

*In the 1960s the Electrolung stood out as a groundbreaking design of rebreather diving apparatus. It was the forerunner of many of the modern computerized diving systems that in the future will undoubtedly become increasingly mainstream in both the commercial and amateur diving worlds. While the Electrolung should probably retain its position, this well researched article by Richard Walsby shows that ideas about the electronic/computerized control of rebreather systems was in place much earlier than previously realized.*

# Before The Electrolung - Electrically Controlled Rebreathers From The 1950s

By Richard Walsby

During November 2008, I was searching the online patent files for early mentions of the use of helium in rebreathers. One patent caught my eye. It was titled "Electrically Controlled Breathing Apparatus", (1) invented by Dr. Roy P Finney, and described a mixed-gas rebreather that relied on monitoring the change in thermal conductivity of the breathing gas as the proportion of oxygen varied with the breathing cycle. The patent mentioned nitrogen and helium as possible alternative diluent gases. The surprising thing was the date. This patent was filed in January 1956, and published in April 1958. It had been published three years before the only other patent I knew, of this nature and period, i.e. the Marion Device made by the Old Dominion Research and Development Corp. of Virginia, although it had been filed later. Dr. Finney's invention could therefore be said to be the earliest published patent for an electrically controlled rebreathing apparatus.

A year earlier, in 2007, Jan Willem Bech (Jan Willem runs the well-known Rebreather Site (2) which seeks to cover the history, development, theory and practice of rebreathers.) had published an article on his website about the Marion Device, noting that it had been submitted to the US Navy Experimental Diving Unit (NEDU) for evaluation and attaching a link to the NEDU evaluation report. Jan-Willem asked if anybody knew anything more about Old Dominion and for any other information about the device, which he believed to be the earliest mention of elect(ron)ically controlled breathing apparatus. The Marion Device (I don't know why it was called this) relied on the paramagnetic property of oxygen as opposed to the diamagnetic property of nitrogen to monitor and control any change in oxygen partial pressure. The patent was filed in May 1952, but not published until August 1961(3), nine years later. It is possible that the reason for this delay was that the US Government was interested in acquiring it.

The NEDU evaluation report (4) was generally favorable, noting that the apparatus as submitted was very much an experimental set-up, not yet even a prototype, and concluding that the principle of operation was sound. They suggested that further work was needed to improve its reliability and recommended that the apparatus be modified to correct its deficiencies before being resubmitted for testing. In the event, Old Dominion did not do this but offered another, different apparatus, known as the REX, in 1957. This relied on the change in the velocity of sound in changing gas mixtures to control its

operation. NEDU had a lot of trouble testing the REX device because of its generally poor standard of workmanship, but concluded that the principle of its operation appeared feasible. Their work was completed in 1959. (5) I have not found any patent that covers this apparatus.

I wrote to Jan Willem with the news of Dr. Finney's patent. Jan Willem had not heard of it before, and his enthusiastic response prompted me to search further. I found that Dr. Finney had not published anything more on diving gear, but had become a successful urological surgeon with a number of patents for surgical implants and other publications to his name.

I wrote to Dr. Finney, who now lives in retirement in Florida, asking him for more details on the background of his invention; what was its inspiration; had he been able to construct a working model; was it tested successfully; was he aware of any other, similar work in the same area; and had any attempt been made to develop the apparatus further? Dr. Finney replied very comprehensively and the quotation below is extracted from his correspondence:

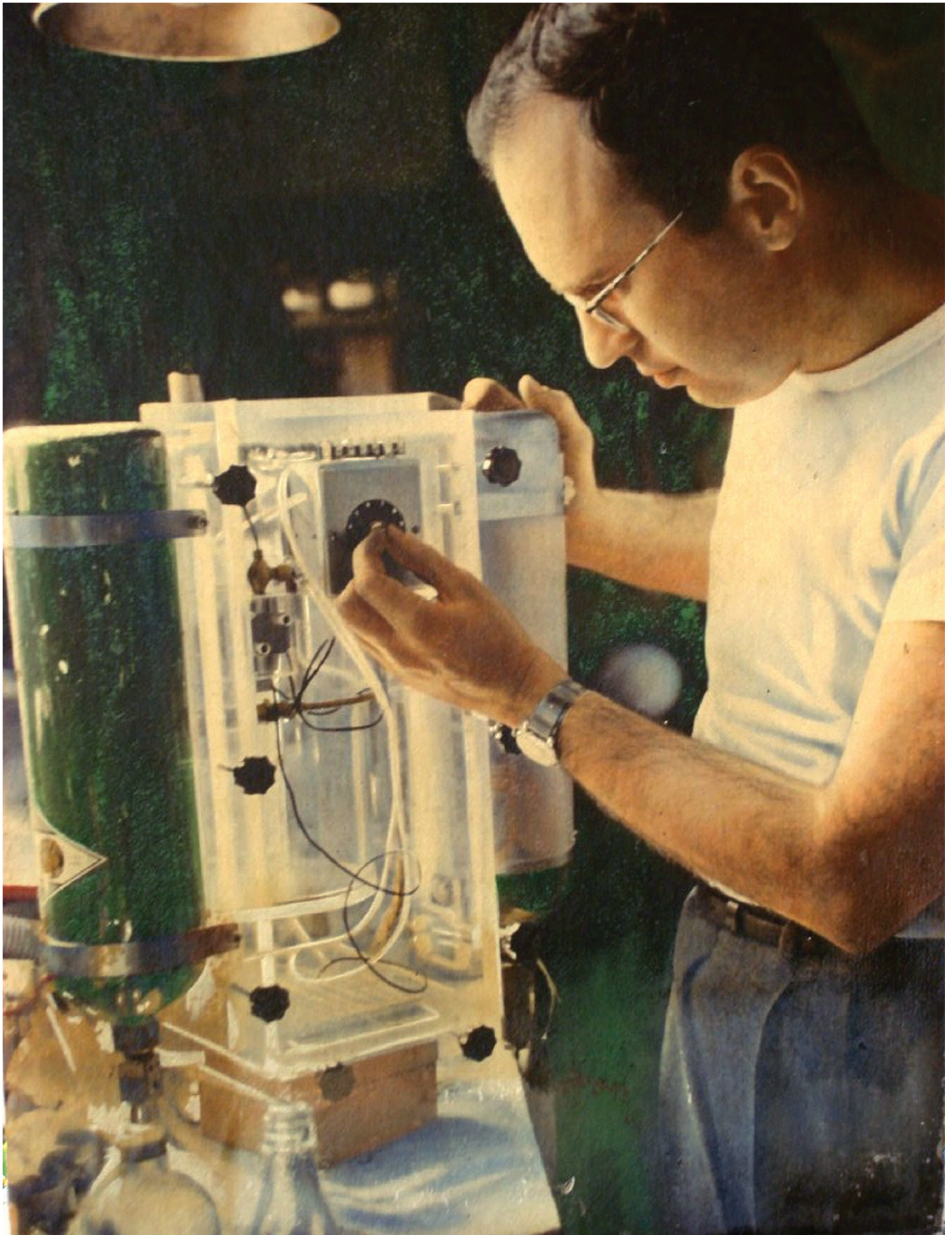
*"... I am the inventor of the patent you mentioned..... I started diving at age 14 when we made a helmet out of an old galvanised hot water tank - in lakes. While in the Air Corps in WW11 in Dakar a friend and I spent most of our free time spear fishing. I made a self-contained diving rig with air tanks about 1944.*

*After discharge in 1945 I bought a Desco O2 rebreather and using this gave me the idea of a mixed gas rebreather.*

*After medical school I went to Johns Hopkins Hospital for five years training as a urological surgeon. The first week there I saw a small 4 x 5 inch oxygen meter which would read % of O2 on a meter scale. I at once realized that if it could do this it could control the O2 % in a mixed gas rebreather. I built the device the following year, in the winter of 1953, in the shop of a friend using the Wheatstone Oxygen detector. [i.e. the circuit used in the O2 meter. RW]. I was in over my head with the amplification needed but managed. I have a picture of me and the device. I was well aware of the dangers of anoxia and knew that one could lose consciousness with no warning whatsoever. For that reason I first tested it in an indoor pool with a group from a local divers club. Underwater I at first had no problems but I later found myself sitting on the side of the pool, coughing and with no knowledge of how I got there. My mates pulled me out.*

*At this point I should add a word about the O2 meter. In 1950s and before, patients needing O2 were placed in an "Oxygen Tent." This was a flexible clear plastic enclosure, about 1x1x1 m in size placed over the upper half of the patient in bed. O2 was fed into this "tent" and the O2 meter was used to regulate this.*







At that time I had less and less time to work on the electronics and I came to understand that in order to be at all safe one would need a triple sensing circuit to monitor O2 levels. A duplex monitor would not work since, if the two were not the same one would not know which was correct.

At that point I realized that I had to proceed with my studies and would not have time to develop this complex, potentially lethal rebreather. So I wrote up the patent with a very old attorney and that was the end of diving work. My childhood friend Charles W. Bailey loaned me \$2500 for the patent application and I gave him a share. He had no part in the invention. Several years later, as you must know the Beckman Corp. of Boston (makers of top quality electronic instruments) made the Beckman mixed gas unit and had a 2 week course in Miami to train persons in its use. A man from St. Petersburg FL went on one of his first dives with the Beckman and died! I felt at the time that if Beckman had not made it safe then I saved a lot of time, money and effort by not going on with its development....."



More than 18 years after Dr. Finney's invention, in August and September 1970, *Skin Diver* magazine carried a series of articles on the Electrolung, a rebreathing apparatus invented by Dr. Walter Starck and Dr. John Kanwisher. The Electrolung was a closed-circuit rebreather which used a computer-controlled solenoid valve driven by a polarographic oxygen-sensor to detect the depletion of oxygen in the breathing gas as it

was consumed during respiration. The sensor drove the valve through a computerized electronic circuit to make up the oxygen concentration required at any particular depth. This meant that the diver could go to exceptional depths, secure in the knowledge that his apparatus would deliver the correct partial pressure of oxygen to avoid the dangers of oxygen poisoning and reduce the risk of the bends on rising to the surface. In 1968 for example Dr. Starck had used his rebreather down to 400 feet on his fish-collecting scientific expeditions.

Although the Electrolung was initially hailed by the press as the first computer-controlled rebreather, to be fair neither of its inventors claimed as much. The introduction to their patents (6) acknowledged the merits of an earlier device patented by Alan Krasberg, who had invented and patented an electrochemical sensor and rebreathing apparatus to use it in May 1966. (7) The particular emphasis of the Electrolung patent was on the safety aspect, provided by having three independent sensors to monitor the oxygen partial pressure. These sensors were connected with "voting" logic, so that if any one of the sensors failed, the remaining two would be delivering oxygen at the correct partial pressure; obviously an important safety factor.

Alan Krasberg sought the help of the J. H. Emerson company (a manufacturer of respiratory apparatus and well-known for their iron lungs for medical use) and Emerson manufactured Krasberg's apparatus for a while before their lung division was acquired by the Westinghouse Undersea Division.

The article in *Skin Diver* generated a huge amount of interest, and Dr. Starck sold several sets of apparatus before licensing production of the Electrolung to the Beckman Instrument Company who sold many to the armed forces of the US and other

countries. Unfortunately, some deaths among sport divers using the apparatus prevented its widespread use, and people came to believe that electronically controlled rebreathers were too complex and dangerous for the general public. The deaths were attributed to insufficient training and unfamiliarity with the strict standards of maintenance required by the apparatus. As a consequence computer controlled mixed-gas rebreathers dropped out of sight of the sports diving public for quite a while until the modern generation of rebreathers appeared for the technical and sport diving community. The Electrolung stayed in limited use amongst specialist divers.

It seems, therefore that the idea of electronic control using some property or other of the breathing gases was very much in the air, so to speak, 18 or so years before the introduction of the Electrolung. The Old Dominion Research and Development Company appear not to have developed the Marion Device or the REX to their fullest potential, although they went on to supply the US Navy with various other bits of diving-related equipment. It is interesting that three of the inventors mentioned here were independent enthusiasts developing their apparatus to help them pursue their underwater passions more effectively.

### Acknowledgements

This article would not have been possible without the generosity of Dr. Roy P Finney in taking the time to answer my enquiry, which came to him quite out of the blue, and also supplying the photos which followed it.

I would also like to thank Mr. Jan Willem Bech for technical comments and correspondence.

### References

- (1) US patent 2830583
- (2) <http://www.therebreathersite.nl>
- (3) US patent 2998009
- (4) NEDU-3-52 ADA037023 Evaluation of the Constant Partial Pressure Oxygen Underwater Breathing Apparatus
- (5) NEDU-1-60 AD0778809 Evaluation of the REX Oxygen Analyzer-Controller for Underwater Breathing Apparatus
- (6) US patents 3556098, 3727626 (rebreather), 3000805 (sensor)
- (7) US patents 3252458 (rebreather), 3410778 (sensor), also an account in *Marine Science Instrumentation*, vol 4, 1968, An Operational Closed-Circuit Constant pO2 Breathing Apparatus by Alan Krasberg

### Notes

The US patents can be read on the Web at Google Patents, or espacenet or the USPTO website, although you may need special software to read the .tiff images on the latter.

The NEDU reports are available on the website of the Rubicon Research Repository at <http://archive.rubicon-foundation.org/>

Dr. Starck's account of the development and construction details of the Electrolung has been copied widely on the web and is available at several sites including The Rebreather Site (ref. 2) or <http://news.deeperblue.net/article.php/423/33/0>

A more general account of Dr. Starck's work including his invention of the Electrolung appears in *Sharks & Other Ancestors* by Wade Doak published by Hodder & Stoughton in 1975. There is also his own book on fish collecting (no mention of the Electrolung): *The Blue Reef*, published in 1978 by Alfred Knopf.

I have found a popular account of Alan Krasberg's lung in *Popular Mechanics*, July 1965 p65 *Half A Mile Down With Scuba*. You can read this in "Google Books"; search for Krasberg Scuba.