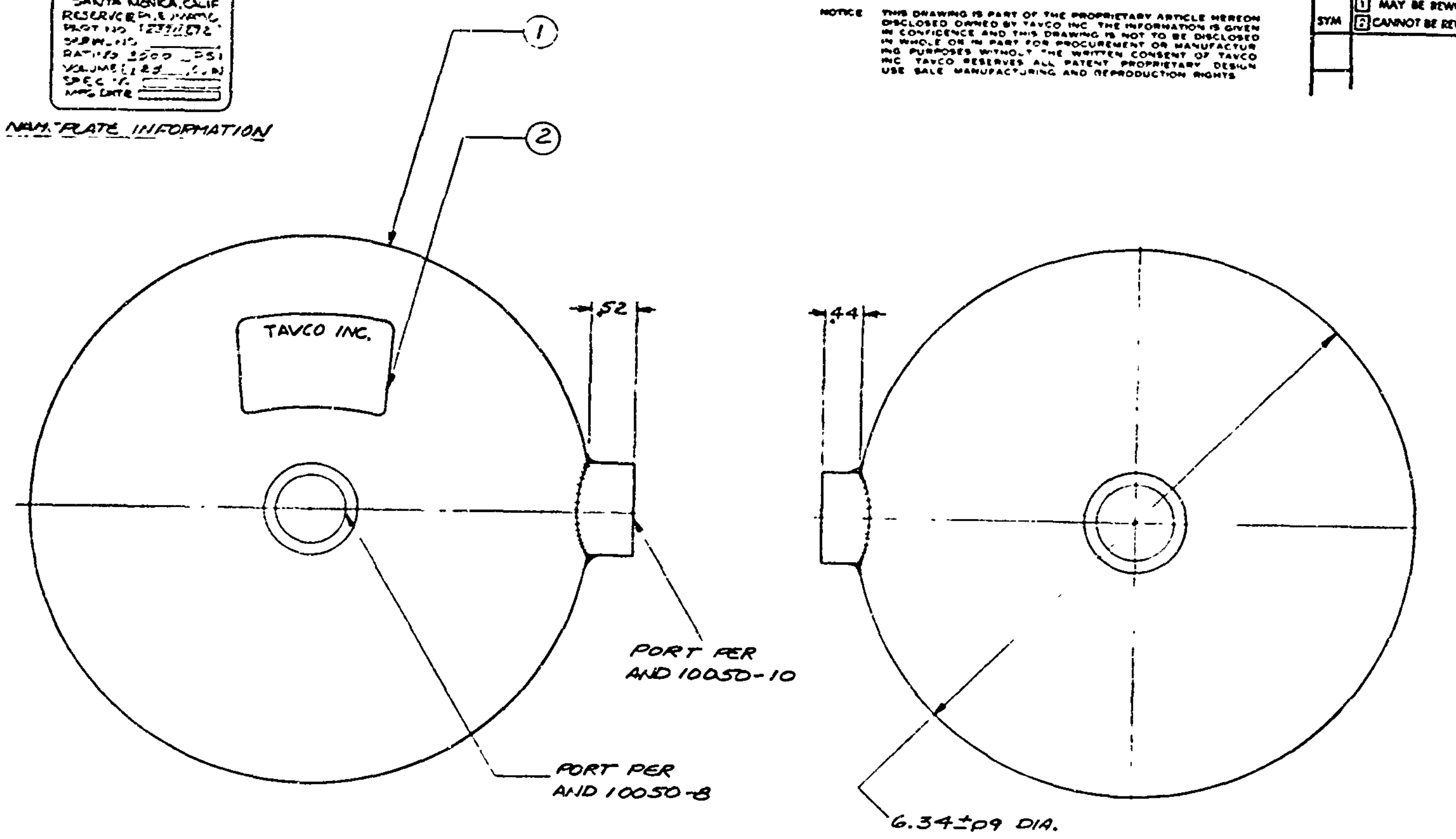
F.O.B. Santa Barbara, California, U.S.A.

Lindbergh - Hammar Associates Inc., 550 Maple Avenue
Carpinteria, Ca., U.S.A. 93013 Tel. 805-684-421

REVISIONS			
SYM	[1] MAY BE REWORKED [2] CANNOT BE REWORKED	[3] RECORD CHANGE [4] NOW SHOP PRACTICE	[5] PARTS MADE OK
			DIS / DATE / DWN / APPD

TAVCO INC.
SANTA MONICA, CALIF
RESERVOIR-PNEUMATIC
PART NO. 23711272
SERIAL NO.
RATING 3000 PSI
VOLUME 125 CU IN
SPEC.
MFG DATE

NAME PLATE INFORMATION



23711272

9- THIS UNIT DESIGNED TO MEET APPLICABLE QUALIFICATION REQUIREMENTS OF MIL-R-8573.
8- ACCEPTANCE TESTING PER TAVCO 43711272.
7- MATERIAL: 4130 STEEL PER MIL-S-18729/MIL-S-6758.
6- EXTERIOR FINISH: PHOSPHATE COAT PER MIL-C-490, PRIMER PER JAN-P-72, LACQUER PER MIL-L-7178, DULL BLACK.
5- INTERIOR FINISH: PHOSPHATE COAT PER MIL-C-490, RESIN COAT PER MIL-C-5056.
4- PRESSURE RATING: 3000 PSI OPERATING
5000 PSI PROOF
6000 PSI BURST
3- VOLUME [illegible] CUBIC INCHES.
2- TEMPERATURE RANGE: [illegible]
1- [illegible] DRY NITROGEN.
NOTES

ITEM	REQD	PART NO	DESCRIPTION	MATL	MATL SPEC
2	1	60015176	NAMEPLATE	VINYLCAL	
1	1	50001134	WELD ASSEMBLY		

LIST OF MATERIAL

DRAWN	LM
TITLE	RESERVOIR-PNEUMATIC 125 CUBIC INCH 3000 PSI
FINISH	NOTED
SIZE	C
DWG NO	23711272

TAVCO INC.
SANTA MONICA, CALIFORNIA

TAVCO, INC.

612 COLORADO AVENUE • SANTA MONICA, CALIFORNIA 90401

Fluid Control Systems

QUOTATION TO:
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

ATTN: Mr. Don Caudy

REFERENCE:

DATE OF QUOTE: 4 June 1970

ITEM	QTY.	DESCRIPTION OR PART NUMBER	UNIT PRICE	DELIVERY
	5-10 pcs	TAVCO P/N 23711272 100 cubic inch vessel recommended for storage of standard 10 cubic foot Oxygen	150.00	60-75 days ARO
	5-10 pcs	TAVCO P/N 23711849 150 cubic inch vessel recommended for storage of standard 10 cubic foot oxygen	160.00	"

PRINTS AND CATALOGUE ENCLOSED

TERMS: ½ of 1% 10 days, net 30 days
FOB: Factory
Quotation expires 90 days

Thank you for this opportunity

TAVCO, Inc.

By: W. Ellwood Jae
W. Ellwood Jae

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Battelle Memorial Institute Columbus Laboratories 505 King Avenue Columbus, Ohio 43201	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Portable Recompression Chamber Environmental Control System Study.

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Summary Technical Report, February 1, 1970 - July 31, 1970

5. AUTHOR(S) (Last name, first name, initial)

Caudy, Don W., Glasgow, James S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 31, 1970	41	7

8a. CONTRACT OR GRANT NO. Contract No. N00014-70-C-0072 b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Supervisor of Diving United States Navy Washington, D. C. 20360

13. ABSTRACT

The major emphasis of the study has been to determine the feasibility of a reliable, portable, lightweight environmental control system for use with the chamber. This report presents the results of the study and recommendations for system development.

A tank-supplied open-circuit system for breathing-gas supply to the portable recompression chamber is the simplest, easiest to operate, and most reliable system. However, except for instances where a large supply of compressed air is available, it is impractical. Semiclosed-circuit and compressor-supplied open-circuit systems appear to offer excellent alternatives to the tank-supplied system without an unreasonable increase in complexity. A closed-circuit system does not appear to offer any major advantages for this application which would offset its deceased reliability and increased cost.

DD FORM 1 JAN 64 1473

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Chamber						
Environmental Control System						
Portable Recompression Chamber						
Recompression Chamber						

Security Classification