

Oral History of  
**Hugh Bradner**

Interviews conducted by Eric Hanauer

4 August 1999

**SIO Centennial Oral History Project**

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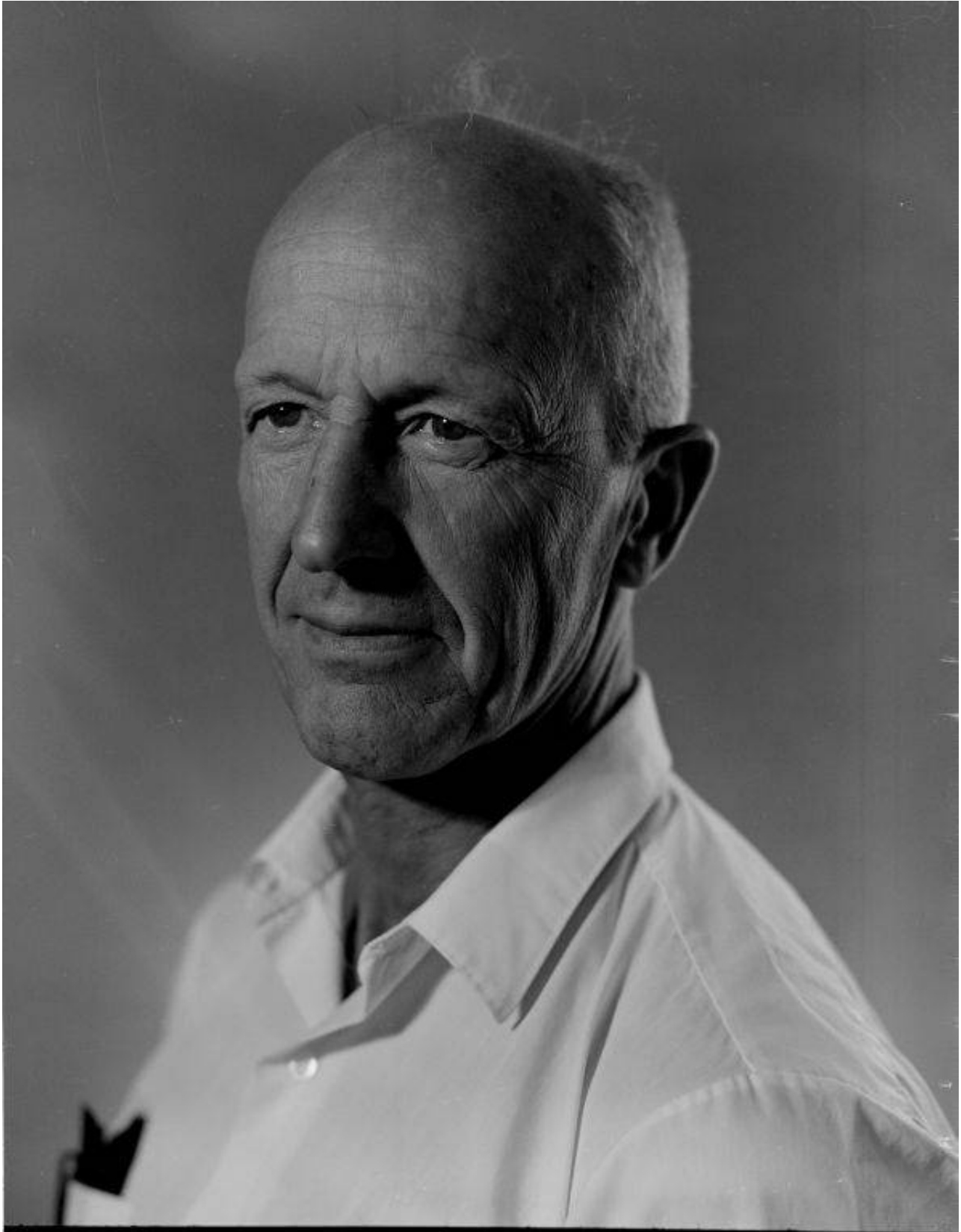
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## INTERVIEW HISTORY

Eric Hanauer interviewed Dr. Hugh Bradner for the SIO Centennial Oral History Project on August 4, 1999. Bradner, who received his doctorate in physics at the California Institute of Technology in 1941, has worked for the U.S. Naval Ordnance Laboratory, the Los Alamos National Laboratory, and the UC Berkeley Radiation Laboratory. He has been a research physicist and professor of engineering physics and geophysics at the Institute of Geophysics and Planetary Physics at UCSD, where he is currently professor emeritus. Hanauer is a professional writer and photographer whose works include *Diving Pioneers: An Oral History of Diving in America* (San Diego: Watersport Publishing, 1994). He holds an M.S. in physical education from UCLA and is associate professor emeritus in kinesiology at California State University, Fullerton. The SIO Centennial Oral History Project is supported with funds provided by Wolfgang Berger of the SIO Director's Office.



Dr. Hugh Bradner, 1972. SIO Photographic Laboratory Portrait File, 1890 – 1981. Scripps Institution of Oceanography Archives, UC San Diego Libraries.

## INTERVIEW WITH HUGH BRADNER: 4 August 1999

**Hanauer:** ##<sup>1</sup> Wednesday, the fourth of August, 1999. This Eric Hanauer, and we're talking with Dr. Hugh Bradner. I'm going to stop and just make sure we're on.

Let's start at the beginning and on your outline here you were talking about when you first started swimming, thrown from the pier into Gunpowder River in 1918. Can you tell me about that incident?

**Bradner:** It was really simple. My dad<sup>2</sup> had faith that by taking this kind of approach it would not turn me off in the water and he was right. He was at Edgewood at the time; my brother was four and I was three. He threw us off the end of the pier in deep water, and well, actually I was happier under water than above pretty much from then on.

**Hanauer:** This was Edgewood, where?

**Bradner:** Edgewood Arsenal, Maryland.

**Hanauer:** Okay.

**Bradner:** Chemical Warfare Service, if that makes any difference.

**Hanauer:** Your father was involved?

**Bradner:** He was briefly the director of it right after World War I.

**Hanauer:** As a civilian or military?

**Bradner:** He was military a short period, as I recall, and then civilian. I don't remember it.

**Hanauer:** Okay. What about your early aquatics background? You were a competitive swimmer?

**Bradner:** Oh, yes, the usual kind of thing. Based in southern Ohio—Hamilton, Oxford—was on swimming teams. Being lazy, never really trained but did sprints therefore and individual medleys; did three-meter board diving, occasional exhibitions.

**Hanauer:** This was before the age of specialization.

**Bradner:** Oh, good swimmers still do that. They just train a lot harder.

**Hanauer:** Did you swim at college?

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<sup>1</sup> The symbol ## indicates that a section of tape has begun or ended. For a guide to the tapes, see the last page of this transcript.

<sup>2</sup> Donald Byal Bradner and Agnes Claire Mead Bradner are the parents of Hugh Bradner (1915- ) and his brother Mead Bradner (1914- ).

- Bradner:** Yes. But we didn't have a swimming team at Miami.
- Hanauer:** Miami, Ohio?
- Bradner:** Yes. I was swimming with the clubs at Hamilton and Oxford.
- Hanauer:** Did you have any interest at that time in the underwater world? Were you doing anything other than this?
- Bradner:** I doubt very much that I ever had goggles or a face plate on during that period. The first of that would have been in graduate school days, which happens to be 1937 to 1941.
- Hanauer:** Okay, and you went to graduate school at Caltech?
- Bradner:** At Caltech in physics.
- Hanauer:** Okay, and at the time, according to your résumé, you were the swimming and water polo and tennis coach.
- Bradner:** Oh, they were very nice and let me have a fellowship. Actually, Joe LaSalle,<sup>3</sup> my roommate there, ran the varsity tennis. I ran the freshman tennis and the water polo and the swimming. And, as I think I may have mentioned, we actually got conference championships in all of those things. Some good guys.
- Hanauer:** At that time, was this your first experience near an ocean? Did you do any surfing or did you get to the Pacific Ocean very much?
- Bradner:** Well, I'm sure that we went along the East Coast for vacations, like at Beaufort, North Carolina, before college years, even. But that would have been mainly seeing what was on the sand at low tide. No diving in the normal sense. I don't remember seeing surfers during that period. And then in the Caltech days we would go down—oh, a couple of times a year—to the ocean along Palos Verdes and so on.
- Hanauer:** Now it was at this time that you made your first homemade diving equipment. What led to that? Can you tell me a little bit about it?
- Bradner:** Well, first what led to it: the usual inquisitiveness, which physicists like to claim. And what caused it was just it seemed to Earl and me it would be nice to be under water longer than breath-holding.
- Hanauer:** This was Earl—?
- Bradner:** This was the guy that was next to my office. Earl Thomas. I'm stuttering because I'm trying to remember for sure. I think it's J. Earl Thomas.<sup>4</sup> He was a Ph.D. student there also. We fairly simply concluded that pure oxygen was the way to go.

<sup>3</sup> Joseph Pierre LaSalle (1916- ), Ph.D. in mathematics, California Institute of Technology, 1941.

<sup>4</sup> Jacob Earl Thomas, Jr. (1918- ), Ph.D. in physics, California Institute of Technology, 1943.

You could pick up an oxygen bottle in the lab, and the next step was again pretty straightforward. You had a carbon dioxide absorber—I don't even remember what it was that we used primarily, but it was a well known thing. The thing that was not well known—at least to us, and I think probably in general not—was the danger of oxygen if you went below about thirty-foot depth. We were lucky enough, or wise enough, to get in touch with somebody at Mayo Clinic, and I don't remember his name. But he cautioned us on that. Then we used this thing up and down to Los Angeles, Palos Verdes and so on area, found the water uncomfortably cold. And so, one weekend Earl and I decided we would go way south—as far south as we could get where the water would be warm—picked the south side of Punta Banda,<sup>5</sup> which nowadays everybody knows is just the wrong thing because of the upwelling. Oh, but the water was beautifully clear. This was a fishing camp. Are you familiar with that part of Punta Banda?

**Hanauer:** Yes. Not in that era. I was there much later when it became a bit of a tourist destination.

**Bradner:** The place I'm talking about you turned off to the south before you get out to La Bufadora, and were working truly on the south side of the point.

**Hanauer:** There's a place called Kennedy's Landing that we've been to, which is south of Punta Banda, and it's still just dirt road, you climb down a cliff.

**Bradner:** That part of it sounds right. I don't remember the name. I can say that at the time we were there, the abalone were more than just one deep at normal low tide, and of course *big* guys.

**Hanauer:** Can you tell me a little more about the apparatus that you made and what did you use for guidance? What made you go in the direction you did? Oxygen rebreathers really didn't come into their own until World War II. So what kind of—?

**Bradner:** Oh, I can't remember whether this is '38 or '39. I think it was '39, but in the notes that I gave you I typed out '38. Guidance, except for that one inquiry to Mayo Clinic, was ourselves. Are you going to have any pictures in all of this? Because there is that one photo of a rear view of Earl Thomas, which shows the apparatus pretty well.

**Hanauer:** Let's just make a note of that and suggest that there be pictures in there and I'm sure that it will be included.

**Bradner:** What you need is either an oxygen valve that is automatic or which you turn by hand; we decided to have a hand turn-on. You need something to absorb the carbon dioxide (Baralyme, I now recall). You need to avoid a dead-gas space. You want a bag of some sort, therefore, which is as big as your deepest breath. We picked a motorcycle inner tube as the bag, put a bottomless coffee can with CO<sub>2</sub> absorber in the line of the inner tube, feed off the oxygen valve and the mouthpiece, and

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<sup>5</sup> Punta Banda is located near Ensenada in Baja California, Mexico.



J. Earl Thomas with diving equipment, n.d. Hugh Bradner Papers, 82-57, Box 1, Folder 97, "General Correspondence, Diving, 1946-1960." Scripps Institution of Oceanography Archives, UC San Diego Libraries.



strapped it on our back. We would exhale and pretty well squeeze the bag dry before letting in oxygen for the first breath. So there would be no danger of having just nitrogen for breathing. The only thing that was unexpected about it was that, if you were diving for—oh, let's say fifteen minutes or half an hour at about thirty feet—

and started up to the surface, you began to feel a little anxiety. Then it dawned on us that that was because we were getting the gas evolved as we rose to higher altitude. This was the anxiety from excess CO<sub>2</sub>. It wasn't a serious anxiety, but it was funny, because you felt just wonderful until you started up. I can't think of anything else with respect to the design. Do you?

**Hanauer:** No, I'm aware that, for example, Draeger was making oxygen rebreathers prior to World War II. When Hans Hass<sup>6</sup> started his serious diving with a rebreather back in '42, he went to Herman Stellzner, who was the head engineer at Draeger. He suggested to Stellzner what he needed, and they rigged it. That's really all I'm aware of in terms of rebreathers prior to that time.

**Bradner:** Well, that's more than I remember, except what I have in subsequent years seen in the literature. Rebreathers, in the sense—at least as sophisticated as we were doing—extend way back, like early 1930s or 20s or 1900s, even. There's quite a bit of literature on the early diving equipment.

**Hanauer:** Can you remember any particular experience that was pretty vivid, besides Punta Banda? Any close calls? Any spectacular things that stand out in your mind?

**Bradner:** The only things that come to my mind, namely the clear cold Punta Banda water and how dumb we can be—and the effect of gas evolution, which we did not anticipate, but it was no problem.

**Hanauer:** Okay. We want to limit this conversation to your diving activities. We need to place it in the broad picture. So now you've graduated, you've got your degree from Caltech, and at what point did you start working?

**Bradner:** Elsewhere on something else? Right. Well, of course, as you know, diving and swimming never were my primary activity. My Ph.D. thesis was on electron optic studies of the photoelectric effect, which has nothing to do with diving. I got finished as quickly as I could, namely in early to mid-spring in 1943,<sup>7</sup> because it was evident the country was going to be in a war. So I went back to Washington to the [US Naval Ordnance Lab in the Navy Yard]. The Experimental Diving Unit was in the same place. I went to the Naval Mine Warfare in the Washington Navy Yard, and did no diving at all. I can't even remember—oh, I probably went down to the east shore once during those years, but I was involved with designing and building

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<sup>6</sup> Hans Hass (1919-), marine biologist, writer, and filmmaker; pioneered use of rebreather and swim fins in diving.

<sup>7</sup> The date is later corrected to 1941.

anti-shipping mines. And then in 1943, when Los Alamos<sup>8</sup> was getting ready to open, I was offered the chance to go out there, and spent the rest of the war years actually working with high explosives on the implosion.

**Hanauer:** The implosion form of the atom bomb?

**Bradner:** Yes.

**Hanauer:** At this point you mention Draper Kauffman, who was the founder of UDT.<sup>9</sup>

**Bradner:** I don't think Draper was.

**Hanauer:** Do you remember interacting with him?

**Bradner:** I knew Draper. I don't think it was the UDT. Gee, I forget the exact title, but it was the Navy demolition, not underwater demolition, but their demolition squad.<sup>10</sup>

**Hanauer:** As I recall, his history was that he was an explosives expert, and his job in the military was to defuse bombs.

**Bradner:** Yes, yes.

**Hanauer:** And a bomb went off that he was defusing, and once that happens you're out of that activity and then his next assignment was to start UDT and he was actually the founder of UDT.

**Bradner:** That could be. I didn't get my brain in gear for that subject. I'll tell you though how Draper and I happened to be acquainted primarily. He and I were dating two sisters.

**Hanauer:** This was during the war?

**Bradner:** During the war in Washington.

**Hanauer:** So you knew him at that time?

**Bradner:** Yes.

**Hanauer:** But at that time he was still in the explosives area?

**Bradner:** Yes.

**Hanauer:** He got into UDT in 1944. They first used UDT in the invasion of the Marshall Islands.

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<sup>8</sup> Los Alamos National Laboratory in Los Alamos, New Mexico has been managed by the University of California for the U.S. Department of Energy since 1943.

<sup>9</sup> U.S. Navy Underwater Demolition Team.

<sup>10</sup> Lt. Commander Draper L. Kauffman started the Naval Combat Demolition Units (NCDUs) in 1943. For more information see the U.S. Naval Special Warfare Archives website at <http://www.navyfrogmen.com/>.

- Bradner:** Oh, well, I probably knew it but I certainly don't know it now. Similarly, I interacted a little bit with Kistiakowsky, and I don't remember in what context in those days. He was the recognized world's expert on explosives, and it probably was in connection with explosives on the mines.
- Hanauer:** What was his first name?
- Bradner:** George. George Bogdan Kistiakowsky.<sup>11</sup> I got very well acquainted with him during the Los Alamos years.
- Hanauer:** I just barely recall the name from what I've read about Los Alamos. Okay now, after the war you went back to using your rebreathers? You came back to California then?
- Bradner:** Well, let's go through the sequence. In '43 I went to Los Alamos, New Mexico. At the end of the war in '45 I was offered a chance to go into high-energy physics at the Radiation Lab, UC Berkeley, which was the plum of places to go, so I went there and tried to learn high-energy physics for the rest of my professional stay until 1960-61 when I came down here. I would say that the dedication was at least a seven-day-a-week one during the Berkeley years. Nonetheless, being a bit of what Walter Munk<sup>12</sup> calls "compulsive dabbler," I wanted to do something that would be useful as a one-day-a-week recreation. And I had these interactions with the Washington people, I'd been out at Eniwetok,<sup>13</sup> and there we were considerably more sophisticated, of course by that time. There were Churchill fins and face plates, and we threw together a open-circuit scuba, using a pilot's-demand regulator, which was all right if you don't let it get corroded too much.
- Hanauer:** Now, in your correspondence you mentioned a trip to the coral lagoons of the Pacific right after the war. Does this refer to Eniwetok?
- Bradner:** Right after the war? No, it would have been probably 1954 or '55. No, wait a minute, 1951 was—. Yes, that would have been about five years after the war, 1950 to '51. I had left Los Alamos in 1945 and was at Berkeley. And Berkeley took part in some of the Eniwetok tests.
- Hanauer:** Okay, you kind of touched on making your own open-circuit scuba.
- Bradner:** That was trivial.
- Hanauer:** I'm just assuming this was before the aqualung really made it to the United States. Because we have this period now from the end of the war until actually '49 was when they started selling the aqualung at sporting goods stores. So between '46 and

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<sup>11</sup> George Bogdan Kistiakowsky (1900- ), professor of physical chemistry at Princeton and Harvard Universities.

<sup>12</sup> Walter Heinrich Munk (1917- ), professor of geophysics, Scripps Institution of Oceanography and associate director, Institute of Geophysics and Planetary Physics, UC San Diego.

<sup>13</sup> Eniwetok Atoll in the Marshall Islands.

'49, were you diving, and if so, what were you doing and who were you interacting with?

**Bradner:** Good question. Very little diving. I was aware of the Cousteau-Gagnan<sup>14</sup> demand regulator. We didn't actually put anything together other than cobbling up pilot's-demand regulators. I think during that period we just followed the Cousteau notion of the two-hose regulator; that the notion of going to a single hose didn't come in until somewhat later. I was not contributing to any diving things during that period. The diving that I did at Eniwetok was strictly a few minutes at a time recreational diving.

**Hanauer:** Okay, then how did you get involved with the UDT underwater swimmers panel?

**Bradner:** Well, first I decided that doing diving things made sense as this one-day-a-week recreation. I had considerable familiarity or acquaintance at least, one would say, with the people and the equipment of the diving. I had been in correspondence with the local UDTs here, as I recall. All in all, it was just an easy thing to start messing around with, and at essentially that same time the National Academy/National Research Council—I think it was they, and not ONR<sup>15</sup> at that time—started a panel on underwater swimmers as part of their committee on undersea warfare, and I knew some of the people and was invited to join it.

**Hanauer:** Who were some of the people that were instrumental in getting you involved?

**Bradner:** Well, Larry Marshall<sup>16</sup> was one. Chris Lambertsen.<sup>17</sup> Ed Lanphier.<sup>18</sup> I can probably dig up some other names, but unless I think about them hard—.

**Hanauer:** I'm sure we are going to get to some of those names as we go on. At this point, were you involved at all with the people at Scripps? There's some correspondence with Connie Limbaugh<sup>19</sup> at this time. At this point it seemed that there were correspondences with Doug Fane<sup>20</sup> and Connie Limbaugh. Fane and Limbaugh were interacting at the time when Connie started his classes.

**Bradner:** I think that was a bit later. I wouldn't flatly guarantee whether I had made any trips down here. About 1953 there were—Limbaugh was working up diving regulations for the University, and I took part in some of that. Then there was a Diving Control Board that was established statewide. I think I remember that those would have been in sort of '53. In 1951-52 there were some studies that involved Scripps. What

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<sup>14</sup> Jacques-Yves Cousteau (1910-1997) and Emile Gagnan developed their demand regulator in 1943.

<sup>15</sup> U.S. Office of Naval Research.

<sup>16</sup> Lauriston Calvert Marshall (1902- ), physicist, UC Berkeley Radiation Laboratory.

<sup>17</sup> Christian James Lambertsen (1917- ), professor of pharmacology, University of Pennsylvania School of Medicine.

<sup>18</sup> Edward Howell Lanphier (1922- ), medical officer and physiologist, U.S. Navy Experimental Diving Unit and Underwater Demolition Team.

<sup>19</sup> Conrad Limbaugh (1924-1960), chief diving officer at Scripps Institution of Oceanography.

<sup>20</sup> Francis Douglas Fane (1909- ), commander of UDT 1 and coauthor, with Don Moore, of *The Naked Warriors: The Story of the U.S. Navy's Frogmen* (Annapolis: Naval Institute Press, 1995).

was it—December of '51 or something like that?—that there was a meeting down here.

**Hanauer:** That was the Swimposium,<sup>21</sup> which was the military applications to diving. This was when, according to Bascom,<sup>22</sup> this was when Cresson Kearny came up with the wet suit idea.

**Bradner:** Well, which, as far as Bascom knows, could be the case. I won't flatly guarantee that we were in there first, but I've been trying to find out. For obvious reasons I don't want to go on false colors.

**Hanauer:** Let's get into that now. Let's talk about how you got involved with the wet suit and how that happened.

**Bradner:** Well, that part I think I can state fairly simply, and I think accurately. As I said, I was interested in doing things in behalf of the frogmen, the UDTs. It was quite evident that there were a number of things that needed improvement in their equipment. The most significant one was suits. If you'd ever used any of the so-called dry suits that the Navy had at that time, there'd be no question about the need for improvement. It's pretty self-evident after the fact that your heat insulation through the suit comes from the dead air that's trapped there, and that you don't have to stay dry, just stay warm. If you've got a layer of appropriate thickness of dead air, meaning small enclosed spaces of air, or other gas, but air is particularly good. So, with that notion, we messed around. I think other people undoubtedly did, too, with trying to put, say, an impervious rubber layer on top and both sides of woolen underwear—not too satisfactory. Foam rubber, which we knew the existence of—pretty fragile.

**Hanauer:** What was it being used for? The foam rubber?

**Bradner:** The foam rubber.

**Hanauer:** That is the question that I've had in my mind. How did you come by this material?

**Bradner:** If I remember rightly, there were molded things, like backs of chairs or underneath the running boards of cars. It was an existing material.

**Hanauer:** Okay.

**Bradner:** There were several people who were making rubber and neoprene and polyvinyl chloride—as I remember, a whole lot of such things. What we were looking for was something that hopefully would have a bit of stiffness of its own, would be unicellular, could be cemented, would stretch an appropriate amount. Certainly, we didn't do a careful survey of everything available on the market and say, "That's what we want." And, in fact, I think I have mentioned repeatedly, that the particular

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<sup>21</sup> The Swimmer Symposium was held December 1951 in Coronado, California.

<sup>22</sup> Willard Bascom (1916- ), oceanographer, research engineer at Scripps Institution of Oceanography, 1951-1954.

neoprene foam rubber—I shouldn't call it neoprene rubber—neoprene foam, that turned out to be the best, although it was quite fragile for a while, was this stuff made by Rubatex. And that Willard Bascom was the one that said, "You should try the Rubatex material." We had been trying other foam materials, but I don't think one ought to try to ignore his contributions. He's made a lot of very fine contributions.

**Hanauer:** This was 1951? Mid-year 1951. Because the Swimsposium was in December of that year.

**Bradner:** Yes. The first thing that I have dragged up is this letter that I wrote to McKinney at the Amphibious Base in August 1950, where I asked, "How satisfactory are the present types of suits?"<sup>23</sup> And I was talking about explosives protection as well as just straight diving suits—temperature—to the extent that I can reconstruct that letter. Then there was the definitive letter<sup>24</sup> to—what was the date on that anyhow?—July, something or other, 1951 to Larry Marshall, in which I said, "Look, you don't have to stay dry to stay warm." At that time, we were starting, not just to think but to try to mess around with materials. And we had built several—not perfect—suits by the time of the December symposium. At that time—you probably have seen the outline of that symposium that's in my notes.

**Hanauer:** Yes.

**Bradner:** At that time, you will recall, there were a number of calculations presented on the thermal insulation of materials.

**Hanauer:** Now was this the first public presentation of your work with the wet suit?

**Bradner:** Probably.

**Hanauer:** What was the reaction?

**Bradner:** It certainly was not a violent reaction, enough for me to remember. I would hazard a guess that it ranged from people saying, "Don't be silly" to people saying, "Hey, of course."

**Hanauer:** Now, according to what I got out of your correspondence, the first ocean trial of the suit was April 1952. Did you participate in that? Or can you recall your first ocean trial?

**Bradner:** Oh boy, oh boy, oh boy.

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<sup>23</sup> Hugh Bradner to Lt. Comdr. McKinney, 18 August 1950. Hugh Bradner Papers, 1938-1957 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: McAllister - Marshall." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>24</sup> Dr. Hugh Bradner to Dr. L.C. Marshall, 21 June 1951. Hugh Bradner Papers, 1938-1957 (82-57), Box 2, "General Correspondence, 1946-1960, McCormick - Marshall." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

- Hanauer:** It said the water was 11 degrees.<sup>25</sup> The suit was an eighth-inch suit.
- Bradner:** Does it say where?
- Hanauer:** It probably does, but I didn't make a note on that.
- Bradner:** I don't recall. I remember a few individual instances, but the dates we'd have to go back and try to find.
- Hanauer:** Would you share with me some of your early experiences?
- Bradner:** Sure.
- Hanauer:** With the suit.
- Bradner:** Fairly early on, I think it would have been in the late winter or spring of—Doug Fane and a couple of his SEALs<sup>26</sup> went down to Punta Banda, and we ran skin temperature measurements with them lying out in the cold water. At about that same time, and here there would be photographs and prints that would probably give the actual date, I did some skin temperature tests in Echo Lake. Somewhat later, I think it was probably a year or two later, I was swimming at Christmas time in Tahoe—wasn't there a 1952 swimmers' study here at Coronado?
- Hanauer:** I don't recall. I do recall correspondence regarding what they called the Swimposiums then, and where they wanted to make that an annual affair.
- Bradner:** There were two things that come to my mind, and I'm not getting them clear. The one was the first big meeting which took place at San Diego in about December.
- Hanauer:** That was December 1951.
- Bradner:** Sounds reasonable. And then, the next summer, there was a month or so long scientific symposium at which, for example, Bob Livingston<sup>27</sup> attended, and he and I did some measurements on metabolism of swimmers. At that time, I think I remember our taking a record set of photos of all of the different kinds of suits that were around, the Pirelli, and so on. I wouldn't guarantee the dates on that, but it would have been during—. Now whether we did any tests—ocean tests—of that I doubt. Livingston and I did what might be called an ocean test of the suits at Christmas, and this would probably have been the following Christmas, off the Golden Gate area of San Francisco. How close are you to finishing?
- Hanauer:** Oh, we have quite a ways to go.

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<sup>25</sup> Eleven degrees Celsius, or 51.8 degrees Fahrenheit. Hugh Bradner to Dr. R. Revelle, 4 April 1952. Hugh Bradner Papers, 1938-1957 (82-57), Box 1, "General Correspondence, Diving, 1946-1960, Rechnitzer - Revelle." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>26</sup> U.S. Navy Sea-Air-Land teams, although the term wasn't in use for the UDTs until 1962.

<sup>27</sup> Robert Burr Livingston (1918- ), professor of physiology and anatomy, Yale University and UCLA; professor of neurosciences, UC San Diego.

**Bradner:** Well, I'll go ahead and say it, but I think you probably don't want it in the record. The thing that I remember most about that is that I put on the suit, face plate, and went out in like three- or four-foot depth water to wallow around for a while, while Livingston watched the thing. Then Livingston went back up to the car for some reason, and a very luscious woman came running down the beach, this completely deserted beach with nothing except this black-suited creature in the water, and threw off all her clothes and lay down behind a rock. That I remember.

But anyhow, ocean tests per se. Other than these things of working with Fane where, by the way, Fane felt that the suits were far from being optimum—they were too fragile, and he did his damndest to get his guys to tear them every time they used them.

**Hanauer:** At this point were you still using eighth-inch suits or were you using different thicknesses of rubber?

**Bradner:** The answer is I'm sure we were using different thicknesses. The basis of the original thickness was just my calculations of heat transfer, and I have the feeling that we went to something thicker than that, three-sixteenths, or even a quarter from time to time during that period. But I wouldn't remember.

**Hanauer:** Now, from your initial drawings, the suits had zippers. Did you start out with zippers or were those added later?

**Bradner:** We tried everything. The reason for the zippers was simply that the material was not as stretchable as you'd like, and in order to keep the water flow reasonably low—for example, around the wrists—it seemed desirable to have something that was a little tighter than you could comfortably shove your hand through. So we put a zipper in. It didn't have to be a waterproof zipper,

**Hanauer:** With the non-flexible material you would tear it without the zipper.

**Bradner:** Yes.

**Hanauer:** And I noticed you also had backing behind the zippers.

**Bradner:** Yes, I forget what we called it—was it gusset? I forget what it's called. But anyhow, sure, behind every zipper you did that, both from the standpoint of comfort and keeping the water flow down.

**Hanauer:** Okay. It's already part of the record that the Navy decided this was not for them, but just for the purpose of making this a complete record, could you tell me about the Navy passing on it and the subsequent fate of the patent?

**Bradner:** Well, these were quite different aspects. Let's start with the patent question. As I've mentioned a number of times, the morality in those days was that one was not supposed to profit by anything that he did under government auspices. The University of California and the Patent Office both independently said—well,



initially, we treated it as a classified project and turned it over to the government for trying for patent. And they, I think very properly, concluded that they didn't need any patent protection. Besides, the patent examiner felt that—I forget the correspondence, but in essence missed the point in the unicellular materials. And so, when that application was refused, they said “Fine, the government doesn't need any”—or they said to me they don't need any patent protection, and so they gave it back to me to turn over to the University. The University asked, in looking this over, did I see any significant commercial aspect to it? In my wisdom, I said, “No, I think maybe fifty people in the country—.” So we dropped the patent aspect of it. Okay, enough of that unless you want to ask some questions.

On the pursuing of the suits then—after that, the UDTs wanted them. Even Doug Fane was much in favor of it, but the Navy couldn't put out contracts and issue them and run all the acceptance tests and so on in less than about seven years at that time. That was sort of par for getting a thing through the military. So, having gotten it declassified, we arranged to have a couple of outfits build them—make them commercially. Doug Fane—I think he was still commanding officer, but anyhow, the commanding officer of UDTs got a discretionary fund, which he could then use to allow his swimmers to go out and buy the things commercially. As far as the diver was concerned that was the origin of EDCO<sup>28</sup> and we also got some outfit down here.

**Hanauer:** Tell me about EDCO. What was your part in starting EDCO and how were you involved?

**Bradner:** Well, in the suit development itself, as I have indicated, it started out as an interest of mine in the UDTs equipment and got several of my pals there at the Rad Lab to join in putting them together in their basement and mine and so on.

**Hanauer:** Do you recall some of the names?

**Bradner:** Well, Hayden Gordon<sup>29</sup> was the chief engineer at the Rad Lab. Dave Garbellano.<sup>30</sup> Another excellent engineer there. Donald Cone,<sup>31</sup> was one of the young guys at the lab. He subsequently, if I understand it correctly, is the one that was responsible for the design of that first Hewlett Packard hand-held calculator, the one working in Reverse Polish. You know the term Reverse Polish?

**Hanauer:** No.

**Bradner:** Well, the way we normally use a modern hand calculator is, we say: 17 (which you key in) *plus 12 equals*, right?

**Hanauer:** Yes.

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<sup>28</sup> Engineering Development Company.

<sup>29</sup> Hayden Samuel Gordon (1910- ), chief engineer, UC Berkeley Radiation Laboratory.

<sup>30</sup> David Wesley Garbellano (1915- ), atomic physicist, UC Berkeley Radiation Laboratory.

<sup>31</sup> Donald Roy Cone (1921- ), electrical engineer, UC Berkeley Radiation Laboratory.

**Bradner:** That's the normal way we do it. However, there are many reasons, I understand—I don't understand, but I am told—mathematically for doing: *17 enter 12 plus* and have the answer show up. That's called reverse Polish mathematics, or arithmetic. Anyhow, I think that Don Cone was the one that was responsible for the concept, the design, the engineering of that first Hewlett Packard.

**Hanauer:** Now, getting back to EDCO. How did that start?

**Bradner:** Johnny Foster<sup>32</sup> was another one of the young guys around the place. There would have been one or two others, also.

**Hanauer:** So these were just basically friends and colleagues of yours?

**Bradner:** Yes.

**Hanauer:** At Berkeley.

**Bradner:** Yes. And then Dave Garbellano decided that somebody needed to go into this as a business in order to be able to make these things reliably and sell them. So Garbellano was the driving force of EDCO. I don't think I was involved in any way with any of the business aspects. I tried in fact to avoid that.

**Hanauer:** Obviously since you didn't have a patent you weren't getting royalties, so you were getting no income at all from EDCO.

**Bradner:** No, but the Radiation Lab allowed me to spend some time working on it. And actually—(and this again I would prefer to not have part of the interview, please).

**Hanauer:** You want me to turn it off?

**Bradner:** No, no, you can leave it on. Garbellano and Hayden Gordon as primary people established a year or two after EDCO a little company called Applied Radiation Corporation, ARCO, whose product was going to be a little electron accelerator for food sterilization. And Marge<sup>33</sup> and I gave them all the money that we could afford at that time, which was a hundred dollars, so we did have a vested interest in ARCO. If I remember rightly, when that was bought up by one of the big accelerator companies in the east, it was a hundred and some to one. That nest egg was the thing which permitted us to buy a house and which was really the basis of our being solvent today.

**Hanauer:** Great.

**Bradner:** So, yes, I owe a great deal to those guys.

**Hanauer:** But not because of the wet suit.

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<sup>32</sup> John Stuart Foster, Jr. (1922- ), physicist, UC Berkeley Radiation Laboratory.

<sup>33</sup> Marjorie Hall Bradner married Hugh Bradner in 1943.

**Bradner:** Right.

**Hanauer:** Okay, let's go back to one question I had, that you were working on neoprene or foam rubber as protection from explosive shock for swimmers prior to its use for thermal protection. Can you tell me a little bit about that?

**Bradner:** Yes, I was much more sophisticated on explosions at the time than I am now in my memory. But bear with me. When you have an explosion in the water—let's say, and you have a creature exposed to it, the main thing that happens is—. ##

**Hanauer:** ## Okay, we're talking about the effects of explosions in the water.

**Bradner:** Explosions in the water. Let's talk about it on a sheep or a person or whatever. The acoustic impedance of flesh and bone are not far different from that of water. So that a shock wave travels right through—let's say through your arm—with probably little damage being done to anything. On the other hand, air has a strongly different acoustic impedance than flesh and bone, and as such when a shock wave traveling through water or flesh or whatever, comes to an air zone, it spalls off: kicks off the outer surface or the surface interface between the flesh and the air. This is the prime source of damage to a swimmer underwater or to whatever; that is, the blasting off of the interior of the lung—the surface of the lung. It looked as though one could—. I don't think there's anything novel about this idea. In fact, I know there's not. One could perhaps improve on that by having, outside of the body, a surface which would absorb some of the explosive energy—perhaps get some spallation in that, but not in the body.

**Hanauer:** Spallation?

**Bradner:** Spallation means the knocking off or blasting off of a thin layer of stuff. Whether this is effective significantly depends upon the relative thickness of that solid material and the wave length of the thickness of the shock front passing through it. If the shock front is narrow compared with the thickness of the solid, then you can get a fair amount out of the solid. So that was what the basis was of wondering about the use of unicellular type of material. There it didn't have to be unicellular, but it had to have air in it.

**Hanauer:** My question on the connection here was: were you using this unicellular material as protection from explosives before you came upon the concept that this would also help with thermal protection? Which came first?

**Bradner:** I couldn't begin to remember. There is that one letter—let me take time out a moment and see if it gives hints that are useful. This was the letter I wrote to Commander McKinney, Commander of the UDTs of the Pacific, Coronado, August 18, 1950. "Lt. Cooper suggests that I contact you concerning the problems in underwater demolition . . . with the thought in mind that some of us here at Cal

could be useful in development of equipment.”<sup>34</sup> So this part of the letter and I think probably the entire letter when we get through it will have to do with the explosive protection. “I was somewhat familiar with the techniques of underwater demolition from the conversations with Draper Kauffman, and Kistiakowsky—how far things have progressed—how satisfactory are the present types of suits? Is there a satisfactory sympathetic detonator?” That’s another subject altogether. “Signaling,” another subject altogether. “Physiological effects of cold water and of oxygen breathing in cold water.” Could be part of the same subject and probably not. “I’d like if possible to drop in and talk to you.” There is nothing in this that says it has anything to do with the divers’ suits. It does show that we were thinking about suits and that we were aware of the possibilities of blast protection. Incidentally, as an aside, there is a significant connection between thermal protection and blast protection.

**Hanauer:** Of course there is.

**Bradner:** So, anyhow, the answer I think is that no, that letter does not say anything about the origin of the wet-suit concept.

**Hanauer:** Before we leave the subject of the wet suit, we do have to talk about this—I don’t know if it’s a controversy or claim—let’s call it a claim by Bascom that Kearny was the inventor of the wet suit. At this point in time, what’s your reaction to that?

**Bradner:** Have you looked at all of that file?

**Hanauer:** Yes.

**Bradner:** I gave Deborah<sup>35</sup> some other stuff yesterday or the day before.<sup>36</sup>

**Hanauer:** I have the correspondence between you and Bascom after his autobiography came out.

**Bradner:** In brief, as I see it—.

**Hanauer:** According to the correspondence, it was kind of left up in the air.

**Bradner:** Yes, and I think that’s all I could do. He didn’t have any information that gave an insight into dates or times. I repeat—and this is very critical—I don’t give a damn who thought of it first, as long as I’m not going around making a false claim. I’d be very happy to continue with the pleasure of being called the granddaddy of it, if it’s valid.

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<sup>34</sup> Hugh Bradner to Lt. Comdr. McKinney, 18 August 1950. Hugh Bradner Papers, 1938-1973 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: McAllister - Marshall." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>35</sup> Deborah Cozort Day, archivist at Scripps Institution of Oceanography.

<sup>36</sup> Bradner refers here to his letter of November 14, 1988 to Willard Bascom, Bascom’s reply on December 15, 1988. These letters have been added to the Bradner Papers, Accession 82-86, Box 2. Scripps Institution of Oceanography Archives, UC San Diego Libraries.

**Hanauer:** Okay. Now there were a number of inventions that you either consulted on, commented on, or perhaps were one of the inventors or co-inventors. I have quite a list here and I'd like to go over some of those and find out what your role was in that. Probably the one we should start with is the underwater contact lens. Can you tell me about your involvement with that?

**Bradner:** Sure. At the time of that first meeting down here, Roger Revelle<sup>37</sup> suggested that it would be really nice to have a face plate which would permit you to see things under water in a normal way.

**Hanauer:** Let me just interrupt for one second. Roger Revelle was not a diver. What was his interest in that?

**Bradner:** He was the director of the study; was a very, very savvy guy; was a very, very close friend. Why not think about that?

**Hanauer:** Okay.

**Bradner:** Anyhow, it sounded like a fine idea, and after floundering around with it for a number of hours, I realized that optically it cannot be done with the conventional situation of a face plate. If you make, essentially, a telephoto lens, you can then restore a good bit of it, but just due to the fact that you are going from an air interface into a water one. And trying to think of ways out of this, modifying the shape of the face plate and so on, just wouldn't work. There's physical principles, it's not a matter of being clever enough. However, if you were to put the interface between the air and the water very close to your eyes, then you might be able to have good vision, both underwater and above. Well, a couple of the guys that I knew in the optometry department<sup>38</sup>—graduate students at that time, at Berkeley. I don't recall whether I went—I'm sure I went to them with the question of what could we do about it. I don't recall whether the final design was based upon joint or their or my input.

**Hanauer:** Do you recall their names?

**Bradner:** I can probably reconstruct them.

**Hanauer:** Okay.

**Bradner:** I'm sure I've got records. Anyhow, I felt that since they were just graduate students and I was several years out of the Ph.D., the kindness would be to put the whole thing under their names. And I repeat: I don't know who started what. What counts is: they did it. I then, with them, got them made commercially. I made up

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<sup>37</sup> Roger Randall Dougan Revelle (1909-1991), professor of oceanography and science policy; associate director and director of Scripps Institution of Oceanography.

<sup>38</sup> "They are the invention of Curtis Nagel, O.D., and James B. Monical, O.D.; the lenses were developed by these two fellows and myself." Hugh Bradner to Mr. Hiram Draper, 12 February 1954. Hugh Bradner Papers, 1938-1973, (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Directory - Dwyer." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

some demonstration test models for turning over to the Navy Medical Lab, Bethesda—was where we turned it over. There’s an amusing story that goes with this, by the way. Livingston and I would, for example, from time to time stick our heads in the bathtub at home and have fun with them; we used them out in salt water and fresh water. They scratched a bit but, boy, they’re worse on dry than they are wet. From time to time I would put one on and wear it, while I was doing acting in a play, so that I could have apparently a dead eye. In other words, they were kind of—.

**Hanauer:** So you could see through them normally on land as well?

**Bradner:** Oh, yes. And anyhow, the UDTs took this back and concluded that it was potentially useful in the form it was intended, namely, if you wanted to dive into the water moving fast or if you were wanting to go up onto the beach and not be as obvious as if wearing a—and so on. In clandestine operations it was useful. But the tough, strong UDTs couldn’t stand having anything in their eyes, so it was abandoned.

**Hanauer:** Was it ever used for any other purposes, as you recall?

**Bradner:** Let me get back to that.

**Hanauer:** Okay.

**Bradner:** The thing that I find doubly amusing in all this is that just about ten years after that, an excellent Navy doctor, Ed Beckman,<sup>39</sup> Captain at that time maybe, conceived the same thing, ended up with what looked like the same package, essentially. Found the same thing. It was great, except the UDTs couldn’t stand that. Now, was it used elsewhere?

**Hanauer:** You may recall I mentioned that, before we started this conversation, that I had read about swimmers in the early sixties were using them.

**Bradner:** Yes, and I didn’t even know about that.

**Hanauer:** You weren’t aware where that design came from or anything?

**Bradner:** I have a vague kind of recollection having heard that it was used in a Hollywood diving production one time. Zale<sup>40</sup> might know that. But they were made commercially by Butterfield in Portland. They existed for—.

**Hanauer:** What was the time frame? Do you recall?

**Bradner:** Dear, dear, dear, dear, dear. I thought I’d made a note of that. The answer is no. It would have been probably—1955 is a pretty fair guess.

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<sup>39</sup> Edward Louis Beckman (1916- ), researcher in underwater physiology.

<sup>40</sup> Zale Parry, diver and actress; set records for women's depth dives; married Parry Bivens 1955.

- Hanauer:** All right.
- Bradner:** Fifty-seven maybe, to be conservative.
- Hanauer:** Let me go down the list of some of the other inventions that I saw in your correspondence. One was the single-hose regulator. What was your role in that and what do you remember about that? Also, if you could put that in a time frame.
- Bradner:** Yes. Well, as you know, the original of the Cousteau-Gagnan—I insist upon both names being there—was a two-hose unit, and the basis of his patent claim and acceptance was that he found to his surprise was if he didn't have the exhale at about the same level as the inhale valve, that it would either be too hard to breathe or it would bubble. Any high school student would have done that—would have said that—but anyhow that's not important. He got the patent. It was, as you again doubtless know from experience, a little bit awkward at times, the hose would catch on something or it would tear or leak, and there's no reason that you shouldn't make the exhaust about the same place as the intake. Particularly if you made the intake valve here and so why not make a single-hose regulator? There's nothing subtle in the concept. Hayden Gordon, who, as I said, was the chief engineer of the Bevatron<sup>41</sup> at UC Berkeley, designed and quote "we" built a few models on it and concluded that to do a really safely engineered design would cost us more than it would the commercial outfits, who could do it equally well. And they would have no problem with having to battle the patent because they were U.S. Divers or whoever it was. And so we abandoned it. It was called "Neptune's Beard."
- Hanauer:** Neptune's Beard! I recall one of the photographs in the current *Explorations*<sup>42</sup> has you with one. I saw the picture also in the Archives. So did you ever turn this patent or this idea over to anybody or did you just let it die?
- Bradner:** Not worth pursuing. Again I'm confident that well before that time other people had done it. The reason that we stopped was that we felt that we were priced out of existence.
- Hanauer:** In 1954, E.R. Cross<sup>43</sup> designed one that he sold but basically they were handmade and he didn't sell many of them, and I think that it was around '56 that Scott Aviation came out with their little plastic one. And then of course the first successful one was the Waterlung which I saw in your correspondence that you had tested or you were involved in the testing of that.
- Bradner:** Yes, we tried here at Scripps to test everything interesting or useful. But anyhow, no, the Neptune's Beard was not a pursued thing. It didn't solve a needed problem that hadn't already been solved.

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<sup>41</sup> Particle accelerator at the Lawrence National Laboratory.

<sup>42</sup> Cindy Clark, "Around the Pier," *Explorations* 6 (1): 31 (Summer 1999). Photograph from Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>43</sup> Ellis Royal Cross (1913-2000), *Underwater Safety, Including Curriculum for Sport Diving Training Program* (Los Angeles: Healthways, c1956).

**Hanauer:** Okay. You write about a decompression meter, a mechanical decompression meter that was designed by Walter Munk and who else?

**Bradner:** Well, Gordon Groves<sup>44</sup> and Walter Munk were the guys, and yesterday I found a reference to their SIO paper<sup>45</sup> that I turned over to Deborah. So that info is available here locally now. I don't recall whether Walter expressed a desire for such a thing and went ahead working on it or whether Gordon did or whether I did it in some discussion with Walter. Any one of these things could have been reasonable. The question is: how do you do it? And on what basis the physiology is assumed. In 1950 the experimental diving unit in Washington, D.C. was charged with making of decompression tables. This had been done much earlier by Haldane for the caisson disease. And the physical picture that they adopted was that the body can be considered a number of different tissues which are permeable to gas, which had different characteristic absorption and evolution times. And that the allowed decompression was based upon the sum of these evolutions, in parallel. Walter and Gordon—I think Gordon—without arguing about the validity of that, made a little model in which were—I think it was three tissues, chambers, in series, not in parallel. So that gas comes out of one and into the second and so on. The thing was hard to see either physiologically or physically, how it's a valid model. However, by the right choice of time constants they were able to get something which for a useful significant range of dives, modeled, duplicated the diving tables well enough. So, we did some mutual discussions of this. I think I probably did some of the mathematics of the series versus parallel gas evolution with or for Walter, or whatever. I don't know how far that got carried. I don't think that it was ever truly tested by the Experimental Diving Unit.

**Hanauer:** From what I read, there were some prototypes that were produced by a company called Foxboro?

**Bradner:** That's something altogether different. I want to tell you about that next.

**Hanauer:** That was a different decompression computer?

**Bradner:** Indeed it was.

**Hanauer:** Tell me about that.

**Bradner:** Well, about that is very simple. My brother was the director of research for Foxboro Instrument Company.

**Hanauer:** His name?

**Bradner:** Mead Bradner. He's "me", and I'm "you."

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<sup>44</sup> Gordon William Groves (1927- ), physical oceanographer, Scripps Institution of Oceanography and University of Hawaii.

<sup>45</sup> G.W. Groves and W.H. Munk, *A Decompression Gauge for Divers*, SIO Reference Series 53-64, December 1953.





Hugh Bradner with diving suit and single hose regulator, "Neptune's Beard." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

**Hanauer:** Okay.

**Bradner:** At that time Foxboro was the best known—I think maybe even the biggest—producer of control instruments for industry in the country. So I asked Mead if they would put together a three-chamber—again I think I’m right, it was just three—unit with parallel rather than series, in other words something which would mock up the assumed physiology. They built one and turned it over to the Experimental Diving Unit for tests. The problem in the thing turns out that the data that they were using, they confused—it’s my fault for not being on the ball at that period—confused between half time and one over  $e$  time. These terms mean something to you?

**Hanauer:** Half time does; one over  $e$  time does not.

**Bradner:** Well, the constant  $e$ , which is .3178 whatever. If things are decaying exponentially, they can decay exponentially to any base that you like: factor of 10, or factors of 3, or whatever. Half time normally means the length of time for exponentially decaying radioactivity, or gas evolution or whatever to come down to half the initial rate.

**Hanauer:** In this context we’re talking about outgassing—ingassing and outgassing.

**Bradner:** Yes, right.

**Hanauer:** Well, specifically outgassing.

**Bradner:** Yes. Whereas, one over  $e$  means that instead of the length of time to come down to half, it would come down to one over  $e$ . That result being that here was a device which could be tested by you or me or any reasonably intelligent person and determine did it agree with what its specifications were. No, the Experimental Diving Unit wasn’t quite that sophisticated. If it didn’t come to exactly the gas pressure versus time of the diving tables, we can’t make any use of it. It was not possible to get those people who had once denied it—I say they denied it because of naïveté. But anyhow, it was impossible to get them to pick it up more. As you know, there are [decompression computers] on the market now with good simple solid-state electronics. Lots of good ones, based, I think in all cases on the Haldane parallel chamber concept—the amount of overpressure that you allow, whether you get one step more sophisticated. There were several little glitches in the decompression tables that the Navy used, where they calculated them on the Haldane principle and then found that they bent a few too many people or didn’t bend enough, so they changed the allowed  $m$  value—over pressure value—and went off on a new slope.

**Hanauer:** Whatever happened to the Foxboro computer? Once the Navy rejected it. Was it ever produced?

**Bradner:** Oh, no, no, it was not ever produced. Mead abandoned it, and I suspect that when he died a year or two ago, it was probably in the pile of stuff in his basement.

- Hanauer:** I recall that SOS came out with their decompression meter in 1959. Was that a parallel thing or a derivative thing? Do you have any opinions on that?
- Bradner:** I have not paid enough attention to this to say anything. Do you know Red Howard?<sup>46</sup>
- Hanauer:** I know who he is.
- Bradner:** Well, Red for a while was following this quite well and would be the one to ask if you care about this. Stuart Mackay<sup>47</sup>—he and I together but he was really the leader of it—did some calculations for mixed gas decompression, and in the course of that developed tables. We didn't make any decompression computer.
- Hanauer:** Okay. The tank-integrated BC.<sup>48</sup> There's a drawing in your files of the tank-integrated BC that you designed and used.
- Bradner:** Well, I'll tell you. It's hard to believe nowadays, but there was a time, like in 1940s, 1950s, when you slung a bottle on your back, normally with a back-pack harness fastened to the bottle, but not always even that, and the concept of having a BC was the next step in it, where a BC we used more often than not for most of us was something that you liberated from the airline, with their approval, of course. But, in other words a flotation vest, completely separate from any scuba gear, and then the next step was to attach—some people favored attaching the scuba bottle to the buoyancy compensating vest, where the BC was not being used for buoyancy compensation, but for safety and rescue. Anyhow, it was sort of a novel question— invention? No, but maybe it made sense to have your bottle permanently attached to your BC, so that if you had to jettison it, it wasn't lying on the bottom of the ocean. But, on the other hand, according to some people, maybe it would be better to jettison the bottle and keep the flotation vest, and so on.
- Hanauer:** So you made this strictly for your personal use? Or did you also make it for friends or what?
- Bradner:** Oh, I'm sure I made it for friends. We certainly didn't ever go in the market on it, build it as a commercial venture.
- Hanauer:** Just so that the people reading this know what we're talking about, could you describe it a little bit? As I recall, the BC was attached to the back plate, the backpack.
- Bradner:** There have been a number of designs, of course, which depended upon the mood of the month. But the one you're referring to, I think, was an aluminum plate that held

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<sup>46</sup> Robert Seth Howard (1950- ), *Pragmatic Approaches to Shallow Water Decompression Studies*, Scripps Institution of Oceanography dissertation, UC San Diego, 1978.

<sup>47</sup> Ralph Stuart Mackay (1924- ), biophysicist, University of California, Berkeley.

<sup>48</sup> Buoyancy compensator.

some tie-down straps and then the buoyancy-compensating vest was—I think—strapped to that plate. It may have been riveted to it, probably not. And what else?

**Hanauer:** Was the flotation in the back or over the shoulders in front? Do you recall that?

**Bradner:** Again it would have depended upon the mood of the month.

**Hanauer:** So there were several models?

**Bradner:** Oh, yes.

**Hanauer:** All right, you worked on a UDT retrieval system, for retrieving UDT swimmers out of the water.

**Bradner:** Yes. Well, this was the result of my spending some time with UDTs and seeing that the standard technique of recovering a swimmer in the water was to shoot a fairly fast little boat past him and have him grab along and have people grab onto him and hope that he can get up on board before you come to the next swimmer, or have to abort that poor guy. And I don't remember, a whole bunch of little gadget designs that we played with. I think the one that was the most satisfactory was a set of loops that the swimmer could grab his hand on, which normally rode down at water level, sort of a little bit ahead of the boat, and when you grabbed it, then that would swing it over and it was pivoted with a shaft in such a way that, as it swung over the boat, it would also rise up enough to get him over the gunwale, and then he could let go, and then it would swing around for the next guy.

**Hanauer:** Well, I think you're being modest here, because I recall seeing films of UDT swimmers being pulled up on the inflatable boat by these loops. So you invented those loops? You were the one who—?

**Bradner:** God knows all that kind of thing. All I can say is that before that time it was not normal, at least not in this country or as far as I know not normal anywhere else. Today there is probably something far, far superior. I was involved with the guys messing around with it, sure. You don't call this invention unless it's something that a lot of people had been stewing about how to do and you make a breakthrough. Then you can say, "Yes, I made the breakthrough." It's very rare to find or do something that hasn't already been invented several times before.

**Hanauer:** You know, I found this in my oral history interviews that, for example, the Bottom Scratchers,<sup>49</sup> Jack Prodanovich and his face-mask thing. There were people in Europe and there were people in Japan who were making face masks and goggles, but there was no correspondence between them. None of them were aware of the others.

**Bradner:** There were probably people in Cleopatra's retinue that did it.

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<sup>49</sup> First diving club, founded in San Diego in 1933 by Jack Prodanovich, Ben Stone, and Glen Orr.

- Hanauer:** Okay, let's continue. A semi-closed circuit breathing apparatus. You did advisory work in that? What was your involvement in that?
- Bradner:** Yes, advisory and joining with—Chris Lambertsen was sort of the guru of it at the time. But the whole question of how do you make a gas-breathing unit that is significantly secure from an enemy seeing it, which will permit you to stay deeper longer than the present air scuba or closed circuit? Closed-circuit mixed gas has got engineering problems. Hal Edgerton<sup>50</sup> drowned his son trying out one of them.
- Hanauer:** Who did?
- Bradner:** Hal Edgerton.
- Hanauer:** Oh, Edgerton, yes.
- Bradner:** So, this was another one of these things where there were a number of approaches being worked on, several of them in Europe prior to the U.S., incidentally. And, sure, I messed around with Lambertsen and Goff<sup>51</sup> and several of the people on the East Coast, with a talk-talk type of blackboard drawing and so on. We designed some things and argued whether they would be any good. I don't recall having made any contributions that somebody else hadn't already made or wouldn't already make.
- Hanauer:** Okay. What about your work with shark repellent?
- Bradner:** Trying out a few things that other people were touting. I can't remember. I certainly was not boldly trying out the sharks.
- Hanauer:** Okay. There was mention of a full-face mask with peripheral vision for UDT.
- Bradner:** There again, it's a hard thing to picture today but the masks at that time were a simple oval glass and, because of refraction in the water, you really didn't see things out the side at all. It looked as though you were but in fact it was some angle like this. All you need to do is to put the glass plates like this. It's obvious. They just didn't happen to be on the market.
- Hanauer:** But were used by UDT?
- Bradner:** Ultimately used by UDT, and by sports divers and so on.
- Hanauer:** I had one of the old U.S. Divers masks with the bends here, but they used to—they finally cracked and that was why they were taken off the market. Then they came up with the three-window mask.

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<sup>50</sup> Harold Eugene Edgerton (1903-1990), electrical engineer, inventor of underwater photographic devices.

<sup>51</sup> Loyal Glenn Goff (1915- ), environmental physiologist; consultant on the NAS/NRC Underwater Swimmers Panel, 1952-1958.

- Bradner:** Mmh, which tend to be a little massive and have a little larger dead air space and so on.
- Hanauer:** They're pretty passé, now, but I remember that old fishbowl .
- Bradner:** Oh, I liked that.
- Hanauer:** Underwater transducers for locating divers.
- Bradner:** There again, one of the things that was needed. There were various reasons for wanting to locate divers. One is just that of a transponder. It could be a transponder which you'd ping on and it beeps back. It depends upon the operation that you're trying to do. Another one would be just that he'd be wearing something which every few seconds would click and with an ultrasonic locator you could point to him.
- Hanauer:** What was your role in this?
- Bradner:** Messing with them. Trying to get some pingers some place, or some transponders some place. Certainly nothing novel.
- Hanauer:** Okay. There's also correspondence with ONR regarding the Navy's purchase of the *Trieste*.<sup>52</sup> Did you play a role in that?
- Bradner:** I haven't thought about it. My guess is that, if I played a role, it was not a particularly helpful one. Why don't you tell me?
- Hanauer:** Well, they asked you for a reference on Piccard. I forget who it was you were corresponding with at ONR, but you were recommending that—the Navy was apparently asking you whether it was feasible or appropriate. You kind of went to bat for Piccard.
- Bradner:** Well, I don't remember dates on all of this. Do you recall?
- Hanauer:** It was the late fifties, obviously. Mid to late fifties because it was 1960 that they made the deep dive.
- Bradner:** Well, let's see. Fifty-five, I think it would have been. No, '54, the fall of '54, when I was over at CERN<sup>53</sup> in Geneva, again pursuing my profession, but I did get pretty well acquainted with Jacques Piccard at that time, and I would have endorsed him.
- Hanauer:** In your letter you mentioned that the financial problems that they had had in pursuing this.

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<sup>52</sup> Bathyscaph built by Auguste Piccard (1884-1962) and Jacques Piccard (1922- ), which made a record dive of 35,810 feet in the Mariana Trench in 1960.

<sup>53</sup> Conseil Européen Pour la Recherche Nucléaire; now the European Organization for Nuclear Research.

**Bradner:** I haven't seen that letter in many decades. Let me comment, and here again this is not for this, but to give you a bit of perspective. I have by audaciousness or luck or whatever at various times been asked about recommending somebody. I would like to claim that my input was useful on Herb York's<sup>54</sup> coming here as chancellor. It was not useful in the letter that I sent to Clark Kerr<sup>55</sup> strongly recommending Roger. It's very difficult to say if somebody is kind enough to ask you for your opinion, whether the opinion you give back has been of any use. So.

**Hanauer:** Okay. We've been going about an hour now. The next section that I want to ask you about is some of the people you interacted with. Do you want to take a break right now?

**Bradner:** No, but I would like to hit a few of the other things.

**Hanauer:** That was kind of my wind-up question for this section on inventions and developments.

**Bradner:** Well, why don't I keep the floor on that subject for a few minutes more because I did try to think through a little of this. First off, note that there was a period of 1950, 1951 when I was out on the Eniwetok bomb tests, and I did some diving, and the obvious question is what did you do differently then? And then in 1951 and fairly shortly after that for several years I was in touch with the UDTs and in various committees where we worried about their equipment, and, in connection with that you mentioned the face-plate optics and underwater contact lenses, the boat swimmers.

A thing which is trivial but was a real need in war games: how do you say, "Bang, you're dead," without actually achieving it. So I messed with that sort of thing. I made calculations.

**Hanauer:** Could I interrupt for just a second?

**Bradner:** Sure.

**Hanauer:** Without getting really super-technical, how did you solve that problem?

**Bradner:** It was simply a matter of getting a device which would make an appropriately heard high-pitch ping when activated by the pressure signal on a not-too-violent shock. So you make a little gadget.

**Hanauer:** An electronic gadget that they wore?

**Bradner:** Yes. Very little use of that. I made some calculations, recommendations actually to make motors using nuclear reactor waste, as a way of having a very long duration, moderately low power motors—boat engines. That I think did have some novel

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<sup>54</sup> Herbert Frank York (1921- ), professor of physics and chancellor of UC San Diego.

<sup>55</sup> Clark Kerr (1911- ), UC Berkeley chancellor 1952-1958 and University of California president 1958-1967.

things in it, but it wasn't used. A thing that I do consider an invention concept was a red light to use at night. Are you familiar with this?

**Hanauer:** When I was in the Army, I know we had, when we were working on night vision.

**Bradner:** This is a different thing altogether. The transparency of water as a function of wave length goes through a very sharp maximum in what we call the visual, particularly the blue-green part of visual, but if you're looking at red wave length light, like the depth of fairly deep red, the absorption coefficient is higher by factors of ten to a hundred than it is in regular light. So if I have a swimmer's lamp with a deep red filter on it, I can see at a few feet distance when I'm down with it but nobody from ten or fifty feet away can see it.

**Hanauer:** Because of the absorption of red by seawater.

**Bradner:** Yes. And that was—I don't know that it's ever been used. To me that was cute, because it was something that hadn't been thought of before. On the mixed-gas breathing gear I messed around a bit, actually made a few sample controls of oxygen regenerator materials, and can go into that further.

**Hanauer:** Let's do that now. You were interacting there with Chris Lambertsen, Parry Bivens,<sup>56</sup> Ed Lanphier?

**Bradner:** Not on the regenerators. The regenerator was simply trying to find safe ways of getting materials that would give off oxygen either from moisture or from CO<sub>2</sub> or just by having a vapor pressure which was appropriate to the surroundings, and so on. The whole notion of using chelates for this was, so far as I know—.

**Hanauer:** I'm not familiar with chelates. Could you explain, please?

**Bradner:** Oh, chelate is a fairly broad chemical term. In particular, some compounds with—maybe compound is even too strong a word—some materials, let's say, with an iron and oxygen of appropriate valence will give off the oxygen. ##

**Hanauer:** ## A long leader on this tape. Now we're on.

**Bradner:** Well, I simply would say that one of the things I looked into was the effects of high power sonar on divers. That should be sufficient.

**Hanauer:** Without violating any security, can you go into a little more detail on that? If not, then we'll just leave it.

**Bradner:** Leave it.

**Hanauer:** Okay. You were talking about additional innovations that you participated in.

**Bradner:** Oh, that's enough. *[Laughing]* We saturated the thing.

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<sup>56</sup> Parry Bivens (d.1963), physician, diver, and inventor.



**Hanauer:** We didn't talk about the speaking dive problem. I had that on my list as well.

**Bradner:** Okay, that one was one in which: if you are trying to speak using an ordinary open circuit scuba, as you know it's not too satisfactory because of the bubbling of the air, and various ways around that have been tried. Similarly, if you have a closed-circuit unit, there are problems. One of the more fundamental ones is, because of this difference of acoustic impedance of water versus air that I mentioned in other contexts, it's desirable to have a leverage system such that the diaphragm which is exposed to your mouth is coupled by an appropriate, call it if you wish "gear ratio," to the diaphragm that's out into the water. It's not a trivial thing to design such a device. So I made a few various designs. I think I remember Chris Lambertsen having also tried a design. Just a gadget.

**Hanauer:** Okay. I want to move on to some of the people that you were involved with. When you started diving or when you became involved in diving, were there any specific role models that you had?

**Bradner:** No.

**Hanauer:** Okay, let's talk about some of the people you interacted with.

**Bradner:** Wait a minute. I might say Bob Livingston was a role model.

**Hanauer:** To what extent and how?

**Bradner:** Just a super bright guy, knowledgeable in physiology and in physics, very competent diver, very fine buddy to be with. We got acquainted there essentially at the time of the Swimposium, so that was well after the time that I "started diving." I was too selfish to have role models.

**Hanauer:** There is a report from Bob Dill<sup>57</sup> about the 225-foot dive that you made with Limbaugh and himself—at that time the deepest dive ever made at Scripps. Dill talks about how he felt a little apprehensive on the dive and goes into some detail on it. Do you recall anything about that dive?

**Bradner:** Yes. First off, I confirm the divers and the depth. I trust Dill. I remember that as a result of that dive Limbaugh gave me a 210-foot card. Why the difference between that and the alleged depth, I don't know. But anyhow, not important. My recollections are the following: First off, we—I don't know whether this was I or Connie and I or Dill and I or what—put together a little storage-battery light, and, at that time the notion of making an oil seal over the top was a little bit, well, there was no such thing as a standard underwater power source that I knew of at that time.

**Hanauer:** This was 1953, I believe.

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<sup>57</sup> Robert Floyd Dill (1927- ), "A Deep Dive to 225 Feet in the Scripps Submarine Canyon," 1953. Hugh Bradner Papers, 1938-1973, (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Dill." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

- Bradner:** Yes, that would be reasonable. So, anyhow, we made a little light which I carried down, and the first thing I remember is the surprise at how pink everything seemed to be as I went down. The second was that when we got to the bottom, I think I definitely felt a little bit of euphoria, not enough to be a concern, but as I started up from this essentially bounce dive, I was not alert enough to see that I was going to bump into a little overhang on the cliff wall. So I think yes, I probably did have some little bit of rapture. That's all I remember of it.
- Hanauer:** Also, according to Dill's paper, this was required to be an instructor in the Scripps program, a 200-foot dive.
- Bradner:** I wouldn't remember.
- Hanauer:** Why did you participate in this dive? Were you qualifying for something or were you just invited along?
- Bradner:** I think that was during one of the periods when I was spending sort of like a month a year down here at Scripps and had a chance to do the dive and did it. It's a little bit, in a sense, like the chance I had to make a mixed-gas dive with Doug Fane's people, which I didn't, because I wasn't smart enough to realize that when they gave a departure time, they meant that's "up-anchor," so I was there ahead of time waiting to go into the parking lot, and they were gone.
- Hanauer:** Tell me a little bit about Connie Limbaugh. What kind of a person was he? What were your interactions with Connie?
- Bradner:** Connie was an encyclopedically knowledgeable guy on diving techniques, and also was very good at animal behavior. I think I remember that this particular anecdote applies to him. Down in the Gulf at one time, it had been said that if you startled one of the big manta rays it would hit you with its flipper, and so he jumped in in front of it and got knocked out. They hauled him back aboard. [He said,] "It could have been accidental, let's try it again," and got hit the second time. I think that applies to Connie. It certainly could apply to him in terms of his type of personality. Very strong swimmer, very strong on insisting on safety regulations for everybody except himself. What else? Excellent teacher, organized courses and insisted upon—. [*Break in tape sound.*]
- Hanauer:** This brings us into your role with the Scripps diving program. So could you tell me how you were involved in that, on the Diving Control Board?
- Bradner:** I haven't thought about this in a very long time, so this is going to be highly qualitative. I think that Connie was clearly the person, the organizing entity, the prime entity, in the diving program of Scripps, and that simply because I was a competent swimmer/diver, I was going along with it as it were. There were a couple of letters that I ran into yesterday that surprised me, in this sense: November 25,

1953; January 18, 1954.<sup>58</sup> The November one says “Thanks for sending your diving regulations outline. Some things that might be added to your list are ‘Don’t try to use scuba unless you are at least good enough to pass the Red Cross senior lifesaving test’ and ‘Don’t go on down until you’ve cleared your ears.’” Things of that nature. It must imply that Connie had erred in the direction of having a very brief outline because it would be pretty presumptuous for me to tell Connie that he should add to his diving regulations “Always rise slowly while breathing.” But it would imply that I was at least made to feel that it was a significant input. And you can judge better than I probably from there on.

I was, except for one month a year, in Berkeley or off doing bomb stuff and so on. I did help him set up a diving course at Berkeley, where he came up and put some of the would-be scientific divers through their paces up there. I was a member of the statewide Diving Control Board, I guess partly because I knew people at this end as well as Berkeley, and I was the only diver up there except for a few of the guys that I had trained. I question though whether I made any significant inputs.

**Hanauer:** You say you trained some of the divers at Berkeley. Was this formal training or just—? Nobody ever waved their hand over your head making you an official instructor or anything like that?

**Bradner:** No.

**Hanauer:** So this was in the era when experienced divers would train the new divers.

**Bradner:** Yes.

**Hanauer:** Okay.

**Bradner:** Needless to say, I was aware of the diving regulations as being promulgated by Scripps or by us or whatever.

**Hanauer:** Who were the major people that you interacted with in UDT?

**Bradner:** Oh, boy. Doug Fane, of course, over several years, fairly closely. Sometimes we’d argue a lot.

**Hanauer:** I don’t want to interrupt your train of thought.

**Bradner:** At the time I would have been pretty well acquainted with the officers of the East Coast, as well as out here. I think that among the UDTs out here themselves there were a Giannotti and a Gallarti, I think.

**Hanauer:** Are you talking about Ray Ghelardi,<sup>59</sup> who was here at Scripps?

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<sup>58</sup> Hugh Bradner to Conrad Limbaugh, 25 November 1953 and 18 January 1954. Hugh Bradner Papers, 1938-1973 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Limbaugh, Conrad." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>59</sup> Raymond Joseph Ghelardi (1920- ), Ph.D. in biological oceanography, Scripps Institution of Oceanography, 1961.

- Bradner:** I probably am, and then therefore strike that one. I haven't thought about these names in fifty years.
- Hanauer:** Tell me about Doug Fane. What kind of a guy was he and what kind of interactions did you have with Doug? I interviewed Doug as one of my pioneers. It was too late to get him in the book. But he was one of the more interesting people that I talked to.
- Bradner:** Well, then, you probably have as much of a perspective on it as I. Let me just recap a couple of anecdotes. One, the only thing I know of that Doug was frightened of was oxygen poisoning, oxygen convulsions. He was so vehement about that that he was irrational in what the levels of capability and danger of oxygen, pure oxygen, were. He had gotten hit once and apparently it was really something. Another aspect of the guy—in complete contrast with that—is I remember seeing some movies that he was taking of his divers locking out of submarine torpedo tubes, and he was with a very steady camera photographing these people going by and at one time there was a significant size shark head in his field of view—blocking him—you see his hand reach out and *push* the shark aside. That's guts.
- Hanauer:** This was when he was working with Fenimore Johnson.<sup>60</sup>
- Bradner:** Sounds right. He tended to shoot from the hip. To a certain extent in that context I would liken him just a wee bit to Bill Nierenberg.<sup>61</sup> Very knowledgeable, maybe shooting from the hip. Bill, by the way, was another one that I made an endorsement on; figuring he'd be a great guy for this campus. Well, Fane. Certainly he had the well being of his own troops heavily in every move he did. He fought for them, he fought for the service.
- Hanauer:** How did he accept the input of—.
- Bradner:** Of us civilians.
- Hanauer:** Of you civilians and you Ph.D.s?
- Bradner:** Generally very, very well. Very cooperative and helpful. I do recall, however, having written one letter appraising what I felt to be the limitations on the current ability of the UDTs . For example, limitations in terms of duration of operation in cold water. And he really raised hell with me, because he felt that I was not giving—I was not admitting to the capabilities that they truly had. I think I was right, but—.
- Hanauer:** To what degree was Limbaugh influenced by his interactions with Fane when he set up the first diving courses? Because, from what I have read and from what I've

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<sup>60</sup> Fenimore Thomas Johnson (1919- ), medical research, Upjohn Company; National Research Council panel on underwater swimmers, inventor of underwater camera housings.

<sup>61</sup> William Aaron Nierenberg (1919-2000), director, Scripps Institution of Oceanography and vice chancellor of Marine Sciences, UC San Diego.

heard, they were very kind of militaristic and I'm just wondering whether he was influenced by Fane, to what degree Limbaugh and Fane interacted at the time.

**Bradner:** I haven't the slightest idea.

**Hanauer:** Okay. Some of the other people that you had a lot of interactions with—you've already touched on Bob Livingston. Can you tell me a little bit more about Bob?

**Bradner:** Oh, qualitatively, Bob was the white knight, really, of young Ph.D., M.D. scientists. He was personal assistant or some such thing to the director of the National Science Foundation, he was a professor of physiology/anatomy at UCLA. He was one of the prime people in the early days of ONR. I wouldn't guarantee that memory. Just an ideal, very creative scientist.

**Hanauer:** Was he an active diver himself?

**Bradner:** Oh, yes, yes, yes, yes. Very good one.

**Hanauer:** What about John Foster? The pictures of the wet suits have him in it.

**Bradner:** Well, Johnny was one of the gang at Rad Lab Berkeley. In that gang, everybody was equal. None of us were quite equal to Lawrence. Johnny was one of the very enthusiastic, active guys in the place. He was the best coordinated man I think I've ever seen. I recall once when we were going to his house, this big Southern mansion style of pillars going up to the second floor, the ground floor was locked, so he simply, how shall I say it, *flowed* up the pillar to the second-story window. He was a guy that had just taken up ski-jumping because he had injured his back in a motorcycle accident and inside of a few months of ski-jumping to fix his back he made the Canadian Olympic team.

**Hanauer:** Wow.

**Bradner:** I repeat, I think I've got the right tale and the right man. Again, it's only been fifty years.

**Hanauer:** Why was he the model for the wet-suit pictures? Was it simply because he was there?

**Bradner:** We all played around with it, and he was a beautiful specimen of a man. Don Cone was also an excellent specimen of a man, just bigger in all respects. He was more like what you normally would view a UDT to be.

**Hanauer:** Okay. Robert Dietz.

**Bradner:** Do you know Bob?

**Hanauer:** No, I don't.

**Bradner:** Well.

**Hanauer:** I just saw a lot of correspondence<sup>62</sup> between you and him.

**Bradner:** Dietz, not Dill?

**Hanauer:** There was a little bit with Dill, there was more with Dietz actually.

**Bradner:** Okay, I'd forgotten all of this. Dietz was a geophysicist, physical oceanography, was probably the first modern times proponent of continental drift—commotion in the ocean. Like so many of the Scripps and UC people, like I guess probably I too, a little bit impetuous, shall I say? There was a case in which Dietz had found an ancient fossil, I think the story was, was driving home with it, was stopped by the policeman for wild driving or too-fast driving or something of the sort, was so excited about this find that he had made that the policeman said, "Go on home." You'd find a lot more useful things about Dietz in connection with the deep-diving, the bathyscaph and stuff. He was one of the very good Scripps people.

**Hanauer:** Walter Hahn.

**Bradner:** Walter Hahn was, I think, the secretary to the Committee on Undersea Warfare and/or probably had several other hats in Washington hierarchy. Very well organized, very thorough, a combination of knowing science. He wasn't a creative scientist but he knew how to set up meetings and get people working. What else about Walter? It's a long time.

**Hanauer:** How about Chris Lambertsen?

**Bradner:** Chris was, as I've said earlier, probably was the world's guru of gas exchange in the human body at that time. Got involved in swimmers' problems, I don't know but I would suspect that he might have gotten involved as Livingston did by way of decompression of pilots, high-altitude pilots.

**Hanauer:** I know that during World War II the OSS<sup>63</sup> was using the LARU,<sup>64</sup> the Lambertsen apparatus. The UDT was not but apparently during World War II, which places it in the forties he was designing closed-circuit oxygen .

**Bradner:** I don't remember whether he was. Was he the one to whom one can attribute the submarine escape equipment?

**Hanauer:** That I don't know. I do know that he made the rebreathers that were named after him.

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<sup>62</sup> Robert Sinclair Dietz (1914-1995). Hugh Bradner Papers, 1938-1973 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Diehl - Dietz" and Box 3, "Correspondence: de Lassus - Dietz, 1953-1956." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

<sup>63</sup> U.S. Office of Strategic Services

<sup>64</sup> Lambertsen Amphibious Respiratory Unit, a self-contained underwater oxygen breathing apparatus developed by Christian Lambertsen for the U.S. military in 1939.



John S. Foster in early wetsuit, c. June 1953. Hugh Bradner Papers, 82-57, Box 2, Folder 24, "Photographs and Sketches." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

**Bradner:** Yes. I think his official title was professor of pharmacology at the University of Pennsylvania or some such thing. He was definitely the senior statesman, very intense, very knowledgeable on the physiology of decompression, recompression, narcosis. Did not like to see drugs used. There are some drugs that apparently affect the onset of the bends fairly usefully but he very wisely, I think, told us to lay off.

**Hanauer:** Now was this something that you had been working with?

**Bradner:** No, no, not at all. It's just that I worked with him at times, and I was inquisitive about decompression. When I say he told us to lay off, I don't mean that we had been using them or trying them, not at all. It's just that his counsel was that you should avoid getting into the state where the bends are the probability, rather than trying to treat them beforehand.

**Hanauer:** Parry Bivens?

**Bradner:** Parry. I may be quite unfair to him, because I don't remember enough. If I do recall correctly, he built commercially some decompression chambers. I think I interacted with him on some decompression calculations or something of the sort. He was knowledgeable, and there were darn few people that could handle the math at that time. I knew him mainly through Zale. I don't recall what that family situation was. I have a vague recollection Zale Parry was raised by Parry Bivens' family—something of that nature. Does this ring bells to you?

**Hanauer:** No, it doesn't.

**Bradner:** Well, then strike it from the record because I don't remember.

**Hanauer:** Zale met Parry when she was a secretary at one of the aerospace companies, and he was an engineer working there.

**Bradner:** Okay.

**Hanauer:** And later he left engineering to go to medical school.

**Bradner:** We have to ask you these things. My memory is not at all trustworthy.

**Hanauer:** There is one letter where you kind of questioned Bivens's credentials and then in a later letter, say "Strike what I said before because he really is knowledgeable," and apparently this was in connection with a decompression computer that he was working on at the time.

**Bradner:** Well, thank you.

**Hanauer:** You don't recall that?

**Bradner:** No.



- Hanauer:** Okay. Andy Rechnitzer.<sup>65</sup>
- Bradner:** Andy's still around. You should talk to him.
- Hanauer:** I have.
- Bradner:** All right. Say no more. He's a wonderful guy.
- Hanauer:** Are there any other people that you interacted with at that time, in that era that I haven't mentioned that you want to talk about?
- Bradner:** That I want to talk about. Thanks for putting that in, because I just don't remember any of these situations or people until I go back and really think it through a lot. I did get pretty well acquainted with the divers of the Mediterranean area during my two stays over there at CERN.
- Hanauer:** Darn, I'm drawing a blank now.
- Bradner:** Good! *[Laughter]*
- Hanauer:** My turn. You know, the guy that invented the Rebikoff [torpedo].
- Bradner:** Rebikoff.
- Hanauer:** Dimitri Rebikoff.<sup>66</sup>
- Bradner:** I can characterize these people quite candidly. I don't know how useful it is or even how accurate. But Rebikoff was bad-mouthed all over Europe, largely because he was so aggressively outspoken, but he was a *damn* good engineer, an inventive one. I don't think he made fundamental concept contributions, let's say to decompression, but he knew his optics, he knew his mechanics, he made very useful devices, was a good reliable guy to swim with. I think I swam with him only once, but I remember having been pleased. Having the general feeling that he had been improperly downgraded.
- Hanauer:** Doug Fane felt the same way, as a matter of fact. Apparently at the time Rebikoff had a falling-out with Cousteau, and Fane really kind of jumped on Rebikoff's side, jumped to his defense.
- Bradner:** Well, good. Cousteau I interacted with, a bit back in the early days before he was the deity. I think he made—I tend to phrase these things in terms of Ernest Lawrence<sup>67</sup> and the Radiation Lab at Berkeley—I think he made in some respects the same sort of contributions to the world that Ernest Lawrence did. Namely, not

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<sup>65</sup> Andreas Buchwald Rechnitzer (1925- ), developed diver safety training program with Connie Limbaugh at Scripps Institution of Oceanography; program manager and scientist-in-charge for U.S. Navy's bathyscaph *Trieste* dives.

<sup>66</sup> Dimitri Rebikoff (1921- ), engineer, inventor of underwater photography equipment and underwater vehicles.

<sup>67</sup> Ernest Orlando Lawrence (1901-1958), Nobel laureate and founder of the Lawrence Radiation Laboratory at UC Berkeley.

by a large number of brilliant things, but rather by being a promoter in the proper sense of the word. If it hadn't been for him, these other things would not have happened. To a certain extent, one might say that even in the early days, Cousteau was promoting to his own advantage, where Ernest Lawrence didn't. But, regardless of whose advantage it was, what he did was very significant.

**Hanauer:** You also carried on correspondence for a while with Philippe Tailliez, mostly in French, which I couldn't read.

**Bradner:** My French is probably not very legible anyhow. Tailliez was the boss of the French Navy group. And I did, while I was over there, manage to spend a little bit of time talking with, diving with the French and the Italians.

**Hanauer:** Can you tell me a little bit about Tailliez?

**Bradner:** I don't remember him that well. Except as the Commandant, he was boss man.

**Hanauer:** At the DEMA<sup>68</sup> show this past year—that's the kind of international convention of the diving industry—Tailliez was given an award. He's ninety-four years old now. He dives on his birthday every year. Dumas.<sup>69</sup> Did you meet Dumas at all?

**Bradner:** Yes. I'm trying to remember whether he was my diving buddy on that dive. Let's say tentatively, I think he may have been. They were several years ahead of the U.S. Competent people, the people I talked with, particularly among the sports divers, ranging from very well educated, well informed, intelligent people, down to—down is the wrong word. The guy who was the head of the diving club, sports diving club, in Cannes, as I remember, was Broussard, whose profession was automobile mechanic. Who else did I—?

**Hanauer:** Did you ever meet Hans Hass?

**Bradner:** No, I don't think so. I have some things he's written.

**Hanauer:** Don't we all. Of all the people we interviewed, Hass was the one that really, kind of, I was in awe of. I was not in awe of too many people. Hass was one.

**Bradner:** Did you ever get a chance to interview Heberlein? Hermann Heberlein?

**Hanauer:** No, I saw some correspondence<sup>70</sup> between you and him.

**Bradner:** We've been very good friends over the years.

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<sup>68</sup> Diving Equipment and Marketing Association

<sup>69</sup> Frédéric Dumas, author, with Jacques Yves Cousteau, of *Le monde du silence* [*The Silent World*] (Paris, Éditions de Paris, 1953).

<sup>70</sup> Hugh Bradner Papers, 1938-1973 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Hahn - Hemingway" and Box 3, "Correspondence, 1953-1956: Heberlein, Hermann." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

**Hanauer:** Tell me a little bit about him.

**Bradner:** Yes. Well, this is more anecdotal than true memory now. First off, he was not the senior, not the oldest son but the next, in a very well-to-do family in southern Switzerland. As such, then he was not slated to take over Swiss Air or that—what’s the name of the big cloth manufacturer in Switzerland?

**Hanauer:** Beneton?

**Bradner:** That doesn’t sound right. But anyhow, there is the one very large one. So he had to take a law degree instead. He was an early and very competent scuba diver, wrote a book, *Einsame Inseln*,<sup>71</sup> "Isolated Islands of the Red Sea," beautifully illustrated with his own photos. The first time we visited in his house, one of the things that awed Marjorie and me was about a half a dozen of the finest violins of the world, that he was just collecting because he liked. He didn’t play. But he also had his own vineyards. What were some of the other aspects of him? He assembled what I think is probably the most complete free-roaming library of literature, of books, of papers on diving, that’s in the world. He set it up for a while under an outfit that no longer had space for it, so it’s now somewhere in Germany. I don’t know the details. That’s enough about Hermann Heberlein. I never did learn to speak his French—Suisse Deutsch.

**Hanauer:** Any other Europeans that you interacted with regarding diving at that time? That really stick out in your mind?

**Bradner:** I did think a little bit about this in preparation, so I should probably look at these notes.

**Hanauer:** The Italians are people that I’m not familiar with.

**Bradner:** Okay. In Italy I went first off and talked with the Pirelli people, and one of the Italian divers, Masserini, arranged a conference with three of them, who all characteristically labeled “doctor” and one acts accordingly. My notes at the time that Dr. Clementi had dueling scars, or what looked like dueling scars. Fajioli, who was the only one of the group that clearly was a diver, had only one arm. Vassinia, who was Dr. Vassinia, was an engineer. And they gave me a verbal tour of the Pirelli activities and arranged for me to go over and talk with the physiology group at Pisa. That was expected to be the most significant. I was of course interested in mixed-gas stuff at the time.

And we had an excellent interview, Marge and I, on the bends. Very cordial people until I made the mistake, I guess it was, of asking about mixed-gas apparatus. So, instead of being a physiologist, I was suddenly unmasked as being a scientist—a physical scientist—a *spy*! We had had adequate communication up until then. You can tell how lousy my foreign languages are, but I can survive in French, and German, and Italian, and Spanish, and sometimes even in English. We didn’t have

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<sup>71</sup> Hermann Heberlein, *Einsame Inseln* (Zurich: Orell Füssli, 1956).

too much problem, until suddenly they concluded I must be a spy. We couldn't find a single word. They shoed us out rapidly.

That's the extent of my Italian interaction. The French one, I mentioned. Back in Geneva I interacted frequently with a guy who subsequently was the president or the director of Rolex watches. He very kindly let me help him pressure-test some of their watches and also high-magnetic field testing. René Jeanneret was a European gentleman in the finest sense of the word. We did interact with quite a bit. Who else? Well, the bathyscaph—Jacques Piccard. We got fairly well acquainted with him. I met his dad, as I remember, briefly. Jacques was—you've talked with him, I'm sure.

**Hanauer:** I have not talked with him. I've heard Andy Rechnitzer's side of it. Of course, there was quite a rivalry going between the two of them about the deepest dive.

**Bradner:** Well, Jacques Piccard was not a scientist, I think probably not an engineer. Those comments should not go on the record. Delightful guy. His wife at that time was a concert pianist, and I think her health failed.

**Hanauer:** So his qualification to make the deepest dive was the legacy.

**Bradner:** Yes. I don't know what Andy's qualification was, other than just plain enthusiasm.

**Hanauer:** We're just about done, and probably thankfully. I hope this hasn't been too much of an ordeal.

**Bradner:** No.

**Hanauer:** You were an observer at the Keller dive<sup>72</sup>—.

**Bradner:** Oh, boy.

**Hanauer:** —and a critical observer, from the letter that I saw.<sup>73</sup> Can you tell me a little bit about that?

**Bradner:** I think I remember adequately or accurately enough. Keller first off was not objective at all. His goal was to make a big splash. He gathered around him a bunch of nonentities who were not knowledgeable. Several of us, and I forget now just who, were invited or asked by our professional committees to sort of watch the dive, comment on it. It was to be a mixed-gas thing with inappropriate knowledge of diving tables, of diving physiology, inappropriate preparations for recompression. If I remember rightly—not giving appropriate or sufficient freedom of the

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<sup>72</sup> Hannes Keller (1935- ), Swiss mathematician, made a record dive to 1000 feet off Catalina Island in a steel diving bell on December 3, 1962 using a breathing gas mixture developed by Albert Bühlmann. Two divers perished on the dive.

<sup>73</sup> Hugh Bradner to Dr. Robert B. Livingston, 7 December 1962. Hugh Bradner Papers, 1938-1973 (82-57), Box 1, "General Correspondence, Diving, 1946-1960: Livingston, Robert." Scripps Institution of Oceanography Archives, UC San Diego Libraries.

professional physiologists who were there. It was such a bad circus show that I, and I don't remember how many others, wrote our protests and said we would not hang around for this debacle. It was just clearly going to—incidentally, in the course of the preparations for that, a day or so ahead of time, Heberlein took a moderately deep dive and was bent enough so that for the rest of his life he had a bone ache, a joint ache.

**Hanauer:** Was this in Keller's capsule?

**Bradner:** Yes.

**Hanauer:** Oh, I wasn't aware that he was involved in that.

**Bradner:** I think I remember that accurately.

**Hanauer:** So you disassociated yourself with the whole thing before the final deep attempt?

**Bradner:** Oh, yes.

**Hanauer:** Through all this time you were also kind of an unpaid consultant to some of the diving equipment manufacturers because you were constantly given equipment to evaluate and test and you gave your opinions on the equipment. One example, the Waterlung.

**Bradner:** I think I would probably choose different wording on it. I was not a consultant. I was definitely unpaid, that's a matter of the principle of it. I think that all of this part of it—appraising equipment—was done in connection with Connie and Scripps. And Jimmy Stewart,<sup>74</sup> of course, after Connie. It was not a matter of my appraisal as an individual in it, but as far as I can reconstruct, it was one of the Scripps people looking at the potential diving gear. ##

## As I recall, what I would do, for instance, if I was down here or Connie sent me up a piece of gear, I'd look it over and try to decide how well made it was and whether we should adopt it as part of the UC diving acceptable or recommended diving gear.

**Hanauer:** Okay, at what point did you phase out of diving and why?

**Bradner:** Out of diving. Well, I phased out of diving—.

**Hanauer:** Meaning active involvement?

**Bradner:** Yes. I phased out of the excitement of diving when a graduate student, Ray Robertson,<sup>75</sup> was down here and drowned.

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<sup>74</sup> James Ronald Stewart (1927- ), diving officer at Scripps Institution of Oceanography.

<sup>75</sup> Raymond D. Robertson (1920-1953), graduate student in electrical engineering at UC Berkeley; employee of UC Berkeley Radiation Laboratory.

**Hanauer:** This was 1953.

**Bradner:** I don't remember the date, but I believe it. It would have been about then.

**Hanauer:** Do you want to talk about that incident?

**Bradner:** Well, it's fairly straightforward. We were down here at the Cove and I swam out ahead of him. He got caught in one of the heavy backwashes which occasionally throw people back into the Cove. He was a very solid competent diver, would probably also have been a member of the Scripps faculty down here, if it hadn't been for this. He was so in control of himself that he inhaled water but didn't lose consciousness. He kept his cool, but simply asphyxiated.

**Hanauer:** And you brought him in?

**Bradner:** Oh, yes.

**Hanauer:** At the risk of your own safety.

**Bradner:** Oh, nuts.

**Hanauer:** You say the excitement kind of went out of it for you after that?

**Bradner:** Yes.

**Hanauer:** But you still stayed involved for another decade.

**Bradner:** Yes. But you asked me a question—what led to the disenchantment of the professional aspects of it, of the military aspects of it. Oh, I made myself a note that it was about 1956 when I tried to size up the problems of getting stuff accepted by the Navy or getting—accepted by the Navy? Yes, turned over to them. You've seen this list?

**Hanauer:** Yes.

**Bradner:** I think that spells out fairly well the fact that I thought there were a number of things where a state of development was clear up to being available to the Navy but they couldn't operate in less than about seven years. I don't know how long it is right now.

**Hanauer:** What they did during the war? They had to make a decision.

**Bradner:** I can tell you what we did during the war.

**Hanauer:** Tell me.

**Bradner:** I went to Washington in spring of 1941, because, as I've said earlier, it was evident we were going to be in a war. I went in to the Naval Ordnance Lab, whose prime functions at that time were anti-ship mining, degaussing and such things, and pro-

mining. My brother, by the way, was in the anti-mining side and I was in the pro. The guys that were in charge there and their senior people, civil service, had been there for such a long peacetime, that it was normal for them to take the view, “Oh, let’s see, I need to buy myself a half a dozen batteries. They’re available now at the corner store. I’m required to put in a requisition. It’ll be about thirty days until that comes. I’m not about to fight this system. As long as I keep my neck pulled in, I’m on civil service, I’ll be okay.” And, when a bunch of us impatient guys came in, we did everything—first off, we didn’t go in under civil service, we managed, thanks to some smart people, to go in as contract employees. That way, we could walk up to a Lt. Commander or the Admiral or to a sailor, and he wouldn’t know how to pigeonhole us, and we could get something done.

Secondly, we did everything that we thought we could get away with to get things moving. I remember one day in the boss’s office, there were pipes—heating pipes of two or three inches in diameter going floor to ceiling, and I had to climb that pipe like a monkey and pound on it to get his attention to get something done. It was just a distressingly slow-moving activity until it was forced apart by these . . . novices. In my case I wanted to get a transfer, it got so bad. And the director of the lab, quite unexpectedly and different from what he did with everybody else, where he said “War is hell,” said that he would put me in touch with the people at Chicago who were just getting ready to open Los Alamos. That’s how I got out of Navy mine warfare into bigger bang.

**Hanauer:** Bigger bang. When did you phase out of the Scripps diving program? Off the Diving Control Board?

**Bradner:** Oh, gosh, I don’t remember. I did progressively less diving. Initially, you could be a real expert at one day a month. By the time I phased out of diving activity, you had to be out essentially every day to even talk the language with the guys who were in a multitude around you. I don’t know. I think that I phased out of the Scripps diving probably five, ten years before coming down here full time. There seemed to be no need for me after that.

**Hanauer:** Okay, let me wind up with a kind of a philosophical question.

**Bradner:** *[Laughter]* That’s what you’ve been getting.

**Hanauer:** You saw scientific diving before and after the advent of scuba. In your view, how did scuba change scientific diving, more specifically here at Scripps, and at what point did it stop being a toy and become a tool?

**Bradner:** I think your opening assumption isn’t even quite right. I didn’t see scientific diving before scuba. There was some. People I suspect like Connie Limbaugh or probably Carl Hubbs<sup>76</sup>—did Carl dive?—anyhow, were doing whatever they could to get and study the stuff under water. Scuba just made an enormous difference in it. When did it start getting real rather than just for the sport or pleasure of it? I can only say

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<sup>76</sup> Carl Leavitt Hubbs (1894-1979), ichthyologist, Scripps Institution of Oceanography.

that I would estimate that at the time that we were trying to set up diving courses at the various campuses that, except for Scripps, probably eighty percent of the people wanting to get a diving course were doing it because they were enamored of diving, and not because they were actually going to make use of it. When I say eighty percent that probably means sixteen out of twenty. In other words, there were very few people also on the campuses.

**Hanauer:** Okay, I'll finish up with the stock finishing question. Is there anything that you were prepared to talk about, that you expected me to ask and I didn't? This gets me off the hook.

**Bradner:** Well, I don't think I really fully prepared on anything, except to try to get a few memories going. No, I'm very happy to answer anything you ask. Let me take a moment and see if there are any key things. Oh, yes, there's one fairly interesting one. I gave a briefing to, I think it was CNO, in behalf of our committee at one time.

**Hanauer:** CNO?

**Bradner:** Chief of Naval Operations. It may have been Chief of Naval Research, I only remember that I was picked by the committee to give the briefing, and started out by the statement that in a period between conflicts why did a good high-energy physicist spend his effort on swimmers and divers when around him people were doing Nobel prize work? And my response was that I felt that a single person could make a greater contribution, a greater impact, in a war situation by diving than by any other activity that I knew. I still hold to that.

**Hanauer:** Okay. Great. Well, thank you very much.

**Bradner:** I've enjoyed it. I don't want to try to do it regularly. I'd probably have to get a memory going. Let's see, Lee Hunt<sup>77</sup> was one that I don't think we mentioned.

**Hanauer:** No, we didn't.

**Bradner:** Lee was the executive secretary, which of course in a committee of the Office of Naval Research or the Academy, really means that he's the one that figures out what we ought to be thinking about and organizes it. Well, Lee took over, if I remember rightly, from Walter Hahn and was for twenty years or so the man that really held it together. And, if you want more information about Lee, you can ask his niece, Deni Menegus over at IGPP. Do you know Deni?

**Hanauer:** No, I don't.

**Bradner:** My whole tale here is spoiled then. Deni is a delightful gal, I think in many respects the finest executive secretary that I've ever known, very fast incidentally in taking

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<sup>77</sup> Lee McCaa Hunt (1926- ), oceanographer, geologist, executive director, Naval Studies Board, National Academy of Sciences.



John Miles's scientific papers and putting them out with never a mistake. But anyhow. Sorry, I shouldn't have taken your time with that. But I do encourage you to get acquainted with Deni Menegus.

**Hanauer:** Okay. Thank you again. ##

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