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HOWARD VOLLUM

Tektronix Co-founder

Oral History Interviews conducted by Jim Castles

April, May, and September 1984

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INTERVIEW 1 - April 20, 1984

Castles: Howard, this is an occasion we have looked forward to for a long time—trying to get you to tell us some of the things about Tektronix that only you know. This is Good Friday, April 20, 1984, in your beautiful home just off Skyline Boulevard, Portland, Oregon, with your lovely wife, Jean, in an atmosphere where you can be relaxed. Tell us about things that occurred that would be of interest to anyone that might like to know what happened then. For instance, let's start with how you met Jack?

Meeting Jack

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Vollum: Well, Jack had the Murdock Appliance Company out on Foster, and he had just started that about a year before I graduated from Reed. I was working as a radio service man at Sears-Roebuck—incidentally, at the store they are just about to close up. I had heard about Jack a number of times, and what a nice operation he had. So I went out to see him. We talked, and we agreed after a while that I should do their radio service. So I quit the job at Sears and essentially went into business for myself doing Jack's service.

Castles: That would have been about 1936?

Vollum: That would have been '36 or early '37. I graduated in '36. Yes, it must have been about the end of '36.

Castles: Before you worked for Sears, didn't you work for another radio—

Vollum: Yes. Radio Specialty.¹

Castles: What did you do there?

Vollum: We built Forest Service radios. They had a contract to build portable radio transmitters and receivers for both the state Forest Service and for the U.S. Forest Service. They were the leading maker of those things in the country. I went over there and we built and tested everything on them for the Forest Service.

Introduction to Oscilloscopes

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The oscilloscope intrigued me as being the really fundamental instrument that was most needed.

Castles: Your interest, however, in oscilloscopes had been piqued prior to this time.

Vollum: Yes.

Castles: Tell us about how you got interested in oscilloscopes? Didn't your father have some background in radio someplace?

Vollum: My father was an amateur radio builder from the first days of the radio stations in Portland. He used to build radios. I think we had a radio when—not when the first radio broadcast came on—that was Holly's station out in Oregon City. But then when KGW came on, KOIN, KEX... And, of course, there was another one which was in a radio shop just across from the library, and that was KGG, King George George. They were

some of the first radio stations and he built some of these and I, naturally, was involved in that. And he used to sell some radios. We usually had Grebe radios—one of the best brands.² Incidentally, they weren't cheap. A five-tube battery-powered radio that you had to buy a loudspeaker and batteries for, I remember, was \$180. That was a lot of money at that time. Now you can buy one for \$4.95 that is more sensitive and probably sounds better, too.

Castles: How about your first oscilloscope? When did you get that idea?

Vollum: Oh, I had read a lot of technical publications and this oscilloscope thing intrigued me. It was a real fundamental instrument that was most needed. But, the early oscilloscopes were big laboratory things. Most of them had cathode-ray tubes that had to be pumped rather than one that was sealed. They were not very bright and they were used a lot for things like lightning flashes and things which had a lot of energy so they didn't need a lot of sensitivity. But I got interested in them. RCA brought out a line of sealed cathode-ray tubes that were at reasonable prices. I think the three-inch one was about \$25, something on that order. So I bought one and built an oscilloscope around it.

Castles: What kind of a gadget was that in those days?

Vollum: Well, it didn't have any amplifiers in it. You connected the signals directly to the deflection plates. But that was not too much of a problem because most vacuum tube devices had voltage swings that were large enough to observe. It had a built-in time base, and a power supply. That was about what it amounted to.

Castles: Did you build your own then?

Vollum: Yes.

Castles: What year would that have been?

Vollum: That would have been 1934, I guess.

Castles: What did you do with it? What use would it have had then?

Vollum: Oh, you could look at electronic signals and whatever you happened to have to look at.

Castles: How did you use it? Where did you use it?

Vollum: Oh, I just used it as a regular piece of experimental electronics. There was interest in making various waveform generators. You could look at audio amplifiers and see distortion and so on. It was not as useful and flexible as the later ones, but it was a very useful instrument. It was about the same size as oscilloscopes were at that time, maybe ten inches wide and fifteen inches high and twenty inches deep—something of that nature. It was portable.

Castles: What did it weigh?

Vollum: Oh, not too much, thirty-five pounds maybe. Something like that.

More About Jack

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People liked him.

Castles: Let's get back to Jack Murdock. How did you and Jack come to the idea of a business?

Vollum: Well, Jack had his store, and he was both a radio and an appliance dealer. He had General Electric appliances, and a very good radio line. He had General Electric, Zenith, and Stromberg-Carlson, which was his big brand, which was the Rolls Royce of radios. He sold a lot of Stromberg-Carlsons to people who had not the slightest intention of buying one when they came in the store.

Castles: How did he do that?

Vollum: Well, he just carefully showed them how good they were and how good they sounded, and they were distinctively better than anything else.

Castles: Was Jack a good salesman and all?

Vollum: Oh, Jack was a super salesman! He always listened to people. And there were occasionally people who came in to complain about something, and they usually ended up buying something before they left the store. And they felt very good about it. He didn't threaten anyone or anything like that. He didn't argue with

people. He had his opinions and he would express them easily and quietly. People liked him.

Castles: I can imagine that Jack Murdock could be a soft sell.

Vollum: Oh yeah! But he was persistent, and orderly. He did a very good selling job.

Castles: What did you decide prior to World War II?

Vollum: Well, Jack had this store. It was up on 67th. A small corner shop that I believe his uncle owned. It wasn't very big, though. Then he had a chance to buy a building on 57th.

The building had about five stores in it—something of that nature. He redid the corner one and made it into a very nice appliance store. It had a model kitchen, and had the service department there, and we had very nice displays of the radios and appliances. And he still had the GE appliances. While that was all going on, my number in the draft came up and one day I was gone.

Castles: Did you make any decisions about going into business prior to the war?

Vollum: Oh, no. We talked informally about what we would like to do, but we didn't make any particular decisions then.

Castles: Did you correspond during the war?

Vollum: Not very much. Some, but not very much.

Castles: Well then, how did you get off the ground in 1945 and 1946?

Vollum: I got released from the service earlier than Jack did, because they had a point system and overseas service counted more than domestic service, and I had a lot of points from the two-and-a-half years I spent in England. I was released in November, I believe.

Castles: I believe that is when I met you. November, 1945.

Vollum: Yes. And I had been home for sometime before that because we had a terminal leave policy and you could take the leave you had accumulated,

and I had accumulated a lot of leave. I was home sometime during the summer and was released in November. Jack was in Seattle, and used to drive down on weekends. I saw him quite often then, and we got to talking more seriously about what we were going to do, because everybody had to start all over again. Everybody's jobs had somehow disappeared. Jack had rented out the stores and the building. He had sold his entire inventory, and so on, before he went into the Coast Guard. So it was a question of starting again. We felt it was worth a chance to do this rather than start another appliance business in that store.

Castles: You said "a chance to do this." Now what are you referring to—"to do this"—did you have something in mind?

Vollum: Yes. We wanted to build electronic instruments, particularly oscilloscopes because I'd had a lot of experiences during the war with advanced type oscilloscopes.

World War II

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I'd had a lot of experience during the war with advanced types of oscilloscopes.

Castles: I want to back up to that, Howard. Tell us about that. The experience you had during the war that gave you this idea. I recall Jack telling me regarding products, "Just wait till you meet Howard Vollum. He knows what we are going to do." Tell us about that.

Vollum: Well, I was drafted and went into the service before the U.S. was in the war. I went down to Camp Roberts in California which was about half way between Los Angeles and San Francisco, really in the middle of nowhere. A deserted spot. We were the first people in the camp and in the buildings. They were brand new. When we got off the train there, coming down from Fort Lewis, they divided us into two groups and said to half of us, you go that way, you are in

the artillery, you others go that way, you are in the infantry. I was in the infantry.

Castles: It was literally that?

Vollum: Yup. It was that simple. They had no reason to put us in either one. I was glad I got in the infantry, because it's more comfortable to walk than it is to sit on one of those hard seats in a truck going over a rough road for a number of miles.

Castles: How long did that last, that you were in the infantry?

Vollum: I was in the infantry about ten months. It was a training program, and this was a camp that trained you for ninety days, about three months, learning the basics, military basics. Being in the infantry meant most every day marching from the barracks to the far end of the camp then marching back, and some days carrying a full pack. Everybody took this basic training, and then they were shipped off to somewhere else.

I took care of the radio equipment.

I didn't get shipped off because one of the officers around there actually came from the Milwaukee area here. He was a Bonneville engineer. He sort of got to know me and I got to fixing some radios. Then they decided I should stay on with the cadre, with the teachers for the next group of the ninety-day draftees. I took care of the radio equipment. We were in a headquarters communication unit. It was a headquarters company. So they had radios in the cars and portable radios. They didn't work very well. At that time the military had the idea that to confuse the enemy, you should have your radio transmission be tunable over a pretty wide frequency. So the enemy wouldn't listen. The problem was that the guy on the other end wasn't listening either. It was really a terrible system.

I worked on those things, then I stayed on for another period. It wasn't as easy as it sounded. The colonel who was the battalion commander had the quaint idea that if the draftees carried a pack, all the cadre would carry a pack and go with

them. So, we got two sessions of pack carrying and that sort of thing. But I was pleased to find that I could do it as well as the next guy, and better than some guys who looked a lot stronger. So, it was an interesting time. I've probably never been in as good physical shape as when I was there.

Castles: When did you get to using oscilloscopes while you were in the service?

Vollum: Well, we didn't have any oscilloscopes at Camp Roberts. I don't know where I would have gone. Other people I knew who were there at the time, most of them went to the South Pacific and some of them had some pretty tough times. I had applied for officer candidate school, and I had just had interviews with officers there. I think I had a fairly good chance, but the government under Vannevar Bush's suggestion was trying to arrange a deal whereby both the U.S. and Britain would benefit by having some technicians and engineers go to England and receive training on English radar sets, serve as radar maintenance men. That was supposedly for six months. Then you would come back and you would be a combat veteran. At least you might have been around when someone might have been shooting something at you.

They had this thing called an electronics training group, which Roosevelt formed as a result of Bush's suggestion. In order to qualify for that you had to have either a degree in physics or mathematics or an engineering degree. So I qualified for that and the application was at just about the same time as officer candidate school. There was not much of anything going on, and I was kind of disappointed that no one had called or that I had no notification.

When Pearl Harbor day came, things changed rapidly.

But when Pearl Harbor day came, things changed rapidly. It was only a few days until I received orders and I was an immediate second lieutenant. One day I was a corporal and a few hours later I was a second lieutenant. I was the first directly-commissioned officer at Camp Roberts, which was kind of interesting. I had been there for a while, so I knew most of the officers pretty well. They took great delight in this. They hauled me over to the

officers' quarters and changed the emblems on my uniform. Then I went down to dinner with them.

The next morning I came down to breakfast, and the colonel was there. He was an unusual kind of guy and asked: "What are you doing here?" So a number of people told him what I was doing there. He thought it was all right, but was a little bit miffed because he had not been consulted about this, had not even heard of it. This was a deal where the whole communication had been with Washington and Bush's outfit. So it had no path through the army like officer candidate school did. I had been interviewed by some traveling guys from Washington, too. The orders were to proceed immediately to Fort Monmouth. It was immediate. I couldn't even come around through Portland, coming home. So I got on the train and went to Fort Monmouth.

Castles: That would have been in New Jersey. What did they have there?

Vollum: New Jersey was the Signal Corps headquarters, and I was assigned as a Signal Corps officer. Fort Monmouth has always been headquarters for the Signal Corps. All we did was just collect there until everyone got there. It was a group of about twenty. They had a few close order drills. Most of these people were civilians and not involved in that sort of thing at all. I was lucky from that standpoint. I knew what to do. We weren't the first group. We were the seventh group, I think.

I was assigned as a Signal Corps officer.

As soon as we got the group assembled, we got on the train and went up to Canada, to Halifax. We waited in Halifax harbor for about a week because they had a little problem with some sinkings outside of Halifax. We had some guys on the ship who were making a second try at it. They had gotten a little bit wet the first time. But, we made it across okay. We didn't go on a troop ship. It was a Dutch passenger liner called the Volendam. It had been taken over for this kind of thing. It was fairly fast. It went with a partial destroyer escort.

Castles: To where did you go?

Vollum: Scotland, to Greenock. Then down to London. We were stationed in one of the suburbs of London, Richmond. A very attractive place. Richmond Park is one of the beauty spots around London. It was maintained during the war in very good style because they wanted to have someplace for Londoners to relax a little bit. It was right on the Thames River. Beautiful. They had a training program there. We had a place nearly on the Thames, and walking to work every day we passed through a cemetery. Captain Vancouver's grave³ is in that cemetery. That was kind of interesting.

Castles: What did you do at that location?

Vollum: It was a three-month training course. You were to spend three months being trained then three months working. That was the program. Then you would come home. You had a choice. You could be trained on the searchlight-control radar, which was a 200- or 250-megacycle⁴ radar that was attached to the searchlights, so you could aim at something rather than just turning the searchlight on. Then you could shoot at them, as a plane illuminated by a searchlight is a very bright target. They also had the gun-laying radar, which was a lower-frequency unit. That was for controlling anti-aircraft guns. It was a somewhat older design. I chose the searchlight radar because it was a higher frequency.

We all took this course in maintenance. The Americans had varying degrees of success with the course. Some of them paid attention and some spent more time in the pubs, I think. Something like that. Anyway, there were two fellows, Joe Woodward and myself, who got the top grades. That was very unusual at that time. There were not only Americans in this course; there were Englishmen there as well. Americans were rarely at the top of the class. As a result of this we both got promoted to first lieutenant. I'd been a second lieutenant about six months. That was a nice recognition.

And then, instead of going on to maintain the radar equipment, they decided I should go down to Christchurch, which is on the [English] channel, and be an engineer on the development of a particular radar. That was great. So, I never was on a searchlight-control site. We were trying to

develop a radar set for control of fifteen-inch guns at Dover, shooting at German shipping. This had a pretty high priority. I was involved with making the display unit for it. This program couldn't finish in three months, so I kept getting renewals of my stay there. That went on for over two years.

We were working on very high-performance radar.

Meanwhile we were working on very high-performance radar. It was undoubtedly the highest-resolution radar that was working at that time. It had one-tenth microsecond pulses. It had a large antenna so it had good resolution in all directions.

They wanted to get it built, so we were at Christchurch for about a year. Then the security people decided that it was not a very good idea to have a radar lab right there on the coast. There had been a few commando raids, not on us, but we had done a few commando raids on them. They felt it would be pretty easy for the enemy, and we certainly didn't have any defense. These security people were almost a kind of joke. They would threaten each other more than they would some would-be enemy. They were mostly old retired guys, mostly from the military or the police service. They were real nice guys to have around, but I don't think they would have been much good if the Germans had come over. So they moved us to the Midlands. That was about the safest place you could be. A place called Malvern. There was no evidence of war there, no bomb holes or anything like that. They had never been attacked and probably never would be. There wasn't anything there worthwhile attacking and you would likely be shot on the way, so it wasn't a very good deal for the Germans.

Castles: I'm curious. Did you see any oscilloscopes in any of that work there?

Vollum: Sure. The standard oscilloscope was a British one made by Cosser. Cosser was kind of a British DuMont. Cosser made most of the oscilloscopes in England, as DuMont did in the U.S. They really weren't made for the kind of things we had to do. They weren't suitable for looking at short pulses. So we didn't have very good

oscilloscopes. For general circuit work they were okay, but we always had to build something special. So we usually had some sort of bench lash-up. They didn't have any cabinets.

Cosser made most of the oscilloscopes in England...They really weren't made for the kind of things we had to do.

Castles: Did you have adequate support there?

Vollum: Oh yes! A lot of things came along there. We had access to all of the technical information, both in the U.K. and in the U.S. We had top security clearances. We had a number of visitors because a lot of people were interested in high-resolution radar. We didn't have time to make a general purpose oscilloscope. We always had to do a special lash-up to do a particular job that needed to be done. They were far from an engineered product. They were rough lash-ups that did what we wanted them to do. I wasn't the only one making oscilloscopes. We had a lot of very expert guys in circuitry and so on. Most of the people I worked with were either Oxford or Cambridge, actually the majority were Oxford. They were very well-educated and they knew their business.

Castles: I believe you got some citations for your work there in England. What were they and what were they for?

Vollum: I didn't get any citations while in England, but after I got back and was at the [Camp] Evans Signal Lab,⁵ I got a citation for the work done in England. It was the Legion of Merit. That, incidentally, carried some points for getting out of the service early, so it had some practical advantage aside from being something you could wear on your jacket. Then, after I got home, for the work done at Evans, I got the equivalent of another one. They give you an oak leaf cluster for the second one. There weren't many captains who received this award. It was more typically a major or colonel's award.

Castles: Did you have something to do with the radar lab at MIT?

Vollum: No. I spent quite a bit of time there, as they were the U.S. radar development center. When I came back to the U.S., the job was to develop a radar which could see mortar shells and find where they were fired from so you could fire back. Mortars were very lethal weapons. More people were killed by mortar shells than by machine guns. The mortar is a hard one to escape from. It comes at you in a big arc, then drops on you and explodes all over the place. So the hope was to make a radar that would track the shell, at least part way, determine where it was fired from, and then fire back. MIT was working on a unit that would do this, and we at Signal Corps Labs were working on one, so we worked together a lot. I went up there every week for a long time. I spent two nights a week on the train going from New York to Boston. Got to know all the porters there well. So, that was my connection with MIT, and I got to know quite a lot of people at MIT as a result of working on the mortar tracking radar project. But I had nothing to do with their program. We tested the combinations of things that we both put together.

Castles: Were you there, then, until you were discharged in November of 1945?

Vollum: Yes. Right.

Early Days of Tektronix: Hiring Engineers

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Choose people who are good engineers, who are ingenious, who can attack new problems.

Castles: Getting back to Tektronix' early days. What criteria did you choose for selecting the early engineers at Tektronix?

Vollum: Oh, I don't think it was any different from what it is now. Choose people who are good engineers, who are ingenious, who can attack new problems. I don't think the criteria was any

different. Most of the people at the start were local people.

Castles: Well now, let's use as an example, John Kobbe.

Vollum: John didn't come along until quite a bit later.

Castles: Quite a bit later, but John didn't have a college background, did he?

Vollum: No, John didn't. Some of the others didn't, some did. We didn't make that a condition of anything.

Castles: Who were the early-on engineers that come to mind?

Vollum: Logan Belleville came in pretty early. Dick Rhiger, I would guess was close to our first engineer.

Early Days of Tektronix: Initial Products

00:44:13

The need was very obvious for a wide-band, lightweight oscilloscope.

Castles: How did you decide, at Tektronix, how to produce certain instruments?

Vollum: That was pretty easy. The need was very obvious for a wide-band, lightweight oscilloscope. We made the first one just sort of from the best we could do. We had the goal of a ten-megahertz oscilloscope and the idea of a triggered time base. Things like that were things that had come along that I had seen and had some experience with.

Castles: Was the 511 the first model?

Vollum: Yes the 511 was first.

Castles: How did you come up with that number? What does it stand for?

Vollum: That's very simple. It had a five- inch tube, had one channel, and was the first of the series. So the second was the 512, and so on.

Castles: *So where did you go from the 512?*

Vollum: Well we had the 513, 14, 15, 16, and 17. We didn't always develop them in order because sometimes there was a need to develop one that was somewhat different.

Castles: *How did you progress from one to another? How did the match take place, and who made those decisions? Did you make those decisions?*

So you see how fast you can go.

Vollum: Once again, they were very easy because when you have a ten-megahertz oscilloscope, it's not fast enough. So you see how fast you can go. You find you can go to fifteen or eighteen, so you make one for fifteen or eighteen. Actually, it didn't quite go that way. The second oscilloscope we made was the 512. It was made because it was essentially a low-frequency oscilloscope. The 511 didn't work very well at low frequencies. So the 512 was a low-frequency oscilloscope. It had very slow time bases, up to thirty seconds. It was decoupled and was very sensitive compared to the 511. It wasn't anywhere near as fast. The 513 was very fast and the 517, of course, was by far the fastest oscilloscope in the world. That was a real achievement.

Castles: *Who else was making oscilloscopes at that time?*

Vollum: RCA had a couple of units that were a rather old design, probably done during the war. They were pretty big things, big consoles on wheels, and they really weren't very good. If you input a square wave, it didn't come out as a square wave. It had all kinds of wrinkles on it. That was because of a fundamental error made in the design of the vertical amplifier. They tried to make them have the widest and flattest frequency response. If you do that without having any concern for the timing and phases of all the signal components as they get there, the display does not look right at all. They had that one, General Electric had one,

and DuMont had a line of oscilloscopes. They were our major competitor.

Castles: *How much did those scopes cost, be it the General Electric or the DuMont?*

Vollum: The General Electric and RCA units were on the order of \$1,500 to \$2,000. They were very large units. I don't think very profitable. They had a lot of stuff in them. DuMont's nearest competitor to ours was \$1,800.

Castles: *What price did you put on the 511?*

The 511 was a great success right off. We couldn't make them fast enough for years.

Vollum: \$595, then \$695.

Castles: *Was it an immediate success?*

Vollum: Oh yes! A great success right off. We couldn't make them fast enough for years.

Early Days of Tektronix: Hawthorne Plant

00:49:11

We had to get a bigger place.

Castles: *Tell us about the old Hawthorne plant. Was that where you first began to make the scopes? Describe the Hawthorne plant.*

Vollum: When we started, Jack had one store section that was not in use. We moved in there, but it was very small. We had to get a bigger place.

Castles: *You were mentioning Jim Jones constructing a building.*

Vollum: Yes. He said he would build a building and lease it to us. We had to find a place to build

it, and we also had to get the materials. That wasn't easy because everything was in short supply. But we had lots of veteran's preferences, and that helped.

We looked all over for building sites, and finally found one on Seventh and Hawthorne. It belonged to the county for back taxes, as did many lots on the east side at that time. We looked at some lots on S.E. Salmon, and almost every one between Grand Avenue and Twentieth, or so, had been taken over by the county. They had a whole department at the courthouse, a real-estate-sales department, and they were selling these lots at appraised value, not for the amount of back taxes. In some cases the taxes owed were much more than they sold for. In some cases, less. Veterans had a preference, so we bought this property, which was L-shaped. Its largest frontage was on Hawthorne, but it also stretched out on Seventh.

So we built a building on it. The upstairs was for manufacturing, but we rented out part of it to Dal Dallas, who had a [sales] rep outfit at the time. In the back, going off of Seventh, we had an area where you could drive in, so we were thinking of doing auto radio repair. In the front we had an appliance store. That was Hawthorne Electronics, and it's been Hawthorne Electronics ever since. The object of that was to provide us some immediate income. There was a demand for electronic products—radios and so on. Jack had connections with distributors, which was very good. So that was a start. It wasn't too long before we needed the space, so Hawthorne moved next door.

Castles: What was the early environment like in that building?

Vollum: It was just a plain, simple building. It had one thing, I remember. It got pretty warm in there. We had psychological cooling. We had a big watercolor painting of Mount Hood with snow on it on the wall. So looking at that picture could make you feel cooler. Well, it got pretty crowded in there. I don't remember exactly how many people we had at the end, but we had a three-shift operation. We had more than a hundred people.

Castles: How early would that have been?

Vollum: That was four years after 1947, I guess. Just before we moved out here [to Washington County].

Jack's Role

00:55:02

Without Jack, we never would have started.

Castles: Discuss Jack and his role in Tektronix at that time.

Vollum: Without Jack, we never would have started. I didn't know anything about the business side of things. Jack had quite a lot of experience at that. He was the general manager. He was involved in the personnel of the operation, purchasing, and the whole bit. That made it possible for me to concentrate on the engineering and technical aspects of it.

Castles: We hear the story of Tektronix starting in a basement in Portland. What was that? Tell us so we can get that straight.

Vollum: In the basement of our house in Sellwood,⁶ I had a workbench before the war. So when I came back I started working with an oscilloscope, which was the natural thing to do. I did this before I got together with Jack. Then we moved it out to Foster Road. But it's true—things did start in a basement, it wasn't in a garage.

Castles: What did Jack have in his basement?

Vollum: He was always doing something like that too. But the construction of the first prototype was at our house.

Things did start in a basement, it wasn't in a garage.

Wartime Stories

00:57:27

Castles: Let's back up at this point. Jean has reminded me of a couple of stories during the war.

What about that story of repairing a radio for a general?

Vollum: Oh yes. That was at Camp Roberts. He was the camp commander and he lived in a house up on a hill that overlooked the whole camp. He had a nice place, but the radio reception was bad because it was a hundred miles from Los Angeles or San Francisco. I think there was a local radio station, but it wasn't very good. Some of my officer friends were telling him that I could fix radios. So he said he would like for me to come up. The colonel, the one who saw me come down to breakfast in an officer's uniform and asked "What are you doing here?" was a real guy for form and all this kind of thing. When the general asked him to have me come up, it really blew him. He really didn't know what to do, but he provided me with a staff car and a driver so I went up and had a look.

Obviously what was needed was a good outdoor antenna. So I drove into the nearest town in the staff car, and bought an antenna kit. We found a tree that was reasonably nearby and we put this long wire antenna up and he got very good reception. Meanwhile while I was working there, the colonel was always bugging him to find out how I was doing. He would say "All right." The general couldn't care less. He was a very friendly, nice guy, who was always talking to me while I was around there. He was just as nice as could be. Had no worries at all. I got it put up and had to report to the colonel immediately to tell him how it worked and so on. That's the way things go, I guess, in the army.

Castles: Jean reminded me of another story. How about the Fourth of July in England?

Vollum: Oh yeah! That was another one. We were at this radar school and the Fourth of July came along, and the commanding officer there—who was a real typical British army major with a swagger stick and all this sort of thing—he called us into his office the day before and said "I really don't know what to do with you chaps tomorrow. I suppose you deserve a holiday. We don't observe this holiday here, but if you want to take the day off, fine, it would be all right." We all said no, we don't want to take the day off, and we just want to keep working. He was really relieved because he didn't have that to put up with. This really helped him. Eased his mind, I guess. He

might have had to submit a report to explain why fifteen people were not at work that day.

Early Days of Tektronix: First Employees

1:01:55

The earliest people were friends of Jack's.

Castles: You mentioned Jack's role with Tektronix in the early days. When did you get some of the other people involved? W.K [Dal] Dallas, for example.

Vollum: He was much later. The earliest people were friends of Jack's, who were in the Coast Guard, except for one person, and that was Glenn McDowell, Jack's next door neighbor. Glenn was an accountant with Standard Oil Company. He finally decided that he would leave Standard Oil Company and go with us. The other guys, like Milt Bave and Miles Tippery, joined us as they got out of the Coast Guard, which was all at different times. Later on Logan Belleville joined us. I don't recall how long that was, but it was several months. Dick Rhiger joined us too. He was an engineer with KGW Radio. He built KGW-FM and put it on the air.

Castles: What about Bob Davis?

Vollum: Bob came along a little later, within the first year, I think.

Castles: Along about 1948?

Vollum: Yes, that's about right. Jack was a strong admirer of Bob Davis. He was a real doer.

Castles: Well, he was in the Coast Guard.

Vollum: Yes. He was in the Coast Guard.

Plug-ins

1:05:00

When we got this wide-range sweep circuit, it became obvious we could make an oscilloscope that would do everything.

Castles: When did the concept of plug-ins come into being?

Vollum: That was substantially later, after we had engineers like Dick Ropiequet and Kobbe and Polits and Poulin. These guys, especially Ropiequet and Kobbe did a lot of development work on wide-range sweep circuits.

For example, on the 511—the slowest sweep speed it had was one second. It really wasn't very good at that. It was hard to make slow and fast sweeps together. That's why we made the 512. It was a different kind of sweep circuit. It had sweep speeds that went from 30 seconds to 30 microseconds. So, when we got this wide-range sweep circuit, it became obvious we could make an oscilloscope that would do everything. If you wanted to make it really useful, you had to have different front-end amplifiers, because at that time, there was no way you could build a really sensitive wide-band front end amplifier. So, if you wanted high sensitivity, you would have a lower bandwidth, which was fine. That meant plug-in units. We put the vertical systems into plug-ins, and that is what created the 530, 535 series and later the 540, 545 series. That was very important.

Early Days of Tektronix: Oscilloscope Sales

1:07:05

We sold to a very sophisticated customer.

Castles: Who bought the number one oscilloscope? We have it back there.

Vollum: I don't think that's right. I don't think the medical school bought the first Tektronix oscilloscope. I think it was on the east coast. It might have been Pratt & Whitney. It was somebody like that. Most of them were sold on the east coast because Burlingame was our representative and they sold them faster than they could get them.

RCA was a very early customer, General Electric and a number of large electronics companies. They bought them as a trial. They had nothing to lose. They had to get new equipment and the Tektronix instrument was by far the most cost effective oscilloscope they could buy. So there was no great selling or marketing effort required. The people who bought them could look at them and see how well they were made, and what sort of parts were used. They could try them out and easily measure performance. We sold to a very sophisticated customer, almost always, a high-grade engineer. There wasn't any great competition at that time. It wasn't such a big investment that they had to risk their company or anything like that. They were just buying test equipment.

Interview 2 - May 8, 1984

01:09:06

Castles: Howard, this is our second session with you talking about Tektronix. The last time was on April the 20th. We talked about Jack Murdock and you before the formation of Tektronix, later the formation of Tektronix in 1946 and the early days of the company. I neglected to ask you - you are a native Oregonian, are you not?

Vollum: Right.

Childhood and Education

01:09:39

Castles: *You have a birthday coming up pretty soon.*

Vollum: Yup. Yup. This month.

Castles: *This month! You were born in Portland?*

Vollum: Yes, in the Sellwood area. May 31, 1913.

Castles: *As a child did you have any hobbies that piqued your interest in electronics?*

Vollum: I don't think I had any hobbies. My father was interested in radio for a long time. He was building radios when the first stations went on the air. So that is how I got involved with electronics.

Castles: *That was one of the early influences in your life?*

Vollum: Yes.

Castles: *Where did you go to school?*

Vollum: I went to school at St. Agatha's, a parochial school. Then St. Stephen's, a high school over on 42nd. and Salmon. Then I went to Columbia University, what is now the University of Portland, for two years. They had a pre-engineering course. Then I went to Reed for two years.

Castles: *You got your degree from Reed?*

Vollum: Yes.

Castles: *What year would that have been, Howard?*

Vollum: 1936.

Castles: *And what was that degree?*

Vollum: It was a BA in physics.

Castles: *You have just showed me a degree which has recently been conferred upon you. What was that, Howard?*

Vollum: Well, the Oregon Graduate Center recently conferred a Doctor of Science.

Castles: *That's among several other doctorates you have received. What were the others?*

Vollum: Yes. That's true. The first one was from the University of Portland. I don't remember the date, but that was a long time ago. That was a Doctor of Science. Then I received honorary degrees from Pacific University and Lewis & Clark and Reed College.

Early Tektronix Products

01:12:32

Castles: *We were talking last time about the early-on products. The first product, what was it, again?*

Vollum: The first product was the 511.

Castles: *You said that you thought that unit had not been sold to the University of Oregon Medical School. Could that one have gone to the National Bureau of Standards?*

Vollum: No. I don't think so. We sold one to the medical school, pretty early. I'm not sure that is actually the one we have. I think the first one we delivered, though, went to one of Bruce Burlingame's customers on the east coast.

Castles: *After the 511, what were the next models to come along?*

Vollum: We might go back. Technically, the 511 was probably the second product, but it was the first one that was a successful product. While we were developing the 511, we needed a calibrator for it. We built a calibrator and thought we could make it into a product. While it was a simpler device than the oscilloscope, we thought oscilloscope customers would need them. We thought there would be some sale of them, but we sold very few of them. It was the Model 101. So technically, the 511 was the second product, but it was the first one to have widespread sales.

Castles: *What came after the 511? Do you recall?*

Vollum: The 512.

Castles: *That came to be. When I looked at an early catalog, that was in 1949. Would that be about right?*

Vollum: That would be about right. We started working on it essentially at the same time that the 511 got into production. Logan Belleville was the engineer on that. It was a quite different oscilloscope. It was a low-frequency, high-sensitivity oscilloscope in contrast with the 511 which was a fast, wide-band, medium-sensitivity device.

Castles: *We noticed in some of the catalog material, that in 1949 there came the 104 and 112. What were they?*

Vollum: The 104 was a square-wave generator. Another piece of test equipment we needed. We sold a few of those over a period of time. The 112 was an auxiliary unit for the 512. It was essentially a duplicate of the vertical amplifier in the 512. It sat alongside of the instrument and made a sensitive X-Y scope out of it, as the 512 did not have a sensitive x-axis. So you used the 112 with it. It was a fairly easy engineering job, because it was an identical chassis to the 512 vertical amplifier, and only needed its own power supply. There wasn't a large demand for it, although we did sell several of them.

Castles: *In 1950 it showed there came the 513, the 514, the 517, and then the number 500! Does that make any sense?*

Vollum: No. I don't think so.

Castles: *But these other products came along.*

Vollum: Yes. The other ones did.

Castles: *Then it says the 105. What would that have been?*

Vollum: The 105 was another square-wave generator. The 104 had just two frequencies. A fast square wave for adjusting the vertical amplifier, and a one-kilohertz square wave as a calibrator.⁷ The 105 was a continuously-variable square-wave generator. It was a unique instrument, and we sold those for a long time. Almost everybody that was working with fairly fast signals wanted it as a source. It was the best signal source available for testing the high-speed amplifiers. Not including television. They were pretty widely used.

Castles: *I have some other numbers here. What were the 121 and 122?*

Vollum: The 121 was a pre-amplifier for the 511. The 122 was a high-sensitivity pre-amplifier which had a lot of the characteristics of the 512 built into it.

Castles: *That same old catalog, 1951, showed a 160, a 161, and a 162. What would they have been?*

Vollum: Yes. Those were all little signal sources of one sort or another. They were the same size package as the 122. They were a group of units that you could put in a rack panel and have a variety of signals available. They were predecessors of similar units we made later, the designations of which I cannot remember. In any case, they were modular units.

Castles: *In 1952, the 524. Would that be right?*

Vollum: Yes. The 524 was a TV version of the 511.

Castles: *The 180?*

Vollum: The 180 was a precision timing generator. It was a crystal-controlled oscillator and frequency divider so you could make accurate time measurements. We made those for a long time too.

Castles: *When did the first portable come along, and do you remember the number of the first portable?*

Vollum: Well, I don't know. If you define portable as just being a flat oscilloscope—which might be what you mean—they were all portable.

Castles: *Yes, but the designation portable—could it have been the 315 in 1952?*

Vollum: No. The 315 was an upright conventional unit, just like the rest of them, except it had a three-inch CRT. The 453 was the first so-called portable.⁸

Castles: *But that came considerably afterward.*

Vollum: That's right.

Castles: *Wasn't that the one that was made for IBM?*

Vollum: Well, it was made with them in mind, although it was a general purpose oscilloscope.

Castles: When were the first plug-ins made?

Vollum: The first plug-ins went with the 530 and 540 series. They were the first oscilloscopes that would use plug-ins.

Castles: Do you remember what year that was? 1954 was the catalog year where I saw that. The plug-ins for the 531 and 535.

Vollum: They came out at the same time as the 531 and 535. I assume that is the correct date.⁹

Castles: Do you remember a meter that Cliff Moulton made?

Vollum: Yes. We called it an L-C meter. It measured small inductors and small capacitors. It gave direct readings on its meter. It was a very convenient device. It was made for our own engineering use because we were involved in high-frequency compensation circuits using small inductors and small capacitors. It was widely sold for a long time. It was a unique instrument.¹⁰

Castles: It showed several more plug-in units in 1955, then there was the 310. Was that the one that Frank Hood worked on?

Vollum: The 310 was a little three-inch portable. Small. And, yes, Frank Hood worked on the 310.

Castles: One of these old catalogs showed a 575.¹¹ Was that a curve tracer?

Vollum: Yes. The 575 was a curve tracer. The 310 was the smallest oscilloscope available at that time. It had very ingenious mechanical construction. It unfolded, and it would still work when it was unfolded. You could get at the interior circuitry and could work on it for service. When you closed it up, you couldn't reach any of it. As long as it was unfolded it worked. That was a unique thing. That was the 310. Then there was the 315, 316, and 317. A number of three-inch instruments.

Castles: When did the rackmounts come along?

Vollum: There were rackmount facilities for oscilloscopes fairly early, but they weren't special models. But there was always a demand for oscilloscopes to be mounted in a rack. So we made many of them that were shaped specifically for a rack enclosure.

Castles: What about the 519?

Vollum: That was another state of the art high speed oscilloscope. It was easily the fastest oscilloscope available.

Castles: Yes. Some of the materials say that was the fastest scope.

Vollum: That's right.

Castles: Who worked on that one? Was it Cliff Moulton?

Vollum: I think Cliff was involved with it. Prior to that we had the 517, which Dick Rhiger did. That was the first wide-band oscilloscope. It was easily the widest-band oscilloscope available. The 519 was a successor to that if you observe by the numbers. There wasn't a 518, as I remember.

Castles: What about components for the oscilloscopes? Who made most of the components? In 1949 we produced our own transformers and inductors. Then you made the decision to make our own cathode-ray tubes. When was that?

Vollum: That was just when we moved to Beaverton, I think, because we didn't do any at Hawthorne.

Castles: That would have been in 1951, then?

Vollum: Must have been 1951. We always, from the start, made part of our components. Probably more and more as time went on.

Castles: The 513 series came out in 1952, right?¹²

Vollum: That's about right.

Castles: That would be the first scope to use the linear ramp to develop a sweep?

Vollum: No. I don't think that is right. The 513 was very similar to the 511 in philosophy, except it had a faster sweep and it had a distributed amplifier which we were also using in the 517—I mean we were using a similar type of amplifier in the 517. The 513 was an approximately twenty-megahertz oscilloscope, eighteen or something like that. It was not fundamentally different from the others except for the distributed vertical system.

Castles: How about the 535?

Vollum: The 315 was the first oscilloscope that had a wide-range sweep circuit that Dick Ropiequet designed. Once you could make an oscilloscope that had a sweep circuit that went from a number of seconds to a fraction of a microsecond, you had a scope that had a wider horizontal range sweep than the vertical system, so it was obviously nice to have a plug-in vertical system. The 531 and 535 were developed with that idea in mind, to be able to use a sweep circuit of Ropiequet's design.

Castles: I believe this shows that it was 1954 that the 535 came along. Would that be about right?¹³

Vollum: Well, it must be about right. It would be fairly close to simultaneous with the 531. The 531 was just a 535 without the delayed sweep system. I'm not sure if they came out at exactly the same time, but it was fairly close.

Castles: But it was the 535 that later became the subject for the court of claims case, right?

Vollum: Yes. Most of the circuitry in the 535, on which we had most of those patents, was also in the 315. Of the two models, the 531 was a little simpler and had a little lower price, but was never as popular as the 535.

Castles: When did the 545 come out? Do you recall that?

Vollum: Probably about a year after the 535.¹⁴

Castles: That's been around a long time.

Vollum: Yes. The 545 is just a faster version of the 535. It was a thirty-megahertz scope as compared to a ten. It was a real good example of bringing out something that was ahead of the demand for it. Nobody really expected something of that performance in that size, weight, and price.

Nobody expected something of that performance in that size, weight, and price.

Castles: One of our old timers recently said that in those days the engineers dreamed up instruments the customers didn't even know they needed.

Vollum: That's exactly right. There was a whole succession of instruments like that, and they were very successful. That's what we need to do.

Castles: I've come upon an old name that Marlow Butler told me about. Who was Charlie Jay?

Vollum: Oh, Jay worked for Dick for a long time. I think he was a shop-type guy, making things. I don't remember when he left.

Castles: Do you remember the first camera that came out, and who developed it?

Vollum: Yes. We had a pressing need for a camera, and, I guess Maury Merrick was the guy who was responsible for that.

Castles: An old catalog shows the C-12 in 1960.¹⁵ Do you remember that?

Vollum: Yes.

Castles: When did storage come along? Was it the 564 in 1962?

Vollum: The 564 was a storage version of another scope we had, called the 561. It had two plug-ins, one for the vertical and one for the sweep. The 564 was the same thing, except it had a storage tube in it. The 561 came out in 1958, the 564 in 1962.¹⁶

Castles: What was the first solid-state scope that Tektronix put out?

Vollum: That was one that Oz Svehaug, along with others worked on. It was a plug-in scope with wide-band capability and a rectangular tube. I don't remember what it was.

Castles: Could that have been the 453?

Vollum: No. No. It was earlier than the 453. It was intended as a very rugged scope, probably for the military. It was never a big seller. It was pretty expensive for its performance, but it was a very good oscilloscope.

Castles: *What about the 422?*

Vollum: The 422 was essentially the first of the portables.¹⁷

Castles: *Wasn't that a militarized instrument?*

Vollum: No. The 422 was not militarized. It was a twenty-megahertz scope with a rectangular tube, I believe, older than the 453.¹⁸ I'm not sure whether it would be classified as a portable. I don't know exactly what that means. In Western Electric terms, anything with handles on it is portable—that two or more men could lift.

Castles: *The 453 became the 454—souped up?*

Vollum: That was another model of it. It was a faster version of it, yes.

Castles: *Do you recall the 485?*

Vollum: Yes. The 485 was a 300-350 megahertz scope.¹⁹ It's still in production. And we have no substitute for it. I was talking to Fred Hansen about that the other day. They are still making cheaper scopes, preferring them to newer scopes that have similar electrical characteristics. But it's very bright, very sharp picture.

Castles: *What about the 465? Was that a big winner?*

Vollum: I don't know.

Castles: *One of the pieces of information that I have indicates that the 465 was a big winner, and maybe it was one of the big sellers, in numbers of scopes. The one we have today—what do you think of the 2465?*

Vollum: That's a very good oscilloscope. That's getting closer to the kind of thing—

Engineering Talent

01:41:18

Castles: *Getting now to people that we had at that time. Who would you say were the most gifted engineers, in your opinion, with whom you worked?*

John Kobbe

Vollum: I'd say John Kobbe was a unique person. He had the ability to solve problems in a very direct, basic manner. He was a very sharp guy. Dick Ropiequet was another very sharp guy.

Logan Belleville

Castles: *Comment please on the abilities and contributions of some people early on, Logan Belleville, for example.*

Vollum: Logan designed the 512. He was involved with a number of instruments. He was a very capable engineer. Very methodical. I don't think he was as tuned into people's problems as other engineers were. He tended to do what seemed right to him at the time, and that was often not what other people wanted. But, he was a very good engineer.

Dick Rhiger

Castles: *How about Dick Rhiger?*

Vollum: He designed the 517. That was a terrific job. He was another very competent, very methodical person. He does a very good job on whatever he does.

Dick Ropiequet

Castles: *You have already mentioned Dick Ropiequet.*

Vollum: Yes. He's much more of an original thinker than either of the other two that we have talked about. He came up with really fundamental things which were the basis of patents we received.

Cliff Moulton

Castles: Cliff Moulton.

Vollum: Cliff was another person who was very good, a very ingenious engineer. He solved a lot of problems that didn't even exist. He always did a very thorough job. He was very good at analyzing problems and seeing what should be done. He was very good at finding new solutions to problems.

Bill Polits

Castles: Bill Polits.

Vollum: He did work on a number of Tek instruments. It's very important to think about this. It was Polits who was concerned with development of the non-resonant probe cable. That was a very important development. There was a lot of team activity there. Kobbe and Polits and Ropiequet worked together a lot. It was very hard to tell whose idea was what because they weren't concerned with whose idea it was. They just wanted to get the problem solved.

They weren't concerned with whose idea it was. They just wanted to get the problem solved.

Kobbe-Polits Passive Probe

1:46:00

Castles: I notice in the year 1956 it shows the introduction of the Kobbe-Polits passive probe.

Vollum: Yes. That was one of the most important things we ever did because, prior to that time, there was no practical way to get a high-speed signal into an oscilloscope. If you used an ordinary piece of coax you would get big reflections on the open end. The solution that the 517 used was an active circuit on the input end, so you didn't have an un-terminated cable. That's a very nice electrical solution but it's not very nice from the user's standpoint. The probes, at that

time, had a tube in them. They got pretty warm. The dynamic range was fairly small. You had to put plug-on attenuators on the front end of the probe. You had a big, clumsy thing to work with.

Kobbe and Polits had the idea that if you made the center wire of the coax a resistive wire, the proper resistivity, you could make a probe that was critically damped and all the reflections canceled out. That was what made the 540 series oscilloscopes practical. Without the passive probe, I believe the 540 series would have been impracticable.

In the following years everyone used these instruments without any thought of where it all came from. We had patents on that and maintained them for a long time. We received royalties from that and licensed a couple of companies to make probes we didn't want to make.

Castles: This also shows 1956 as the year of development of the distributed vertical amplifier—Kobbe, Polits.

Vollum: We had distributed amplifiers long before that. The third oscilloscope, the 517 that Dick Rhiger did at Hawthorne, had distributed amplifiers.²⁰

Frank Hood

Castles: Frank Hood has been mentioned a couple of times. What about Frank?

Vollum: Frank was a very good engineer. He was good at packaging oscilloscopes in a nice, compact form. I think the 310 was probably the best example of that. Frank was very handy if you needed any photography done. That was his hobby, which he turned into his business later on.

Jean DeLord

Castles: How about Jean DeLord?

Vollum: Jean was not an engineer. He was involved with research activities. He was an early worker with gallium-arsenide, very early.

Move to Sunset Plant

1:50:23

Castles: When we talked in the first session, you were giving some detail on the production process in the Hawthorne plant. We then went to Sunset. How was the decision made to go to Sunset?

Vollum: We had a five year lease at Seventh & Hawthorne and the lease was about to expire. The ground there was too small to build an adequate building. We had a three-shift operation there at the last. This wasn't the ideal way to do it, so we wanted to find more space. Obviously, we had to move outside of the city in order to do that.

So we looked around and tried to decide which direction to go. It was sort of a choice of deciding whether to go east of the city or west. West seemed more attractive, generally. You had to go a long way east to be where you could get land, and so on. We looked around for a place. One thing we wanted to do was not go so far out that we were out of the Bell system telephone area. At that time West Coast, or whatever it was out there, their service was pretty bad.

We found this property close to Sunset Highway on Barnes Road which seemed to meet all of our needs. As I recall it was about five acres at the start. It had a number of attractions. One of the things we were looking for was a place which could provide a wide variety of living accommodations. Our people were in various modes as far as living requirements were concerned. Some were building their own houses. Some wanted acreage. Some wanted apartments. All of these things were quite close in that area.

Castles: Did you take a survey of the employees in any way at that time?

Vollum: Not a formal survey. But we talked with a lot of people.

Castles: Was Bill Webber with Tektronix at that time?

Vollum: Yes.

Castles: What year would Bill have come?

Vollum: He came while we were still at Hawthorne. It must have been '48. '47, maybe '48.

Castles: Did you know Bill during World War II?

Vollum: Yes. Bill was executive officer at Evans Signal Lab. He was a real easterner. I never expected him to appear in Portland, but he did.

Castles: Who was he with before coming to Tektronix?

Vollum: He was with Westinghouse. He was with Westinghouse before the war and continued with them after the war.

Castles: Who did the planning for the Sunset building? How did you do that?

Vollum: That was the same as Hawthorne. Mel Lofton designed the building on Hawthorne and also did the one at Sunset.

Castles: How much space did you know that you needed there?

Vollum: You mean building floor space?

Castles: Yes.

Vollum: We didn't do any forecasting of what we would need. We thought we built a place large enough for us there on the five acres. Only part of the five acres was buildable. The part that goes up by Barnes Road was fairly steep.

Castles: The reason I asked about space requirements is that shortly after completing the building there, you added on two Quonset huts, on the back.

Vollum: Yes. We needed additional space. We didn't have unlimited money to build everything we wanted.

Castles: Do you remember who you bought the property from there at Sunset? Do you remember Henry Holbock?

Vollum: I remember the name.

Castles: He had a farm next door.

Vollum: Yes.

Castles: Eventually we had to acquire additional space for parking, and we finally got up to something like twelve or fourteen acres.

Vollum: I didn't think it got to be quite that much. Maybe.

Cathode-ray Tubes

1:56:50

If you could make them more sensitive and and brighter, you could make a wider-band oscilloscope.

Castles: Let's get back to the decision on the cathode-ray tube. This says that in 1951 Tektronix decided to produce its own cathode-ray tubes. What led up to that?

Vollum: The cathode-ray tube was the component that really determined the performance of an oscilloscope. If you could make them more sensitive and brighter, you could make a wider-band oscilloscope. There was really only one manufacturer of tubes that were really designed for oscilloscope use. That was Allen B. DuMont Laboratories. We bought tubes from them. But they were a direct competitor in the oscilloscope business. They made some instrument tubes that were quite good. But we had some ideas to make them still better. The only way to do that was to make them ourselves.

Castles: What did we have in the way of quality control for tubes? Was there anything we had to overcome?

Vollum: There was nothing different. If you make a good one, you make a good one.

Castles: Were there hurdles to overcome to make our own

We didn't have very many people who were experienced in making cathode-ray tubes. We didn't have any, as a matter of fact.

Vollum: Well we had to develop a lot of technology. There were a lot of things that we didn't know how to do. We didn't have very many people who were experienced in making tubes. We didn't have any, as a matter of fact. We didn't want to just copy other tubes. Some of the technology was standard vacuum tube technology and was well known. We had to devise ways of doing some things. We had to find sources of supply for parts.

Derrol Pennington

Castles: What was Derrol Pennington's contribution toward the tube?

Vollum: He was the manager of the tube activity. He was a biochemist, not a cathode-ray tube engineer. There were a lot of chemical problems related to tube technology. Lots of problems with coating and cleaning surfaces and things like that. He is a very ingenious guy. He had a lot to do with us making cathode-ray tubes.

Joe Griffith

Castles: How about Joe Griffith?

Vollum: Joe was the first person we hired to make tubes, but he did not work out very well. Joe was a very expert glassblower. And he still is. A very unusually skilled glassblower. But there is a lot more to making tubes than sealing the glass pieces together.

"Dal" Dallas

Castles: What about W.K. Dallas and his contributions to the company?

Vollum: We rented an upstairs office to Dal in the Hawthorne building. He had a manufacturer's representative operation. He became interested in Tek. Then after a while he came with Tek and became sales manager.

Castles: Was there a time when he operated on a commission basis with Tektronix?

Vollum: There might have been. I really don't remember whether he did or not.

Castles: You don't recall whether there was a contract agreement with him, early-on, in the early days?

Vollum: There could have been. There were two classes of representatives. Some acted as distributors. They bought from the manufacturer and sold to the user. Some went strictly on the basis of a commission. We had both, actually, at times. Dal could have well been on a commission.

Profit Share

02:03:50

Castles: When did profit share start with the company? Who came up with that idea, and how did it work?

Vollum: Profit share developed out of a production bonus plan. At first we were producing only one model, then two models and so on. It was pretty easy to keep track of the number of instruments built and shipped. We had a pool, then, that we could proportion to the number of instruments shipped. That worked fine when you had only a few models. The reason we chose that is there was no way the Company could affect that. What your expenses were made no difference. There were so many dollars per instrument.

But after we got several instruments going, it got very complicated to do this. So we thought we should go on some other basis. We talked to people about it and felt it should be something like this production bonus. But they said no. It should be on a profit basis. That's the way the profit share started.

Interview 3 - September 18, 1984

2:05:48

Castles: Howard, this is another one of our sessions where you go back into the early history of Tektronix. I have some more questions I would like to ask you. When and where did you meet Bill Webber?

Bill Webber and others

2:06:01

He was looking for a job, and we had one for him. We were glad to see him.

Vollum: Bill was executive officer at Evans Signal Laboratory. That's where I met him.

Castles: That was during World War II. When did you meet Allen DuMont?

Vollum: I never did meet Allen DuMont.

Castles: Oh, I thought you had some contact with him.

Vollum: We knew a lot of people from there, but I never met him.

Castles: Where was it that you met Bill Hewlett?

Vollum: Hewlett was also a Signal Corps officer. I never got to know him well. He was in the area there at Belmar. I think he was headquartered at Ft. Monmouth.

Castles: Going back to DuMont. Did they have an engineer there named Cristaldi?

Vollum: Yes. Sam Cristaldi was their chief engineer. I saw him usually at shows and we always got together. We had a little deal. We always spent a couple of hours going around the show together. Which always surprised the other people in the instrument business.

Castles: When was it you met Walt Dyke?

Vollum: That was after he came out here. He was at Linfield College. He was at MIT, but I didn't have any contact with him there. I knew some people that he knew there.

Castles: *When did you meet Logan Belleville?*

Vollum: Logan had been around the Portland area as a radio engineer with the Forest Service before the war.

Castles: *Was he ever at MIT?*

Vollum: I don't know.²¹

Castles: *But you met him here in Portland?*

Vollum: Yes.

Castles: *Where was it you met Jack DeWitt? Was Jack DeWitt here when you were first a civilian?*

Vollum: Jack DeWitt was director of Evans Signal Laboratories. He was Bill Webber's boss, among others.

Castles: *You and Bill Webber made a couple of trips together during the early days of Tektronix. Was there a time when you were the engineering branch, so called, of Tektronix? What was the connection with which you and Bill made trips?*

Vollum: We went down to negotiate with HP a time or two. Bill was never involved with engineering. He was always concerned with administration. Bill was working for Westinghouse, and went back to Westinghouse after release from the service. Then he decided to move west and appeared here in Portland.

Castles: *Was Bill Webber with Westinghouse when he moved to Portland?*

Vollum: No. He had left Westinghouse. He was looking for a job, and we had one for him. We were glad to see him.

Castles: *Bill, sometimes, very jokingly refers to his job description when he came to Tektronix "to help Jack" [Murdock].*

Vollum: Yes. I think that sounds good. Yes, sort of as Jack's assistant. There was another fellow, a Portlander, that came from the lab, whom you

may know – John O'Donnell. But he, of course, was a native Portlander.

Castles: *When was it—and where was it—that you met Bob Davis?*

Vollum: He was a friend of Jack, and I didn't meet him until Jack brought him down from Seattle.

Pricing

2:11:51

Castles: *Let's go back to the early days. I'd like to get your philosophy on pricing and service. How were the prices established for Tektronix products?*

Vollum: We were really anxious to get into the market, so we set our price at the lowest we thought would give us a reasonable profit. We have always tried to maintain that. We could have increased the prices substantially. And, we probably would have made more money. But, on the other hand, we just wiped out all the competitors.

Castles: *So, it wasn't just what the market would bear?*

Vollum: No. Not at all. Not at all.

Castles: *More related to cost?*

Vollum: Yes.

Field Engineers

2:13:00

Service was always very important. It was our number one sales tool.

Castles: *What about the philosophy on service?*

Vollum: We tried to do everything we could to keep the instruments that we sold going. It was just a short time after we started that we got field engineers who were capable of servicing all of the equipment that we built at that time. That developed into the field engineering force when

we took over our own distribution. Prior to that the reps like Neely and Burlingame and others were very competent to service the equipment.

Castles: Whose concept was the field engineers? Was that your concept?

Vollum: No. That was Dal's concept. He had been one. He had been a Western Electric field engineer during the war.

The idea of having a technically-able service man there, rather than a salesman, was key. Since we had a limited range of products that were actually serviceable by a user, or any skilled person, they did a lot of the warranty service, and they did a lot of training of the customer's technicians so they could maintain the instruments themselves. It was usually quicker to fix an instrument yourself rather than send it someplace. Service was always very important. It was our number one sales tool. Many customers got to know the Tek field engineer, and trusted him to do a good job for them. Thereafter, they wouldn't even consider another brand.

Distributors

02:15:45

Castles: What about the transition from distributors to field offices? When did that occur and how? What do you have to say about that?

Vollum: We had sort of planned that from the very early days. But we couldn't do it right at the start. That was Dal and Jack Cassidy, I think. Cassidy opened the first field office in New York—took it over from Burlingame Associates, who had sales and service on the east coast. The whole east coast.

Castles: Do you recall who some of those early distributors were?

Vollum: Yes. Norman Neely and Burlingame Associates were the first two. Both of these were HP distributors. Neely knew Burlingame, as they had both been distributors before the war. Dal knew Neely very well. We got these two nearly simultaneously. Everything had been so disrupted that after the war everyone had to start over. In most cases the manufacturer's representatives got their old lines back, and in some cases they took on new ones. Our line was extremely

complementary to HP because HP didn't make any oscilloscopes and we didn't make any signal generators or anything like that. So they were very complementary.

These were very good distributors, which was big advantage to us because they had established relationships with customers, large customers. So, when they brought a new line of instruments around, customers had confidence they wouldn't have had otherwise. Furthermore we knew if they took on our product line they would support it. If we'd had a Tektronix field force at the start you would have a guy going out completely unknown to the customer. We had no reputation. There were a lot of scopes bought on customer confidence in a rep firm they knew.

Castles: Did you foresee a need for oscilloscopes?

The oscilloscope was always the most useful and versatile electronic instrument.

Vollum: Oh yes! The oscilloscope was always the most useful and versatile electronic instrument. I had been involved with them for at least ten years before we started Tek.

Castles: Did you ever perceive that there would be a certain amount of scopes needed by the world, and then there would be no more needed?

Vollum: I suppose you could think about something like that, but the world is pretty big so we didn't worry about fulfilling all of the oscilloscope needs.

Castles: Someone made the comment to me one time that you didn't figure there would be a need for more than, maybe, three hundred of these. Do you recall anything like that?

Vollum: I don't think we ever made any estimates like that. The electronics business was evolving very rapidly. There wasn't really very much before the war. There were only the radio broadcast stations, some recording business and the telephone company.

There was a different market after the war than before.

After the war things were very different because lots of people had spent four or five years working on non-voice-related equipment such as radar and all of its variations. All this involved generating and maintaining fairly precise waveforms. That's where you needed an oscilloscope. So, there was a different market after the war than before. Television was just starting and was probably the number one item.

Castles: There was no digital then?

Vollum: No. There was no digital. Digital is not very old. RCA was the major force behind television, but there were dozens of television manufacturers. Everyone who had manufactured radios started into manufacturing televisions. That was a real big push. Everyone was interested in having a television. Television was somewhat more advanced in Europe than it was in the U.S. It had been there longer. But the U.S. got started in a big way. That created *the* really major new industry.

Marketing

02:22:58

Castles: Tell us about going to shows. What was that like in the early days?

Vollum: That was a most important activity. At first there was just a single show in New York. The Institute of Radio Engineers show. That was in March of each year. Virtually the entire electronics industry would be there. It was a big show. The users, the engineers, the buyers would come to the show to see what was new. You got to talk to them and learn what they needed and wanted and what their opinions were of existing products. It was a very important thing.

We always had new things at the show. That was one of the key things. We always had big crowds because we had new things to show that were very attractive. Also, we had very knowledgeable people to talk with visitors. The field reps would

be there, but we would have our own engineers there too.

Castles: How about DuMont at the shows?

Vollum: They had a somewhat similar operation to ours. They were also handled, I believe, by a rep. I think it was about the same.

Castles: What would you have to say about Hewlett-Packard?

Vollum: They were big at the shows too. As I said, Tek and HP were not competitive in the least. A lot of the reps were common with Neely and Burlingame. Often times the same rep would be at our booth showing off Tek equipment, then at another time be at the HP booth showing off their equipment.

Castles: What kind of a role did you play in the advertising policy of Tektronix?

Vollum: Our first advertisements were very simple. A picture of whatever we were advertising and its technical specifications and, maybe, a very brief statement about it. They were usually a single page ad, black and white. We consistently had the highest readership in the magazines. I don't think it was because the advertisements were particularly good, it was just that they told an interesting story about a product that customers wanted to know about, wanted to buy. For that reason we got stacks of plaques for the best readership in the magazines. I think we won awards for twenty or thirty months consecutively – something like that.

Castles: Did you personally take an active role?

Vollum: Yes. We didn't ever turn an ad over to an agency or anything like that. The agency usually had some sketches about the arrangement of it. We wrote the text and put in the materials. I was involved with every one of the ads for a long, long time.

Company Growth

2:28:03

There's always a demand for instruments that are faster, brighter, and better generally. That is what we tried to do, as fast as we could.

Castles: We have been talking about things that are in the forties and in the fifties. Wasn't Tektronix' fastest growth in the fifties?

Vollum: That depends on how you look at growth. The fastest growth you have is at the start. You go from zero to one. You will never again make such a big step as that.

Castles: What were some of the consequences of fast growth?

Vollum: We were always behind in production at that time. We were selling more than we could produce. I don't know about any special effects. Our philosophy has always been to make things that are attractive to customers, attractive enough that they would buy them. Then, manufacture the products for them. It wasn't until what I would call recently that we had such a thing as a profit plan or anything of that nature. We just did the best that we could. And that was usually fairly good.

Castles: Where would you put need in there? Need for the instrumentation.

Vollum: What do you mean?

Castles: I'm trying to draw a distinction between whether the growth was attributable to customer need for the products, or was it because Tek brought out new products showing customer the need for the instruments.

Vollum: All of the things we made were to meet needs that were pretty obvious. There wasn't much of a problem in the relationship there. All of our customers needed good instrumentation and

there were lots of new people going into electronics, and electronics was going into fields that it had never been in before. There's always a demand for instruments that are faster, brighter, and better generally. That is what we tried to do, just as fast as we could.

Castles: Would you say that the growth was technology driven, or was it market driven?

Vollum: It was technology driven.

Castles: How did you and Jack personally feel about the fast growth of Tektronix in the fifties? What type of planning did you do for that kind of growth?

Vollum: We tried to get people who were rather broad and very able in a lot of fields. We never did plan for X-percent growth for the next year or anything like that. We took whatever came, and it usually came because we had things people wanted to buy. I still think that's the best philosophy. Otherwise is not a very good way to do it.

Castles: Were there any kind of stresses that grew out of this growth?

Vollum: No. I don't think so. Some people called us about why they were not getting delivery of their scopes. We once got an anniversary card from a guy who had his order in for a year. He sent us a first anniversary card. We didn't like that very much.

Patents and Licensing

2:33:00

Castles: What about the patent philosophy of Tektronix? What did you feel about the patent policy in those early days?

Vollum: In the early days we didn't particularly worry about patents, one way or the other. We just tried to do the best thing we could. We weren't a very big factor in the industry. It wasn't until later that people got to bothering us. It was very hard then, as it is today, to know whether somebody is using your patent, or whether you are using the other guy's patent. Usually a patent doesn't involve a complete device, just some part of it. There wasn't very much effort to create positions.

RCA had a strong patent licensing activity because the RCA labs were set up to develop circuits mostly for the radio and TV business, and then to license them. That is what provided the income for the lab. They were always anxious to get on with that. They didn't worry too much about us, because we were not competing for their customers. We were providing products which helped their customers as well as ours, hence made more money for them. So they didn't really try very hard.

Castles: Were you worried about others copying our products?

Vollum: No, not particularly. We always had another one not too far away. There wasn't very much of that happening anyway.

Castles: What about Western Electric?

Vollum: Western Electric had a patent licensing thing. Their patent customers were somewhat different than RCA's. They did it more as a defensive, protective device. The only time we got in a problem with them was when somebody that was paying royalties on something we were using complained to them that we should be paying royalties too. That it was unfair. We were not directly competing with them usually. They used to come around once a year, maybe more often. It was a long time before we ever took a license from them. It never did amount to very much.

Castles: You did take a license from RCA, though, didn't you?

Vollum: Yes. We took a license from RCA. I don't remember when. The people they dealt with produced large numbers of things. Their licenses per use were usually very small. We didn't make very many things so it wasn't a big thing with us.

Castles: Do you recall the percentage? Wasn't it around one percent?

Vollum: Yes. It was in the order of one percent. It was quite small.

Castles: Whereas Western Electric had a much higher rate.

Vollum: Yes, they had a higher rate.

Castles: Early on I remember when patents first came up. What was that Isbister patent? Was that Sperry Gyroscope?

Vollum: Yes, that was Sperry. That was a fairly basic patent that concerned delaying a signal. Generating a trigger, and then delaying the view of the signal so as to get a view of it. We did that. It was a pretty fundamental part of our scopes. We didn't get the idea from the Isbister patent or anything like that. It was an entirely different idea, but they did have a patent. It was a wartime patent. Bill Webber did a lot of negotiating with them, ending in our having to get a license with them. It didn't last very long.

Castles: What was Tektronix first instrument for which we got a patent? Was it the 535?

Vollum: No. The patents which were important to us were the ones that Dick Ropiequet, John Kobbe, and others developed. They were first used in a low-frequency scope, the 315. Then the 530 series came from that. They used the same circuit.

Castles: Do you recall who got the first patent for us?

Vollum: Yes. I don't recall his name. He was not a patent attorney. He was a patent agent.

Castles: Olie Olson?

Vollum: Yes.

Castles: Those patents we got in the early days were the ones we went after the government for, weren't they?

Vollum: Yes. We got more interested in taking out patents when the pressure from RCA, Western Electric, and others increased. Western Electric was not terribly interested in collecting money. They were more interested in avoiding complaints from people from whom they were collecting a lot of money, even though you used it for a totally different purpose. A lot of Western Electric's patents were very broad. Many of their patents we used were never intended for such a use, but were still covered by their claim. We were looking more for getting trading stock with them because Western Electric, in particular, would make you a very good deal if you had any patents you would cross-license with them.

Castles: Did they have the original patents on the transistor?

Vollum: Yes. But that was never a problem as far as I know.

Court of Claims Case

02:41:22

We never objected to fair competition.

Castles: Why was the government so intent on copying?

Vollum: They wanted the particular oscilloscopes that we had. They had sort of standardized on them. There was always pressure within government to put procurement out for bid so they could buy from the lowest bidder. If other suppliers wanted to compete, they essentially had to copy because the government would not accept anything else.

Castles: That eventually led to the Court of Claims case?

Vollum: Yes. That eventually did.

Castles: What are the benefits Tektronix derived from the Court of Claims case?

Vollum: Outside of the cash settlement, I don't think we derived anything from the Court of Claims case.

Castles: Sometimes it is stated that Tektronix got more dollars by stopping the government from copying than we did from the final judgment. How do you react to that?

Vollum: Yes. I'm sure that is true. That was certainly one of the objectives of the suit, to stop the competition. We never objected to fair competition. But when we spent the money that we did on the development of unique circuits, to have them copied by competing suppliers gave them a significant cost advantage, so they could sell their product cheaper. They were precise copies. They didn't vary at all. As a matter of fact,

you couldn't tell the difference by looking directly at them.

Castles: I recall that the specification on the bid was to manufacture a Tektronix 535 oscilloscope. In order to do that you had to copy our product.

Vollum: Yes, right.

Castles: What about the sympathy of the government agencies toward us?

Vollum: I don't know about sympathy. We tried to treat the purchasers of these copied instruments as if they were Tektronix instruments because they were buying Tektronix instruments too. The copying was only on a couple of models. Two models, I guess. So, we tried to take care of the customers. We never refused to help them maintain anything. I think we maintained a very good relationship with the customers at that time.

Castles: It seems to me that sympathy of the using agencies was with us. The problem was the Justice Department. Weren't they the pushers, then?

Vollum: Yes. They were up to the same old thing they have always been up to.

Hewlett-Packard: Cross-Licensing Agreement

02:44:54

Castles: What was your philosophy regarding the cross-licensing with Hewlett-Packard?

Vollum: We knew that when we put in our own series of field offices in the west, Neely wouldn't have an oscilloscope line. With most reps, oscilloscopes were about one third of their business. So, it was a major thing for them to lose. We knew then that Neely would pressure HP to build an oscilloscope, and that would fit in well with all the other HP reps, as they had all lost their oscilloscope line one at the time as we took over their areas. So, we knew that we would set up HP as a competitor. However, we didn't know what they would make.

As it turned out their first scope had the same basic circuits that ours had. We weren't very happy about that. We hadn't expected that. In some ways we were pleased by that because we

thought they might come up with something radically better, which they didn't.

So Bill Webber and I went down and talked with Dave [Packard] and Bill [Hewlett] about that. We asked them "Why did you do this?" They said, "We really tried our best to get around these, but there is just no way that we could see." So they made them. They were not particularly unwilling to pay something for that. We felt they would be making some new inventions that would be useful to us, and neither of us wanted to get involved in engineering around something—that would not be productive. So we reached an agreement.

We could use any of their designs and they could use ours.

We received \$65,000.00 and a cross-licensing agreement. We could use any of their designs and they could use any of ours. They were already using ours, and there was no way you could stop them.

Castles: Was that for a particular period of time? Five years maybe?

Vollum: I think it was for five years, yes.

Castles: Then it was renewed once?

Vollum: Yes, I think so.

Castles: Whose decision was it to go with Bob Davis?

Vollum: What do you mean—go with him?

Castles: When he was made general manager back in the late fifties. Was that Jack's decision?

Vollum: No. That was mine.

Castles: Who do you remember among the old timers that you would like to comment on?

Vollum: I can't remember any we haven't talked about. Do you have any suggestions?

Castles: You have mentioned the contributions of John Kobbe. Do you think that the patents John contributed to the company were important?

Vollum: The patents were important, but more than that, his genius in developing other circuits and instruments and just engineering generally.

Castles: What were Dick Rhiger's contributions to the company?

Vollum: Rhiger developed the 517 which we sold for many years as the world's fastest oscilloscope. He had been a broadcast engineer with KGW. The last job he did before coming to Tek was to build KGW-FM, which was later discontinued. But it was the first FM station on the air. It was really a tight race between them and Stan George, who was Dal's very good friend at KOAP.

Glenn McDowell

2:51:51

Castles: Tell us about Glenn McDowell.

Vollum: Glenn was Jack's neighbor and Jack's friend. We welcomed him because we needed an accountant to head that department. At the time, he was an accountant working for Standard Oil Company. He left and joined us as one of the early members of the group.

Castles: How soon after we started Tektronix did you put together Hawthorne Electronics?

Vollum: As soon as we moved into the building at Seventh and Hawthorne. We wanted something that would have some fairly immediate income because we knew the manufacturing business wouldn't have any income for a year or two. We had a nice location there at Seventh and Hawthorne with a certain amount of walk-by traffic. It was in a commercial district so we thought we may as well use it for that. Jack had the connections with the radio lines Zenith, GE, and so on. We knew all the Portland radio jobbers, so it was easy to set up the business. Glenn sort of got active in that. When we needed the space, they moved to a building that was right on the corner of Seventh and Hawthorne that belonged to Byron Broms' father. So Hawthorne represented us in this area for a while. We finally made a deal with Glenn to take over that store for his interest in Tek.

Castles: Glenn was one of the founders of Tektronix.

Vollum: Yes. I don't know how you define founders. He was one of the early ones. He was as early as anyone because he was not in the military so he was around here all of the time.

The video ends here.

¹ Radio Specialty Mfg. Co., 2023 S.E. Sixth Avenue, Portland 14, Oregon.

² A.H. Grebe Co., Inc., Richmond Hill, N.Y.

³ Captain George Vancouver RN (22 June 1757-10 May 1798) was an English officer of the British Royal Navy. He is best known for his 1791-1795 expedition that explored and charted North America's northwestern Pacific Coast regions, including the coasts of contemporary Alaska, British Columbia, Washington, and Oregon. He also explored the Hawaiian Islands and the southwest coast of Australia.

⁴ "Megacycle" was a term used for millions of cycles per second. The term "megahertz" became universally used in the 1970s.

⁵ Camp Evans, New Jersey, is a former military base associated with Fort Monmouth. It is located in Wall Township, although it is often said to be located in Belmar (its postal zip code is Belmar's, although it lies outside the borough). The property overlooks the Shark River.

⁶ According to the 1937 and 1944 editions of the *Portland City Directory*, the Vollum family lived at 1115 S.E. Lambert in Sellwood.

⁷ The first Tektronix catalog showing the 104 indicates that it has four frequencies: 50 cycles, 1 kc, 100 kc, 1 mc.

⁸ Later in the interview, Vollum refers to the 422 as the first portable. The term is a loose one.

⁹ The August 1953 short form catalog for the Wescon trade show first introduced plug-ins and the 535 oscilloscope. The 531 was not mentioned. The first plug-ins were the 53A, 53C, and 53D.

¹⁰ The "Type 130 L, C Meter" was introduced in the August 1954 catalog.

¹¹ The March 1955 catalog introduced the "Type 570 Characteristic-Curve Tracer," which "pictures dynamic vacuum-tube characteristics." The 575 was a similar instrument designed for viewing transistor characteristics and was introduced in the March 1957 catalog.

¹² The 513D, with delay line, and the 513 without delay line both appeared in an October 1950 catalog.

¹³ The August 1953 short form catalog for the Wescon trade show first introduced plug-ins and the 535 oscilloscope. The 531 was not mentioned. The first plug-ins were the 53A, 53C, and 53D.

¹⁴ The first catalog to contain the 545 was dated March 1955. The 541 was introduced simultaneously. Also introduced specifically for the 540 series was the Type K plug-in. Thus, it was 19 months between the 535 and 545 introductions.

¹⁵ The C-12 first appears in the June 1961 catalog.

¹⁶ The 560 and 561 first appeared in the June 1961 catalog. The 564 first appeared in the June 1963 catalog.

¹⁷ There were many oscilloscopes before the 422 that Tektronix called "portable" and pictured in outdoor environments. For example, in 1953 the 310A, 4 MHz, weighed 23 lbs., and in 1959 the 317, 10 MHz, weighed 33-1/4 lbs. They all required an AC power supply, were heavier than the 422, and were single-trace

instruments. The 422 was battery operable, but so was the older 321.

¹⁸ The 422 was a 15-MHz oscilloscope.

¹⁹ The 485 was 350 MHz with a 50-ohm input impedance. The input could be switched to 1 megohm input impedance with a bandwidth of 250 MHz.

²⁰ The basic idea of a distributed amplifier was disclosed in a British patent in July 1936. The term "distributed amplification" was coined for the title of a paper by Ginzton, Hewlett, Jasbert, and Noe in the August 1948 *Proceedings of the IRE*. Author Hewlett was the co-founder of Hewlett-Packard. The paper also discussed T coils, later used by Tektronix more famously than anyone else.

²¹ According to Holly Black Belleville, Logan--who was president of the local IRE chapter while working at the Forest Service Lab--went to MIT with two or three other people and stayed for the duration of WWII.