

# The History of Buoyancy Compensators

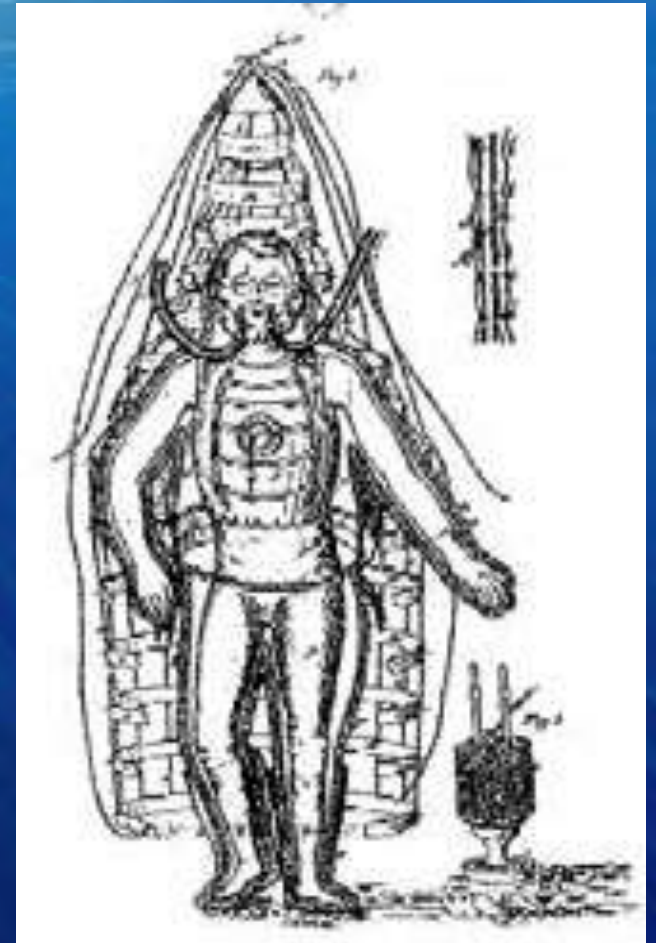
## Deflating Some Myths...

An interpretive review of the evolution of buoyancy compensation in SCUBA diving with specific regard to the USA.

**Warning** – Academics beware! This is for entertainment purposes only...Facts and truth as aspirations of this presentation. Some “facts” are interpreted or flat out ignored for humorous effect and some names are changed to protect the guilty... This takes a strong US perspective to entertain and make a boring topic interesting for the audience only...29 Calories from Fat.

# What is a Buoyancy Compensator?

Device attached to a divers body able to retain and vary an amount of air in order to affect the overall **buoyancy** of the diver in water and **compensate** for changes in buoyancy that occur in the other pieces of the divers system.



**Myth Deflated!**

**Jacques Cousteau did NOT invent the SCUBA buoyancy compensator...**

Hall Diving Suit 1830  
Potential early AT-PAC design

# Our Timeline

- BC<sub>ou</sub> (Before Cousteau) – 700 BC 1943ish
  - Ancient
    - Assyrian Seal Teams
  - Archaic
    - Archimedes, Da Vinci,
    - Hard Hats
- AD<sub>u</sub> (After Dumas) – 1950
  - Vintage: (SeaHunt Era) 1947 - 1966
  - Classic: 1967 – 1983
  - Contemporary: 1984 – Today
  - Jetson: The Future



Ancient

Archaic

Vintage

Classic

Contemporary

*Future*

# 722 – 705 BC: Assyrian Seal Teams



Myth Deflated!

The Assyrians did not invent Sink the Stink



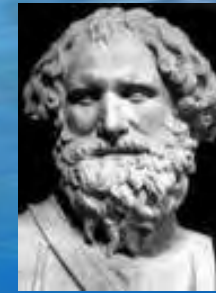
- In reaction to an indefensible location, Assyria creates a strong army under Sargon II
- Metal armament equipped SEAL teams
- Used breathing bags (perhaps) made from airtight goatskins



– PHEW!

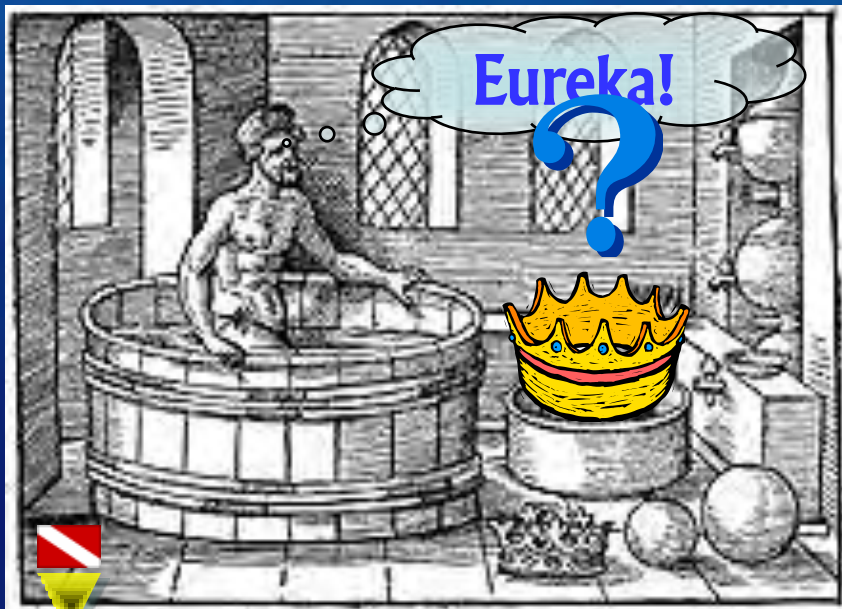
Ancient

# 3<sup>rd</sup> Century BC- Archimedes the Greek P.I.



Archimedes Law:

An immersed object is buoyed up by a force (the *Buoyant force*) equal to the weight of the water it displaces



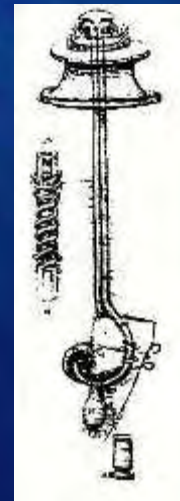
# 1500's – Leonardolung Designed

- Leonardo da Vinci designs the first known SCUBA in the Codex Atlanticus
- Combined surface air supply and buoyancy control
- Leveraged leather extensively in the design of a watertight drysuit with glass goggles and hand fins



## Myth Deflated!

**Cave divers did not design the P-Valve...  
Da Vinci's drawings were so detailed we can confirm  
that he invented it!**



## Myth Deflated!

**This was never built, but was abandoned in favor of  
the diving bell...**

# 1810 - Hall's Diving Suit

- Patented
- Took the term "Dry Suit" literally
- Proposed layered materials of rubberized fabrics
- May have invented the overpressure valve
- Design actually used



## Myth Deflated!

While reinforcing is evident throughout Hall's suit...

There is no truth to the rumor that Hall's suit was for early shark diving tourism



Ancient

Archaic

# 1823 – Macintosh Waterproof Fabric

- Rubber dissolved in Coal Tar (Naphtha)
- Patented the first rubber/fabric sandwich
- Allowed the creation of the full diving dress for Deane Brothers / Siebe closed diving dress
- 1839 - further enhanced with the vulcanization process (Charles Goodyear)

## Myth Deflated!

**Macintosh didn't set out to develop the raincoat because he lived in Scotland, he was just trying to find uses for Coal waste products!**

**His work enabled Siebe's full diving dress with a vulcanized/canvas dry suit**



Ancient

Archaic



# 1828 – Paul Lemaire d' Augerville's BC

- Not much is known about his system
- Decided to innovate over the common practice of using diving bells for salvage
- Patented a diving system with weight integrated buoyancy compensation weighed over 100 lbs...
- Was used for a few years before falling into obscurity with the development of the Cousteau and Dean systems
- May have influenced the development of the Buoyancy Compensating Device (BCD)
- B...

**Myth Deflated!**  
This genius inventor wasn't an engineer he was actually a Parisian Dentist with offices on the same street as Cousteau's (Ave. St. Honore)  
Cousteau notes his invention in 2000  
<<Watch out for SCUBA dentists>>

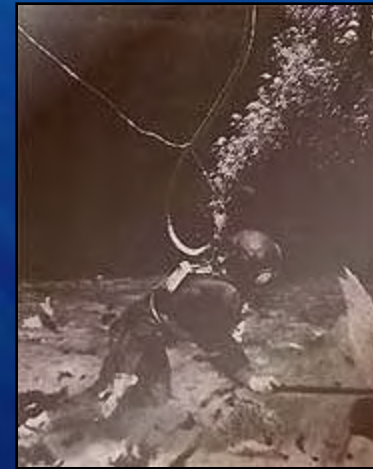


# 1837 Siebe's Hardhat and dress

- Based on smoke hats and prior systems developed by the Deane Brothers with partial dress gear
  - Self Rescue was required by the Deane Brothers
- 1819 Siebe create open dress helmet and jacket
- 1837 Combined dress and helmet
- Allowed buoyancy variation/equalization through simple valves



**Myth Deflated!**  
**Walking on the bottom wasn't all that it was cracked up to be...**  
**Surface supplied divers used buoyancy compensation and self flotation in the 1830's!**



# 1950 –Dumas’ SCUBA compensator

- Arguably deserves “First BC” Title
- Dumas
  - Taught Cousteau to dive
  - Was a spearfisherman
  - Was the deep diver in the group
  - Was a self taught engineer
- Controversy over the design
  - Described as a Horn
  - Stayed on
- Further

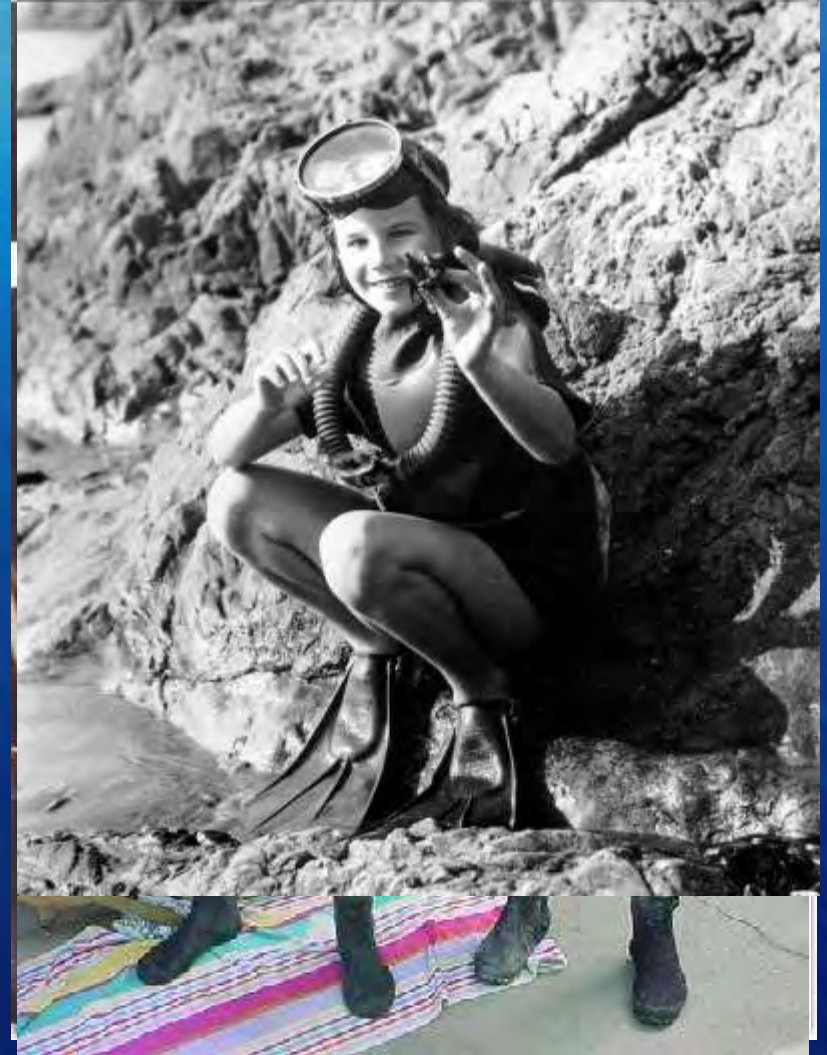


**Myth Deflated!**  
**While Dumas was known for his humor...**  
**He did not invent the whoopee cushion!**



# 1950s- Diving Captures our Imagination

- Small numbers of Aqualungs disperse into the world...
- Scientists and military divers rapidly respond
- The underwater world becomes “open” to the adventurous
- Training starts



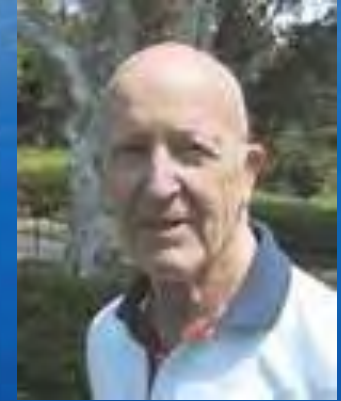
Ancient

Archaic

Vintage

# 1951 Wetsuits are invented

- The Navy requests a swimmers suit
- Hugh Bradner has a free weekend
- Willard Bascom suggests Rubatex Neoprene
  - Sold as rug padding in aircraft
- 1953 Engineers at UC Berkeley form EDCO
- Documented in Scripps Institute files
- Buoyancy Swing for a diver increases by 10+lbs...



Bradner



Bascom

**Myth Deflated!**  
**The wetsuit was not necessarily invented by Hugh Bradner.**  
**The Santa Ana Sentinel records Art Brown of Laguna make wetsuits in April 1950...**



*Start the New Year*  
... with ...

**The EDCO**  
**SUB-MARINER**


*Soft, Warm, Comfortable*  
*Neoprene Foam Rubber*

THE SPORTSMAN SHORTY . . . \$45  
THE SPORTSMAN FULL SUIT . . . \$75

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**C** ORPORATION

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Berkeley 8 - California



SKIN DIVER — JANUARY — 1951

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Vintage

# 1950's Mae West and self-rescue

- Driving needs
  - Self Rescue
  - Swimming
- Surplus/ Mae West Vests
- Res-Q-Pak
- FLOTO
  - Sausage



**FLOTO**

# Res-Q-Pak in action



... submerge and if he has not already done so, inflate his safety float. If the victim is wearing a weight belt, grasp the quick release strap and pull to jettison the weights. When you come to the surface ...



Then grasp the victim firmly and begin the tow, using a scissors kick and one arm for steering. Leave your own mask and mouthpiece in position and continue SCUBA breathing since the weight of your tanks will keep you low in the water. Do not inflate your own safety float unless you begin to feel the effects of exhaustion.

Another method of towing involves the use of the safety tube, or life buoy ... a larger float which should always be used by divers when operating from the shore or a considerable distance from their diving platform.



... remove the stricken diver's mask and mouthpiece. Keep him face up so that his tanks will remain underneath him, adding to his buoyancy.



**Myth Deflated!**  
**The Res-Q-Pak did not spawn the hoppity-hop ball craze of the 1960's**



From Skin and Scuba Diving – 1961 by Gustav Della Valle

Ancient

Archaic

Vintage

# Scripps Scientists start diving...

- First formal non-military training program for SCUBA
  - Training in proper weighting
  - No buoyancy compensation training
  - Significant Physical Training
  - Made Scripps Canyon diving a challenge...
- Set precedence for all academic diving



© San Diego Historical Society Photograph Collection.



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Vintage



# 1958 Sea Hunt Creates a market

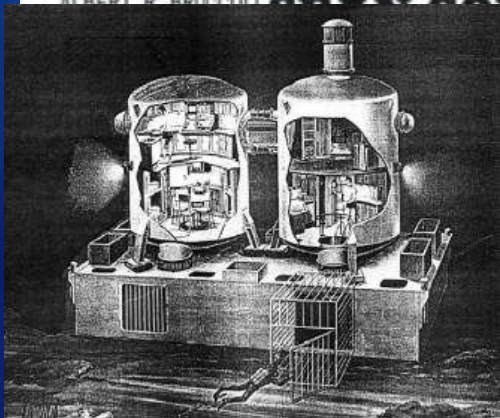
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*c*

ab



# 1960's



# A generation is engaged

- Media Blizzard
  - SeaHunt
  - Cousteau's films
  - National Geographic
  - Thunderball
- Certification Agencies started
  - LA County 1954
  - YMCA 1950
  - NAUI 1960
  - PADI 1966

Someday...  
I am gonna  
redesign this  
mask...



I look just  
like Dustin  
Hoffman in  
The  
Graduate...



# 1960s – Lifevests and self rescue

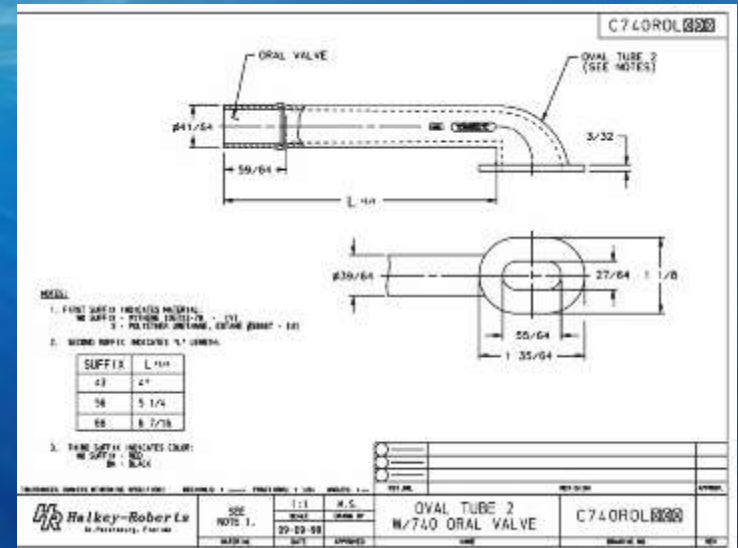
- First Cataloged 1958 U.S. Divers catalog
- Surface Flotation, Self Rescue
  - Small oral inflators
  - CO<sub>2</sub> Inflation
  - SCUBA specific
  - Crotch Straps
- Construction
  - Hand Glued nylon/neoprene Construction
  - RF Welded Nylon/PU (quality problems)



# Where did the parts come from?

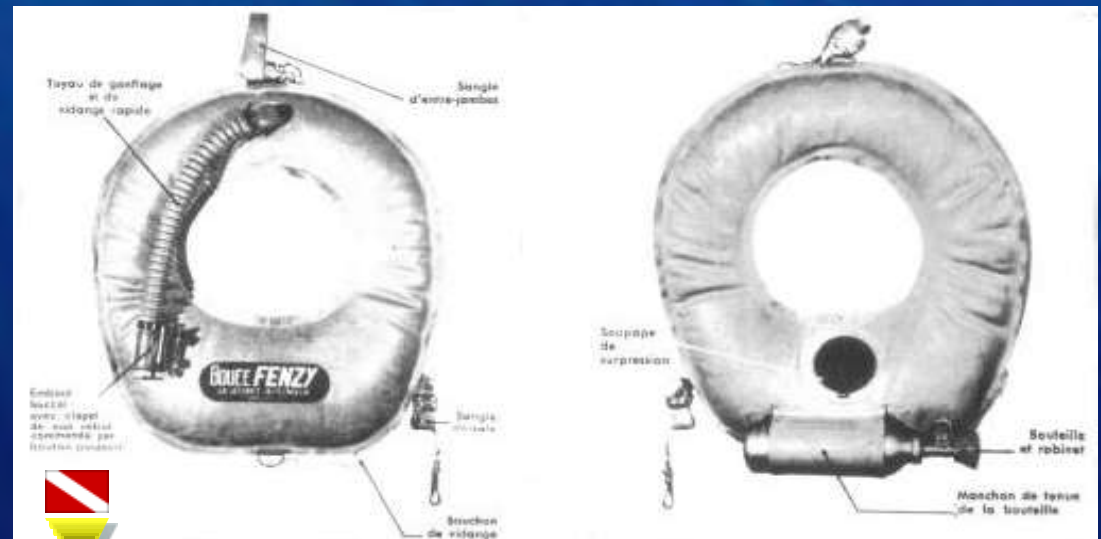
**Halkey-Roberts**  
An **Atrion** company

- Supplied inflator valves
- CO<sub>2</sub> Manifolds
- Oral Inflator valves
- CO<sub>2</sub> cartridges from Sparkletts



# 1961 Fenzy Frenzy

- First commercially successful “Modern” Buoyancy Compensator
- Invented by the Underwater Research Group of the French Navy
  - Self-Rescue device
- 1968ish appeared in numbers in the US market



Ancient

Archaic

Vintage

# Fenzy-lution and the ABLJ

- Breathable Valves
- Shoulder dump valves
- Single Bag 3-D Design
- Super-tough Construction



# Mid-Vintage Era – US “Compensators”

- Oral inflation hoses properly positioned
- Overpressure valves
- Construction Innovations
  - “Double Bag” Nylon bag with Nylon/PU
  - Radio Frequency Welded construction
- Lagged European development



Ancient

Archaic

Vintage



# Automatic Buoyancy Life Jackets

- European Solution
  - Early Adopter of Self Rescue
    - Club driven training
    - Safety focused
  - Breathing bag concept familiar to military O<sub>2</sub> Rebreather teams
  - Market was far advanced in UK, France through 1960's



# 1970's Styles...

- True Buoyancy Compensators in the US market
  - Inflation and deflation at depth
  - Over Pressure valves
- Jacket Styles
  - Scubapro Stab Jacket
  - Soniform OEMs BCs
  - Seatec Innovates
- Back Inflation
  - Watergill Stuns
- Large volume Horse Collars
  - US Divers
  - Scubapro
  - Nemrod
  - Seatec
  - Soniform (various brands)
- Hardshells



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Vintage

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# US catches up...

- Fenzy
- Nemrod
- Scubapro
- Mares
- Cressi-sub

## Automatic Safety Vest?



We really used our noodle when we designed our new Buoyancy Compensator Safety Vest with automatic purge-off.

If there's one piece of Seamless/Nemrod diving gear that we've worked our brains overtime to develop, it's the new Seamless/Nemrod Buoyancy Compensator Safety Vest.

Name what you want, and the Seamless/Nemrod Buoyancy Compensator Safety Vest has it. An oil, grease, ozone and sea water resistant skin of nylons, hypalon and neoprene; easy-to-fasten stainless steel cinches; rubber waist belt and crotch strap; large flex hose with oral inflator and mouthpiece, and automatic purge-off. Model illustrated.



Use your noodle. Buy the Seamless/Nemrod Buoyancy Compensator Safety Vest. See the Seamless/Nemrod Buoyancy Compensator Safety Vest at your favorite dive shop dealer, or send for our new 1977 catalog (a 382 page Seamless/Nemrod diving handbook on diving. Write the Department, Seamless/Nemrod, 253 Hallock Ave., New Haven, Connecticut 06503.

**Seamless Nemrod**

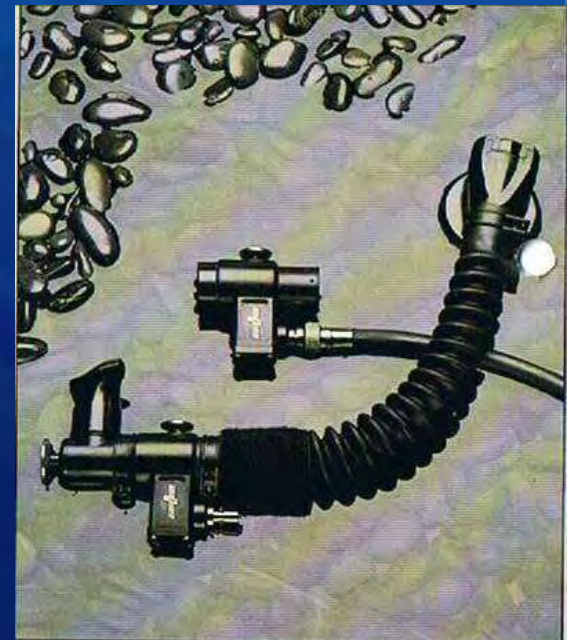
# 1971 – Scubapro Stab Jacket

- Patented 360 degree flow through design
- Neoprene coated fabric
- Labor intensive (!) hand manufactured
- Designed by a dentist?
  - Valve placement...



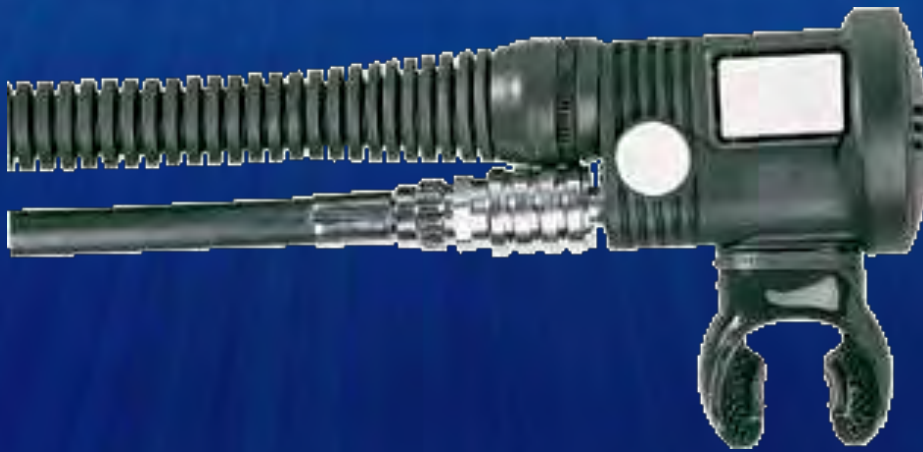
# Power Inflators

- 1968 Fenzy BC systems with large diameter hoses and “breathable” oral inflators appear in the US
- 1969 Greenwood Patent issued
- 1971 Scubapro Power Inflator released
- 1975 Seatec, Soniform set standard for quick disconnect
- 1983ish Apollo Schrader valve inflator designed



# ~1979 AIR II Breathable Inflator

- 1978 Scubapro patented design



# 1973 – US Divers BC II

- Power inflator
  - Bypassed Greenwood Patent
  - Right side inflator
- Oral Inflator
- Top Dump with Overpressure valve
- Double Bag with PU bladder



Ancient

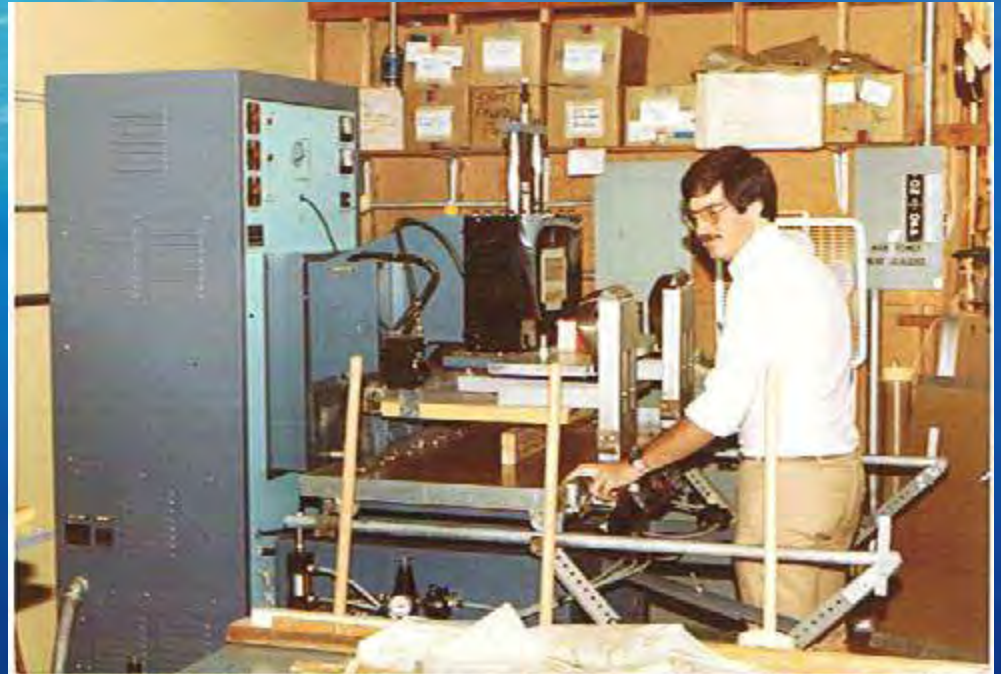
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Vintage

**Classic**

# Focus: Techniques and Materials

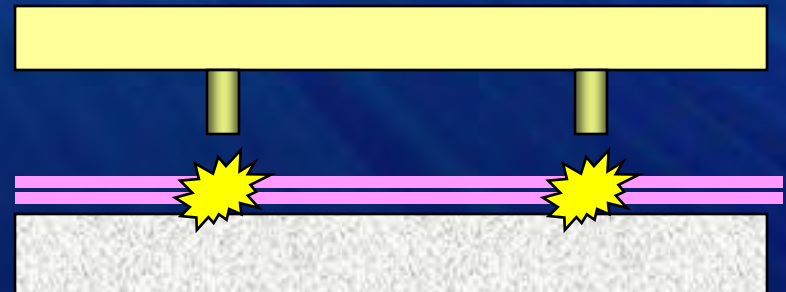
- Radio Frequency (RF) Welding
  - 25 – 50 KW
- Blown Polyurethane (PU) film
- Fabric/PU laminates
- Offshore tooling, production



**Myth Deflated!**

**Contrary to popular belief...**

**Buoyancy Compensators  
aren't sonically welded!**





# 1971 – 1986 Jackets

- Bypassed Stab Patent
  - Split underarm
- Lifted diver from under arms
- Integrated backpack
  - Used standard back pack/straps
- Soft Pack Developed
  - Seatec Manta



Ancient

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Vintage

Classic

# 1972 – The Watergill At Pac

- Watergill Manufacturing
- List of firsts
  - Wings
  - System BC
  - Weight Integrated
  - Shell System
  - Cummerbund



Capt. Chad Carney – early '70s

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# The At-Pac was ahead of its time...



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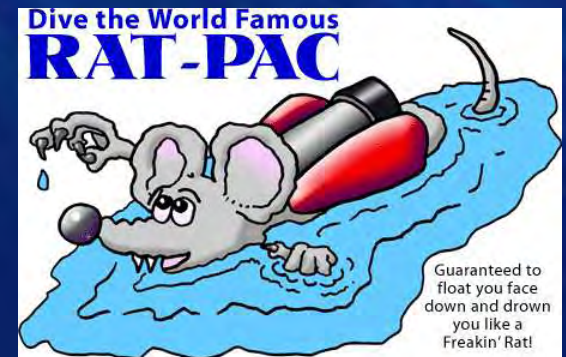
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Vintage

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# Politics, Marketing, and Success

- Sold through select dive shops
  - Tied closely to NASDS instruction
- Watergill – Seapro ownership transition
- Campaign to discredit the BC
- Lifesaving need still present
  - “Float ya face down and kill ya...”
  - “Ya can’t dump the air...”
  - “Ya can’t dump the weight...”



# 1970's – 1980's WINGS

- Everyone else made wings...
  - Scubapro BCD
  - Seatec
  - SeaQuest
  - Soniiform
  - Zeagle



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# Shrouds and Shells

**UDS-1 SYSTEM**  
ALOHA ADVENTURE! THE ALL-IN-ONE SYSTEM!

NEW! RECOMMENDED U.S. DEPARTMENT OF COMMERCE SAFETY EQUIPMENT QUALIFIED AIRCRAFT OWNER LICENSE REQUIRED!

The new, patented UDS-1 System will meet all requirements for 10' Containers & Water Tank systems, back pack, Aqua-Lung® requires air flow and adequate circulation. Free 2-way oxygen and safety mechanisms in one system. The only equipment and shroud system available for the ultimate in underwater adventure.

The UDS-1 System contains 100 lbs. of air at 2,000 psi. The new two-system UDS-1 adapted aluminum cylinder. The tank is pressure resistant with a steel or which acts on one of the (two) cylinders. (Using 1/2 in. R. 40 valves)

The automatic valve closing. Also provides three air checks valve. Make it possible to shut the cylinder without opening the tank. Safety oriented the hand allows both sides the hand. The other hand acts to shut the valve system. A built-in check valve allows the air system pressure to rise to zero, allowing the hose to be disconnected after being operation.

The included Pro-Dive 2, 5,000 psi gauge (1) also provides additional high pressure submersible pressure gauge. Complete with an 80' standard 2194.

During use, the shroud can easily attach the Pro-Dive 2, 5,000 psi and 2194 gauge. (one) at the base of the tank. The On-Off valve shuts off air from the high pressure cylinder. Allowing the regulator from the supply. (one) machine pressure from the remaining extended 50' stage Aqua-Lung regulator is easily attached through an opening in the side of the case. To prevent sucking water through the regulator and tank, the reserve water is allowed to flow through the problem only. (one) from the tank.

For use with submersibles, (one) can be added or additional second stage regulator, there are also the pressure secondary parts, in addition to the one for the regulator.

The UDS-1 is a fully integrated system with a single tank manifold containing the 2" valve, 1/2" valve, 1/2" valve, 1/2" valve, and 1/2" valve. For added safety, the UDS-1 is made of stainless steel. For material durability, all other materials, and the case and tank of stainless steel.

The shroud is made of all new, high quality material. The shroud is made of high quality material. The shroud is made of high quality material. The shroud is made of high quality material.

The shroud is made of all new, high quality material. The shroud is made of high quality material. The shroud is made of high quality material. The shroud is made of high quality material.

THE UDS-1 System Complete






# 1976ish..Dacor Nautilus

- Fixed volume
  - Regulator/inflator maintained volume
- Automatic buoyancy
- Conceptually flawed
  - Due to variable buoyancy of the wetsuit and tank



Ancient

Archaic

Vintage

Classic

# April 1985 - Advanced Design Vest

- Shoulder adjustable
- Replaced the jacket style
- Wasn't Patented
- Continues to be produced by most manufacturers
- "Moved" the backpack
- Remains in favor today

Myth Deflated!

Seaquest often hired talent for ads, but...

The Darkhaired guy is Don Rockwell, President of Aqualung and SeaQuest...



Our new Advance Design Vest is here—and buoyancy design will never be the same! Originally developed to give dry-suit divers greater freedom of movement, its uncluttered fit is perfectly suited to wet-suits and free diving as well!

It's leaner! Buoyancy in the ADV is around the shoulders. You'll float higher when vertical.

It's completely adjustable! Whatever your build, our ADV is practically a custom fit. Straps adjust the torso length with large D-rings that are easy to handle—even underwater with gloves or mitts. Plus, the padded, cummerbund-style body band adjusts for a snug, natural fit.

It's integrated! Jacket and back pack are one. The shoulder area is padded, and the design has been anatomically engineered to carry the weight of your tank just above your hips, instead of on your shoulders.

minimizing fatigue and maximizing stability and comfort. It looks good! It feels good! It works great! In fact, there's only one thing the ADV doesn't do: It doesn't get in your way.

For SeaQuest/Mares full catalog call 800/524-5200.

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Gear for Adventure.

## Designed to set you free.

Introducing the ADV (Advance Design Vest)

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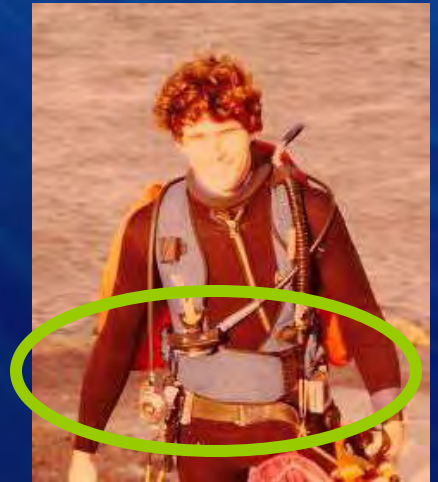
Vintage

Classic



# 1980's Comfort Features!

- Cummerbunds
  - At-Pac inspired
  - No more webbing
- Separated Bladder from waist strap
- Releasing Shoulders
- Six sizes



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Vintage

**Classic**

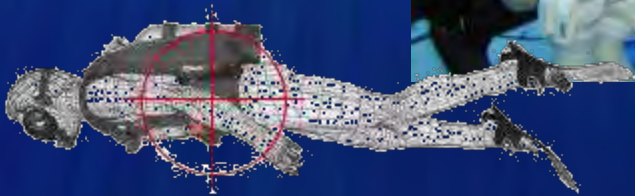
# 1980's Comfort on land...

- Softpacks
- Backpacking Technology
  - Shore diving needs
- Quick Release Shoulders
- Sizes, Colors



# Focus: Designs and Engineering

- Independent engineering: John Ratliff – Parasea
- Lee Somers – Michigan Sea Grant
- Steve Paulette – URI
  - Low Drag, High Thrust, The check is in the mail...
- Jim Middleton – USN NEDU
- Jon Hardy – Scubalab
- NASA WETF
- PADI, NAUI



# Focus: Military

- 1950's – Swimmers Vests
  - Antimagnetic Requirements
- 1980's – EDU Approves some commercial BCs
  - Need to remain with Diver negates jackets, wings
- 1990's – Approves (ANU) many Commercial BCs
  - <http://www.supsalv.org/webapp/anu/home.asp?user=public>



Non-Magnetic Swimmers Vest  
Navy Seal Museum

# Focus: PATA (Pink and Tiny with an A)

- 1960's – Wow – that's a woman diver!
  - Zale Perry is the First Woman of Diving
  - The horsecollar doesn't come in pink, but it fits
- 1970's – Women's "Fitness to dive" challenged
  - Donna Tobias applies to the Navy's dive school
  - Make the BC in an XS and an S size
- 1980's – Consider women's needs in sizing, comfort, style
  - Make the XS, S, M, L in Pink
  - BCs can look fashionable
  - BCs can be more comfortable for women and men
- 1990's – Vocal demand from a large, knowledgeable group
  - BC models designed by women, for women, tested by women
  - W.E.T.T. Women's Equipment Test Team
- 2000 – Necessity to fit a range of body shapes and sizes
  - Design for 40% of the market with a range of models
  - Large opportunities for improvement remain!
  - Offer functional styles for different types of diving
  - Tech / DIR – Make the XS backplate (in pink)
  - Scubawomen.org



# 1990s: Travel/ Low Volume BCs

- Started with the At-Pac
  - Retractable bladder
- SeaQuest Explorer (1992ish)
  - Jacket Style low volume
  - Bill Oliver Influenced thinking
  - Better buoyancy training developed
- USD Calypso
- Sherwood Destiny 30
- Zeagle BCs



Ancient

Archaic

Vintage

Classic

Contemporary

# 1990s - Systems BCs take off

- At Pac started it...
- CUDA Systems – not pictured
- Zeagle Systems
- Sherwood Destiny (Soniform)
- DiveRite Transpac
- Plate/Pac combinations



# 1979 - Backplates

- Invented by cave diver Greg Flanagan during the first NSS/CDS cave training course held by Scheck Exley...
- Made from an aluminum road sign

## Myth Deflated!

Contrary to popular belief, it wasn't invented as the result of a forklift running over a sheet of aluminum.

However... The outer plate from a Scubapro Stab Jacket was used as a pattern!



Ancient

Archaic

Vintage

Classic

Contemporary

Future



# Focus: Weight Integration

- 1972 At-Pac
- 1975ish Scubapro
- 1989 Zeagle
- 1995 Weight Pocket Systems



Gravity



Gravity



Gravity



Pull



Pull



Pull

# Living the Dream – The Future?



Ancient

Archaic

Vintage

**Classic**

Contemporary

*Future*



# Everything old is new again...

- Streamlining
  - Back inflation
- Less and More
  - DIR 2.0
- Electronics
  - Sense, Control
- Tuned weighting
- Training and Knowledge
- Fit Fit Fit Fit Fit
  - Materials
  - Experienced design
- Wings for dogs?



Ancient

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Vintage

Classic

Contemporary

*Future*



# Stuff I missed

- Back Packs
- Rebreather BCs
- Electronics
- HOW BCs work
- HOW to tune your buoyancy
- What you need to look for in a BC
- DIR systems
- Really Controversial topics
  - Tank Counterweights
  - Recalls
  - Production outsourcing

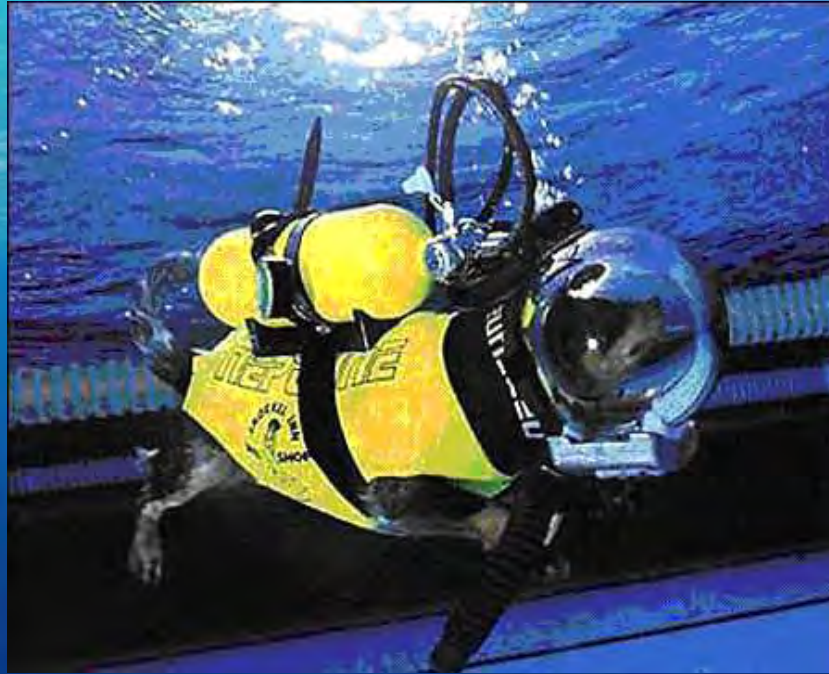
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- Jennifer King
- Harry Averill
- Don Rockwell
- Capt. Chad Carney
- Scubaboard.com
- Historical Diving Society
- Divinghistory.com
- Going Under Dive Center, Minnesota
- Steve Hornsby - Underwater Sports, Kirkland
- Scubapro, Aqualung/SeaQuest. Mares/Dacor, DUI
- The US Navy, Seal Team Museum, EDU facilities
- NASA WETF Facility
- DEMA



**Going Under Dive Center**

# Final Words...



**Myth Deflated!**

**Contrary to popular belief...  
Buoyancy Compensator design  
does not rely on animal testing!**



**THANK YOU!**

David McLean  
January 2006

# Appendix





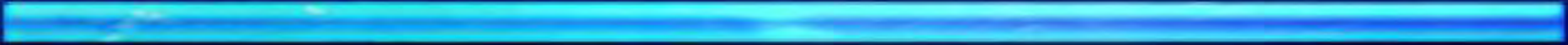
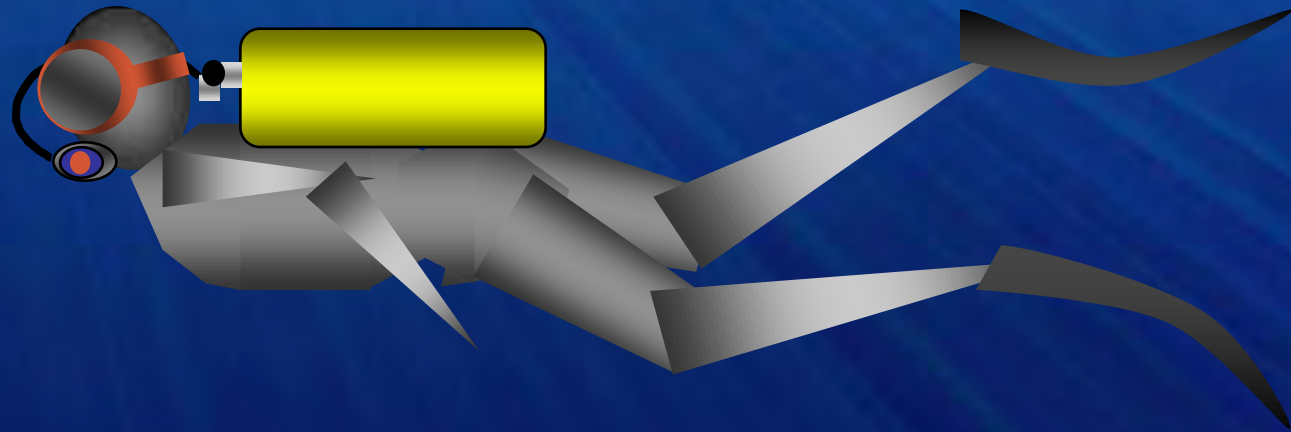
**USN ANU**



# Links

- Assyrian perspective
  - <http://www.adventurediveandsnorkel.com/id51.htm>
  - <http://timeline-of-underwater-technology.ignaut.net/>

# Diver Model



# David McLean Bio...

- Dive History
  - 1970ish Certified NAUI Junior Scuba Diver - used a double hose reg. in class!
  - 1976 Research Diver Certified Scripps Institute of Oceanography (they swear they will never certify someone that young again.)
  - 1979 Naui (5675 retired) / PADI (forgot the #) Instructor certified – retired
  - 1981 President UCSD Dive Club
  - 1980 - 85 Divemaster for Scripps Aquarium Collecting Expeditions
  - 1989ish American Academy of Underwater Sciences (AAUS) Founding Member
  - NACD Basic Cave Trained (Jarrod Jablonski)
  - Undergrad Degree from UCSD in Marine Archaeology (Oceanography, Anthropology, Engineering plus five years at Scripps Institute in Physical Oceanography)
  - Diving Experience - 2300 hours underwater.
  - Travel - Been diving a bunch of interesting places all over the world, most everywhere EXCEPT Micronesia, where my nephew lives. He won't let me forget it. You would think I would go someplace where I could stay for free...
- Professional Life:
  - 1982ish started at Underwater Kinetics, then moved to a small company run out of two garages called SeaQuest as an Engineer, designed BCs for seven years, including the ADV Spectrum style.
  - Recruited to launch MARES in the USA through HEAD sports as Product Manager (a dive company in Colorado? You have got to be kidding!), then Sales Manager for Florida.
  - Director of Sales and Marketing at Soniform - we made about 30% of the BCs for the world. I started three brands for them that were very popular (perhaps too popular) internationally, but not sold in the US.
  - We were purchased by Scubapro in 1987 and we moved Scubapro out to San Diego to a facility we built, so we "became" Scubapro. I finished up my career as Product Manager of Scubapro in 1989.
  - <Big gap where I moved into technology, networking, Software Development, Dot-Com startups>
  - Currently I work at Microsoft as a Product Manager doing HR Technology and staffing systems strategy. I am sure you clearly see the fit of this with everything else I have done.