PrairieTek 220

1988   PrairieTek 220
         First 2.5" disk drive

Why this Is Important

The advent of the 2.5" hard drive blew away the portable computers of the late 1980's which came in two forms, heavy with a 3.5" hard drive, and light with a pair of floppies. The smaller size coupled with improvements in reliability and lowering of power, created a practical mobile product and enabled a new computer industry segment. The PrairieTek 220 provided 20MB formatted capacity in a form factor which used 30% less space than a 3.5" drive. When volume production began in 1989, the PrairieTek 220 displaced 25mm high 3.5" drives in the emerging portable computer market, a category which has since grown to exceed the volume of desktop machines.

Discussion

PrairieTek was founded in 1986 by Terry Johnson, who had pioneered transition of the industry to smaller disk drives during the early 1980s. His earlier background in disk development included extensive experience at IBM, Memorex and Storage Technology. Johnson had been founder of Miniscribe, an early manufacturer of 5.25" and later 3.5" drives. He was a co-founder of CoData which, as noted in his Oral History [1], evolved into Conner Peripherals.

> *Finis came up to Longmont to the guest house. He decided that he liked what John [Squires] had developed there. Finis basically came into the company and he wanted his name on the door. That was something that John and I certainly were not interested in. So it turned out that CoData became Conner Peripherals and when Finis came in the front door, so to speak, that I went out the back door.*

A new front door opened.

> *I moved on and basically funded another start-up in my guesthouse this time. So there's one for the basement and two for the guesthouse.*
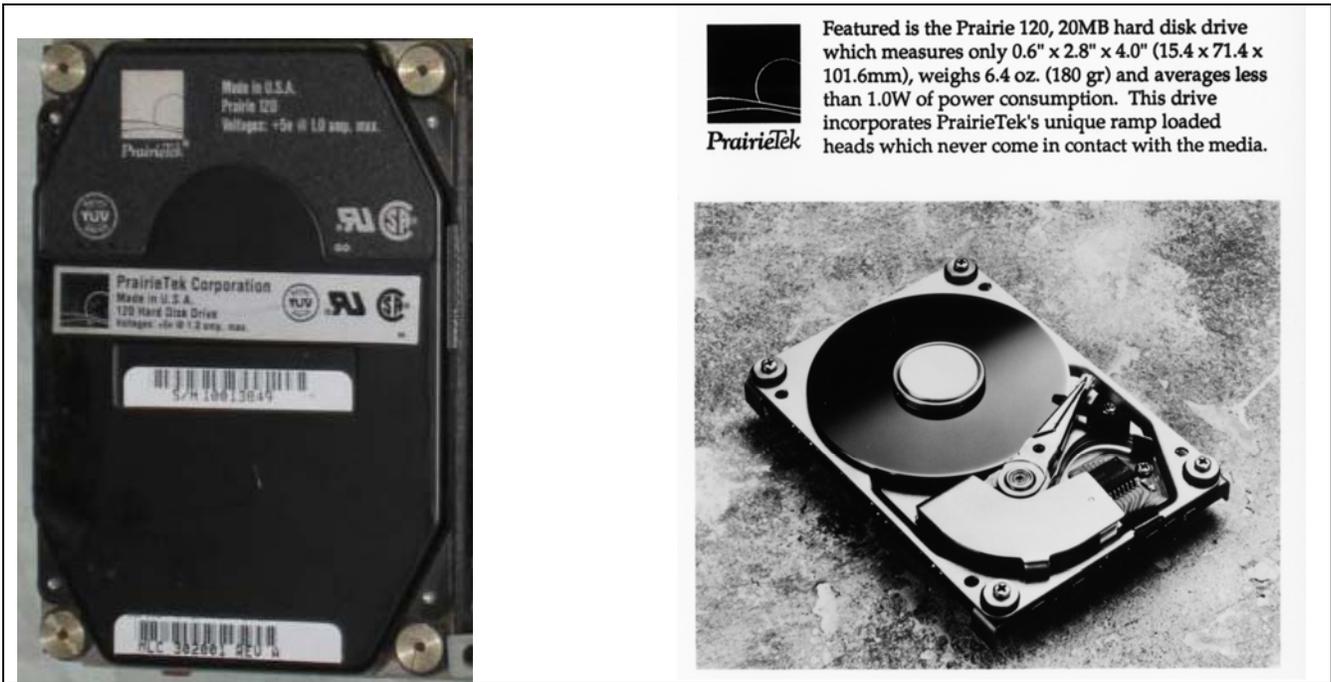
Jim Morehouse	Terry Johnson	Jim Stineheifer	Steve Volk	Ken Jochim
VP R&D	Chairman	President	VP Sales	VP Engineering

Source: Jim Porter Archive

The 2.5" drive departed from the practice of following the 5.25" and 3.5" FDD form factors, being designed expressly for portable applications. PrairieTek's volume production of the 25mm high PT220 20MB drive got underway in 1989, and the company's arrangement for additional production with Alps Electric started in 1990.

Featured is the Prairie 120, 20MB hard disk drive which measures only 0.6" x 2.8" x 4.0" (15.4 x 71.4 x 101.6mm), weighs 6.4 oz. (180 gr) and averages less than 1.0W of power consumption. This drive incorporates PrairieTek's unique ramp loaded heads which never come in contact with the media.

Source: Jim Porter Archive

HANNOVER, WEST GERMANY, 1990 MAR 24 (NB) -- Prairietek, the US company that developed the industry's first 2.5-inch form factor drive early last year, has released two more hard drives in the 2.5-inch format.

The first drive, the Prairie 120, is an even smaller version of the 20MB Prairietek 220 released last year. The 120 is 21.4MB drive with a 23 millisecond access time and tips the scales at just 6.4 ounces. The drive's dimensions measure and incredible 0.6 x 2.8 x 4.0 inches, including an integrated AT/XT drive controller. The 120 uses less than 1.0 watts of power. The 120's big brother, the Prairietek 240, is 42.8MB hard drive in a 2.5-inch form factor. The unit requires less than 1.5 watts.
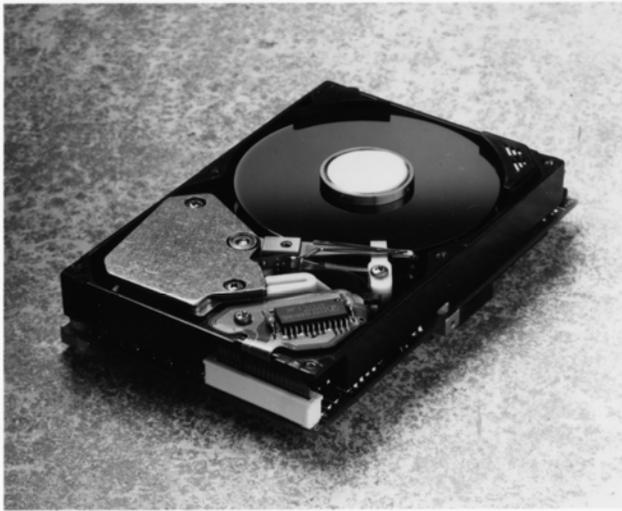
According to Steve Volk, vice president of sales and marketing with the company, the 240 is a logical step forward from the 220, the first 2.5-inch drive, since it uses the same power, yet provides twice the storage capacity. This makes it ideal for use with the latest generation of 80386SX-based portables currently under development.

Source: http://www.ddds.tk/online/hardisk info/first 2.5 hd/the first 2.5 hd.htm

JVC and Conner Peripherals were the only competitors, and the latter was first to recognize that the market was transitioning to higher capacity drives. PrairieTek's single disk 40MB model, potentially a cost-effective competitive product, was delayed by development of the 17mm PT120 and was late to market. After failing to raise sufficient cash to continue, PrairieTek ceased operations in the summer of 1991.

Featured is the Prairie 240, 40MB hard disk drive which measures 1.0" x 2.8" x 4.6" (25.4 x 72.6 x 116.8mm), weighs 9.1 oz. (258 gr) and averages less than 1.5W of power consumption. This drive incorporates PrairieTek's unique ramp loaded heads which never come in contact with the media.

Featured is the Prairie 242, 40 MB hard disk drive which measures only .75"x 2.75" x 4.0" (19 x 70 x 102 mm), weighs 7.94 oz. (225 grams) and uses only 60 milliwatts of power in stand-by mode. This drive incorporates PrairieTek's patented ramp loaded heads which never come in contact with the media.

Source: Jim Porter Archive

In 1992 Conner Peripherals and Alps purchased the PrairieTek patent portfolio for $18M in a bankruptcy auction. The portfolio covered features that were commonly adopted across industry e.g. Patent # 4933785 encompassed a broad range of novel concepts including the power management capability that ATA and SCSI incorporated into their standards.

By the time PrairieTek went out of business there were 10 other manufacturers making 2.5" drives, all with capacities larger than 20MB. Toshiba, a company which had not made desktop machines but was big in portables was an early leader, having designed a drive from scratch for their own use. Toshiba started with glass substrates in 1990 (PrairieTek used aluminum substrates).

There are no cables in a laptop to account for variances in connector position and OEM designers had to make a decision on what vendor and model disk to use before the disk was available. If the disk failed evaluation the laptop designed around the mounting holes, connectors, and connector locations was dead for lack of a second source 2.5" drive.

An invitation-only meeting hosted by Sun Microsystems in early 1990 raised industry ire. The subject matter was Sun's concern about the lack of cohesive industry direction and physical incompatibility between drives being offered (PrairieTek, Conner Peripherals, JVC). In attendance were AMP, Areal Technology, Conner Peripherals, Intellistor, JVC, Maxtor, Miniscribe, PrairieTek, Rodime, Seagate, and Zenith.

The rocky road to a common form factor began a few weeks later with formation of the SFF Committee.(2) The major differences disappeared early but the Conner Peripherals 'design to build' market strategy did little to encourage total commonality. David White, editor of the SFF-8004 2.5" Form Factor Drives specification, won industry concurrence at the November 1993 SFF meeting when he made it known that Compaq would only purchase drives which met the SFF-8004 specification. It marked a distinct change in industry attitude when, only two months later, Western Digital asked David to be editor of a project to specify the 3.5" form factor.

Although PrairieTek was not a financial success, the 2.5" design represented a dramatic technological step forward. The merits of patents have been studied extensively, and the US Patent office in its 1976 Office of Technology Assessment and Forecast wrote that:

> … the number of times a patent document is cited may be a measure of its technological significance.

A patent is deemed "significant" if it passes the 20/20 measure, 20 or more citations over a period of 20 or more years. Harhoff, Narin et al (1999) conducted a study in which they found that the greater the number of times a patent was cited, the greater the economical worth of the patent. The Hall, Jaffe et al (2005) analysis of how market worth reflects the influence of patents on company valuations includes some very interesting data.

> The most highly cited patent since 1976 is patent #4,440,871 assigned to Union Carbide Corporation in 1984…a total of 349 [citations] up to July 2003.

As of July 2003, #4,933,785 had received 173 citations, a number which makes PrairieTek an exception that illustrates rules are meant to be broken.

> …small firms...have very few highly cited patents

As of July 2012, #4,933,785 had received 211 patent citations, one issued as recently as 8/2011.

> …the mean number of citations per patent is just over three, and that the distribution is extremely skewed, with about one-quarter receiving none…6 is the median… and only a few dozen (out of millions) receiving 100 citations and more.

PrairieTek's #4,933,785 is not only in elite company, it ranges over a diverse number of areas, covering 16 different USPTO (United States Patent and Trademark Office) Classifications.

The most difficult issue to overcome in a device aimed at portable applications was protecting the data. This could not be done if the heads and media were parked on the media as in the CSS (Contact Start Stop) of Winchester-class disk drives because it does not take much of a jolt to cause head/media slap.

In 1974, Ivan Pejcha of ISS (Information Storage Systems) filed #3,984,873 to patent the load/unload of rotary actuators. When ISS did not pursue the rotary project, Ivan joined StorageTek, where he worked with Roy Applequist and Jim Moorehouse (amongst others) on the SuperDisk that first shipped in 1975.

Despite empirical evidence to the contrary, it was commonly believed that heads thrown into the media area (as was done in the era of removable disk packs) would kiss the surface, and eventually cause damage to the head or media, or both. Jim proved otherwise by using ultra high speed photograpy to film the results of swinging the head in and out over a ramp. The back EMF (ElectroMotive Force) of the motor was used to power the unload mechanism which retracted the heads when power dropped.

Ramp loading dramatically improved the number of start/stop cycles that a drive could endure before failure. The Achilles Heel of CSS was stiction, if the surface was too smooth the head slider and the media 'bonded' in the same manner as two sheets of wet glass stick together. Texturing was a process by which the media surfaces was deliberately roughened to introduce asperities that reduced the degree of stiction.

Ramp loading has been almost universally adopted on all classes of drive from notebook to enterprise class because the smoother the media, the lower the flying height, the higher the areal density. Failure has no parents and success has many e.g. Hitachi's claim(10) of being first to 'discover' load/unload in the mid-1990s pales in light of PrairieTek's first ship in 1988.

> *Load/unload technology was discovered in the mid-1990s… Hitachi Global Storage Technologies was the first hard disk drive manufacturer to implement load/unload technology, and found the wear durability benefits proven in early large hard drives incorporating the technology worthy of further research and development efforts.*

Prior to introduction of the 2.5" drive, portable computers were underwhelmingly useful. Compaq's $4,800 20MB Portable II of 1986 looked like a suitcase, weighed 26 pounds, plugged into wall power and was unpopularly referred to as a luggable. Smaller and lighter battery powered laptops were floppy-only until the $5,400 14 pound and 8" thick SLT/286 with a 3.5" 20MB disk arrived in 1988. The body was so thick, the keyboard was on a coiled tether and removed from the body.

| Compaq SLT/286 | Compaq LTE/286 |
| Courtesy of www.computinghistory.org.uk | Courtesy of http://pc-museum.com |

Only one year later, the re-packaged $5,000 6.7 pound 2" thick LTE/286 with a 2.5" 40MB drive joined the notebook market. The claimed 4.8V 5.0 A/h battery life of up to 3.5 hours was a gross exaggeration, the real life was much shorter. The biggest power hogs were the display screen and drive, and users could not stray far from wallpower.

The 2.5" drive revolutionized the laptop and notebook categories, and customer demand blew past the introductory 20MB product so quickly that PrairieTek never gained a foothold. Apple's $2,300 PowerBook 100 was introduced in 12/1991 to less than acclaim because of the storage deficiency stated succinctly by Crystal Waters in February 1992's Home Office Computing:

> *Having used the [Powerbook] 100 constantly in the past few weeks, I know I wouldn't feel cheated by buying it - if only it had a 40MB hard-disk drive option...*

Although Apple did respond with a 40MB option a few weeks later, it lagged well behind the curve of

IBM's $2,950 6.5 pound 120MB ThinkPad 700 of 10/1992. The $4,350 7.6 pound 120MB ThinkPad 700C cost 50% more because it had a color screen. The claim to fame of the re-badged Zenith sold as the $2,199 ThinkPad 300 was up to 10 hours of battey life (5.9 pounds and 120MB). The short-lived 3.8 pound 170MB ThinkPad 500 introduced in 8/1993 was withdrawn only four months later.(12)

The 2.5" drive spawned a wave of innovation in mobile computing, which saw product lives measured in months, not years. This flurry required and relied upon display screen improvements and ever-increasing storage capacities: the 1992 Disk Trend report listed 11 manufacturers of 100-200MB 2.5" drives.

Alps Electric	Fuji Electric	Maxtor	Toshiba
Areal Technology	IBM	Quantum	Western Digital
Conner Peripherals	JVC	Seagate Technology	

PrairieTek lost its 1989 shipment lead in 1990. and Conner Peripherals never relinquished it. Capacity reached 60MB in 1990, and total ships of all sizes hit 869,000 by year end. Laptops were very much single drive installations, so drive shipments multiplied by average laptop prices represented market segment revenue. At an average price of $3,000, notebooks represented $2.5 Billion in revenue. No wonder every manufacturer was chasing the pot of gold and pressuring drive vendors to keep increasing capacity - the objective was to come up with an all-in-one replacement for desktop systems.

Year	<30MB	,000	30-60MB	,000	60-100MB	,000	Total
1989	PrairieTek	20	US Other	1			
	Conner	4					
	YE Total	24	YE Total				
	Top 3	100%	Top 3	1			25
				100%			
1990	Conner	485	US Other		Conner	15	
	PrairieTek	110	Conner		US Other	1	
	JVC	185	Tohiba				
	YE Total	780	YE Total		YE Total	16	844
	Top 3	100%	Top 3		Top 3	100%	
						Source: Disk Trend	

Capacity and shipment growth continued rising without any interruption in pressure, and by year end 1992 almost seven million more drives had shipped. Prices were dropping, and at average laptop price of $2,500 those drives enabled an additional $17 Billion in segment revenue.

Year	<60MB	,000	60-100MB	,000	100-200MB	,000	Total
1991	Conner	1,065	Conner	915			
	JVC	460	WD	103			
	US Other	105	US Other	83			
	YE Total	1,762	YE Total	1,141			
	Top 3	93%	Top 3	96%			2,903
1992	Conner	506	Conner	1,017	Conner	246	
	Seagate	160	Seagate	235	Toshiba	265	
	NonUS Othr	216	Toshiba	191	Seagate	196	
	YE Total	1,014	YE Total	1,983	YE Total	930	3,927
	Top 3	87%	Top 3	73%	Top 3	76%	
						Source: Disk Trend	

PrairieTek enabled a market which generated almost $20 Billion of revenue in only four years, albeit a revenue stream that benefited other companies. The concentration of power was intense, in any one capacity segment three companies sold three quarters or more of the drives shipped.

Moderator: Dal Allan

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