Ocean Simulation Facility Facts

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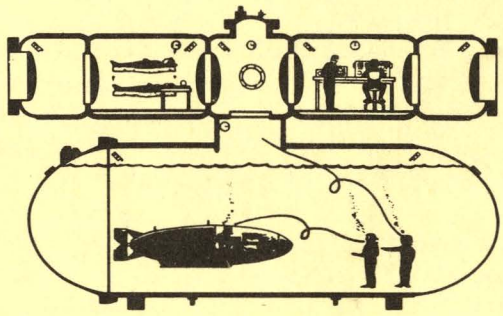
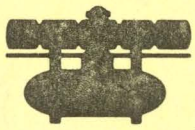
Ocean Simulation Facility



FACTS

May 1973

NAVAL COASTAL SYSTEMS LABORATORY
PANAMA CITY, FLORIDA 32401



The Navy's new Ocean Simulation Facility (OSF) is nearing completion at the Naval Coastal Systems Laboratory (NCSL) in Panama City, Florida. It is unique in the capability to test and evaluate man and equipment together in a simulated deep ocean environment to depths of 2250 feet.

With this new installation it will be possible to test underwater systems and the men who will work with them in controlled ocean conditions including desired temperatures, salinity, light level, turbidity and pressure. Such things as swimmer propulsion devices, small submersibles and diving innovations can be tested in near-actual conditions in the safety of a controlled laboratory environment where medical and engineering monitoring of men and equipment is possible. Underwater habitat living and swimming conditions can be experienced by divers without the risk of delayed accessibility.

The OSF is regarded as a national resource and will be made available, when possible, to governmental, educational, and industrial organizations. The facility is staffed by highly trained scientists and engineers who are experienced in hyperbaric chamber development and naval diving programs.

OSF operations are directed from a centrally located control room and supported by the latest in control systems and scientific equipment for biomedical monitoring, breathing gas analysis, life support and a computer controlled data acquisition system.

One of the U. S. Navy's major laboratories, NCSL is located on the northern coast of the Gulf of Mexico. It is environmentally suited for year-round open-sea testing because of a mild climate, warm waters, good harbor facilities, and the presence of a 65-mile wide continental shelf. NCSL is expanding its role in coastal oceanography, marine ordnance countermeasures, and other programs related to the coastal environment.

OCEAN SIMULATION FACILITY

FACTS

Naval Coastal Systems Laboratory
Panama City, Florida 32401

May 1973

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I. GENERAL

A. LOCATION: Naval Coastal Systems Laboratory
Panama City, Florida

B. DESIGN AND CONSTRUCTION ADMINISTRATION:
Naval Facilities Engineering Command, Southern Division
Charleston, South Carolina

C. ARCHITECT-ENGINEER:
Sanders and Thomas
Pottstown, Pa.

D. PURPOSE: Allow fully instrumented testing of both man and equipment together under a controlled and simulated ocean environment, independent of natural conditions of time and place.

E. VARIABLE PARAMETERS

1. Pressure: 0 to 1000 psig
   a. Simulated depth: 0 to 2250 feet of seawater
   b. Atmospheres: 0 to 68 atm
2. Vacuum: 1 torr or 151,000 ft of altitude
3. Temperature
   a. Wet chamber: $29^{o}F$ to $90^{o}F$
   b. Dry chamber: $50^{o}F$ to $110^{o}F$
4. Humidity in dry chambers: 50 to 95% relative humidity
5. Salinity: 0 to 40 parts per thousand
6. Turbidity: as required
7. Light level: as required
8. Dry chamber gas constituents: as required

II. BUILDING DESCRIPTION

A. GENERAL

1. Contractor: Dyson & Co., Pensacola, Florida
2. Contract Cost: $1,116,505
3. Structure:
   a. Steel structure with concrete block and brick veneer
   b. Designed to withstand hurricane winds up to 120 mph
   c. 380 tons of structure steel
4. Foundation of Building
   a. Concrete
   b. No pilings
   c. 70 tons of reinforcement steel
5. Foundation for Chambers
   a. Separate from building foundation
   b. Concrete with steel reinforcements
      (1) 472 cubic yards of concrete
      (2) 30 tons of steel reinforcements
      (3) Monolithic (one pour)
   c. Dimensions:
      (1) Thickness: 5 feet
      (2) Length: 100 feet
      (3) Width: 26 feet

B. HIGH BAY AREA

1. Purpose: House pressure chamber complex and check-out pool
2. Total area of main floor and mezzanine: 10,460 sq ft
3. Check-out pool
   a. Dimensions: 15 feet wide, 30 feet long, 16 feet high
   b. Water volume: 50,500 gallons
   c. Water filtered and heated
   d. Use: Check-out of divers and equipment under ambient

conditions prior to wet chamber entry

4. 30-ton bridge crane
   a. Use: Equipment handling
5. 5-ton bridge crane
   a. Move material on mezzanine area
   b. Lifting equipment and center chamber hatch
   c. Servicing of atmosphere conditioning loops

C. MECHANICAL EQUIPMENT ROOM

1. Total Area: 2310 sq ft
2. Purpose: House the major portion of the mechanical and electrical support equipment
   a. Two hot water boilers
   b. Four refrigeration units required for building and chamber operation
   c. Compressors for life support gases (2 helium, 1 impure helium, 1 mixed gas, 1 oxygen, 1 nitrogen, 2 air)
   d. Pumps (vacuum, Bldg. fire protection)
   e. Electrical power substation
   f. Motor control center
   g. Emergency power diesel generator (300 KW/375 KVA, 560 HP)
   h. Cryogenic helium reclaimer

D. THREE-STORY SUPPORT SECTION

1. Total area: 8,865 sq ft
2. First floor
   a. Duty room and lobby
   b. Office area
   c. Conference room
   d. Research and development shop (work benches, small lathe, drill press, sheet metal brake, bench grinder, band saw, vacuum pump, and miscellaneous hand tools)
3. Second floor
   a. Berthing rooms
   b. Day room

c. Food handling area

d. Gear storage area

4. Third floor

a. Mixed Gas Laboratory

(1) Function: Maintain, replenish, and calibrate diving equipment

(2) Equipment: mixed gas manifolds, high and low pressure air manifolds, gas transfer pumps

(3) Floor material: Torginol

(a) Seamless, copolorimized epoxy with paint chips

(b) Monolithic (one pour)

b. Medical laboratory

(1) Use: diver examination area prior to and after dives in chambers; during dive, various tests (EEG, EKG, Urinalysis, core temperature, etc.)

c. Control room

(1) Control of various activities in pressure chamber complex will be initiated, monitored and terminated

(2) Remote control of facility by manual operation from control consoles

(3) Communication center

(a) Voice intercommunications

(b) Television monitoring

(c) Viewport monitoring

III. PRESSURE CHAMBER COMPLEX

A. GENERAL

1. Contractor: Hahn & Clay, Houston, Texas
2. Contract Cost: $2,468,387
3. Fabrication material: HY 80 steel
   a. Low-alloy, high-strength quenched and tempered steel
   b. Minimum yield strength of 80,000 psi
4. Special requirements
   a. Design standards: ASME Boiler & Pressure Code Section III Class A "Nuclear Vessels"
   b. Fabrication standards: NAVSHIPS 0900-006-9010, 6-66 Fabrication, Welding & Inspection of HY-80 Submarine Hulls
5. Total weight of chamber complex and supports: 825,530 pounds
   a. Weight of chambers: 674,530 pounds
   b. Weight of supports: 151,000 pounds
6. Designed cyclic life
   a. 2500 cycles over a 0 to 1000 psig pressure excursion
   b. Approximately 24 years at 2 cycles per week
7. Designed leak rate: 10% per day
8. Noise level design criteria
   a. 55 to 65 decibels at 500 to 5000 cycles/sec
      (1) Average office to noisy home
   b. Acoustical damping accomplished through use of open-cell Fiberglass cloth
9. Chamber interior lighting
   a. Lamps: Quartz-Iodide lamps
   b. Power:
      (1) 250 watts ea in dry chamber
      (2) 1000 watts ea in wet chamber
   c. Lamp housing: 20 gage type 304 stainless steel

B. WET CHAMBER

1. Quantity: One

2. Location: Main floor, high bay area
3. Design: Cylindrical body with hemispherical heads
4. Dimensions:
   a. Overall length: 47 feet 3 inches
   b. Full diameter length: 30 feet
   c. Inside diameter: 15 feet
5. Wall thickness
   a. Cylinder: 3 inches
   b. Hemispherical heads: 1-1/2 inches
6. Weight: 300,160 pounds
7. Volume (internal): 7100 cubic feet
8. Capacity: 55,400 gallons of water
   a. Fill time: 2½ hours
   b. Drain time: 15 min.
9. Number of viewports: 24
10. Wet chamber door
    a. Full diameter access: 15 feet
    b. Weight: 33,753 pounds
    c. Seal: "O" ring
    d. Locking: 96 radial finger-pins
    e. Operation: Hydraulic
    f. Future design: Permit removal of door and provide for future installation of an additional 30-foot cylindrical section.
    g. Maximum time period for full closing & locking: 20 min.

C. DRY CHAMBERS
1. Quantity: Five
2. Location: Mezzanine floor, high bay area
3. Wall thickness: 1-1/2 inches
4. Inside diameter: 8 feet
5. Overall length: 62 feet 7½ inches
6. Chambers
   a. Outer chambers (Chambers A and E)
      (1) Length (internal): 8 feet
      (2) Weight: 46,130 pounds (ea.)

(3) Volume (internal): 440 cubic feet (ea.)

(4) Number of 6" viewports: 6 (ea.)

(5) Number of instrumentation ports: 4 (ea.)

(6) Number of access hatches: (One (ea.) (42 in. diameter)

(7) Number of medical locks: 1 (ea.)

(8) Deck area: 45 sq ft (ea.)

(9) Appurtenances

(a) BIB system

(b) Intercom system

(c) Fire protection system

b. Inner Chambers (Chambers B and D)

(1) Length (internal): 12 feet

(2) Weight: 74,300 pounds (ea.)

(3) Volume (internal): 620 cubic feet (ea.)

(4) Number of 6" viewports: 7 (ea.)

(5) Number of instrumentation ports: 6 (ea.)

(6) Number of access hatches: Two (ea.), (42 in. diameter)

(7) Number of medical locks: 1 (ea.)

(8) Deck area: 55 sq ft (ea.)

(9) Appurtenances

(a) 4 bunks (ea.)

(b) 1 sink/commode combination (ea)

(c) 1 shower head and shower curtain (ea.): (CNR-Nitroso rubber coated Beta cloth)

(d) BIB system

(e) Intercom system

(f) Fire protection system

c. Center Section

(1) Weight of center chamber and trunk: 133,510 pounds

(2) Length: Center chamber - 10 feet
Trunk - 6½ feet

(3) Volume: Center chamber - 540 cubic feet
Trunk - 330 cubic feet

(4) Number of 6" viewports: 5 (ea.)

(5) Number of instrumentation ports: 4 (ea.)

(6) Number of access hatches: Center chamber
2 (42 in. diameter)
1 (48 in. diameter)
Trunk - 1 (48 in. diameter)

(7) Deck area: 55 sq ft

(8) Number of medical locks: 1

(9) Appurtenances
(a) 4 seats
(b) diver's platform and hoist
(c) wet suit storage area
(d) BIB system
(e) intercom system
(f) fire protection

D. VIEWPORTS

1. Manufacturer: Naval Civil Engineering Laboratory (NCEL)
Port Hueneme, Calif.

2. Material: Acrylic plastic material (unshrunk Plexiglas "G" grade)

3. Design
a. Conical
b. Window held in place by HY-80 steel flanges

4. "6" - inch viewports
a. Dimensions of windows
(1) Thickness: 2½ inches
(2) Conical angle: 60^{o}
(3) Low pressure diameter: 5 inches
(4) High pressure diameter: 7.8 inches

b. Total number: 55

c. Number/chamber

(1) Wet chamber: 24 (2 located each hemispherical end, 18 located in cylindrical section)

(2) Center section

(a) Center chamber: 5

(b) Trunk: 0

(3) Dry chamber No. 1 and 2: 7 ea.

(4) Outer chamber No. 1 and 2: 6 ea.

5. "4" - inch viewports

a. Dimensions

(1) Thickness: 2½ inches

(2) Conical angle: 60^{o}

(3) Low pressure: 3.0 inches

(4) High pressure diameter: 4.7 inches

b. Total number: 8

c. Location: One in each 42 inch diameter personnel closure hatch

6. Sealing

a. "O" ring seal between window and flange

b. "O" ring seal between flange and chamber

c. Maximum allowable helium leakage rate

(1) 5 scc/sec "6" inch viewports

(2) 3 scc/sec "4" inch viewports

7. Approximate cost: $75,000

E. ACCESS HATCHES & DOORS

1. 42 inch diameter personnel closure hatch

a. Design: circular

b. Locking: 3 dogs, single "O" ring seal

c. Total number: 8

d. Number/chamber

(1) Outer chamber: one in end opposite adjacent dry chamber lock (total: 2)

(2) Dry chambers: one in each end (total: 4)

(3) Center lock: one in each end (total: 2)

2. 48 inch diameter hatch

a. Design: circular

b. Total number: 2

c. Location

(1) Trunk: one (interchangeable)

(a) Upper trunk position: restrict access from the trunk to the center chamber

(b) Lower trunk position: restrict access from the trunk to the wet chamber

(c) Locking: hand wheel dog assembly

(2) Center lock: One on the overhead

(a) Locking: internal breech lock mechanism

(b) Contains diver platform hoist

3. 15 foot diameter wet chamber door

a. Design: hemispherical

b. Location: wet chamber

c. Locking: radial finger pin design (96 pins)

4. Medical locks

a. Dimensions

(1) Length: 26 inches

(2) Diameter: 18 inch I.D.

b. Volume: 3.7 cubic feet

c. Number/chamber

(1) One per each dry chamber, outer lock, and center chamber

(2) Total number: 5

d. Equalization valves are interlocked to prevent depressurizing the chamber

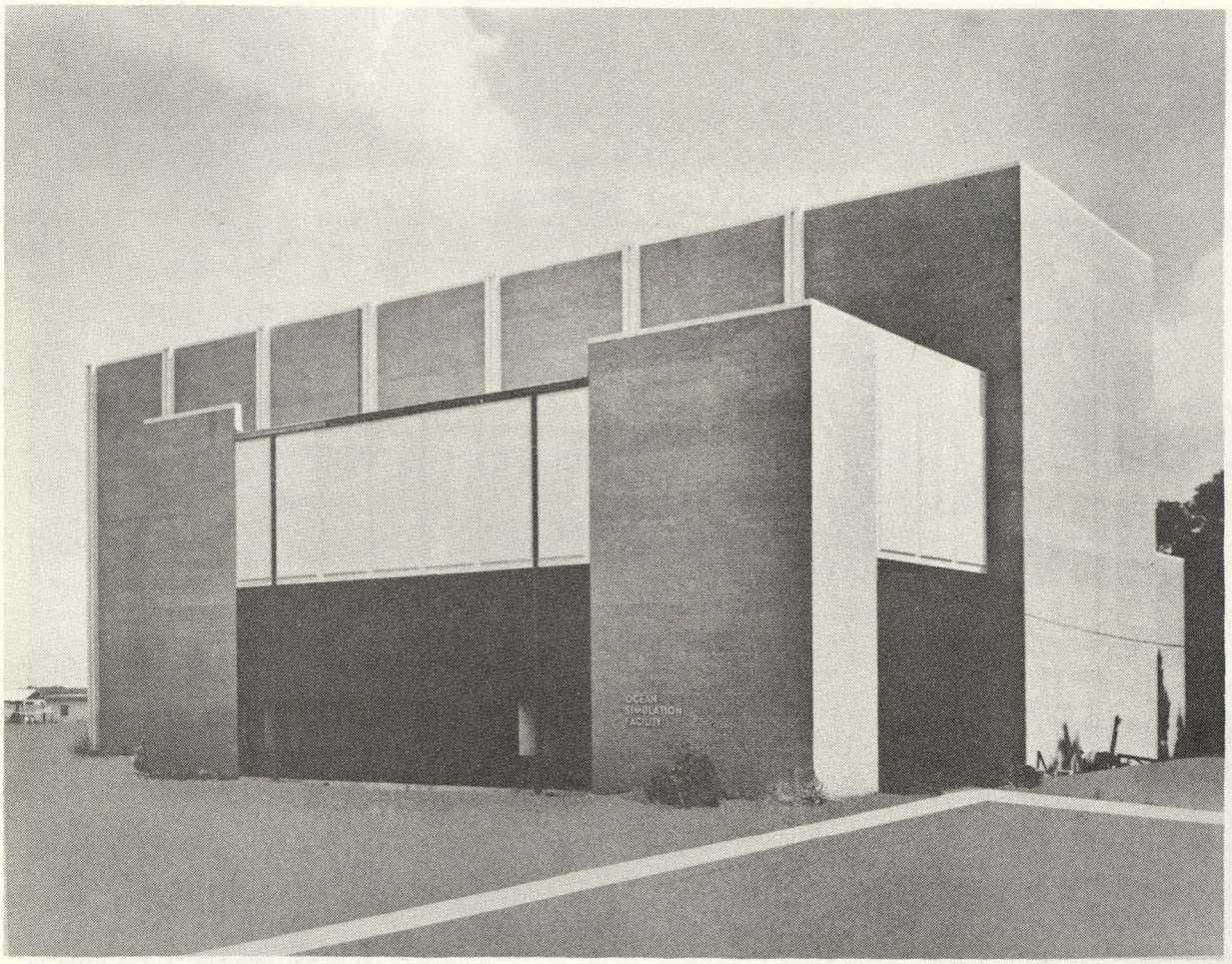

FIGURE 1. OSF BUILDING

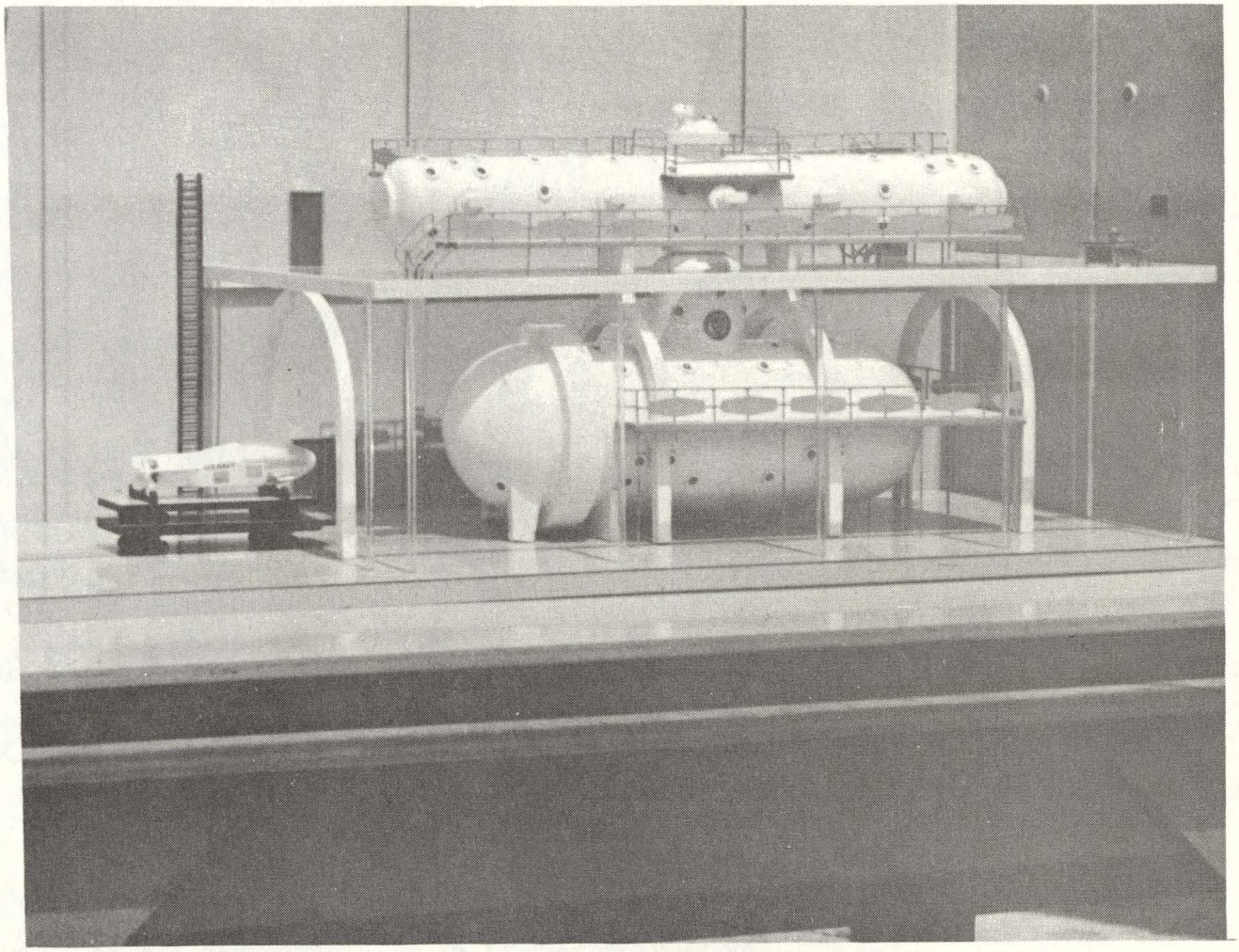

FIGURE 2. MODEL OF OSF CHAMBER COMPLEX

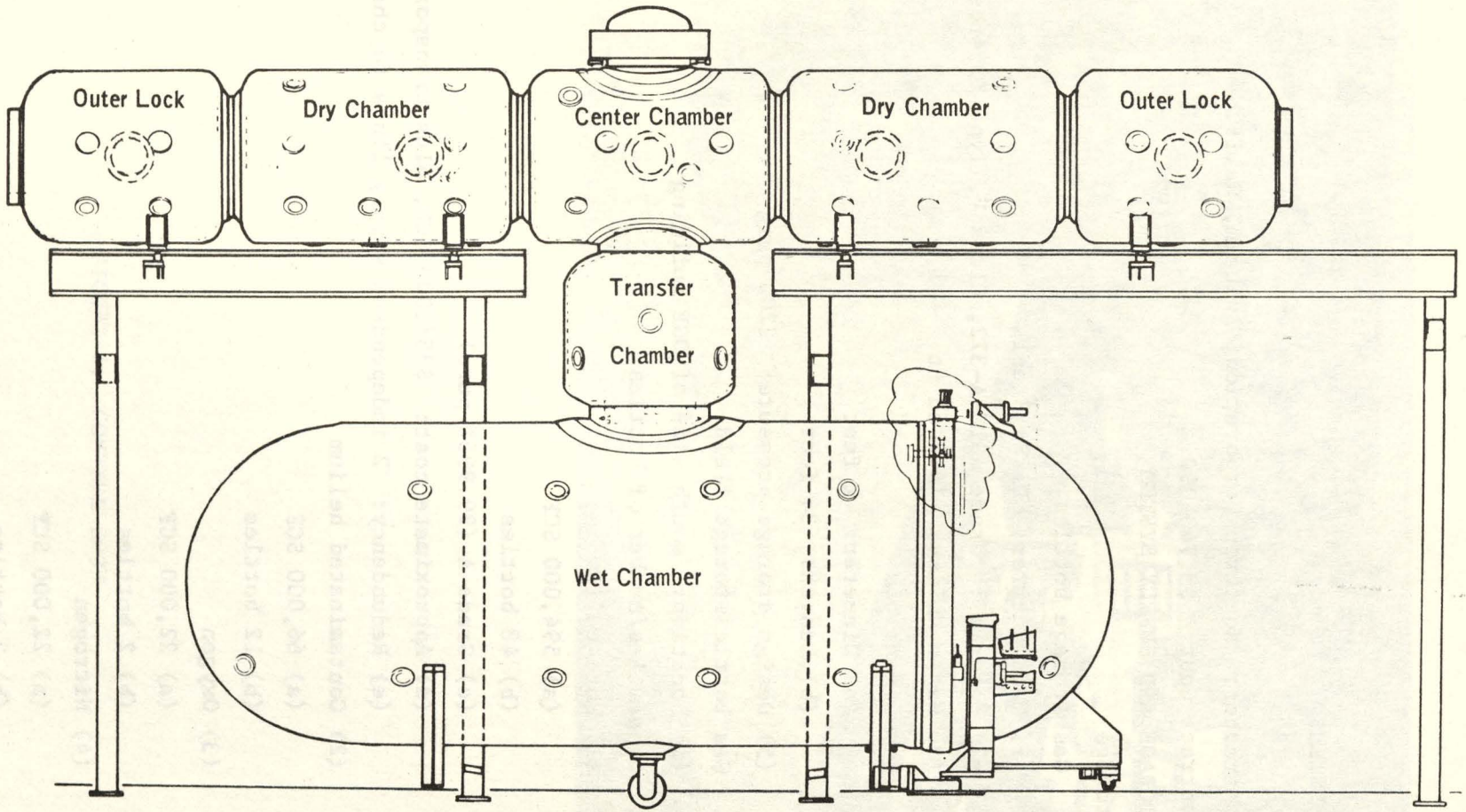

FIGURE 3. OSF PRESSURE CHAMBER COMPLEX SCHEMATIC

IV. SUPPORT SYSTEMS

A. GENERAL

1. Contractor: Northrop Corporation, Anaheim, Calif.

2. Contract Cost: $3,740,000

B. GAS STORAGE AND SUPPLY SYSTEM

1. Storage

a. Gas storage bottles

(1) Manufacturer: U. S. Steel

(2) Material: Grade ASTM-A-372, Class V, Type E, steel

(3) Water volume: 78.7 cu ft

(4) Dimensions

(a) Diameter: 2 feet

(b) Length: 34 feet

(5) Design storage pressure: 2200 psig

b. Gas bottle storage field

(1) Location: south side of OSF building

c. Capacities/number of bottles

(1) Pure helium

(a) 594,000 SCF

(b) 48 bottles

(c) Grade A (99.995% pure)

(d) Approximate cost: $35/1000 SCF, plus transportation

(e) Redundency: 2 independent supply lines to chamber

(2) Contaminated helium

(a) 66,000 SCF

(b) 12 bottles

(3) Oxygen

(a) 22,000 SCF

(b) 2 bottles

(4) Nitrogen

(a) 22,000 SCF

(b) 2 bottles

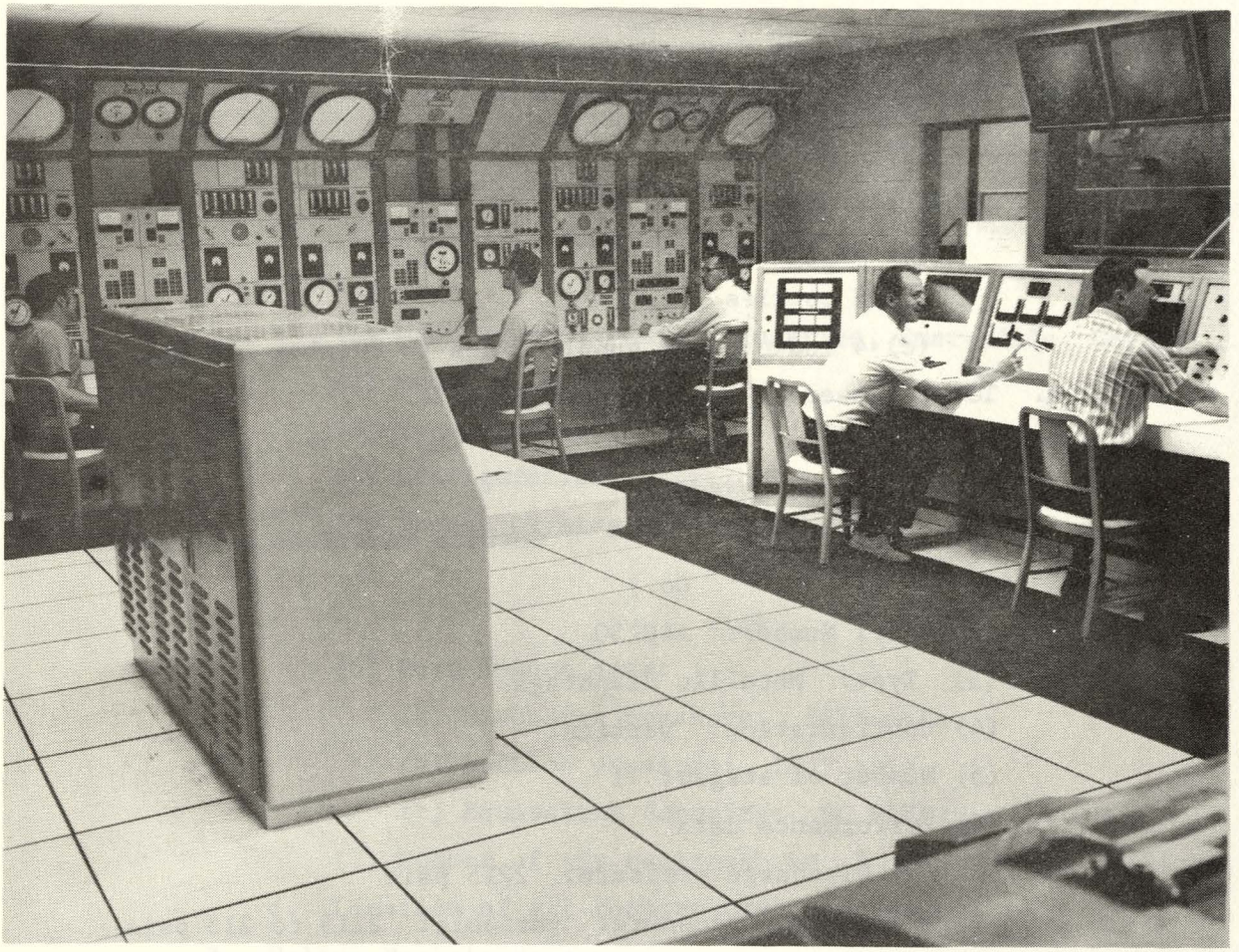

FIGURE 4. CONTROL ROOM

(5) Air

(a) 44,000 SCF

(b) 4 bottles

(6) Mixed gases

(a) 88,000 SCF

(b) 8 bottles

(c) 4 independent supply lines to chamber BIB systems

d. Total number of storage bottles: 76

2. Compressors

a. Helium, mixed gases

(1) Manufacturer: Corblin (American Instrument Co.)

(2) Model Number: A4C150

(3) Type: Metallic diaphragm

(4) Configuration: vertical

(5) Number of stages: 1

(6) Performance data

(a) Discharge pressure: 2215 psia

(b) Suction pressure: variable: 2215 to 215 psia

(c) Equivalent capacity: 2215 psia - 385 SCFM
215 psia - 30.5 SCFM

(d) Displacement: 3.62 CFM

(7) Number of compressors: 4 (2 helium, 1 impure helium, 1 mixed gas)

b. Oxygen, Nitrogen

(1) Manufacturer: Corblin (AMINCO)

(2) Model number: A34C150

(3) Type: metallic diaphragm

(4) Configuration: vertical

(5) Number of stages: 1

(6) Performance data

(a) Discharge pressure: 2215 psia

(b) Suction pressure: variable 2215 to 215 psia

(c) Equivalent capacity: 2215 psia - 235 SCFM
215 psia - 18.2 SCFM

(d) Displacement: 2.3 CFM

(7) Number of compressors: 2

c. Air

(1) Manufacturer: Rix Industries, Emeryville, Calif.

(2) Model number: KB98

(3) Type: piston

(4) Configuration: vertical

(5) Number of stages: 3; two stages teflon ring, third stage water lubricated cast iron ring

(6) Performance data:

(a) Discharge pressure: 2215 psia

(b) Suction pressure: 14.7 psia

(c) Equivalent capacity: 50 SCFM

(7) Number of air compressors: 2

d. Location of all compressors: mechanical room

3. Helium Reclaim System

a. Manufacturer: CVI Corporation, Columbus, Ohio

b. Model number: P0025-3100

c. Performance: compress and deliver 25 SCFM to storage at 3000 psi at 75°F

d. Purity: not less than 99% Helium

e. Technique: cryogenic

(1) Liquid nitrogen bath liquifies oxygen and nitrogen and freezes out oil and water

(2) LN_2 storage capacity: 300 gallons

f. Regeneration period: 24 hours

g. Minimum output before regeneration of N_2: 250,000 SCF

h. Location: mechanical room

4. Gas Mixing Unit
   a. Manufacturer: Airco Cryogenics, Irvine, Calif.
   b. Model number: 24030-1
   c. Inlet gases: oxygen, helium, nitrogen, air
   d. Mixture delivery capacity (Max): 60 SCFM
   e. Operation: uses pure gases themselves and electrical power for operation, mixes binary and ternary mixtures of breathing gases
5. Vacuum pump

C. ATMOSPHERE CONDITIONING SYSTEM
1. General
   a. Number of atmospheric loops: 6
      (1) 5 for chambers, 1 redundant
   b. Contractor: Mine Safety Appliances, Evans City, Pa.
   c. Type of atmospheric loops: parallel
      (1) Cooler and heater one leg
      (2) CO_2 scrubber, contaminant filter, particulate filter other leg
   d. Velocity of supply gas into each chamber
      (1) 20 to 30 FPM, produces no draft effect
   e. All pressure vessels in this system designed, fabricated and tested in accordance with Class A, Section III of the ASME Boiler and Pressure Vessel Code (Nuclear Vessels)
   f. All piping in the system fabricated and tested in accordance with USAS B31.7 (Nuclear Power Piping)
2. Carbon Dioxide Scrubber
   a. Maximum allowable partial pressure of CO_2: 4.0 mm of Hg
   b. CO_2 absorber: 4-8 mesh Baralyme granular, nonregenerative
   c. Pressure vessel
      (1) Manufacturer: Youngstown Welding & Engineering Co., Youngstown, Ohio
      (2) Material: type 304 stainless steel
   d. Number: one per loop, six total
3. Particulate Filter
   a. Remove particles 0.3 microns and larger
   b. Efficiency: 99.97%

c. Filter material: glass-asbestos material

d. Pressure vessel

(1) Manufacturer: WYE

(2) Material: type 304 stainless steel

e. Number: one per loop, six total

4. Contaminant Filter

a. Remove body and equipment odors

b. Absorber: Purafil pellets (nonregenerative, granular)

c. Pressure vessel: shares same vessel as particulate filter

d. Number: one per loop, six total

5. Circulation Blower

a. Type: positive displacement, 3 lobe, rotary pump

b. Performance: 0 psig - 500 ACFM

1000 psig - 200 ACFM

c. Power:

(1) 10 HP

(2) Electrically driven variable speed drive

(3) Located outside pressurized case, through a penetration which is equipped with a water seal

d. Manufacturer:

(1) Blower: M-D Blowers, Inc., Racine, Wisconsin

Model number: S81-4012C

(2) Pressure vessel: YWE

(3) Shaft seal, SEALOL, Inc., Providence, Rhode Island

e. Number per loop: 1

6. Temperature Control

a. General

(1) Chamber temperature range: $50^{o}F$ to $110^{o}F$

(2) Temperature measurement method: filled-system thermometer

(a) Expandable fluid, sensitive to temperature, in a sealed system. Increased temperature increases

fluid pressure which is transmitted through a capillary tube to receiver.

b. Cooling unit

(1) Manufacturer: Mine Safety Appliances

(2) Type: U-shaped, two pass shell and tube heat exchanger

(3) Cooling medium: brine (30% ethylene glycol, 70% water)

(a) Manufacturer of refrigeration unit: Frick

(4) Design pressure criteria: 1000 psig at 50°F shell side
150 psig at 20°F tube side

(5) Number: one per loop, six total

(6) Design, fabrication, and testing requirements

(a) Class A of Section III of ASME Boiler and Pressure Code

7. Humidity Control

a. Humidity range: 50 to 95% relative humidity

b. Dehumidification

(1) Cooling unit chills air below dewpoint temperature, condensing moisture

c. Humidification

(1) Moisture added by atomizing-type nozzles

8. Pressure Control

a. Pressure range: 0 - 1000 psig

b. Control: (1) Automatic: sensing-segmented differential system - Electric-pneumatic, (2) Manual

c. Depressurization rates: variable from 3 feet of water per hour to 2400 feet of water per hour (40 ft/min)

d. Maximum pressurization rate

(1) 75 ft of water/min in outer locks

(2) 40 ft/min in dry chambers

D. GAS ANALYSIS SYSTEM

1. Oxygen Analysis

a. Operation

(1) Continuously monitor oxygen level

(2) Automatically admit oxygen whenever level falls below set point

b. Detection

(1) Polarographic

(a) Continuous partial pressure monitor

(b) Technique: chemical analysis based on comparative measurements of current-voltage curves obtained during electrolysis of a solution under specified conditions

(c) Model: Beckman

(2) Chromatographic

(a) Measures percent concentration

(b) Discrete sample analysis (not continuous)

(3) Paramagnetic

(a) Continuous sample analysis

(b) Technique analysis based on the magnetic susceptibility of gas mixture

c. Normal range of allowable 0_2 partial pressure

(1) 130 to 230 mm of mercury

2. Carbon Dioxide Analysis

a. Operation

(1) Continuous CO_2 monitoring

b. Detection

(1) Nondispersive infrared analyzer

(a) Measures percent concentration

(b) Model: Beckman Model 315

(2) Electrochemical cell

(a) Measures partial pressure

(b) Technique: Measure pH of solution to CO_2, compare to pH of standard solution

(c) Model: Beckman 315

(3) Chromatographic:

(a) Measures percent concentration

(b) Discrete sample analysis (not continuous)

c. Max allowable CO_2

(1) 5000 ppm (4 mm of Hg)

3. Carbon Monoxide Analysis
   a. Operation
      (1) Continuously monitor CO level
   b. Detection
      (1) Non-dispersive infrared analyzer
      (2) Chromatography
   c. Max allowable CO level
      (1) 10 ppm or .008 mm of Hg
4. Total Atmospheric and Trace Gas Analysis
   a. Mass Spectrometer
      (1) Capabilities
         (a) Analyze any gas
         (b) Good job of separation and identification, poor job of quantification
      (2) Technique
         (a) Employs mass separation of molecular particles by magnetic and electric fields.
      (3) Model: DuPont Type 21-49D
      (4) Approximate cost: 37K
   b. Gas Chromatography
      (1) Capabilities
         (a) Analyze a given sample for constituents
         (b) Excellent job of separation and quantification, poor job of identification
         (c) Feed output of gas chromatograph into a mass spectrometer, then each component can be positively identified
      (2) Technique
         (a) Separation of various gases by passing a sample into a separation column where each constituent remains in column for a different length of time.
      (3) Model: Beckman GC-4

E. BUILT-IN-BREATHING SYSTEM

1. Manufacturer: Scott Aviation, Lancaster, New York
2. Purpose: Routine diving operations & emergency situations
3. Overboard discharge for each mask
4. Number/chamber
   a. Outer chambers: 4 units (ea)
   b. Dry chambers: one 4-man BIB unit panel at each end of each chamber
   c. Center chamber: 4 units
   d. Trunk: 4 units (for use in wet chamber)
5. Total number of BIB units: 32

F. WET CHAMBER WATER CONDITIONING SYSTEM

1. General
   a. Capacity of wet chamber: 55,400 gal. of water
   b. Fill time: 1 hr., 45 min.
   c. Drain time: 15 min.
   d. All pressure vessels in the system are designed, fabricated and tested in accordance with ASME Boiler and Pressure Vessel Code Section III, Class A (Nuclear Vessels)
   e. All piping designed, fabricated, and tested in accordance with USAS B31.7 (Nuclear Power Piping)
2. Temperature Control
   a. Performance Characteristics
      (1) Temperature range: $29^{\circ}F$ to $90^{\circ}F$
      (2) Max. rate of change: $2^{\circ}F$/hr for heating cycle
          $3.5^{\circ}F$/hr for cooling cycle
      (3) Variation of temperature $\pm 2^{\circ}F$
   b. Cooling Cycle
      (1) Number of heat exchangers: 2
      (2) Manufacturer: Repco Engineering, Montebello, Calif.
      (3) Performance: 190 tons
      (4) Type of heat exchanger: single pass
          (a) Sea water pumped through tubes; ethylene glycol

solution through shell

(b) Designed for 1000 psi at 150°F tube side, 150 psi at 25°F shell side

(5) Dimensions and characteristics of heat exchanger

(a) Overall length of unit: 35 feet

(b) Diameter of unit: 20 inches

(c) Tubes; straight, 3/4 in. outside diameter, stainless steel

(d) Fouling factor: .001

(6) Refrigeration unit

(a) Manufacturer: Frick

(b) Cooling medium: ethylene glycol
- circulated at rate of 700 GPM
- entering temp 20°F, exiting temp 30°F

(c) Tonnage: 190 tons

(7) Design, fabrication and test requirements

(a) Heads - Class A of Section III of ASME Boiler and Pressure Vessel Code

(b) Tubes - USAS B31.7

(c) Shells - Section VIII of ASME Boiler and Pressure Vessel Code

c. Heating cycle

(1) Number of heat exchangers: 1

(2) Manufacturer: Repco Engineering, Montebello, Calif.

(3) Performance: Add 1,350,000 BTU/hr to seawater at a flow rate of 1,100 GPM

(4) Type of heat exchanger: single pass

(a) Seawater pumped through tubes; boiler water through shell

(b) Designed for 1000 psi at 150°F tube side; 150 psi at 200°F shell side

(5) Dimensions and characteristics of heat exchanger

(a) Overall length of unit: 72 inches

(b) Diameter of unit: 14 inches

(c) Tubes: straight 3/4" O.D. stainless steel

(d) Fouling factor: .001

(6) Heating medium

(a) Boiler water

(b) Circulation rate: 135 GPM

(c) Entering temperature 200°F, leaving temp. 180°F

(7) Design, fabrication, and test requirements

(a) Heads - Class A of Section III of ASME Boiler and Pressure Vessel Code

(b) Tubes - USAS B31.7

(c) Shells - Section VIII of ASME Boiler and Pressure Vessel Code

3. High Pressure Filter

a. Rated capacity: 1100 GPM

b. Filter media: Cellulose capable of removing all particles 15 - 150 microns in size or larger

c. Manufacturer: Repco Engineering

4. Circulating Pump

a. Manufacturer: Ingersol Rand

b. Type: single stage, centrifugal

c. Characteristics

(1) Capacity: variable from 200 GPM to 1100 GPM

(2) Dynamic head: 50 feet

(3) NPSH: 10 feet

(4) Motor: electric, 20 HP, 1800 RPM

G. HOT WATER SUIT SYSTEM

1. Purpose: Supply hot water for use with 4 closed-circuit heated diving suits

2. Characteristics

a. Temperature: 113° F

b. Flow rate: Maximum of 8 gal/min at max. pressure differential of 5 psig

3. Heat exchanger
   a. Manufacturer: Repco Engineering
   b. Type: tube in shell
   c. Performance: heat 8 GPM of suit water from $60^{o}F$ to $113^{o}F$
   d. Heating medium: boiler water
      (1) Circulated in shell at rate of 22 GPM
      (2) Enters at $200^{o}F$; leaves at $180^{o}F$
   e. Design, fabrication, testing standards - Section VIII of ASME Boiler and Pressure Vessel Code
4. Tank Reservoir
   a. Capacity: 50 gal.
   b. Equalized to chamber pressure
   c. Design, fabrication, testing standards: Section VIII of ASME Boiler and Pressure Vessel Code
5. Circulating Pump
   a. Manufacturer: Ingersol Rand
   b. Type: single stage centrifugal
   c. Capacity: 10 GPM
   d. Pressure differential across the pump: 5 psig

H. SANITARY & POTABLE WATER SYSTEM

1. Sanitary System
   a. Location: dry chambers (1 & 2)
   b. Facilities
      (1) Folding sink
      (2) Fixed commode
      (3) Shower head with shower curtain (Beta cloth) and drain
   c. Sanitary disposal tank
      (1) External 50-gallon high pressure tank for each dry chamber
         (a) Fabricated and tested in accordance with ASME Boiler and Pressure Vessel Code, Class A, Section III (Nuclear Vessel)
         (b) Manufacturer: Repco Engineering

(2) Vented into dry chamber via a suitable filter

(3) Valves are interlocked to avoid depressurizing the chamber while emptying the sanitary tank

2. Potable Water System

a. Use: supply fresh water for drinking and sanitary facilities and fire protection hand lines

b. 50-gallon tank for each dry chamber

(1) Pressurized 30-50 psi above chamber pressure by helium source

(2) Fabricated and tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code (Pressure Vessels)

(3) Manufacturer: Repco Engineering

c. Potable water heat exchanger

(1) Capacity: heat 5½ GPM of water from 60°F to 140°F

(2) Heating medium: boiler water

(3) Design, fabrication and testing standards: Section VIII of ASME Boiler and Pressure Vessel Code

I. CHAMBER FIRE PROTECTION SYSTEM

1. Manufacturer: Northrop Corporation

2. Approximate cost: 60K

3. Extinguishing agent: water

4. Characteristics

a. Deluge sprinkle system

b. Low pressure (floating - water inside chamber)

(1) Pump provides 35 psi pressure differential above chamber pressure

c. Operation: normally automatic

(1) Manually overridden from outside or inside

d. Once in operation, continuous, recirculating system

5. Performance data

a. Flow rate: 4.5 gal per min per sq ft

b. Response time: 2 seconds

6. Detection
    a. Infrared flame sensing detector
        (1) Capable of discriminating between flames and other sources of heat radiation
        (2) 4 detection sensors per chamber
        (3) Activates the fire protection system
    b. Total hydrocarbon detector
        (1) Measures the combustible vapors in atmosphere
        (2) Operation: Continuous monitoring of hydrocarbons; senses any increase which might indicate the possibility of a fire before it starts
        (3) Number: one, sequenced between all chambers
        (4) Does not activate fire protection system
7. Spray nozzles
    a. Type: Conical
    b. Number/chamber: 14-16 Depending on chamber
8. Hand lines (hoses)
    a. Location: dry chambers No. 1 and 2
    b. Diameter of hose: 1/2 in. I.D.
    c. Water supply: chamber potable water tank
9. Center Chamber Fire Protection System
    a. Water source: 855 gallon high pressure tank
    b. Design, fabrication and testing standards, Section VIII of ASME Boiler and Pressure Vessel Code
    c. Manufacturer: Repco Engineering

J. PIPING, TUBING, AND VALVES
1. Piping and tubing
    a. Oxygen system
        (1) Material: Monel (nickel-copper alloy)
        (2) Working pressure: 2500 psig
        (3) USA Standard: B31.1 & B31.7
    b. Helium, nitrogen and air system
        (1) Material: type 304L stainless steel
        (2) Working pressure: 2500 psig

(3) USA Standard: B31.1 & B31.7

c. Mixed gas system

(1) Material: type 304L stainless steel

(2) Working pressure: 2500 psig

(3) USA Standard B31.1

d. Atmosphere conditioning loop

(1) Material: Type 304L stainless steel

(2) Working pressure: 1000 psig

(3) USA Standard: B31.7 Class 1

(4) Pipe diameter: 4 inches

e. High pressure (above 100 psi) water system

(1) Material: type 304L stainless steel

(2) Working pressure: 1000 psig

(3) USA Standard: B31.7 Class 1

f. Low pressure (below 100 psi) water system

(1) Material: carbon steel

g. Ethylene glycol solution

(1) Material: carbon steel

h. Control air piping

(1) Material: copper tubing

i. Refrigerant piping

(1) Material: copper tubing

2. Valves

a. Gas service (oxygen, helium, nitrogen, air, mixed gases)

(1) Fittings

(a) Tubing system: flat face type that will allow removal without cutting or springing line

(b) Piping system: Flat-faced fittings

(2) Material

(a) Oxygen, all material in contact with oxygen excluding seats: Monel, all seals: Kel-F or Viton

(b) Other gases

(A) All material in contact with gas: series 300 stainless steel

(B) Seats: stainless steel or monel

(C) Seals: Teflon, Nylon or Buna

(3) Designed working pressure

(a) Atmosphere conditioning loop: 1000 psig

(b) All others: 2500 psig

(4) Maximum envelope leakage rate

(a) 4×10^{-5} cc/sec at 2400 psig

(5) Types of valves in gas service system

(a) Globe, needle, ball, check, relief valves, and flow regulators (flow fuses)

b. High pressure water system

(1) Fittings: Flat-faced fittings

(a) Valves connected directly to chambers: ring-joint flanges

(2) Material

(a) All wetted surfaces - series 300 stainless steel

(b) Seats

(A) Globe and angle valves: stainless steel, monel, teflon or nylon

(B) Ball valves: Teflon

(c) Seals

(A) Globe and angle valves: Teflon or Nylon

(B) Ball: Teflon

(3) Designed working pressure: 1000 psig

K. DATA COLLECTING SYSTEM

1. Performance Capabilities

a. Collect data

(1) Physiological data

(2) Environmental data

(3) Equipment and vehicle data

(4) Strain gage data

b. Display data - CRT or hard copy teleprinter

c. Distribute data

d. Record data - 2 digital magnetic tape units

2. Computer

a. Manufacturer: Hewlett Packard

b. Model number: HP2116C

c. Type: digital computer

d. Memory: magnetic core memory

(1) 16,000 words of memory

e. Programming capability ALGOL and FORTRAN

f. Input signals: 400 channels

(1) 200 channels for strain gages

(2) 200 channels for experimental data

g. Output: 2 magnetic digital tape recorders (IBM compatible)

3. Strain Gage System

a. Purpose: monitor stress changes in chambers during cyclic action

b. Performance: record in microinches-per-inch the outputs of 98 strain gages

c. Capabilities: measures strain over the range of 10 to 3300 microinches-per-inch

d. Overall accuracy: ±5 microinches-per-inch

e. Strain gages

(1) Construction: Bakelite gage bonded to stainless steel shim stock

(2) Resistance: 120 ohms

(3) Nominal gage factor: 2

(4) Method of attachment: permanent, welded type

4. Cathode Ray Tube (CRT) Terminal

a. Use: provide means for rapid visual display of alpha-numeric data from the computer

b. Operates through use of a keyboard command generator

5. Magnetic Tape Recorders
   a. Provide the means for recording both operational and strain gage data on magnetic tape
6. Teleprinter
   a. Used for communication with the digital computer and hard copy data output
7. Patchboards
   a. Provide means for routing data from the chambers to the various consoles and data system
   b. Number: 3
8. Future Potential
   a. Direct link to the countermeasures evaluator (hybrid computer)
      (1) Burroughs B-5500

L. CLOSED CIRCUIT TELEVISION SYSTEM

1. General
   a. Purpose
      (1) Monitor the activity within the chambers
      (2) Communication from the chambers to the control room (especially under high helium pressures when speech becomes garbled)
   b. System capability: capacity for 9 TV cameras
2. Television Cameras
   a. Manufacturer: Hydro Products
   b. Tube type: Vidicon
   c. Circuitry: solid state
   d. Length: 21 inches
   e. Diameter: 3½ inches
   f. Location of cameras
      (1) One in each dry chamber
      (2) One in center chamber
      (3) Two in wet chamber
      (4) Total number: 5

3. Lens
   a. Dry chambers - normal lenses
      (1) Type - color corrected f1.8
      (2) Focal length: 10.0 mm
      (3) Focus range: 3 inch to infinity
      (4) Angle of view: 55^{o} horizontal, 45^{o} vertical
      (5) Focus control: Remote (from supervisory console)
   b. Wet chambers - zoom lens
      (1) Zoom range: 4:1
      (2) Focal length: 13 to 52 mm
      (3) Control: remote (from supervisory console)
4. Pan and Tilt
   a. Wet chamber cameras only
   b. Control: supervisory console
   c. Travel range: 340^{o} pan axis, 190^{o} tilt axis
5. Monitors
   a. Manufacturer: Hydro Products
   b. Number: 6
   c. Screen size: 23 inch, diagonal

M. COMMUNICATIONS SYSTEM
1. Purpose: Provide means of communication between chamber occupants, chamber operators, and the supervisor.
2. Mode of Operation: "Open" chamber microphone
   a. Chamber operator or the supervisor shall be able to monitor the chambers at all times
3. No Switches or Electronic Components Located Within Chambers
   a. Eliminate switch-arcing in a gas atmosphere
   b. Only microphone pickup and speaker located inside chambers
4. Speakers
   a. Location
      (1) One in each chamber
      (2) One underwater speaker located in wet chamber

(a) Has pressure equalizing tube going from compliance chamber to air space above water

(b) Power: 20 watts

b. Constructed of a minimum amount of combustible material

5. Microphones

a. Location: one in each chamber except wet chamber

b. Type: omni-directional universal mounting

c. Frequency response: 10 kc or more in a 1000 psi HELIOX atmosphere

d. Manufacturer: Shure

6. Amplifier

a. Use: drive speakers

b. Power output: 20 watts (RMS)

c. Output

(1) Accommodate tape recorders

(a) One operated continuously for safety monitoring

(b) One used for recording experimental data and research work

N. CONSOLES

1. Supervisory Console

a. Alarm panel

b. Keyboard and cathode ray display

c. Environmental indicator panel with provisions for monitoring critical chamber functions

d. Mission time panel

e. Television matrix switch with camera control

f. Hatch status panel

g. Two intercom panels

(1) Communication with chambers

(2) Communication within the building

2. Outer and Dry Chamber Consoles

a. Number: 2

b. Monitor and control critical functions within their related chambers

(1) Pressure

(2) Humidity

(3) Temperature

(4) Gas mixtures

(5) Fire detection

(6) Lights

(7) Communications

3. Center and Wet Chamber Console

a. Monitors and controls critical functions within the related chambers

(1) Pressure

(2) Humidity

(3) Temperature

(4) Gas mixture

(5) Fire detection

(6) Lights

(7) Communications

(8) Seawater pumping controls

(9) Wet suit system parameters

4. Data Acquisition Console

a. Hewlett Packard digital computer

b. Magnetic tape subsystem

c. Mission time clock

d. Digital voltmeter

e. Scanner control unit and two cross bar scanners

f. DC bridge power supply and a strain gage signal conditioning subsystem

5. Gas Storage Console

a. Gages for monitoring the gas bottle storage field

b. Indicating switches to control the gas bottle manifold valving and compressors

6. Gas Analyzer and Sampler Console
   a. Standard Beckman stream selector with modification to permit the use of two recorders
   b. Two infrared analyzers
   c. Supplementary flowmeters, gages, and selector valves
7. Manual Operating Panel
   a. Number: 5
   b. Primary function: Act as an emergency, back-up control for gas systems of related chamber in event of a power failure
   c. Location: Mezzanine, adjacent to chambers
8. Biomedical Console
   a. Analog Waveform Displays (oscilloscope) - 16 channels, suitable for ECG, EEG, EMG, respiratory flow, respiratory volumes, etc.
   b. Numerical Displays - 4 heart rates, 4 body temperatures.
   c. Meter Displays of Chamber Environment - O_2 partial pressure, CO_2 partial pressure, relative humidity, temperature
   d. Strip Chart Recorder (thermal) - 4 channel, programmable to record any desired four signals.
   e. Signal Conditioning - provides capabilities for conditioning bioelectric signals, transducer signals, and low level dc signals and for processing biomedical signals to derive heart rates and respiration rates. Total capability 24 channels.

0. BIOINSTRUMENTATION (planned capability)
   1. Acute Monitoring
      a. Body mounted signal conditioner will process signals from electrodes and transducer for transmission by hand line or telemetry.
      b. Outputs: ECG, EEG, Respiration Rate, Body Temperature, Blood Pressure (Cuff Method), and oximeter.
   2. Chronic Monitoring
      a. Biotelemetry of ECG, Respiration Rate and Body Temperature.
   3. Physiological Experiment Support
      a. Respiratory Measurement System - flow and volume.

b. Respiratory Mass Spectrometer

(1) Manufacturer: Medspect

(2) Model: MSBR

(3) Functions: measures inspired/expired gas partial pressure (P_{He}, P_{Ne}, P_{N_2}, P_{O_2}, P_{A_r}, P_{CO_2}) - blood gas measurements using intra-arterial cannula.

c. Blood Gas Analyzer

(1) Manufacturer: Instrumentation Laboratory, Inc.

(2) Model: 113-02

(3) Utilizes syringe samples

(4) Measures P_H, P_{CO_2}, P_{O_2}