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OXYGEN UNITS UNDER DEVELOPMENT BY THE NATIONAL DEFENSE RESEARCH COMMITTEE

Background Of The Problem

The immediate program of Section B-7-B is concerned with supplying the Services with oxygen for the following purposes: (1) breathing oxygen for the use of aircraft crews at high altitudes; (2) for medical therapy; (3) for cutting and welding; (4) as a secondary fuel in underwater propulsion of submarines. Other conceivable uses for oxygen, not now active on our program, concern bursts of power for airplane engines, rocket propulsion of airplanes, etc. These subjects might well become of considerable importance in the inderterminate future.

At present, military and naval sources of oxygen are dependent for the most part on transport of high pressure cylinders. Although oxygen in cylinders may be supplied for aircraft, for therapeutic purposes and for cutting and welding in the field, the weight of the cylinders is a very great drawback in view of present transportation problems, and furthermore there is such a shortage of the cylinders themselves that the present demands can by no means be met. Not only are sufficient number of cylinders today lacking, but the practical impossibility of returning empty cylinders makes it impossible to keep up with the demand for oxygen in the field. If for no other reason than the shortage of cylinders the present program on units for producing oxygen in the field would be warranted.

The inadequacy of commercial supplies of oxygen for operating in various parts of the world has been anticipated by the armed forces. Consequently, orders have been placed and are being filled for some 250 mobile oxygen producing units mounted on trucks for the Army Air Corp. The Engineer Board also has about twenty-five on order. The units which have been delivered to date operate satisfactorily but have the drawback of being excessively heavy and bulky, and hence of limited utility in many remote areas of operation. The N.D.R.C. oxygen program is focussed on making improvements on the type of mobile units now in commercial production, as well as developing entirely new types for special uses under the many special conditions now confronting the armed forces.

The increasing use of oxygen by aviators is necessitated by changing air combat tactics which drive planes to higher and higher altitudes. The second factor is a contemplated increase in the length of flights necessitating an improvement in the present cumbersome system of cylinders. The Air Corps is most insistent upon the immediate development of new facilities, and hence the urgency and importance of this phase of the program is emphasized.

Of equally great importance, if not greater, is the use of oxygen for therapeutic treatment of battle casualties, especially those resulting from use of poison gas. It is contemplated that tremendous quantities of oxygen will be required at and near the battle front for such a purpose and today facilities for supplying such oxygen are unavailable. Furthermore, the duplication of present facilities is impractical, and hence new methods and new equipment are being sought, not only as an improvement but as the very means of such supply itself.

In a similar manner large number of field operations for the repair and maintenance of equipment require oxygen for cutting and welding. Here again present facilities are inadequate both as to quantity and kind.

Units Under Development

With the above remarks on justification of the program the following specific description and use of the units contemplated at present will be given. Two main types of oxygen-producing units are represented, one in which oxygen is separated from the atmosphere by a chemical reagent (Salcomine) and the other in which the separation is made by liquefaction and rectification of air (the so-called mechanical system). In the following list the chemical units are grouped together at the first. These are followed by the mechanical units. In each case a code symbol is given indicating the character, capacity, and destination of the unit.

In this code the **initial** letters have the following significance.

A = Air as heat exchange medium
C = Chemical
E = System with expansion engine
H - High
I = Intermediate pressure
L - Low pressure
M - Mechanical
R = Refrigerant as heat exchange medium
S - Suspension of Salcomine in a liquid
W = Water as heat exchange medium
X = System requiring facilities other than atmospheric air and fuel for operation.

The numeral represents the capacity of the unit in cubic feet of oxygen produced per hour, or, if followed by the letters lb. the pounds of liquid produced per hour. The concluding small letters indicate the department of the Services most interested, which are as follows.

AC - Army Air Corps
Bu A- Naval Bureau of Aeronautics
Bu S- Naval Bureau of Ships
MC - Army Medical Corps
NRL - Naval Research Laboratory
EB - Engineers Board

The table on the following page summarizes the information upon these units with more precise description of the individual units succeeding.

OXYGEN UNITS IN DEVELOPMENT BY B-7-B
as of August 5, 1942

No.	Code	Description	Size	Weight	Utilities	O_2 Production	Testing	Delivery of Prototype	Use
	Chemical Units								
1.	CWX-300-NRL	Six reactors operating in pairs from laboratory utilities; completely automatic for continuous evolution of O_2.	8'x 5'x 6'	2000 lbs.	Air -(80 PSI (50 CFM Water at 70°F	300 CFH 98% purity	Present	Present	Cutting & welding Emergency shipboard operation.
2.	CW-70-NRL	Field unit demountable into sections for carrying	2'x 5'x 5'	600 lbs.	Air -(15 PSI abs. (90°F Gasoline	60 CFH	9/1/42	10/1/42	Field therapy for landing parties, etc.
3.	CA-25-MC	Small portable field unit	?	?	Air 90°F	25 CFH 95%	-	-	Field therapy
4.	CAX-100-AC	In two sections mounted in engine nacelles. Utilizes methoxy derivative of Salcomine.	2 units, each 1'x 2'x 2.5'	300 lbs. total	Air (22" Hg. (50C [illegible]e exhaust gases	100 CFH 95%	8/15/42	8/21/42	Breathing O_2 for crew in flight.
5.	CA-500-AC	Disassembled unit for transportation by bomber - operation in the field.	7'x 14'x 7'	16,000	[illegible] - 120°F [illegible] -	500 CFH 2000 PSI	Not yet designed	-	Cutting & welding, charging cylinders, etc. in the field.
6.	CWX-600-BuS	Reactors, controls, etc. for operation with compressed air, steam, water, etc. on board tenders. Can be disposed conveniently on shipboard.	13'x 20'x 7'	13,000	Air -(200 CFM (80 PSI Steam(450 lbs. at 10 PSI (100 lbs. at 150 PSI Water, 160 gal/min. at or below 75°F Electricity, 25 KWH/hr.	600-1000 CFH 150 PSI	9/1/42	10/1/42	Cutting & welding in machine shops on tenders.
7.	CW-1000-AC	Mobile, self-contained, trailer-mounted unit, employing a circulating water system for heat transfer.	2 units 7'x 14'x 7' each	32,000 (including trailers)	Air between -60° and +120°F 15 gals. fuel per hr.	1000 CFH 2000 PSI 98%	11/1/42	12/1/42	For charging cylinders & other O_2 uses in the field for the Air Corps, Engineer Board & Medical Corps.

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No.	Code	Description	Size	Weight	Utilities	O_2 Production	Testing	Delivery of Prototype	Use
	Chemical Units (continued)								
8.	CR-1000-AC	Similar to No.7 but employing Freon as heat-exchange medium.	2 units 7'x 14'x 7' each	32,000	Air between -60° and +120°F Fuel: 11 gals./hr.	1000 CFH 2000 PSI 98%	12/1/42	12/3 1/42	Same as No.7.
9.	CWS-150-?	Salcomine suspended in white oil and treating in liquid circulating system.	?	?	Air Fuel	150 CFH 98%	-	-	Therapeutic use in field.
	Mechanical Units								
10.	MIE-1000-AC	Trailer mounted (2) lower pressure unit - expansion engine & oxygen compress r. Starting time, 8 hrs.	2 units 8'x 14'x 7' each	22,000 including trailers	Air between -60° and +120°F Fuel: 6 gals./hr.	1000 CFH 2000 PSI 99%	11/1/42	12/1/42	Same as No.7.
11.	MH-1000-AC	Similar to No.10, but operating on a high pressure Linde system. Start-up time of 8 hours.	2 units 8'x 14'x 7'	22,000 including trailers	Air between -60° and +120°F Fuel: 7½ gals./hr.	1000 CFH 2000 PSI 99%	11/15/42	12/15/42	Same as No.7.
12.	MH-400-AC	Similar to 11 but of smaller size and mounted on a single trailer.	One truck or trailer. 8'x 16'x 7'	9000 with trailer	Air Fuel: 3 gals./hr. Water: 8 gals./hr.	400 CFH 2000 PSI 99%			Same as No.7.
13.	MHR-85lb.-AC	Trailer mounted unit employing auxiliary refrigerant cycles on the cascade principle. Produces liquid O_2.	One large trailer	25,000 with trailer	Air between -60° and +120°F Fuel	85 lb. liq. 95%	4/1/43	-	Same as No.7.
14.	MIEX-400lb.-BuS	Shipboard unit, Diesel engine drive, reciprocating compressor & expansion engine, packed column. A pilot plant for submarine propulsion unit. Compression to 500-600 PSI.	4¼'x 6½'x 14' without engines and compressors.	20,000 without engines and compressors.	Air Cooling water Fuel	411 lbs. liquid 95%	3/1/43	5/1/43	For laboratory test at Annapolis and eventual trial installation on submarine.

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o.	Code	Description	Size	Weight	Utilities	O_2 Production	Testing	Delivery of Prototype	Use
	Mechanical Units (continued)								
5.	MLEX-400 lb.-BuS	Similar to No. 14, but operating on air compressed to 105 PSI and using rotary expander and compressor	-	36,000 without engines and compressors.	Air Cooling water Fuel	400 lbs. liquid 95%	After 3/1/43		For laboratory test at Annapolis and eventually for production of liquid O_2 at a shore or ship base.
6.	MHX-35 lb.-BuS	Simple high pressure liquefaction and rectification unit to operate with 3000 PSI air available on submarines.	2½'x 2½'x 6'	100 lbs.	Air: 20 CFH at 3000 PSI	35 lbs. liq. 95%	9/15/42	10/1/42	Production of liq.O_2 on submarines while surfaced to condition atmosphere while submerged.
7.	MLE-100-AC,BuA	Small unit operating at 150 PSI with expansion engine.		350	Air: at 6 PSI Fuel	100 CFH 95%	9/1/42 without compressor	11/1/42 with compressor	Production of O_2 for supply of crews on bomber while in flight.
8.	MH-100-AC,BuA	Small unit operating on Linde system at 3000 PSI.		350	Air: at 6 PSI Fuel	100 CFH 95%	No schedule or compressor.		Same as No. 17.

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A. SALCOMINE UNITS

(1) CWX-300-NRL Naval Research Laboratory Unit.

This unit occupies a space of approximately 8 ft. by 5 ft. on the floor by 6 ft. high and weighs about 2,000 lbs., including 290 lbs. of Salcomine. It will operate entirely automatically to produce a continuous flow of oxygen of 98% purity or better with a capacity of 300 cu. ft. of gas at NTP delivered at 20-30 lbs./sq.in. gauge. This unit was originally designed to operate at an air pressure of 250 lbs./sq.in. at which pressure the production rate would be in the neighborhood of 500 cu.ft./hour. But inasmuch as this pressure was deleterious to the life of the Salcomine it is contemplated that the unit will be operated exclusively at 80 lbs./sq.in. A redesign on the basis of 80 lbs./sq.in. will materially reduce the weight of the unit. For its operation it will require its supply from external sources of 50 cu.ft./min. air (NTP) supplied at 80 lbs./sq. in. and twenty gallons water per minute at 70°F., besides electricity to operate controls etc. and some auxiliary air supply to operate automatic valves. It is believed that all the necessary facilities are available upon shipboard, where it is contemplated that the unit will be used as an emergency supply of oxygen for cutting and welding. The production obtained in the initial tests has proved highly satisfactory for this purpose.

The unit is in process of testing at the Naval Engineering Experiment Station at Annapolis. If accepted by the Services it is expected that the unit may be put in production within three months. The chief bottleneck to production will be the supply of steel and copper for construction and cobalt salts for salcomine as well as some pressure and flow instruments and gas valves involved in the operation of the unit.

(2) CW-70-NRL Naval Medical Unit.

A completely self-contained unit approximately 2 ft. by 5 ft. by 5 ft., weighing 600 pounds, including 100 pounds of Salcomine, is being constructed capable of transportation into the field in small sections, easily handled by one man, for use by the Navy (Marine Corps) on landing parties, etc. to supply oxygen for therapeutic purposes. The unit will produce 50-70 cu. ft. of 95% oxygen per hour. It is expected that the research will be completed upon this unit in one month and that approximately one month later the unit will be delivered to the Services. It is believed that the unit will satisfactorily fulfill the requirements of producing therapeutic oxygen for landing parties, which oxygen is urgently needed. Production problems are the same as in (1).

(3) CA-15-MC Field Medical Unit.

A small unit producing 15-25 cu.ft. of oxygen per hour has just been requested by the Medical Corps to supply oxygen for therapeutic purposes in place of cylinder gas. The size of the unit is determined by the requirements of the field group on a unit operating at the battle front. No data is yet available upon such a unit, but presumably it will be a scaled-down model of (2). Working models can be produced in four months.

(4) CAX-100-ac Bomber Unit.

A chemical unit to produce 100 cu.ft. of 95% oxygen per hour on board bombers. It will be constructed in two sections, each section occupying approximately 1 ft. by 2 ft. by 2½ ft. , the total weight of the two sections being 300 lbs., each section to be mounted in one of the engine nacelles. These units are very simple, comprising aluminum tube reactors filled with 150 lbs. of the methoxy derivative of Salcomine which absorbs oxygen from the air readily at approximately atmospheric pressure. Absorption of oxygen will take place from air supplied from the engines' supercharger with cooling by the upper atmosphere. Desorption will be induced by heating with a mixture of air and exhaust gas. It is estimated that the unit will operate satisfactorily on absorption only at temperatures below 5°C so that in general the operation will be confined to higher altitudes in warm weather. Any light-weight unit producing oxygen for planes is in great demand by the Air Corps. It is believed that the present model can be tested and in the hands of the Air Corps in three weeks' time. Although the unit itself might be produced commercially in two months' time, it will probably take four to six months to adapt it completely to the airplane construction and operation. Bottleneck materials are aluminum and cobalt salts.

(5) CA-500-AC Air-borne Chemical Unit.

A request has been made for units to be operated in the field but capable of transportation by air. Although no definite designs have as yet been produced for such a unit, it is believed that the characteristics of such a unit may be obtained by scaling down to any desired production, for example 500 cu.ft./hour suggested, the characteristics of either unit (7) or (8) following. It will be possible to so design the unit that it can be taken apart into sections, no section weighing more than 500 lbs., the largest sections being the engines required to drive the air and refrigeration compressors. As originally conceived, the problem was to provide such a unit for transportation by a bomber. If in fact large air transports are available for handling bulky and heavy articles, it may become entirely feasible to transport one of the mobile truck units described below as a single item.

(6) CWX-600-Bu S Shipboard Welding Unit.

A unit occupying approximately 10 ft. by 20 ft. floor space by 7 ft. high, weighing 13,000 pounds, including 800 lbs. Salcomine is designed to operate on the facilities found on shipboard, namely compressed air, cooling water, electricity, steam, etc. The present model under construction, because of the lack of corrosion resistant metals has been built of steel for operation with fresh water as the heat exchange medium. In order to test with sea water, a heat exchanger weighing 2,400 lbs. is supplied. Naturally, this can be omitted with a consequent saving in weight if the apparatus as a whole is constructed of corrosion resistant materials. The following facilities available on shipboard will be required for operation of the unit: steam at 10 lbs./sq.in. for heating reactors, 450 lbs./hour; steam at 150 lbs./sq.in. for operating purging ejector, 100 lbs./hr.; sea water for cooling, 160 gals./minute; electricity, 25 kwh/hour. The dimensions given above are for the present test unit and it is to be understood that the elements of this unit can be rearranged in a flexible manner to use the space upon shipboard to good advantage. Under normal conditions of operation, for example, 200 cu.ft. of free air compressed to 80 lbs./sq.in., cooling water at 75°F, the unit will produce 600 cu.ft. of 98% oxygen per hour. If lower water temperatures in the neighborhood of 65°F and higher air flows are used, the oxygen yield may be made to approach 1000 cu.ft./hour. Higher yields are also obtained if the system is operated at 250 lbs. air pressure for which it is designed, although at this pressure the rate of deterioration of the Salcomine is excessive.

This unit will be ready for testing by September 1st and for delivery to the Navy by October 1st. It is contemplated before October 1st to run extensive tests on operation and life of the Salcomine material. The unit is designed to produce cutting and welding oxygen for use in the machine shops of tenders. It is expected thereby to materially relieve the cylinder shortage. Manufacturing problems are similar to those described in (1).

(7) CW-1000-AC or EB Water Type Chemical Truck Unit.

A unit will be made to produce approximately 1,000 cu.ft. of free oxygen of high purity compressed to 2,000 lbs./sq.in. for charging cylinders etc. This unit is to be portable and suitable for operation in the field. It will have a total weight of approximately 32,000 lbs., 20,000 lbs. of which is for the apparatus itself, 12,000 lbs. for two trailers to carry the apparatus in two sections. The trailers are approximately 7 ft. by 14 ft. by 7 ft. each. One trailer will house the engine and compressors, the second trailer the chemical reactors, controls, etc. The unit will comprise three chemical reactors operating in an automatic cycle to give a continuous supply of oxygen. Heat will be supplied through a boiler and hot water circulating system; cooling for absorption will be supplied through circulation of cool water and a Freon refrigerating system. Approximately 150 HP will be required for operation, requiring 15 gallons of gasoline fuel per hour. In addition to the air compressor the unit will be supplied with an oxygen compressor. This unit should be ready for testing by November 1st. Difficulties of manufacture are similar to those described in (1). The weight can be materially reduced by the use of aluminum, and this and instruments and compressors required are the chief bottlenecks.

(8) CR-1000-AC or EB Freon Chemical Truck System.

This unit is similar to that of (7) except that the heat exchange system supplying refrigeration for absorption and heat for desorption will be a rather complicated one involving Freon instead of water. The overall size and weight of the unit are the same as (7), but the fuel consumption is somewhat less, being 11 gallons/hour. This model should be ready for testing by December 1st. The problems of manufacture are the same as those of the preceding unit.

(9) CWS-150- ? Liquid Suspension System.

A system wherein the Salcomine is suspended in white oil and the suspension circulated through a system providing contact with air for absorption, heat for desorption, separation of oxygen and recycling. A system producing approximately 150 cu.ft./hour of oxygen of 98% purity or better suitable for cutting and welding or for therapeutic purposes in the field is being designed. No data are available at the moment, but it is believed the weight and size of the system will be comparable to that of the preceding systems. This liquid system appears to have some advantages of operation and maintenance not found in the previous systems all of which are based upon the reaction of dry Salcomine with air. It is believed that this unit will be ready for testing in three months.

With one exception all of the above units involve the use of the reagent Salcomine (cobalt disalicylalethylenediimine). (4) employed the methoxy derivative of Salcomine. One big question in all of these units is the life of the chemical. At present it is observed that the capacity for oxygen output decreases about 2% per day's operation; the capacities given above are the maximum for fresh material. It is estimated that one lb. of Salcomine will produce approximately 100 lbs. of oxygen during its lifetime, although in the later stages the rate of production is lowered considerably. Hence there is a real problem of supply and replacement of chemical in all of these units. Systematic work on improving the life of the chemical has just started and it is quite reasonable to assume that definite inprovement in the life will be made in the near future.

B MECHANICAL UNITS

(10) MLE-1000-AC Low Pressure Mechanical Truck Unit.

A unit to produce 1000 CFH (NTP) 98% oxygen is designed to occupy two trailers approximately 8x14x7 ft. each for a total weight of 22,000 lbs. of which 11,000 lbs. is for equipment and 11,000 lbs. for trailers themselves. The unit will be self-contained and comprise a compressor for air delivering at a pressure 105 PSI, drying equipment for the air, two expansion engines, power unit, a packed rectification tower and other miscellaneous equipment including an oxygen compressor for charging cylinders at 2000 PSI. The unit will operate with air cooling in atmosphere as high as 120°F or as low as 60°F. Approximately 60HP is required for operation requiring 6 gal. of fuel per hour. About 8 gal. of water is required per day for operation. Approximately 8 hrs. is required for starting up under most adverse climatic conditions. The unit will be ready for testing by November 1st and should be in the hands of the Air Corps in two or three weeks afterwards. This unit is believed to be a definite improvement over the heavier units now being produced for the Air Corps by the Independent Engineering Company and the Air Products Company and undoubtedly will meet with immediate and enthusiastic reception. These units are in urgent demand not only by the Air Corps but by the Engineer Board as well. The chief bottle neck in production will be compressors, but aside from this, manufacturing should be closely related to the units now turning out on scale of three a week for the Air Corps by the above noted companies.

(11) MH-1000-AC High Pressure Mechanical Truck Unit.

A portable unit of the approximate size and weight of #11 also mounted on two trailers is designed to produce 1000 CFH (NTP) of oxygen compressed to 2000 PSI. The unit will be provided with a four stage air compressor and a four stage oxygen compressor driven by an internal combustion engine consuming 7½ gal. fuel per hour. The system will operate at high pressure (3000 PSI for starting up and 850 PSI for continuous operation) employing an expansion valve for refrigeration with a Freon fore-cooler system. Start-up time is 8 hrs. under most adverse conditions. As in system #11 operation is possible in the air temperature range of -60°F to + 120°F. The oxygen will be dried by cooling to -11°F by Freon refrigerator. This unit will be ready for testing by November 15th and the remarks in regard to use by the Services and manufacturing made in connection with unit 11 apply here as well. Presumably, a choice will be made between units #11 and #12 for manufacture.

(12) MH-400-AC Small Mechanical Truck Unit.

A high pressure unit somewhat smaller than (11), producing 400 cu.ft. of oxygen, is designed to be mounted upon a single truck or trailer of 8 ft. by 16 ft. floor space. Operation will be at high pressure with a straight

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Linde system and a compressor will be furnished to supply oxygen at 2,000 lbs./sq.in. The present model is designed to use available equipment and therefore will weigh a good deal more than a unit designed for light-weight equipment. The capacity is fixed by the power available from a Ford Mercury engine. With present compressors the weight of the equipment is estimated at 8,000 to 9,000 lbs., whereas with suitably designed compressors the weight should be approximately 4,000 lbs. In operation cooling is obtained by the evaporation of water requiring approximately 200 gallons for a 24 hours' operation. 3 gallons of gasoline are required for one hour's operation as well as $\frac{1}{2}$ lb. of KOH for drying of air and removal of carbon dioxide. The Air Reduction Co., designers of this unit, guarantee its performance in view of design before completion of model and seek acceptance by the Services for large - scale production, thus saving approximately two months on construction and test of model. On this basis about four months will be required to develop compressor and place unit in production.

(13) MHR-85 lb.-AC Cascade Trailer Unit, for Liquid Oxygen.

A trailer-mounted unit is being designed and built which will operate on the cascade principle of step-wise cooling and liquefaction of air by the use of auxiliary refrigerants. In addition to the main air compressor a separate compressor will be required for each refrigerant used. It is contemplated that either two or three refrigerating systems would be required depending upon the climatic conditions under which the system is operated. This system is designed to produce 85 lbs. of liquid oxygen per hour of approximately 95% purity. It will be entirely self-contained and mounted upon a single truck or trailer of rather large size and weighing 25,000 to 30,000 lbs. It is estimated that the unit will be ready for testing by April 1st, 1943. The chief bottleneck in production of such units will be the compressors.

(14) MIEX-400 lb.-Bu S Medium Pressure Submarine Pilot Plant.

A proposed method of operating a submarine when submerged on a fuel and oxygen mixture requires the production of large quantities of oxygen on board the submarine for which purposes a plant producing from 2,000 to 4,000 lbs./hour is required. The design of such a plant is held in abeyance pending the construction and testing of a pilot plant producing 400 lbs. of oxygen per hour. Two such pilot plants are being designed and built. The one described herewith operates on air compressed to 500 lbs./sq.in. (the initial test to be at 600 lbs./sq.in.). The equipment comprises reciprocating air compressor handling 4,360 lbs. of air per hour and two expansion engines operating in stages between 600 and 20 lbs./sq.in. A Diesel engine is to be supplied to operate the compressors of the pilot plant, although the full size unit will employ the main engines of the submarine. A column packed with Berl saddles will be used as suitable for operation upon a rolling and pitching vessel. The pilotplant will be set up and tested at the Stamford plant of the Air Reduction Company in approximately seven months, will be moved to the Naval Engineering Experiment Station at Annapolis in another two months and will eventually be installed for preliminary tests on a submarine.

(15) MLEX-400 lb.-Bu S Low Pressure Submarine Pilot Plant.

A unit similar in size and output to (14) is being designed and built employing a rotary compressor and expander to operate at approximately 105 lbs./sq.in. air. This unit will be built in a somewhat later sbhedule than the previously mentioned one and after testing at Annapolis will probably be installed at some ship or land base for the production of liquid oxygen.

(16) MHX-35 lb.-Bu S Submarine Air Conditioning Unit.

It is desired to provide a unit for producing liquid oxygen utilizing the 3,000 lb. air available upon a submarine. The liquid oxygen is to be produced while the submarine is on the surface, stored in insulated containers, and then slowly evaporated while the submarine is submerged in order to increase the oxygen content of the atmosphere. A small and compact liquefaction and rectification unit, the Mond unit, has been obtained from the British and will be tested for the above noted purpose. This unit is capable of producing about ten lbs. of liquid oxygen per hour. A second unit is being designed and built which will produce about 35 lbs. of liquid oxygen per hour, and it is expected that the second unit will be ready for delivery to the Bureau of Ships by October 1st. Inasmuch as engines and compressors are not required for the unit, it will be simple to fabricate and will occupy very little space.

(17) MLE-100-AC, Bu A Low Pressure Mechanical Aircraft Unit.

A small unit comparable to the Ricardo-Mond unit of the British for the production of oxygen for the crew of bombers while in flight isbeing constructed. The liquefaction and rectification equipment is very simple and will be more or less a facsimile of the British equipment. It is proposed to rebuild a Franklin air-cooled engine to provide a combination of engine and compressor comparable to the Ricardo engine-compressor, weighing in the neighborhood of 250 lbs. The entire self-contained unit should therefore weigh about 350 lbs. This will produce 100 cu.ft. of oxygen per hour at altitudes up to 20,000 ft.; above that altitude it will be necessary to use a supercharger both for the engine and the compressor. About three weeks will be required for the construction and testing of the rectification equipment, but three months will be required for the development of the compressor. A small expansion engine is required, one of which is now available for the test unit. If this unit should be accepted by the Services, it is evident that chief bottleneck would be the production of the engine-compressor and the expansion engine. As in all the liquid oxygen equipment, it will be necessary to use copper for a major part of the construction.

(18) MH-100-ac, Bu A High Pressure Mechanical Aircraft Unit.

The liquefaction and rectification equipment will be even simpler than that in (17) since no expansion engine will be required. However, it will be necessary to have a compressor delivery air up to 3,000 lbs./sq.in. At present no satisfactory compressor or modified compressor is available other than the Ricardo British unit. The Ricardo unit is too complex for duplication and the modification of a Franklin air-cooled engine, while possible, would lead to a rather bulky unit as it would involve the addition of two steeple cylinders in addition to the modified construction indicated in (17). No schedule is available at present either on the development or manufacture of this unit.

The mechanical systems appear to have an advantage over the chemical systems in bulk and weight and furthermore they alone are capable of producing liquid oxygen. There is an increasing interest in the production of liquid oxygen, especially at bases at which larger units may be operated. However, all of the mechanical systems have an appreciable starting-up time for the attainment of low temperatures in the equipment and the liquefaction for sufficient air for the operation of the rectification column; in the units above this starting-up time varies from 2 to 8 hours depending upon the excess power available for starting up.

S. S. Prentiss