# *You Should Meet Melville Eastham*

Charles H. House, December 10, 2010

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*When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science.*

*— William Thompson, Lord Kelvin, (1824-1907)*

The *Electronic Design* Engineering Hall of Fame in December 2010[1] honored inventor Melville Eastham, founder of General Radio, for his contributions to the electronics industry, especially his bold and forward-thinking leadership in fostering outstanding employee policies. Much of what became known as the HP Way at Hewlett-Packard traces back to Eastham's strong practices and his benevolent outlook re competitors.

Hewlett-Packard today is world-renowned as an electronics and computing giant; General Radio, however, is known to but a few history buffs. What happened?

General Radio (GR) was a Boston firm which created the entire field of electronic instrumentation, beginning with the American advent of radio. When World War II broke out, General Radio was five times larger than any worldwide competitor. It had a reputation not only for developing terrific instrumentation for electrical engineers, but also for establishing leading business policies. GR revenue was twenty-five times larger than that of the fledgling three year old Hewlett-Packard at the start of 1942.

Eastham and GR had crafted a close alliance with the Massachusetts Institute of Technology (MIT) for many years, and when MIT spearheaded the academic /government alliance for electronics research and development during World War II, GR supplied key leadership and technology. MIT was without question the cradle of American electronics innovation at the time, underscored by winning an astounding $117 Million in government awards for military electronics work during the war. The spin-out Harvard Radio Research Labs garnered another $30M. Although Stanford had pioneered much radio technology, their pre-eminent radio engineering leader, Fred Terman, moved east in early 1942 to manage the Harvard Radio Lab. The net result: Stanford was awarded a paltry $50K during the entire war.

Eastham, 53, took a half-time leave from General Radio to manage a radio navigation system at MIT's Radiation Labs as well as serving in Washington as a co-director for the prestigious Office of Science Research and Development (OSRD) that guided the university funding. Donald Sinclair, 32, who would succeed Eastham as GR's Chief Engineer, then President and finally Chairman of the Board, also divided his time and led the Search Receiver section at the Harvard Radio Research Labs for Terman.

General Radio management, faced with huge wartime demand for their products, concluded that they would rather subcontract more than half of their orders, mostly for the less complex equipments, to other manufacturers instead of developing a much larger manufacturing presence. Terman and Eastham steered several contracts to Hewlett-Packard, which greatly increased HP revenue without taxing HP engineers. *The HP Phenomenon* notes that: "HP's contributions were mechanical only – machine lapping and honing surfaces, which improved electrical performance."

While Hewlett-Packard grew substantially during the war, the post-war wind-down led to a seventy percent reduction in staff, to sixty-five people; General Radio, by contrast, maintained its four hundred and forty person workforce. Entering 1948, General Radio revenues and employees were six times larger than HP. Moreover, at a time that television was becoming the new electronics fad for America, General Radio had products ready for television production, broadcast, and reception, while Hewlett-Packard had nothing of consequence for television engineers, operators, or users.

Melville Eastham, aged sixty-five, retired as CEO and from the General Radio Board in June, 1950, virtually simultaneously with the outbreak of the Korean War. Donald Sinclair took over the engineering labs; Arthur Thiessen became President. Television did indeed 'take off' – from a base of 3.6 million television sets in 1950, America added another twenty million sets in the next three years, overlapping the Korean War.

And yet, when the Korean War ended, HP was thirty percent larger than General Radio. What happened?

In late 1939, Stanford Engineering Dean Fred Terman called David Packard and Bill Hewlett early one morning to say that he had a visitor in town, Melville Eastham, the founder and President of the General Radio Company, based in Boston, Massachusetts. Terman casually told the two, "I think it would be good for you to meet him."

Packard, 27, was very uncomfortable with the idea, since Eastham was the leader of their chief competitor. The meeting occurred, however; the young pair related later that it was cordial, marked by the old gentleman's "welcome" to the club of ethical competitors. They took note of it, listening very carefully to his multiple stories about how to run a company.[2] Terman mused later that they learned well, modeling much of HP's 'humane' evolution on the wisdom that they learned during this encounter rather than from Packard's stint at the much more impersonal General Electric.

Eastham was an incredible pioneer, both for the field of electronic instrumentation and for enormously far-sighted employee-centered business practices. Each would be profoundly significant for the young Hewlett-Packard Company founders. Eastham grasped in 1915 the idea that the nascent radio industry lacked high quality measuring instruments. Precise tools existed to measure electrical parameters (voltage, resistance, and direct or alternating current) but Marconi's radio waves and the signals possible with de Forest's audion tube were not yet able to be quantified. The electronic instrument business evolved slowly, GR leading the way. This is well described in a GR 50th anniversary monograph by CEO Arthur Thiessen: [3]

> In 1924, GR began developing a long line of products, many of which were firsts in the electronic instrument business. The first commercial low frequency audio oscillator (the Type 377) was announced by GR in 1927. This oscillator was followed in 1928 by a beat-frequency oscillator (the Type 413).

For GR's eleventh anniversary (June, 1926), the first issue of the GR *Experimenter* appeared, "published each month for the purpose of supplying unbiased information pertaining to radio apparatus design and application. We aim to treat fairly and thoroughly subjects of interest to experimenters." The publication was distributed to qualified experimenters for free; in 1965, its circulation was about 130,000.

1928 was a banner year for GR, hiring five new engineers to add to the four on staff. J. Warren Horton, an MIT graduate and Bell Telephone Labs designer, joined as the new Chief Engineer. GR produced its first audio voltmeter in 1928, the Type 426-A Thermionic Voltmeter, the first commercial vacuum-tube voltmeter.

> There soon followed a number of new instruments, the most notable of which was the Type 403 Standard-Signal Generator. This…was the first commercial standard-signal generator ever marketed…. This pioneer was soon followed (April 1929), by the world's first commercial primary standard of frequency…. A monumental development for its day…, the time was precisely compared with standard time transmissions, which were being broadcast daily by the U. S. Naval Observatory in Washington.[4]

Just as the Great Depression engulfed America, General Radio increased its plant size by about 60 percent for a total of 66,500 square feet, with 142 employees,. The immediate impact of the stock market crash was modest, but within a year, things became dire. Shipments, $934,000 in 1929, slipped modestly to $843,000 in 1930. But in 1931, they plummeted to $593,000 with a loss (first since 1919) of $17,000. In 1932, billings were $515,000, and orders even less at $381,000.[5] General Radio developed a novel way of dealing with this economic disaster:

> It had long been the Company's feeling that the best way to ride out these business recessions was to adjust the number of hours in the manufacturing work week rather than the number of employees on the payroll. With sales only a little more than half of what they had been, the production group could be employed (only) half time. Hard though it was to live on this drastically reduced income, it was a good deal better than walking the streets seeking a job when there were no jobs….
>
> But, the Company had to resolve another problem promptly, and that was… the salaries of the engineers and managers. Engineers were urgently needed at full time and more to complete new instrument designs whose sales would eventually help to pull the Company out of the depression….
>
> To solve this, Eastham developed an idea… known as the "K" pay plan. The basic idea is that the salaries of all who are paid under the plan shall be readily adjustable up or down with the state of business.... "K" is a multiplier by which the regular base salary of each participant is multiplied to determine his actual pay month by month…. Only those in a position to influence the course of business by their individual efforts should be under it, it being unfair to ask those not in a position to influence "K" to be paid according to its value. It has been a remarkably effective incentive system (for) 33 years.[6]

This K Plan allowed GR to maintain and even accelerate its R&D innovation pace. The rapid rise of European exports helped General Radio, as they surged from 18% in 1932 to 39% of revenues in 1937. New orders in 1934 rose to $744,000, with shipments at $676,000. Europe was enjoying the rise of radio popularity that the United States experienced a decade earlier. But in fact, the creative R&D labs were the real savior. An unusual product, the Variac, quickly became a top profit generator. It and two other 1933 releases showed the versatility of the company's engineering staff:

> The June-July, 1933 issue of the GR *Experimenter* was remarkable. In that one issue, three new products were described – each a forerunner of major (industry) significance. The most important was the Variac® adjustable auto transformer, which … provided for the first time a means to adjust 115-volt and 230-volt power-line voltages smoothly from zero to something above line voltage….
>
> A second instrument was the Type 535-A Electron Oscillograph…. In 1931, GR marketed the first commercial instrument. It was in two parts. The tube was mounted separately on a stand, and the power supply, in a separate cabinet, was connected to it by a cable. Professor Frederick Bedell of Cornell University had invented the 'linear sweep circuit', which provided a means to traverse the spot across the screen at a constant speed and with a steady display. Based upon this invention, GR produced the first commercial linear sweep circuit, called the Type 506-A Bedell Sweep Circuit. It was housed in a separate cabinet so that a complete oscilloscope consisted of three parts: the tube, the power supply, and the sweep circuit.
>
> The Type 535-A Electron Oscillograph combined the tube and its mounting with the power supply, and in 1934 GR announced the Type 687-A Electron Oscillograph, which, in addition to the power supply, incorporated the sweep circuit all in one housing. This was the first complete oscilloscope ever marketed. It was followed by the Type 770-A, an advanced design which included most of the features found in oscilloscopes today. It was never marketed, however,… difficult to manufacture and probably too expensive.
>
> This history would be incomplete without noting that a few years (later), the Company dropped their production. The reason was … the instrument, unless excessively expensive, was not suitable for most accurate laboratory work. Under the impetus of radar development during World War II, the CRT was developed to a degree that seemed impossible in the thirties. By this time GR had been out of the business for several years and had so many other projects afoot that it never re-engineered a new oscilloscope. *This was a considerable error in judgment, as the oscilloscope eventually became one of the most widely used of all laboratory instruments.*

> The third pioneer instrument of major significance described in that issue of the *Experimenter* was the wave analyzer, a very advanced instrument for its time which provided the means for making accurate, harmonic analyses of wave forms by direct measurement. The best wave analyzers of today still use the principles introduced in that instrument in 1933. *(italics added)*[7]

Thiessen's GR history is remarkable for its glimpse of business elements that were unique to the instrumentation discipline, e.g. the very wide number of products at very low volume, that necessitated a quite different set of manufacturing, quality, and inventory management skills. In 1928, for example, the catalog listed 168 'major' products, with average sales per product about $500 per month. This is much more akin to the sales of individual parts from the back shelves of Radio Shack than the sales of cell phones or personal computers. The HP of 1950 wasn't much different.[8]

GR, 25 years old in 1940, had 215 employees and $1.25 million revenue. Twenty percent of the employees had college degrees, most in electrical engineering, and fully ten percent of revenues were re-invested in R&D. Eastham continued to add benefits for his employees, putting in Blue Cross-Blue Shield in 1938 as a fully-paid company benefit for employees. Vacations were extended to three weeks for all employees in 1940, and a pension plan for retiring employees was launched in December 1941.

Pearl Harbor Day – December 7, 1941 – changed irrevocably the fortunes of both General Radio and HP. Nearly every company in almost every industry became part of a massive re-allocation of effort. But General Radio faced a very unique situation:

> For some manufacturers this transformation was radical: automobiles to tanks, refrigerators to machine guns, fertilizers to gunpowder. General Radio was faced with problems of another sort…. The first was to resist the urging of military production planners to plunge into the production of large quantity "primary" electronic requirements---military radio sets, radar (then highly secret), and the like. (GR) argued, rightly…, that there was much capacity for that kind of production in the country in plants practiced in quantity production, but that without adequate instrumentation they would be badly handicapped…. Those plants and laboratories… soon called for instruments in unprecedented quantities, and still more were required for maintenance of the military electronics gear which became ever more complex and sophisticated.

> A second problem … was the so-called priorities system. Government planners had devised a priority system whereby the makers of primary implements of war – guns, tanks, aircraft, and the like – would by first priority, receive a sufficient supply of needed raw materials. Others would have to wait. What the planners overlooked was that no gun could be fired, no airplane fly, without its auxiliary equipment, much of which was electronic, and the makers of electronic equipment could not design, test, or calibrate the performance of those complicated devices without instruments. Finally, after months of frantic conferring between GR and others in related industries and the U. S. War Production Board, the problem was understood in Washington, and corrective steps to amend the priority system were taken. When this was done and materials began to flow again,… it became obvious that the Company could meet the demand for its instruments only by taking fast and drastic action to expand its output. *A vigorous program of subcontracting was started, in which dozens of outside suppliers were provided with manufacturing drawings and know-how to make the subassemblies, leaving the critical operations of final assembly and calibration and test to the practiced GR personnel. Many of the less complex instruments were farmed out completely.*
>
> Multiple-shift operation was not practical because one bottleneck was the shortage of skilled personnel, but, by working long hours (the 48-hour week was standard) and by the most efficient use of its craftsmen and technicians, the Company was able to achieve a remarkable increase in output, which was sufficient to meet the urgent demands and almost enough to meet all of the military requirements (*italics added*).[9]

Even though much was subcontracted out, General Radio's revenues leapt from $1.25 million in 1940 to $4.5 million in 1944; full-time employees grew from 220 to 440. HP, by comparison, went from $106 thousand in 1941 to $1.54 million in 1944 in revenue, and 6 to 210 employees. At war end, sales fell for each – GR in 1946 sold $2.98 million, down 34%, and HP sold $790 thousand, down 49%. GR kept all of its full-time employees, while HP cut back severely, to sixty-five full-time folk by year-end.

Bill Hewlett and Dave Packard, both 1934 Stanford graduates, were 25 and 26 when they began their company in 1938 at Fred Terman's urging. Hewlett's thesis described his invention of a novel RC-oscillator that even after licensing a GR patent was able to be priced nearly 80% lower. It proved a solid foundation for the company. Packard soon contributed a market winning voltmeter, and Hewlett completed a sophisticated wave analyzer just before he was called up fulltime for Army duty in December 1941.

Hewlett had journeyed to MIT for his Master's Degree after graduation, studying under Vannevar Bush (Terman's PhD advisor) and Ernst Guillemin. Bush headed OSRD for President Franklin Roosevelt, with Eastham by his side, and Guillemin worked half-time with the MIT Radiation Labs alongside Eastham during World War II. The Army assigned Hewlett as a liaison between the Army research labs and the new university research groups, a role which would give him access to interesting work and people.

Packard remained at HP's helm. From **The HP Phenomenon**, it is worth noting that:

> Packard was often in Washington D.C., competing for government contracts. Fifty hour workweeks were normal for employees; Packard devoted eighty hours, frequently sleeping on premises. From Harvard Labs, (Terman) helped steer several engineering jobs to HP; they produced finished products from the working prototypes developed at MIT or Harvard Labs. Thus, HP was able to move from the Audio range – 20 cycles to 20 Kilocycles – into the UHF (Ultra High Frequency) Radio Frequency range with the Model A, designed by the U.S. Navy labs….
>
> HP, more nimble than the much larger General Radio company, won much business during the war.... Cort Van Rensselaer, an undergraduate Stanford engineering student, started at HP in 1942,… worked on an RF-frequency meter that tuned over quite a wide frequency range, for which HP had a production contract for a hundred units: "*It was designed by General Radio, but apparently they couldn't fill the needs of the buyer."* [10]

Thiessen's account of the next few years is telling:

> These years in the late forties were devoted to the steady, balanced growth of the organization, to the introduction of new and improved instruments, and to the expansion of marketing activities to cover the broader fields of instrumentation which had been the outgrowth of wartime developments.
>
> …Competition, prior to 1940, was not a serious marketing problem. GR's problem in those days was to pioneer the very use of measuring instruments. World War II and the events that followed were to change that dramatically. As the electronics industry grew, so did the instrument segment of it, the necessity for good measuring equipment had long since been well established.
>
> Immediately following World War II and the temporary slowdown of Government-financed research, hundreds of business-minded engineers and scientists decided to go into business for themselves. Many of these ventures were successful, and they were often the contractors for Government procurements.

> Because of vigorous competition in bidding, the risk of extremely wide swings in volume with changes in the direction and funding of defense work, and the allowed profit under Government contracts was generally quite low, these manufacturers soon sought business in the industrial field. One result was that electronics in general and the instrument business in particular became one of the most highly competitive of all in the intrinsically competitive U. S. economy….
>
> GR's growth would have been much greater had the Company elected to participate in numerous Department of Defense procurements of highly specialized requirements. The Company wisely adhered to its policy of self-financed, controlled growth.[11]

Coming off World War II, commercial television caused enormous public interest. GR introduced new TV monitors in 1947 and 1948 that were the first in the field. Also, in 1948, after field tests and demonstrations lasting two years, the unique Type 874 coaxial connectors were announced. GR seemed poised to profit extremely well from this new broadcast medium; HP was absent in this arena.

But General Radio passed up a second opportunity – microwave signal generators. Not only did GR invent the first wholly integrated oscilloscope, they had pioneered wideband signal generators and frequency sweepers. These tools were fundamental for both the MIT and Harvard Research Labs, as well as for the Navy and Army Air Force during the war. At war end, the Navy tried to sell their unfinished program back to industry – notably to both GR and to Varian, which had produced the essential microwave tubes. Each declined, believing that the commercial markets were too small.

The strategic choices at this point would prove crucial. Both MIT and Harvard Labs had heavily invested in microwave radio, radar, and sonar during the war with great success. Each had dabbled with computers as well, but the key contribution in that arena was at the University of Pennsylvania with ENIAC. Radar, sonar, and computing were all 'digital' technologies, not amenable to test instrumentation that either GR or HP built, but tailor-made for oscilloscopes that GR had pioneered a decade earlier.

MIT at war's end voted heavily for computing as the next wave to ride, led by both Ernst Guillemin and Vannevar Bush. Analogous to Terman's bold work in radio design two decades earlier, Guillemin wrote a textbook that provided unifying mathematics to link the analog and digital realms via Fourier transforms, giving analytical backbone to the value of oscilloscopes as the primary analysis tool. Vannevar Bush provided an even more exciting contribution with his seminal paper, "As We May Think" which caught the public imagination about how computers might impact the 'new world'.

Terman, arriving back at Stanford in 1946, was indignant about the vast sums of money that MIT and Harvard garnered from OSRD during the war while Stanford was ignored. He felt strongly about a bright microwave communications future, especially with his ex-students who had founded companies near Stanford working with these technologies. And Stanford had practically no capability in digital design technologies.

Terman tried, unsuccessfully, to persuade Packard to buy the rights to the Navy signal generator program. When Hewlett returned, though, the duo not only bought the rights, but hired four key microwave designers from the East Coast labs. Packard meanwhile had interviewed Howard Vollum at Hewlett's request; Vollum demurred, opting to set up Tektronix in Portland, Oregon company in 1947 to build oscilloscopes.

Curious twists – the structure of irony. Eastham, born and raised in Oregon, would watch Tektronix emerge as a major instrument competitor, with a product concept that GR pioneered, which was vital for the computer technology that neighboring MIT was espousing. Meanwhile, HP and Stanford were chasing commercial microwave communications for which GR had created the tools, but squandered the rights.

Strategic shifts take time to evolve. In the interim period right after the war, GR was able to re-establish a strong export business, fueling sixty-six percent growth to $4.00 million over the next two years. HP grew by 175% in the same two years, to $2.18 million in 1948, selling higher frequency tools to domestic companies and radio stations, groups that had hitherto only bought instrumentation from General Radio. Tektronix, just underway, managed to sell fifty 'scopes in 1948, for $257,000.

In 1948, HP launched its first microwave sweeper, followed by six more in a decade. This was a commercial version of the Navy's microwave signal generator, invented by General Radio engineers for the Navy but oddly ignored at GR after the war.[12] Key designers Bruce Wholey and Art Fong had both become good friends with Bill Hewlett. With their skills, HP changed the rules, focusing on the microwave spectrum, several orders of magnitude faster than any broadcast medium – whether AM or FM radio, or VHF or UHF television. Instead of relying on the local radio or TV station, HP's bet was on AT&T building up the national grid of microwave repeater stations.

An ancillary bet at HP focused on frequency stability of the local broadcast station. Anyone who experienced the 'fading in and out' of radio signals in a local area during the 1930's to 1950's, followed by a mad dash to retune the station in order to hear the football or baseball play, knew how frustrating this could be. For this problem, the new HP Frequency Counter was far more effective than GR's monitors. In 1950, HP launched the Frequency Counter. It quickly became HP's best selling product.

General Radio had no counter in its lineup. Beckman, via Berkeley Labs, was the only early competitor. Al Bagley, the inventor of HP's counter, told a small audience in July 2010 that he got a call from a GR designer after two years of HP sales, who sought to know the counter's manufacturing cost (GR management believed that HP was losing money on this product). Bagley related that things were so cordial between the designers that he shared the data. Two weeks later, the same engineer called back, ruefully saying that the project had been canceled because GR management didn't believe the supplied data. Thus, GR missed another critical opportunity.

Eastham retired, aged sixty-five, in June 1950 from GR, apparently oblivious to both the Hewlett-Packard and Tektronix competitive threats, done "under his nose". Bear in mind that all three companies were privately owned, so GR couldn't "get the numbers". At year end in 1950, GR booked $4.9 Million in revenues, while HP sold $2.3 million, and Tektronix $1.2 million.[13] Three years later, GR managed only $9.8 million, 30% of it internationally. HP and Tektronix (with only U.S. sales), did $12.9 million and $5.9 million in revenues respectively.

CEO Thiessen cites the Korean War as the turning point:

> July 1950 marked the intervention of the United States in Korea, which had an effect upon the Company similar to that experienced at the beginning of World War II. The essential military requirements for all kinds of electronic equipment, including instruments, again skyrocketed. To meet its part of these requirements, the Company was able almost to double its production within eighteen months to an annual level of over $7,000,000 by the end of 1951. By 1953 business had reached an annual volume of almost $10,000,000…. In the decade between the end of World War II and 1955, the Engineering Department had been very busy, and an important series of new instruments and improvements on old flowed – into production, laboratories and industries.[14]

Business historians usually focus either on one company at a time, or on broad general trends. Each approach is inadequate to understand the issues that surround the evolution of these three companies, companies that together provided much of the design capability in world electronics for the second half of the 20th century.

General Radio, the venerated world leader, grew revenues and profits by a factor of five in the post-war decade; they were both satisfied and a bit smug about it. You would likely think that your company is 'doing fine' if you managed GR and didn't know the HP numbers. After all, the growth rate from 1946 to 1950, coming off the lows after World War II, was a compounded 15% per year, as fast as any peacetime growth in GR history. The Korean war buildup created an immodest growth rate of 36% per year for three years. The inevitable aftermath still had a 6% growth rate per year. Why wouldn't you be proud?

Meanwhile, an upstart HP, enabled by product designs from the leader's designers during a wartime crisis, assumed the leadership mantle, growing revenues by twenty-five times. Starting in 1946, HP was one-third the size of GR; a decade later, they were 75 percent larger, a monumental shift in the instrumentation power structure. And while the Korean War played an important part in the growth spurt of the company, the growth continued strongly after the Korean War which indicated that sales were not just, or even primarily, military-based, but had a strong commercial value as well.

Moreover, Tektronix had emerged in the same period, and in fact passed GR in 1956, with revenues of $16.1 million vs. GR's $11.2 million. In just six tumultuous years from the start of the Korean War until the second Eisenhower administration, the world's electronic test equipment leader – bigger than HP and Tektronix combined in 1950 – tripled in revenue, but astonishingly was now – gasp – a distant third, behind each of its rivals by a considerable amount.

Concern at General Radio headquarters in 1956 about HP led to hiring a Harvard MBA student, Thomas Perkins, to spend the summer calibrating and testing a bevy of Hewlett-Packard products against their claimed specifications. Perkins reported at the end of the assignment that not only did every HP product meet its stated specifications, but in virtually every case they exceeded them by an average of thirty percent.[15]

Still, for GR's 50th anniversary biography (1965), CEO Thiessen glibly wrote:

> The decade from 1950 to 1960 was marked by the almost explosive growth of competition and by the continuing trend in instrument design toward automatic or at least highly simplified operation. The Company shared well in this growth; its shipments grew from $4,450,000 in 1949 to $16,000,000 in 1960. [16]

The irony had to be obvious for the assembled General Radio team. HP had "gone public" in late 1957, Tektronix did so in 1963. Now, the numbers were visible; they told a savage story of missed opportunity. In 1965, GR had sales of $20 million; Tektronix was four times that, and HP was more than eight times larger. Somehow, the industry re-structuring of instrumentation eluded GR.

This was not a case of two hard-bitten companies following different principles and practices with their employees than the paternalistic flavor that Eastham created at General Radio. In fact, all three shared a common culture in that regard, and were among the leading companies in the world to instill such concepts as profit sharing, excellent health coverage, and other extended benefits. Each had incredibly loyal, dedicated, capable and enthusiastic employees – similar in almost all respects. No, the answer does not lie in managerial approach and attitude toward the employees, nor in the skills and inventiveness of those employees. What, then, was it?

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1. Compare and contrast GR and HP R&D programs and business strategies
2. Identify and rank the three key differentiators between GR and HP business strategies from 1942 through 1952; repeat for 1952 through 1960.
3. Correlate business strategies with business performance

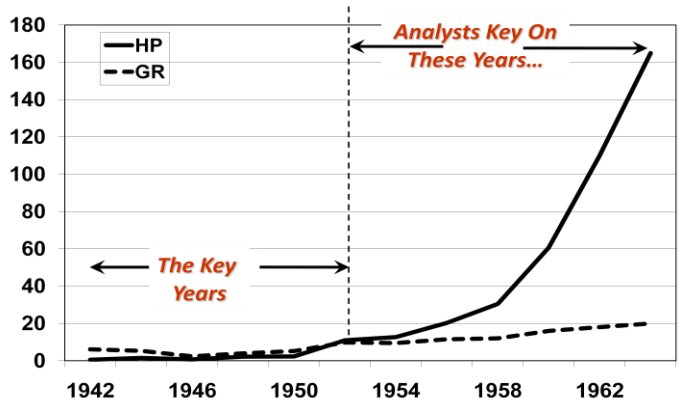


Figure 1. Annual Revenues in $ Millions

It is key to understand the 'early years' where the strategies were shaped, in order to understand how the growth rate differences unfolded later

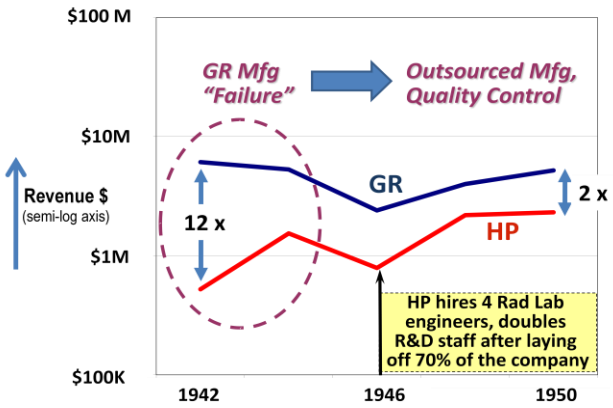


Figure 2. Revenue comparison and key events, GR and HP, 1942-1950

HP hiring of four key engineers in 1946 parallels the GR hiring of four key engineers and a chief engineer in 1928 just prior to the Great Depression.

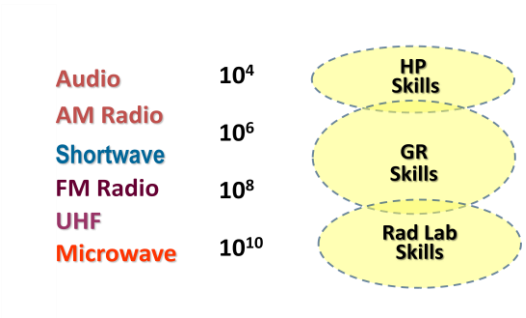


Figure 3. HP vs GR skill-sets as a function of communication frequency circa 1945

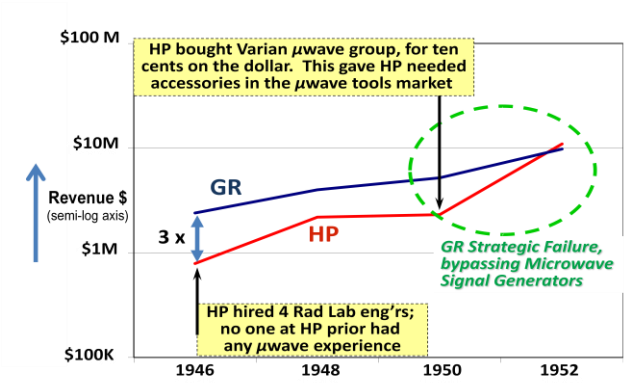


Figure 4. Revenue comparison and key events, GR and HP, 1946-1952

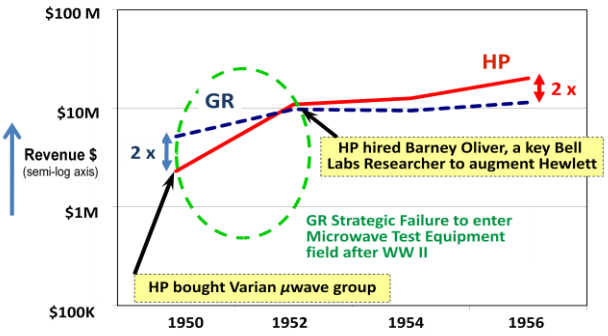


Figure 5. Revenue comparison and key events, GR and HP, 1950-1956

General Radio decided against Microwave Test Equipment at the end of WW II, allowing HP to buy GR technology cheaply; Varian likewise sold its Microwave Tools Group to HP cheaply

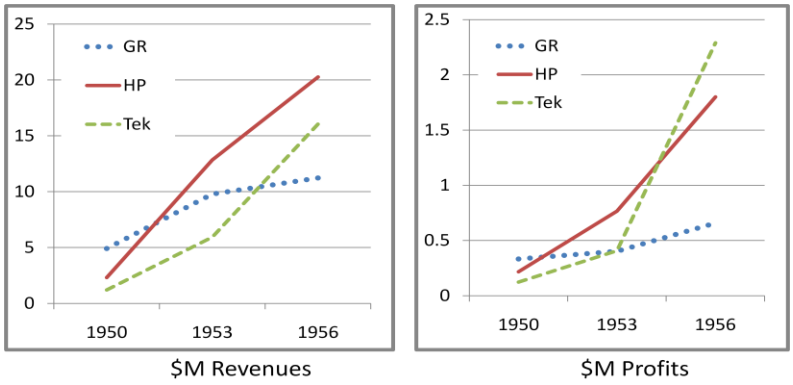


Figure 6. Revenue and Profit comparison, GR, HP, and Tektronix, 1950-1956

HP and Tektronix sales and profits after the Korean War continued strongly upward

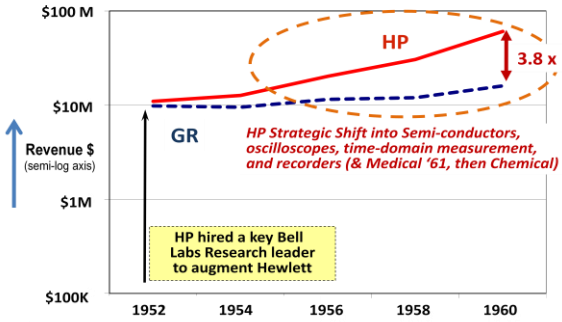


Figure 7. Revenue comparison and key events for GR and HP, 1952-1960

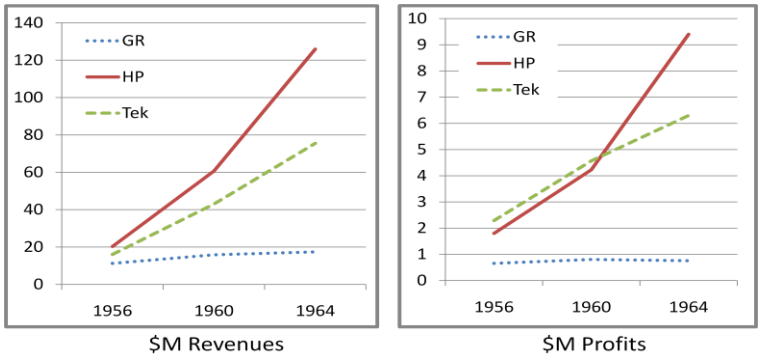


Figure 8. Revenue and profit comparison – GR, HP, and Tektronix – 1956-1964

## Endnotes

[1] ---, "Melville Eastham: Workplace Innovator Crafts Early Electronic Products, *Electronic Design*, December 9, 2010, pp. 64-65.
[2] Packard, David, *The HP Way: How Bill Hewlett and I built our company*, Collins, NYC, NY, p. 52 (must check this)
[3] Thiessen, Arthur E. *A History of the General Radio Company,* General Radio Press, Concord, MA, 1965, pp. 15, 18 . All revenue and profit data compared with data in Table 1, pp. 245-46, of Van Veen, Frederick, *The General Radio Story*, Lulu Press, 2007.
[4] Thiessen, *ibid*, p.31
[5] Thiessen, *ibid*, p.33
[6] Thiessen, *ibid*, p. 34
[7] Thiessen, *ibid*, pp. 38-40
[8] House & Price, *ibid*, pp. 21-22
[9] Thiessen, *ibid*, pp. 49-50
[10] House & Price, *ibid*, pp. 28-29, 41
[11] Thiessen, *ibid*, pp. 74-75
[12] House & Price, *ibid*, p. 25
[13] Fiscal years ended in May for Tek, June for GR, October for HP
[14] Thiessen, *ibid*, p. 57
[15] House & Price, *ibid*, p. 552; Minck, John, private correspondence, November 11, 2010. Perkins reported that "GR management was convinced that HP was somehow cheating, that there really would be no way that the prices they were charging were commensurate with the performance they boasted." Perkins promptly joined HP upon graduation from Harvard. At HP, he found unconcern: "Their (GR) products were viewed as 1930s era design, stogy, black crackle, klunky."Perkins interview, by Charles H. House, March 24, 2006.
[16] Thiessen, *ibid*, p.75