SUCCSESSES

A PREQUEL TO “FAILURES”

By Tom Caauwe, April, 2019







Of course, my greatest successes were fathering three fine sons which resulted in seven grandsons, one granddaughter and, so far, five **Great** granddaughters. But the following is of other lesser successes:

Through the years my work was seldom recognized. I know what I did so I will blow my own horn a bit.

All my life I always wanted to invent things. The following describes some of these whether they be original or just a better application of things already invented. Sometimes they were done to fit the application better by making better trade-offs.

I think God gave me a gift to troubleshoot problems. Some of the following are successes in troubleshooting. Seldom did I fire up a new design that immediately worked, but I always seemed to be able to troubleshoot it and find out what was wrong and correct it.

The dates given were taken from my Engineering notebooks for about the first 25 years when I worked in the Film Division. The last ten years I worked in the Test Lab but I don't have those books. I usually just used the date a project was first mentioned in the books. I had to guess at some of the dates, but I think I have everything in chronological order.

Education

I did take a lot of science courses in High School and the one year of college. I was always surprised to find I was able to put these to use in my work. Even biology and the higher math was useful. Of course, working on guns with my Dad was also helpful.

The electronic knowledge was from the Ground Radio School I had at Scott Air Force Base east of St Louis that I went to through with Air National Guard. A 36 week course that was the best electronic school they had. Six hours of class each day where I took many notes and then studied them two hours each night. I graduated in the top ten percent of the class. They said the education was equivalent of a four year degree, but I didn't believe them until I was hiring EEs just out of college and found they had less training than myself. Somehow the Lord enabled me to remember and apply what I learned.

I also went back to college for night classes a number of times. Electronics was advancing so fast that a person had to do that. In Air Force school they had heard of transistors but said they would never amount to much.

1945 ? Automobile Headlight Glare Reduction

Before I grew up and started at Dale Products, I had one idea that although it was never adopted, I always thought it may be in the future. I thought all car windshield and headlights should be polarized about 30 degrees to the right. This would allow you to see your own light just fine but would cut the light from oncoming cars with headlights also polarized 30 deg to the right by quite a bit. Idea rejected on the grounds of cost.

Others have probably thought of this too.

It may be that the new LED headlights are directional enough that this idea will no longer be valid.

3/1961 Minuteman Missile Resistor Load Life

Soon after I started at Dale Products (Later Dale Electronics and then Vishay.) I was given the task of drawing up the load life trays used to test resistors for Minuteman Missile resistors in the Load Life ovens we were building. This was my very small contribution to the space program although our film resistors were used in future space exploration. I had made a number of contributions to the design and production of those resistors.

How Film Resistors are Manufactured

Our original carbon film resistors were made by placing small ceramic rods and sand in an offset quartz bottle that was run into a furnace, tumbled and heated to about 800 deg. C. It was purged with nitrogen and then methane gas (later natural gas) was introduced. The gas produced carbon like an acetylene torch gives off when lit without oxygen. This deposits a resistive carbon film on the cores.

Metal Film resistors are made by evaporating (in a vacuum) nichrome metal that condenses onto ceramic cores that are tumbling in a drum.

Tin oxide film resistors are produced by spraying hot ceramic cores with a tin chloride solution which forms a resistive tin oxide layer on the core.

In all cases, the resistance layer on the cores produces a range of low resistance that varies from one core to the next.

Usually a more conductive end band is placed on each end of the core. Then the cores are sorted to value, then cap and leads are placed on them.

To cover the entire resistance range, a spiral cut is made around the body of the resistor. The current must then take a longer and narrower path than it had than by just going from end band to end band. This spiraling can be done at different pitches to reach the desired value. It can also be stopped accurately when the target resistance value is reached.

In the case of the carbon resistors and the metal film precision (**.**1% tolerance) resistors, the cut was stopped low of value and rubbed up with a little grit on a cloth covered stick.

The parts were then either painted with silicone paint, coated with liquid epoxy or molded in epoxy.

Printing or color-banding was then applied to mark the resistance value, and parts packaged bulk, card pack or reel packed.

In all of the above there were exceptions and alternate processes.

4/1961 Tube oven for Tin Oxide production Book 1, Page 7

To produce the tin oxide resistors, it was decided to run ¼" X 12" ceramic rods thru an 850 deg C tube furnace and spray them with a tin chloride solution as they emerged which would form tin oxide on the surface. The rods could then be scored and broke into pieces for further processing.

I initially wrapped a ½" ID ceramic tube with nichrome heating element wire and placed it in an eight-inch irrigation pipe filled with fire brick and exploded mica insulation. I made two sets of unfired lava rollers. One set of rollers to feed the parts in and the other set of rollers to pick them up after they were sprayed.

The first furnace broke on first use. So, I made the second one of fused quartz. That worked but the project died because of patent problems.

I'm sure others have built tube ovens, but I did have to design this one from scratch. The formula for calculating the type and size of nichrome heater wire was quite lengthy.

6/1961 Tunnel Oven Temperature Control Book 1, Page 27

When Dale Rogers needed a cure oven to develop the epoxy coating on film resistors, he got one from the Wirewound division. It was a high temperature 208V tunnel oven and would not control well at the lower temperature he needed. I did some testing on it and found that by dropping the voltage back to 110V would be too much.

The best solution turned out to be a couple of 300W lightbulbs in series with each element. That resulted in the heating elements to be on about half of the time which is the best way to control temperature with on-off controllers.

Use of light bulbs to limit current may have been used by others.

3/1962 Tin Oxide Frypan

While working on the tin oxide project I coated the bottom of a Pyrex baking dish with tin oxide and made a "Frypan" out of it, but the company was not interested. But it did work! The tin oxide formed an even heating element, eliminating the usual hot spots that conventional elements produce.

I believe Corning Glass also made one of these so it's not original.

12/1963 Spiral-To-Value Kickout Book 3, Page 1

My first major assignment was to develop a good method of mass-producing tin oxide resistors. Because the film was hard it could not be spiraled to just below value and rubbed up like the carbon and metal film resistors so, I had to develop a "Spiral to Value" controller. (Later known as a "Kickout")

To do this I used an AC type comparison bridge ("Bridges" measure resistance) and amplified its output to drive a solenoid to knock the resistor carriage away from the grinding wheel. This device went through a number of modifications for use on a number of different spiral machines. Each machine in sequence had to be faster and more accurate.

The output of the bridge looked like a full wave rectifier output that was collapsing as the resistor came to value. I then used a thyratron tube and gated the screen grid with a full wave bridge voltage shifted 45 degrees.

At one point I changed the bridging voltage from 60 Hz. to 400 Hz. to enable the testing to occur 800 times per second instead of 120. (Tested every half cycle)

Previous kickouts just used a meter relay. (Kickout value -5% to 0%)

AC bridges were commonly used because ac amplifiers were stable, but dc amps were not. Later a stable form of dc amplifier became available known as a "operational amplifier". At that time, I started to use "op-amp" DC bridges and eventually added "Autopitch/Calibration Cut". Discussion on these later.

1963 ? Tin Oxide on a Beryllium Oxide Substrate.

I deposited some tin oxide on some beryllium oxide washers that I was given. Beryllium oxide is a ceramic that has high heat conduction similar to aluminum. I mounted one on a chassis used to test housed Wirewound resistors and ran the power up as high as I thought I dare. The chassis became so hot that the lab manager burned his fingers when he tried to pick the chassis up.

Since Beryllium oxide dust is quite poisonous, no further work was done with it.

1964 ? Evaporation Area

For most of my time in the Film Division, I was either assigned to the evaporation area or had full engineering responsibility for it. And I also had other hats as well. Electronic design of production equipment was primary, but the processes up and down the line was often my job too. At one time I rewrote all of the process specifications all the way down the line.

The major goals at evaporation were to increase output, hit the required resistance values and obtain as many of the low “Resistance Temperature Coefficients, (“RTC” or just “TC” with category “T-9” as best.) as were being sold. We also needed the parts to hold up under Mil-Spec testing in the Test Lab.

The road to these goals was long and slow going.

The volume was greatly increased when Ben Detrick changed us from loading the parts on a “Ferris Wheel” to placing bulk cores in a tumble drum.

The value problem was improved by insulating the side of the drum and measuring the resistance from the side to the rest of the drum while they tumbled. Also, this was improved by the evaporator controller and a computer to calculate the run set up.

The TC problem was most improved by mixing two types of the nichrome wire we used to evaporate onto the parts. (“R” and “S” wire is mentioned in a later write up.)

Many things were done by myself and the other engineers I had working for me in the evaporation area. (Dennis Miller, Morey Enquest, Dave Clark and Jim Wilson)

6/1965 B. Conrad Spiraler Book 4, Page 32

Byron Conrad was a machinist that had his own room in the machine shop, downtown at Plant 1. He only reported to the company president and would only take on jobs he wanted to. Also, once a machine he built was moved to the production area, he would not have anything more to do with it. To add to those limitations, he never produced any drawings of what he built and did not supply any schematics of how he wired the controls for the machines.

He built three automatic spiralers for the film division and I was tasked with qualifying these before moving them to production. One major problem was his use of old worn out transmissions that caused a wavy spiral. I refused to accept the machines until he finally agreed to put new transmissions in.

After we had them running, we wanted to build more, but did not want to take the machines out of production while we disassembled, measured them and made drawings. So, one night a machine was disassembled and the parts were given to about five different draftsmen. But since they each measured the holes, etc. from different points, nothing worked.

Another problem was his control system. He used latching relays and placed half of the relays on one side of the machine and the other half on the other side. He then made up a wire bundle (all white wires), tied them firmly together and ran them thru a piece of conduit. This made it impossible to trace the wiring and we had to disconnect all of the wires to make up a schematic.

About the only success I had on these was to get them working but they caused us a lot of grief for the couple of years that they ran as evidenced by the numerus notations in my notebooks. That I was able to get my “Kickout” to work on his machine was a challenge and a success.

3/1966 Hydraulic Spiralers Book 6, Page 95

After I worked about a year at Dale, a downturn in business caused me to be transferred to the Test Lab for a while. In the meantime, Jerry Bottenfield designed and built an automatic spiraler operated by hydraulics. Dr Hyde from UNL worked for Dale Electronics that summer designing a new kickout using op-amps. A technician wired the kickout and machine. Both the technician and Dr Hyde then left and never turned

any of it on. I was then transferred back to the Film Division and tasked with getting the whole thing working.

I had to learn about op-amps, troubleshoot the kickout design, the machine wiring and work out the timing of the cam switches. Also help with the mechanical debug.

After studying up on Operational Amplifiers, I modified some of the op-amp design and checked the machine wiring which was mostly good. The greatest problem with the machine wiring was the signal ground from the part being spiraled was returned on the frame (a poor conductor) along with the higher current devices such as the hydraulic solenoids. This formed a ground loop and the solenoid current interfered with the signal going to the kickout bridge. I solved the problem by supplying the kickout its own ground. I have run into ground loop problems a number of times during my work at Dale and have always had problems getting others to understand ground loops. They usually just want to put in larger common wires instead of supplying independent commons.

However, the greatest problems with the hydraulic spiralers was that the speed of the hydraulic actuators changed as the hydraulic oil warmed up and made the timing impossible to maintain. There was also the fiasco of the oil line breaking and dumping 5 gal. of oil on the floor overnight. Two machines were built but none were successfully run.

The education I got on op-amps did make it all worthwhile. I designed quite a few pieces of equipment around them.

4/1966 Resistor White Spots Book 7, Page 12

For some time, we were plagued by small white spots showing up on the large 2 W resistors. (1/4" X 2" rod substrate) and the 1 W (1/4 X 1" rod substrate) When the spiral ran into a spot the part would go high and be scrap. We were blaming the ceramic maker but then I noticed the same thing on the smaller parts. There were a smaller number of bad parts but about the same number of spots per evaporation lot. After some investigation I decided it was due to a technician that worked in the evaporation area and did the fire cleaning of the substrates. He was producing small droplets of saliva when he talked, and these were landing on the already cleaned parts and causing the problem. I had to diplomatically ask him not to talk over our parts and when the parts cooled to put a cover over them. No problems after that.

Just good trouble shooting.

8/1967 Sorters B 8, P 50 & B 15, P 52

Originally, we had to sort all of the blanks coming out of the carbon furnaces or the metal film evaporators to 8% increments. That way, once the pitch of the spiral was set, the spiral length would only vary 8%.

The first methods were of course to sort manually with a comparison bridge with its meter calibrated to the required values. I later modified a Little Brown Bridge to do the same.

Then the Mechanical Engineering section designed a handler that would move one part at a time on a wheel to a test station and then drop in down a chute that passed 15 different flapper doors that could open to divert the part into different bins.

I then attached the electronics to measure the part and energize the correct rotary solenoid to open the correct flapper door.

About six of these machines were built and used for quite a while. However, they were used much less and some of them scrapped when the spiralers started to have Autopitch installed so most of the sorting was no longer necessary. (Autopitch covered later.)

1968 ? Dancing Christmas lights

When we moved to Woodland Park, a $50 reward was offered for the best Christmas lighting. I designed and built a “Black Box” that I could run music to, and it would drive sets of lights, depending on the range of notes. I connected it so high notes turned on blue lights, middle notes turned on yellow lights and the low notes turned on red lights. These were shined on a Christmas bouquet of silver dried weeds in front of a six foot cut out of a sparkly deer. Won first prize.

Later on, a small commercial light box came on the market that did the same thing, so I guess it was a good idea.

1969 ? Welwyn Spiraler

We bought a company in London Ontario that also produced metal film resistors and we were setting them up with some of our resistor production machines. In one case we gave them the drawings for a “Walking Beam” spiraler, the latest at the time. I had the electronics for it built and tested on one of our machines and then sent it up to them. They could not get the machine to run, so I was sent up there for a week to see if I could figure it out. It took a few days, but I discovered the motor was running backwards. Changed two wires around and it all worked great.

2/1969 Production Increase, 1/10 W For $.5 million Book 10, Page 64

I met with the Engineering Manager and the Mechanical Engineering boss one Saturday morning to try to come up with the new equipment that was going to be needed to handle the expected sales increase the next year of tenth watt resistors.

We were having a problem figuring out what we needed because the parts split between different machines as they proceeded down the lines depending on E-Rel vs Standard, Cap only vs Cap & Lead, Sorted vs No Sort, Roll Coat vs Mold, Small Order vs Large Order, Wattage size Etc.

I finally said we needed to plot all of the machines on a chart, showing each machines capability and capacity. Then add the equipment needed for the additional load. The Engineering manager said that it was a good idea and I should have it ready the following Monday!

I did and showed the new machines that would have to be built. But then I was told I was in charge of having the new equipment built! That meant dealing with our own machine shop, finding outside machine shops, getting the electronics built by my own technicians and finding outside builders and well as ordering the materials and many parts.

I knew our own machine shop had a bad habit of building bad parts and then charging us again to make new ones. The shop manager almost came across the table and hit me at one point when I said I wanted to farm out more of the work for that reason.

I was also assigned a number of machinists to assemble the machines. Some of the equipment was available for purchase which I also handled.

All of this in addition to my normal responsibilities of the Evaporation Area and the Electronics Area. (Plus, numerus troubleshooting assignments on the lines.)

Cost of the project was $.5 million. (In 1969 dollars.)

6/1969 Little Brown Bridge Book 11, Page 9

We had been using AC comparison bridges for testing parts on the lines. These used electron tubes and were limited in range. They also needed a lot of maintenance as the tubes failed as conditions changed and they needed adjustments to keep them accurate. (Power blinks usually knocked out several bridges every time.) Cost for these bridges was about $750 each.

To replace them I designed a hybrid Wheatstone/Kelvin bridge with an op-amp that had a low power requirement that could be operated from batteries. I used a thumbwheel decade and an extruded aluminum case. The design allowed battery power (1 yr. life) and a test range of 1 ohm to 100 megohm. This was a great improvement over the AC comparison bridges which could only cover the range of 500 ohms to 1 megohm. The cost was just $138 each. At one point we built 70 at one time to increase our production. Several hundred were eventually built. Being totally portable was a great advantage.

Wirewound decided to build some for their lines. I told them not to use Wirewound resistors for the decades because soldering them in required higher temperature that would ruin the switches. They used wirewond resistors anyway and never got the bridges to work. I was able to get the bridges from them, replace the decades and put them to good use.

They did need some maintenance each year and with so many in use, the maintenance department was complaining. I checked into it and found no one was really trained to fix them and often were doing the wrong thing. So, I wrote up a procedure for them and a new hire fixed about six of them in one morning with no further assistance.

I also built a couple of “Super bridges” that were .02% accurate (vs .1% accurate for the Little Brown Bridges) by using some concentric dial decades from ESI. QC used these for checking the Little Brown Bridges.

I also built a “Power Bridge” where we could greatly increase the power to the resistor under test. This was also a modified LBB.

This is a case of making the best trade-offs in order to cover the required range with .1% accuracy and make it a portable device at the lowest cost. Hybridizing a Wheatstone bridge with a Kelvin bridge is probably unique.

Still another modification was required in the Test Lab to measure the water being supplied to the Moisture Chambers. The water had to measure less than 1 megohm between a couple of standard electrodes. They had been using a Leeds & Northrup DC bridge, but that caused the water to break into hydrogen and oxygen that formed bubbles on the test electrodes and therefore the reading would rapidly increase as they were testing. I modified a Little Brown Bridge to be an AC bridge and the problem was solved.

6/1969 Resistance Temperature Coefficient Tester Book 11, Page 27

We had been sample TC testing each batch of resistors in oil one at a time by hand. This was not always accurate, was labor intensive and time consuming. So, the mechanical engineers designed a system to handle the parts by feeding them down a

riffle chute, through an initial test station, drop them on a chain that went through an oven and then test them again before leaving the oven. This avoided heating and cooling the resistor carrier, (the chain in this case) and the parts came to temperature quickly.)

We had no computers at that time nor digital ohmmeters. So, I read the parts on a DC bridge and stored the deviation output as a voltage on a capacitor. The part was read again at the hot end and compared to the first reading stored on the capacitor. The difference was the Temperate Coefficient. This was fed to a printer that converted DC voltage to numbers.

A chain connected to the oven drive chain drug a set of magnets along the top of some small printed circuit cards. Reed switches on the edge of the cards connected the bridge output to the capacitors. The magnets picked the right reed switches at the right time. One capacitor on each card stored the initial reading and another was charged to the same voltage and used to "guard" the voltage from leaking off the other capacitor. I don't know of other circuits using this method.

Later this system was converted to use an IBM System 7 "mini" computer. (About 2 ft sq. and 4 ft high.) To "boot" this computer you had to set a row of dials and push a switch a number of times so the computer would read the program off a cassette tape.

Still later another TC tester was built using a large wheel in an oven to heat the resistors for a high temperature test, a chain for room temperature test and a wheel in a cold chamber for low temperature test. A digital ohmmeter was used, and the reading stored in an early desktop computer (HP 9816) which would print out the results.

After the first tester was built, an E-Rel engineer complained they got different TC readings on their TC test system. They loaded the parts on rather massive trays, measured the parts on the tray, placed the trays in the oven for about a half hour, (the longer time was needed to heat the tray), measure the parts again and calculate the TC. I eventually proved to him the parts were getting a permanent shift in value because they were in the high temperature longer. They needed to stabilize the parts better before testing.

5/1970 Autopitch B 12, P 74 & B 16, P 9

It was always a great challenge to feed parts to a high speed spiraler in small presorted groups. Each evaporation lot was normally sorted down to groups of about 8% spread, so the spiral length would vary by only 8%. Instead of sorting, I decided that the "Kickout" needed to pretest each part as it came into the chucks, calculate the spindle speed, for the spiral pitch it needed, and bring it up to that speed.

Quite a bit of calculating, as well as trial and error went on before I determined I needed to**:**

1. Calculate the amplification factor (Final value divided by blank value) with an Op-amp by putting the final value in the feedback loop (a dialed in decade) and the blank as the input resistor. (An Op-amp will multiply a voltage from the amount of feedback resistance divided by input resistance.)

2. A multifunction Op-amp then took the voltage to the power of **.**4 (**.**5 is sq. root) and subtract a constant that was needed for low amp factors.

3. This voltage was stored on a capacitor while the part was being spiraled, and then amplified to drive the spindle motor.

I found I could go all the way from 1.2 amp factor to a 1000 amp factor with no adjustments. Since the parts coming out of the evaporators only varied about + or – 40%, the system worked fine, and the spiral length variation could not be measured. It enabled us to use entire evaporation lots with no presorting.

This still left the kickout accuracy at high speeds to be solved.

8/1970 Calibration Cut B 13, P 80 & B 15, P 70

Since the kickout accuracy depended mostly on the rate of the resistance change in respect to the final value, I needed a way to slow it down without having to slow the machine down. The solution was to just spiral to 70% of the length (Minimum length per MIL-SPEC) and use the remaining 30% of the length for a calibration cut that would change the value more slowly. It turned out that I needed to stop the spindle quite abruptly, (5 milliseconds), reverse direction and then more slowly bring it back forward to about 70% of original speed. This formed a cut that looked a little like a check mark. When the changing value was observed on an o'scope the resistance change went rapidly to a constant rate of change to about 5 times slower. (10 times slower could be achieved but was harder to get set up.) This enabled us to have 5 times better kickout repeatability. This increase in repeatability along with the increased repeatability the laser gave us, enabled us to meet the increased speed (250 pieces per minute of each of the two heads of the dual head laser spiralers.) of the laser spiralers with sufficient accuracy.

Being able to run evaporation lots of parts with little attention and having accurate kickout enabled one operator to run up to five spiralers at once. This brought the spiral process labor cost down from being the most expensive process to be the least expensive and blew the competition out of the water.

The Japanese found out we were using the lasers but without Autopitch and Calibration Cut they could not bring the labor cost down. Feeding small groups of sorted parts would occupy one operator full time. Not having room at the end of the spiral for the calibration cut would cause them to run only 20% as fast as we did to get sufficient accuracy.

The company that sold us the lasers told the Japanese competitors we were using lasers, but we still beat them on price, so I don't think they had anything like the Autopitch and Calibration Cut.

We used permanent magnet dc motors for the spindle and drove them as high as 3000 RPM. Reversing them in 5 milliseconds required the amplifier driving them to go from supplying about 15 watts running power to supplying 800 watts of reversing power. They were low inertia motors, but we did have to send them back to the factory ever so often to repair the armature windings. The field magnets were so strong that it took a special fixture to remove the armatures. The accurate control of speed was obtained by using a power op amp (40 volts at 20 amps) to drive them and a dc tachometer (generator) on the back of the motor for the op amp feedback loop.

7/71 & 9/74 Evaporator Controllers

In the Film Division, we used bell jar vacuum chambers to evaporate nichrome wire, wrapped on tungsten rods, onto ceramic cores to make the resistor blanks.

The power to heat the tungsten rod was controlled manually with a variable transformer and by watching the resistance change of a test strip.

It was found that some operators did a better job than others, but even their control was not all that consistent.

So, I watched what the best operator was doing and built a controller to do the same, but of course the controller was much more consistent. This did improve our output of T-9s some.

I then worked quite a bit with the machine and operator on day shift that did most of the high value parts and was able to bring her production of good parts up quite a bit too.

1/1974 Racal-Dana Digital Ohmmeter Book 15, Page 94

While in Norfolk I tried several different digital ohmmeters. The HP brand used too low of a test voltage and was too unstable on high values. The Fluke meter "Slugged" when a reading was taken, and one of the four leads was open. It then took about 25 reading to come back into accuracy. The Leeds Northrup did not have enough resolution. But the Racal-Dana 6000 proved to be repeatable to .003% over its entire range including the top and bottom of each range. Therefore, I used it for several applications in the Film Division and in the Test Lab. Some of the other divisions also took up using it.

5/72 & 3/75 Voltage Coefficient Tester B14, P 101 & B 16, P 76

The John Fluke Company manufactured a lot of electronic test equipment. (Including the digital ohmmeter that I did not like.) They wanted to buy some high value resistors (100 meg ohms) with low voltage coefficient (VC). Up to that time the testing for VC was primitive and inaccurate. I designed a tester that would continuously measure a part at 1000 V, 100 V and test for offset of the tester at 0 Volts. It would apply each voltage for 1½ line cycles and display the output as VC on a meter.

This eliminated seeing any heating the part might see, eliminate 60 cycle interference and give us good repeatability and accuracy.

I devised a way of checking the accuracy by testing ten parts for VC, selecting parts with low and similar VC and then placing them in series to test them again. The John Fluke engineers disagreed with this method until I sent them the math that proved it's worth. They then sent back a letter praising my method, said we would be sole source for low VC resistors and ask if they could have a schematic of the tester. Our management declined their request and considered taking out a patent on the system. However, if we were to patent it, everyone could use it and we would not be able to prove infringement.

6/1976 Jap Reeler Conversion Book 17, P 82

We purchased some machines from the Japanese so we could load them from 40 piece trays, and they would place the parts on the standard taped reel pack.

I installed a 360 degree rotary interrupter for machine timing so the microprocessor would know when to index to the next part and when the indexing was done. I had some problem with the interrupter and had to add another single interrupter to reset it each machine cycle.

10/1977 Evenohm R vs S – Mix Book 19, Page 29

To make the metal film resistors, we wound nichrome wire on a tungsten rod, mounted the rod in a vacuum chamber on high current electrodes and ran a high

current thru it to heat it up and melt the nichrome. It then evaporated the nichrome and the other elements in the wire, and deposited them on the parts that were tumbling in a drum close to the rod.

The Temperature Coefficient of Resistance (TC) of the parts was difficult to control. At times it would be quite positive and other times quite negative.

One day we had a "rep" from a competitor of our wire vendor visit us. He had worked for the other company and knew that sometimes they were sending us "Evenohm S" wire but marking it "Evenohm R". (The wire was sold by TC, not chemical composition.)

We had the Chem lab analyze several batches of wire and found the batches that were giving us large negative TC to have a much different chemical composition.

I contacted our vendor and arranged to have the lots properly marked.

We then set up a program on the HP9825 (An early computer) to calculate the correct mix of "R" and "S" wire to get TCs close to "0".

This worked well, but we needed to have enough wire for each evaporator to have its own supply so it could use the same batch for a long period of time. However, I could not get Purchasing to agree to it, making my job harder.

4/1980 "A" Frame House

About 1978 everyone was talking about energy savings and solar energy. At the time I had a Chemical Engineer, a Physicist and another Electrical Engineer working for me. We had all four of our desks pushed together in the engineer area. Every time we went for coffee, we talked about heating and cooling a house with solar energy. Quite often we considered the advantages of using a swimming pool to do so.

The swimming pool could be used as a solar collector and store the heat at a lower temperature and then a heat pump could be used to concentrate the heat for the higher temperatures. The pool could also be used for air conditioning to receive heat (hot water) from the heat pump and then get rid of the heat by evaporating the water.

At the same time we had, at work, a very early form of a personal computer. It was a HP 9825A Desktop Calculator. It had a cassette tape for long term storage, a row of led lights for a display and a huge (for that time) 15K of memory. It used cash register 2.5 inch tape for print out. It could be programmed in "HPL"- Hewlett-Packard Language that was close to Basic, except more like RPG (Reverse Polish Notation) because the statements were backwards of Basic.

I used it to write a program to calculate the temperature of the pool day by day, using a different sun angle different degree day each day, and a different heat requirement each day. This actually worked out fairly accurate to what I experienced after we started living in the house. The program helped me decide the size and shape of the pool and the dimensions of the windows above it.

Scott helped me design the house and made up the drawings. He told me about some plywood "I" beams called "TJIs" that had some real advantages. He was in college taking architectural drafting at the time.

One main advantage was they were available in lengths up to 80 feet and cost just $1.79/ft for any length. This enabled us to use 40 ft. lengths for the "A" frame roof with no splices.

Among some of the things we learned as we lived there was the pool covering requirement in the winter. Initially I floated black plastic on the surface. This caused the top quarter of an inch of water to get quite hot, but the hot water did not mix to the lower

level and therefore lost heat thru the plastic. I then tried clear plastic that allowed the sun to heat much further down. Later I used clear bubble pack that preserved even more heat in the water. In all cases, the plastic reduced the evaporation loss. However, instead of the pool area and house being too humid, it became too dry.

The doors I installed under the windows and the top vents at the A frame peak were quite effective during the summer and kept the inside temperature within two degrees of outside. I made the top vents too big to begin with and had to change them later on. Eventually I made double layered closable shutters over the vents to reduce heat loss in the winter.

The pool housing gave the house a double shell characteristic on the south and upper ceiling.

Initially tried to draw hot air from the top of the "A" frame but the furnace blower could not pull the hot air down. Later on, I installed a blower to take the hot air from the peak and blow it into the upstairs library. When the thermostat called for heat and the "A" frame peak was above 90 degrees, it would turn on the peak blower and not the furnace. That did work well, and supplied some heat even in January.

In air conditioner mode the hot water discharged from the heat pump went into a whirlpool that I blocked out in the corner of the pool. It then overflowed into the main pool. This kept the whirlpool very comfortable during the summer and heated the main pool. However, the main pool would get too warm at times so I installed three ceiling fans above the pool that I could turn on to cool it. At times I even had to set a fan to blow across the whirlpool if we had too much hot weather.

The pool was built quite inexpensively by using Surewall. (Block stacked up and the plaster-like Surewall spread and pushed in-between the blocks.) I ordered heavy fiber glass and resin direct from a manufacture though Dale Electronics and enlisted the whole family to put it on. Eventually I had to paint it with epoxy.

More information on the house is in the publication "Living in the Caauwe 'A' Frame house" that I wrote up for the new owners of 624 N 18th St.

1982 ? High Value Test/Mark Earth Magnetic Field Problem

I designed an op-amp tester for the final test/mark operation. There was a long lead from the test station to the bridge that could not be fastened down. One of the machines became erratic after it was moved. They had oriented it North/South and it seemed to be erratic if the lead was moving. I decided this was due to electrical current being induced in the lead when it moved in the earth's magnetic field. I had them turn the machine back to an East/West orientation and the problem was solved.

1/1983 Weld Monitors Book 23, Page 92

HP was a very good customers of ours but was having a problem with the leads falling off the film resistors and were threating to discontinue buying any resistors from us, including Wirewound. Therefore, we had about four engineers out on the line that was giving us the most problems, trying to find out why. I talked to the guys and thought maybe I could sense the problem by analyzing the weld pulse. The Engineering Manager told me to go ahead and try.

I used an oscilloscope and tried watching the waveshapes of voltage, current, wattage, watt-sec and all the possible combinations. No luck. But one day, Tom Bertsch (a Mechanical Engineer) was running parts through one at a time while I watched the 'scope. He would run one, say "That's a good one" or "That's a bad one"

and then test it by wiggling the leads to see if they fell off. I realized he was calling it correct every time, so I asked him how he could tell a good one from a bad one before he even checked it. He said he watched to see how much of the lead melted into the cap, indicated by how much the lead electrode moved. **Eureka!** I ask if he could mount a small position transducer on each side, so I could sense the amount of movement. Of course, he could so while we waited for the transducers to come in, I made up a microprocessor unit to monitor the transducers.

The monitor had a digital readout for each side and a switch to change from "wire extension", "amount of follow up" and to "end position of the electrode from the cap". It also had LED lights on each parameter. Yellow for approaching limit and Red for out of limit. When the out of limit was encountered it would enable a solenoid to punch the part out of the chain. If three "Out of Limit" parts were encountered in a row, it would shut the line off.

It also measured the weld pulse and subjected it to limits.

Using the monitor, we could affirm we had the right wire extension, were getting a sufficient follow up and the electrode holding the wire did not end up too close to the cap. (Too close indicated the wire was bulging out into a worn electrode.) This solved most of the problems. The wire extension could be held in tolerance, the pulse power set right, and the electrodes were dressed properly. However, it showed us even more: One day while observing the read-out meters showing wire extension, and recording the variation so I could set limits, the operators shut down the line for break. When they came back, the wire extension was way long and beyond what the monitor would allow the line to run. They kept restarting the line and the extension slowly came down and the machine ran again.

I showed this to Tom, and he moved the rubber rollers that drove the wire extension, so the wire was on a different part of the roller. That way the roller no longer changed with warm up. It stayed long and was readjusted to the correct setting.

This had been a serious problem every morning when they started up the line.

Then I noticed that the "follow up" was often too great by the time second shift started. This was caused by the electrode wear. The electrodes were "dressed" on third shift. By also dressing the electrodes after first shift, we had less problems.

Eventually Jim Parsley convinced the machine shop to start making the electrodes from #3 bronze alloy and the electrodes only needed dressing once a month.

I checked the analog output on the transducers with an oscilloscope on all of the welders and found the wire extensions varied from part to part, usually in a pattern of two. That is, two long, two shorts etc. I showed this to Tom, and he had the Geneva drives that drove the rollers replaced. The detected wire extensions varied a lot less after that and were much easier to set.

NOTE: Geneva Drives change rotary motion into step motion in four steps.

After about a month we once again had complaints from HP of leads falling off and a Saturday morning meeting was called to decide what we could tell HP. (There was no discussion as to what was causing the problem.) In the middle of the meeting I got an idea and just got up and walk out to the line to check it out. As I suspected, maintenance had disconnected the relay that the weld monitor used to shut the line off when the welder was beginning to make bad parts. (A red light on for more than three consecutive parts.)

I reported this back to the meeting, But the division director was only interested in coming up with a lie to tell HP,

I was in trouble because I didn't make the shut off fool proof. Maintenance was not reprimanded.

I have never heard of a similar weld monitor probably because not many manufactures weld copper leads to brass caps.

Wirewound attempted to use one of these monitors but it was not applicable to their steel cap and nickel lead design.

Later on, Jim Parsley designed and built a "400 pc/min" welder. (I saw it run at 500 pc/min very smoothly.) However, the coaters on the line could only run at 325 pc/min, so having a 400 pc/min welder was not necessary. But this welder did perform much better.

When Jim first got his new welder running, I had to put a monitor on it. But the monitor didn't like it. It kept shutting it down and Jim was about ready to hit me. Finally, he said he would dig into it. A day later he had me come back and try again. It worked perfectly. He had found a screw that had not been tightened way down deep in the assembly. We have been great fiends ever since.

We were both transferred to Columbus at the same time and car pooled together for about a year. We found we both had the same engineering philosophies.

Corporate engineering also made a 400 pc/min welder by putting two standard welders together. But it vibrated so bad it just about walked out of the room.

1984 ? Omega CN 9000 Temperature Controller

When we needed a better and less expensive temperature controller, I discovered the Omega CN9000 with a digital readout. At about $100 a copy it was the lowest priced controller that could do all the jobs. About 2 inches square and about 8 inches deep, it could physically fit any application. It accepted inputs of thermistors, thermocouples and temperature dependent resistors. The outputs could be mechanical switches, triacs, analog voltages or digital. They could also phase fire triacs, work as on/off controllers as well as time proportioning controllers. They would do anticipation and critical damping.

We used them throughout the film division and later in the test lab. We even replaced Blue M Saturable Reactors with them. (The Blue M controllers were considered the best available up to that time.) They then caught on with the other divisions. At one point, the manufacturer, Omega, replaced them with a new controller, but it just wasn't as good, and the demand made them return to the CN9000.

1985 ? MF50 Short Spiral

A spiraling problem was brought to me one day. They were trying to spiral MF50 parts (our smallest) and the kickout spread was way wide. The cores were only .040" in diameter and about .060" long. The spiral was a partial turn about .080" long. They were trying to do a "5" amp factor. That is the blank they were starting with was just 20% of the final value so they had to go from 20% to 100% (X 5) in .080 inches. (80% of final value change in .080 inches.) The only spiralers available to do these parts were older manual machines that had carriages that were a bit flimsy.

I looked at the parts under the microscope and discovered most were chipping or gouging out at the end of the spiral to the extent of up to .003". Since each .001" of spiral was changing the resistance 1%, the chip or gouge was causing the kickout value to vary up to 3%. Actually, more because it was gouging in the radius direction instead of the direction of the spiral. (They needed to hold less than +-.5%.)

I recommended they use lower blank values and to tighten up the carriage. Problem solved.

5/1985 Long Line Heater Guns Book 24, Page 24

The cure ovens for the powder coat parts were made with heat guns that blew air through the gun, down onto a horizontal deflector and on down to the parts as they moved along the moving chain.

A major requirement was that the guns had to put out a high temperature while the chain was running but quickly drop back to a medium temperature when the chain was stopped.

I did not want to use phase fired triacs to drive the heaters because when they switch on, they continually put a spike on the power line that can feed to test equipment throughout the plant, Therefore I used only “Zero Crossed” triacs. (Turn on & off only when the power cycle crosses zero volts.)

I also did not want to draw a lot of heavily positive or heavily negative half cycles of current from the plant’s transformers as that would overheat the transformers.

The solution was microprocessor control, using various patterns of whole cycles and no more than one half cycle for the 2 sec on/off period I used. This gave me 240 different power levels to use for controlling temperature. The patterns were also made up to produce as even of heat as possible.

The microprocessor enabled me to critically damp the temperature rise and fall, to prevent overshoot and undershoot. It also enabled a rapid transition between the two temperatures Thus preventing overheating as well as under curing the parts.

I do not know of any other temperature controller using this technique.

3/1986 Vertical Oven Temperature Control Book 25, Page 55

The long lines consisted of a welder to attach wire leads to the end caps of the resistors then drop them onto a continuous chain to take them to an epoxy roll coater, up and down thru a vertical oven then to color banding, another vertical oven, a test station and finally to reel pack at the end.

The vertical ovens were copies from some Japanese ovens we had purchased, but the doors on the side did not seal very well and the top and bottom of the ovens were not closed. They were heated with three vertical heating elements behind each vertical chain and driven by a separate power phase on each element. (3 phase power, 208-volt, delta connection.)

For some time, we had parts failing moisture testing at the lab. We had gone to doing a similar test with pressure cookers for quick results. Eventually the Engineering Manager asked me to look into the problem.

I discovered the elements were glowing red hot and “curing” the parts epoxy coating with infrared heat. I knew from past experience that parts cured with infrared would not pass moisture testing.

I had them seal up the oven doors and block the tops except for a small vent hole. (The bottoms could not be closed due to the chain.) This resulted in having too much heat input and poor temperature control. To correct this, I changed the wiring to the heaters from 3 phase 208V delta to 110V “Y” which dropped the controllers back to suppling power about 30% of the time instead of less than 10% of the time. The temperature of the heaters was then lower, and the parts then cured better.

However, we occasionally still had problems. I then discovered some elements were burned out, causing the others to be on longer and emitting the infrared heat. Eventually I looped the wire going to each element thru a toroidal coil and fed the output of the coil to an LED light. The lights were then grouped together on a panel to enable the operator to tell when one of a group of three elements was out.

An additional problem arose when the testers on a line would occasionally act up. I discovered the neutral line going back to the main power bus was only a #10 wire and not large enough to handle the heaters when connected in "Y" configuration. The heating elements neutral wires were changed to the much larger "00" size and the tester neutral wire used the smaller #10 neutral. Once again this was a ground loop type problem.

Nothing unique about this, just good engineering practice.

6/1986 E-Rel Load Life Failures Book 26, Page 8

For some time, E-Rel parts were failing Load Life testing after being on test about 600 hours. (1000 hours required.) The failures were shifting **Negative** which was very unusual for any test except moisture. The Failure Lab dissolved the epoxy off of some failed parts and found small metal chips, probably solder flakes from the "tinned" leads. E-Rel would make some changes and declare the problem solved and talk the government into allowing them to place another 13,000 pieces on load life test which would allow the failure.

I did not work for E-Rel, so I never got involved. However, the negative shift indicated that a small chip was shorting out a spiral when the varnish precoat E-Rel applied to their parts deteriorated after about 600 hours. (The E-Rel manager would not admit this was the problem.)

When I started using a digital ohmmeter on the Standard resistor long lines in place of the analog bridges, I started to get complaints that the ohmmeter was rejecting some good parts. But it was found that these jumped back a forth between 1% to 6% low and "on value". Looked like a chip problem to me. I tested the parts on a "Current Noise Tester" we had purchased some time before and found that most of the parts pegged the needle – extremely noisy. These parts were found to contain chips.

I started watching the lines and checking the rejected parts for slightly low parts that were extremely noisy. I found most of the Standard lines had about 100 ppm of the total order had chips. Except the "RN" line had 500 ppm of low and noisy parts. On inspection I found the "O" ring that held the parts in the welder wheel was running through a pile of dirt and metal chips from the lead material. Maintenance cleaned out the debris and made a shield to prevent the pile from occurring again. The low and noisy part count went back to 100 ppm.

I proposed that QC set up a program to monitor the lines as I was doing. Then when a solution to the chip problem was installed, they could tell if it was effective and if the solution continued to be effective. Very often when we fixed a problem, it would crop up again a month later. My proposal was not accepted and E-Rel continued to have the same chip problem for years to come.

The chips were less of a problem on the Standard lines because we did not have as critical of testing. ("R" failure rate vs "S".)

8/1986 QCorp Reel Tester Book 25, Page 28

Quality Control wanted an automatic tester for sampling large reels of parts, so we bought a reel to reel test machine.

I then installed a digital ohmmeter (Dana 6000) to it, a microprocessor, a keyboard, a display and a printer.

I programmed the processor to ask for the sample size and the reel size. It then calculated the number of pieces between samples and proceeded to test the parts at that interval. It recorded the value of each part and built a histogram of good parts and recorded the number of failures. The histogram then printed out with each "X" representing a certain number of parts, depending on the number that could be printed across the page. It also printed the number of failures.

1986 ? Laser "Spiral to Value", Point One Percent Parts (0.1%)

I sat in on a "Cost of Sales" meeting that told us what profit each line was making. I noticed the **.**1% parts sold for quite a bit. It showed our cost to be mostly labor because we spiraled them on a manual spiraler and then rubbed them up. (3 pieces/min.) After the meeting I talked to one of the product technicians and told him I thought I could modify a laser spiraler to do those parts at 75 pieces /min. if he could coax them gently down a long line. (So the handling wouldn't rub the parts to a higher value.) He said he could, so I talked to the Engineering Manager. I estimated we may get as high as 25% loss, but the final cost would still be much lower than present cost. At the time, scrap was a big issue, so he was reluctant. After doing some of his own calculation he told me to go ahead and modify the next machine being built. I put a trimmable bridge in it for more accuracy but getting the electrical noise out of the bridge's signal was tricky. I finally had to put the vibration bowls on a timing switch to turn them off during the time that kickout could occur. The bowls were the biggest source of the electrical noise. Then by slowing the machine to 75 pcs/min/head, we were able to spiral to within + or - .05%. The technician took it from there.

He eventually got the cost down from **$0.14** each to about **$0.04** each and the selling price only went from **$0.19** each down to **$0.14** each. That was enough for us to get almost 100% of the market and we made a lot of money from it.

The Tech got a big reward for this, and I was happy for him even though my name was never mentioned.

Our sales success told me that no other company had this capability.

1987 ? Scanner – Reading Stations

The Test Lab had been using an IBM Series One Computer and some HP 9816 computers along with various digital multimeters and HP scanners as reading stations to test trays of 20 resistors for load life testing. The scanners were three wire type and cost $15,000. They would not do low value parts that required four wire connection.

I used a STD BUS microprocessor system and made a 5-wire scanner that cost just $5,000 ea. In four wire configuration it would do low value parts. In the five wire configuration, it could supply a guard voltage for reading networks and for reading high value parts, up to 100 megohms.

A later modification enabled it to do parts down to **.**01 ohms.

It improved capability at a lower cost.

Along with the 5-wire scanner, I used a Racal-Dana 6000 multimeter and an IBM PC to make a reading station. We ran extensive tests and found the system would hold .003% repeatability all the way through the range we had to test. (When testing for

change of resistance, repeatability is more important than accuracy.) It also ran about twice as fast as the HP 9816 computer/HP scanner systems and six times faster than the system that used the Series One computer.

A rep. from Collins Radio came to the lab and was running gage capability studies on our equipment. I showed him how we had tested our systems, and he sent the testing we had done to his boss. He came back and said our system was superior to all other system they had seen, and they no longer needed to do further testing. Coming from Collins Radio, it was a nice feather in my cap.

1988? Thermal Shock Machine Rebuild

The Test Lab needed more thermal shock machines to cycle the parts between 125 deg C and -55 deg C. These sold new for about $85,000 each. Instead, I purchased used ones for about $15,000 and rebuilt the electronic controls on them with more up to date and better components. We put much better chart recorders on them and usually had the refrigeration systems cleaned up. End cost was about $25,000 each. I think we did three of them that way and had better ones than if we bought new.

1990 ? Printed Circuit Connector Strips for Reading Load Life

To power the parts on the load life trays, we used brass shorting strips under the trays that would contact all of the parts to apply power. They could then be removed for testing.

The test fixture was made of two printed circuit boards on edge that the trays were set down on, so each part could be scanned individually. However, the contact forks that the shorting strips and later the pc boards contacts used, tended to spread slightly after time and the pc boards were not wide enough to make up the difference.

To correct this, I had the pc board manufacturer plate additional copper on the board to get to the thickness we needed.

1991 ? Load Life Power Supplies

When I started in the lab, they were using a limited number of power supplies set at specific voltages and the divisions (Film, Wirewound, Inductors etc.) supplied parts for test of the values that could be supplied using the voltages available. The output of the supplies was switched with a timing cycle of on 1 ½ hours on and ½ hour off. The switching was done with large, high current relays which drew an arc between the contacts when they opened. (DC supplies.) It was feared this arc was causing damage to the resistors, so I calculated the proper arc suppression across the contacts (Resistor and capacitor) for each power supply. This helped, but we still had some complaint and we could not get the exact voltage required for each load because the voltage could not be adjusted for each load and the voltage drop of the wiring varied with each load.

To make a soft on & off for each supply, I designed and built raw (but filtered) three phase main supplies that used “Zero Crossed” solid state relays on the input. (Zero Crossed relays only turn on or off when the power line crossed zero.) I then made up individual regulators on plug in cards that could accurately be set for each load at the tray of the resistors.

The operation was then to switch the regulator cards on or off as required and then turn the raw supply on. (Zero crossed so they came on soft.) The output of the cards would then be coming on soft too. When time came to turn off, the raw supply was turned off, also soft, and then the cards were switched as required. This was controlled by a computer.

The computer also continually scanned all cards and recorded time, voltage and current output of each card and logged the results for later print out.

I also did a spreadsheet for entering each load. The spreadsheet calculated and kept track of:

1. The proper voltage.
2. The oven being used.
3. The total wattage added to each ovens heat.
4. The current drawn from each regulator card and watched for card overload.
5. Showed with raw supply was being used and how much current was being drawn on each timing cycle. (Four cycles used so we did not have one fourth of the regulator cards on at a time.)

1992 ? Inductor Load Life Power Supplies

Inductors (Coils) were built in Yankton and Israel. For Load Life, a given current was required for each size and value instead of a voltage like resistors were. The lab had been just measuring the resistance of the units and calculating the voltage required to get the proper current. However, the coils were made of copper and changed quite a lot with temperature. So, the heat of the ovens and the heat from the current changed the resistance of the coils quite a lot and they were not being properly loaded.

To correct this problem, I made up some current regulator cards for the Inductor load life. I ran into some problem with the cards oscillating but fixed it by adding capacitors close to the loads.

1992 ? Dual Station Load Life Reading Station

Load life testing required four to five technicians most of the day to test all of the load life that needed testing each day. They were using the HP9816 and the IBM Series One type reading stations.

To speed things up I built a dual test station using the system described earlier that allowed the operator to have the machine scanning one tray while she loaded the other. This, along with the faster operation of the new scanner, the PC and the Racal-Dana multimeter enabled one operator to do all of the load life reading in one morning.

Major cost savings and major capacity increase!

1994 ? Auto Q-Meter

When I went back to work at the Test Lab for my last ten years at Dale Electronics, they wanted me to look into the testing of the coils made in Yankton. I eventually had to make it a high priority and spend some time with it. I found**:**

1. The method of pretesting the fixture for capacitance was flawed.
2. The method of testing the fixture to account for its added impedance was wrong. They tried to do it by finding its capacitance and converting it to inductance.
3. The test fixture called out in the Mil-Spec caused half of the repeatability errors. It bent the part and also would contact the part in different places. This caused about a 2% variability.
4. They had to dial a variable capacitor and watch an analog meter to find the resonate peak. Because the part was heating up from the voltage the Q-meter was applying it, it was difficult to find the peak. This also was causing a 2% variability.

5. Heating of the part while being tested was rapidly changing the Q which added to the poor reading of the Q Meter.

The two 2% variabilities added together like any noise would. That is, the square root of the sum of the squares. (RMS). So, the square root of 2% squared plus 2% squared is 2.83%. That was precisely what we were seeing. Eliminating one 2% error still left the other 2% error so both had to be addressed.

To correct these problems, we first designed a zero-insertion force fixture that also controlled the part position between the contacts. It also stayed mounted on the Q-Meter and did not have to have a calibration. This corrected the fixture error of 2% but we still saw the 2% of the meter readability problem.

So, I modified a Q-meter. I installed a digital Voltmeter in place of the analog meter and fed the output to a PC. Also added a printer.

I then installed a stepping motor to drive the Q-Meter tuning capacitor. Then used an accurate capacitance meter to make a table of stepping motor steps vs capacitance which was placed in the computer. (Stepping motors in “micro step” mode are not very linear.)

To operate, the computer drove the stepping motor and found the resonance point. It then scanned over the peak of the resonance curve, reading ten points and recorded the voltage then looked up the capacitance for each point. Using a polynomial regression program, the computer then found the capacitance of the peak. From this it could calculate and print the inductance and Q.

This changed the repeatability of the inductance readings from **2.83%** to **.03%.** This was way better than I expected because my initial investigation was not near through enough to determine the problems that accurately. The detected Q readings were also higher (better) because it took the reading before the part could heat up very much. (The part heating raised its resistance, “spoiling” the Q.)

I showed this system to the Yankton Inductor engineers and sent a sample fixture and test reports to Mike Rader at the Naval Crane Test Lab and to a couple of our competitors. However, the system was not implemented at that time because it would cause too much changeover of inventory and what the customer would need to order to get the same results. After I left the lab it was tried again but I don’t think it was adopted then either.

In the above, I talk about repeatability rather than accuracy. This is because there are no NIST inductance standards, just Q standards.

I did find an old article in a magazine written by a gentleman (Atlaw) that also investigated the problem. He said that his readings deviated from the Impedance Analyzers by about 6% on one end of each range. My Auto-Q readings deviated about 1% at the end of each range and could have been adjusted to read the same by adding a 1 picofarad fixture correction factor.

I actually recommended switching to an Impedance Analyzer even if the Mil-Specs had to be changed. The fixture should be changed at the same time to something similar to the one I designed. But no one wanted to tackle the Mil-Spec change.

HP also had an automatic Q-Meter, but it did not have an accurate Capacitance meter built into it and it searched for the peak of the response curve like the hand operated Q-Meter did. Its repeatability was also only about 3%. When I showed my machine to the HP rep, he said I should call the HP Q-Meter design engineer and tell

him about it. I did but he didn't understand and just wanted to know what problem I was having.

The large improvement in repeatability was great, but I guess repeatability is not really required of inductors. They are, after all, the least precise of the three passive electronic components. (Resistors, Capacitors & Inductors)

1995? Group B Testing

While working in the test lab, the film division needed "Group B' testing every day with a one day turn around. This meant being able to load and unload trays of parts quickly. So, I had the techs make some test trays with spring loaded connection posts that opened with a top push button that could be loaded quickly. (vs soldering each lead to a post) These fit directly into ovens and cold chambers for testing and then could be unloaded quickly by pressing a bar along the top of the tray.

We met a need in a very short time.

1997 ? Vibration Machine

We had to test a number of our parts on large vibration machines that were like three-foot diameter speaker coils. These were usually used to sweep the frequency though the normal audio range.

Before I arrived in the Test Lab, they had purchased a new machine and put the old and the new in the same room. But the old one started to act up when it hit the frequency where it changed from constant displacement to constant acceleration. The previous facility engineer had not been able to find the problem nor had I for some time.

Then one day I traced an interfering signal all the way back to the pick-up on the vibration driver. The pick-up was essentially a microphone. By wrapping a towel around it to insulate it from outside audio noise, it stopped the stray pick up. The noise turned out to be the cooling fan on the other vibration machine. It was making noise at about the same frequency as the changeover frequency and resonated in and out with it around the changeover point. Ordered some "Sonicsorb" rubber to cover the machine's pick-up and the problem was solved.

Good but belated troubleshooting.

1998 ? Black Maria

I had a lot of 35mm slides I wanted to keep. I discovered my Canon Elf 990is (A gift from my brother Russ.) would focus down to 2" and had an optical zoom to 3X, so I decided to use it to digitize the slides. First, I built a prototype system that I mounted the camera on and it seemed to work OK so I started to build the final version. Russ found out what I was doing and ask if it would do his medium format slides. (2" X 2"). I said I could add a small modification to handle those slides. I built two units and experimented around with the camera to find the right settings. I had two different holders, one for each size of slides. The 2' X 2" had to be a little farther from the camera. Darkening the room and aiming the system at a brightly lit projector screen, I could take the picture of each slide fairly quickly. I then transferred them into the computer and used Photoshop and later Piccasa3 to crop, correct color, contrast, brightness and to clone out things I didn't want. That was more than I used to be able to do in the darkroom and made up for things like poor camera flash, film gone bad, poor exposure, poor composition, bad lighting and a poor photographer (me). It also enabled

me to give applicable pictures to friends. (Jerry, Jeanie and Linda Borer and others) and family.

I sent the second unit along to Russ with a manual, but a couple of weeks later he called for “Black Maria Tech Support”. He couldn’t get the camera set up right because he had neglected to read the manual.

In the old days the horse drawn paddy wagons were painted black and were called “Black Marias”. So, when that other great Thomas inventor (Thomas Edison) built the first movie machine, he had it in a large black tar paper covered box and called that his “Black Maria”. Hence, I called my small black box device The Black Maria.

In all, I have converted about 9000 slides to digital. My own, Marilyn’s, Dad’s, Scott’s, David’s and numerus friends.

I had also used a scanner to copy the printed pictures from my photo albums.

1998? Increased Testing Volume in the Test Lab

I worked as Facilities Engineer in the Test Lab for ten years. In that time, we increase the though put volume by five to ten times in almost all of the various types of tests we were doing. At the end of the ten years, we still had the same number of people working and had only slightly increased the amount of floor space we were using.

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1945 ?	Automobile Headlight Glare Reduction		P.1
5/1970	Autopitch	B12, P74 & B16, P9	P.9
6/1965	B. Conrad Spiraler	Book 4, Page 32	P.4

1998 ?	Black Maria		P.22
8/1970	Calibration Cut	B 3, P80 & B15, P70	P.9
1968 ?	Dancing Christmas lights		P.6
1992 ?	Dual Station Load Life Reading Station		P.20
6/1986	E-Rel Load Life Failures	Book 26, Page 8	P.17
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3/1966	Hydraulic Spiralers	Book 6, Page 95	P.5
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6/1976	Jap Reeler Conversion	Book 17, P 82	P.11
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6/1969	Little Brown Bridge	Book 11, Page 9	P.7
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5/1985	Long Line Heater Guns	Book 24, Page 24	P.15
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3/1961	Minuteman Missile Resistor Load Life		P.1
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2/1969	Production Increase, 1/10 W For $.5 million	Book 10, Page 64	P.6
8/1986	QCorp Reel Tester	Book 25, Page 28	P.17
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6/1969	Resistance Temperature Coefficient Tester	Book 11, Page 27	P.8
4/1966	Resistor White Spots	Book 7, Page 12	P.5
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12/1963	Spiral-To-Value Kickout	Book 3, Page 1	P.3
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4/1961	Tube oven for Tin Oxide production	Book 1, Page 7	P.2
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3/1986	Vertical Oven Temperature Control	Book 25, Page 55	P.16
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1/1983	Weld Monitors	Book 23, Page 92	P.13
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1998?	Increased Testing Volume in the Test Lab		