Bendix Radio Foundation
Oral History

Cramer Bacque Interview

Introduction

On July 19, 2006, Cramer Bacque, a long-time employee of Bendix, was interviewed by Joe McCormick, Guil Vogt, and Ken Kidd of the Bendix Radio Foundation. Cramer Bacque is in a unique position to provide information on the history of Bendix in Baltimore. He worked for many years, both for the Radio/Communications Division and for Field Engineering. In addition, he was involved in interpreting much of the material assembled by Pat Hyland for his autobiography, completed after his death. This gave Cramer a detailed knowledge about the early history of the Radio Division.

The interview was held at a Denny's restaurant in York, PA and recorded on audio tape. (CD's of the original audio tapes are included with this document.) The following text is a literal transcription of the recorded audio tapes. No attempt has been made to edit the text; it is strictly conversational. In a few places, the exact words were not intelligible; these are indicated either by a (?) following a best guess, or by […]. After their first appearance on a tape, when their first names appear, the speakers are identified by initials, C – for Cramer Bacque, J - for Joe McCormick, G - for Guil Vogt, and K – for Ken Kidd.

Bendix Radio Foundation

Cramer Bacque Interview

<u>Tape 1, Side A</u> — July 19, 2006 - York, PA

Guil – What started this was Jerry Woodall apparently talking to you at the Retiree's Luncheon on June 8, 2006. He was very enthused at what you had told him. He didn't know the story.

Cramer – Lets set this up as what happened was Pat Hyland was writing a book of his life and he, in writing this book, started doing it like would you believe 50 years before he was gonna ...either have it published or whatever he was going to do with it – he was writing an autobiography.

G – What year are you talking about?

C – The date we're talking about is - Hyland started writing this back in the mid-thirties and the way he was writing the book-he was jotting down things on pieces of paper and sticking them in his desk. He continued to do this for about fifty-some years, and then, unfortunately, he died. His wife really needed to finish the book because he wanted that book to be finished. But she didn't know how to piece this stuff together. So she looked around and found the names of some people that might be able to help. And of course W.P. Hilliard was one of them, and they went to the corporate office of Bendix Automotive out in South Bend. Pete Leatherwood, who is a good friend of mine, Pete was able to help with some stuff and said hey, why don't you call Cramer? I'm sitting at my desk at Field Engineering and the phone rings and it's Hughes Aircraft and they want to know about Pat Hyland's career at Bendix.

G – What year is this?

C – 1989, 1990 roughly. He died in 1988 – he was 91 years old. So I got on the phone and we pieced this stuff together and I added some things that I had found which was really over in the Communications Division's vault, which somebody destroyed. Which made me angry as all get out. In that vault was every contract and sales order that had ever been awarded to Radio Research or Bendix Radio or Bendix Communications Division and really what happened there was that somebody destroyed it but prior to that being destroyed, back when I did the Communicator, a brief history of the company. I was able to go down there and research that stuff and I found a lot of stuff in there and I remembered it.

G – It really was destroyed, not just lost?

C – It was destroyed because somebody, after Raytheon took over, somebody in Contracts decided to get rid of all that old stuff. That has cost us dearly.

J – We spent al lot of time up there in that vault-you know that.

C – I know that, Joe, but

J – I didn't think anything had been touched.

C – Yes.

J – When we got in there everything was just…

C – But the contracts files were gone. Let me tell you what happened. We were involved in a lawsuit. The typical annual lawsuit and AlliedSignal has got an incompetent legal department. What they did is they contacted a Washington outfit. What we were being sued for was FPS-20 high-powered radars …

J – I remember that, yeah

C - …causing cancer, cataracts, etc., etc., etc. We had been through this about thirty times before. Our patent attorney handled it at the Division. All he had to do was pull out the contract which had the indemnification clause; we were indemnified against all lawsuits relative to that equipment as procured by the Air Force-that was one of the terms of the contract. They couldn't find it! You know, I'm getting us off the track, but they couldn't find it. I had to go back and try to get them to find the damn contract-I was with these lawyers over and over again, and I don't know what happened. But we had been through this before, and the files at AlliedSignal, they were also gone. The legal department apparently doesn't keep files, because we had been through this before.
Anyways, Hyland died, the book got written and it was published as Call Me Pat. And Hyland was born in 1897 and he was Canadian-born. His family relocated to New England. He became interested in amateur radio and we're talking about at the time 1905, 1910,1912, back in there. And his bible was the Amateur Radio Handbook And he learned a lot about radio from the handbook. When WW I came, he went in the Field Artillery. and went to France. He found out they had no communications. So what he did is he took some French radios and some German captured radios and pieced them together and guess what? They now could communicate; they didn't have to rely on the carrier pigeons. I'm serious. And the war ended and he came back to the United States. And he got a job at a company which [he had] known about in New England, in Bristol, CN, called New Departure

G – The ball bearing …?

C - That's right, and he was a machinist at New Departure. And he didn't like it. He is sitting in front of his machine one day doing his work, and he looks out the window, he sees this big sign - "Join the Navy and See the World". And Hyland decided to try to join the Navy. So he wrote a letter to the Navy Department saying that he was an accomplished radio man and what he had done and what his background was and the Bureau of Navigation came back and said "OK, if you pass the code test, we'll enlist you as a radioman first class. So Pat Hyland was enlisted as a radioman first class. He was assigned to Pensacola. He got to Pensacola and he was involved in the very first radios going into airplanes. He worked at Pensacola, he knew a lot of the junior officers, he flew with them, he solved a lot of radio problems. Then, one day, chief of Naval Aviation, Admiral Moffat came down with his staff. The purpose of this was to check out a Commander who had to keep his code up. This Commander… in the Navy in those days … had to take a code test. And Hyland was assigned the job of the code test. Well, they never did give the code tests. Hyland was telling them they were all wet on air defense, that the guns couldn't traverse fast enough to shoot down a low-flying high-speed airplane-100 miles-an-hour, 120 miles-an-hour and this Commander was impressed. Out of a clear blue sky they promote him to Chief Petty Officer. So he becomes a Navy Chief, Chief Radioman, at Pensacola, working away and then comes a set of orders to a cruiser, the Marblehead. He goes on the cruiser and the equipment is antiquated. He's shocked! The Bureau of Ships is, you know, Stone Age equipment compared to what they had in Aviation. So he's not very happy there. And the Captain is not very happy with him because he is an Aviation radioman primarily, not a shipboard type. Anyways, suddenly one of those Lieutenant friends of his shows up and says, "Hey, this ship has a catapult on it, we're getting an airplane, and you're going to be flying with me." So he continued his tour of duty flying off the Marblehead. He then decides to leave the Navy. It's been six years in the Navy and Pat had met one of the Lieutenants, had gone to Washington and they had some programs that they needed somebody to work on that they had confidence in. The Naval Research Lab was relatively new; it had been formed in 1922 and the Lieutenant wasn't too keen on them, but he was keen on Pat Hyland. He told Hyland, "If you leave the Navy, come to NRL, we'll get you a job and we'll run these tests…

G – What, roughly, time frame?

C – We're looking now at roughly 1926, '27, right in there. So Pat goes there and NRL says, "No way-get out of here! You don't have a degree, you have no formal training. We're not going to do it." And Hyland found out he could take a test, so he takes the test and he gets a 70 and 75 is passing. But he is a WWI vet and he got five points. So now he's acceptable. NRL says, no, no, we've got too many non-degreed people here; we don't want you." This Lieutenant says, "Look, I'll open up a slot for a degreed person if you hire him, OK?" So Hyland was hired by NRL. He was working with a guy named Leo Young. Now Leo Young was the father of the Leo Young that we knew, Joe, at NRL; that was his son. His son followed in his father's footsteps.

J – Oh Yeah, OK.

C – While at NRL, they had a problem with airplanes. The receivers didn't work. Because of ignition noise. And Hyland says," Hey". He saw if you put a static shield around it, a Faraday shield, you could cut that noise down, and he redesigned the spark plug. And put a different kind of wiring in it. However, the pilots – "Unh unh, nobody's touching the magneto circuits in the airplane-if it goes in the engine, you're not gonna do it." One day, out of a clear blue sky, he's working for NRL, here comes a guy from Bendix – "I heard about this-what about it?" "Aaaah, we don't think much of it, but look, here's $10,000. Give us the rights to it."

G – I'm sorry, this to whom?

C – Hyland is given ten grand, and Bendix goes off and files a patent on it. Hyland, in the meantime, is still working, doing the things for this officer that needed to be done. And the experiment – one of the big things was an improved radio direction finder. Direction finding was always a problem and NRL was given the job, and Hyland was given the job of working on this direction finder. In the meantime, though, he and Leo Young decided to set up a company. They didn't incorporate but they set it up, and the company was known as Radio Research, it had Hyland, who was an unpaid employee, and Leo Young, who was an unpaid employee, and a technician whom they hired because he had a cellar that they could use to work in. There were three people and what they found was, we're talking 1928 now, talking about things happening in the radio industry. We're starting to see people talking about commercial radio, and one of the big things was frequency control and that's what happened. Hyland and Leo Young designed crystal-controlled oscillators, and they sold them, and they were built in the cellar by this technician, who was paid on a time and material basis.

G – They apparently had enough knowledge to work with crystals.

C – Oh, yes.

G – It seems like another whole field.

C – It's a whole field. And they were experts in this. Leo Young and Hyland were absolute experts in the crystals.

J – They were still working at NRL.

C – They were still with NRL, but, see, the laws were different then. You could do that, and then you could also sell to the same Government agency that you worked for. Anyways, they are working away and Hyland's working on this direction finder. And what you do for a direction finder is you will put an airplane on a compass rose and a compass rose is a 360 degrees… and you move the plane around five degrees at a time or whatever, and you see what errors you get in the bearings.

G – You calibrate your magnetic compass.

C – Right. And your radio direction finder.

G – Oh, OK.

C – All right? So they place this airplane two miles away, they fire up the transmitter, and suddenly Hyland turns on that CW transmitter, and what they're using is detector current, and suddenly the G D detector goes wild! Hyland says, "What's going on here?" He keeps looking, and he sees every time an airplane goes out to the runway to take off, the meter does all this. And he starts working around it and he finds out "My gosh, we're getting re-radiations" is what he called it, from the airplane. He gets a hold of Leo Young, and Leo confirms this, and they immediately go to the top brass at NAVAIR, and NAVAIR says, "Well, not much we can do about it, but OK, that's nice." Hyland goes to the Director of … well, Leo Young went to the Director of the Lab who went to Bureau of Ships and Bureau of Ships says, "We want nothin' to do with that". So Hyland keeps running this experiment while doing the direction finder. His boss finds out about it and tells him to cease. Well he and Leo decide they will continue the experiments on Radio Research time. So they continue the experiments. This was 1931. Hyland gets fed up with what's going on at NRL and quits and devotes full time to Radio Research. He then decides the cellar is not good enough. "We need to move into better quarters." They rented an abandoned store in Washington, D. C. The store was abandoned and they had 200 square feet of floor space. They were still building things and by then we now had broadcast stations on the air. So Radio Research decided to equip a Ford Model A truck with receivers and antennas to measure field patterns of these radio stations and confirm their frequencies; since they were well known as being experts, they got business in this area. Well, things are looking good at Radio Research, so Hyland says. "Well, we're going to rent another store." So they doubled the size of the store to 400 square feet and they continued to flourish. While they were doing these measurements, they invented what later became known as the LM frequency meter, which was called the CFI, the crystal frequency indicator. What this was was a technique of measuring frequencies where you had ten oscillators that were crystal controlled and by beating those different oscillators, and calibrating them, you could get any frequency that you wanted. So what you would do is you would have a calibration chart, and if you wanted to measure the frequency of something, you simply fed the frequency in and tuned this until you got a zero beat. And read off the thing and that would tell you the frequency. If you wanted to use it the other way, you would set it up ahead of time and then it would transmit out. It was a very unique technique and it was very good. Unfortunately, they didn't patent it. But the Navy … they got their big contract; they sold ten of them. They built the prototype and it worked beautifully. They built the ten for the production run. None of them worked. Hyland is sitting there "What in the name of heaven is going on?" And what happened was, he took it apart, the prototype, and checked it against everything, and put it back together again, and it didn't work either. And he started thinking, "When I took this apart, there was a screw that was loose." There was a condenser and there was a holding screw on the rotor. What had happened, if you tighten that up, it actually changed the capacity by putting pressure on that. So what he did, he loosened the screw, and guess what: it worked! All of them worked. He never told anybody, put 'em all together and shipped 'em.

G - Loose screw and all! It's like the performance of the transmitters on the APX-72, BI-5, etc

C - So, anyways, Hyland got things really rolling and then he decides to build a building, a big 1200 square foot building. And he does. In Washington. We're talking about early 30's. Things really boomed in that short period of time when he left NRL.

G - That's surprising, because that's the depression.

C – That is right. That is the depression. And the next thing that happened, which was disastrous to Hyland.

Ken – Is that the building you're talking about? [Looking at pictures in the December, 1985 Communicator]

C – Yeah.

K – That's your Communicator article.

C – Yeah, that's the building. Now that was the early building, OK. Then he made what he considers to be a huge mistake. He decided to double the size of the building. But you've got to remember, they didn't have many employees. Leo and he were not accountants and they gave their time free. What he didn't know was that in 1931 all of his work that he had done on direction finder multipath interference fields –reflections or re-radiations, a patent, two patents, were filed in his name and Leo Young's name and they were awarded in 1932 to Radio Research. So they got patents for the detection of aircraft by using a radio. Two of 'em. Hyland then – things were looking really good. Then disaster strikes. This is familiar: when you're doing a lot of government business, it seems it's either feast or famine. He learned that lesson, but unfortunately, Roosevelt was elected President.

G – So that would have been early '33.

C – Elected in '32, took office in '33. What do you think his first act was? Freeze the banks. What happened is he closed the banks. And Radio Research couldn't get any money out of their bank. Hyland had hired two new people, a machinist and a draftsman, at one-third the going rate, $15 a week is what he was paying them […] forty-five, and he now had this problem, in spades, of no money, because they had money but they couldn't get to it. He ended up going to Riggs National Bank, and they were able to help.
And some of the merchants helped by accepting chits while the banks were closed. He called Marcus. Charlie Marcus was a very important man in Bendix. He was the real brains behind the whole company. He came on with Vincent Bendix and he was the architect of building the company. Charlie Marcus talked to him and said, "Oh, OK, I understand your problem with everything else, he said, but, you know, you're working on this new direction finder, which they were. The new direction finder,…they had hired

Wilbur Webb. Now Wilbur Webb was the inventor of the automatic radio compass. The problem with direction finders was that you got two nulls and it made it difficult determining the real bearing plus, you had to manually do it. Will Webb came up with a technique where he got a cardioid pattern and got one null, and got a patent on it. A very important patent. However, there still remained some problems. And one of the problems was solved by Bendix with what was known as the Autosync. It's a synchro, a small synchro. Well, a synchro enables you to transmit information, a position of a rotor from one place to the other. You've got a transmitter on one side, you either have a delta or wye set of windings. If you rotate this, that changes the fields on the other side acting as a motor. So it follows. So Webb was working on that. Charlie Marcus went back and they talked around. In 1935, they bought half of Radio Research for $100,000.

G – Who bought?

C – Bendix. Charlie Marcus went back, and Vincent Bendix was flush with money; We'll do it. So they bought half of it. Charlie then convinced Bendix that the radio business, the electronics business was something that was really going to expand, and that he should really look into buying other companies as well. Now these are small one-man and two-man companies we're talking about with no money and a lot of ideas and patents. So in 1936, he bought W. P. Hilliard Co., Dayton Audio Products, Jenkins and Adair, and another outfit in Dayton. Two outfits in Dayton made test instruments, not CFI, but test instruments. Jenkins and Adair made radios. W. P. Hilliard was aircraft radios. That was called the Bendix Radio Corp. and it was moved from W. P. Hilliard and from Dayton and parts of Radio Research to – 1936 now – to Chicago. Why Chicago? Bendix had bought Stromberg Carburetor Co. and carburetor sales were very high (?) so Bendix no longer needed the building there so they moved that into that building - part of Radio Research, W. P. Hilliard, and those outfits that were in Dayton.

K – But Jenkins and Adair was in Chicago also.

C – Yeah, they all went there and they ended up at Stromberg.

K – There was a little piece of that from an Ollie Ports biographical sketch in which he says he started …

C – He did.

K – Jenkins and Adair in the basement and billiard room …

C – They were small companies, but they had ideas and patents and Bendix had more to develop. The next thing that occurred was that Will Webb was sent to Chicago. The company then won a big contract in South America. Now winning this contract was either during the acquisition or before it – they won a contract with the Argentine Air Force and this contract was for radio equipment and it was a big one in those days. So the company was flourishing. Two of the people that worked on that contract were Bob Davis and Dick Able. Now, an interesting sidelight here – they went to Argentina and

Davis flew by Clipper. Able missed his plane. That plane crashed. Able wouldn't fly, but he finally got there by boat. They designed and built these transmitters – high-powered high frequency transmitters and receivers – a communication system. The interesting thing was, in 1980, Al Hohman got an order for some parts for those radios. Now the parts were unique and this was a Bob Davis design - from the thirties - what Davis did - and listen to the thing here- … As you probably know, in any high-powered thing you had a problem with DC filaments. And what happened was the filaments would have uneven emission. One side of the filament would gain resistance more than the other and the emission would be different. The solution was to center-tap the filament. What you had to do was buy the tubes, which Davis did, open 'em up, center-tap the filament, put 'em back together again, and that's what was shipped. We got that order for those tubes in 1980, and we found somebody who could do it and we did it and we fulfilled the order. Anyways, things were really …

J – I wasn't aware of that.

C – Joe, you were General Manager.
So Hyland was the first General Manager. And he does a poor job.

G – Let me just say, they were making aircraft radios, for probably other people than Argentina.

C – Oh, yes, they made a communications system. They made the ground transmitter and everything OK.

G – These were high frequency?

C – Yes, all HF. So Hyland did a lousy job as General Manager, and … this is 1938. If you could remember, unfortunately, back in the early days, Vincent Bendix, when the company went public, General Motors bought 40% of the company. They controlled the board of directors. And then at the time in '38, since the company had grown, it was only 23%, but it was still a controlling interest in the company. Anyways, because of this, they sent Ernie Breech in to determine what the Hell was going on at Bendix. This whole thing with Ernie Breech coming in with accountants to Bendix Radio was to find out what the Hell was going on, and they didn't like it. In fact they didn't like anything that was going on within Bendix. It wasn't just the Radio Division, although the Radio Division was one of the leading losers at that time because Bendix had just won the automatic radio compass contract in 1937 and hadn't started delivery yet. And you know what happens. You have a lot of out cash and material and stuff and in those days, there were no progress payments. You only got the money when you delivered the product. So you had to have the capital up front. Well, when the storm troopers came in from General Motors, they pushed Vincent Bendix aside, and from 1938 on, he had little influence on the operation of the company. And the next thing that happened was he said you don't need the plant in Washington and Chicago. Consolidate.

G – This the General Motors guys?

C – That's right. And we have just the place to put it. Baltimore. The plant in Baltimore, on Fort Ave., was owned by General Motors. That's how it landed at Fort Ave. Furthermore, he (Breech?) argued with Hyland. Hyland said the radio business is a different kind of business, and he said no it isn't, they're all the same and Hyland was sent off to do marketing and sales in Washington, D. C. They did not have a General Manager; they had a Plant Manager of the Radio Division. So at that time they had no General Manager. There was Hyland and then there was the Plant Manager. They still had that building down in Washington and they had to get rid of that. That had to be sold. They moved to Fort Ave., and the number of employees was about 500. The people that worked in Chicago - Bendix owned the building and the plant was closed, and the guard was given names of employees that were in South America or wherever they were, and when they came back from their trip they were given an envelope that said we've moved to Baltimore. If you want your job, come to Baltimore. Now Malcolm Taylor was one of those. Malcolm Taylor drove to Baltimore in his 1934 Ford. I talked to him about this; and Will Webb had cornered the market on the radio compass. Everybody wanted it, but the order we got was for 1200 of them and that order, when it was being built, we ended up without work. Feast or famine. Tried to talk to people about gaining new business and it was futile. Hyland went to NAVAIR - he was well respected at NAVAIR – it was called BUAIR in those days, it's called Naval Air Systems Command today but it was Bureau of Aeronautics and Naval Research Lab. And if there was any work available, we could have gotten some, but the depression was still on and the circumstances were bad. In 1930, we ran out of direction finder money and that was the crucial time that some events really changed the company and everything happened. Hyland was ostracized to Washington, still down there, the Breech crowd decided to close the Division. And they were going to take what products they had and put them in other Bendix divisions. Transfer the few key people and shut her down. One of the things they had to do was to inventory all the radio equipment, all the parts they had, and they needed somebody to do that. They hired him away from – he worked for DeForest-DeForest Laboratories; as you probably remember, Deforest was the inventor of the triode tube. It was E. K. Foster. E. K. Foster was as stock clerk for Deforest and he knew radio parts. So they hired Foster to come down and do all this inventory so they could get the stuff ready to go to different places. While Foster is inventorying away, the Luftwaffe has decided to bring the British to the negotiating table. Hitler did not want to fight the Brits; it was only because they invaded Poland and they had this agreement that they ended up fighting the British, and they really didn't want to. So the Brits and Churchill will fight them on the beaches and everything else; he decided to pick a town [Coventry] in England and blow it off the face of the earth. What we find out later –this is many, many years later – Churchill knew they were going to do it because the code-breakers had broken the code and were reading the German mail. They had the Enigma

G – But they couldn't let that fact be known.

C – Right. And they didn't want to … Churchill says, "Hey, that's not a big enough thing. Let 'em Blow it up." So what happens, they sent a group to the United States to build their radios because Coventry was the entire electronics industry of the British

Empire. So they come to the United States – now in those days, the way they came by plane, they flew in on a seaplane. They landed you know where – in Baltimore at Harbor Field which was a seaport at one time. They landed at Harbor Field and then took the train to Chicago. You say why Chicago? Well Chicago was the heart of the American radio business. All your major companies were in Chicago. The Brit's problem was, they had this unique radio that operated at VHF and they needed to get somebody to build these radios and they couldn't find anybody in Chicago. It was a failure. They came back and reported to the embassy in Washington. The embassy said, "You know, this guy Hyland is here and there is a plant in Baltimore, Bendix Radio. You got to go by there anyways on your way back. Why don't you go there and see what they do? This Hyland says they have been doing all kinds of things." They came to Bendix Radio and Bendix had been doing experimental work at VHF. They knew the language, they knew what they were talking about, and the Brits gave us a contract right then and there, right on the spot, for the King George and Queen Elizabeth VHF radios.

K – More by chance than pre-planning.

C – There was no pre-planning here. It just happened!

J – By the way, when we were talking about the contracts in the vault which had been destroyed, when we [BRF] were there, we were there many many days, we were told by people at Raytheon on Joppa Road that the lawyers that were working on that lawsuit came in and took all the files. They couldn't remember who the lawyers were, what company it was, but they took them, they didn't destroy them, they took them to build up their case for this lawsuit.

C – But they couldn't find it, because they called me back, the lawyers called me back. See, I told them about the contract files and where they were. What the lawyers got, they took all the drawings on the FPS-20. All the parts and everything else. They had a girl there for a long time.

J – And they probably didn't save them, either,

C – No, they don't save anything.

J – So those lawyers did not take those files. We were told by somebody …

C – The files were destroyed; they weren't there.

J – They were destroyed. Records should have been there that they were there. There should have been a record in the vault.

C – No, there was no record at all. I'm telling you, you know these things happen, Joe, and here's the other thing. They went to Rome, NY, Rome (Rome Air Development Center) sent them back to the National Archives, the National Archives sent them to Fort Dietrich. They went to Fort Dietrich and Fort Dietrich couldn't find them. We're talking

about the original contract. If we don't have a copy, the Government surely has; they couldn't find it. Because that clause … But the thing that aggravates me is that's not the first time they've been sued over that and there were files all the time back – well I know they were at Bendix, but when the Bendix legal department left and AlliedSignal came in, …
So we're now building the equipment for the Brits; it's a VHF radio. And right after this, the US starts to buy stuff, in large quantities. And Bendix Radio is looked upon as being a supplier. The Army Air Corps decided to evaluate the VHF radios because all of the radios we had up to that point were HF. They found out it was clearer, better, so they went to the Brits, and the Brits gave Bendix the license to build them for the Army Air Corps. And it was called the SCR-522. Ninety percent of the aircraft that were flown by the Air Force in WWII used the VHF radio from Bendix.

G – Now not to interrupt, we had General Motors people who wanted to close things down. I understand that now we have more business coming in.

C – Yes, that changed, changed very quickly. Also, Bendix hired a new General Manager, a fellow named Hugh Benet. He was the General Manager of Bendix Radio during WWII. The Factory Manager was E. K. Foster. From supply clerk to Factory manager, and he did a hell of a job. He did, I'm serious. And the production of the Division was unbelievable. We had eleven plants in the Baltimore area, all on the streetcar lines. When Fort Ave. was in being, and you probably know this from other things, but the building that we ended up in as Bendix Radio, was actually being built for the Friez Division. And what happened is when they saw what was going on, it immediately switched to the Radio Division because of the demand for radios. Hyland is still not in the good graces. Ernie Breech is still calling the shots, except now, Vincent Bendix has been ousted. They promoted Bendix to chairman of the board, and then fired him. The next thing that happened, Breech wants to get rid of Hyland. Its 1943. Hyland had gone around to the Divisions pushing engineering, that's the future - we have to plan for it, we have to do it, we have to push engineering. The General Managers of every Division were factory people and they didn't want to be bothered with engineering. And Hyland kept saying we've got to do this, we've got to look to the … we've got to do these things. Interesting events happened in '43. The first thing was, remember that spark plug that we talked about before? We got the patent on it. 1943. Fifteen years it had been […] and was finally settled in 1943, Bendix was granted the patent rights.

G – For a shielded sparkplug?

C – Right. Next thing was the detection of aircraft by radio. Bendix ran an advertisement on that. We'll get to that in a little bit. They had a board meeting, and at this board meeting, Ernie Breech was going to fire Pat Hyland. So the first order of business was the lawyers. A lawyer got up and said, "We finally got this patent; its worth a lot of money to the company, we won it, it does a lot of good things and its great. Who's the inventor?" "Pat Hyland." "Oh." An advertising guy gets up and says, "Well, we've got this 'Radio waves that detect airplanes'. We've got the patent on that. Who's the inventor?" "Pat Hyland." And that ended that. Charlie Marcus told Pat Hyland later, "Hey, forget it. It's

all off." So Hyland, had been shifted from Washington to New York to be with Charlie Marcus, because engineering was run out of New York City. The corporation was a strange thing in those days. Charlie Marcus, although he wasn't an engineer, was Vice-president of Engineering. But he really worked very hard – he had vision, and he always pushed new things, and with Hyland working there, it helped enormously. 1940. The Navy decides to put radar on an airplane. NRL is given the job, naturally. NRL came to Bendix Radio and said. "We want you to build the transmitter and receiver for this ASB, and Bendix did that. They built the transmitter and receiver and shipped it to – it was a typical NRL-Bendix relationship where it was a phone call and you go do it. The Bendix unit operated at 400 MHz. The rest of the system, antennas, displays, everything else, NRL did. NRL changed the frequency to 515 MHz. Now the reason they did it was that they wanted to make the antenna smaller. They were yagi antennas - there were two yagi antennas mounted underneath the wing of the PBY or whatever airplane it was, and the display was a double A-scope, vertical. It had two traces, double trace, vertical trace, dual A-scope, and you would see the targets, and what you did to get the bearing of the targets, you would equalize them by manually rotating these antennas. The antennas had a 60-degree beamwidth.

G – You were adjusting phase.

C – No, you were adjusting signal strength. There was no phase in those days.

J - You could do that by turning the aircraft.

C – Or, turning the antennas. You could do it either way. Onboard the airplane, they had a gear arrangement that was manual. There were no motors.

G – Oh, OK, I had envisioned these far apart but they were all on the same mount that they could move.

C – No, they were independently moved. Under each wing. Essentially we've got two signals and what you wanted to do was make them equal.

G – OK, they're kind of like windshield wipers.

C – Yeah. So then we rotate these things. They could be rotated 90 degrees, but they had a 60-degree beamwidth. It was a ship's radar. Eventually, they changed it. There were 26000 of those built. We didn't build any except the original prototype. Because NRL realized that we were at maximum capacity on all the other stuff that was going on. 1943, Radar is new, but they are using it, but nobody has come up with the physics of determining the range of the radar set. The job was given to Bendix Radio by the National Bureau of Standards. Dr. Page gave it to Bendix. Arthur Omberg did the original work on the radar range equation. Now, he broke it down into three pieces, which everybody did later on. One was target characteristics, the other was the atmosphere, the other was equipment performance. He didn't know what to call these other things so he called them S-factors. There wasn't any work done on that until much

later, but Bendix did the radar range equation, and it was classified. It was done in ’43 and it wasn’t exposed until the sixties. They de-classified it in the sixties. Arthur Omberg, who later left Bendix, was a terrific guy. Chuck Greenslit knew him very well. Bendix was looked upon as a real expert in the radar field. In WWII, in radar, Bendix was given the job of two production jobs. One, design, develop and produce fire control radar for the Coast Artillery.

G – This would be a ship-locating radar?

C – Yes, and it was an MPG-1. The chief engineer was Bob Davis. The second radar that we built was the MPN-1. Art McComas worked on that. That was a “build-to-print”. Gilfillan Bros. had developed that. That’s a GCA. So we had Ground Controlled Approach radar and the MPG-1 which were being built in WWII. It was rather interesting, because Hyland at this time was still in New York City, and then they decided to move to Detroit. Now Ernie Breech was still President of Bendix Aviation and remained President until the end of the war. And General Motors controlled Bendix until the FTC made them divest themselves of it. It was about 1947 that General Motors had to give up control of the company.

J – Why did they have to give up control?

C – Anti-trust. They had to divest because Bendix had patents on power brakes, power steering, all the automotive stuff. In fact, at the end of the war …

J – It had nothing to do with radar?

C - It had nothing to do with radar. Bendix was sued by the FTC for anti-trust at the end of the war. Anyways, during the war, Bendix Radio produced 100,000 CFI’s, and produced in spades all kinds of those radios, the SCR-522’s, […] the British. I’ll give you another thing that I learned recently. A friend of mine was working with a museum out in Colorado and was talking about the SCR-522, because we were being sued on that too. The lawyers – we were being sued because that equipment was used by the FAA and a guy got cancer so they blamed it on the tube sockets, and I told them they were made of phenolic and glass and the lawyer said, ”Well, how does that cause cancer” I said, “It doesn’t! Go get a materials expert and solve the problem”

End of Tape One

<u>Tape 1, Side B</u> — July 19, 2006 - York, PA

Cramer – OK, we had a MIG-15 with a Russian version of the SCR-522 in it and it included the crown seal that the Brits gave us that we had to put on every one of the SCR-522's as a licensee. So, we're at the end of the war and things go bad at Bendix. Sales volume drops precipitously, commercial aviation is virtually non-existent, automobile manufacturing has not started up again. Radio Division sales dropped drastically and Benet is called in by the new president of Bendix, Malcolm P. Ferguson. When Breech left – you wonder where did Breech go – he went to Ford Motor Company. Breech went to Ford Motor and Malcolm Ferguson was named President. And we've all had dealings with Malcolm Ferguson over the years; I did early in my career. I went to the North Pole on Skate. I came back. Out of the clear blue sky, I get a letter of commendation from Malcolm P. Ferguson who wants to meet me personally and discuss the trip.

Joe – What year was that?

C – 1959, Joe, I want to tell you something. You want to see corporate politics in action? Everybody in the chain of command from Ferguson down to my supervisor wrote me a letter of commendation.

J – Once he wrote his.

C – Once he wrote his, you know what I mean, Joe? I couldn't get a pay raise before that.

Ken – Now you are a celebrity.

C - Yeah. Its corporate politics, Joe. You know that. Anyways, Ferguson comes down here and meets with me, and that causes problems because he wants to meet alone. So I meet with Ferguson alone. He gives me a lecture on how to run a business. You run a business like a wheel. Its got three spokes on it. One spoke is the customer, one spoke is the shareholder, and one spoke is the employee. When all three are in balance, the wheel runs fine. The customer is entitled to a quality product for what he pays, the employee is entitled to a fair wage, and the shareholder is entitled to a fair profit. If you move one or the other - if you pay your people too much, the wheel becomes unbalanced, the bearings go bad and the company goes out of business. That's Malcolm Ferguson's philosophy.

Guil – All because you went on a submarine.

C – I go on a submarine and that's what I get. We didn't talk about the submarine trip. So anyways, Bendix … Hyland comes in - this is interesting because, at the end of the war, Hugh Benet left Bendix. And they put W. P. Hilliard as General Manager, and Hilliard was not a General Manager. At the end of the war Engineering got involved in too many things at once. Television, radios, all kinds of stuff and the engineering department was spread too thin and it was a disaster. So Ferguson sent Hyland into the Radio Division

and he essentially installed E. K. Foster who was the Factory Manager as General Manager. And Hilliard was let go, although he was one of the founders of the company. But he was not a General Manager. And Foster became General Manager.

G – Foster must have done a good job.

C – He did. During WWII his production … I'm telling you, Foster was a hell of a factory manager; that factory ran really good. He really operated a good factory and it produced … and here's another thing I didn't realize. Do you know that during the war, Bendix took all the contracts fixed-price? We were one of the few companies that did that. At the end of the war, when they instituted price controls, Bendix couldn't take fixed-price. We had to go on a "price re-determined" basis. Which you would re-determine your price after you did your work. But they were still very tough on us. The big fight at Bendix was black-and-white television or color. Bendix opted to go black and white and dropped the color TV completely. And they never made any money on TV except the very first model. The first model television built was a push-button television. It was in the South. That TV, when I was in Memphis in 1949, was the only TV that worked in the South, and the reason was the transmitters were far away, and you needed to have a good antenna and a low-noise front end. And Bendix had that. And that push-button television set worked … it was a ten- or twelve-inch set. And it worked terrifically good. The industry changed and we were priced out of it so Bendix went out of the TV business. But to get back to 1948. An event happened in '48 which was really unique. A fight had been going on all during the war between General Marshall and General Arnold. General Marshall was against a separate Air Force. It was the Army Air Force and he was going to keep it that way. The young Turks wanted their own air force and they convinced Congress. So when the Defense Act of 1948 caused complete revamping of the Defense Department, we got a brand new Air Force., the United States Air Force. The Army was bitter, extremely bitter. So what they did, they transferred only the airplanes and the air depots to the Air Force. Well, that's nice. The first mission given to the new Air Force was air defense. They didn't have one radar or one piece of electronic equipment on the ground. They had no ground equipment, no radars, nothing. The radars that had been built in WWII belonged to the Army and the Army was not going to give them up. So, they had to buy a radar. It was agreed that the Watson Laboratory at Fort Monmouth would be responsible for this and would be transferred to the Air Force, and the people were all upset because they were living up in Monmouth, New Jersey and they were moving them to Rome, New York, where it's cold and nasty in the wintertime. They were given the job of procurement. However, the Defense Department had an adviser named Dr. Goldberg, and Dr. Goldberg was very knowledgeable of what happened in WWII, who built what and everything else. So, in order to buy this new radar set, they put it out for bid. It was an unusual bid. The proposal was limited to three pages. One page would be the resume of the chief engineer, one page would be a budgetary estimate, and one page would be a block diagram with a little description. That was it.

K – Radar at this time was still a top secret?

C – Oh, yeah. So, Bendix was awarded the contract. The reason we were awarded the contract was Bob Davis

G – Davis's name went in?

C – Yes, absolutely. Chief Engineer, did the MPG-1, and if you remember, in WWII, Bendix was …MPG-1 was the only radar developed in WWII that met performance, schedule and cost. The factory capability of Bendix in WWII was unmatched. The reliability of Bendix equipment in WWII was unmatched. Now let's go back to this reliability a minute. I didn't relate it before. When Hyland and Leo Young formed Radio Research, they learned very early that you needed to thoroughly test anything you built, and they did temperature cycling, shock, vibration, and other types of tests. Those became standard procedures in Bendix, in its commercial equipment, and later on in its military equipment. The National Bureau of Standards, in WWII, in 1943, sent a group of people into Bendix to find out why their equipment was so good. And when they saw these things, they reported back, and that is the start of the MIL Standards for shock, vibration, and stuff like that. It's only logical, though, according to Hyland and Young. OK, if you want an oscillator to be stable, you want it to be stable across…

G – A temperature range

C – Right. So they…

G – Whatever else it's doing

C – That's right. So they really did those things. And in the Bendix Beam, a 1943 (December 1, 1943) edition, they had a picture of the crew in from NBS, the National Bureau of Standards.

G – We can probably find that.

C – You can find that. That's the reason they were here – to find out why. Well, anyways, we won the FPS-3 contract.

J – Is that what it was, the FPS-3?

C – Yeah. It was the FPS-3, 1948, Davis is the chief engineer.

G – You said something about you would go with the company that built the WWII radars.

C – The MPG-1

G – Who recommended – did somebody recommend to the Air Force which company to go for>

C – Watson Lab evaluated the proposals; Goldberg was instrumental in the award of the contract. The Defense Department really called the shots. So the FPS-3 was awarded for 135 FPS-3's. These were going to be placed all around the world and they were going to provide air defense and the new Air Force was off and running. However, and it was a side angle here real quick, Col. George Goetz – interesting, I knew him when he was a Colonel, and twenty years later he was still a Colonel, he never made General, but one of the smartest, perceptive guys in the Air Force – Goetz said, "Hey, we got no supply depot, we have no training, we have no people that know the radar. We need help." So he came to Bendix and met with E. K. Foster. Foster has got his hands full. This is after the FPS-3 has been in production - Foster's got his hands full building these things. He's General Manager. Davis won't let anything go unless it's perfect. He's producing these things, they're on schedule. He (Goetz) comes in and says, "We need help". And the Director of Engineering was Wilbur Webb at that time. Foster says, "We can't do it. We're too busy, we don't…, we can't… we just can't do it". Goetz says you gotta do it. No. So they went back to headquarters and Malcolm Ferguson, and Ferguson came down and leaned on Foster, and Foster says OK, we'll do it. He called on Bill Webb. Well then, Bill Webb says, "OK then, we've got to get somebody to run this operation. It'll be a part-time job, one day a week." Les Graffis was picked to run the support, which later became Field Engineering.

J – What Year?

C – 1950. October of '50. George Goetz was a really a perceptive person because the Air Force had nothing. We ended up setting up supply depots all around the world, supplying spare parts, doing all kinds of things. But anyways, the FPS-3 is being designed, a design that's in production, the first model is due in 1950, December of '50. It's to go to Bikini Atoll to control aircraft during the A-Bomb test, and it was delivered on time and it did its job very nicely. Things were changing, though. Aircraft targets were getting smaller. Aircraft were getting faster. You didn't have the Queen Mary at 30,000 feet anymore, like the B-29's, the B-50's. Jets were coming. So …

G – No prop return.

C - … the Air Force, 1952, awards a contract to Bendix for what was called the FPS-3A. I'm sorry, excuse me, the FPS-3A was not then … the FPS-3A was … the FPS-3 as Davis designed it, everything was outside. There was virtually nothing inside. The magnetron, the STALO, was all up on the antenna. You had sliprings that sent the IF signal down, and you had a preamp down below and the you had your receiver cabinet. Davis put all his effort upstairs, OK. To relocate all that equipment, they called that the FPS-3A. The high-powered FPS-3 was to be the FPS-3B. we were awarded a contract and that was the beginning of what later became the FPS-20. However, it was a lot more trouble than people thought. There was a mod to the FPS-3. Essentially, you kept the range mark generator, the reflector, and pedestal, and replaced everything else. Unbelievable. The antenna feed - we were directed to use what was known as the Cambridge Feed, which came out of Lincoln Labs. It was a slotted line feed.

G – Sometimes known as a trombone?

C – Yeah. And we also had a feed horn at the bottom to give a thumb at high altitude. The Three was very good - to get back to the FPS-3 a minute – the Three had an upper beam and a lower beam – it essentially had two radars, an upper beam which looked high and a lower beam which looked low. It had MTI on the lower beam, no MTI on the upper beam. And it worked well. Very reliable, built like a brick ____house, you know, and you look at the guys that worked on it, we all worked with them, they're gone now, but they were great engineers, particularly the antenna. That antenna had to work in 120-knot winds with two inches of ice on it. So you know the guys that did the pedestal, the bull gear, and everything else really put an effort in on it. So we got the Twenty and we had trouble with it. We couldn't get the G.. D… klystron. The klystron came from Litton and it was Government-furnished. We didn't pick the tube. The Air Force-Rome, New York picked the tube. Davis had designed everything and we also were handicapped by the unavailability of the big hydrogen thyratrons. So we had to build a dual modulator with four modulators in parallel.

G – To supply the current?

C – Yeah, right. To supply the current to the tube.

G – These are hydrogen thyratrons?

C – Hydrogen thyratrons, four of them in parallel, two in each cabinet and you had to time those babies right down to a gnat's eyelash. The first eighteen systems-nineteen including a bull model-were built with that. Then we got the 1257 big thyratron and went to the single modulator. So, in the radar business,

Break

C - … went down there and found some stuff that they had thrown away. And here's a copy of a letter from Roscoe Turner

G – Ah. I knew we were going to get to Roscoe today somehow, but I didn't know how.

C – He's looking for money…Anyways, there's Roscoe

G – November, '37. I don't know whether Joe ever heard the Roscoe story with the BI-5. We put the first BI-5, wasn't it Indianapolis…

C – Indianapolis.

G - …and Cramer's there, I'm there, and a bunch of us are there putting the first one in, and I don't know how he got started on it but, was Turner from Indianapolis?

C – Yes, he has his museum there.

G – OK. So Cramer proceeds to tell the FAA people about Roscoe Turner. And this is pretty interesting, and everybody's there listening about like we are today, I think, …

K – Are these Bendix guys?

G – No, these are FAA guys. Roscoe Turner is an airman. Roscoe Turner was a guy that flew airplanes and air races.

C – Right. And he always looked for money, and he dressed himself up as a Colonel in the Nevada Air Force, which was non-existent, and he wore puttees and had a cap, crushed hat and everything else, and he won the Bendix Trophy one year. And then this is the second letter that he wrote - this is what he writes chastising Bendix for letting women in the race. Politically incorrect.

G – The FAA people hear this story, and there is a blank panel somewhere on the cabinet …they would come in the next day and they have the Roscoe P. Turner Memorial BI-5. They weren't being sarcastic or anything like that , it was just done to…

C – That's what we found out, Joe. We were ready to leave and we're watching things and the power keeps going down, and Guil says, "We got a problem". Remember that?

G – I do remember that problem.

C – That was the spewing problem in the tube.

J – It was a what problem?

C – Spewing problem.

G –I didn't remember where we first saw it. I thought we first saw it in …

C – No, we saw it in Indianapolis. Joe, if you operated it at low power, …

G – Low power, key word, low.

C – Right. You've got spewing, and the tube would die after maybe 100 and some hours. We did all the tests …

J – I never heard this problem.

C – Oh, yes. It was a big one because …

J – That's where they wanted to operate, at low power; I never did understand that.

C – That's right, they operated the damn …

G – FAA and their damn …

C – But the test that we had to run was the full power test. If you remember, we never saw the problem.

G – We did not see the problem because we were fully intent on meeting the 5KW. So everything was geared to meet that. We went into a life test at Bendix so someone said, lets… This was the system, so one channel was run at high power and one was run at low power, and the low-power one died. The logistics of the situation were exactly what Cramer said, the tube boiled off stuff from its cathode. The tube was made by Eimac. It wasn't hot enough to keep it suspended and it was a resistive thing that plated out on the inside and loaded the cavity up.

J – I do remember that.

G – And Dalmas had known that this had happened in the past, and he said, "I'll bet that's what's happening…

C – It happened on the FPS-85.

G – That's how he knew it. We took a Bernzomatic Torch, heated up the ceramic tube, put the tube back in and it worked. So that's the proof, OK. We didn't go in the tube, we just - all this was external. Now the statistics were, there was one stage, the lowest-power stage in the transmitter was the critical point so that was one out of four tubes, stages, and one out of four tubes would exhibit that situation because of the temperature, so your odds were one in sixteen that it was going to go down the tubes.

C – The problem was when we tested it with Machlett tubes …

G – The solution was to go to a Machlett tube. So you had to write a spec that said go buy a Machlett tube but didn't say buy a Machlett tube. Eimac couldn't build them. So we devised a test. You run the tube at low power, and you check it in this Q circuit, and if it plated out, you couldn't accept those tubes. And only Machlett could pass the test. We thought we were going to have all Machlett tubes, and the next thing we know,…

J - Eimac buys Machlett.

G – Eimac buys Machlett. The dummies sold them the material. And Eimac goes off and builds all our tubes. That was the second phase. The first thing that happened to that tube was the German guy whose name was Bernhardt (?), a guy in Salt Lake City. The very first Five in the type test when the set was running, we had given them test sets to determine the PRF – we had to set our own PRF's – and they had thumbwheel switches on there, and you could go in one-microsecond intervals in the pulse period. The grid in the tube was mechanically resonating because of our operating PRF. A guy comes up from Florida who we bought the transmitter from, and he knew that. We went out to Salt Lake, and Salt Lake says. "No problem, we'll just use the grids with wire across them".

They already know about the problem … damn grid vibrating. “We’ll just put that in the tube.” I said that’s only going to double the frequency. “No, no, no, we put the bar off-center”

J – Who built the transmitter?

G – I can’t remember the company, in Tampa, Florida. RFD, Radio Frequency Devices. Anyways, he came up here and he said “Oh, that’s what’s happening” … It’s interesting. Roscoe Turner played a part in the Indianapolis installation. That’s how we got here.

C – He had a museum there. They took his plane and moved it from the National Air and Space Museum in Washington to his museum along with the coat that he wore of the lion that used to fly with him. Anyways, Roscoe Turner flew in the Bendix race that started in ’31 when Vincent Bendix was approached by Henderson who was in charge of the National Air Races in Cleveland. It was the Bendix race, which was a transcontinental race; it was not a high-speed race around a track. You had to navigate, you had to manage fuel, you had to do all the things. And, Vincent Bendix put up the most money, the highest prize, $15,000 first place. In 1931, Jimmy Doolittle won it.

J – That was a lot of money then.

C – Yes it was. But the big thing that happened, that Roscoe got all upset about, was that in ’36, Walter Beech encouraged Louise Thadden and Blanche Noyes, two women, to fly in the Bendix race. He said, “I’ll give you a plane”. And they took off, and the weather was bad, it was nasty, raining and everything, and they averaged only 167, 168 miles an hour something like that. They landed, they were trying to hide. They didn’t realize they won the Bendix race. There was old Vincent Bendix in his raincoat … Roscoe was upset. All the men were really upset because letting women fly… The Bendix race was the only race they could fly in, Vincent Bendix, when he set up the race said,” Anybody can fly in it, I don’t care”. So, later on, Jacqueline Cochran won the race. Interesting. I can’t remember the guy’s name now, but in ’37 and ’39, he won. In ’38, she won. And when Purple had the reunion of the Bendix participants in the race, or their relatives, and they made the film, this guy was still bitter. He was 84 years old, and he said, “I have the humility to be beaten by a woman”. I couldn’t understand it. This guy was really, really, you know… Anyways, the Bendix race advanced aviation, particularly in the field of navigation, controls, and stuff like that. In WWII, something about the Bendix company, not the Radio Division, every airplane built for the military used a Bendix pressurized carburetor. Every one. We had 100% of every airplane built in WWII had a Bendix pressurized carburetor on it. It was patented by the Stromberg Carburetor Corp. and that led to one of the biggest profit makers in the company, the fuel control, fuel injection for aircraft, which is really a fascinating field. The things that they have done for jet engines – they have a spray technique for the fuel and the pattern of the spray determines the thrust and efficiency – its phenomenal, the things that have been done there. They were done out at the plant out in Indiana.

G – In Indiana. Because Radio worked on fuel injection for automobiles.

C – Oh, most assuredly. We got the patent on it. Bendix got the patent on that, and by the way, Volkswagen had to cough up money because they violated our patent. Noble Pribble worked on that. I don't know whether you knew that or not.

G – I know McMullen rode a Buick around with that on it

C – Oh, Charlie. He was something else. God rest his soul. The first day I reported to work, I was going to Field Engineering. I had to get an introduction to the company from Charlie McMullen.

G – That ought to be an experience.

C – He's up there, and I'm sitting there, you know, just waiting for all these good things, and Charlie looks out the window and says, "There goes a '28 Essex!" And then he starts telling us the virtues of the '28 Essex.

G – Charlie McMullen is the only man – when he was the President of the Management Club, he had to give the invocation, and he had the greatest sense of humor and delivery style. He's the only man who ever gave the invocation where I had trouble keeping a straight face, because it was absolutely funny. He didn't really mean it to be that way. …

C – Anyways. Let's get back to Dr. Bergher (?) for a minute. He had been responsible for awarding the FPS-3 to Bendix. And, - I can't recall his name right now – he came back to Bendix Comm. Division after being at Systems Division and he was in the R & D Department, but in 1950, 1951, I think it was '51, he did a study on proximity fuses for missiles. And Dr. Goldberg and the Navy were so interested that we were awarded a contract to do research on proximity fuses. This led to another Division, the York Division. But what happened is, it was actually Bendix Radio, and it was at Pimlico. He had three departments. I wasn't here, but three departments went to Pimlico, and that was occupied in 1951. Three departments were Field Engineering, a Guided Missile Division, and the fuse, proximity fuse department. Hyland had been pushing guided missiles to the Navy, and he was well respected in the Navy. By the way, at the end of the war, Hyland was given the Medal of Freedom– the highest award a civilian can get. Another interesting thing …

G – The General Motors guy had ousted him from the company.

C – He isn't ousted yet; he's still with the company. Bendix got the guidance system for the Regulus missile. Charlie McMullen was responsible for that, and it was awarded by guess who? NRL. Bendix had an outstanding relationship with NRL. We always, due to culture or whatever, saw eye to eye on a lot of things, and NRL had great confidence in us. So, McMullen and Bendix did the guidance of the Regulus. Now the Regulus was an outgrowth of the LUNE (?) which was really a V-1 reconstituted in this country. We took some German V-1's and used them as guided missiles. And they were going to be on submarines. Hyland pushed very hard for Bendix to do more than that and we ended up getting a contract to do the Talos missile. And the Talos remained in production for

many, many years and later it was also used as a target. And it was done at Mishawaka. One of the key people was Wilbur Webb. He transferred (1952) to Mishawaka (as General Manager) and then died (1957). Died at an early age. He was very well versed in control systems, and that was the big thing on the Talos. We were in the guided missile business. Regulus got canceled, but Mishawaka proceeded to go for many, many years. Getting back to radar, once they got the network in, and they were going to operate it with the FPS-20's, they then decided …

J – In the US or around the world?

C - Everywhere.. They decided in the US that we got problem. We got gaps, and the gaps are severe. So the Air Force came to Bendix and said … The gap filler was born. It was an un-attended radar and it was to be placed where we had physical gaps in the network.

J – FPS-14 and FPS-18.

C - FPS-14 and FPS-18.

G – Well, the FPS-14, wasn't that pretty well based on the ASR-3?

C – That is exactly correct. The -14 – magnetron – that we built, around 250 of those things, and they were built cheap. I think we only got about $100,000 a copy, but the production was enormous.

Short Break

Bendix won a contract to maintain the Pacific Missile Range and the big thing that they did was recover the nose cone of the missile after it impacted in the lagoon out in Enewietok. And the way they initially did this was, they had a [Mills] station built by Pacific Division which was a group of under-water sonar receivers placed in the lagoon and three towers with people in them with optics. As the missile would come in, they would pick it up and try tracking it optically, and when it hit in the lagoon, and it got to the bottom, it would set off a practice depth charge, the sound would be received by the three sensors that they had, and then go out and send a diver over, and hook a line to the nose cone. These were in the days when they could have transmitted the information, but they didn't want to do that, they wanted to recover it (the nose cone) so, in the process of doing this, one of the things that you have out there in the Pacific is a quick squall. When that happens, you don't see it. The rain obscures it. We found that the water salinity in every direction isn't equal, the sound didn't travel at a constant speed in every direction, so guess what: you couldn't find it. And Jack Trant was given the job of building a radar that would be a splash detector. And he did. He took a weather radar and mounted that thing and focused the narrow (beam) – you know you didn't have to scan or anything - in the lagoon over a narrow area - high-speed sector scan – and when the thing came in, it worked like a charm. It worked beautifully.

G – This would have been using an RDR?

C – Yeah. He took an RDR – He modified the Hell out of it. He increased the PRF, cut down the peak power, because the maggie wouldn't take it, you know, - he only needed short range.

G – We did a lot of things with the RDR.

C – Yes. It worked beautifully.

G – I used the RDR receivers in the nuclear cloud radar that we built for Lawrence Radiation Lab. It had to be a different transmitter, of course.

J – You mean a different frequency?

G – Yes. It was, I believe, 36,000 MHz. The wave guide was about as big as a straw. That was a fun radar; it was put on the front of a B-57, the Martin Canberra. It made the snout go out real long because it was a humongous thing and had this really strong cradle that held the radar, azimuth turn gears and everything. George Walter, I was on it, I can't remember who else. But in any case the radar was delivered and operating and we never thought much more about it, and one day we get a call - they want us to repair the radar "What's wrong with the radar?" "Well, we landed the plane on it." The nose wheel didn't come down. The front of the plane ground through the radome, which was easily replaced, ground through the azimuth change gearing into this nice strong cradle which we had built, and by that time the thing had quit rolling. The radar didn't even fall apart. They sent the radar back and George Walter fired it up and said, "You know, it works?"

** Sidebar about the Shuttle **

C – I don't know what the relationship [with NRL] today is with Raytheon and NRL, but Bendix had an exceptional relationship with NRL.

J – I'm not aware of much activity when we were involved with them on the APX-72. For some reason, we got away from them in the late 50's, early 60's. There wasn't any activity at NRL with Bendix. Early on, maybe.

C – Joe, there was more than you think. We run all the Navy satellites today through NRL. Field Engineering still does. We built the Minitrack for them.

J – Minitrack was for NRL?

C – Yes. That's where NASA came out of. The people at NASA – I mean the people at NRL involved in Minitrack all went to NASA. And that has been very good over the years. And still today, we operate all the Navy satellites. Out of Blossom Point. Of course it's now called Honeywell and all that crap …

** Sidebar about pensions and Health Insurance **

J – How much more history is there?

C – I can give a little more.

J – We're up to the FPS-20.

C – Let's talk about gap fillers a little more.

End of Tape Two

Tape 2, Side A — July 19, 2006 - York, PA

Joe – It was still in Engineering.

Cramer – I'm going to back up just a little bit. One of the things that pushed the FPS-20 was not only the fact that the targets were going to be smaller and you needed more power and you needed better receivers and you needed to work with the SAGE system. And that was a major, major problem because Lincoln Labs and MIT who had worked on the SAGE, primarily Lincoln, had done some weird things. And one of the things they did, they picked a 12-bit computer to be the SAGE computer. Now, that is awkward. And IBM, who ended up building the machine, did not want to build a 12-bit computer. IBM wanted to build a 16-bit computer. And of course the 16-bit computer would have cost a lot more money. So eight bits wasn't enough so they settled on twelve. And that has hampered us to this day. You'll see here in a minute. The idea of SAGE, a Semi-Automatic Ground Environment where you would have a control center – operationally it was patterned after the Brits in WWII. The Brits had the chained home radars, the stations fed the information to sector, sector fed to group and they sent the interceptors up and they did the interception. So we had all these air defense sectors in the United States. The Boston Air Defense Sector, the New York Air Defense Sector. These controlled the fighter planes. And the idea was to determine the enemy was coming, and you sent them up and they would do – shoot 'em down. The FSQ-7 was the primary sector computer and that also would be the FSQ-8 which was a higher order which would combine sectors. It was in a big blockhouse, many, many stories, thousands and thousands of vacuum tubes. The biggest problem with it was the false alarm rate. Statistical noise, when sent into a computer, will give you a false alarm. Now the false alarm rate, if you look at what we were dealing with – we're dealing with in the radar set, which they process later on in their quantizers, eight hits of noise that would occur in a resolution cell. A resolution cell …

Guil – Eight hits per second?

C – No, a resolution cell. Take the radar, and it's scanning at five RPM, OK, which was another thing – five RPM, 5096 azimuth change pulses, that gave you a bin. That bin, if you got eight hits in that bin it would declare it a target. So the quantizers were contracted to Burroughs, the radar was Bendix's FPS-20, and the computers went to IBM. IBM feared radar. They came to Bendix and subcontracted the input to their computer to Bendix, and we built the displays for the SAGE System and the input. And that was done in what we called the IBM building. That's how it got its name. It was a subcontract. So we were building those. The SAGE System could only handle, and this is what was shocking to me, I was flabbergasted, thirty targets, both real and imaginary from false alarms. Thirty targets! That's all. The SAGE System worked where you had fifteen scans of information that was processed and displayed, but the computer would only handle thirty targets at a time. This meant false alarms were really crucial. So the folks at Burroughs set their thresholds pretty high so you weren't clipping as much noise so you were loosing a lot of sensitivity out of the radar set. So you were not getting the

performance of a manual system with the automated system. You could take a guy with a scope and he would do better than the automated SAGE System. So the Air Force, when they found this out, they continued their manual ops at the site, and that continued for quite sometime. Furthermore, there were just some pure physical things that caused great difficulty. The site's grounding systems: ground wasn't ground and you would have AC hum down in the ops building which is where the FST-2 was. So to get rid of that hum, you've got to set that threshold even higher. So you had a de-sensitized radar essentially working through SAGE System.

G – This was mid-50's through 60?

C – That's right, that's right. They also found that, hey we need to get this gap-filler stuff – we got holes in the system. The holes were physical. There's no two ways can – you know, low-flying aircraft in this area, you're not going to get 'em. So the goal was to have every range block, range/azimuth cell block in the United States covered by three radars. That was the goal. The FPS-14 and FPS-18 were to be unattended radars. We got the job of building the radar, Westinghouse built the FSW-1, which was the control of the radar, remote control. Budd Lewett, the vacuum cleaner company won the contract for the quantizer.

J – FST-1.

C – Right. The FST-1.

J – I was the only person who knew how to set it up – that storage tube.

C – Hey, Joe, let me tell you. They forgot about something, and that was, where these sites were, there was no electrical power. You had to run off a Diesel. The Diesel takes fuel, and it needs attended to. How can you have an unattended site? What happened, the Air Force had to man the gap fillers. They had to put people out there because they couldn't run the damn things. And headquarters was saying no, no, you can't do it. Because they're at tops of mountains and – you know, where theses things are, they're inaccessible. … You know all about it, Joe. OK, they're in God-forsaken places. So we ended up with all the gap fillers out there, and the -18's came out, which were real high-powered – the -18 had 1-megawatt peak power, it had MTI, good MTI, because it was coherent; and the gap fillers were working really good, but they were manned. Then came "We need more warning". They had to put the Texas Towers up. So they put Texas Towers up, got more warning. "Then we need more stuff in Canada." The Canadians said, "You're not bringing any Bendix equipment up here". So we had to license Northern Electric to build the -20's.

G – In Canada.

C – Yes, they were built in Canada.

G – This was the Pine Tree line?

C – The Pine Tree Line was FPS-20's built in Canada. They were called the FPS-508's

J – The -30's now were …

C – The -30's came about because the Navy – here's what happened. The Navy agreed that they would provide radar picket ships to cover the Dew Line extended. And the Navy found out that those picket ships would get rocked and knocked around the North Sea up there and in short order, they weren't able to do it. So what was needed was the Dew Line extended radars, and that became the FPS-30. And you worked on that. So you know about that.

G – Who built the radars across Canada that were in the Dew Line?

C – In the Dew Line? The Dew Line radars were of two types. One type did not work at all. It was the FPS-23. The other type was called the FPS-19. The FPS-19 was a back-to-back radar that was built in WWII and Chuck Greenslit built a very similar model of it for Sweden. It's in the Swedish Museum today. Those radars were back-to-back 'cause they scanned very, very slowly-one RPM. And with a low scan rate to get the data rate up you got back-to-back antennas. So the Dew Line radar …

J – Alternating between – so they wouldn't interfere with each other.

C – Yeah. The Dew Line FPS-23 was built on the basis of the patent filed by Pat Hyland. Hyland's patent dealt with bi-static radar and radar that – they were all bi-static. The transmitter and receiver were not located in the same place. The transmitter would be located in one place, the receiver in another place. And that didn't work on the Dew Line. So we had all these radars that were functioning - -20's were in production; since we built 135 FPS-3's, there were 135 mod kits for the -3's, there were 135 FPS-20's built. As mods to the -3's. The Japanese, Tokyo TKC Company bought the radars for JASDAF – Japanese Self Defense Force. They bought FPS-3's, and they would not shut down those FPS-3's. Those -3's ran forever. The Japanese kept those things running and running, and while I was at Comm. Division, we were still selling FPS-3 parts. In the '80's to the Japanese.
G – So the FPS-3 ran in there in the '80's.

C – Yes. The -20's – they got those too, but they kept those -3's running forever. And our licensee there was Tokyo TKIC or TKC. TKC was responsible for providing the field service and parts and stuff like that; we licensed them to do that. Charles Marcus had licensed all around the world Bendix products at the end of WWII. The Japanese paid Bendix the royalties for the Bendix parts that were used in Japanese aircraft manufactured in WWII.

G – You're kidding.

C – I'm not kidding. The paid us …

G – The royalties for the fighter planes that fought against us?

C – That's right. They used Bendix generators, Bendix electrical systems. This is why, if you've read, they find a generator that looks like it came from Amelia Earhart's airplane.

G – I know. I've read that book.

C – But it isn't.

G – I know, its got metric threads.

C – OK, the generator is a Bendix generator, hers was a Bendix generator – these are built by license by the Japanese. In WWII. So, we got paid at the end of the war for all of the stuff that was used.

G – Her look-alike radio did, according to the book, have metric threads because Bendix was asked to figure out if they had built this radio.

C – Yeah. The whole thing, when you start really getting into it, Guil, the whole thing in the radar area, the '50's were big radar time and Bendix led the field. Our relationship with Rome, New York was good, but it was starting to wane a little bit because some of the older people who had been there were gone and Andy Bickus was our rep up there, and he had come out of the Air Force at Rome, and we had good relationships up there and we got a lot of contracts. But GE was pushing, always pushing the Air Force to change the radars, and they were unsuccessful up until recent years; recently they were successful. That was another story. General Electric built a low-powered radar called the FPS-8, and the FPS-8 had a small antenna on it. It was an L-band with a small antenna. In order to give the FPS-8 more range, the Air Force contracted with them to get an antenna that gave 35DB gain, which was the same size that we had on the -20. They called it the high-gain antenna. Their sales department was successful in convincing people in the Air Force that weren't knowledgeable that they needed to increase the gain on the FPS-20's antenna with the high-gain GE antenna. They were successful. Air Force came to Bendix and we built two FPS-20's with the GE antenna. These weren't mods; brand new, and were called the FPS-20B. Davis did that; we built two of them. We supplied the polarizer. GE had the feed horn and the reflector. Later on, the pressure continued to build, and they wanted to change the antennas on the -20, and they put it out for bid, and we bid it using the GE reflector, and GE bid it using the Bendix polarizer, and Raytheon bid it and underbid everybody. So Raytheon ended up supplying the antennas, mods to the FPS-20.

J – Was that the beginning of their radar?

C – Yeah, … Raytheon is an interesting company. It was formed by Vannevar Bush, and what he did, he stole RCA's patents on tubes, and said sue us. And they started making tubes. Bendix twice was negotiating with Raytheon to acquire the company. Once, they had almost settled the deal when Vincent Bendix fell on the table, drunk. And that ended

it. And the second time was with Ernie Breech not wanting to pay $4.50 a share when they figured it to be $4.25. Raytheon went into the radar business primarily with the CAA. Malcolm Ferguson, after the ASR-3 and PAR 2, which was a precision approach radar, that nobody wanted - it was an interesting radar set. Bendix won the ASR-3, and we won the PAR-2. The PAR-2 is a precision approach – this is where you're telling the pilot what to do. The airlines didn't want it, the operators didn't want it because they would be responsible for any aircraft accidents. The pilot said you're not going to hold me responsible with a guy giving me instructions. Nevertheless, we got a contract to build the damn thing, and it was never accepted until the late '50's. The contract was awarded in '52.

G – It seemed like it went on forever.

C – That's right Poor Jack Trant. And it went on forever because nobody wanted it. We installed the PAR-2 in Dulles, got it signed off, we got paid, and then were paid to dismantle it and take it back. Glen (?), with his team – he called and said they want to change the contract. What do they want to do? They don't want it; they want it removed. Can you imagine that? Putting all this stuff in the control tower and then taking it back out? So what happened, Bendix – Malcolm Ferguson said, "No more business with the CAA". So Raytheon won the ARSR-1, the Air Route Surveillance Radar, and that's their principle entry into the radar field. They followed that up with the ARSR-2, and then they focused over on the military side and they got in bed with the Army and the anti-aircraft controlled radars, which ultimately led to the Patriot, which was a phased-array radar set. Raytheon followed very closely what work had been going on at Bendix, and they also, because they were in Boston, were given pretty good treatment by Electronic Systems Division. Air Force's. When we bid Cobra Dane, they managed to get the spec changed, which put us at a disadvantage. And the Cobra Dane, of course, was the locator of shots coming from the Soviet Union, up in Chemya. And that gave them a big step forward. They also participated in the Sentinel system, which was a failure. This was the first attempt that we had at an anti-ballistic missile program out of Huntsville. GE built the PAR and they built another one; neither one worked, but who cared. They declared it operational and dismantled it. I don't know if you remember that or not.

G – Oh yeah, this was […]

J – This was after the FPS-85.

C – After the -85. Now the FPS-85 at Bendix … Let's get back to Hyland a minute. The 1954 – and I personally know what was going on here, not from the company standpoint, but I was in the Navy, and I was teaching the APG-30 fire control radar which was on the F9-F, and we were told that Hughes Aircraft had come up with this new system, and that our system, the APG-30, would be obsolete, you wouldn't have to do the things you had to do. The APG-30 replaced a potentiometer on the throttle; that's all it did. It was a range-only radar, and what it did was automatically change the gun sight reticules which were dot surround. If you got the target within those dots and pulled the trigger, you'd hit it, some bullets would hit it. You're firing a 20-mm cannon, OK, or 50-caliber machine

guns. So the APG-30 was a range-only radar The pilot was required to fly the airplane watching the dots; he didn't have to worry about the controls. See, it used to be that he'd take the throttle and move it this way to make the dots larger or smaller and that really gave the lead. It was a lead-computing gun sight was what it was. So it worked very well, but this new one was coming out and it was going to be done by Hughes Aircraft. So I'm teaching my class, telling every here's the APG-30, we're going to get a brand new equipment, it's going to be coming out. We sent two people out to go to school on it. They leave, they come back, it's not ready. It's not even close to being ready. So we're sitting there wondering what's going on out there. Well, what's going on is Hughes Aircraft was that out of control. And Howard Hughes went to the Air Force and said, "What can I do to solve the problem?" And do you know what the Air Force told him to do? Hire Pat Hyland. Hyland gets a phone call from Hughes Aircraft. They want to talk about a job. Hyland goes out there, they interview him. The say, "I want you to run Hughes Aircraft". He never met Howard Hughes. It was always some intermediary. Hyland says, "I don't know if I want to move out to California; its expensive out here". "Don't worry about it. We'll give you what salary you want." So he gave them a number. They said, "That's fine with us". "I've got to find a place to live." "We'll take care of it." He bought a house without even seeing it. They bought it for him, and his wife went out there. He's at Hughes Aircraft, and what a mess! So he said, in his book, he took all the mistakes that he'd made at Bendix, and all the solutions that he done to it, he had to apply them all to Hughes Aircraft.

K – He wasn't a very successful manager at Bendix Radio.

C – No, but he had learned. And he said you don't disregard experience and mistakes that you made before. The big thing is don't make them again. And he turned Hughes Aircraft around. And they developed the fire control radar and it's then sent to the Air Force. Now you haven't heard the end of the story. When Dick Abel was let go, at Bendix, you know who hired him? Pat Hyland.

G – So he went to Hughes?

C – He went to Hughes, but then, another one of his buddies had a better job for him. So Dick Abel finished his career working for guess who. W.P. Hilliard.

K – Where was he at that time?

C – He was up at where Bill Reed came from. I can't remember the company right now. Bill Reed was working for W. P. Hilliard at I can't remember the name of the company right now and Dick Able went to work for W. P. Hilliard. It's a small world, isn't it? So, getting back to Raytheon, Raytheon has parlayed all of its government business and its radar business and GE acquired RCA. RCA had won the Aegis program, phased-array radars, in spite of the fact that there were other people that could do it better. They were hell-bent to do their one design which came out of APL. When the phased-array concept came about, the Air Force led the way with the boxcar on the roof. Our competitor was Pat Hyland and Hughes Aircraft. And we whipped them. And we won the FPS-46, the

ESAR. After the ESAR, despite the fact that no mission was ever declared for the radar set, we took the contract for the FPS-85 for $30 Million to build the building, and Grogan knows this very well – it was fixed-price, $30 Million-the building and the equipment. Then it burned down. After it burned down, they decided there was a mission for it. In 19- - switch back here a minute – Bendix Radio did something that not many people know about - it was done from Field Engineering, when Sputnik went up. The Defense Department was shaken, just unbelievably shaken and we've got to know what's up there. And the guys at NRL said, "You know, we can take the Minitrack receivers and build a big transmitter, two gap fillers and illuminate the sky and receive these signals using the bi-static technique. NRL gave Bendix the contract to do it. Bendix Radio did it. Field Engineering Department, C. Y. Thomas was the program manager. Prior to that C. Y. ran the school. The project was given – what was done was the Brick Bat Priority. The Brick Bat Priority is order of the President of the United States. In 180 days, Bendix Radio had a system on line and working. We took twenty 50-Kw transmitters, TV transmitters, built a 2-mile antenna at Lake Kikapoo, Texas, and put these transmitters there and phased them all together to put out one megawatt of average power. Didn't move it, just put the fan up. The Minitrack receivers were running at 108 MHz. We got the transmitters from the TV suppliers. We got these things and we built sites - receiver sites across the United States. They're still working today. Now that was done in 180 days. So that was a move forward in knowing what's up there. … The Air Force really, really … When the second -85 came about, the space track mission was there. Although SPASUR was good, it couldn't identify anything. It just told you …

G – The fan beam was called SPASUR?

C – NAVSPASUR.

G – And the receiver system, did that have a name?

C – They were Minitrack receivers, 108-MHz receivers, the same ones that we built for the Geophysical Year 1957, International Geophysical Year. Vanguard missile, RCA with the satellite, us with the ground terminal; put the ground stations in South America, Fort Myers, up in Maryland, down at Blossom Point; orbit the satellite, prove it could be done, shut everything down and everybody go home. That was it, OK, that was the experiment. Charlie McMullen was at NRL. NRL said, "Are you interested in building these Minitracks". "Yeah." So they gave us a contract to build the Minitracks. The Minitracks were NRL-designed, packaged by us, 108-MHz system. You know what happened. The Vanguard blew up on the pad, the Russians took the Sputnik up, so General Medaris got them to use the Redstone, which was a glorified V-2 and we lost the satellite and we're tracking them with these stations. The President was upset, declared he'd have a new Agency, fired the people involved, so to speak. President Eisenhower set up NASA. The people he transferred to NASA were the same people that had been working on the program before. So the group went from NRL to NASA. As soon as that happened, when Congress passed the bill for him, he wrote in "civilian only". Army Map Service was to do the operation and maintenance of these ground stations. They called Murray - Weingarten and said, "Murray, can you do this?" Murray says "Yeah, when do

you need ‘em?” “Well when can you supply ‘em.” “Thirty days.” And in thirty days, we were operating and maintaining the Minitrack stations. Then the next thing that happened at Bendix Radio was another experimental program, Mercury, Project Mercury. Mercury was to be - put in eighteen ground stations around the world, orbit a man, and shut everything down. The winning contractor was Brown and Root for construction, and AT&T, Western Electric for the ground stations. Western Electric subcontracted the ground stations to Bendix Radio. So we built all of the Mercury equipment. And we installed eighteen ground stations, all around the world. This was a big thing; Bob White was the corporate program manager on that. Bob got the Pacific Division to supply the display consoles. So Pacific supplied the display, Pacific also won the contract and supplied the telemetry. So we had a Bendix-built thing. Now if you looked at the equipment, you’d say something’s crazy here because much of the equipment was taken out of a junkyard. Since it was a one-time experiment, we used the pedestals from the SCR-584, and we got them from a junkyard up in New York. Much of the equipment came out of a junkyard, was overhauled, painted, modified of course, and shipped out. We had the telemetry receiving subsystem, we had the acquisition aid, AKAID was a quad-helix antenna on an SCR-584 pedestal, servo system, and a receiver. And then the telemetry was receivers built by our friends out in Pacific Division. Communications was hard-wired telephones that were initially … the first tape recorders - we had some of those, they were built by Ampex, the Ampex recorders, and the ground stations, we installed them all around the world, we were responsible for everything that was in remote locations, very remote, Kano?, Nigeria is an example of one that was just unbelievable. In the middle of a damn field, you know, you’ve got this … So Mercury was on its way. Well, we have a change in government, Jack Kennedy gets President, and the next thing you know, we’re going to the moon. So, in order to go to the moon, you’ve got to practice docking and everything else, need a new spacecraft, have to modify all the systems and we did that at Bendix Radio. Apollo we did not win. On Apollo, we lost it to Collins and that was a bitter pill because we knew more about it, and I guess maybe that’s the reason we lost the contract. However, Field Engineering was able to maintain the O & M of these ground stations. And we knew the ground stations would disappear someday because already the plans were in effect for the TDRS. Now TDRS is a Tracking Data and Relay Satellite. What we would do is put four satellites in orbit. These four satellites, you’d have three that you used and one was a backup. And you’d no longer have ground stations around the world. You would have one big ground station which is in White Sands, New Mexico, and you would have the relay from the spacecraft through a TDRS to another TDRS, if necessary, and then to the ground, and the same way back up again. Now, Bendix Radio supplied a big, big feature to the network – was the aircraft operations, and Howard Naslem(?) was our chef pilot. We had a fleet of aircraft that would calibrate the stations, meaning we had to fly them all around the world, at fixed altitude, and we had a spacecraft transmitter system on the aircraft, simulating what you did to the spacecraft, including telemetry and everything else. We would calibrate and evaluate the station. This was a big, big thing, and Bendix Radio pilots flew – let’s see, the first one was up – I guess it was fifteen years, roughly, and never had an accident.

J – What was the name of that program?

C – That was part of the NASA O & M contract. Bendix Radio – Field Engineering had changed its name, OK. However, the flight operations remained under Bendix Radio. We did not transfer … Now the airplanes were all hand-me-downs. General McArthur's "Bataan" was one of the aircraft that we were using. It was a Connie. This led to something – Bendix Radio supplied engineering support to the network. This was a group of about thirty people, and we had an interesting thing happen because we had a real fine engineer, I don't know where he is now, I haven't seen him in years, although he's still alive, Dwight Brown –

J – He's dead. Dwight's son is Ange's son in law.

C – I'm sorry to hear that. Let me tell you, Dwight Brown was just a terrific engineer, just quiet, unassuming, and he worked for NASA on the support contract. Dwight had a lot of flying time, and he developed, through experience and through knowledge, an antenna system that he was using on the NASA airplane. Then another event happened. It suddenly came to the Air Force's knowledge, that hey, we've got nothing on Apollo. NASA now had it's own launch site, Launch Pad 39 at the Cape.

K – The Air Force is out in the cold.

C – Listen carefully. Who was the launch support contractor? Bendix Radio. How 'bout that. Who was doing the ground stations that were in existence? Bendix. Who was supplying all the – "Bendix". Who won the Unified S-band? Collins. But where is the Air Force? The ships are out there, but that's not Air Force. The Air Force had no part of Apollo. So the Air Force went to NASA and said, "What are you going to do if you're orbiting and you have to have trans-lunar injection and you have no ship or ground station coverage?" And NASA said, "Well, I guess we'll just have to orbit again". "Wouldn't it be better to have an airplane out there?" So what happened is, out of a clear blue sky comes an RFP for the Apollo Range Instrumented Aircraft. Charlie McMullen said we ought to bid it and we do. I worked on the PDP, the definition phase, It was a terrible RFP. We had 518 contract end-items we had to address. It was just stupid. They were using 375 for the first time and all this crap. Anyways, we teamed with Douglas Aircraft. We felt that that antenna, the nose of the plane with the radome on it – you've got to chop the nose of a 707 off - a C135 – and put the …
Anyways, fine, at Bendix we decided to go with Douglas. Collins, in the driver's seat, 'cause they had the Unified S-band, - remember, this is a flying tracking station – they go with Lockheed and they are prime.

G – Lockheed is sub?

C – Sub. In spite of the fact that the airplane only required a new generator and the radome in the nose, that was it - the mod to the airplane, essentially. The rest of it was the electronics contractor. So Collins decided that cost-wise, most of the cost is electronics, we'll go that way. Well, I got news for you. That did not go ever very well with the Air Force. But they weren't about to tell them. So we finished the PDP and we had hired a

guy from the Cape, and he couldn't get anything done right – Pete Piccoli – Anyways, comes the time for negotiations – just two bidders – they go up to Boston, Grogan led the team up there, and of course Foster told him to bring back the contract Anyways, to make a long story short, we did; we won the contract. And ARIA, although it didn't make any money, was a very successful program. We had some really good engineering on it, we delivered that system in one year and one of the reasons we won was that Dwight Brown's antenna, the stuff that he did on that other contract, we had that cold and we knew exactly what to do, and what would work and what wouldn't. Our problem was that we got a real taste again, a bitter taste of sub-contracting within the corporation. We went to Eclipse-Pioneer to do the pedestal and stuff for the antenna, and man, it's terrible dealing with sister divisions.

J – It's a nightmare.

C – Isn't it, Joe? I don't know what makes it that way but it was unbelievable. But we won the job and we delivered the eight airplanes, and things went very well at Tulsa. The equipment worked beautifully, we had no great difficulties with it. There were times when we thought we had difficulties, and I will explain this to you one time. After Piccoli left, Chuck Greenslit became the program director and Charlie McMullen was the program manager. We used to have a meeting at seven o'clock every morning. And we're at the seven o'clock meeting and everybody's telling him the problems of the day. Just unbelievable, you know. McMullen looks at all of us and says, "As I see it, I've got three choices". I said, "How in hell did you come up with three choices. I can't think of one." McMullen says, "I've got three perfectly good TA's that are approved. It's just a question of which one I use to get out of town." That was Charlie. So. Col. Politzer is coming. He's going to read the riot act to us. I get a call from Tom O'Mahony. O'Mahony says, "He's really boiling mad, Cramer, he's coming down there, be ready for him". I tell everybody Politzer is on his way. He never shows. Politzer rented a car at the airport, is speeding on the beltway, got a ticket, gave them a raft of shit and got thrown in jail. When he got out of jail, he took the car, went back to the airport and went back to Boston.

G - Such is the fate of our company?

C – Yeah. We delivered it in a year. In one year we delivered that thing. And that was a huge effort. And the guys like Sebring, and Mackey, you could just name them, all over the place, they put in untold hours and really did a first –class job. One of the biggest things they did was the 202 wiring which was the complete wiring of the airplane. And that's a lot of wiring, and not one mistake in it. When we installed that stuff out at Douglas, the only screw-up was Douglas Aircraft. And they had a typical airframe solution. They put the air conditioning vents that went down to the equipment in the wrong place. They were going to move the equipment, set up a new weight and balance and everything else. Bob Hancock says why don't you move the damn ducts, which was all it took. They made new ducts with … But getting back to radar again –

Joe – I wanted to ask you some questions ...

C – Sure, Joe, go ahead.

J – The FPS-14 and the FPS-18 – how many of each of those did we make?

C – We made 98 -14's and 148 -18's.

J – OK, I do remember the number 48. Now, did the -18's replace the -14's?

C – No, they were all installed all over the place.

J – OK, that's what I never could understand.

C – Yes, you either got a -14 or an -18. They did not replace -14's with -18's. Those were all sent to gap filler locations.

J – So they must have determined what would have the higher priority. The -18 was better performance.

C – They had the better performance, but once the got the -14's installed, the 98 -14's that were installed, they weren't going to change them out. They turned 'em on and they were running.

J – And the FPN-34 …

C – OK, we'll talk about the -34's. Yeah, Joe, this was a crazy procurement by the Air Force that really caused problems. The Air Force transports had changed. They had jet transports now and their flight patterns and flight characteristics were different from a propeller-driven transport. So at the airfields, what they wanted was a longer-range radar to take the place of the CPN-18. The CPN-18 was built by Bendix for the Air Force. It was an airport radar very similar to the ASR-3. So the CPN-18's were at all these airfields and they wanted longer range. So they got the idea to build an L-band radar with a guaranteed 100-mile range, dual-channel, magnetron, (don't know why), MTI, staggered PRF to eliminate blind speeds so to speak, circular polarization on the antenna, and a remoting system for 10,000 feet of wire, so that you could put the radar – and then run the – remoting the video back to the displays. Rome put out the RFP, we won the job. We designed it, everything went smoothly except for the antenna. The antenna had an unusual specification, which was impossible to meet, and they wouldn't hear it. We decided to build our own antenna. They did not want that. They wanted the General Electric antenna that they had developed earlier. We said no, we're going to build our own antenna. Henry Dantzig did the design. What was the Spec problem? The spec problem was side lobes. It was impossible to get side lobes that are 25 db down – from a side lobe, you go isotropic, you can't get down there, otherwise – if I'm looking up at this angle and I've got a side lobe that's 18 db down at that angle, and I've got 35 db on the nose of the beam, I can't get to 25 db below that. Rome says that's the spec, you've got to meet it. Well there's no way to meet it. And Henry kept fighting them – Henry is a

fighter. We eventually capitulated and bought the GE antenna and put it on. The Air Force then determined this radar didn't have the data rate that they were looking for. It's an L-band radar and they were going to spin it at a much lower speed, and the Air Force didn't want that. Furthermore, they got to thinking about things and decided that, you know, we really don't need that; we'll go along with the ASR-4. The ASR-4 was a Texas Instruments radar that replaced the ASR-3 at the airports.

J – But these are S-band.

C – They're S-band. That's right. And they decided since he FAA was now going with the ASR-4, that the Air Force would buy the -4 to modi… So we built two of these.

J – FPN-34's?

C – Two FPN-34's, and delivered 'em, and the FAA says we might want to look at this. So they sent one of them to NAFEC.

G – I remember being down there; I worked on the -34.

C – They tested it, and it never went anywhere because it was out of place. It was not the radar that they wanted, it was just the wrong radar. If you want the high data rate, you've got to go with something that's going to spin the antenna fast. And you can't spin that big sail at that speed.

J – TPN-12 was a strange … I worked on that.

G – Yeah, we both did.

J – That was a subcontract from somebody, that was not - we weren't the prime.

C – Was that the mortar …

J - … underneath, there was a … the equipment hung underneath this big pedestal, this tripod.

C – That was the rangefinder, wasn't it?

J – No, it was navigation, it was guidance.

C – Chuck Greenslit may be able to tell you about that, 'cause I don't know.

J – I worked on the transmitter. I think George Walter worked on that, too.

G – I did the receiver …

End of Tape Three

<u>Tape 2, Side B</u> — July 19, 2006 - York, PA

[Noise]

Joe – Only two FPN-34's. That's what I thought.

Cramer – Two FPN-34's. No others were built. Now, I'll tell you the second story of the FPN-34.

J – And then we got out of the radar business.

C – Yes. The big thing here was – we didn't really get out of the business, totally, but as a prime we did. There was an event that occurred when it was declared that the threat was not Soviet bombers. The threat was missiles. So the Air Force reconfigured it's air defense, and in the process of doing this, they shut down a lot of radar sites. Some of these sites that were shut down were actually providing a dual use. The FAA was using the video. So the Air Force said to the FAA if you want the radar, you can have it. So the FAA acquired about 40 FPS-20's. So these were in operation around the United States.

J – For enroute tracking.

C – For enroute traffic control. The FAA – the sets that they didn't take that were there, the Air Force didn't know what to do with them. And Sheriff Colvin was talking to a Colonel in the Pentagon. This Colonel had a problem. The State Department had agreed to furnish radars to India, to Iran, to Israel - let's see, there is those three, I can't remember which other – I think those were the – there was six and six is twelve – no, there's more than that – some other foreign countries involved here, and the Air Force was given the responsibility of doing it. They didn't have any money. So Tony Mazarro and I said why not take those excess -20's, we'll overhaul them, make them like new, we can do it cheap. And this colonel went back and he came back to us and said give us a proposal. So we went - we sat down, we figured OK, we need new antennas, so we bought the GE antenna, we subcontracted to Bob Davis, his group, the feed horn and the polarizer, we subcontracted to Davis's group the parametric amplifier we were putting in, and then that's where the shit hit the fan because the Air Force came back and said no, no, no, no. We have a GE para-amp you've got to use. We developed it, we got to do it. A long story short, we got a big fat contract to overhaul the -20's, make them look like they're new, put a para-amp on them, an new antenna and polarizer and ship them out to these countries. That's when I got conned. Foster – the work was not going on too well up at York and they needed business. And Foster says, "How about York Division doing all the mechanical work, air compressors, water pumps, all the other stuff like that". So Graffis called me in – Graffis was a good friend of the General Manager up there. He said, "Go to York and give me an assessment if they can do the job". I come to York, Bill Niedheimer meets me, I get a red-carpet treatment. I had never been treated like that.

Takes me into the place – we're going to do the water pumps here, we're going to do that there - shows me - I mean, I – man, I go back, I give a glorious report to Graffis, we award them the contract. Ten years later, I'm at the Comm. Division having lunch with Palmer. A guy comes in, used to work at York. He says to Palmer, "Hey, Palmer, you remember the time we put it over on that guy from Field Engineering?" I'm listening, my ears popped up, Palmer didn't get a chance to warn him, he said, "You know, we showed him where we were going to do all that work and then we didn't do it there, we rented a tent and did all the work in a tent". That's what they did; they built a Goddam tent and did all the overhaul work. Anyways, we supplied all the radars to Iran and to India and other places. And the Isreali's came in, and they were hot because the US Air Force had gone to Bendix Radio and gotten a low production price for two FPS-20's, and that's what they charged the Isreali's. And they were giving them overhauled units. And Major Davis(?) says, "We want to go to the factory and see the production." I said, "You're there". "What?" So they got two FPS-20's. Then, Bendix International needed – they went out and found out the Spanish Air Force needed a - some PPI's and a video remoting system. So I did it; I got R. J. to bid me the FPN-34 video remoting. And we won it. I bought two used UPA-35's – they know they were going to be used – we overhauled them, sent the displays over – that was the last job Bob had before he retired, was the FPN-34 video remoting. That was 1970.

J – He didn't do the FPN-34, did he?

C – No. But he needed work and he had –

J – OK, I think I remember that.

C – Then – Davis had developed a para-amp and the Navy came to us and said we want to see a U-2 at 70,000 feet at 200 miles.

Guil – The -30 could have probably done that.

C – Well he said, "We've got an FPS-20. What can you do for us? We're flying flights over Cuba and they want to control the flight from Key West." So we did the arithmetic, came back and said we'll give you a para-amp. I got a-hold of Ted Eby, he built me the para-amp, we tested it, went down there, they took that U-2 up and got him at 219 miles. Got a call from the Navy. "You did it. Everything's fine." So – But you're right, we were just about out of the radar business about that point in time. But we weren't alone. There were a lot of other people, too, and it got to be very competitive and very hairy …

J – Raytheon went on for a long time, ITT, Gilfillan, kept going – they went on for a long time.

C – Now Gilfillan, they built for the Navy and the Navy ships used the Gilfillan SPS-58, and it was an S-band radar, a pretty good radar, but you're not building many. You're building one or two a year. So the cost is pretty high on those things. And the Navy – they won't buy unless have a – its got to go on a ship and there's the ship it's bound for

and that's the way they do it. Now we did – and of course the ARSR-3 was our last real try, Westinghouse beat us on that, and of course they didn't do well financially on it. But getting back to General Electric, they bought RCA and …

G – That was in the late 80's, wasn't it?

C – Yeah, and then – mid 80's, no, a little later. Then they sold everything to Lockheed-Martin. They got out of the military business completely.

G – Is that right?

C – Yeah. You got to understand something.

G – No, I was tracking them – we were dealing with the crypto people at Camden, New Jersey, and that was RCA and they got bought by GE while we were dealing with them.

C – Right. Well they – GE can't make the money that they want dealing with the Government, and that's Bossidy and Jack Welch – they demand 15%. And you can't make 15%. And, you know – before I retired, I had many arguments with Bossidy when he came down. We got into a big fight over nothing. And he refused to understand something about our business at Field Engineering. Field Engineering are non-exempt people controlled by the Act that deals with setting wages and benefits. Field Engineering does not set wages and benefits for non-exempt people. It's set by the Government. It's called the Service Contracts Act. And what happens, when you bid a contract, they tell you what you have to bid. Now that's a minimum; you can pay more, but if you do that you're crazy. OK. So we don't control benefits or wages. He's sitting in the back of the room and we're trying to explain it to him, and he won't accept it. I got so fed up one day, I said to him, "You know, our product goes home to dinner every night". Our product was people. If we can get more money for a person, we make more money. He didn't understand that. He felt that if you pay people more money, you're going to lose money. And you're not because you're going to recover it. 'cause 98% of our contracts were cost-plus-award-fees, and the award fee was based on performance. And when he left the company, it was a good thing he did because Honeywell would have been in real trouble. This new CEO they've got there is turning things around. That's why Honeywell's stock is much higher than General Electric's. The last radar we built was the Argentine Radar. That was the last one, and …

J – That was an FPS-20 …

C – It was a '20 upgraded, significantly upgraded with computer-controlled displays and stuff like that

J – And a display room …

C – And it worked out pretty good – I'll tell you, it was a very, very good performing radar.

J – They just had a civil war in the middle of it, that's all.

C – Yes. The whole thing with this …

G – Leo Kerr had some beautiful stories about installing that, like driving down the road, gunfire breaking out.

C – Oh yeah, well … That was the last radar that we did and …I'm trying to think of something here. The most unique radars that we ever did was in 1961, '62, and this was one which Al Moeller and company and the rest of those guys just outdid their selves. The Berlin Wall had gone up …

G – Is this Templehof?

C – Yeah. The Berlin Wall went up and we thought we were headed for WWIII. And the only way were going to get in to Berlin was through those air corridors, the three air corridors, there's one the North, South-center, and South. And we had three radars controlling those air corridors. And the Russians were known to jam on occasion. The same – the day after the Wall went up, we got a contract from RADC to upgrade those radars with every electronic countermeasure known to man.

J – What was the radar?

C – The -20's.

J – They were -20's.

C – They were 20's modified with WEXVAL.

J – The '20's got up into the hundreds, FPS-100 something …

C – Yeah, well the -100's had the GE antenna on it and a paraamp.

J – Is that what it was?

C – Yeah. So we went – we got a contract, we pulled the GPA-102 and -103 off the assembly line, we had to put the Westinghouse ARC-20 in, and the General Electric VICI(?). VICI was an IF canceller supposed to be the real, the real MTI…

G – The so-called better one, right?

C – It didn't work worth a shit. So we got the job…

G – I'm listening because I worked on the MTI on the -20, on the GPA actually.

C – Anyways, thrashing over there, and we had to install stuff in piecemeal, so the first thing we had to do was take all the receivers out and put 'em in, and we needed a minimum down time and I'm flying in to do the work, MIG's on both sides of us, and a commercial airliner. We land in Berlin, some British airline-Germans weren't allowed to fly in at that time. We got the GPA kits in and then the next big thing was the antennas, change out the -20' antenna and put in the vari-polarizer, which was fabulous. And the vari-polarizer enabled you to change polarization manually, and you could put a jamming signal out there and you could null it out, or minimize it by changing polarization. The jammer was usually one polarization, if you went orthogonal to that you were in good shape.

G – You said you got the GPA's, -102's, 103's were actually in production then?

C - Yes they were in production, we pulled them right off the line.

G – So you pulled the receivers.

C – Pulled the receivers.

G – That's the receiver system. But now there was a … That was the MK-448.

C – Yes.

G – The MK-444 …

C – Was a frequency-jumping transmitter, never went anywhere.

G – Oh, I thought that went into Berlin.

C – No, it did not. It went to Rome, New York. We tested it at Rome on the test site. Berlin, we got three sites, and we got over there, and unfortunately the team leader had a family problem and I ended up running the team; and Air Force Generals were on my back, I mean all the time. They really thought it was WWIII, I mean, you know. "You're taking our radar off the air for how long?" You know, to change an antenna.

G – Yeah, it takes a little while.

C – Takes a little while. So we got the systems up and running, and then we had a disaster. The damn rotating side lobe antenna motor burned out. And that's seventy feet in the air.

J – Rotating side lobe antenna?

C – Yeah. What happened was this. As part of this kit, we had a side lobe blanker, and Dick Cox designed an antenna that rotated and had the gain of a side lobe, so you would be able to cancel the side lobe out.

J – Was it synchronized to the main sail?

C – Yes.

G – But not coaxial with it.

C – No – it was mounted right close by though. Dick did the design on it. Garbut did the mechanical stuff and the motor. This thing's seventy feet in the air. I've got to pull it down. I get it down, I figure I'm replacing the motor, but I'm not putting it back up, I'm going to let it run a while. The Goddamn thing ran for 24 hours and burned out again. Called Garbut, go back to Diehl, Diehl finds out that they built the damn motor with the wrong insides that overheated, so we had to get that taken care of. But other than that, everything worked …

J – That was to reduce jamming again?

C – Yes. Then we're sitting down, we had just done Berlin's antenna, we're all sitting down patting ourselves on the back, and German television comes on and the war mongers are shown up on there changing the antenna. That's what we were, we were the warmongers. We were right near East Germany. Templehof is right there; you look right across. But the equipment worked great. Now the MK-444 was the idea that if you had a frequency-hopping transmitter,

G – They couldn't keep track of you.

C – Well, I've got news for you. What happened was the carcinatrons - broad-based jammers wiped that out. Because the noise would spread across the whole band, all right, so the frequency hopper did no value at all. What had happened is the jammers before that had holes in them and the -444 would look for the hole and set you there. And it worked. We proved it at Rome. But then the guys came back with the new carcinatrons and that put an end to the -444.

J – Carcinatrons.

C – Yeah. That was a - that was an oscillator, it's a high-powered oscillator –

K – Countermeasures work until the counter-countermeasures catch up.

C – That's right, that's really what happened. But anyways …

G – Do you know how the GPA-102 receiver system got formulated? John Martin was involved.

C – John Martin did that from WEXVAL. What happened was the Air Force funded us in 1950's well it started earlier that that. When the -20 was first built it had – the first -20

upgrade, there was no anti-jam features in it. The Air Force then came back and said we want a non-coherent MTI, which is called anti-chaff, and we want some anti-jam receivers. And within thirty days, Bendix designed what was called the Quick Fix. And that was the name of it. The official name in the book was the Quick Fix. The Quick Fix was a log receiver that took a DC voltage and fed it back to the preamp so if the noise level went up the log detected it, fed back the DC and lowered the gain on the preamp and kept the noise out of the receiver […]. The real reason was thirty targets in the SAGE system …

G – To keep you from overloading their computer … We fought that computer on many different occasions.

C – There was a poor man's Dicke Fix because we didn't have wide-band in front of it, it was the Pie receiver; Pulse Interference Eliminator receiver which was part of the Quick Fix. And the non-coherent MTI was done nicely by putting gates – you could gate around – we had a range and azimuth gate, you could set them up on a PPI, you could get it over the cloud chaff or whatever, and would switch to non-coherent MTI and would work very well – participated, OK – if the chaff wasn't moving internally, it did OK. Again, what are we talking about, we're talking about overloading the computer. What happens when you've got weather?

G – It wants to overload it.

C – You know what the solution to that was? They put a - The Air Force did this – very quickly they put a mapper in between. The mapper was nothing more than a photo pickup – you took a grease pencil and took all the weather and you blanked it out; you blanked out the targets too, but the SAGE system was still up and running … The whole thing had all kinds of short-comings.

G – The wide-band version of the receiver system which followed after Quick Fix got us the FPS-65, -66, -67 –

C - -64,5,6 and 7. And what we did there – we created - we did a lot of good things. The receiving system design choice kept me employed for six years. So …

G – I got you set up so you could tell this story.

C – I know. Joe, in order to save money, …

G – No, no. In order to have quiet receivers.

C – Quiet receivers. We used tube sockets with built-in bypass capacitors.

G – Everybody who didn't work for R. J. Davis used those sockets, incidentally. They were on the -34.

C – So he used these sockets. They're good for ten years, Joe. After ten years, they fail, OK. Well, I spent about six years fixing those things, OK. At least my department did.

J – They were to take out high frequency?

C – Yeah. Bypass.

G – You normally bypass the filament leads and maybe the cathode lead, whatever. And you can buy tube sockets and you can specify which pins have … so we would just in general put bypass capacitors on anything that didn't have the signal because the receiver was quiet-it didn't go off and oscillate at some dumb place that you weren't even thinking of, you know.

C – Anyways, John took – after the WEXVAL tests that were done up in Wisconsin, the WEXVAL was really good. And they then came back and gave us a contract to do the MK-448. We started on the MK-448 and there were some bad designs. To make a long story short, the Air Force wasn't happy. We did some things that were dumb. We had a perfectly good designed log receiver, but somebody said we needed to use a different type of log receiver, so Parker Cope designed a different log receiver that didn't log, OK. This was a unique design and it was terrible, OK. And it didn't CFAR –

G – Let me tell you what I knew about that. The first one was put on South Truro and the Government squirted jammers at it, and we would AJ until they turned the jammers off, and then all our thresholds would seek the threshold, and when the jammer went off, the front end would come in and blast through –

C – And wipe out the SAGE system.

G – And wipe out the SAGE system. So we had to redesign it and it worked.

C – Well, what you had to have – the solution to that was a cascaded Dicke Fix with the log, and John Martin came up with that.

G – One site …

C – You put the Dicke Fix receiver first …

G – On Long Island –I mean on – what is that?

C – South Truro.

G – South Truro – Cape Cod.

C – Cape Cod. So you put a Dicke Fix receiver, which is a wide band, a hard limiter, and a narrow band. And that will CFAR. However, if you get off-center CW jamming, the

noise level goes down, and noise level going down is just as bad as it going up because as soon as you go by, it goes back up again –

G – The thresholds are all down there. They were busy tracking Hell out of it.

C - So, what John did he put the Dicke and then he put the log, but he didn't operate it as the log. He ran 60db into the dynamic range of the log receiver. So what would happen was when the Dicke noise went down, the gain of the log went up and the noise stayed the same. And it worked beautifully. So then we also had – Terry Kravits had some problems with some of the stuff he designed.

G – Yeah, that was all of the CFAR circuits that maintained these thresholds.

C – So, we didn't feed video out as video, we fed digits out. It went to the SAGE system. That meant that there was no such thing as a threshold control over in the OPS room, because they got a digit. Whether the digit was from system noise or a target, they got a fixed digit. Well all Hell broke loose because they had been masking problems in the system by raising the threshold. That made everybody go back to square one and fix all the problems. Anyways, we got it in and it worked pretty good. Then we had the MTI, which was a wide band MTI, and it CFAR'd also. We made a bad mistake on the type or STC we employed. We used a noise injection STC, and although it did fine, it also destroyed the sub-clutter visibility. So we had to make up a new STC, which we eventually did, and put in. That was another one. I found out that the STD destroyed the sub-clutter and I called over there right away 'cause I was running the school on that thing and I …

G – You were actually putting signals through it and testing it.

C – You better believe it. I was doing all that stuff. But – you know, it was a good system, and the Air Force, when they got around to using it, it worked very well. And as I relate to …

G – It was completely backwards in certain ways.

C – Yes.

G – The sensitivity time control used to reduce the sensitivity at close-in range and then bring it back up. For this one here, because it was all CFAR, you couldn't do that so you had to inject noise to mask and reduce the sensitivity, but it reduced the sub-clutter.

C – So what we did is we put a - we put a negative waveform in and injected noise on top of that so it was flat, and it worked beautifully. All the noise injection did was it was a noise fill to keep the digitizer from staying the same rate. Well that -64, -5, -6 and -7 were very successful and we built 57 of those. And …

G – How long do you figure they worked? That was the last radar incarnation.

C – Well let's talk about this.

G – When was the last -20 off line. That would have been it's incarnation.

C – It is not off line.

G – Oh, it's still running.

C – Just recently, I happened to get an email from some damn place saying that – somebody from the FAA may have sent it to me, I don't know, that the Union was all upset at what was going on down in Puerto Rico. So I started investigating what was going on In Puerto Rico. In 1962 we sold two FPS-67A's to the Navy, one for Puerto Rico and one for Gitmo. The Puerto Rican radar went up, and the Navy used it. Ultimately turned it over to the FAA. It provides long-range air surveillance for Puerto Rico. Later on in life, I modified it, put an interface kit on it, did a few other things, put a RF-STC; the FAA modified it-they put a remote maintenance monitor on it. They are so reliable they took the people up on the hill, moved 'em out and laid two guys off. And the Union went ballistic. The -67A is still working in Puerto Rico.

G – The last Pine Tree Line itself, that's …

C – It's all gone.

G – What, in the eighties?

C - Yeah, they replaced it with a trip-wire system and then they never really implemented it to any great degree because the bomber threat is really greatly reduced …

G – The -30 went in around 1960 and the DEW Line ran for a pretty good while.

C - Yes. I don't know if all the -30's are gone. I would imagine they are but I'm not sure, because I'm not sure about air traffic if they've done anything, but I know this, that in the system today, the FAA radars are ARSR-4's and -3's – most of f the -3's are gone – the ARSR-4 – and then the airport radars are ASR-9's and -10's.

G – Now, OK, the BI-5 was in the -8.

C – The BI-5 is still running in a lot of places.

G – Is It?

C – Yes. The other thing is that the military went to the Lockheed-Martin, which was General Electric – they are the […] for the Navy, and that's being used for their search radars today.

G – I would think they would still have some radars strung across Greenland because of air traffic because we used to see the Scandinavian Airlines go over.

C – I don't know – I couldn't confirm that, OK. I could only state what I know.

G – In 1960, it was a big event when an airplane came through. The FPS-30 could see close to 600 miles. It was a 200-mile radar and one of their complaints was second time around and even – I was up there, I saw third time around …

C – Unbelievable.

G - You could count the number of scallops in the display flight pattern and figure out whether …

C – That was a powerful radar.

G – Right. And they would come at 200 miles blooming. With the pulse compression – it was bright as – it was no faint little target, it was there. You ought to be able to see any of them. … We got to go all over the world with this stuff –

C – It's all gone now. Now the Iranians were still using the FPS-100's, but I don't know if they've been able to get parts for them. We know this – show you how – when the FPS-20 spec came out, the goal was 1000 hours out of the klystron. Last time we checked, we were averaging 35,000 hours.

G - I wonder how we did that. I know that Al Sinsky figured out the current density to the cathodes in the tubes that are used in the -85 and determined that if you kept it below a certain number, that tube was going to last a mighty long time.

C – Yes. I attribute a lot of stuff to Davis, - R. J. – his care about the product once it left the company. He continually was looking for ways to extend the life of the tube, and something which I did not know, which R. J. found, which – we put a red bulletin out on it – I was reluctant to do it, but we did it, because it was true – I didn't realize that water gets ionized and loses cooling properties. R. J. found the solution – a tablespoon of 20-Mule Team borax in the water supply.

G – I don't remember what was cooled anymore.

C – The klystron.

G – The klystron had water cooling running through it?

C – Oh, my yes. Cooling on the – all over the place. You had a water pump pumped six gallons a minute.

K – Forced water cooled.

C – Yeah.

G – Was there anything under oil in that klystron?

C – Yes, you better believe it. The entire socket system was immersed in oil, and R. J. was one of the first ones to make sure the pulse transformer had bellows; a lot of people didn't understand that.

G – The oil expands.

C – Right. Well, not only bellows, but silica gel in an air vent so that any air that ever got in there was passed through the silica gel which took out the moisture. R. J. knew that moisture was bad and he needed to keep that so the bellows were there and it worked great.

G - The bellows were there to allow you to really seal it.

C – Yes. Is there anything else?

G – No, we're in great shape here. You've done very well. Thank you.

J – You have to be exhausted. I know I'm tired.

C – I'm not, I'm not. You know, it's just this thing here. When I started researching all this stuff, it was fascinating to go down and look at the sales orders from Radio Research, from the Naval Aircraft Factory, 400 nuts of certain kinds, screws, bolts, Hyland sold anything that he could to any – you know. And you look at these sales orders and there was all kinds of stuff – it was a history in itself. And our contract section was really on the ball, Joe, they kept them all. I told Maener when I saw this stuff, it was fabulous. Jack Bickel came to work at Bendix as an Army – in the US Army, then got sent to the United Nations.

G – Jeeze, I never heard that.

C - Did you know that?

G, J, - No.

C – Jack went up there to the United Nations. He worked up at the United Nations while he was in the Army and then came back to Bendix Radio cutting shippers. I told him it's all he ever did - cut shippers, either on one side or the other. That's all he ever did.

J – You mentioned Andy Bickus. He died, didn't he?

C – Yes, Andy passed away. Andy was a First Lieutenant in the Air Force and he later became the Bendix rep at Rome, and of course we didn't do ourselves any good when we pulled out of there. We moved Bickus and sent him to Boston - I guess we didn't think there would be more business there, but that was a corporate decision and –you know…

J – He came to Comm. Division. They moved him to Comm. Division.

C – Yes. Later he came to Comm., but he was at Boston.

J – Now you started at Radio in '59.

C – '58. June of '58.

J – In Field Engineering? Hired by Field Engineering?

C – Right. Hired by John Dee(?).

J – And then when did you come to Radio Division? Bendix Radio?

C – That was Bendix Radio.

J – Later on. You stayed with BFEC for a longtime.

C – Well here's what happened. When I joined, we were Department 474, Bendix Radio.

J – Right. I understand that.

C - In 1961 they made us a separate corporation, OK. That was done to avoid taxes in foreign countries. I stayed there 'til '74.

J – Stayed where?

C – At Field Engineering.

J – Outside of Radio Division.

C – Outside of Radio Division. '74, Frank Adams brought me back. You know what happened there. That was the day that – Emory - we all were bidding Cobra Dane.

G – […]

C – So what happened is Frank Adams called Murray and said we'd like you to send some people to sit in on a presentation on the Cobra Dane.

J – I remember that now. I was Director of Engineering.

C – I – Good old Cramer had been fighting this paraamp on the FPS-20. It cost a lot of money. The GE paraamp was $50,000. I found a vendor who said he could build a low-noise L-band amplifier with a 2.5db noise figure. I said Jeeze, that's just what we're looking for. So I cut an order. He never delivered. I kept calling "Weeeeell, we're not there yet." OK. So I go to the Cobra Dane meeting. It's L-band. They're going through the receiver, and they're going to buy 2.5db low-noise solid-state from guess where? Same Place!

J – That guy was a good salesman.

C – I held up my hand, I said Emory, Emory, he can't do it. He says what do you mean? I got a quote. I says I got an order and he ain't delivered. Frank Adams is listening. Because of that, Frank felt that I should go to the Comm. Division. He called Murray and said, "I'd like Cramer to come to the Comm. Division". Murray said, "Go. If it doesn't work out, you always have a home".

J – And the rest is history. You retired from Comm. Division.

C – No.

J – You went back to Field Engineering?

C – As VP of Marketing.

J – OK, when was that?

C – '86.

J – Yeah, I was down with Purple then

C – You were with Purple them.

G – In '86 you went back.

C – Yeah. And that was, you know – we really started to go down hill then.

J – Field Engineering?

C – No, the company. That's when Purple bought that Goddamn – that company on the West Coast and brought in that meatball …

J – Amex

C – Amex, and their leader who was

J – He was awful, he was a charlatan

C – Purple ought to have known – you know – he wasn't welcome in the Navy Department, in any of their offices because of his hostile actions when he was at Amex. When he was with Amex, they would go in and demand contracts because they were an 8A company and - you know, you can't do that to people. You just can't. And then of course when Purple left, we ended up getting Kirk and he had no idea what was going on.

J – Bob Kirk?

C – Yeah.

J – He came to get rid of Purple.

C – I know.

J – He was hired to fire Purple; it took him three years. He was with us for a long time before …

C – But he never did anything, Joe.

J – No, not a thing. He was down in Arlington. I felt sorry for him. I used to go in and talk to him. Purple would come in and say what are you doing in there?

G – Purple was the one that the Navy was unhappy with, demanding, or the guy from -?

J – When we bought Amex –

G – The Amex guy was the one.

C – Here's what happened. We bought Amex and they thought the guy who headed up Amex was going to be Purple's replacement. The guy came in there and it was very quickly – the henchmen that he brought with him were unbelievable. They weren't - furthermore, they had never been in a competitive environment. You know, we had to fight for just about every bid we ever won. They didn't. They were 8A's. They thought you could go in and strong-arm people. And – you know – there's one more thing I didn't mention. We had a - at Rome, New York, the first chief scientist at Rome New York was Harry Davis.

J – Oh, I know Harry Davis, yes.

C – When he left Rome, we lost a good friend.

J – Oh, yeah.

C – Because he was in a position to do things there that were right. I don't know, maybe Joe does, maybe you all know this, that Lincoln Labs did it's best to kill the FPS-85. They went on record – Herby Weiss went on record as saying that it would never work. I'm telling you, you know when it worked, they had egg all over their face.

J – It started with the line array. When we got that line array, they started fighting us on phased-array radar right away.

C – Right away. But, you know, the interesting thing here about that on the -85, even when it was working, they didn't want to admit that the damn thing was functioning. I mean it. Herby Weiss had gone on record. And let me tell you, there was a young Captain at the Air Force that says we're going with this, we've made up our decision, and the Captain was right. We proved that you could do all those things. It wasn't something that was just out of the clear blue sky.

J - Lincoln Labs never thought you could do anything without them.

C - That is correct. They had nothing to do with the -85.

J – They had some great guys, no question about it.

C – Joe, that's right; they did.

J – But it's hard working with them.

C – But it's very difficult, very, very difficult.

End of Tape Four

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