A History of the Univac Magnetic Tape Plating Facility

Located in the Basement at 3747 Ridge Avenue, Philadelphia, Pennsylvania

By Douglas C. Wendell, Jr.

The work in the basement of Ridge Avenue was the culmination of the first project I was assigned to. Ted (Theodore H.) Bonn was doing research aimed at developing a process for making magnetic recording tape by coating a non-magnetic metal supporting tape with a thin magnetic metal coating–the idea being that a thin coating would be capable of recording a higher data density than possible on the thicker iron oxide coating then used on recording tape. Another important consideration was that a metal-based tape would be mechanically stable, unlike the paper based recording tape then in use.

I was hired in November of 1947 at The Electronic Control Company located in several floors at 1215 Walnut Street above a Lane Bryant store. I was interviewed by John Mauchly, J. Presper Eckert, Isaac Auerbach, Frazer Welsh, Ted Bonn, and John Sims. They decided to take a chance on me, liking my combination of a degree in chemistry from Haverford College along with my electronics training and service as an electronic technician in the navy during WWII. I was assigned as a chemist to assist Ted Bonn who is an electrical engineer. My job was to provide additional chemical expertise for the magnetic alloy deposition project that Ted was working on. I had theoretical knowledge of electrochemistry, but no direct experience in electroplating. I studied the literature Ted provided: an elementary textbook on electroplating by Blum and Hogaboom and a practical book, The Metal Finishing Handbook published by Metal Finishing magazine. Bernie Victor was our capable lab technician. Our chemistry laboratory unceremoniously resided in the second floor lavatory.

Ted Bonn had found two interesting processes in the patent literature for depositing nickel-cobalt alloys that might be useful as magnetic recording surfaces. When I was hired, he was investigating one non-electrolytic process [commonly known as an electrolysis process] which used a chemical reducing agent to deposit a layer of nickel-cobalt onto strips of copper tape. This process required a near-boiling aqueous solution with a short useful working life, and also required that the plated sample be heat treated in hydrogen in order to improve the magnetic properties. The resulting test tapes had magnetic properties which varied along the length of the tape. The other plating method being considered was a more conventional nickel-cobalt electro-plating process with a special modification that superimposed an alternating current onto the normal direct current. In this process, the superimposed alternating current is larger than the direct current, a process sometimes used in decorative plating to produce a brighter surface. Although somewhat encouraging, neither process provided the desired magnetic properties.

We tested the magnetic properties of our samples by plotting the magnetization loop on a B-H hysteresis loop tracer which Ted had built. The result was displayed on an oscilloscope. The most promising results came from the electrolysis process with the hydrogen heat treatment, but converting this uncertain process to continuous tape production didn't seem feasible. We only ran a few experiments with the electrolysis process after I started work. Ted decided we would concentrate on the electroplating process with superimposed Alternating Current (AC). After some weeks of indifferent success, Ted proposed combining the two processes--trying a combination of superimposed AC electroplating with the chemical reducing agent from the electrolysis process. We made a little progress so it seemed worthwhile to continue with the combined process. I decided to add an additional component to stabilize the plating bath, a buffer chemical making it more like some commercial plating baths described in the text books. Ted had initially used the composition given in the patent. The tests were tedious, because for each bath composition tested, we had to vary five major parameters: temperature, pH, current density, the ratio of direct current to alternating current, and the amount of the reducing chemical. In each experiment, we plated five test tapes, varying the AC to Direct Current (DC) ratio for each tape with the other variables constant. I decided to include a control test with each experiment, plating a sixth tape with just direct current--no superimposed AC. Ted had already tried straight DC with the plating bath described in the patent, but the result was uninteresting. We ran the next set of tests with the reducing chemical and the buffer salt and included a control test with no AC. The first five samples, run with different current densities of both AC and DC showed no significant improvement, but when we saw the test loop for the control tape, just DC, we got the kind of thrill that happens when your underdog sports team unexpectedly wins its game. We repeated some of the earlier experiments, this time using just direct current and we obtained a repeatable range of magnetic properties that would provide the recording engineers with a selection of values to work with.

We had run over 500 tests before we found the properties we were looking for. We used the last few tests to optimize the plating process. Our development work was now finished and we were ready to try the plating process on a large scale. Our patent attorney, George Eltgroth, filed the patent application while we were still at Walnut Street - it was issued in three or four years (about average). The Bonn-Wendell patent became widely investigated and was used by various companies in the computer industry in the production of tape, disks, and drums for many years.

Here's an interesting note: at a meeting of the Electrochemical Society 15 or so years later, I was startled to find that we were famous--at least in my little specialized field. I received the accolades since I was working as an electrochemist, but we were both recognized as pioneers by workers in other companies in the magnetic data recording field. This was years after I had switched into other work. Later, at Burroughs, I received patents in various areas: metal etching, a digital logic device, a magnetic memory element formed from a thin strip of permalloy, and an electrostatic memory storage element.

With the chemical work done, the next task, or rather project [consisting of many tasks] was to design and build a tape plating machine with its supporting apparatus. Then in early 1948 the Electronic Control Company became the Eckert Mauchly Computer Corporation and we moved to the building at Broad and Spring Garden Streets. There was no longer a need for electro-plating experiments, but there were months of design and parts fabrication to be done for the plating machine. The design was a team effort and in the end, fifteen or twenty persons were involved, but these are the people I especially remember: Ted Bonn of course, and myself, also electrical engineer Frazer Welsh, Frank Tees and his draftsman Bill Boss, mechanical engineer Bob Roedder and his machinists as well as Pres Eckert and John Mauchly who provided valuable design advice and monitored progress. The purchasing department under Enea Bossi and his purchasing agents, notably Eddie Whiteman and Bob Newton, did a great job obtaining unusual items--for example parts made of special corrosion resistant alloys. Ted Bonn went back to doing electronic design work and I assumed the task of coordinating the design, and construction of the machine and its auxiliary apparatus, and later on managing supplies and training operators. The initial design effort had begun while we were still in the Walnut Street building and continued on Ridge Avenue.

As we worked on the preliminary design of the tape plating machine, the space requirement for the plating operation became apparent as well as the need for water and the disposal of waste water. Installing such an operation in the Spring Garden Street building [or any conventional office building] would have been a major project, even assuming we were able to get permission from the owner. We did set up a very small plating laboratory in order to do some chromium plating and other types of plating for wear resistance on magnetic recording heads and corrosion resistance on some small parts.

I wasn't very busy during the early design stage while we were at Broad and Spring Garden and I received an interesting assignment: go to the Franklin Institute Library and read and report on some articles on the work Dr. Shockley was doing at Bell Labs. So I reported about the work on transistors. I remember reporting that it looked promising but there was a long way to go before transistors would be available for computers.

The Yellow Cab Company acquired the Broad and Spring Garden Streets building and became our new landlord soon after we had moved from Walnut Street in 1948. Not very long after that, some time in 1948 or 1949, Eckert-Mauchly had outgrown the space in the Yellow Cab Building which made installing the plating machine in the Spring Garden building moot. We obtained a release from Yellow Cab allowing us to vacate under reasonable terms, and we moved to a vacant knitting mill on Ridge Avenue between Allegheny and Lehigh Avenues.

I learned from Pres that had Yellow Cab not agreed to the release, we would have obtained a "contract" to test automobile horns 24 hours a day or something similar. Another observation about the Yellow Cab operation: the taxicab dispatch transmitter signals were picked up by the BINAC circuits which then had to be shielded.

An important early decision was that the magnetic properties of the plated tape must be continuously monitored during the plating process. This meant that at the end of the plating line just before spooling, the finished tape had to pass thru a B-H hysteresis loop tracer. The design of the in-line B-H loop tracer was discussed at length by Pres Eckert, Frazer Welsh, Ted Bonn, and me. Ted Bonn's loop tracer used two alternating current magnetizing coils with two sensing coils, into one of which our tape samples were inserted--the other sensing coil being used to neutralize the air induction in the first coil. The magnetizing coils got very hot, so the B-H loop test had to be done rapidly and the magnetizing current switched off before the coils burned up. The loop tracer on the plating machine was expected to run continuously, so overheating could be a serious problem. From elementary text book theory, the magnetizing field strength in a coil of fixed dimension depends on ampere-turns--the product of current times the number of turns of wire. Therefore it didn't matter whether we used many turns with a small current or a few turns with a large current to get the required field strength. We decided to go with magnetizing coils of about 50 turns of copper tubing, using a high current, and cool the conductor by running water through it.

Pres and I shared an amusing incident relating to the design of the production continuous loop tracer. He became concerned that the Philadelphia water supply pressure might not be enough to cool the coils adequately. I found a pressure gauge and Pres and I went down to the basement to check. I attached a heavy hose to the gauge and held the hose against the water faucet and turned the handle. We just had time to observe the pressure when the hose got loose and squirted us. It got a laugh from both of us. [The pressure was around 50 PSI, much higher than needed.]

The availability of a large basement at Ridge Avenue solved the problem of where to put the tape plating facility. The large electroplating room became my domain until around the beginning of 1952 when George Sutton became foreman over the production team. My technician during much of that time after the plating machine was built was Robert Laurens, a Belgian who had been a merchant ship sailor during WWII, and who was a good mechanic and chemical technician. Eventually, with tape production running smoothly, I was released to the engineering department for development of plated memory disks. I worked for Reed Stovall on that project until I resigned in the spring of 1952 to work for a chemical company for a year before joining Burroughs in 1953.

I forget how many months elapsed before we had the tape plating machine running, but it was a very interesting period. We created a concrete-lined trench in the concrete floor to drain waste water from the plating process rinse tanks. A student summer helper [a neighbor of Frazer Welsh's, last name: Ryan] and I learned to operate a jackhammer for opening up the trench. [The Good Lord preserved our hearing, I know not how, and I still sing in choirs and choruses. The first chorus we sang in had just been started by our technical writer, Joe Chapline, organist and choirmaster at St. Peter's Episcopal Church in Mt. Airy, Philadelphia.]

My young helper and I continued to get the area ready to hold the plating machine and when we got the main structural elements from the shop we assembled the framework of the machine. Some of the smaller parts had already been made at the Spring Garden Street plant, and as more finished parts became available, we completed the assembly. I suppose there were more than a thousand parts. I ordered the chemicals and other expendable supplies. It was sometime late in 1948 before we were able to run the machine to test its ability to handle tape. My high school friend and helper had started college before he had a chance to see the finished machine.

Electroplating requires direct current electrical power. While still at Spring Garden Street, I had calculated the required current and voltage and with advice from Pres Eckert I designed a power supply using heavy transformers bought from a war surplus store nearby on Callowhill Street. We had learned the Ridge Avenue plant was supplied with two phase power [I suppose, half a century later, they may have converted to the now ubiquitous three phase power]. I explained to the store owner how we were going to use the transformers in a two phase bridge rectifier circuit which he claimed wouldn't work. I guess I told him not to worry, I knew what I was doing, and of course it worked fine.

We knew that the chemical composition of the plating bath would change with use and would have to be monitored. We obtained an instrument for measuring the solution pH and I set up a chemical laboratory in which we could periodically analyze the plating solution. The plating solution which Ted and I had developed at Walnut Street, used nickel and cobalt chlorides buffered with ammonium chloride and with the ingredient sodium hypophosphite–the special ingredient controlling the magnetic properties of the deposited alloy. The critical nickel-cobalt ratio of the plating bath changed with time and had to be periodically corrected. Chemical control of the plating process was comparatively easy thus the laboratory became available for other chemical problems arising in the plant.

The phosphor-bronze base tape was one mil [one thousandths of an inch] thick and half an inch wide. It had the strength, flexibility, and smoothness required for the tape handling units–then under development by Bob Mock and Ned Schreiner under Frazer Welsh. The thickness of the plated surface was a bit less than one tenth of the base tape thickness [0.08 mil]. We never measured it directly, but calculated it from the difference in weight between a sample of tape before and after plating.

Much earlier, when first working with the electroplating bath combined with the reducing chemical, Ted and I had wondered if the addition of the reducer would cause additional metal deposition beyond what would be expected from Faraday's Laws of Electrolysis. We included in some of our measurements of plating thickness, measurements of current and time, calculating the weight of metal to be expected. The answer is that the addition of the reducing agent did not cause significant additional deposition as measured by the ordinary laboratory equipment in our facility.

The plating machine had to move great lengths of phosphor-bronze tape through seven different baths. The tape was conducted through each cleaning and rinsing bath on a frame holding two stainless steel rollers. The photo below shows the arrangement of the frames and the diagrams show how the tape moves over the top roller then down and under the bottom roller and up again to the top roller. The bottom roller was angled enough to offset the tape by a little more than its half inch width so the return of the loop came up alongside the previous loop. In the actual machine, there were fifteen loops. I was reminded by Ted Bonn after he read the first draft of this paper that the idea for setting the top and bottom rollers at an angle came from Frazer Welsh.

The frame and the bottom roller that dipped into the plating bath were made of a non-conducting material to prevent alloy being deposited on them. The second plating machine had two frames in the plating bath allowing twice the plating speed. All the upper rollers were kept above the liquids in the tanks. The upper rollers above the plating bath were of a special metal alloy to prevent corrosion by the plating bath and still conduct the current required for the electroplating process.

The photograph of the tape-plating machine shows it not in use, with the working parts out of the tanks which can be seen in back of the tape handling mechanisms. The machine was raised and lowered by a small electric motor helped by the heavy cast iron counterbalance weights that can be seen in the photo. When not in use, or when being serviced, the raised machine is rolled on tracks away from the tanks. Eventually, the plating machines were moved to the Pep Boys Building on Hunting Park Avenue where the photograph shown was taken.

After I became a Burroughs employee, I visited the plating room at the Pep Boys building during an open house at the Sperry Rand plants in Philadelphia when the I.E.E.E. [an engineering society] held a meeting in Philadelphia. My friend, George Sutton, the foreman of the plating shop was describing the operation of the plating machines to guests when his voice failed and I relieved him for about half an hour while he rested his voice.

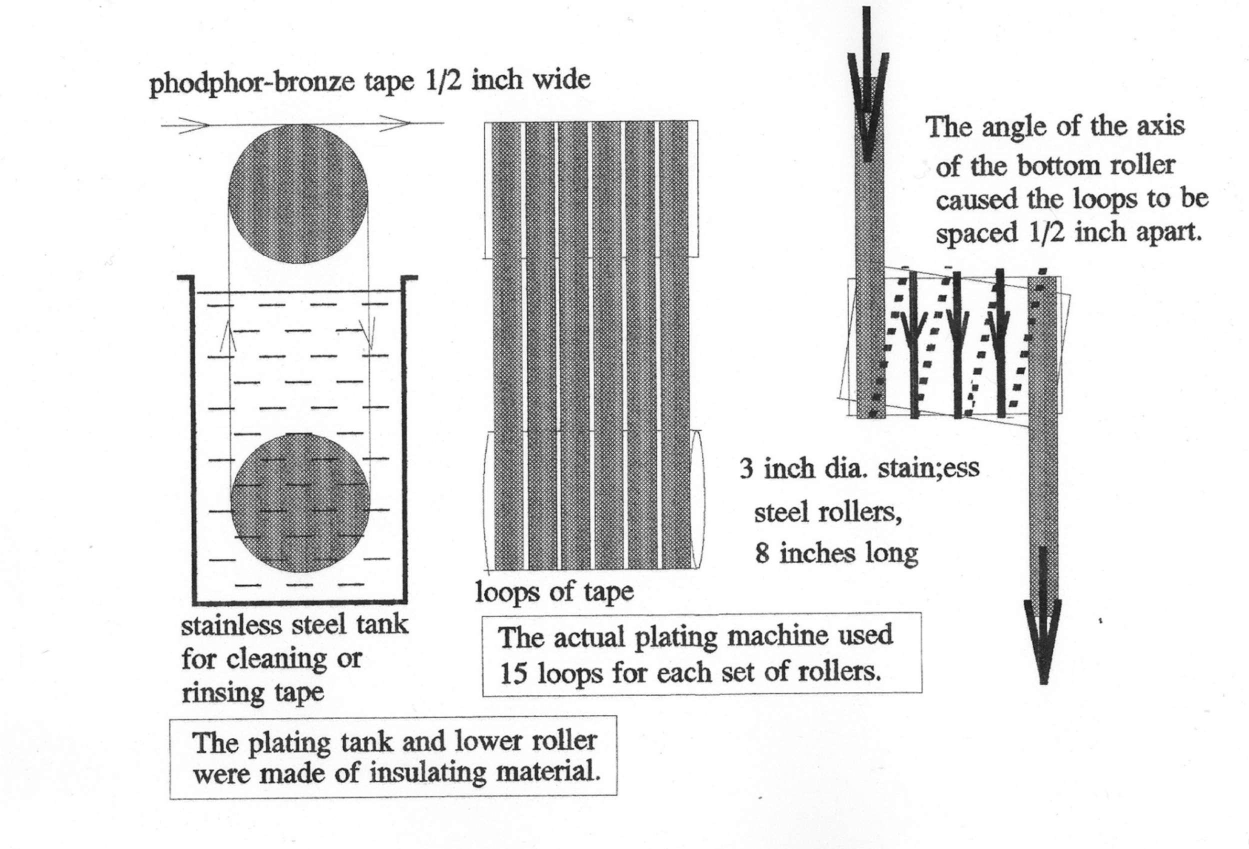
The picture of the plating machine came from a Sperry-Rand brochure from the 1970s–an employment promotion for hiring engineers mailed to me around 1970. I did return to Sperry in 1979, but as a programmer and worked there two years before returning to Burroughs not long before the merger with Sperry Univac. I did get to meet Herman Lukoff and Pres Eckert in my second term at Univac and I was there when, sadly, both John Mauchly and Herman died – I attended both services.

What a learning experience those years were for me! I learned a ton of stuff about all kinds of electroplating there, which was a great help when I went to Burroughs. I learned a lot about corrosion resistant materials as well as mechanical and electrical design. I had to learn how to manage and train a crew of operators. And, in celebration of a most memorable occasion in July of 1949, six people from the Ridge Avenue plant [plus six wives or husbands] traveled to Morristown, New Jersey to attend my wedding to Nancy Carpenter.

For 25 years I did design, engineering, and laboratory research work in chemistry and physics. I finally switched into programming in 1972, starting at hardware level [microprogramming]. Later I programmed in machine languages, and finally in the high level languages Pascal and Algol. During my two years at Univac from 1979 to 1981, I did only microprogramming. I retired in 1991 from both Burroughs and Univac simultaneously [Univac and Burroughs had merged in 1986 to become Unisys.] My final assignments at Unisys were to write instruction manuals for several machine level computer programs.

When I returned to Univac in 1979 after working 26 years at Burroughs, I renewed my friendship with Tony Occhiolini who then kindly provided me with the three staff pictures of the early days [1948] from the company archives. The pictures were taken at the Eckert-Mauchly plant at Broad and Spring Garden Streets shortly before the move to 3747 Ridge Avenue. I also want to thank Ted Bonn for helping me get started. I thank the many friends I worked with for welcoming me back when I returned to Univac in 1979.

SIMPLIFIED DIAGRAMS OF TAPE HANDLING MECHANISM

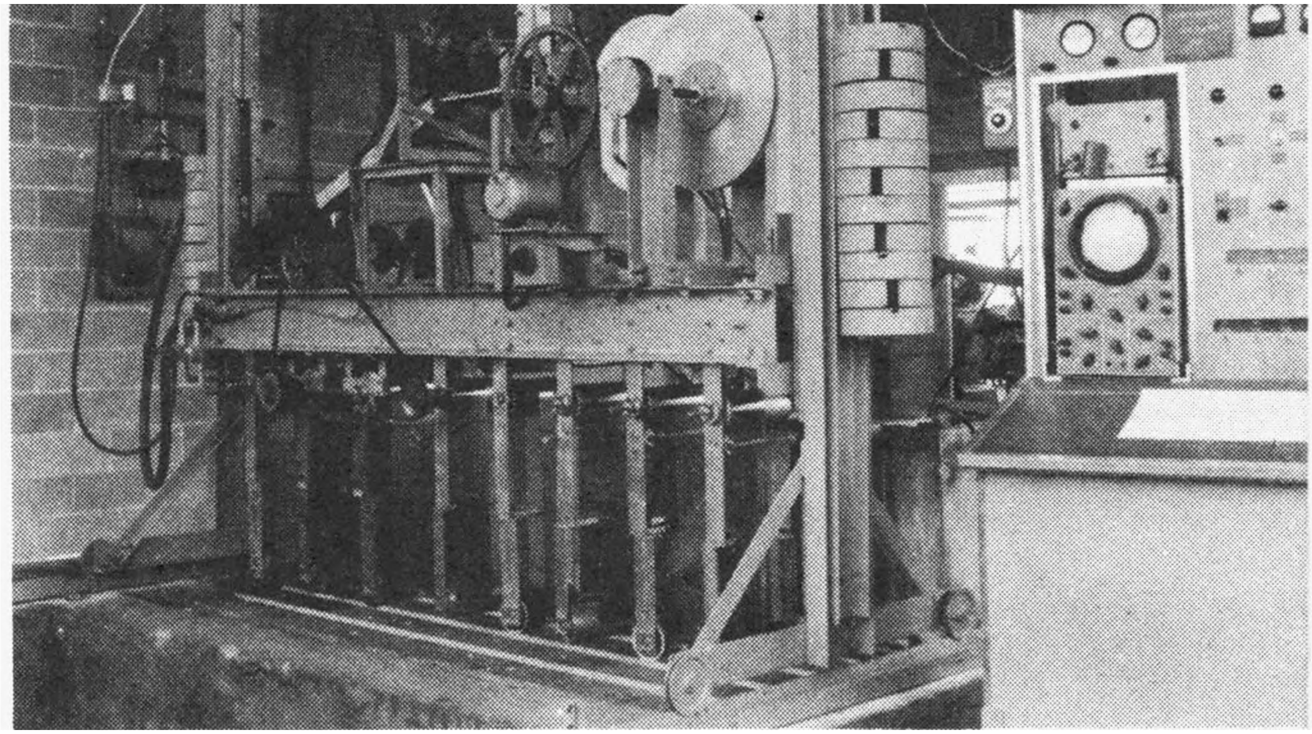


The tape was moved at a speed of around six inches per second [twelve for the second machine] by a motor that turned the top roller [or rollers] over the electroplating bath. The take up spool was turned by a motor with enough torque to just keep the spool turning. Also several roller stations before the plating bath were powered by motors controlled by sensors in order to prevent damage from excessive tension on the tape.

A variable power supply capable of supplying up to six volts was designed using two war surplus transformers; each connected to one phase of our two phase power lines. High current rectifiers were connected in bridge circuits which had the advantage or reducing the 120 cycle ripple. We were concerned that the ripple might cause a problem in plating, but that was not the case. The net ripple was less than 20%.

A similar transformer operated the water cooled magnetizing coils for the B-H hysteresis loop tracer. The oscilloscope for monitoring the B-H loop can be seen next to the Tape Plating Machine [figure on next page].

TAPE PLATING MACHINE



The tape plating machine electroplated a nickel-cobalt alloy about .08 mil (.00008 inch) thick on a base tape of half inch wide phosphor bronze, one 1 mil (.001 inch) thick. It plated at a rate of approximately one foot per second on the machine shown. The finished tape was re-spooled onto conventional computer tape reels for computer data storage. This machine was the larger of the two built, having twice the tape speed of the first machine. Both machines were moved from Ridge Avenue to the Sperry Rand facility leased from the Pep Boys Company on Hunting Park Avenue.

{Editor's Note: *This document's text, drawing, and photo were received from Al Rollins, the webmaster for the Blue Bell retirees' club web site. Some reformatting from the original text was done to facility use as a Legacy document on the VIP Club site - July 23, 2008.*}