San Diego Maritime Museum

Oral Interview with

Dr. Fred Noel Spiess

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Interviewed by: Robert G. Wright

Interview being done at Dr. Spiess' home
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Dr. Fred Spiess, Professor Emeritus of Oceanography, Marine Physical Laboratory, Scripps Institution of Oceanography. This is a continuation of the interview we did on July 16, 2004. The first interview was about his submarine service during World War II. This interview is about R/P FLIP (Research Platform).

Robert Wright (RW): Could you give me your full name, please.

Fred Spiess (FS): Yes, I'm Fred (not Frederick) Noel Spiess (i before e, especially in Spiess). The Noel part comes because I was born on Christmas, and my Mother figured that was the proper thing, and so. The Fred was from my Father.

RW: Where were you born?

FS: I was born in Oakland, California, Christmas of 1919.

RW: I assume you went to school up there.

FS: Yes, grew up in Oakland, in a small city adjacent to Oakland called Piedmont, went to high school there, and when I finished high school – that was 1937 and at the end of depression times, and my classmates either went to Berkeley, which was close by, or to Stanford, if they were the more wealthy ones. I went to Berkeley and graduated in Physics in class of '41. When I went to Berkeley I joined Naval ROTC also, so that in '41 when I received my Bachelor's Degree, I also received an Ensign's commission in the Naval Reserve, and with about half a dozen others in that Naval ROTC class, we went off to submarine school, we sort of figured that would be an interesting thing to do. We knew we had to go somewhere, because in the middle of '41 there would not be much time between when you got your commission and when you got your orders, so we went off to submarine school as of the first of July in '41.

RW: Was that in Groton?

FS: That was in Groton.. In those days that was <u>the</u> submarine place. I stood one in my class there so I had a choice as to where I was to go when we graduated, and I decided the weather was turning cold in New London, so that going to the Asiatic Fleet seemed like a really good thing to do so I opted for a boat out there. That was where I spent the submarine business in World War II. We've talked about that separately pretty much. Toward the end of the war it was clear that things were winding down. Originally I had planned to go for a graduate degree in Physics, which was my major as an undergraduate at Berkeley.

RW: In '41 you graduated as what?

FS: That was a Bachelor's Degree in Physics, in fact I was going to just keep on going there to a graduate program, but then I had this four or five years of driving submarines, and it wasn't clear as things were winding down whether I would stay in the Navy or go back and pursue the world of Physics. An opportunity came up to do both, essentially, in the sense that the Navy had a post-graduate education program that had been running, oh, they had a tradition of doing that from way back in the '20s, I think. There was one course that was advertised when I came in from my 12th war patrol that said for reserve people there was a one-year course that didn't involve any commitment to do anything else afterward, and so I put in for that, went out and made the 13th war patrol, came back and had orders to be Executive Officer on the new construction boat in Philadelphia, *Trumpeter*, went there and after about a month I got the orders to post-graduate school, so at that point I moved away from the operating submarine force and went off to a graduate course of a year in Communication Engineering at Harvard. That was really kind of nice because the war ended while I was there and I could decide whether I was going back to the academic world or stay in the Navy. I did reasonably well so I was able to go back to Berkeley and said, "Look, when I graduated you told me I could have a Teaching Assistantship in Physics to help pay for graduate work. What's the status? Can I have that back?" They said sure. I had had enough time to convince myself that I could go back and do the academics, and so I went to Berkeley and started in the Fall of '46 as a graduate student. The financial situation was really pretty good. The University had a lot of married students coming back with the GI Bill. We were motivated and we were encouraged to follow that, too, because the GI Bill thing was really a great move. I went back and started in. The University had some low-cost housing that they had taken over from the shipyards in Richmond, California, where they built a lot of the Kaiser-built ships. At the same time I was a little reluctant to leave the submarine business and at that time the Navy decided it would start a submarine component in the Naval Reserve. There had not been one before World War II, and so I became involved with that as Commander of the Submarine Reserve Division in Oakland, California.

RW: Were you a full Lieutenant at that time?

FS: By then I had made Lieutenant Commander.

RW: I would <u>hope</u> so.

FS: I made Lieutenant Commander while I was at the University post-graduate thing. That worked out really pretty well – I could have the best of both worlds. On Tuesday nights I was a submarine officer – since I was commanding officer of the unit, there were some other times that I could work at it, but it was a way of keeping in touch with submarine business while I was working toward a PhD in Physics.

RW: Were you being paid by the Navy?

FS: Yep. There was pay for - essentially you got paid for a day when you did your day's drill and then you'd go off and do two weeks of active duty. Some of that I did more than two weeks because I was involved with a couple of other people in writing curricula for this new submarine reserve thing. The end result of all of that was that I motored along towards my Physics PhD which was in nuclear physics, and had the good fortune to be in a group headed by well-respected physicist Emilio Segré, who eventually got the Nobel Prize. Segré was an Italian, part of a group at the University of Rome, under the leader of that group, Enrico Fermi, who was a big person in the nuclear physics world by then, too. That group was the one that first found out about the fission that would be the basis for nuclear power. They pretty much all emigrated to the United States, Canada or England in the late 1930s, and became involved with the Manhattan Project, the nuclear bomb work. Segré had a group at Los Alamos.

RW: Were you an instructor?

FS: Most graduate students in that era in Physics helped run lab sections for the undergraduate Physics courses. Segré is the one who eventually signed off on my thesis, he was my advisor for my research work. I worked in his group at Berkeley.

RW: Was he a pretty good guy?

FS: He was a very interesting guy. He was very intent on the physics that was being done. There are a variety of stories about sometimes a little more interested in the physics than with his kids who were growing up around him, and that sort of thing. He was a good mentor, or patron, or whatever. I only took one actual course from him, and that was before I had my Bachelor's Degree. He had arrived at Berkeley in 1939 or '40.

RW: He must have been in his 40s or ?

FS: Yes, I would guess so. I was trying to remember how much older he was than I, 20 years maybe.

RW: He probably wanted to get away from Mussolini.

FS: Yes, well, it wasn't a pleasant environment for that group in Italy. So, I guess my main Segré story has to do with the controversy in the University of California, called the Loyalty Oath Controversy, that all the faculty members, there were implications in the late 1940's that people thought there were a lot of communists in the University of California, and everybody should have to swear an oath to obey the Constitution. Most of them sort of thought that that was inherent in where they were anyway, and there were a lot of lead faculty members who objected to this, very strongly. It was kind of a "when did you stop beating your wife?" kind of plan almost. It was interesting that the theoreticians were notable among those people who were opposed, and some experimentalists such as Segré didn't really care very much one way or the other. There was another member of the Farraday group who was a theoretician there, Ferowick, and I can remember Segré coming down the hall and saying, "You've already sworn an oath to the Pope, to Victor Emmanuel, to Mussolini, to the United States. What's one oath more or less? Sign the oath and get on with your work." That was the Segré pragmatic attitude to things.

Anyway, when I finished the PhD I was still enamored of the submarine business and, of course, the nuclear power thing was in an infant developing condition, and so I went off, as most of my classmates did, to various places to interview for jobs, and one of the places I went was the General Electric Nuclear Power Laboratory, called the Knolls Atomic Power Laboratory [KAPL}.

RW: They didn't do any recruiting in those days?

FS: Well, they were recruiting, but it was our market not theirs, 'cause there weren't very many, compared to number of jobs, so openings for physicists were really pretty good. So anyway, I was offered a job which I accepted at the Knolls Atomic Power Laboratory. They were one of the two laboratories – the other one was run by Westinghouse – that were designing and building submarine engines, essentially.

RW: Where was it located?

FS: That was in Schenectady in upstate New York. I went there with my wife and three kids, and we settled in.

RW: What a change was <u>that</u>, from California to New York!

FS: It was a change, all of a sudden there was <u>winter</u> for us. My wife and I had grown up in the San Francisco area, and now with the snow and ice, we learned how to keep the car on the road. It was an interesting time, but I had been there not quite a year when one of my wife's sisters out in Oakland, California was being married, and I had enough vacation time that we decided we would go back home for this wedding. So we packed the 3 kids in the Plymouth convertible and drove back across the country. While I was there in Oakland, it turned out there was a laboratory associated with Scripps Institution of Oceanography, called the Marine Physical Laboratory. It was primarily a spinoff from what had been a big undersea research laboratory that was run by the University of California during World War II. It was called the University of California Division of War Research. When the war ended most of that was transferred into a Navy laboratory, initially called the Navy Electronics Laboratory here in San Diego, and vestiges still exist on Point Loma.

RW: They had a branch up in the Bay area and down here.

FS: The Navy Electronics Lab was really a big establishment, but the University decided that it would maintain some interest in this. There was a really eminent physicist who had joined the University of California group, Carl Eckart, who had become interested in marine geophysics and underwater acoustics and that sort of thing, and he convinced the University that they should keep a small laboratory in the work in this field in the '50s, and so it turned out that that lab needed a physicist, and a classmate friend of mine, a graduate student, had been invited to come down here from Berkeley – he hadn't quite finished his degree yet - and he interviewed for a possible position in the Physical Laboratory. Well, when he heard about this position he said, well "Spiess is in town and he has much more of a marine kind of background than I do My friend, P. J. Thompson, had much more of an army background. He was interested in the job, sort of, but he arranged that the <u>two</u> of us would come down and be interviewed, so we came down and talked to Roger Revelle and Carl Eckart.

RW: This was out on Point Loma?

FS: Yes, the Marine Physical Laboratory was located right alongside of the Navy Electronics Laboratory, and it had only recently been included as part of the Scripps Institution of Oceanography. When the Marine Physical Laboratory was first established in 1946, it was an independent University of California laboratory. In 1950, roughly, it became part of the Scripps Institution of Oceanography. It was administratively a lot easier for the University of California to have just one entity here in the San Diego area, and Scripps had been part of the University since 1912, so it was a logical kind of thing, and in fact, it was extra logical because this happened at a time when Carl Eckart was the Director of Scripps, also before Revelle was Director. The upshot of that was, Eckart and Revelle offered Thompson and myself a job. Thompson said no, that he hadn't finished his PhD and he had other things on his mind. He eventually became a member of the Atomic Energy Commission and he really hung in there as far as the nuclear power world was concerned. Our whole family drove back across the country again to Schenectady, and I thought for a little while, and I decided it would be a lot more fun to be running a small, in fact, submarine-oriented research group in Scripps Institution of Oceanography Marine Physical Laboratory than it would be to be one of 2,000 people working on a submarine engine for General Electric. So, the next month we all piled back into the car and drove back out here and I started in at the Marine Physical Laboratory.

RW: Was this about 1954?

FS: That was in '52, and the first project that I had was one that involved development of a sonar system for submarines, and then I had the chance to go up actually to install and pilot versions of that in several of the submarines based here in San Diego. In the summer of '53 our system was looking pretty good, and the Navy said we'll put it on a submarine and send it out to WestPac to do one of the patrols the Navy was carrying out over there on the far side of the Pacific. It was decided that they needed some technician to go along with this system, but they didn't want to take just some civilian, and since I was a Lieutenant Commander in the Naval Reserve, I was given orders to go to active duty and ride this submarine out on the WestPac patrol. It was kinda fun, 'cause I was senior to the commanding officer of the submarine, so we went off and worked out there gathering information for the sonar system. Through this I sort of developed a very close connection between the fundamental physics that goes into underwater acoustics and the submarine operational world. The upshot of that was moving along toward the FLIP thing that we began to talk about. I was on a variety of advisory committees for Navy underwater acoustics programs, and one of those along about 1959, the Navy decided that it was going to at least investigate the possibility of building a weapon system that would essentially look like a torpedo but would really be a rocket, and it could be squirted out of a torpedo tube, it could go up to the surface, take off and go 20 or 30 miles and drop back into the water with a nuclear depth charge and sink the submarine.

RW: You're talking about pre-Tomahawk.

FS: The Tomahawk thing was a cruise missile that was deck-mounted and launched from the deck of submarines.

RW: Tubes? It's the same size, it's 21 inches.

FS: That was a later – this system was called SUBROCK, and it was before.....there were some cruise missile things that were being done where they put a big pressure-proof pod on the deck of the submarine to carry the cruise missile in that case. This was our program called SUBROCK that was started in about '59 or '60.

RW: Then it was a pure rocket.

FS: Yes, and it was really based on the fact that people had found that there was pretty reliable acoustic propagation in the deep ocean out to a range of about 30 miles or so. The way the sound would be refracted in the ocean was that the sound would tend to bend downward, if you think of a sound source someplace, the sound would generally be bent downward. But if you were in deep enough water, the structure was such that it would bend back up after a distance, and ...

RW: It was the temperature layer of the water that caused that?

FS: Yes, it was warm up on the top which made it so that it was getting cooler so the sound velocity was dropping and bend down, but when you get down about 1000 meters or a number of that sort, the water would be pretty much a constant temperature, but the sound speed increases when the pressure increases, so the sound speed would increase as you went below this sound channel axis. That would make the sound bend back up again. As it turned out in many areas, sound that was originated at some place near the surface would focus about 30 miles away in typical Pacific ocean conditions, and so the Navy wanted to take advantage of that and build sonar systems that could find submarines at 30 miles and could in fact not just find them but track them and then, in fact, destroy them. That's what the SUBROCK system was supposed to do. It had an alternate payload, either a honing torpedo or a nuclear depth charge. The nuclear depth charge thing had been tested out of San Diego with some participation by Scripps people back in about '56 – Operation Wigwam it was called – and they actually built some sections of submarines, took them out, Scripps helped find an area that was really pretty much devoid of biological material and that sort of thing so that there wouldn't be excessive contamination.

RW: It must have been small potency, it would cover a large area. I know it generates a lot of heat.

FS: It generates a <u>really</u> <u>nasty</u> pressure wave, and so it's one of these things where in conventional depth charge world you usually go deep, because it makes it harder for people to get a good ......

[end of side 1]

RW: I know that in some cases pressure was ....the idea of a depth charge off a destroyer was not necessarily to hit the sub but to get enough pressure on the hull to ....

FS: …to break something. I don't think that depth charges were ever designed to break the pressure hull, they were designed to break valves and things of that sort, and would make it so you would have flooding. The thing about the nuclear depth charge was that over a fairly big zone, and I don't know what the numbers turned out to be, there'd be a very pronounced pressure wave that this explosion in the water would generate, and if you were down near your collapse depth that was added to the sea pressure, and so you didn't want to be down deep – you wanted to be up near the surface if you were going to have people messing with you with nuclear depth charges. With Operation Wigwam they actually built some sections of pressure hull and moored them and used that as part of their measuring system to verify their performance.

RW: The thing I was thinking about, is why bother, the war is over with but we had the …..

FS: We were into the Cold War, and we had the Russians, and not only did we have the Russians – the Russians had all of the German technology. That was really a key element in all of this from the antisubmarine warfare viewpoint. The Russians were building submarines and they had all of the technology that the Germans …they had scooped up all the German technology and the German engineers right after World War II. It was not a very pleasant thing that we were looking at. It looked as if they could have quite effective submarine operations, and worldwide. This SUBROCK thing came along, and clearly if you're going to shoot at a submarine that's 30 miles away you really have to know where it is. So the question was – if you had a sonar contact on these people, how accurate would the information be that came back to you – would the ocean have deflected the sound so that maybe you thought the submarine was here from your sonar system, where it was really over there.

RW: And than you've got a whale and things like that…..

FS: Well, this was a straight out fire control problem. It was a question of if I determine where the target is using acoustic means, what can I say about where the target is in the real world. So they put together a committee of our underwater acoustics people to help answer this question in the early stages of development of the SUBROCK system. I was a member of that group, and we sat around and decided, well we really didn't have any experiments that would tell us what the answer to this was, so we really should put together a research program that would indeed measure what the error and direction might be. We were one of the groups that was chosen to start in on this program, and since we had been operating a lot with the submarine people here in San Diego, the first things we did – a colleague of mine, Fred Fisher – did some experiments in which we tried to put the submarine at periscope depth, have a ship with a sound source that would be off with some kind of balloon-type thing or something so that you could see it at some significant distance away, and see if you could make measurements of what the direction of arrival of the sound was that the sonar system found as opposed to where the periscope said the target was. Well, that was a pretty hard thing to do, because you couldn't get out anywhere near in 30 miles, and in addition the submarine that was going to launch the weapon was in the situation where they could find the target at 30 miles, they would not be at periscope depth. We were pushed into thinking of a better experiment. There had been some talk in the oceanographic community – this is sort of a diversion for a moment – about new kinds of ships and building up the oceanographic capability for the United States, and one of the things that had been proposed by the committee that was involved in that study, was the idea of what they called Manned Spar Buoy Laboratories. Essentially the idea being that you build a big column-like thing and you could sit it out in the ocean and do experiments that might be rather interesting.

RW: It would be a stable platform.

FS: Yes, it would be a stable platform. We started thinking about that as a way of doing this experiment that we wanted to do, because it could put the hydrophones, the listening sonar things down at the bottom of something like this and the top would still be sticking up out of the water. So we began to think about how to build something of this sort. We discussed it some with an acoustics-type physics person at Woods Hole Oceanographic Institution, Alan Vine, who was a free spirit and a free thinker, and we talked to him about the idea that we might - in those days there were a lot of surplus submarines lying around. If you could take a submarine and just tilt it up on end you'd have your spar buoy. We looked into that and it turned out that it was really not a good way to go, because there was so much modification to do. The other thing that kind of emerged at that point was the fact that we'd like this thing to be capable of operating either in the vertical or the horizontal position, because if it was always going to be in the vertical position, it was going to be very hard to tow from one place to another to do an experiment in the middle of the Pacific and then want to do one in the Gulf of Mexico, or whatever. The obvious thing for any kind of submarine person was to build a submarine that didn't really submerge, just kind of half way submerge. That was really the beginning of a serious thought about FLIP. There were three of us in our Marine Physical Laboratory working together: Fred Fisher, myself, and another physicist called Philip Rudnick, who was somewhat more of a theoretician than either Fisher or myself. We were more "build something and see how it would work" kind of people. Anyway, we decided that this was a pretty good thing to think about, and we convinced the program managers for the SUBROCK Program that this would be a good thing, at least to study, so we began doing some development work on this concept, and that started most naturally with some small models, things that were maybe a meter long or so, that you could put in a wave tank and build waves.

RW: Sort of a hardware ?

FS: Right. We were convinced that this was the right thing to do, the question was how to do it. We did that, and then we began to think about – it showed pretty naturally that the spar buoy would be a pretty stable platform. We began to think in terms of what shape should it really be, cylindrical seemed too easy, and that's the first thing that any physicist would think of. So we began to build some models that were more the order of 1/8th size. We had sort of fixed on 300-foot draft as being a reasonable number, 'cause that was kind of compatible with where a submarine might be hovering to use it's sonar to find somebody at 30-mile range, and so we looked at several different configurations. Some of them worked better than others. It's hard to remember when you're working in a team how a particular concept or idea emerges, but one that I think I would give Philip Rudnick credit for, was to looking at the mathematics of how you decide how a wave is going to move something up and down, it turned out that you could have something that would be a lot less reponsive to the waves if it were kind of slim in the upper part and thicker in the lower part. Rudnick did the calculations to show that this could indeed be the way to go. It's sort of like a hydrometer. There are these things that they use to measure the density of a liquid, where you have kind of a cylinder with some weights in it, but you only have a very thin thing that sticks up through the top of the liquid, and consequently it's very sensitive to the density of the water. What we wound up with was something that was about, half of it was about a cylinder that was maybe 12 or 15 feet in diameter and then it would spread out and be another cylinder that would be maybe 30 feet in diameter, so we put this kind of model together, we built some 1/8th-scale things to look at the flipping process, we ran them out in San Diego Bay. That was very educational in itself because one of the things that we tend to forget about, is you have this thing that is sitting up on the surface and it's going to end up in the vertical going down 300 feet, the center of it is going to be about 150 feet down and it's going to be a lot heavier than it was to begin with, otherwise that's why you put the salt water in the tanks to make it go down, and so basically what you're doing is you're dropping a real heavy thing from the sea surface down to 150 feet. Well, it doesn't just go from the sea surface to 150 feet, it goes to 150 feet and has some velocity associated with it, so it tends to go further than that, although in the long run it will bounce back up and stay at the depth it was designed for. When we did our first 1/8th-scale model studies in San Diego Bay it turned out we'd better do something about that, because when this model flipped for the first time it went completely submerged – that 50 feet of it that was supposed to be up in the air after this was all done – was almost completely submerged. We had to have the tanks filled rather slowly so that it would take a little while for this to happen. You might still bounce 5 or 10 feet or something, but that wasn't going to produce any nasty situation.

RW: FLIP means what?

FS: That was just a name we picked because we decided to call the operation going from horizontal to vertical - flipping.

RW: So that's not an acronym?

FS: No, it's not. After the fact some people did say that it meant Floating Instrument Platform, but that was after we had already been calling it FLIP, and people kept asking us if that was an acronym for something, so one of our colleagues came up with that explanation of how to describe it. We were then able to convince the program managers for the SUBROCK Program that they should let us build one of these things.

RW: Was this Navy money or the civilians?

FS: This is Navy money, well, civilians and Navy people. There was the Naval Ordnance Laboratory back on the east coast in Maryland that was the lead laboratory for this weapon. They funded us to build this thing, and we built it knowing it was built to do this particular experiment, but we also built it knowing that if we had a stable floating platform that could easily be moved from one place to another, the idea was that when this thing was laid out horizontally floating on the sea surface, that you could tow it at maybe 8 or 10 knots to go somewhere, and once you were on station you'd flood the back end and it would swing around into the vertical with a 300-foot draft and 50 feet sticking out of the water. The idea then was you could make this thing really do the right experiment but it could also do other experiments.

RW: Was it built at National Steel?

FS: No, it was built up in Portland. There was a shipyard up there that was into building barges and things of that sort. As we approached a final design for this, it was clear that this was no longer something that three physicists were going to make drawings that a shipyard could bid on and build a structure that was strong enough. We found a then-young Naval Architect, Larry Glosten, who had started up a practice in Seattle. He had been in the Navy during World War II, and a couple of Navy Admirals who we talked to who were in the shipbuilding world, said "That's a good person to work with." In the early phases of this we worked with a much bigger Naval architectural company, and we realized that our little one-shot thing was really not going to attract the attention of their lead people.

RW: No ongoing contract.

FS: Right. So we talked to Larry Glosten, and he was interested. That's probably part of why it was built in Portland, because he knew the yards up and down the coast, and we needed a yard that was going to be willing to do something that was really quite different, but that was then not very likely to have a big follow-on construction program. It wasn't going to be model No. 1 of 100 of these – it was going to be No. 1 of No. 1. Glosten did a very good job of doing the detailed design.

RW: How about the lab part now? You fellows have an inport on the front end that looks like the bow of a ship, is low, not much superstructure on it, and it's filled with desks and lab stuff. Right?

FS: Yes, right. The shape of that bow was dictated by looking at how the thing might behave when it was under tow, whether it would slam, and we talked to several Naval architectural people. There was a very good person up at was then the Naval Architectural Department at the University of California, Berkeley, and we came to the conclusion that we really needed a bow that looked kinda like a ship so that when it slammed it would not break, and at the same time be reasonably faired as far as making the towing operation easy, and that is how it came out. Basically it has this section that is about 50 feet long that looks like the beginning of a ship, then stuck onto the back end of that is this long two-diameter cylindrical structure that is 300 feet long. The whole thing is about 350 feet long. Compared to an ordinary fleet submarine of the day, it was sort of that kind of length, but it was a lot thinner.

RW: In the lab part, what was elected to put in there?

FS: We wanted to put in enough electronics to be able to do the kinds of experiments we wanted. We wanted to be able to put in half a dozen racks of electronics, we wanted to be able to mount things on the hull itself so that when you flipped into the vertical position those sonar receiving elements that we might put down there would be at a place that you knew very well – you'd know that they were 300 feet down or 150 – whatever you wanted.

RW: You were duplicating a submarine.

FS: Sort of. In this case, to use the vertical structure to have listening capabilities at different depths, so that all worked out very well. I drew on the submarine side of this. Basically the package and the air supply to and the piping that had to do with flooding and blowing the air back out, blowing the water back out of the tanks, this was really like a real submarine ballast tank system, so submarine experience was really pretty good in that context. When it came time to go to a shipyard, Gunderson Bros. small shipyard up in Portland was the one - they were building minesweepers and barges for the Navy – they turned out to be a good one to work with. We needed somebody in the shipyard to be our person who was there every day and could interact with the builders when they came upon something that they didn't understand. At that point I was fortunate enough to draw on my submarine reserve experience, because back in the days when I was commanding a submarine reserve unit, we had a nonoperating submarine alongside the pier that the Navy provided, along with some Navy people, to help support the training programs for submarine reservists. Most of the reserve units had a submarine of some kind, some World War II submarine – the nuclear thing hadn't matured to the point where diesel engines were obsolete – and when our training submarine appeared in our submarine reserve unit, it came with a submarine guy, Earl Bronson was his name, who was an ex-enlisted man but who had become a Lt. Cmdr. by then He had retired from the Navy some years after that. He was very good at working with the shipyards. He had been a shipyard superintendent around Navy shipyards for submarines and had the necessary ability to work with the workers to see that things went our way and we really achieved what we wanted to build. I had kept in contact with him after our interaction in the reserve program ended, and I knew he had retired and gone to live in Oregon, so I gave him a call, and he was ready to stop being a farmer, which he had sort of decided he would do, and agreed that he would be our person in the shipyard, which was really very good because as we went along there were unforeseen things and opportunities – this was the only time a ship like this had ever been built – and he was able to swap things around with the shipyard people in such a way that the budget would not increase. He was really very good in seeing that things worked out. Eventually the ship was built, launched – in fact, my wife Sally was the one who christened it.

RW: It was launched and christened on June 22, 1963.

FS: I think 1962 is the right number. The date is close to right, it was in June. Once it was launched, of course, there was a certain amount of fitting-out to be done.

RW: By the way, it was all vacume tubes in those days.

FS: Yes, the electronics that we were catering to was all vacume tube stuff. Once the ship was in the water and all the fitting-out had been taken care of, then we had to bite the bullet and flip it for the first time ....

RW: ....carefully.

FS: Yes. Earl Bronson and I spent a lot of time making check-off lists, and whatever else to be sure we were going to do it right.

RW: I assume you start at the bottom tank, slowly you fill the bottom tank.

FS: Well, it wasn't quite as simple as that. We actually filled all the tanks at once, except that we had one tank that had, what you would think of as a deck when it was in a horizontal position. Anyway, it was divided into two parts and we had some small openings in that dividing bulkhead. One of things was that we knew that whatever part we were going to have flood slowly would have to be a little stronger in its ability to handle pressure difference between the inside and the outside of the tank, because it wouldn't necessarily be equalized inside and outside, whereas the tanks that could flood fairly quickly you could assume that the pressure was going to be fairly nearly the same inside and outside, and so the structure did not have to be like a pressure cone.

RW: How thick is the .HULL?

FS: Well, it was various thicknesses in different parts of the ship. This was a major part of what Glosten came up with and in fact in the vicinity of this transition between the two cylinders, instead of having just two cylinders butting one against another, Glosten put in a conical transition, and we used some high-strength steel because part of the problem was not so much this pressure difference effect as it was making the ship strong enough that when it was horizontal it wasn't going to break when it was being bent by the waves. If you have a wave that is about the length of the ship, you are going to have times when the crest of the wave will be in the middle of the ship and you'll have the middle pushed up and the two ends sagging down, or a corresponding problem is when the peaks of the waves are at the ends and are lifted up and you have a sagging situation, so it was building for that that really dictated how much steel, what kind of framing .....

RW: It was rigid, not flexible.

FS: It was rigid in the sense that the wing of your airplane is rigid. When you drive along in your big air transport craft and you look out at the end of the wing, and every now and then it does indeed flap up and down. It's basically a rigid structure but it's not absolutely very small deflection, and in fact if you go out to sea in FLIP, it's a thin enough structure that it does have some noticeable deflection. You can stand at one end where the people are when you are towing and you can look all the way aft and you can see the thing bend.

[end Tape 1, Side B]
[start Tape 2, Side A]

RW: Were you excited with your new toy?

FS: Well, I think the main thing was to get it into action, and we naturally .....

RW: Oh, it was towed down to San Diego?

FS: Well, no. After it was built in Portland, we decided that there was enough uncertainty about this flipping thing, that we would like to do it for the first time in some very, very friendly environment, and it turned out that up in Puget Sound there was some arm of Puget Sound, called Dabob Bay, and it had been used, was in fact at that time in use by both the Naval Torpedo Station that was up there in Puget Sound, and a research group at the University of Washington, the Applied Physics Laboratory, a laboratory a little bit like the Marine Physical Laboratory here. The University of Washington people had in fact built an acoustic-tracking system in this arm of Puget Sound. Well, to begin with it was about 400 feet deep, and we wanted a place that would really accommodate our 300-foot-draft ship, but they had also built a tracking range so that they could put a little gadget on a torpedo and track how it moved as it went through this area so that they could see whether the torpedo was doing what it needed to do. So, we made an arrangement with them that we would simply tow FLIP up there, we would base it there for a bit and finish the fitting-out part and do the initial flipping in Dabob Bay. So we did that and when we were ready we in fact had mounted on it some of these acoustic gadgets so that we could indeed track how the parts of FLIP moved through the water as it went from horizontal to vertical. We were pretty sure that this was all going to work, except that there was one part we weren't too sure about, and that was as this flipping process takes place - the two ends of the process are really pretty well defined, the horizontal and the vertical – there's a place kind of midway where there really isn't anything that tells you which way is up in terms of rotating around the long axis of this thing, but you are still not all the way up. So we actually put inside the ship some concrete so it would know which way was supposed to be the keel side when you finally got to horizontal. Basically we were concerned about the fact that when you flipped you might also rotate around the long axis. When you were finally vertical that didn't matter, but if you're only halfway up and all your people are standing on what is the horizontal deck you're suddenly going to be looking down into the water, and we didn't really want that to happen. That was the one thing we were prepared for. We had on our strap-on life jackets and our hard hats, so we were prepared for the fact that we might wind up in the water in the middle of this transition, even though the thing would wind up in the vertical looking just the way we wanted it to be.

RW: Ok, now, you were up in the lab section up on the bow .....

FS: We were standing on what was the deck of that, and if you think of that....the horizontal deck and the long cylindrical thing, we were up here, nobody inside. Everybody was outside, in fact to this day the ship does not flip with anybody inside it. Everybody who is on board is outside, and basically there is this horizontal and then there is a small deck.

RW: Is it gimbaled?

FS: This part is not gimbaled, no. In fact in our initial flippping there was nothing that was gimbaled. You just stand there and as the flipping operation takes place, it doesn't go all that terribly fast, it takes maybe 15 or 20 minutes almost for the first part of the flip operation to take place, because if you visualize, the water is flooding into these tanks but the tanks are just sitting there on top of the water so there is not much pressure for them to flood. But eventually they get to where they're pretty nearly full and then in maybe a manner of a couple of minutes you go from maybe being at say about 15 degrees from horizontal to being vertical. What you do is, you always stand near a place where something that was the deck and is going to be the bulkhead and the other thing that is the bulkhead is going to be the deck. As long as you are in a corner of that sort then all you have to do is readjust your feet, and you don't really realize that you do indeed wind up standing on the bulkhead which is now the deck. It's a real simple process. So we just went ahead and carried out the flipping operations. We learned some things, there were some funny noises down there in the ballast tanks and we made some adjustments of flooding the deck.

RW: The valving.

FS: Well, this really had more to do with the flat deck that was separating the two halves of the last tank that was going to flood. So, it was a pretty successful trial operation. We were unique enough that in fact there was a lead photographer from *Life* magazine, which was then the big picture thing, and we had a *Life* magazine cover done by Fritz Gorrel who was one of their lead photographers who was there during the initial trials. I had the pleasure, or the responsibility, of being in charge of the trial crew. Typically when you order a ship from the shipyard, usually the shipyard at the time of delivery knows more about the ship than you do. In this case we knew more about the ship than the shipyard, and so we provided the trial crew. There was one person from the shipyard that had been heavily involved in all of the detailed work, but the rest of us were all from the Marine Physical Laboratory: Fred Fisher and myself, and Earl Bronson who was going to be the officer in charge once we had shaken everything down, and Bud Monday who was head of our machine shop at the Marine Physical Laboratory, plus one person from the shipyard. We had a very successful time and stayed based up there in Dabob Bay for several weeks making minor changes and getting ready for the tow back down to San Diego, which took place shortly after that. When we got down to San Diego we – two things: one was, we were sooner or later going to have to flip in the real world and we did that, again kind of favoring our ability to have not too nasty a situation. We went off on the leeward side of San Clemente Island, over where the Navy had done a lot of testing on its Trident missle launching and things of that sort. There is a major Navy establishment there, as you know. We went out there to do our first oceanic flip and that went alright. However, we hadn't really put anything inside……

RW: I was going to ask you about the lab part.

FS: When we built it we didn't have anything inside. It was divided up into compartments – well I shouldn't say we didn't have anything because there was a machinery space, we were going to need electric power, and so in part of it we did have machinery that was on trunnions so it would swing from one position to the other for a small diesel engine generator situation that would provide our electric power. That part was all installed as part of the construction operation so that we had the capability to have electric power and we had wiring into the other compartments in the ship. Other than that we had no living capability in there. We had to sort of shy away from calling this something that people were going to live on because this was being built with a Navy contract and Office of Naval Research money, and the Navy is pretty possessive about wanting to know all the details of ships that were going to have people living on them. Since we didn't say anybody was going to live on this ship, the idea was we were going to tow it out and maybe people were going to go on board after it was vertical. We fairly quickly moved into a mode in which it was clear, as someone said, "You know when you see the size of the tugboat you're going to use to tow this, we'd really rather be riding on FLIP than riding on the tugboat in heavy weather." About some months after we had successfully flipped and we had indeed been on board, we had been in the compartments when it was horizontal and when it was vertical, we took our sleeping bags along and simply lived on board that way for the first little while.

RW: What about sanitation?

FS: We had a head that discharged overboard – nowadays we don't do that anymore – but back in those days we did. We had just one major facility and it was hooked into a pipe in such a way that we could, although it would be fixed while you're actually flipping, once you were in one position or the other you could go down there and undo some bolts and turn it around into the other position so you could sit comfortably on it whether the ship was in the horizontal or the vertical operating mode.

RW: Did you have freshwater tanks?

FS: We had freshwater tanks, yes, and fuel tanks for the diesel engines that were providing power. It was really just as well that we didn't do much more than that. Sometime afterward, not very long afterward, we asked for some additional funds and actually went in on the inside and put in a galley which is on a big trunnion, with a refrigerator and range and so forth, and all this equipment are all on one big frame that then can rotate from one position to the other. Once you're in one position you put in a lock so that it just isn't going to wander around unpredictably. But all of that, I think we did a much better job of fitting it out for living for having actually been in the spaces when we were both vertical and horizontal rather than having to rely on some paper model or something of that sort of how it was going to feel when you were in the vertical position.

RW: So essentially, under tow you rode it.

FS: That's right. It was clear from fairly early on that having to do a personnel transfer out in the middle of the ocean was something you can do but you'd rather not have that be the fundamental operating problem. We've done lots and lots of personnel transfers, both horizontal and vertical positions, but we built it quickly, arranged it so we could live on board while you're being towed out to station which might be several days in some instances, and then when you're vertical you can live comfortably in it, also.

RW: What's the furthest you have gone from San Diego?

FS: We did one major operation. The Navy had a wave and climate thing that they did air-sea interaction, a whole bunch of ships in the Atlantic, so we took FLIP through the canal and on across the gulf and out into off Bermuda some place, I think where that operation was carried out, as far as FLIP was concerned.

RW: Were you part of that team?

FS: No, I was not on board for that operation, it was some different scientists. In the early days of FLIP I did some of the.....Fred Fisher was the one who wound up doing what we called the Bearing Accuracy Experiments. We actually did the experiments that we had promised we would do, in fact we did them a lot better than you could ever have done using a real submarine or something of that sort, because we could have our hydrophones rigged to do the very best job you could of determining the direction of arrival of sound, and we had a variety of different ways of determining where the ship was that was operating the sound source, and so Fred Fisher was able to do the experiments that showed the bearing accuracy problem was not a severe one. Meanwhile, of course, we were thinking through the fact that we knew this would be useful for a lot of other kinds of experiments. For example, the Navy Electronics Laboratory for some little time had a small version of a Texas Tower here off Mission Bay.

RW: Gene LaFond.

FS: Yes, Gene LaFond's thing. They used that, for example, to study internal waves, the way the density structure moves around inside the ocean, and they did that by rigging booms out from this Texas Tower which sat on the sea floor and then having instruments that would profile up and down and see how the temperature structure would change with time in the ocean. From very early on it was clear that we had a Texas Tower that could sit in the middle of the deepest parts of the ocean and sit stably and do experiments at that same time. In fact, fairly soon after the first experiment that we did that was not part of this Bearing Accuracy thing, was that Walter Munk who lives up the street here, put together an experiment to see how the storms at the south end of the Pacific Ocean, which generate really pretty impressive wave fields, how the swells from those storms propagate across the whole Pcific Ocean up to as far as the Aleutians, because you indeed see waves from those things in the Northern Pacific Ocean. So he had a set of experiments that he did in which they had wave-measuring capabilities on a whole bunch of islands from down in the South Pacific on up to Hawaii, but there was a big gap between Hawaii and the Aleutian Islands. So we arranged to tow FLIP out, set it up about half way between Hawaii and the Aleutians and provided it with the appropriate wave-measuring capability and sat there for a week or two while these other stations were also running, and provided datapoint for this inbetween. Then not too long afterward I had a graduate student, in fact he was a Naval officer, who built some booms that we could rig out from FLIP once it was in the vertical position. I borrowed equipment from Gene LaFond at the Navy Electronics Laboratory to do the same kind of internal wave experiment as LaFond had done from his Texas Tower, and that was a PhD thesis for that student. A second student came along, Rob Pinkel who is now a full professor at Scripps, who did a much more elegant version of that experiment and has continued to be a FLIP user to this day. For example, just within the last two years, summer before last maybe, we took FLIP out, based out of the University of Hawaii facilities out in Honolulu, and then took it out and moored it as a major observing point for an experiment that was being done to understand the generation of turbulence as currents flow across the Hawaiian chain. That was a major National Science Foundation, Office of Naval Research experiment. We've done a fair amount of underwater acoustics work primarily looking at what the background noise is like in the ocean, because FLIP is a very quiet platform, there is very little machinery running, and it's also a good place to hang hydrophones down all the way through the whole water column and make measurements without having them being jerked up and down by a ship or a buoy or something.

RW: It probably picks up animal sounds as well.

FS: Yes. It's used in recent times particularly to pick up whale noises and how whales behave around things of that kind.

RW: Is FLIP still a Navy ship?

FS: It is still property of the United States Navy. In fact, most of the big ships in the academic oceanographic fleet in the U.S. are Navy ships. The Navy built them. The Navy then essentially gives them for operational purposes to various academic institutions, maybe the University of Washington, Scripps, or whatever, and once you get the thing it's your responsibility to maintain it, to raise the funds to make it operate, to provide the crew and everything else. Scripps has several ships that are in that category. Our biggest ships are all .....

RW: They're not doing that out of the goodness of their heart. They want feedback.

FS: Oh yes. They want a healthy oceanographic program. A great deal of the actual operational funding comes from the National .....

RW: ....'cause they don't have the funds.

FS: Well, it comes out of other government agencies, particularly the National Science Foundation, so the Navy is supporting the national oceanographic program by providing the ships, but particularly in today's world they provide very little of the operating funds for these ships.

RW: What do you think the future is of THE FLIP?

FS: It's hard to say. It's kind of interesting. Back in the '60s when FLIP was built there were a number of other spar buoy-type laboratories that were built, too. The French – Cousteau built one that was moored, it didn't flip, it was just permanently moored in the Mediterranean to be a meteorological and other observational station. That stayed active for some time then they had a fire and the French government decided it would build a second version, and that program stayed active into the early '70s. The Naval Ordnance Laboratory that had been a major player in this initial SUBROCK thing, built a flippable thing that was kind of like FLIP except that you didn't live on board. They used it for a number of experiments over a period of ten years and then decided they didn't have any more experiments that needed that capability so it went off to the junk heap. There was a General Motors laboratory up in Santa Barbara, a marine laboratory that was heavily Navy-funded, and they built a smaller varsion of FLIP that was used for some experiments out here in the California tide, but by 1975 FLIP was the only craft of its kind that was left around. It still is supporting good science. How much longer that will go on and whether there will be a move, well there have been several moves to try for replacement. So far these have not been successful. FLIP is now 42 years old, and we've taken good care of the hull. It's a very simple structure, so we have places where joints have been replaced. All of the ballast tank piping has been replaced, I think twice by now.

RW: Salt water isn't very friendly.

FS: Sure, but the piping is all very simple, it's all out in the open. When you're horizontal it's all out there in the open on the deck. It so far has been a very useful ship, and has certainly outlived our expectations as to how long it would be useful. I can remember during the design process, one of the questions that Larry Glosten asked was, "I have to put in something here for corrosion allowance. How long do you think this is going to last?" Of course we were young kids and 5 years is a long time, and we said "How about 10 years." So with good care, currently it is operated as part of the Scripps fleet, although a lot of the liaison is done by the Assistant Director of the Marine Physical Laboratory, a retired submarine officer, Bill Gaines, and there is an officer in charge, Athanasios ("Tom") Golfinos, who has been with the thing now for 20 years. He is dedicated to keeping it in good shape and we do a variety of inspection operations to insure that ....

RW: Do you drydock it?

FS: We do drydock it about every five years or so.

RW: Where do you take it?

FS: The last time it was done in the floating drydock down at the Submarine Base. We made a deal with the Navy that we'd drydock it there. I think that we've drydocked it at National Steel, and Campbell's. So maintenance is just something you have to do right. There isn't anything that says that it couldn't go on for another four or five years anyway, in a good, safe operating mode. The people who do use it would like something that is, as you can imagine, would be bigger and have more payload.

RW: I have a vision that it could go to the Maritime Museum along with their fleet. The point is I don't like to see it scrapped.

FS: Well, I think I have visions of that kind, too. One way to preserve an interesting aspect of it would be to scrap only part of it. That would be to cut it off some place so that you could mount it as if it were vertical and sticking up out of the water. In that case it would not take very much mooring space. Its horizontal footprint would not be very big.

[end Tape 2, Side 1]

FS: Anyhow, sooner or later we're going to have to think about what to do. It's certainly been around long enough that it qualifies as a historical kind of thing, I think.

RW: That's the point. If you could get a historical designation legally, it would go a long way to preserving it.

FS: Yeah, yeah. I was involved in one of those things here. The first building here on the Scripps campus was built in 1903, and the University had some studies that said that it was a seismic risk. The building was built in <u>1910</u>. So we got the Director of Scripps in that era, Bill Nierenberg, to release some money so we could do a study of what it would take to strengthen in a seismic sense, and we did indeed go ahead and did all the historic preservation things. It is now a National Historic Monument, the highest category these things go. There was a little group of us that wanted to see our heritage maintained.

RW: I want to go back to a couple of names: Roger Revelle, what kind of a guy was he?

FS: He was the kind of guy where you'd get a different answer from everybody. He had a knack for seeing the big picture.

RW: He was a big guy, anyway!

FSs: He was a big guy, yes, and he had a way of taking something that might have been thought of in a very narrow way and realizing, or helping others to realize, that it had much bigger importance. To myself, he and the physicist Carl Eckart, were the two who convinced me to come here, and once I was Director of the Marine Physical Laboratory – I started that job in 1958 – I was exposed to Roger Revelle as the leader of Scripps and in the sense as an administrator, and he has been given a lot of poor grades as administrator 'cause he was not an administrator at all, but in that era there were a bunch of us who were interested in particular aspects of ocean science and what we could do, and he was very good at having some things that he himself would push but helping other group leaders to be very effective, helping you to be on the right committees in the broader spectrum of what was going on in ocean science, and certainly for some time I was sort of his deputy as far as operational Navy kinds of things. I could go off to a meeting and make a commitment that as long as I didn't do something absurd - I don't know whether I'm in that category or not – but basically he would trust those of us who were group leaders to go off some place and negotiate something, and when we came home we would find that yes he would back us and help us to see that these things would come about.

RW: You didn't have to consult with him ahead of time.

FS: That's right. He was very good at helping other people in the institution to get things done as well as engineering big things like the International Decade of Ocean Exploration. There was a big complex of Indian Ocean expeditions that he really instigated. The International Geophysical Year, we had a big component in that. He was a stimulating person to be around, and he had a vision of where things were going. He had a bigger vision than just Scripps Institution of Oceanography for right here as far as that's concerned, 'cause the whole manner in which UCSD came into being was really heavily influenced by his thoughts and activities.

RW: How about Carl Eckart?

FS: He was a theoretical physicist. He had made his initial mark in the early '20s when quantum mechanics was new and there were two different formulations that people were groping for – how could these both predict what was going on in experiments when they both started from fairly completele different, in fact, assumptions and mathematical formulations, and he as a young man had the necessary insight to be able to prove that these two things were indeed just different mathematical ways of doing the same job. He was very well respected, a member of the National Academy of Sciences and that sort of thing. I'm not sure but I think he came here at the beginnings of World War II when the University of California put together its Division of War Research, which was started I guess before December of '41. He became convinced that there were a lot of good theoretical problems to be attacked in the Ocean Science world and that would be an interesting way to spend his time after the World War II thing had closed down. But there was some indication that in fact he had chosen to come here rather than what most of the nuclear people did, that was to go to Los Alamos or Oak Ridge or whatever and do the bomb thing. This was a different kind of thing, we were doing the antisubmarine warfare thing and it was the kind of thing you could in your mind say yes this is a real wartime thing, but we have to do this. This is not going to have any larger implications about destroying the world.

RW: He had more input here than he would have had at Los Alamos.

FS: Well, that's probably true, although even here in World War II, there were others of his stature who were involved in the University of California Division of War Research. There is something about a lot of us feel about doing work in the ocean, in that era particularly, there's still a place where individual experiments or individual people's activities could have a real impact. By the time I got my PhD in Nuclear Physics, for example, which was in late '51, that was already into the big Physics world. If any really major experiment was going to be done by a team of people, the Nobel Prize thing that Segré was involved in, was a shared thing. There was one other physicist who shared the prize and there were a number of other very good physicists who were involved in the experiments. The big physics world had kind of begun to jell even by the early '50s. It's jelling now in the Ocean Science world – facilities being proposed to put cable out to major parts of oceanic ridges to have continually operating equipment. These are all things that don't happen unless you have a whole bunch of people all pushing together to see if it's going to happen. That's really the way things are going. Back in the early days when I first started having graduate students, which was in the early '60s, the first ten of my graduate students had all done at least one expedition where they were Chief Scientist. In todays world, ships are expensive, we've generated a lot of Chief Scientists, and the idea that a student might be Chief Scientist on a significant operation just doesn't seem to happen, hasn't happened for a decade at least.

RW: Are you saying that it's still an open field on studying the ocean?

FS: There's plenty left to do, lots of things. There are the kinds of things that places like Scripps and Woods Hole will place to take part in, because one of the things like a place like Scripps you interact with people in a variety of disciplines. You go out into a Physics Department these days and people will talk about interdisciplinary things, but they mean one part of Physics versus another, cooperating with another part or something of that sort, whereas here primarily, I think, because we use the same facilities and the same ships, there is strong interaction between biologists and chemists and physicists and engineers or whatever, so interdisciplinary things and views and activities that are important parts of what's going to happen in the next decade in Ocean Science come easily for the oceanographic institutions, the good ones anyway. Things like what goes on at ridge crests. There are biological things happening because warm water is coming out of cracks in the bottom of the sea, is related to volcanic activity and so suddenly you have things happening where microbiologists and deep-ocean physicists really have to talk to each other. If you're going to put together these big equipment installations, they pretty much have to be looked at from the point of view of moving the biological part of our understanding of the ocean ahead along with our understanding of the earth below and what the chemistry of things is likely to be, what's influencing the chemical nature of the ocean, and the fact for a long time at Scripps the interaction between what goes on in the ocean and what goes on in the crust of the earth below has been a major aspect of study.

RW: Is that pretty much unknown?

FS: There's a lot known but one of the things that happens is that as you know more you find that you know less, and so you find out about the things you didn't know, or that there are things out there that you didn't know. So, for example, I lived through and some of the gear I built and some of the students who worked with me played a major role in this whole world of Plate Tectonics that has become our understanding of how the crust of the earth works. We know that that's why there are a lot of earthquakes where we live and on up the coast and not many over on the Atlantic coast. The question of what's really moving things around underneath there still we can describe what's going on but understanding what's going on down below is still not very well established, and the ramifications of what's going on, at ridge crests for example, are still being investigated and new things being discovered. I haven't said anything about the interaction between the ocean and the atmosphere, which is an insoluble major field of study, one that is really very active partly because it's harder to study what's going on down at the bottom. What's going on at the top you have some additional insight because you can fly satellites that can look down and tell you what the temperature field is like, what the water color is like, things that you would use as at least the boundary conditions for understanding what's going on in the volume of the water, in order to have almost a day-by-day view of the dynamics right at the surface.

RW: Like in the paper the other day, saying that we may have an El Niño because it's warm over in the South Pacific.

FS: Right, and that's been a very successful experimental program in which people started out knowing you could moor buoys out in the ocean and track what's going on, and that worked its way up into being a program in which there are quite a lot of buoys, I don't know how many, but there's a big string of them all down in the Equatorial Pacific that provide that information along with the information about what's going on not just at the surface but on down below, and then the surface observations from satellites that you have a continuous picture to tie together what you see from these sampling points of the buoys.

RW: One of the projects with Convair when I was there, they came up with these weather buoys, these huge round .....

FS: We called them discus buoys.

RW: Some of the technicians I worked with had to service them at first and they said it was awesome, you'd get seasick quick on that. That was a big contract for awhile. I'm thinking of fishes, fishing industry, but that's all surface. What you're talking about is 10,000 feet down.

FS: Well, somehow my interest focused on the bottom crust – I think because I like simple things. The part down at the bottom doesn't change so fast, in other words it's more amenable to a simple-minded kind of thinking about how to make things go.

RW: Carl Hubbs. Did you know him? I used to meet him down at the Maritime Research Society we had on the *Star*.

FS: Yes – one of our colorful characters. Not just a colorful character, he was a really very much respected scientist.

RW: Well, do you think we've pretty much covered everything?

FS: There are a whole 20 graduate students that all have their own stories.

RW: Well, the reason this interview is important is because it has to do with San Diego maritime history, and it will go into the files of the Historical Society.

FS: I guess for my own research, the main part of that, although I did experiments in underwater acoustics using FLIP when it was young, in that same era and out of that same SUBROCK thing, we were able to build a system that we could tow down very close to the sea floor using a coax cable that went up to the ship, that then we could have a whole bunch of sensors on that capability to do acoustic imaging of the sea floor, and photography, and make magnetic measurements and a whole bunch of other things. That really blossomed in the same era as FLIP, because in that SUBROCK program there were two kinds of questions: one was there were these targets that were out 30 miles of convergence zone. The other kind of sound propagation that was even better understood in the '50s, was that sometimes sound travels down, hits the bottom and bounces up and there is still enough intensity left that you can learn things by listening to what we would call bottom bounce paths, and if you want to use that information to tell where the target is, then you have to know something about the tilt of the sea floor because - if you and I had a sound path here - if it bounces on a tilted surface it's going to go off somewhere else and so the Navy had to understand what the statistical nature of the sea floor reference is. In the late '50s early '60s, there was no way to do that other than to build a system you could tow down near the sea floor and then you could make measurements on the right scale. That's basically what funded the beginning of that system. It was further pushed by the early '60s loss of the submarine *Thresher* that showed, among other things, the fact that we didn't really have as much capability as we could have to find things on the bottom of the sea. It took quite a while to find *Thresher*. It was months and months before we finally found it, and when it was found it was - most of that effort was in fact carried out by various groups in the academic research world, because we had equipment you could tow down there near the bottom.

RW: I understand the Russians were hot after it, too.

FS: Well, I don't know. There was enough activity out there it would be hard for them to do that, but I'm sure they were interested. Actually this deeply-towed instrument system that we put together and took out and used, and a whole variety of things, that's what got me interested particularly in the spreading centers of the ridges on the bottom of the sea, 'cause we had the gear to go down and find out what those were all about.

RW: Did the *Thresher* exceed its depth or did it run into something?

FS: It scrunched before it ever got to the bottom. It had some leakage problems.

RW: Do you think they were out of control?

FS: Well, it certainly eventually got out of control.

RW: I mean, they started down, if they had control of the sub they could bring it to the surface.

FS: Well, they apparently had enough flooding that they didn't have enough air to get it to – it was a kind of a multiple, as nearly as people can tell, there's been quite a lot of work done on that. It must have been multiple kinds of things, one part of that being the human equation, in the sense that you tend to have some confidence. One of the things that submarine people have is a lot of confidence in being able to handle things themselves, and sometimes that can backfire by your not starting to blow your ballast tanks quite as soon as you might because you thought you could probably take care of this problem that was developing, and so by the time you're really ready to blow your ballast tanks, they may have been down deeper than they really wanted to be, or the designers of the ballast system felt they ought to be. It's just one of those things that if you've ridden in a submarine for awhile you get to think about that every some while.

RW: Well, I want to thank you for this second interview. We'll put it to good use.

FS: Sure. What I realized is that I should have had with me a – we put together some things that are just a cutaway view of FLIP on a board that's about this size. I should have gotten my hands on one of those. What I maybe could do is send you a cutout view and a photograph and then you can describe that and tack it onto this so it will be part of the interview. I thank you very much. Next time I see you at some ……

[end of Tape 2, Side 2]