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When Axion and BMW gave a joint presentation at the 12ELBC conference in Istanbul last September, it was a milestone event for the technology firm —a recognition of how far the firm had come and the growing acceptance of its lead carbon technology. The struggle to survive for the better part of a decade was coming to a close. Mike Halls reports.

Against all odds

Combine Russian technology with North American commercial know-how. That was the thinking back in 1999 when a consortium of Russian scientists, led by Igor Filipenko, decided to create a Canadian start up R&D firm named C&T Technology.

C&T had been working to develop a new energy storage technology that combined the energy properties of a lead acid battery with the power properties of a carbon-based supercapacitor.

Unfortunately they chose to partner with another Canadian start up company (Mega-C) that had engaged in illegal stock sale transactions. In February 2003, the Ontario Securities Commission began an investigation that effectively blocked Mega-C from any access to new financing.

With Mega-C running out of money, Kirk Tierney, acting general manager of Mega-C, called a group of Mega-C's largest investors to Toronto that June and told them their investment, as well as the North American future of the "lead carbon technology", were both in jeopardy. After a couple of meetings the group, later to be called the Investor Watchdog Group (IWG), agreed to invest another $500,000.into Mega-C while they explored potential options for keeping the company afloat.

It was the start of a long and often desperate struggle to make a success of the company and its technology.

After 45 days of fact finding, the IWG was advised by attorneys and forensic accountants, that it would take approximately $10 million to get Mega-C back to square one and then, of course, millions more would be needed to develop the technology.

The scientists had gone months without a pay check, had lost confidence in Mega-C and wanted to go back to Russia; the bill collectors were at the door and all credit had been shut off; and Mega-C's Canadian engineers were sending out their resumes.

Granville: Slogged it out for Axion from the beginning

While the technology won rave reviews from the scientific community it became clear, relatively early, that it was not as far along as Axion had been led to believe and that some major challenges would have to be overcome.

The core team forms

The IWG moved quickly and formed a new company in September. Led by three key people who still play a major role in Axion today — Bob Averill, Glenn Patterson and Tom Granville — they formulated a plan to forge a new agreement with C&T to keep control of the technology and a strategy to provide a recovery mechanism for the shareholders of Mega-C.

They elected Granville as the first chairman of Axion and elected Averill, Patterson and Tierney to the board. Averill and Patterson would prove to be key investors who would help nurture Axion through the difficult times ahead and each brought his own expertise and experience to the board.

Averill was a gifted mechanical engineer who had already co-founded three medical implant manufacturing firms that had all moved from R&D to profitable manufacture and were all sold to blue chip corporations — 3M, Styker and Zimmer Holdings. He also held, and still holds, 28 patents.

He was enamoured with the potential of the lead carbon technology and immediately set out to better understand it and in so doing, became the company's chief sounding board.

He was also the bank of last resort. Granville later recalled, "I don't know where we'd be today without his financial support during our times of need".

Patterson was the past president of Oregon Electric. On his watch, Oregon Electric grew from $16 million in annual revenues in 1994 to $127 million in 2000. The firm was sold to utility giant Montana Dakota in 2001. One of the reasons Patterson invested in Mega-C was because he saw the potential of lead carbon providing utility scale storage.

Other IWG members played major

roles in the company, especially assisting Granville in his fund raising efforts. Joe Piccirilli, Jim Smith and Jim Eagan were invaluable in this regard as the IWG helped to raise money and invested money of their own. (IWG members were to invest $20 million over the years).

Hard talk

Granville was soon called upon to put to use his start up, fund raising and national level labour negotiations experiences as Axion first raised seed money in October 2003; then negotiated a new licence agreement with C&T in November; then in early December, negotiated a trust agreement between Axion and the shareholders of Mega-C; and finally in 2003, negotiated a reverse merger with Tamboril Cigar Company, a clean public shell, that closed on New Year's Eve — just 90 minutes before the shelf life of the shell expired.

In January 2004, he assisted John Petersen, a securities attorney who had vast experience with small public companies, in negotiating with C&T for the purchase of all the patents for the lead carbon technology and then, a week later, for the outright ownership of C&T.

The sales to Axion were concluded with money, shares and options as part of the arrangement, the Filipenko-led C&T group insisted that Axion be a public company trading on a major US exchange. The reverse merger with Tamboril had satisfied this requirement. Through this entire period, Axion continued to raise much-needed capital. The old IWG accounted themselves very well and were joined by Filipenko and Malitsky, former C&T shareholders, and by friends and family of the Axion shareholders.

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Threats of litigation

And speaking of challenges, a bankruptcy filing by Mega-C in Nevada opened the flood gates of litigation. Axion was hit with two separate suits over the ownership of the technology; a suit between Axion and the trustee of the debtor (Mega-C); a suit between the trustee of the shareholder trust and Axion and more.

"It seemed like I was spending more than half of my time in Nevada [where Mega-C was incorporated]" Granville said, "and a good portion of Axion's money as well".

> "One of our worries at the start was that, in spite of our strong patent position, we would develop an anode that might be copyable. However, we soon realized that reverse engineering would be extremely difficult if not impossible."

Finally, after five years of suits, counter suits and appeals, the court ruled that Axion was the rightful owner of all of the technology and that no one else had any claim on any part of it.

The phoenix arises

When cultures clashed and things got complicated at Axion in Toronto, Granville moved in and took over as chief executive in the summer of 2005. One key need he identified was that of chief technology officer. It wasn't just finding a top notch candidate in terms of education and experience, it was finding the right candidate from the universe of specialists active in Axion's field. Finding someone with the right entrepreneurial, make-it-happen-approach was a necessity for this start up.

The search narrowed down and finally Granville decided that Ed Buiel was the man to take the job.

Buiel, whose doctoral thesis was "*The Development of Disordered Carbon Materials as Anode Materials for Li-ion Battery Applications*" clearly had the academic background needed. Although then only in his early 30s he also had the relevant practical hands-on experience in working on projects for 3M, Maxwell, Molley and Nesscap.

In early 2002 Buiel had started work as project leader for the Energy Storage Group of MeadWestvaco Corporation, one of the largest producers of activated carbon in the world.

His team was focused on developing activated carbon materials for electrochemical applications including Lithium ion batteries, organic ultracapacitors, and asymmetric lead-carbon capacitors.

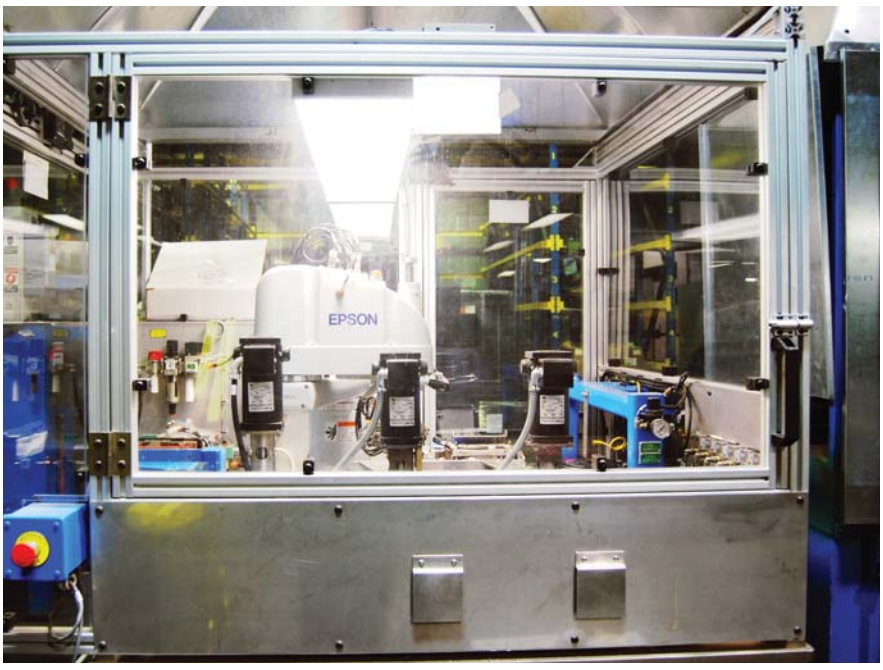
On top of this his responsibilities included managing a USCAR-Advanced Battery Consortium project to develop activated carbon materials for hybrid electric vehicle energy storage systems. He also managed a joint programme with Sandia National Laboratories to develop lead-carbon capacitors for grid-connected energy storage systems.

Another key player joins

Buiel leapt at the chance of taking the Axion technology further and swiftly joined the firm.

Throughout this period, the perennial background worry for Granville, the management team and Axion's board of directors was a shortage of money. The development overheads continued to burn through their resources while no revenue was coming in.

Moreover what Granville and the



The new lug caster station for Axion's automated electrode line at New Castle

board could clearly see was that what they had thought was a stage II company ready to be taken further was still a long way away from being anything like a second stage venture.

At this point in late 2005, another milestone — and a stroke of good luck, at least for Axion — happened. But it required enormous agility for the luck to work.

A Pennsylvania firm called New Castle Battery Company was in trouble and had its assets foreclosed on by their first position creditor, a large Pennsylvania bank. Unfortunately for the bank — but a stroke of fortune for Axion— the bank officer in charge of the sale fell ill. The bank was unable to dispose of the asset in a timely fashion and so they eventually opted for an internet auction.

Race to buy a factory

Searching on the internet for production machinery, Buiel came across the auction notice. Since he was travelling to Cleveland the following week, and New Castle was only an hour away from Cleveland, he scheduled a visit to look at equipment. What he found instead was a mothballed plant full of very usable battery equipment and inventory.

The New Castle Battery plant had three battery lines with a permitted capacity of 3,000 batteries per day. He called Granville who flew in the next day to meet the former owners and learn the particulars. The particulars were that the auction was positively going forward piece-meal on the following Tuesday, all the items had been marked and they weren't about to stop the process.

To make it worse, it was Thanksgiving week so there were only a couple of days to work with before the auction the following Tuesday. The bank said it was "unavailable" to talk about anything related to the upcoming auction. Granville called a bank executive friend of his from New York who made a connection for him in Pennsylvania and negotiations began.

Axion offered a $100,000 non-refundable deposit to stop the auction and give Axion time to do proper due diligence.

But there was one problem, there was no money for this transaction.

Granville, as he had done so often in the past, called on Bob Averill. The money was there the next day.

With the due diligence completed, and the opportunity almost too good to be true, Axion made an offer to do a "quick close" discounted price. Granville found out the bank had assessed the property, for loan purposes, at $5.4 million, so the bank thought it was worth much more and Axion agreed.

> The contract with Exide was, at least in media terms, a watershed for Axion. It was an endorsement of the product, the firm and signalled Axion was on its way to becoming a major battery player.

Enter Bob Averill once more who was willing to bankroll the full purchase. Granville entered the bank to talk over the sale and when he came out Axion was the owner of the equipment and assets of a lead acid battery company — and for a total price of just $720,000.

"The prime purpose of the acquisition," said Granville, "was that it gave us a ready-made manufacturing line and test facility for our new battery product. It allowed us to put our new negative electrode into a traditional lead acid battery case, with a standard positive electrode, electrolyte, separator material, and the like. It allowed us to run it down a standard lead acid battery line."

Business models

At this point it's worth looking at the business model that Axion had been working on. In the early days Mega-C focused on a simple arbitrage play. The Axion business model, however, was more all-embracing.

The company could see that there were a wide variety of end-users that would find the new batteries attractive, but as their research went further they could see a different goal ahead. A bespoke anode that could be fitted into lead acid battery lines all over the world. An activated carbon negative electrode replacement that made other manufacturers batteries better.

"One of our worries at the start," said Granville, "was that, in spite of our strong patent position, we would develop an anode that might be copyable. However, we soon realized that reverse engineering would be extremely difficult if not impossible."

Moreover, the firm reasoned a quicker way to market — and a more effective one as well — would be not to approach the market with a totally new battery product but rather a traditional one with a new wrinkle. "In terms of our business model, we did not want to be in the position of being strictly a battery manufacturer. Rather we saw ourselves as a supplier to lead acid battery manufacturers," said Granville.

But if most of the elements vital for success were now in place, the final leap to production had yet to be made.

New R&D headquarters

New Castle Battery became the R&D headquarters for Axion and for the next two years it was a question of continuing the long developmental slog.

Axion sought out talented people and brought them to New Castle. Bob Nelson, for example, with 30 years of lead acid battery experience and long referred to as one of the founding fathers of VRLA battery technology. Enders Dickinson, who had taken over Ed Buiel's job at MeadWestvaco and who also had experience with a large lead acid battery manufacturer. Phil Baker, former chief operating officer for Trojan Battery. Jack Shindle and a dozen more highly respected members of R&D and engineering teams. Axion cherry-picked the best of the former New Castle Battery Company employees, such as Joe Cole and Tim Holler and brought them in. In fact, building a broad based team has continued at an accelerated pace through 2010.

Starting in earnest in 2007, the factory began to once again make high profit margin specialty 16 volt racing car and collector car batteries on its AGM line. It also produced some standard legacy lead acid battery products that were sold to battery distributors and battery purchasing groups.

On track

En route there was the growing acknowledgement that Axion was on the right track.

In 2007 the firm was awarded the Frost & Sullivan Technology Innovation Award for North America in the field of lead acid batteries.

Frost & Sullivan said Axion's new PbC batteries have "the potential to revitalize the lead-acid battery industry by breathing new life into an established technology that was not well-suited to the requirements of important new applications like hybrid electric vehicles and renewable power."

But endorsements are not the same as cashflow and Granville continued to push for more funds to keep the business moving forward.

The most immediate came from the

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state of Pennsylvania which in 2007 provided a $1.2 million grant in anticipation of Axion creating new jobs in the region. Pennsylvania has continued to back Axion's development with promotional grants for solar and storage projects. Funds were also forthcoming from a third tranche of investment from venture capital firm the Quercus Trust which in June 2008 completed its $18 million of financing into the firm.

Moreover, Axion had looked at the possibilities of toll contract manufacturing — Granville termed it his "filler strategy" — and had spent time preparing the factory for this boost to income.

So in addition to the existing AGM line being used as a test bed for Axion's new PbC product — the existing manufacturing capacity of 3,000 batteries per day could be expanded upward with full use of all of the production lines.

Filler strategy pays off

In September 2008, Axion received a purchase order to produce 92,000 flooded lead acid batteries under a toll manufacturing contract that was estimated to be worth $6.4 million. However, the economy was falling apart at the time and the full implementation of the contract never came to fruition. Of course that doesn't mean that the possibility of substantial flooded production no longer exists at Axion.

Also that summer, Axion received a $1.2 million grant from the office of Naval Research to develop a product for use in assault vehicles and in the silent watch programme.

Axion's next decision was to place it firmly in the mainstream of the battery industry. Axion needed to advance further on the key offering contained in its business plan — linking up with a major battery manufacturer that would eventually place Axion's production line in the manufacturer's own plant.

That happened in April 2009 when Axion signed a contract with Exide Technologies. Although Exide — as is routine in these matters with non-disclosure agreements — effectively gagged Granville from revealing much of the details of the partnership — the barebones that could be announced revealed its potential importance.

Axion was to supply its lead carbon batteries and related technology and components to fit into Exide's existing manufacturing capabilities. It was a three phase programme running from an initial test period to escalating deliveries of the final product which would be targeted almost entirely at the automotive sector — electric vehicles, hybrids, plug-ins, military and marine transport applications, automobiles and light trucks. It would also target electric grid applications.

In all the three phases were to end in April 2012. The original arrangement, while allowing the existing East Penn cooperation to remain in place, was otherwise an exclusive one.

The contract with Exide was, at least in media terms, a watershed for Axion. It was an endorsement of the product, the firm and signalled that Axion was on its way to becoming a major battery player.

The timing of the move was fortuitous as well — two weeks later the EU announced that CO_2 emissions from cars would have to be reduced by around a quarter. "This virtually provides a made to order market for our carbon products," Granville said at the time.

"Our price point, our cycle life, and our ability to achieve much greater charge acceptance served to immediately open the doors of large European vehicle manufacturers."

ISS and beyond

Or beyond, Indeed the potential of Axion's battery was being explored by automobile manufacturers who were investing heavily in finding better ways of introducing stop-start technology — enabling car engines to switch off their engines when at standstill but restart at the touch of the accelerator — into their cars (called ISS) as well as regenerative braking where energy generated from the change of momentum gets fed into the battery. Cars using this technology are called hybrids and microhybrids.

Existing lead acid batteries were unsuitable for regenerative braking. The raw burst of recharging energy was typically dissipated into excess hydrogen gas. In addition, lead acid battery's charge acceptance dissipates over a short period of time and, without Axion's new lead carbon anode, lead acid batteries would, as ever, require long re-charging times.

Moreover, ISS also put unusual strains on a regular lead acid battery that shorten cycle lives.

By contrast the Axion battery could successfully be used for hybrid and micro-hybrid cars. The important thing to remember here is that if the battery isn't charged, the engine cannot shut off because it must continue to charge the battery until an acceptable voltage level is obtained. If the engine does not shut off the entire purpose of stop/start is thwarted — CO_2 emissions aren't properly

The Power Cubeis being commissioned onsite at Axion's plant. It can be configured to provide 1MW of power with fast discharge (responding in milliseconds) and fast full recharge (less than 10 minutes).

reduced and mileage per gallon isn't significantly improved.

The PowerCube and beyond

Wisely, Granville had made the agreement with Exide exclusive only in terms of some parts of its production process. "This agreement will not restrict us from marketing directly to the applications that are important to us such as power quality, grid storage, wind, solar and the automotive conversion market," he said at the time. Over the next 18 months Axion began to develop products for these markets through its PowerCube product.

The PowerCube packs a 500kW-1MW punch and was designed to fit into a Smart Grid electrical distribution system where energy from solar or wind power could be stored in an electrical distribution system. It also has application for power quality, power smoothing, back up power and power arbitrage.

The final end to a near-perfect year for a firm that was now freeing itself from the trappings of being labelled in its development phase was a large injection of funds — just over $26 million — through a private placement of some 46 million shares to investors that were now more than eager to become involved.

Axion's balance sheet was beginning to look healthy.

The funding was partially used to fund plant improvements at Axion's main battery plant on Clover Lane and to provide equipment for the company's next generation automated line at the electrode production facility on Greenridge Parkway.

In 2010, the firm has looked at expanding its use of the technology/chemistry further. In June it launched a programme to develop a battery solution and a battery management system with Norfolk Southern Corporation, a major US railway firm. The aim would be to allow railroads to develop clean energy hybrid locomotives that would operate on battery power and recharge their batteries through regenerative braking and charging stations

Once again, the PbC battery is a best of show here because of extremely high charge acceptance and, when compared to lead acid batteries, much faster re-charge capabilities. "For example," Granville said, "On re-charge, PbC batteries charge back to nearly 50% of the battery's capacity in just 30 seconds. By contrast, lead acid batteries provide less than a 2% return of charge in that same time frame."

The firm's paper at the Istanbul ELBC conference in September was perhaps the final endorsement needed for its technology. The paper *Dynamic Charge Acceptance of Lead-Acid Batteries in Micro Hybrids* was presented by Axion's R&D team and — exceptional for these events — was jointly prepared by BMW, which is working closely with Axion. At the same conference, Axion presented a strong case for PbC charge acceptance and fast rate of recharge to the ALABC.

Perhaps the final word should go to Granville who told most of this story to *Batteries International* while attending the conference. "It's been an educational experience. When you set out, with limited funds, to make something that has never been made before, and to design a production facility to make it in quantity, there are huge challenges," he said.

"But we've been persistent and struggled against sometimes overwhelming odds to get where we are today. Our board of directors has been enormously supportive and are a major reason for our success. The same is true for our investors who have exhibited patience and understanding over time.

"The road is long and we're not there yet but the most difficult years are now clearly behind us." ■