AUTHOR – Harry Goldbacher

Except for several temporary reductions of force I was continuously employed from my initial 1965 hire until my involuntary retirement in 2007 – by Univac, Sperry Univac, Sperry, Unisys, Paramax, Loral, and finally Lockheed Martin.

Memories of my time at Univac, Blue Bell are fond ones I often revisit and tell to folks one and two generations my junior. Though they sometimes look at me in disbelief and puzzlement, they seem to enjoy these early computer age stories.

PREFACE

Initially, this paper was meant to augment a 2008 article, *"Plated Wire Memory Usage in the UNIVAC Minuteman Weapon System Computer,"* by Larry Bolton, Clint Crosby, and Jim Howe. In April 1965, Joseph S. Mathias, PhD, (Dr. Joe) hired me as a Chemical Technician in the Univac Physics and Materials department at Blue Bell, PA. My job was to work on the plated wire program, then in its early stages.

I was inspired to write this paper by recently found photos from the mid 1960's – photos of the *"wire machines,"* as they were often called. To the best of my knowledge [and the remains of my long-term memory some fifty years after the fact], here is how it was on the wire program. Comments, corrections, and additions are welcome. More important, however, enjoy the read.

THE PRODUCT

A 9 mil diameter, 16 inch long Be-Cu wire on which was plated a 10,000Å magnetic film of 80/20 Ni-Fe (Permalloy), having two stable magnetic states (unilateral anisotropy) and Non-Destructive Read Out (NDRO) properties: i.e., the *Plated Wire Memory Element.*

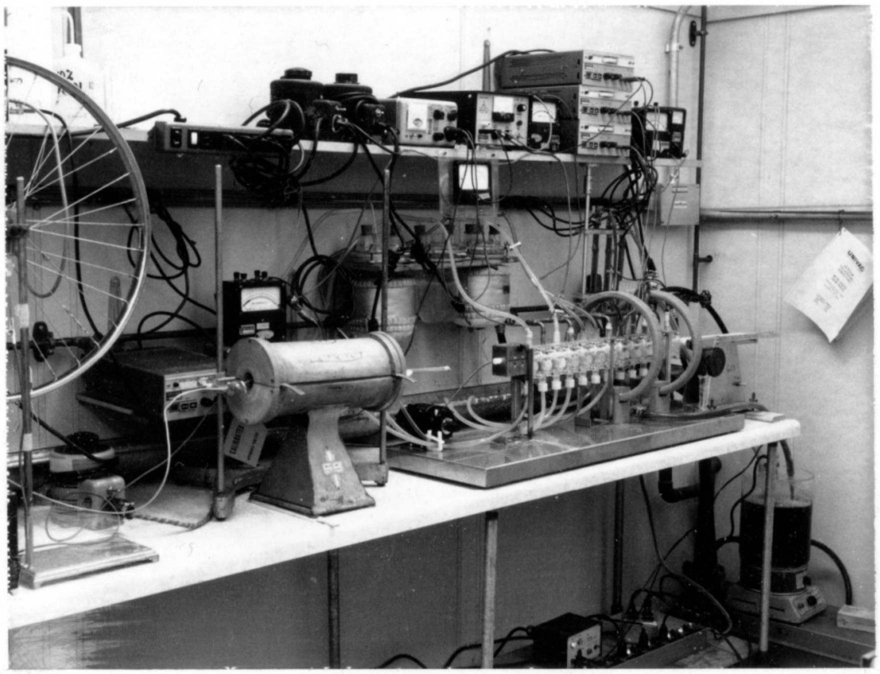
EARLY WORK

For research work at Blue Bell, Little Falls Alloys provided this 9-mil wire substrate on spools six inches in diameter. We unspooled (unwound) the wire into a cardboard barrel to relieve the twisting induced during the manufacturing and spooling processes; then, rewound it a couple of hundred feet at a time onto a bicycle wheel from which the wire was later fed into the experimental plating line. These un-windings and re-windings we called *Wire Droppings.*

The early, pre-manufacturing plating line prototype was called the *Research*, or for obvious reasons, the *Bench Plater.*[see photo on next page]. When plating processes became better defined and more repeatable it was still used for limited production and certain experiments.

Magnetic testing was performed manually, off line, at the *Test Bench* [not shown.] Here, random wire samples were inserted into and pulled through a test fixture, a hollow tube about half the size of an AAA battery, where we measured easy and hard direction magnetization (Hc and Hk), and magnetostriction (μ). To measure μ, the wire was fixed at one end and twisted at the other to determine at what angle of twist an unacceptable change in magnetic properties occurred. We also tested for DRO (destructive readout) and ABD (adjacent bit disturbed), phenomena which defined *Bad Spots* or *Failures.*

By these means, we were able to manually tune the plating process by adjusting solution temperatures, electroplating currents (voltages), pH's, and concentrations. By the time the manufacturing process had matured, all the testing [except *Twist*] had been automated.



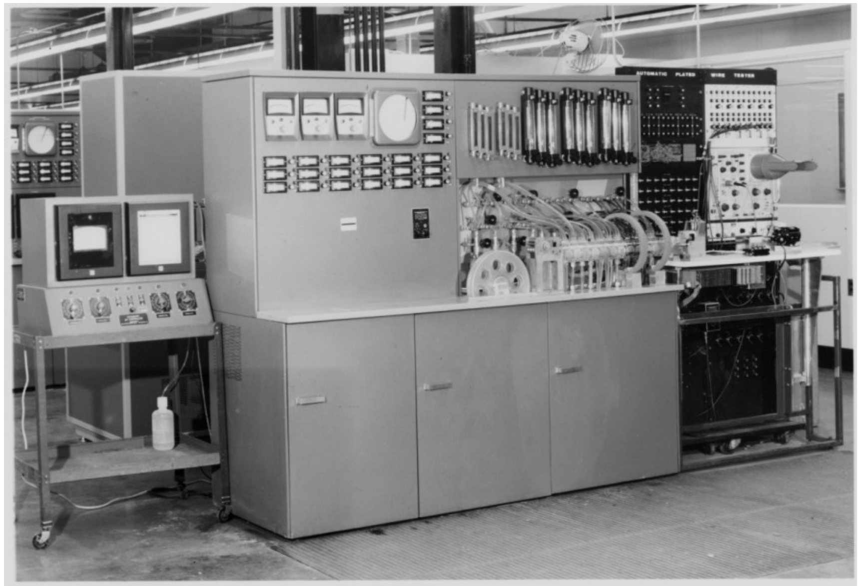
Bench Plater, c. 1965

Having built a high volume, automated prototype plating system, and deployed a number of production units [12 at Blue Bell], we acquired a wire drawing machine from Little Falls and drew our own wire from the 20 mil stock down to the 9 mil substrate.

MANUFACTURING PROCESS

After the on-line anodic cleaning and acid etching processes, the wire was plated with copper to provide a uniformly rough surface on which the Permalloy film was deposited, plated in the presence of a magnetic field to establish the film's anisotropic, two stable magnetic states (1 and 0), required for memory elements. [Notice the Helmholtz coils around the Ni-Fe deposition cells.]

The source of copper was a solution of copper cyanide (CuCN); the Permalloy, one of nickel, iron (ferrous sulfate), and cobalt, with 1,3,6-napthalene trisulfonic acid trisodium salt hydrate (NTS) added as a film stress reliever during the deposition process. Solutions were closely monitored for pH and concentration then adjusted by the technician as required.



Production Plater, c. 1967

PLATING LINE

The wire was pulled directly from a plastic spool and pushed through the line by a set of "pull/push" rollers; pushed because at a diameter of 9 mils, the force required to mechanically pull the wire off the spool and through the length of the plating line would have placed it under undo tension during the deposition process; and the deposited film could suffer magneto-strictively due to substrate distortion when the tension was relaxed.

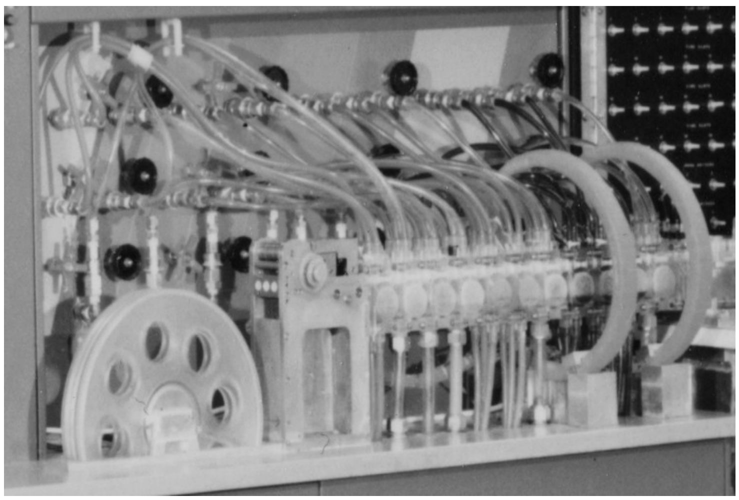
Inside each cell was a Teflon diffuser designed to not only create a uniform, air-free liquid flow through which the wire passed, but to also provide a hydraulic assist in its passage through the system, a design which minimized the jamming caused by the pushing process. The diffuser redirected the flow from perpendicular to the wire, to a flow jet nearly tangent to and in the direction of wire travel. Nevertheless, a jam detector was designed which when activated, shut off the wire drive and plating currents, and sounded an alarm.

Within each plating cell diffuser, was a platinum anode complementing the cathode [wire]. Technicians controlled the voltages and solution flows. Production units did not require the annealing furnace used on the research unit to relieve internal substrate stresses and straighten the wire prior to plating. The production plating line consisted of:

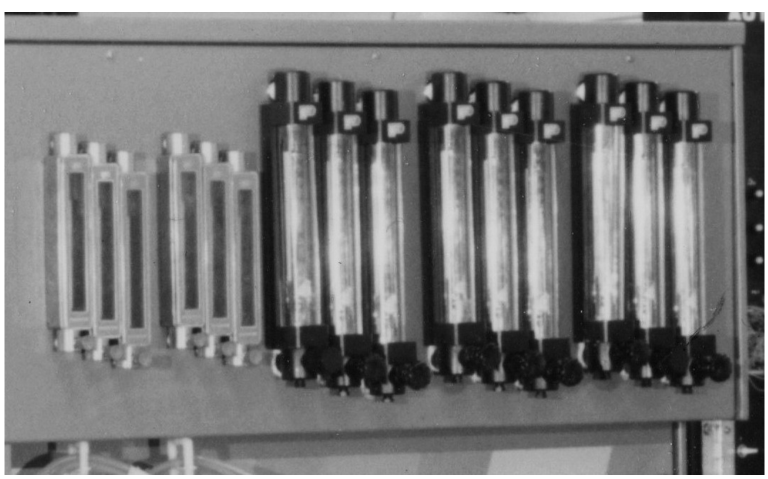
- Wire "push/pull" roller drive
- Anodic caustic wash, one cell; remove lubricant left over from drawing process
- Water rinse, one cell [preferable distilled water]
- Acid etch, one cell: roughen surface in preparation for copper plating.
- Water rinse
- Copper deposition, two cells; deposit uniformly rough surface prior to Ni-Fe deposition.
- Water rinse

- Ni-Fe deposition, three cells; deposit an 80/20 Ni-Fe film of 10,000Å in the presence of a magnetic field parallel to the wire.
- Water rinse
- Mercury contact: provide terminal connection for dc current passing through the wire during plating and automated testing processes.
- Cutter: cuts the wire at prescribed length. Should a failure be detected before a specified length is achieved, the cutter is activated and the failed length, discarded. Acceptable wire pieces were boxed in a grooved, plastic palette/box for storage.

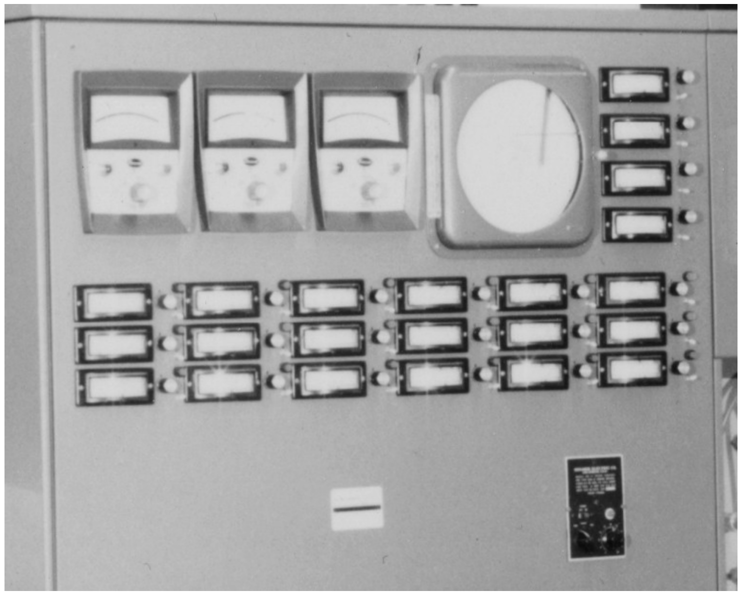
The cutter did not mechanically cut the wire, but applied a short duration, high voltage current between the two small mercury pools just after the test fixture, effectively cutting out the failure. It was occasionally called the "Zapper."



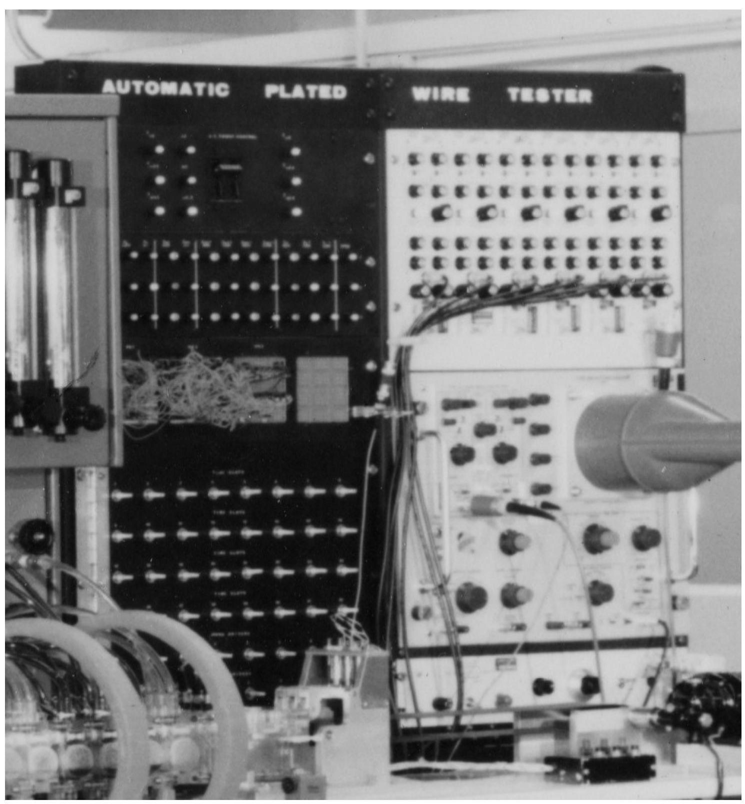
Plating Line



Solution Flow Controllers



Current, Temperature, Controllers and pH Monitor
(Wire travel speed controller, lower right)



On-line Automated Wire Tester

ENHANCED MANUFACTURING PROCESS

Efforts to increase manufacturing throughput were moderately successful. The manufacturing plating line was modified to accommodate three wire lines in one system, an improvement over the single line capability of the research and early manufacturing prototypes. [The line shown above is such a triple barreled system running with one spool.] Typical production wire speeds ranged between 18 and 24 inches per minute, but experiments were conducted with speeds up to 100 inches per minute. The Blue Bell wire plating facility, at management discretion, sometimes operated three shifts, seven days per week.

WIRE-SPEAK

Staff who worked on both the research and manufacturing side of the program had a jargon few outside the program knew:

- **Nuts** – 1,3,6-napthalene trisulfonic acid trisodium salt hydrate (NTS)
- **Fizzy Pump** – small 60 cycle oscillating pumps used to circulate process solutions
- **Locked In Solid** – a condition where long continuous lengths of plated wire passed through the system without error. Named so because all the lights on the automated tester remained green for long periods of time.
- **Super Wire** – an expression used especially in the days of manual testing for wire with unusually good test results.
- **Drawing Room** – the area where the Little Falls wire drawing machine was located.
- **Whammy** – a 24 hour, 3-shift manufacturing run. (Double Whammy, a 48 hour run.)
- **Almond Joy** – the acid etch was HCl. The copper plating bath, CuCN. Should acid and cyanide accidentally mix, the results would be lethal hydrogen cyanide gas (HCN). Though no one we knew ever smelled it and lived to tell, we were advised that this deadly gas has the odor of burnt almonds. We took special care with these reagents.
- **Unit Charge** – for a manual test, the technician had to walk a wire sample from the research plating room to the test bench, a distance of perhaps fifty feet. From six or eight feet away a nine mil wire is not visible to a passer-by, who hence, only sees a fellow employee with one hand held palm down at chest level, holding between his thumb and forefinger a small, invisible object, the *Unit Charge*.

Harry Goldbacher - a.k.a. Goldbacher, H.
hired 04/26/65 - Univac Life No. 006189
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Editor Lowell A. Benson's notes:

1. UNIVAC/Sperry used plated wire memory in the commercial 9200 and 9300 computers produced in Blue Bell, PA and in the AF AN/UYK-11 Minuteman launch and control computers produced in St. Paul, MN.
2. Thanks to Harry for finding the 2008 article on our website and for taking the time to create this engineering and production process description paper.