Frank at Harvard

(this is transcribed nearly verbatim from the recorded proceedings)

I'd like to start with a disclaimer: Frank was at Harvard from 1955 to 1958. And during that first of Frank's four trips (as it turned out) to Harvard I was busy navigating grades 7 through 9 at Summit (New Jersey) High school; so I didn't interact with Frank at all at Harvard, and I've tried to reconstruct this by a lot of digging. And I've probably not been terribly successful. So those of you with more accurate information should feel free to chime in!

Part I: Frank as Graduate Student

Here's Frank at Harvard, during his graduate student years (Figure 1), in one of the few photographs we've managed to find from that era. He came to Harvard in 1955, fresh from the navy; although not, like his namesake, from the *Royal* Navy, as in this drawing (Figure 2) of the Golden Hind -- or maybe it's *not* the Golden Hind (laughter). He had served as an electronics officer on the heavy cruiser Albany; and here is a picture of the Albany (Figure 3). This is, in fact, the Albany in its first incarnation of five or six Albanys that have been in the U.S. Navy. Frank probably knows this history well. This is a 22-gun sloop of war, on the authority of the worldwide web this morning.

Here's the actual Albany (Figure 4) that Frank served on (Frank, do you recognize that?). This is 1946, and this rust bucket of a ship is called a "heavy cruiser". It was subsequently converted to a guided missile cruiser in June of 1958 – here's proof (Figure 5) – at the very time that Frank was receiving his PhD. For whatever it's worth, Frank, the Albany lives on still, reincarnated in 1990 as an attack submarine (Figure 6).

So here's Frank (Figure 7) fresh from the navy (laughter). I had to recycle some of these pictures because we had a dearth of good pictures of Frank. In fact Frank's Navy career was quite relevant to his later scientific career. He had graduated from Cornell several years earlier, in 1952, with an obligation (because of ROTC) to spend some time in the Navy. That was a chance to learn plenty of electronics. He became so adept (and essential) at keeping the Captain's TV set running that he acquired the nickname "gitme," as in "Gitme that feller Drake."

As you might expect, his Navy years generated plenty of grist for Frank's storytelling mill. For example, while moored in port, the modern day Drake was sent as Navy

emissary up to the Spanish at Cadiz, in the shadow of the giant U.S. warships towering over the diminutive Spanish fleet. You see, around those parts the name Drake is synonymous *with El Barbariano* – the barbarian – or sometimes *La Pirata*; and tourists are regularly shown the places "where women and children were slaughtered by the English Barbarian," or "the only church left standing by the English Barbarian," and so on. Frank, representing the U.S. Navy, gave an interview, which seemed to go well; but they only caught his name at the end, and Frank had to beat a hasty retreat. Well done Frank!

Anyway, Frank arrived at Harvard in 1955 and got a summer job working at the Agassiz Station Observatory, out in the town of Harvard, Massachusetts. At that time the site had several optical telescopes, and also the recent 24-foot radio telescope. One of his three jobs was, literally, to grease the gears of the latter – Frank was "bottom hog on the trough" at that moment. Here's a shot of the 24-foot telescope (Figure 8). Those of you old-timers may recognize it; the assembled bigshots are T.K. Menon, Bart Bok, and the visiting Martin Schmidt.

Frank's second job was to put the 61-inch optical telescope back into commission; it had fallen into disrepair over the years, following its construction some twenty years earlier. Here's a picture from *The Harvard Crimson* in 1956, showing the 61-inch Wyeth reflector telescope during its refurbishment by our own Frank Drake (Figure 9). Frank got together an aluminizing chamber, personally put down the linoleum tiles on the floor (still there!), and he got this telescope working. He even made a discovery – he did a 5 hour exposure with an H-alpha filter on gamma Cyg, and discovered a nebula surrounding it. Fresh from the flush of discovery, he wrote to Minkowski at Palomar suggesting that the 200-inch telescope could do a better job. In response he got a rather peremptory letter back from the great man, who refused to waste his time because, as he informed Frank, "Young man, there *is* no such nebula around gamma Cyg."

Frank was a clever guy even back then; this was nicely demonstrated when he built an IR photometer for the newly refurbished 61-inch telescope. He built a chopping photometer, with the rocking mirror glued to a loudspeaker; a second copy balanced the thing to cancel vibration. The cleverness came when he decided to use an ellipsoidal mirror instead of lenses; but a custom ellipsoidal surface would cost $10,000. Frank realized that you could do much better – he learned the language of optometry, and "prescribed" a sphere+cylinder approximation to the desired ellipse. The thing cost him 3 bucks (for two)!

Here's the 61-inch telescope, in a contemporary view (Figure 10). It's still there, carrying out radial velocity surveys under the direction of Latham and Stefanik (who found the first credible extrasolar planet, HD114762). And in this photo you can see our optical SETI pulse detector, bolted to the side of their echelle spectrograph, along with astronomers Stefanik, Zajac, Papaliolios, Coldwell, and Wolff (left to right).

So Frank did us a good turn there. He had assumed that he was going to do optical astronomy, but he was quickly unmasked as a guy who knew how to make electronics work. He and Dave Heeschen were essentially the only people who knew how to use a soldering iron around there. So he was pressed into service, and joined Bart Bok's radio astronomy group.

This was a time of tremendous excitement. Neutral hydrogen in the galaxy had been discovered only 4 years earlier, here at Harvard, by Ewen and Purcell. Harvard had the only graduate program in radio astronomy in the country, and the very entrepreneurial Bok had raised funds and had an active group of 8 or 10 students making hydrogen line observations of anything that would stand still, and even stuff that wouldn't.

So Frank's third job was to help with the 60-foot radio telescope, which was just then being born. This is what it looked like in September of 1955, a mere 3 months after Frank arrived on the scene (Figure 11). Just a hole in the ground, then, but it was growing fast! Here it is 2 months later – big foundation, right down to bedrock (Figure 12). That's Dave Heeschen (and his car), and Kochu Menon; I'd like to point to Frank, but he seemed camera-shy – as a surrogate we see only his Ford! (laughter).

Here's the pedestal going up (Figure 13). It's hollow and shiny – sort of like the tin man in the Wizard of Oz. (We've now painted it with aluminum paint, so it's even more like a tin man.) And again, here in March of 1956, no sign of Frank. Now the dedication was scheduled for April, so here we are with a month to go, and its still just a shell of a pedestal: no gears, no motors, no dish…no nothing. Cutting it pretty close! And here's one *week* before dedication (Figure 14). Still no dish. Sometimes I think we put things off to the last minute, but nothing like that!

And here it is, finally, on dedication day (Figure 15). They got the dish on it! Looks complete, but I'll tell you about some things that aren't on it quite yet. We don't see Frank, but he is very much here (be patient!). That's "Mrs. G." (Cecelia Payne-Gaposhkin, Frank's ultimate thesis advisor) over to the right. And Frank will be revealed, soon enough.

First, though, let me just show you a few other photographs from that heady day out on the hilltop. This one I find particularly artistic (Figure 16); it's a shot of "Doc" Ewen and Ed Purcell (a very youthful looking Ed Purcell), with the horn that they used to make the discovery of 21 centimeter neutral hydrogen radiation from the galaxy five years earlier. The gorgeous 60-foot dish towers over it, seats still set up from the dedication. For historical perspective I'd like to show you that same horn, where it made its discovery, sticking out of a fourth story window in the Lyman Laboratory, which is right across the common from here (Figure 17). That's Doc Ewen, hanging on for dear life.

And here's what's on the other side of the wall (Figure 18), to give an idea what radio astronomy looked like back in those days. Here's the horn antenna, tapering down to an L-band waveguide, feeding a bunch of reclaimed World War II mixers, oscillators, and so on. Perhaps the most charming item is the pair of earphones hanging here – a rather SETI-like suggestion!

Continuing the history of that dedication day, here's the actual guest book (Figure 19). First page, from April 28, 1956. Bart Bok right on top! Then Harold ("Doc") Ewen, Dave Heeschen, "TK" Menon and so on. Well this goes on for about twelve pages. I was looking for Frank: Was he really there? Does he really exist? Well, here's the last page (Figure 20), and here he is, one of the last four people to sign in: "Mr. & Mrs. F.D. Drake, Harvard U." He signed in late, but in pretty darned good company – there's Ed Purcell, the Gaposhkins, Harlow Shapley, and so on.

But, where was Frank? *This* isn't Frank (Figure 21), it's Alan Waterman from the NSF, with Donald Menzel in rapt attention, waiting his turn. Frank's actually in this picture – but you'd need x-ray vision to see what he's up to. We've arranged that! (Figure 22) Frank's job, you see, was to watch that prominent switch, connected to a wire which is connected to nothing. Frank's looking out through the crack, so when the switch is ceremonially turned on, he switches the real life switch inside the pedestal, and the dish moves! (And we'll come back to "Frank and The Switch" at the end.)

Here's the article that came out in the *Boston Globe* (Figure 23). The "60 -Foot Harvard Telescope Looking Back 200,000,000 Miles." Now, you know, that's *really far* -- that's three times as far as the sun, almost! But if you read the article in detail you'll find that they meant *light-years*, not miles.

It’s always fun to look back at historic electronics, which folks at the time always make the mistake of calling “modern”! Here’s what they had back then (Figure 24), where I’ve taken the liberty of sketching in a block diagram.

What are these giant racks? Who are these nerdy-looking people? What are they doing? You can learn about this from the *Globe* article: *“The receiver is a four-bay console containing an amazing assortment of electronics material. In the first bay the process electronics men called heterodyning. In laymen's language the doings in the bay decreases the frequency of the radio signals. When they leave the bay the wave length will be increased to about 987 centimeters, almost 10 meters, from the 21 centimeter length they had originally.”*

So they think that's a real stretch! How about this: *“In the second bay the process is continued so that when the signals enter the third bay the frequency has been decreased still more and the wave length increased this time, to nearly 45 meters.”* Wow*! “In the third bay the radio signals are divided into 20 separate signals.”* Double wow! And then they say that the last one has a power supply, which shouldn't concern you at all.

Now let me just show you those bays again; so here it is -- 1, 2, 3, and 4, and I'll give you the overlay so we can understand what these guys were doing. So here's the first mixer. Here's the second mixer. And, here's the 20-channel receiver….uh, anyone see a 20-channel receiver? (laughter). Well, I've been asking about that 20-channel receiver and the best I can make out is that there never *was* a 20-channel receiver at Agassiz Station. It was designed, it was built, and it never worked! Instead of a 20-channel receiver they used a single-channel leadscrew-driven plunger-in-a-cavity slowly scanning receiver. It had been cobbled together from some surplus radar stuff, and used on the 24-foot dish; they moved it to the 60-foot dish, and that’s what they used for all the observations.

Okay, this is the happy gang of nascent radioastronomers (Figure 25), which includes (left to right, top row) Frank, Bill Howard, Ed Lilly, Kochu “TK” Menon, and Dave Heeschen; in the bottom row there's Doc Ewen, Mary Connolly (now Sandage), and their boss Bart Bok. You may recognize that same smiling Frank from the earlier Navy photo (laughter). This shot was apparently taken in front of the Faculty Club.

Those were happy times. Frank describes a colloquium after which George Field was speaking with some young character, whom Frank did not recognize, about excitation of hydrogen in space. Frank chimed in, and basically insinuated that this gentlemen

didn't really understand anything about the excitation of hydrogen. Frank set him straight afterward – it was Ed Purcell! Frank, did *you* understand the excitation of....?

Frank's thesis was studies of "Neutral Hydrogen in Galactic Clusters," particularly his favorite, the Pleiades; here's the title page (Figure 26). A nicer view is the spine, in gorgeous collegiate crimson (Figure 27); shows we actually tracked the thing down. Now, there's this old joke about how many people actually read a thesis; it's often said the correct number is three – your thesis committee! I often doubt that all three actually read it. But the old story is that you should put a twenty dollar bill somewhere in your thesis, and then come back 25 years later and see if your thesis has preserved its virginity.

Well at Harvard we have institutionalized this process! We have on the front page a sign in sheet, which they claim is for copyright reasons and so on – but I suspect it's basically to keep score. Here is the sheet from Frank's thesis (Figure 28). Would you like to see who read it? Right!

There are charming anecdotes from that period, some adequately embarrassing about Frank to qualify for inclusion here. Once, according to Kochu Menon, Frank and Mary Connolly woke him up at the cottage at 2 AM, and said that they were going back to Cambridge because all the signals had suddenly disappeared from the radio telescope during their run. So, Kochu went down and took a look, and indeed there were no signals coming down. Got his flashlight out, climbed up into the pedestal, and found that all the cables had snapped. Turns out Frank was doing a scan around the North Pole with a rather slow scanning receiver, and he wasn't quite done when it was Mary's turn to take over. He begged for another half an hour, and he got it. And that's what it took to break all the cables!

As Kochu was relating this story, but before he reached the punchline, I blurted out "let me guess, he banged it into the parking lot." No, he said, it was *George Field* who did that. (laughter – George was in the audience!) Another marvelous story of Frank from that time is when Frank, Dave Heeschen, and George Field (and their spouses) were on their way to a radioastronomy symposium in Paris. They were spending a day or two in New York on the way, and as they came down to the hotel lobby the first day they saw people milling around with name tags that said "Jehovah's Witness". A convention. The next day when Frank came down he was wearing a name tag: it said "Jehovah." (laughter)

Anyway here's what the 60-foot telescope looks like now (Figure 29). Among other improvements, it's grown to 84 feet, particularly striking when compared with my 6-

year-old son who's pointing to the Cassegrain radome. And the receiver we're running now has 250 million simultaneous channels, compared with the single channel receiver in Frank's day. But we owe Frank a debt of gratitude for making this radio telescope work, as you made the optical telescope work; they're still working for us!

Part II: Frank Visits Harvard Again (and Again)

My narrative so far has been a bit "theoretical" – I wasn't there, because I was busy being a schoolkid, back in Summit (NJ), fiddling with my ham rig and other nerdy delights. But our world lines were destined to entangle, soon enough. First was in 1969, for the Loeb Lecture series, hosted by the Physics Department. This is an honor among honors, for distinguished people to give a series of lectures for a week or two. Here's a listing (Figure 30) of the first few years' worth – you see it was kicked off with none other than Enrico Fermi and Freeman Dyson. That's a hard act to follow! Here's Rabi, and Bethe, Yang and Lee, and Gell-Mann. And here, in 1969-70, along with Academician Kapitza we have Professor F. D. Drake.

And here I've unearthed the vintage poster, listing his talks (Figure 31). He was officially talking about pulsars, but he couldn't resist getting in a shot for SETI. I, for one, am grateful that he did, because it was this lecture that launched me into this field; it was a revelation that you could go beyond idle speculation – you could actually *calculate* stuff. So, Frank gets the blame for corrupting some youth.

And here's Frank again (Figure 32), in 1995, coming back to help us dedicate the 250-million channel search that we called BETA: Billion Channel Extraterrestrial Assay. Not quite a billion, actually, but "close enough for government work." (Happily, it's funded almost entirely with private support – by The Planetary Society and the Bosack/Kruger Foundation.) As promised, here's Frank and here's The Switch. This is the switch that starts the telescope – history repeats – only this time we actually had it wired up, so Frank was permitted out in the open. Technology overcomes shyness.

And here is the control room (Figure 33), with someone blocked out (although some of you may know that I used to wear beige everything). An amusing thing here is that we're in the same control room as in Figure 24, and there are still 4 racks of equipment. The one over on the left has the 250 million channel receiver, replacing the rack that was supposed to have 20 channels but actually ended out having just one. So electronics has become millions of times more powerful, and it doesn't need any more space! As it turns out, Frank actually used this opportunity to segue into a little bit of *optical* SETI: Here's Frank up on the dish, during the dedication of the 250 million channel BETA, using purely optical techniques! (Figure 34)

And finally, here's Frank and other dignitaries at the symposium we had after the dedication of BETA (Figure 35). On the left, curiously, is his fellow Loeb Lecturer Freeman Dyson, one of the planet's more unconventional thinkers on SETI (and everything else). More entanglement of world lines.

Well, *this* trip marks Frank's most recent voyage to Harvard. All of us at this University have been incredibly enriched by Frank's works and visits here. As George Field remarked to me, "Frank is a special guy, quiet but with a sparkle in his eye; he knows the answer and he gives it to you quickly." "I've always admired him," he added warmly. And, *I've* always admired him.

Frank, I don't know what I'd be doing today, but it wouldn't be SETI if it weren't for your inspiring series of lectures here back in the 1960s. They showed me (and many others, I imagine) that searches could be done, with available hardware; and, best of all for a technoid like myself, they showed *how* to do them. So, when I had a sabbatical in 1978 – you'll probably remember – I indulged a whim and wrote to you asking if I might be permitted to "search for life in Puerto Rico." I think you got the joke. You were like a father to me: sent me down there, offered me up a stipend even. (An epiphany comparable to Carl Sagan's discovering that you could actually earn a living as an astronomer – my gosh, one can earn a living doing *SETI*?) And when you visited down there and found me holed up shyly in the library, you chased me down to the control room to *do an observation*, as you so eloquently put it. I've been hooked on SETI ever since, and to me it's the best addiction I can imagine! Hooray to you, Frank. To me you continue to this day to be the most sensible – and at the same time among the most imaginative – voices in SETI.

Thank you all.