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EMBRACING MEMBER INITIATIVES & COLLABORATION - #MAKEITHAPPEN

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | NOV/DEC 2016

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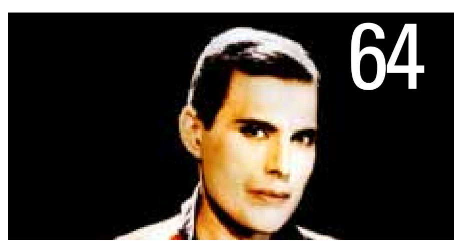

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MANAGING EDITOR
Minx Avrabos | minx@saiee.org.za

TECHNICAL EDITORS
Derek Woodburn
Jane-Anne Buisson-Street

CONTRIBUTORS
K van Rensburg
G Teunissen
G Maluleke
W Coetzee
D Basson
H J van der Bijl
H Broschk
J Buisson-Street

EVENTS
Gerda Geyer | geyerg@saiee.org.za

CPD & COURSE ACCREDITATION
Sue Moseley | suem@saiee.org.za

MEMBERSHIP & TECHNOLOGY LEADERSHIP
Ansie Smith | smitha@saiee.org.za

ADVERTISING
Avenue Advertising
T 011 463 7940 | F 086 518 9936 | E barbara@avenue.co.za

PHOTOGRAPHER
AA Photography | 083 260 3753

PUBLISHER
South African Institute of Electrical Engineers

SAIEE HEAD OFFICE
P.O. Box 751253 | Gardenview | 2047
T 011 487 3003 | F 011 487 3002
E wattnow@saiee.org.za | W www.saiee.org.za
Office Hours: 8am-4pm

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November spells a certain frenzy in the air. Everyone seems to be squeezing in 'just one more' meeting, or 'just one more' project before the December holidays. In reality, the December holidays are effectively only 3 weeks long – not long enough to really rest and recharge your batteries (my opinion) and then back on the hamster wheel! But… that's just me!

This issue of **watt**now features Technology – and it is a tremendously interesting topic to work with, with technology constantly changing. I share with you the technologies involved on Trolley Assist Developments (pg18); The Internet of Things (pg22) right through to asking you, "which country will ban oil burning cars first?" (pg36).

My old 'staatmaker', Dudley Basson, wrote a beautiful article on Kelvin's Vortex (pg46), something that we actually 'see' everyday.

This issue's 'history' article is a white paper published by the Father of Electricity, Dr Hendrik van der Bijl, published on 15 April 1913. This paper was aptly translated from German to English, thanks to our Council Member, Mr Hermann Broschk. Read it on page 54.

Now – back to business - as you might know, the production cost of any magazine, not excluding **watt**now, is astronomical. The cherry on the cake is that one cannot rely on the South African Post Office to deliver a decent service.

I therefore, as the Managing Editor, request you to send an email indicating if you would prefer to receive an online, downloadable version, or a printed copy of the **watt**now magazine.

Your input as a SAIEE Member is extremely valuable to me, and I therefore urge you to assist me in establishing the correct way forward.

Please send an email to **wattnow@saiee.org.za** and within the subject line please indicate YOUR SAIEE MEMBERSHIP NUMBER & **watt**now online/print – **whichever you prefer**. Members, who opt for their printed copy, will still receive their copy in the post.

I wish all of you a wonderful festive season. Stay safe and get there in one piece.

Until 2017, enjoy the read.

Minx

Earn CPD Credits

Visit www.saiee.org.za to answer the questions related to these articles to earn your CPD points.

TC MADIKANE
2016 SAIEE PRESIDENT

The SAIEE considers collaboration with other stakeholders as vital in delivering our mandate. Currently we have Memorandum of Understanding (MoU) with various parties from different industries.

On the 7th of October, SAIEE signed an MoU with the South African Committee of Cigre, which was represented by their Chairperson, Mr Prince Moyo. We are looking forward to working with Cigre on various aspects.

The Universities of Technology are struggling to provide in-service training. The institute, under the leadership of Past President Prof Pat Naidoo, approached Eskom to assist two years ago. This resulted in an MoU with Durban University of Technology (DUT) and Nelson Mandela Metro University (NMMU) to offer students in-service training. To date, we have more than 100 students on the programme both in KwaZulu Natal and the Eastern Cape. On the 11th of November we will be signing an MoU to incorporate Mangosuthu University of Technology (MUT).

On the 21st of October, SAIEE had its annual banquet in Wanderers Country Club which had more than 300 attendees. The adjudication committee had a mammoth and challenging task this year because of the quantity and quality of nominations received. I would like to congratulate all the recipients of the 2016 awards.

We were honoured by Eskom Group Executive Capital, Abraham Masango who was our guest speaker, and thank you to Eskom's Board and CEO for the good working relationship that SAIEE has with Eskom. There is a detailed article in this edition which covers the annual banquet, including pictures.

It was an honour to attend two events for other Voluntary Associations in October and I had an opportunity to mingle with our industry partners.

The Association of Municipality Electricity Undertakings (AMEU) hosted their 65th National Convention at Emerald Resort Casino, where Mr Moferefere Tshabalala was inaugurated as President. The guest speaker was Minister of COGTA, Honourable Des Van Rooyen.

I also attended the Cigre Gala Dinner in Bedfordview, where the guest Speaker was the President of CIGRE, Dr Rob Stephen.

The South African Institute of Electrical Engineers hopes that the challenges that are faced by all Institute of Higher Learning will be resolved amicable by all the stakeholders concerned, and that potential Electrical Practitioners would be able to write their examinations without any disruptions.

I will endeavour to visit most of our current Bursars before they write their examinations to motivate and encourage them. I would also like to thank our members who have provided mentorship to SAIEE's Bursars this year. Indeed their role in #ploughback is noticeable and appreciated.
The prestigious 65th Bernard Price Memorial Lecture, which was supposed to take place at the Senate House, East Campus, and Witwatersrand University on the 20th of September was postponed due to student's demonstrations. It is anticipated that this function will take

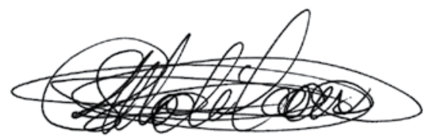
place towards the middle of November, but a notice will be issued via the website, facebook, emails and sms.

I would like to congratulate Mrs Sy Gourrah for being elected as the SAIEE Junior Vice President for 2017/18. She will be part of the Office Bearers as from next year after the Annual General Meeting. With Sy's wealth of experience in the engineering space as Past President of Association of Municipality Electricity Undertakings (AMEU) and Head of Electricity for Buffalo City Municipality, SAIEE will be in good hands.

Under the mission to #makeithappen, I visited Mangosuthu University of Technology. What an inspiration to see how much energy and enthusiasm there is among the students to join and participate in SAIEE activities. I am pleased that they are in a process of establishing, what I consider will be, a vibrant chapter, with the assistance of Lecturers and the KZN Centre.

Lastly, SAIEE would like to wish all Matriculants all the best for their examinations this year, and we are confident that the class of 2016 will provide us with at least a handful of future leaders, who would in time take the baton and continue to drive the vision and mission of SAIEE.

I would like to wish all our members, afiliates and readers a fantastic festive season.



TC Madikane
Pr. Eng | FSAIEE | FSAAE

SAIEE Annual Banquet

The annual SAIEE Banquet took place on the 21st of October at the Wanderers Club, Illovo, JHB. This auspicious event saw a few surprises.

The annual award winners are:
Keith Plowden Young Achievers Award, sponsored by Powertech Transformers, was presented by Bernard Meyer. The South African Institute of Electrical Engineers (SAIEE) has an annual award for the most outstanding young achiever of the year in the field of Electrical/electronic engineering. An award for an engineer 35 years or younger who has the spirit of achievement, creativity and leadership coupled with innovative, entrepreneurial action plus an infectious enthusiasm that counts for this award. Maanda Ramatumbu received the Keith Plowden Young Achievers award. He is a director on the Pfuxani STEM Foundation board, an NGO which aims to empower school children pursue Science, Technology Engineering & Maths related careers by improving their attitudes towards Maths and Science subjects. He is currently a manager at Accenture South Africa's Utilities practice, focusing on Asset Management within the Smart Grid Services capability. Maandla is also the SAIEE Gauteng Centre Chairman.

Keith Plowden Young Achievers Award:
From left: Bernard Meyer, CEO Powertech Transformers and Maanda Ramatumbu, Chairman, SAIEE Gauteng Centre

SAIEE Engineer of the Year Award is sponsored by Actom and was presented by Tembela Caza. This award is for a member of the SAIEE who has energetically and voluntary worked towards promoting electrical science and its applications to the benefit of the SAIEE, members and the Southern African community through his involvement in Institute affairs. This award recognises and honours the member for his contribution. The 2016 recipient, with 21 years experience as a practicing engineer, is none other than Nhlanhla Mbuli. He has served as Council Member of SAIEE for 4 consecutive terms during 2008-2011. Nhlanhla was elected and served as Council Member of ECSA for the 2009-2012 term. He has also served as a Member of Professional Advisory Committee (PAC): Electrical (2010-current). He is a reviewer of candidates for registration as professional engineers, conducting the required interviews on behalf of the PAC. He also participates in interviews of candidates for evaluation of qualifications (on behalf EPQEC Committee of ECSA).

SAIEE Engineer of the Year:
From left: Nhlanhla Mbuli and Tembela Caza, CEO Actom.

SAIEE Engineering Excellence Award, sponsored by City Power, was a tough decision to select only one excellent engineer, therefore we decided to have two recipients: They are:

SAIEE Engineering Excellence Award:
From left: Prof Pat Naidoo and TC Madikane, SAIEE President.

- Prof Pat Naidoo, who° is a Professional Engineer and specialist consultant, currently serves the Durban University of Technology, in May 2016 he was appointed as a Professor of Practice: Electrical Engineering, University of Johannesburg and thereafter as a Research and Innovation Chair – Green Economy, Faculty of Engineering and the Built Environment at UJ.
- Paul Johnson is a rare individual: he joined Eskom more than 30 years ago, and has made substantial contributions to engineering in South Africa ever since. Through his efforts South Africa is recognised as a contributor to international Standardisation (through the International Electro-technical Commission and AFSEC.

SAIEE Engineering Excellence Award:
From left: Mr Paul Johnson and TC Madikane, SAIEE President

SAIEE President's Award sponsored by ATNS (Air Traffic Navigation Services) and was presented by SAIEE President, T C Madikane.

This year, two recipients received this award – each one who each made momentous achievements in their respective fields. They are:

- Dr Rob Stephen – graduated from the University of the Witwatersrand in 1979 with a BSc Electrical Engineering degree. He joined Eskom the electrical utility in 1980. He is past chairman of SC B2 on overhead lines, and has held positions of Special reporter and working group chairman and has authored over 100 technical papers. He was recently elected President of Cigre in 2016.

.

- Sicelo Xulu - was appointed MD of City Power in September 2012. In August 2012, he was elected as President Elect for The Association of Municipal Electricity Utilities (AMEU) and in October 2014, Sicelo was inaugurated as President of the AMEU.

SAIEE President's Award:
From left: Dr Rob Stephen, Cigre President and
TC Madikane, SAIEE President.

The SAIEE also awarded long service awards to its staff. The recipients are: Minx Avrabos (5 years), Androzette Muller (6 years), Sue Moseley (8 years), Stan Bridgens (10 years), Gerda Geyer (20 years) and Herbert Hlanze (26 years).

SAIEE President's Award:
From left: Mr Sicelo Xulu, MD City Power and
TC Madikane, SAIEE President.

The annual banquet would not have been a success, without our sponsors. They are Actom SA, ATNS, Avianto, City Power, DEHN Africa, Monte De Dois, Powertech Transformers, PPS and Spier Wine Estate.

SAIEE Annual Banquet (continues)

Stan Bridgens received Long Service Award (10 yrs) from TC Madikane

Minx Avrabos received Long Service Award (5 yrs) from TC Madikane

Gerda Geyer received Long Service Award (20 yrs) from TC Madikane

From left: Prof Marwala and TC Madikane, SAIEE President

Sharon & George Debbo

John & Priscilla Gossling

Francois & Marlize du Plessis

Dr Ben Kotze

Rod & Ann Harker

Victor Shikoana & partner

Ian & Mel McKechnie

Annalize & John Eyrich


Dr Rob & Dawn Stephen


Chris & Althea Campbell


Prof Pat & Maureen Naidoo with their family.


Leryn & David Bavin


Fate & Tapiwa Muzondo


Collin Reddy with partner


Belinda & Paul Johnson


Virginia & Lucky Huma


Esther & Cornay Keefer


Vincent & Wendi Tiedt


Niressa Chetty with partner


Elmarie & Hendri Geldenhuys


Thami & Tumisang Maphumulo


Thandiwe Nkambule & partner


André & Janine Hoffmann


Julie & Hermann Broschk


Andrew & Sally Anderson


SAIEE Council Women with Bertha Dlamini (middle)

WATTSUP

SAIEE Annual Banquet (continues)

Jacob & Gladys Machinjike

Lara & Frik Botha

Our wine sponsor - the DEHN Africa team.
From left: Julien Puttkamer, Etienne Gerber, Alexis Barwise (MD), Kenneth Roets & Steven Weber

Lihle Mbothwe

Xu Han & partner

Carl & Hilda Hempel

Bruno & Clarisse Bukasa

Zwelandile & Thandeka Mbebe

Barbara & Tom Eichbaum

Viv Crone & Bea Lacquet

The PPS team

Tshepo Mahlabla & partner

Dawie & Sy Gourrah

From left: Sicelo Xulu (City Power), Abraham Masangu (Eskom) & TC Madikane (SAIEE President).

Saurabh Sinha & TC Madikane

Stan & Margrit Bridgens

duToit & Elize Grobler

Tusani & Amelia Mtshali

The University of Johannesburg (UJ) Team

Josephine & Jack Rowan

Prof Jan & Elma de Kock

Bronwyn & Graeme Eddey

Nicky & Stephen Reynders

Teboho Machabe & partner

Darryn Cornish & partner

TC & Mahle Madikane

Nhlanhla & Phumelele Mbuli

Vukile & Nonjy Zuma

Mnqobi & Nonto Mfeka

Andreas & Minx Avrabos

Appointment to the Global Sales & Marketing Division for the Manitou group

The Manitou group, the world leader in all-terrain material handling trucks, is announcing the appointment of Laurent Bonnaure as Executive Vice President Global Sales & Marketing and member of the Executive Committee. Responsible for the group's worldwide sales and marketing strategy, he will be overseeing all of the Manitou group distribution subsidiaries as well as the Global Sales and Marketing teams and will manage the global dealer network. Laurent Bonnaure will continue the development of the Manitou group initiated under the responsibility of François-Frédéric Piffard, who will remain head of Sales & Marketing until the end of 2016.

"Manitou is an extraordinary company that is expanding in global markets and territories that are still open to new growth opportunities thanks to its high-added-value products, the continued innovations in its products and services, and its employees and dealers who are proud of the company and its products. Continuing to strengthen our global leadership and constantly improving our customers' satisfaction are the main challenges for the coming years. Building on the remarkable work of François-Frédéric Piffard, I will be concentrating my efforts to accelerate Manitou's development and taking on these new challenges, alongside our teams and our entire network", says Laurent Bonnaure.

Academy of Engineering elect SAIEE Fellows

The SAIEE congratulates three of its Council Members who were nominated, elected and inducted by Tureman Goba, President of the Academy of Engineering. at an auspicious celebratory occasion at the Pretoria Country Club recently.

Dr Pat Naidoo and Mr Ian McKechnie, both Past Presidents of SAIEE, and current Council Members with Mr Colin Matlala, a loyal and long serving SAIEE Council Member.

The SAIEE congratulates these members of our noble institution, and more so, that they are recognized and acknowledged for their engineering contribution to South Africa by the Academy of Engineering.

SAIEE Signs MoU with Cigre

From left: TC Madikane (SAIEE President) & Prince Moyo (Cigre Chairman - South African Chapter)

At the October Council meeting, SAIEE President, TC Madikane signed a Memorandum of Understanding (MoU) with Cigre (Conference Internationale des Grandes Reseaux Electriques). Prince Moyo, Cigre Chairman - South African Chapter, co-signed the agreement, cementing the collaboration of two associations in the engineering discipline.

Major PV project celebrates its impact in the Northern Cape

Ready to cut the ribbon at the inauguration of the Mulilo Sonnedix Prieska PV project pictured from left: Chris Aberdein (Mulilo), John Cullum (Mulilo), Greg Austin (juwi), Chester Williams, Franck Constant (Sonnedix), Prieska Mayor Howard Tshume, Andreas Mustad (Sonnedix), Taniya Krishna (Women in Power), Jeanne-Marie Fatti (Standard Bank), Jan Malan (Nedbank)

The 86MW Mulilo Sonnedix Prieska PV project, one of the largest in Southern Africa measuring 125 hectares, was officially inaugurated in the Northern Cape at a series of formal events attended by major players in the renewables energy sector.

Attendees celebrated the successful completion of the project and its significant Socio-Economic Development (SED) impact in the region, which has empowered local communities with significant skills, investment and employment.

The plant was officially opened by Sonnedix CEO Andreas Mustad and South African developers Mulilo in the presence of Prieska Mayor Howard Tshume, who thanked Sonnedix and Mulilo on behalf of the Siyathemba municipality for investing in education and local business: *"This plant will enable small businesses to emerge – thank you for choosing this area to develop our society."*

The opening was honoured with the presence of all the project partners (Mulilo, Women in Power, Nedbank and Standard Bank – Facility agent, Fieldstone, Norton Rose Fulbright and Arup – Advisors) and all of the companies involved in the plant construction process, including the EPC Contractor juwi, their main sub-contractors and suppliers (PiA Solar, ABB, BYD).

Protect analogue camera systems with DEHN surge arrester

Factors including low cost, compatibility with other components, a wide range of video signals and the protection of existing systems have made certain that analogue CCTV cameras are still widely used.

A compact arrester ensuring the protection and availability of video transmission systems, the DEHNvario 3in1 surge arrester guarantees unrestricted operation of analogue camera and video transmission systems, even during thunderstorms.

Representing a new generation of arresters that protects different signals of power supply and information technology systems, the DEHNvario stands out due to its extremely flexible connection technology. This complete solution protects three interfaces in a single device: the supply voltage; data interface; and video signal. This largely eliminates an incorrect selection of devices.

The DEHNvario 3in1 solution is ideally suited for analogue cameras that require:

- Power feed
- RS485 feed (pan, tilt, zoom functions);
- and analogue video signals feed (BNC).

With its high discharge capacity of up to 5 kA (8/20 µs) per core, it can be used according to the lightning protection zone concept at the boundaries from 0B to 2 and higher.

WATTSUP

Technology driving the evolution of logistics

Detlev Duve
Managing Director

As technology continues to advance at a startling rate, logistics is perhaps one of the industries that must adapt the most quickly. If this seems surprising, consider that all the world's most innovative products and services at some point require storage and transportation over great distances, within short time periods.

"A few decades ago, the challenge was to transport fresh produce timeously without damage or compromise," says Detlev Duve, Managing Director of DACHSER South Africa. *"Today, complex and highly sensitive medical equipment must be transported across diverse terrains. Mega-production systems that weigh more than 50 tons must be driven to ports and safely shipped. And hazardous but necessary chemicals used in modern solar thermal power plants, must be transferred from European warehouses to remote African power plants, thousands of kilometres away."*

Economists believe that a new Industrial Revolution is underway. Labelled 4.0, it has given rise to extensively networked, autonomous production lines used in smart factories around the globe. These lines can produce extremely high quantities or, conversely, individual products or single items. This flexibility is a fundamental departure from traditional production lines and requires supply chains, and the requirements from logistics providers, to be redefined. *"Transport from A to B is only aspect of a multidimensional supply chain,"* says Duve. *"At DACHSER, we have implemented advanced systems to anticipate - and meet - the multi-dimensional needs that arise."*

Locally, DACHSER South Africa customers making use of DACHSER warehousing and added value services are now able to register, log in and track their inventory and shipments, real-time. An electronic data exchange platform is used to exchange important information with the customer. Online supply chain management systems enable DACHSER to precisely control each individual shipment, from pick-up to delivery.

Duve says, *"We are committed to harnessing the power of technology and to finding innovative ways to provide fulfilment and last-mile delivery services. This way, clients can focus on the evolving technologies that impact how they produce their goods, while we seamlessly take care of their logistics."*

Are you looking to "green" your home or business?

Did you know that making energy saving improvements to your property could increase its value by 14 per cent and reduce your electricity bills by 75%. This Power Up system will change the way we live.

Not only can energy efficient improvements add real value to your property but they can also help protect you from rising energy costs. The Power up system is Africa's leading off-the-grid alternative energy solution with twice the performance of others on the market. The ergonomically designed, compact high-tech control unit, has a crystal battery bank that lasts five times longer and produces up to three times the daily power output of other deep-cycle systems.

With the aesthetically appealing and trendy look of an iphone and slightly larger than an average laptop, it's compact enough to be discreetly tucked away in a garage, lounge, kitchen, or under a desk in an office.

Harvesting power from a variety of sources uses the energy to power your home or business immediately whilst also saving the energy to crystal battery banks (which are far greener and safer than gel or lithium technology) for use when you need it. The system is easily installed, requires no maintenance, is safe for any living space, and picks up power within 10 milliseconds of a grid failure or disconnection.

For info, visit www.powerupsupply.com.

Solar farms move to the cities

Urban property developers have realised the potential of city rooftops for solar farming, with factories and shopping malls being transformed through the installation of acres of solar panels on previously underutilised roof space.

juwi Renewable Energies has assisted Growthpoint Properties in identifying its premium properties as ideal locations for solar farms. Northgate Shopping Centre, co-owned by Sasol Pension Fund in Johannesburg, is the latest urban mall identified for the company's rooftop solar installations.

Greg Austin, MD of juwi Renewable Energies, the EPC provider to the projects says that solar is moving into cities on an industrial scale: "*The Northern Cape is the centre of the solar industry in the country, but large-scale property owners in urban areas are realising the potential cost-saving in bringing solar farms closer to the area of demand and creating own-consumption solutions.*"

Shopping centres, with their large flat roof areas, are ideal candidates for solar. At Northgate Shopping Centre in Gauteng, a newly completed 960 kWp roof-mounted solar PV installation is set to produce 9% of the energy required by the shopping centre. The installation is believed to be one of the biggest thin-film PV technology projects in the country. "*Although, not new to South Africa, thinfilm technology has a higher energy yield in low-light/shading conditions, a higher energy yield at high temperatures and with increasing efficiencies and decreasing prices internationally, this installation will guide the way for future thin-film projects in South Africa,*" explained juwi Project Engineer, Coen Fourie.

Fourie elaborated that three different roof formats have been used in the project. "*These PV modules can be used on any roof or carport – flat or pitched, as at Northgate. The rooftop system can be applied to a wide range of applications including industrial complexes, hospitals, airports and office blocks.*"

"*Growthpoint Properties is committed to solar energy generation, and the leading driver for this project was a combination of electricity production and maximum demand savings,*" said Werner van Antwerpen, Head of Sustainability and Utilities at Growthpoint.

According to Fourie, the project which took 12 weeks of construction, was completed on schedule, and entered commercial operation on 15 August 2016. A portion of the installation and interconnection was carried out at night to minimise the impact on the centre.

The project supported local skills and job creation: "*We used local labour for the project, all of whom were trained on site.*"

juwi will provide Operations and Maintenance services to Growthpoint on the Northgate project, as part of their growing fleet of more than 120 MW of solar PV installations being monitored from their Cape Town office.

Earn CPD Credits

Trolley assist development going places

Open cast mining has always been an opportunity for the operation of diesel-electric driven haul trucks, which are powered by a diesel-electric drive system consisting, in principle, of two electric drive motors, integrated through gears into the rear wheels of the trucks, an electric generator/alternator, and a powerful diesel engine.

Trucks with electric drive systems can be fitted with a trolley assist system, while mechanical trucks cannot be operated on a trolley system. The Siemens truck trolley assist system involves the substitution of the diesel fuel by cheaper more ecological electric energy.

Instead of generating electricity from the diesel engine and generator on the truck, the electric energy is supplied from a dedicated substation (E-House), and fed to the electric drive and motors of the truck via overhead feeder lines.

The overhead feeder wires (catenary) are fed from a transportable rectifier substation, called an E-House, while the transformers are installed on a base/skid. The modular design allows for ease of relocating the system as mine activities progresses over time.

The E-House and equipment are robust, and designed to cope with rough environmental and operational conditions, which include the continuous varying load conditions of between zero to 150%, depending on the duty cycle of the trucks.

BY KARL VAN RENSBURG **I** SIEMENS SOUTH AFRICA **I** RAIL ELECTRIFICATION

Siemens provides the complete trolley assist solution, from the design stage, static calculations, supply and delivery of material to installation and commissioning of the entire system. Siemens has optimised the trolley system for mine operations, which has high demands for mechanical stability, operating reliability, low maintenance cost and a high availability.

Trolley assist has been utilised at mining sites around the world since the early 1980s, South Africa is regarded as a world-leader in installed capacity of this technology – having recently celebrated the launch of Siemens' 4th generation trolley assist substation technology.

The 11 MW substation boasts an output of 1.8 kV of DC voltage, and up to 10 000 A, to ensure the running of haul trucks with a nominal gross vehicle weight of 550 000 kg, and a payload of approximately 325 000 kg.

The substation can accommodate a duty cycle of running two fully loaded trucks continuously, and under overload conditions allows for three trucks for ten minutes, or four trucks for one minute, along the overhead feeder lines of approximately 850 m sections.

The substation is housed in a 6m x 3.3m x 3m E-house, that weighs approximately 8500 kg, and includes the the 1.8kV DC switchgear, rectifiers, 33 kV ring main unit,

Trolley assist development

continues from page 19

cooling equipment, battery charger, control panel and the Siprotec AC - Sitras Pro DC feeder protection devices.

The control and protection of the entire substation is automated with a Siemens PLC, and distributed Input/Output units interfaced via an industry standard Profinet fieldbus, which significantly reduces the number of interface cables between equipment, allowing for the effective control and monitoring of the substation and equipment, via a touch panel, or from a remote location.

Cooling of the E-House is provided by two inverter air conditioners, which keeps the inside temperatures between 18 ˚C to 22 ˚C under all operating conditions.

Another breakthrough is that 90% of components in the E-House are entirely manufactured by Siemens, compared to past E-Houses which contained approximately 30% Siemens components.

Sourcing nearly all of the components from the Siemens portfolio, guarantees compliance with International standards, greater quality control, and improved functionality.

A further major benefit, when compared with the previous generation of E-Houses, is the improved safety features, as a result of the modular design of the AC/DC switchgear and rectifier modules, that prevent direct access to live high voltage components.

Correct switching sequences and DC feeder line test procedures can now be implemented with failsafe software procedures, doing away with mechanical interlock keys.

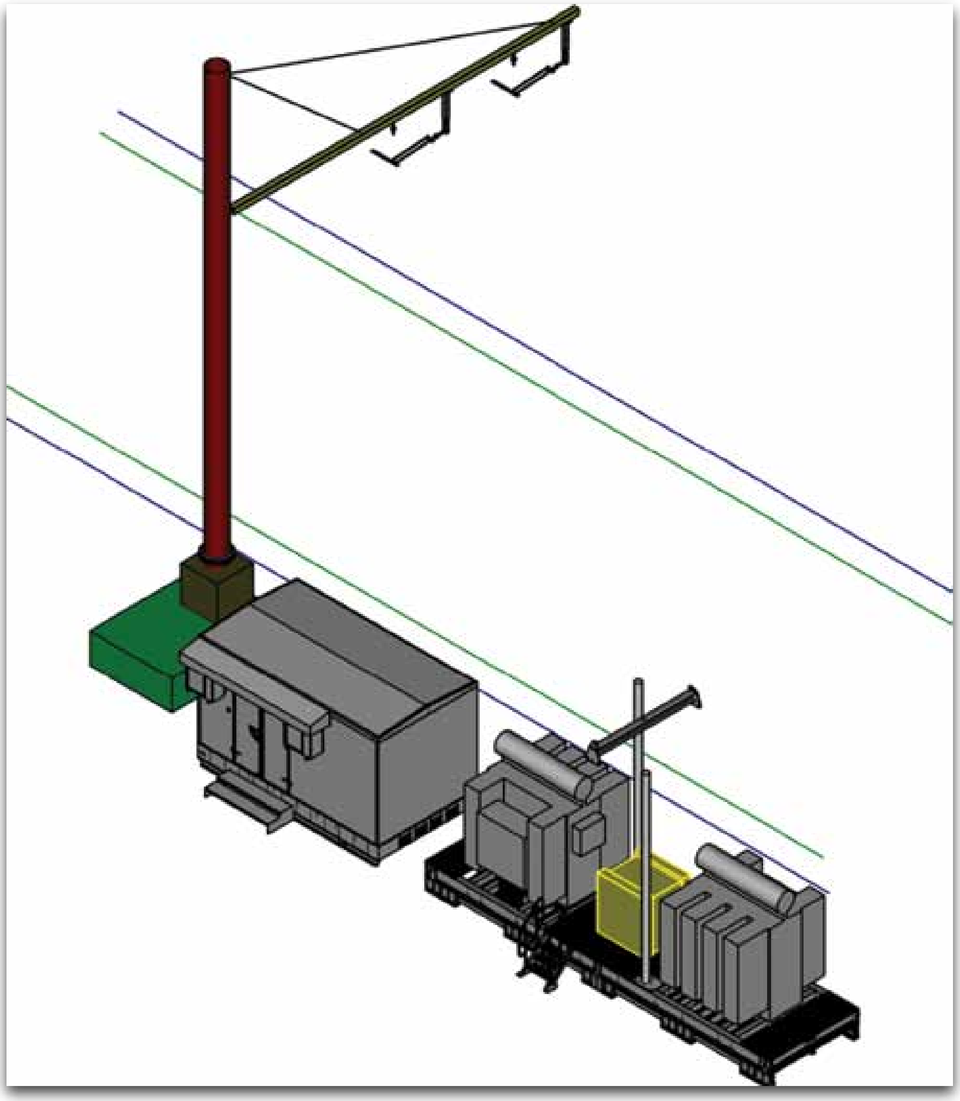


Figure 1 3D Design Model of Main Mast Pole, E-House and Transformer skid

FROM HUMBLE BEGINNINGS

In its early days, trolley assist involved two single copper contact bars, one for each of the positive and negative supply feeds, and heavy duty current collecting poles. Electric power was provided to the overhead lines via a roadside rectifier substation, rated at a maximum power output of 3 MW.

In these first generation traction substations for trolley assist, the traction substations were fed from the public network, (typically 3 phase 11 kV to 36 kV AC), and converted to the 1200 V DC voltage required by the trucks, which were equipped with DC motors.

These substations were generally constructed in two parts (a transformer skid and E-House) for portability, making it easy to relocate them as mining operations developed. The equipment for the substations was largely pre-installed when delivered to the mine. This results in

a shorter installation and commissioning period. In the second-generation trolley assist system, the substation power increased to 5 MW, supplied from a medium voltage transformer (11 kV or 33 kV AC).

It also consisted of AC switchgear, rectifier, DC switchgear, parallel feeder contact lines for the positive and negative poles, and a pantograph with sensor system to guide the truck driver along the haul road.

With a trolley DC voltage range between 1200 – 1600 V DC, it was possible to power dump trucks with a payload of around 170 000 kg.

The third-generation substation technology gave rise to the demand for bigger trucks and the introduction of AC wheel motors. Output power increased to 10 MW with a nominal feeder voltage of 2600 V DC.

The change from DC wheel motors to AC wheel motors and the associated drive technology significantly reduces costs, and increased availability, due to less scheduled maintenance.

The higher torque produced by the AC motors and drive system means that the trucks can accelerate faster, and reach higher speeds when carrying heavier loads. Faster and more sophisticated DC feeder protection relays were introduced, to protect feeder lines against thermal overload and short circuit faults.

Logic control systems were introduced to allow the substations to be fully automated, with auto reclose DC feeder breakers, which further reduced down time in the event of an external fault on the feeder lines.

ADVANTAGES OF TROLLEY ASSIST

Normally the speed of a truck on a gradient is limited by diesel engine power. If the same truck could get more power by connecting to an overhead electric feeder line while travelling on an uphill gradient, it could sustain a higher speed. The diesel engine would be idling, and fuel consumption would be reduced by 95%, greatly reducing noise and emissions to the environment.

Billions of litres of diesel are consumed annually by the global mining industry, which is under severe pressure from weak commodity prices. Loaded haul trucks on uphill gradients typically account for 70 – 80% of a truck's total fuel consumption.

A trolley assist solution is installed on any uphill stretch, between the loading area (pit) and offloading points (dump or process plant). With the inclusion of the electric drives, the electric power supplied to the wheel motors of the haulage trucks enables the vehicles to move faster uphill, which results in quicker turnaround times, and higher productivity for the mining operation. For example, if the duty cycle time is reduced by 20% as a result of the increase in speed on the uphill gradient, a fleet of 32 trucks on trolley assist, can produce the same results as 40 trucks operating on diesel. This results in reduced capital costs if the study is done at the feasibility stage. Engine operating and maintenance costs are directly linked to hours of operation of the haul trucks, and using trolley assist on gradients reduces the cycle time of the haulage trucks, thus increasing the intervals between maintenance schedules.

The technology has been supplied to open cast mines in South Africa, Namibia, the DRC, Zambia, and as far afield as North America. New business interest has come from mining companies in Botswana, DRC and Sweden.

Figure 2 Fully Assembled E-House

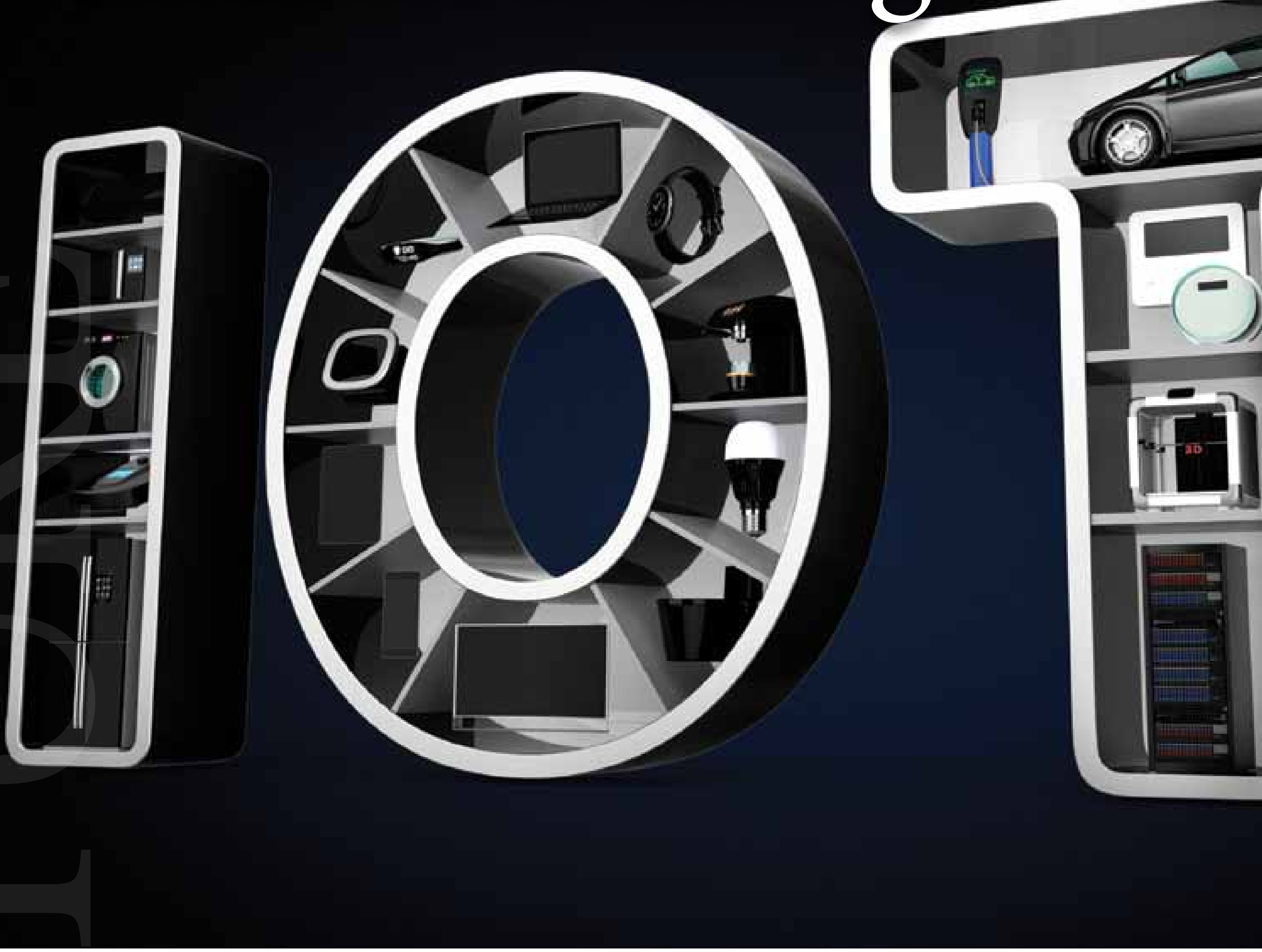
Switchgear

The goal of mining corporations is always to reduce the cost per ton of the commodity produced over the life cycle of the assets, and the trend is clearly toward larger trucks, shorter cycle times, with a leaner fleet and overall lower cost of ownership, all of which can be achieved by the benefits of a trolley assist solution.

This E-House concept is being promoted to the rail customers. Recently, a 5 MW, 3 kV DC containerised substation was commissioned in the Northern Cape. This E-House solution was designed to comply with the specifications of the rail customer. The recent developments in the 11 MW DC E-House solution, and the 5 MW, 3 kV DC solutions positions Siemens to approach the international markets in terms of exporting the solution.

Earn CPD Credits

Engineering the Internet of Things



All around us connected devices are proliferating. New, innovative products are emerging almost daily, and familiar products are benefiting from newer, smarter functionality. These developments come with the promise of making us healthier and safer, as well as more efficient, innovative, competitive and profitable.

COMPILED BY I MINX AVRABOS

The Internet of Things (IoT), which holds great potential, also presents new challenges to the engineers tasked with building the devices. In this article, I will identify the most critical challenges and describe a platform solution, supported by robust applications, that can help you engineer the best possible IoT products.

According to analysts' estimates, by 2025 there will be 20 to 30 billion connected devices globally, representing a market opportunity approaching R150 trillion ($11 trillion) [1]. While innovations in factory automation, smart cities, consumer electronics and healthcare stand out, virtually no aspect of the global economy will be left untouched by the "collect-connect-correlate" value of the IoT.

The research firm Gartner points out that digital technologies such as the IoT are changing business models and disrupting every industry, e.g., blurring traditional industry boundaries such as those between cars and smartphones to create the connected car. As a result, market incumbents, seeking to offset the threat posed by technologically savvy startups and new entrants from historically disparate industries, are speeding technology acquisition. In parallel, nimble IoT pioneers are accelerating their investment in digital technology and are gaining a clear competitive advantage. Jeff Immelt, CEO of General Electric, synthesized the impact of IoT when he noted, *"If you went to bed last night as an industrial company, you're going to wake up this morning as a software and analytics company."*

As a technology leader in your organization, it is highly probable that you have, or shortly will be, tasked with the implementation of an IoT strategy for your products. Like many of your peers you may be wrestling with how to begin the journey from a "product" to a "smart connected product" that requires technology and skills from outside your traditional domain of expertise.

THE THREE ELEMENTS OF THE INTERNET OF THINGS

In its simplest form the Internet of Things comprises three elements: the things, the network or gateway, and the cloud, as illustrated below.

THE THINGS

Products, such as cars, phones, robots, industrial equipment, and even homes, are becoming smart and connected. More and more processing power is being added to the things, as are sensors that may be used to measure acceleration, orientation or touch. The things also include communication systems, like Wi-Fi and Bluetooth, that connect them to the network. The main focus of this white paper is on designing the things, using engineering simulation to manage both the opportunity and complexity represented by the IoT.

THE NETWORK

Sitting between the cloud and the things, the network is integral to the IoT infrastructure. Without it there are no connected devices. A robust and reliable network includes high-speed routers, switches and gateway technology. Each of these components can be considered things in their own right, and can benefit from engineering simulation. Network design and protocols are important issues of the IoT, but they are not discussed in this white paper.

THE CLOUD

The cloud consists of data centers and the software that runs much of the business logic of the IoT. Data centers house servers along with infrastructure technology, which includes supporting networking equipment, environmental control systems and a reliable power grid. A lot of attention has been on the cloud infrastructure, but the cloud software that operates and maintains IoT devices is of special interest to engineers designing the things.

The Internet of Things

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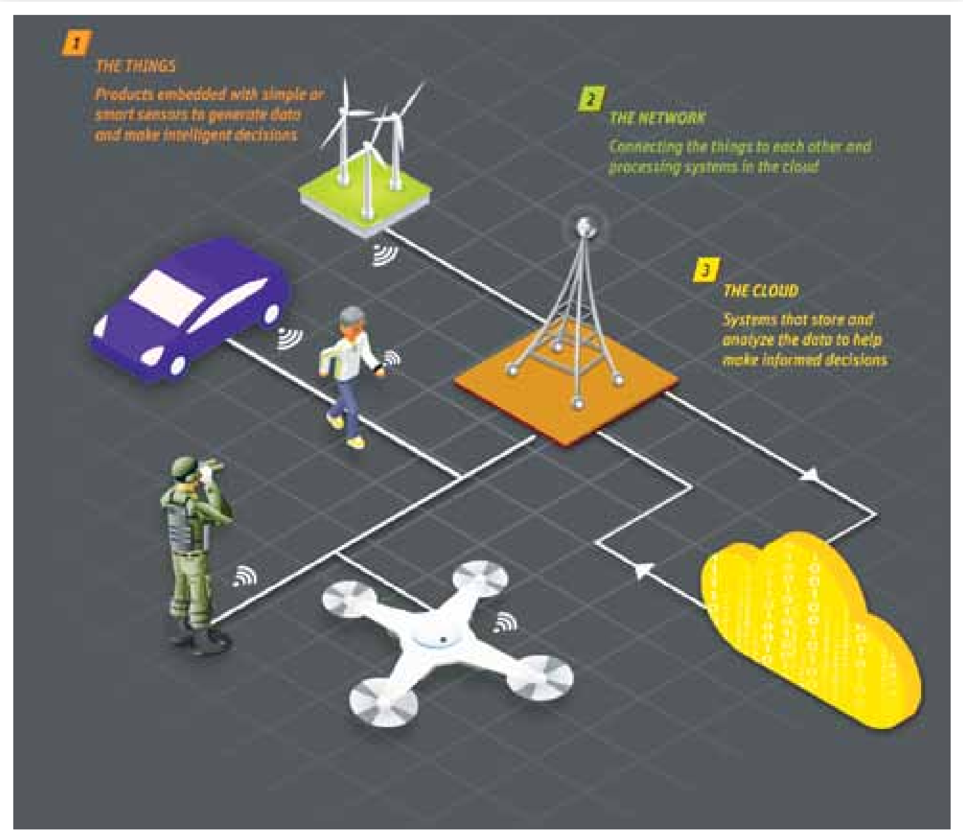

The interaction of the three elements of the Internet of Things

Experts agree that the value of the IoT will be fully realized through analysis of data collected from the things. For example, the vibrations of a turbine engine can provide crucial insights to improve operational decisions. Industry leaders like GE and PTC have developed platforms that can connect to simulation tools to optimize the performance of field assets and drive future innovation.

One way of optimizing performance through simulation is to use "digital twins." The idea of a digital twin [2] begins and ends with simulation: Each physical thing has an accompanying virtual double - a digital twin. Actual performance data collected from the thing is then compared in real-time against the model predictions of the digital twin to identify possible performance issues and take preventative maintenance action. The same data can also be used to drive design and simulation of next-generation products.

While both business and technical data analytics are important to an overall IoT strategy, in this paper we will focus on the design challenges faced by engineers who create the hardware and software components for the things, the network and the cloud.

Our discussion will include design of electronic components and embedded software, but exclude discussion of communication protocols and analytics systems and methods.

THE FIVE CRITICAL CHALLENGES FOR ENGINEERING

Smart and Connected Things Research has shown that best-in-class companies who adopt simulation- based approaches early in their product design cycle "are able to make better decisions throughout the process. This enables these leaders to drive higher quality and lower cost products, as well as deliver the innovations and features that differentiate their products. Ultimately, this pays off in a 15 percent increase in profit margins on new products, three times that achieved by their peers." [3]

Why is simulation crucial to IoT product development? The transition from mechanical to electronic systems, including millions of lines of software has added layers of complexity. And while this transition to electronic systems has improved product reliability in many ways, the density of wireless connections, transistors, and software has created additional challenges. Simulation has been in use for decades to design components. But companies building the IoT infrastructure are dealing with multi-faceted challenges that require higher level of reliability, precision, robustness and innovation - all at reduced cost. To achieve these goals, companies can neither design in silos nor rely on traditional build-and-test methods, or they will simply be out-innovated.

Simulation has leveled the playing field, enabling smaller companies to compete with large incumbent enterprises. Using simulation, a few engineers can virtually prototype and refine their ideas - going beyond traditional engineering discipline boundaries, resorting to multi-domain and multi-physics analyses. In a recent report,

the Boston Consulting Group [4] listed simulation as a critical success factor in the connected economy.

Our work across multiple industry sectors globally, with companies who are addressing the problem of engineering the Internet of Things, has high-lighted five engineering challenges. While these challenges are not new to experienced professionals, the sheer size of the IoT opportunity and the competitive forces are leading to one conclusion: The winners and losers in the IoT economy will be separated by their ability to address these challenges consistently and urgently.

SIZE, WEIGHT, POWER AND COOLING (SWAP-C)

Whether designing planes, cars or smartphones, engineers need to optimize products for size, weight and energy-efficiency, or the products may lag behind competitors. The addition of IoT technologies, such as pervasive connectivity and sensing, brings with it a higher density of electronic components, leading to additional size, weight, energy and thermal challenges. For example, the modern hearing aid is a smartphone connected device, providing significantly more functionality than previous-generation devices [5].

It includes a flexible printed circuit board, a battery, a receiver, an antenna and, in many cases, a telecoil. The flexible printed circuit board incorporates more than 60 different components and integrated circuits. The designers must manage all these components in a constrained space while optimizing performance - using enough power to deliver reliable wireless connectivity, keeping the device cool, ensuring longer battery life, and minimizing device weight, size and interference with other electronics.

SENSING AND CONNECTIVITY

Smart connected products are "smart" because they can sense their environment, communicate with other electronics, and enable decisions and outcomes. For example, modern cars that contain Advanced Driver Assistance Systems (ADAS), are equipped with a host of sensing and communication technologies. Over the next four years, the ADAS market could grow from R120 billion - R405 billion ($8.4 billion to $30 billion) [6]. The adaptive cruise control function utilises radar and laser-based sensors embedded in the bumper to keep cars at a safe distance from each other at a given speed. Blind-spot monitors and lane-departure warning systems ensure that drivers stay safely within their lanes.

Cars can monitor and report traffic conditions, informing other GPS-equipped cars to alert their drivers and suggest alternate routes. Unlike previous generations of automotive engineers, the engineers designing modern cars - loaded with ADAS - need to pay added attention to reducing electromagnetic interference that may wreak havoc on the electronics. Maintain- ing signal and power integrity at all times is crucial; with drivers relying on these systems to make decisions, false reporting could lead to bad outcomes.

RELIABILITY AND SAFETY

Given the vast numbers of connected things being projected to emerge in the coming years, reliability is a must if the economic argument for the benefits of connected products is not to be outweighed by the cost of maintenance or lack of uptake by the market. Many products, such as those in the automotive, aerospace and medical industries, will be in safety-critical environments, and will need to meet relevant reliability and safety standards. This is particularly true in the realm of the embedded control and display software that is needed to operate the integrated mechatronic products of the IoT.
In the most complex products, such as connected cars and aircraft systems, validating the tens of millions of lines of safety-critical embedded software code is one of the critical paths.

INTEGRATION

As the complexity of products has increased over time, engineers have broken down the design process into smaller pieces. While this component-level, bottom-up design methodology allows for very thorough component level verification, significant late-stage issues arise when the components are assembled to create the system. This system and subsystem-level integration effort often leads to over-design, cost-overruns, and even poor design trade-offs to meet product release deadlines.

For example, when integrating an antenna in a wireless fitness band, the antenna engineer may find that the antenna isn't working as expected. The installed performance of the antenna may be different due to the curvature of the wristband, the presence of a biometric sensor antenna, or even the metallic clasp that holds the wristband together. The complexity of IoT devices, the environment in which they will operate, and the need for higher safety and reliability mean that engineers' late-stage integration challenges have increased significantly.

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DURABILITY

One of the attractions of the IoT is that trillions of sensors and communication systems will be deployed to collect and share useful information 24 hours a day, seven days a week. These systems will be expected to perform reliably not just in their intended environment, but also in what are often extreme, harsh environments whose exact conditions are difficult to define in advance. For example, consider a sensing system at the end of a drill bit in the oil and gas industry, or in an unmanned military system operating in a hostile electromagnetic environment.

The ambitious Aquila project by Facebook utilizes a drone with a wingspan of a Boeing 737. The drone will use lasers to beam Internet to remote parts of the developing world. The design specifications for this solar-powered drone call for it to fly for up to three months at a time. These design scenarios are incredibly difficult to anticipate or explore using a physical test regime, yet the expectation is that the product must perform in these mission-critical environments.

And while not all products need to endure these extreme conditions, they need to be tested for durability. Consumer electronics users, like smartphone and tablet consumers, for example, expect their devices to withstand minor drops and impacts. Exploring and ensuring performance in a variety of operating environments is a core engineering challenge.

A CONSOLIDATED SIMULATION PLATFORM AS A SOLUTION

Quickly developing cost-effective solutions for highly complex IoT-enabled products requires changes to engineering product development processes. We are seeing IoT product pioneers break down the barriers between traditional engineering silos and use engineering simulation tools that can connect a series of discrete functional application areas in a common working environment, or simulation platform. Research has shown that product development teams that consolidate their simulation-driven product development capabilities on a single platform are 24 percent more likely to meet product launch targets and 37 percent more likely to decrease the length of their product development time compared to those who have not consolidated. These are critical metrics that can define whether your IoT product development efforts succeed or fail in this highly disruptive and competitive business environment.

Let's consider an example. ADAS are a key technology challenge on the journey to the IoT-ready connected car. Integration of this system requires sensors, safety-critical embedded software, data processing and a complete systems engineering view. These are traditionally segregated engineering disciplines, yet the tightly coupled behavior of this system demands an integrated engineering approach and a simulation platform that supports the overall solution from the advanced physics at the component and system levels.

Take a radar system as an example. First we need to understand its stand-alone performance using simulation tools.

But the radar system needs to operate successfully when installed on the vehicle, and is subject to the elements such as rain and ice. Simulation of the whole radar and fascia assembly solves such integration issues upfront. The behavior and response of the vehicle to inputs from the radar system is to a large extent determined by the vehicle's onboard control software. Verifying and validating the hundreds of thousands, and sometimes millions, of lines of embedded software, and their interaction with the physical components, is a critical path design work package.

ADAS is a classic example of a large, complex system encompassing the entire vehicle. To virtually validate ADAS design, all other major vehicle systems, such as control systems, human-machine interfaces, brakes and vehicle dynamics need to be modeled in a comprehensive system simulation. Then that comprehensive vehicle and ADAS model needs to be run through a real-world model of roads, buildings, pedestrians, etc., to test the ADAS' behavior in simulated driving scenarios.

THE SEVEN CRUCIAL APPLICATIONS FOR ENGINEERING THE INTERNET OF THINGS

Of course, an integrated solution developed on a consolidated simulation platform, such as the ADAS described above, can only be successful if the underlying discrete simulation applications are in place. Seven applications that are crucial to designing successful IoT-enabled products have been indentified, and which make up the discrete components of the consolidated platform-based solution. If IoT product development is your business, it is imperative that you and your engineers understand and apply these applications to maximize your chances of success. To illustrate these applications more clearly, I'm also sharing examples from industry leaders who are using the applications to develop innovative solutions to gain market advantage.

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ANTENNA DESIGN AND PLACEMENT

The performance of wireless systems can be very different in the real world when compared with the prototype testing environment of an anechoic chamber. Multipath signal propagation and fading are just some of the issues created by the presence of complex real-world structures, mobility, and even human beings.

Additionally, modern devices use multiple wireless technologies and frequency bands, requiring multiple antennas. As a result, antenna coupling and co-site issues can degrade performance.

Consider a scenario where a wireless sensor network is deployed in a factory. Each sensor uses a dipole antenna to communicate with other sensors. The ideal radiation pattern of a dipole antenna resembles a donut, but, when deployed in an industrial setting, the complex structures and the interference from other antennas distort the radiation pattern, reducing antenna efficiency, increasing power consumption and leading to unreliable performance and failure.

So, how can engineers ensure reliable wireless connectivity within an industrial setting, or on a car, plane or smartphone without having to resort to time-consuming build-and-test methodology? Certain software solutions exist, where engineers can perform a near-field analysis to predict the effects of the entire industrial environment on the performance of antennas and wireless devices. The finite element domain decomposition, 3-D method of moment, hybrid, and Shooting and Bouncing Ray (SBR) techniques can also be used to quickly solve electrically large and complex full-wave electromagnetic models. This approach provides greater insight, improves accuracy and increases reliability.

As an example, engineers at Synapse Product Development — a leader in wearable electronics — have used tools to increase antenna range by a factor of five, while reducing their overall design cycle by 25 percent.

CHIP-PACKAGE-SYSTEM DESIGN

Designing high-speed printed circuit boards (PCBs) and semiconductor integrated circuits (ICs) poses significant challenges due to design complexity in the form of lower operating voltages, circuit density and faster data rates. In addition, many IoT product design teams need to address size, weight, power and cooling considerations.

Whether designing a PCB or an IC, engineers must balance the requirements of three broad areas that affect product reliability - electrical, thermal and mechanical performance. Engineers also need to simulate the interactions between the semiconductor die or the IC, the IC package and the PCB.

Power integrity analysis is necessary to ensure a proper power delivery network, and signal-integrity analysis is needed to minimize crosstalk and increase design robustness. Addressing thermal reliability calls for simulation to evaluate the impact of temperatures of the board and associated components, ensuring that the devices operate reliably over the specified temperature range.

And mechanical reliability requires a thermal stress simulation to evaluate thermal and mechanical stresses in the board, along with solder joints between the board and its components.

In addition to performing individual physics simulations, engineers must consider the interaction between physics disciplines, coupling signal integrity analysis with thermal simulations and connecting thermal simulations with structural analysis. This method provides a holistic view of the overall reliability of PCB design.

A chip-package-system workflow, enables engineers to improve electronic system performance. The workflow enables PCB designers to simulate their designs, including crucial information from IC and package models. Conversely, the workflow allows IC designers to include the impact of package and PCB when verifying their IC designs.

With all relevant system-level considerations modeled and simulated, engineers can reduce electromagnetic interference, increase Electrostatic Discharge (ESD) protection, and improve the electronic systems to power the IoT economy. An international telecommunications company leveraged solutions to design high-speed networking technology, reducing costs by more than 67 percent.

POWER MANAGEMENT

Anyone whose smartphone battery has run out understands the essential role of power management. But power management isn't just about smartphones or Wi-Fi. Energy harvesting, wireless power transfer and low power IC design are the building blocks on which many IoT devices will be built.

Energy from mechanical motion, heat, piezoelectric material and electromagnetic emissions can be captured and converted directly into electricity. When designing energy harvesting systems, engineers need to consider several parameters, including energy source, transducer type, power efficiency, required power levels and energy storage.

Importantly, when designing wireless systems, safety is a key consideration. Standards and regulatory agencies limit the amount of electromagnetic energy that can be delivered to living tissue.

At Vortis Technologies, engineers are applying software to solve the problem of wasted RF energy in cell phones, which not only reduces battery life but also creates acoustic noise.

The company's innovative phased-array antenna system delivers 125 percent improvement in battery life, resulting in 2.25 times additional talk time in a smartphone. The new antennas can be designed in one-tenth the time required using a build-and-test method.

SENSORS AND MEMS DESIGN

Sensor and MEMS (microelectromechanical systems) designers face business and technology challenges when designing, prototyping and creating compelling products that can mean the difference between success and failure. To gain a competitive advantage, sensor manufacturers need to develop their products as fast and efficiently as possible.
MEMS and sensors are complex because of their special functions, challenging manufacturing processes, and tiny size. MEMS are so small that performance measurement equipment can impact device function, making it difficult to obtain reliable performance data. Simulation provides accurate insight into the performance of these devices beyond what physical prototyp- ing provides.

Proven solvers and coupling solutions enable the high-fidelity analysis of device designs. Once an initial design is created and simulated, the entire device can be optimized before building, including the interaction of the components.

For example, an initial design may be optimized to minimize power use and temperature spikes by varying physical size and examining performance tradeoffs.

EMBEDDED SOFTWARE DEVELOPMENT

The modern electric vehicle can contain 50 million to 100 million lines of code. With autonomous vehicles on the way, we can expect software content to rapidly increase. But embedded software is not just for cars:

It is essential to add richness and smart functionality to many IoT devices, including industrial equipment, robotics, planes and drones.

Because many of these products and systems are safety- or mission-critical - for example, braking systems on cars and planes - the control software must operate flawlessly. When systems fail, they must fail in a predictable way to minimize damage.

Often, there are industry regulations, certifications and qualifications that govern the reliability and performance of software. Software development is no longer just about writing the code: It is also about verification and validation.

For each line of implementation code, software engineers often find themselves writing many more lines of verification code. Despite the amount of effort expended, software code bugs continue to persist, leading to safety recall, security breaches and sometimes tragic outcomes.

Engineers can use various software solutions to model complex systems, understand the interaction of various subsystems, and generate high-integrity software code that complies with many industry standards.

The ability to generate millions of lines of code at the push of a button not only removes human coding errors, but also increases productivity, quality and traceability of code. Moreover, this capability shifts engineering effort from code to system, further improving engineering productivity, innovation and end product

DESIGNING FOR HARSH ENVIRONMENTS

IoT devices must operate in the real world, which can be an unforgiving place. Fast-growing applications such as drones, wearables, self-driving automobiles and smart industrial equipment must operate reliably in harsh environments, where they may be subject to vibrations and physical impact. Despite these conditions, IoT devices must be robust and stay active for extended periods and across great distances without maintenance. A malfunction can result in mission failure, significant investment to repair or replace the system, and even risk to human lives.

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Whether they are used in industrial, aerospace or consumer applications, IoT devices are subjected to harsh environments, including vibrations, impact and fatigue. NASA has shown that 45 percent of first-day spacecraft electronics failures were due to damage caused by vibrations and stress during launch. According to SquareTrade, dropped iPhones have cost American consumers R81 billion ($6 billion) in recent years.

Engineers must consider these potentially harsh environments very early in the development process when design choices can be made at the lowest cost - and with the least impact on the project schedule. Physical prototyping is simply not a viable option for many obvious reasons.

Not only is it difficult to create all the possible test scenarios given the constraints of time, budget, location, and resources, but the measurement results can vary greatly and lack the fidelity needed for IoT and many other critical applications.

VIRTUAL SYSTEM PROTOTYPING

As product complexity grows, so does the need for enhanced simulation capabilities. The hottest innovation areas require system simulation to work. The complexity within systems arises from the challenges of connecting the individual pieces to ensure they work together as designed and expected.

Coupling physical attributes of a product with the systems and embedded software, companies can greatly minimize integration issues, reduce costs, increase the likelihood of first-pass success, and ensure that products perform as expected. While it is easier to visualize the IoT in terms of individual devices or components - a smartphone, a thermostat, or a wind-turbine - the complex and invisible networks that connect them, as well as the cloud that stores and delivers data on demand, require sophisticated modeling and simulation.

The smart wind turbine, for example, needs to adjust its behavior according to wind patterns, the amount of energy on the grid, and the behavior of other smart wind turbines.

The interactions of the software, the electronics hardware, and the multi-domain nature of the problems significantly increase the complexity of the engineering challenge. Simulation software can help by providing validation results that include systems-level qualities, properties, characteristics, functions, behaviors and performance insight.

Based on this high-level perspective, system designers can make informed design choices that optimize the performance of not only each individual component, but also the entire system.

Engineers designing the Internet of Things technologies face considerable challenges, including SWAP-C, sensing and connectivity, safety and reliability, integration, and durability. Platform-based engineering simulation, supported by seven applications — antenna design and placement, chip-package-system design, sensors and MEMS design, power management, embedded code generation, harsh environment design, and virtual system prototyping — is crucial to maximizing the IoT opportunities for your organization.

Many of the world's leading companies are already using solutions to deliver the most innovative products spanning smartphones to spacecraft, autonomous vehicles to drones, and robots to wind turbines.

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What is E-learning?

Although the concept of E-learning is no longer new, there are still many people not aware of this concept in the context of further learning.

E-learning is a more effective and flexible way to study, without being in the actual classroom, but still have all the benefits of being in the classroom. The concept is about having access to study material and a professional lecturer, without being in a physical classroom.

This could be at home, in your own study/office, or anywhere else where one has access to the internet. This learning methodology is not to be confused with the distance-learning concept, since with distance learning, the access to a professional lecturer is based on support, and written communication with limited real time contact with the lecturer.

E-learning is an ideal way to further one's qualifications when one is living far from accredited learning institutions, or when one has difficulties in getting to the class room during normal class hours, when the classes are presented. E-learning is about attending classes without being in the physical classroom, but instead being in a virtual classroom.

This concept is also very useful when companies need training for the whole company with offices/plants across the country. Learning can be structured in a very cost effective way, with staff logged in from all the various offices/sites. The challenge is to be equipped to provide high quality programmes, that adhere to the Quality Standards set by the relevant Quality Assurance Body, for the relevant Qualification, Industry and or Sector.

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The best way to achieve this Quality Education Standard with E-learning, is to follow a blended approach in presenting the learning content to students/industry.

There are only a few accredited providers who have the ability and technology to render this accredited services, with Virtual Classrooms, using a full blended approach. One such provider is IDC Technologies South Africa, which has vast experience in E-learning across the world, and established the virtual classroom approach in South Africa two years ago. They offer national certificates N4 – N6, National Diplomas, as well as fully accredited Advanced Diplomas in Engineering, where they also integrate basic qualifications with Work Integrated Learning (WIL). This is a concept that the SETA and Minister of Education is now supporting. The Draft WIL Policy of the department is available on the Department of Higher Education and Training website.

With E-learning it is simply a question of logging into the site of an accredited E-learning institution, where a professional lecturer will be available to present a subject that is on their programme offering schedule, at a specific time and day of the week. Students will have access to the virtual classroom, as well as online Learning Management System, that will give them access to the course content, and recording of any lesson that they missed, or they need to review. Lecturers are also available to book consultation and revision sessions.

What are the advantages of the E-learning type of study method?

- No need to be physically at the institution of learning – no travel costs,
- Can log in from anywhere as long as there is internet access,
- Direct access to qualified lecturers during the training sessions,
- Times of the classes can be prearranged

E-Learning

continues from page 33

to suit most of the students – especially for students in the working environment,

- The presentations are recorded, and students can refer back to the recorded presentation should there be any uncertainties, or a need for a repeat of the actual presentation. This also allows students who missed a session, for some or other reason, to catch up the missed presentation.

WHAT COURSES ARE PRESENTED?

There are a large number of courses presented by this way of studying. Just access the internet and search E-learning courses.

WHAT HARDWARE AND SOFTWARE IS REQUIRED?

All you need is a stable connection to the internet, Google Chrome and/or FireFox Browsers on your PC, speakers and a microphone. Webinar links are provided before each session, so no software required.

WHAT ARE THE COSTS OF E-LEARNING COURSES?

The costs of these E-learning courses will vary. However, in many cases the costs are less than the normal attendance courses. The reason being lower overhead costs for the E-learning institutions.

IDC TECHNOLOGIES E-LEARNING

For technical studies we have Instrumentation Data Communication Technologies (IDC Technologies South Africa) which presents E-learning courses backed up by IDC of Australia. They have been High Quality Accredited Education and Training service provider for more than 20 years. IDC Technologies South Africa presents National Certificate (N4 to N6) courses up to diploma level, and post diploma level.

CONCLUSION

E-learning is a way of providing all students and companies with the opportunity to enhance their skills and competencies. In addition, it improves the productivity of the company, and the country, in a cost effective way. This does not sacrifice the expertise needed to drive the productivity and day-to-day operation of th business.

Since access to E-learning is easy, and comes at a lower costs, companies can get reimbursed for this training through the skills levy. There is no excuse therefore, for not improving ones qualifications, skills and competencies of our workforce. wn

Earn CPD Credits

Which Country will be the first to ban oil burning cars?

Dr. Joe Romm, in his recent article *"Which will be the first country to ban oil burning cars"*, provides us with more information on the recent decision of German Bundesrat to ban fuel-burning cars.

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LITHIUM RACE FROM THE DIESELGATE

- The German Auto Industry Is Finally (Maybe) Done With Gas.

Everybody is still in a total disbelief that Almighty Auto Lobby in Europe can really loose and the German Parliament has finally decided to ban sales of all new cars with Internal Combustion Engines (ICE) by 2030. Autos have just celebrated the DOUBLING of cancer hazard pollution limits for diesel cars, after the DieselGate.

One can be also very cynical after of years calling and waiting for this action, and I ask you to wake me up when it will really happen. But the ugly truth is that autos have finally understood that they cannot survive pushing "Clean Diesel", and "Not So Dirty Gas" any longer. People are not buying it. It makes more sense to rush and finally build all those electric cars before Tesla and EVs from China have taken over the world.

Tesla Model S crashes all sales of luxury sedans this year, leaving the Mercedes S-Class and BMW 7 in the dust. With 400,000 orders for Tesla Model 3, consumers have sent a very powerful signal that they are ready for the best electric cars.

FEATURE

The end of ICE?

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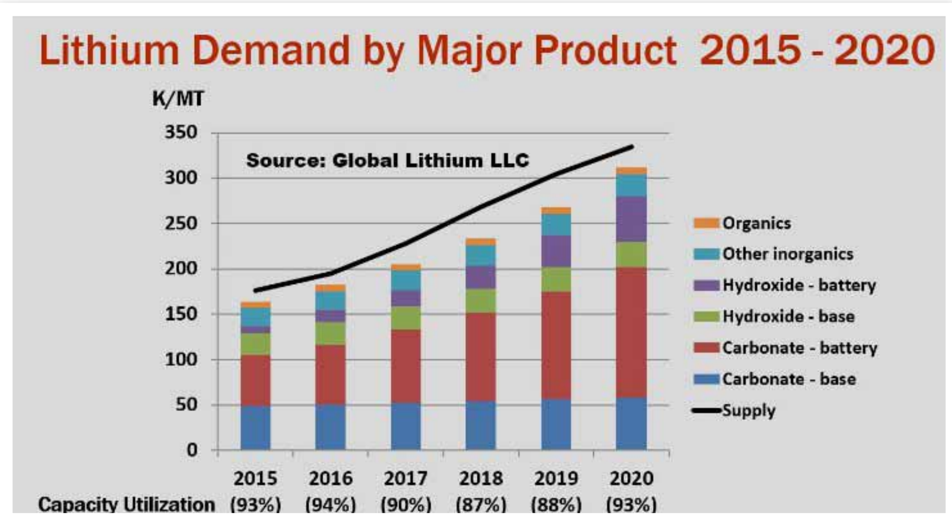


There are not many of them yet: GM Bolt, Opel Ampera-e and Tesla Model 3 will start the real race, with both priced below $40k and having 200 miles of range.

The Great Germans will be fighting back the ban of ICE cars, such as they are doing now in India, with the ban on diesel cars. However, the train has left the station. DieselGate lawsuits can put Volkswagen out of business, and they all understand very well now that first customers are going to Tesla. Next the investors will be selling shares in all dinosaurs, who cannot see what is coming - all cars will be electric. Voices for the real change are getting louder, and you can no longer dismiss them. Lithium technology is here, and cheaper lithium batteries change everything. Lithium is the magic metal at the very heart of this Energy rEVolution.

ELECTRIC REVOLUTION

\- New Lithium Supply And Demand Forecast.

Joe Lowry provides us with his conservative outlook for Lithium Supply and Demand up to 2020.

"Always do your very own Design Development (DD), but at least you have the best data to work with. Now we have news to put his view into perspective: Germany calls Europe to ban all ICE cars from 2030! It means that ramp-up in building production facilities for EVs and Lithium Batteries must be started now. We are finally talking seriously about The Switch to renewable Energy and Electric Cars by 2030! Lithium Technology is here, and Lithium is a magic metal at the very heart of this Energy rEVolution."

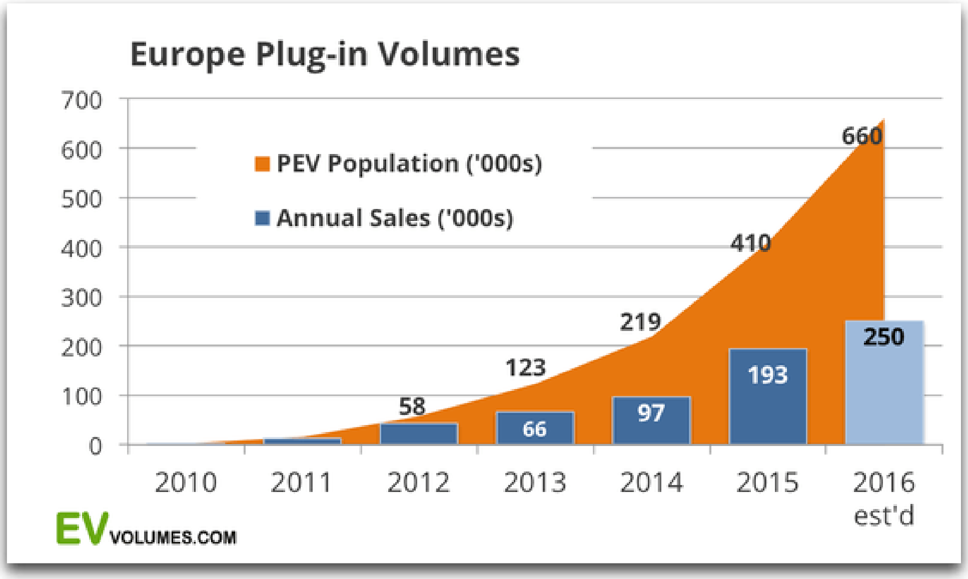
GERMAN PUSH TO BAN COMBUSTION-ENGINE CARS BY 2030 WINS SUPPORT AFTER DIESELGATE.

Germany would like to join Netherland and Norway in banning sales of ICE cars from 2030. It means that they will now have to make electric cars, and all that news about dozens of electric cars coming in the next 10 years is getting more credibility. Lithium Battery makers are already moving into Europe: Mercedes, LG Chem, A123, BMZ and Volkswagen have all announced Lithium Megafactories in the making, and security of lithium supply will be coming on the European investors' radar screens very soon.

This tipping point for electric cars to replace oil burning cars, is the result of the technological advance called "The Learning Curve", when doubling of production brings an average of 26% in cost reduction. Bloomberg expects that by 2022, Electric cars will be cheaper to buy than the comparable class of oil burners, due to the expected 14-19% cost reduction of lithium batteries every year.

Numerous studies have already confirmed that, even with the existing energy mix in the US grid a few years ago, Electric Vehicles (EVs) were much cleaner than ICE ones on the full life cycle. From lithium battery making, including the production of lithium, to the electricity to charge this battery. Now they are getting even cleaner, with the energy mix of the US grid taken over by the renewables.

What is very important to note today, is that this year, renewable energy is breaking records every single month, even in the US. Energy Storage, with lithium batteries, will be next to grow exponentially and will consume more lithium battery capacity than EVs. Fossil Fuels are consumable resources, and renewables are technology. The functions for the progress of development for Solar Power and Lithium Batteries are not the same as the famous Moore's Law, but still very impressive, with prices going down dramatically over a period of time with mass volume production. In the case with Solar Power particularly, we are getting to the stage when the dramatic decrease in cost have already made Solar the cheapest source of energy ever. Cheap lithium batteries change everything and



now we can store electricity, the most efficient form of energy known to us, and use it when we want it.

CLEANER CARS FROM CRADLE TO GRAVE

It is time to study the *"The new economics of energy storage"* from McKinsey&Company - they will be pitching it to their clients now.

Elon Musk has already announced that lithium battery packs at Tesla now produced at $190 per kWh. Mass production of lithium batteries at Tesla Gigafactory will bring this cost down to $100 per kWh by 2020. Energy storage is the missing link between renewables and the old grid, it will consume even more lithium batteries than exponentially growing electric cars.

In places such as China, India and Africa, trillions of dollars will be saved on infrastructure through going with smart grids empowered by Solar and energy storage. There is no need for fixed telephone lines if you have mobile networks. The same is happening with Energy Generation and Utilities right now. In this case, we are talking about the disruption of $8 trillion dollars Energy industry, compared with to $4 trillion dollars of transportation.

If you believe that there is too much hype about Energy Storage now, the anecdote from Tony Seba will be timely: In the mid-1980s, AT&T hired McKinsey&Company to forecast cell phone adoption by the year 2000. They had estimated 900,000 cell phones, and were off by a factor of 120X, grossly underestimating the growth in the market, and adoption of that new disruptive technology. There were 109 million cell phones by 2000.

Battery technology, particularly in the form of lithium ion, is receiving the most attention and has progressed the furthest. Lithium-ion technologies accounted for more than 95 percent of new energy-storage deployments in 2015. They are also widely used in consumer electronics, and have shown promise in automotive applications, such as plug-in hybrids, and electric vehicles. Prices for lithium-ion batteries have been falling, and safety has improved; moreover, they can work both in applications that require a lot of energy for a short period (known as power applications), and those requiring lower amounts of energy for longer periods (energy applications). Collectively, these characteristics make lithium-ion batteries suitable for stationary energy storage across the grid, from large utility-scale installations, to transmission-and-distribution infrastructure, as well as to individual commercial, industrial, and residential systems.

"Our model confirms the centrality of lithium-ion batteries to utility-scale energy storage, but with two important caveats. First, it is critical to match the performance characteristics of different types of lithium-ion batteries to the application. For example, we looked at two major lithium-ion-battery providers that were competing to serve a specific industrial application. The model found that one company's products were more economic than the other's in 86 percent of the sites because of the product's ability to charge and discharge more quickly, with an average increased profitability of almost $25 per kilowatt-hour of energy storage installed per year." McKinsey&Company

THE ENERGY COLLECTIVE

Electricity generation from wind, solar, and other renewable energy technologies have set monthly records every month so far in 2016, based on data through June released by the U.S.Energy Information Administration (EIA).

"Both hydroelectric and nonhydroelectric renewables have contributed to this trend, but in different ways. After a lengthy West Coast drought, hydro generation has increased and is now closer to historical levels. Non-hydro renewable generation continues to increase

FEATURE

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year-over-year and has exceeded hydro generation in each month since February 2016," the EIA said in a statement.

According to EIA's data, net U.S. electricity generation from non-hydroelectric, utility-scale renewables (biomass, geothermal, solar, and wind) through June 2016 was 17 percent higher than in the first half of 2015. Electricity generation from conventional hydropower also rose, by nearly 12 percent. Combined production from all utility-scale renewable sources was up 14.5 percent compared to the same period in 2015.

Not only has electricity generated by renewables exceeded previous levels, in every month so far in 2016 — in other words, more renewable energy was produced in January 2016 than any other January on record, more renewable energy was produced in February 2016 than any other February, and so on — but renewable utility-scale electricity generation hit an all-time high of 16.55 percent of total domestic generation.

Those weren't the only records broken, either. Utility-scale wind power rose 23.5 percent in the first half of 2016, setting a new six-month record of 5.96 percent of total generation.

Meanwhile, generation from utility-scale solar, thermal and photovoltaics grew by 30.3 percent, and accounted for 0.87 percent of total utility-scale electrical output. The EIA also estimates that distributed solar photovoltaics, or rooftop solar systems, expanded by 34.3 percent. Combined, utility-scale and distributed solar comprised 1.26 percent of total generation. A year ago, solar was responsible for just 0.94 percent of electricity generation.

Together, wind and solar grew by nearly 25 percent over the first half of 2015, and now provide almost as much electricity as conventional hydropower. Biomass and geothermal were the only renewable sources tracked by the EIA that have experienced declines so far in 2016.

Of course, renewables aren't the only record-breakers out there. July 2016 was the 15th record-breaking month in a row in terms of global temperatures, data from the U.S. National Oceanic and Atmospheric Association (NOAA) showed. And Gavin Schmidt, director of NASA's Goddard Institute for Space Studies, reported that July 2016 was also "absolutely the hottest month since the instrumental records began."

Electricity generated from coal plummeted by more than 20 percent, and nuclear power stagnated, growing just one percent, per the EIA data. Generation fueled by natural gas, on the other hand, was up by 7.7 percent.

Still, Ken Bossong, executive director of the SUN DAY Campaign, noted that renewable energy has continued to defy projections. *"Renewable energy's share of net electrical generation for the balance of 2016 may dip a little because electrical output from wind and hydropower sources tends to be highest during the first six months of each year," Bossong said in a statement. "Nonetheless, the data thus far is swamping EIA's earlier forecast of just 9.5% growth by renewables in 2016."*

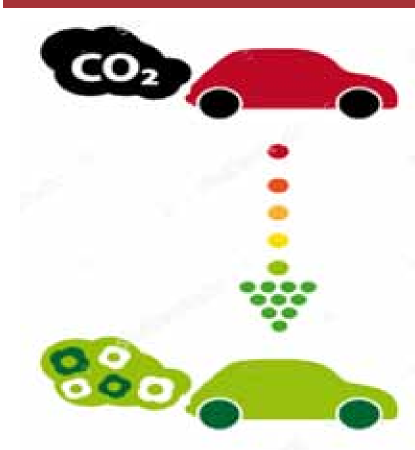
Electric vehicles are now in the fast lane, with the first electric cars priced below $40k with a range of over 200 miles, coming to the market: GM Bolt and Tesla Model 3. BMW i3 with the new larger battery, Renault Zoe with 400 km range and Nissan Leaf with upgraded battery, are driving the sales in Europe. China stands on its own with 25 companies making 51 models of electric cars.

LITHIUM BATTERY TECHNOLOGY IS HERE TO STAY

The benefits to the consumer are massive. Electric vehicles provide better performance, with 0-60 mph in as little as 3 seconds. Tesla electric cars have a much better passenger safety, and running costs of EVs are in the order of 90% lower compared with oil burning cars.

Electric vehicle progress is inevitable, and Tesla shows what is coming with Tesla Model S outselling ALL luxury sedan brands in the U.S. and Western Europe, by a very wide margin. In the Q3 of this year, Tesla Model S sales were almost double that of Mercedes S-Class, and more than double that of BMW 7!

Finally, as Dr. Joe Romm pointed out, governments are now starting to wake up to the horrible cancer hazard air pollution on our streets from fuel-burning cars, and voices for the ban of such cars are becoming stridently louder. wn



SAIEE Railway Chapter Work Group

BACKGROUND

The Railway Chapter is an extension of the South African Institute of Electrical Engineers (SAIEE), Power and Energy Section (PES). Since the vast majority of railway traffic in South Africa is hauled by electric trains, it means that the railways use electric energy intensively, and the Power and Energy Section therefore deemed it necessary to establish a Railway Chapter. The Chapter was officially launched on 2 December 2015 at the SAIEE Head Office in Johannesburg.

PURPOSE

The purpose of the SAIEE Railway Chapter is to:

- Generate interest in the field of Electrical Engineering and Electrical Railway Engineering amongst its members, through presentations of topical electrical railway related matters given at its meetings.
- Schedule and arrange visits for its members to railway facilities, to enable members experience at first hand, the full scope of engineering in railways.
- Create awareness of the electrical engineering complexities/challenges/ successes in railways amongst the membership of the SAIEE by means of papers published in the SAIEE magazine **watt**now.
- Support the SAIEE in its strategy to market general -, electrical - and railway engineering by means of outreach visits to schools, so that interest is generated amongst scholars to study towards a diploma/degree in electrical engineering.
- Increase SAIEE membership amongst students, graduates, professionals and interested parties who are non members.

APPROACH

The Railway Chapter members meet regularly to discuss, make resolutions and implement these in support of its purpose.

The Railway Chapter may arrange ad hoc meetings or establish ad hoc committees to investigate and submit recommendations in respect of:

- Annual focus areas to achieve specific objectives;
- Annual programme of activities such as presentation topics at monthly meetings, site visits, outreach programme visits and publication topics for the **watt**now magazine;
- Technical investigations into specific electric railway engineering problems raised by Railway Chapter members.

MEMBERSHIP

The Railway Chapter membership is open to – but not limited to – SAIEE members who are involved in electric railway engineering.

MONTHLY MEETINGS

The Railway Chapter meets once a month. The preferred meeting venue is SAIEE House, Observatory, Johannesburg, unless otherwise advised. The preferred meeting time is 16h30 on every second Thursday of the month.

All meetings will have agendas and minutes. Minutes of a meeting will be available within one week of the date of the previous meeting.

Included in the agenda of every meeting will be a 1 hour long ECSA validated presentation, that will earn each member who attends 0.1 CPD point. Attendance of 10 meetings during a year will earn a member the compulsory annual 1 CPD point, at no cost to the member.

MANAGEMENT AND COMMUNICATION PROCESSES

The Railway Chapter is managed by the following office bearers:

- Chairman;
- Deputy Chairman - stand in for Chairman;
- Secretary;
- Deputy Secretary- stand-in for Secretary.

The Chairman is responsible for:

- Chairing of monthly Railway Chapter meetings;
- Performing the overall management of Railway Chapter activities;
- Implementing Railway Chapter strategies;
- Interacting with SAIEE staff and PES members, including submission of a quarterly activity report to the PES;
- Presenting recommendations of the Railway Chapter to the PES for approval;
- Informing Railway Chapter members of any requirements from the PES.

The Secretary is responsible for:

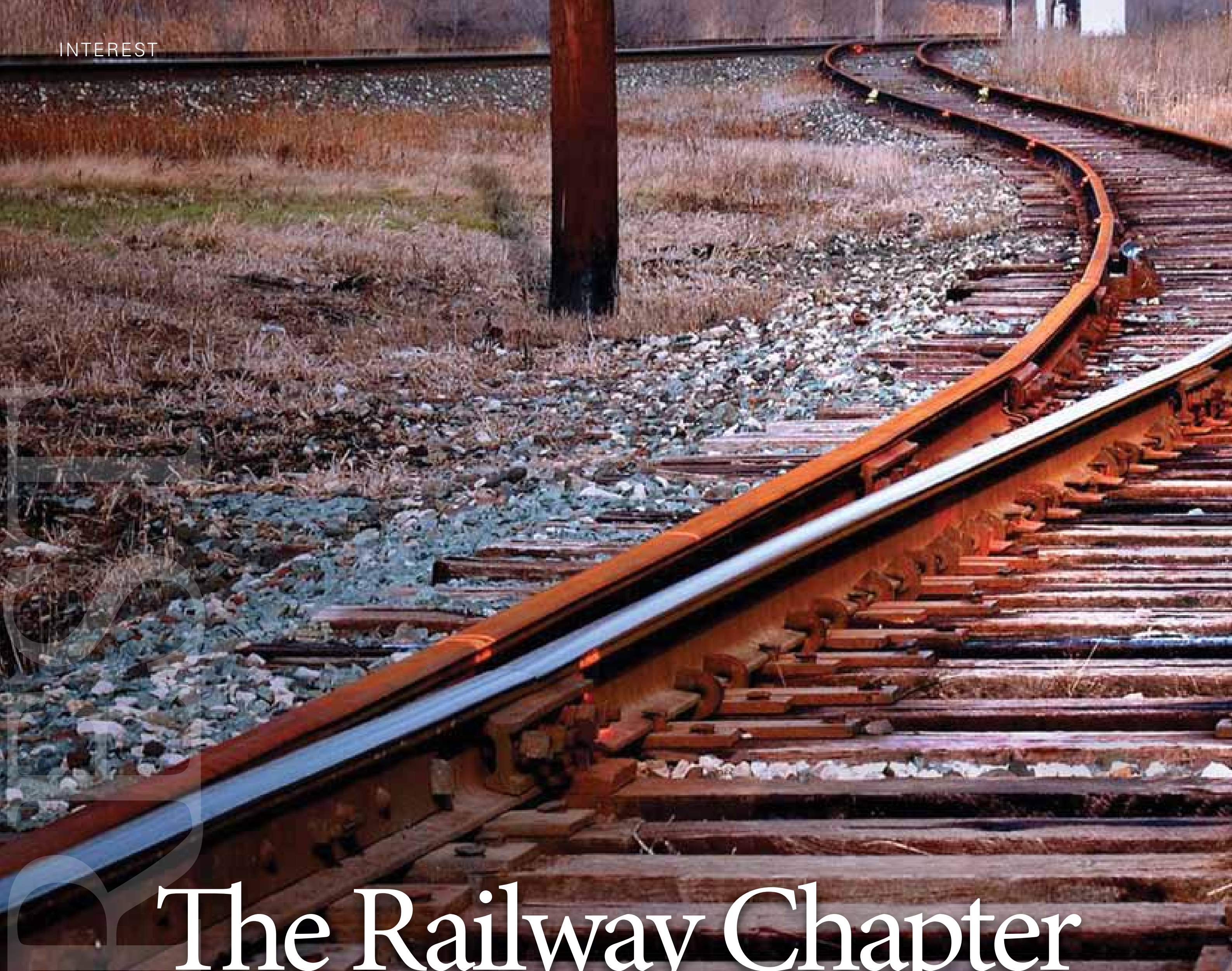
- Taking minutes of meetings;
- Distributing minutes of meetings to the Railway Chapter members;
- Arranging the meeting in advance and communicating this to the Railway Chapter members;
- Informing the Railway Chapter members of upcoming events;
- Providing an attendance register at each meeting and keep an up-to-date list of contact details for each member.

The term of office of the Railway Chapter Office Bearers will be for one calendar year, where-after the incumbents can make themselves available for re-appointment.

STAY UP TO DATE

Please like our page on Facebook using this link: www.facebook.com/SAIEERailwayChapter.

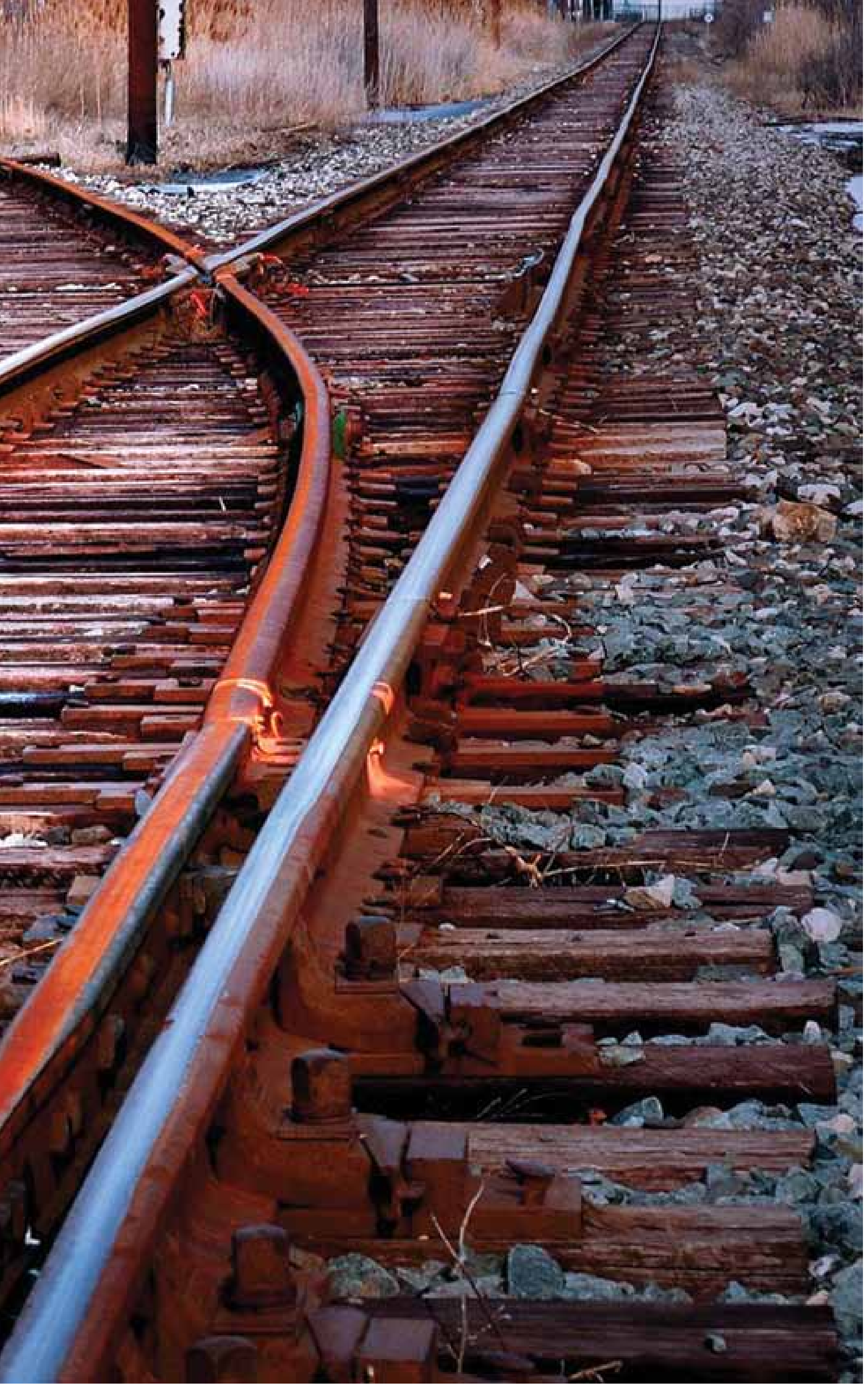
SAIEE RAILWAY CHAPTER



The Railway Chapter work group

The South African Institute of Electrical Engineers Railway Chapter Work Group visit to the Transnet Freight Rail, Railway Technology Development Centre

BY I GODFREY MALULEKE I MSAIEE
WILLIE COETZEE I MSAIEE



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- Support the SAIEE in its strategy to market electrical engineering in general, and electric railway engineering in particular, by means of outreach visits to schools, so that interest is generated amongst scholars to study towards a diploma/degree in electrical engineering.
- Grow the membership of the SAIEE amongst students, graduates and professionals, who are not yet members, as well as by attracting other interested parties.

The Railway Chapter Work Group members hold a monthly meeting every second Thursday of the month, in the boardroom at SAIEE Observatory House. During each meeting electric railway related issues are discussed, and an ECSA validated presentation is given by a railway specialist.

VISIT TO THE RAILWAY TECHNOLOGY DEVELOPMENT CENTRE

The visit to the Railway Technology Development Centre (RTDC) took place during June 2016, and was attended by nine Railway Chapter members.

The activities for the day were as follows:

- Welcoming and safety briefing by Joseph Bonga, who is the RTDC facility manager.
- Introduction of the Railway Chapter members, and a historical overview of the RTDC by Willie Coetzee.
- Presentations by the specialists from RTDC regarding their areas of responsibility.
- Visits to different facilities with demonstrations of equipment at RTDC.
- Wrap-up, conclusion and thanks to the hosts by Lukhanyo Nyakaza, chairman of the Railway Chapter.

The Railway Chapter

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Group picture of the Railway Chapter members and some of the RTDC staff members.

RTDC is a facility of the Technology Management Department of Transnet Freight Rail, and is located at Koedoespoort, Pretoria. It was established about 5 decades ago, by what was then the Mechanical Department of the South African Railways. Ground breaking railway engineering work resulted from this Centre such as the development of the Scheffel self-steering bogie, and the establishment of the world speed record of 245km/h on 1067mm track gauge. This world speed record was established on 31 October 1978, with re-geared electric locomotive E1525 (fitted with a streamlined nose cone), and the blue test coach. This speed record is still unbeaten.

The Railway Technology Development Centre is the only one of its kind in Southern Africa and supports the rolling stock specialists of Transnet Freight Rail, with its unique railway test and development facilities. When required, it conducts work for Transnet Engineering, an operating unit of Transnet, as well as for the Passenger Rail Agency of South Africa (PRASA). The facilities available at RTDC are as shown in the diagram.

COMPRESSION TEST RIG

The compression test rig is used to verify compliance of Transnet Freight Rail wagons and locomotives, with the structural requirements in the rolling stock vehicle specification. The tests performed are listed below:

- Superposition of vertical and longitudinal loads.
- Buff (compressive) longitudinal loads.
- Vertical operating loads.
- Vertical loads on the coupler.
- Lifting (using the lifting eyes – whole locomotive/wagon lifting).
- Jacking (using jacking pads – either whole locomotive lifting or only one side to remove a bogie).
- Loads at interfaces.
- Twist loads (body twist).
- Other loads (ie. roof loads, tippling).

IMPACT TEST FACILITY

The impact test facility towers above the buildings of RTDC. It comprises of a 93 meter long ramp which is at its highest point 12.5 meter above ground level.

The purpose of an impact test is to demonstrate the ability of a locomotive or wagon to remain fully serviceable, and to show no signs of permanent deformation or fracture under normal shunting impacts. This is the only facility in the Republic of South Africa that can perform impact tests on Tank Containers. It is accredited with Transport Canada for Tank Container tests.

METALLURGICAL LABORATORY

The metallurgical laboratory provides unique railway related services which are:

- Failure investigations of wheelset components.
- Provision of specialised welding procedures, perform certification of Transnet welders, and resolving of welding related problems for Transnet.
- Resolving materials-related issues for Transnet. For example, material fracture and failure analysis supported by the Scanning Electron Microscope.
- Perform Quality Assurance of all new components in the specialist technical areas of rolling stock wheelsets, bearings and drive train (this comprise of the gears, gearcase and resilient bushes of a locomotive).
- Corrosion testing of materials and Non-Destructive Testing

METROLOGY SECTION

The expression "to measure is to know" is attributed to the physicist Lord Kelvin (1824 – 1907), but if the measuring equipment is not calibrated, one still does not know whether what is being measured, is accurate. The metrology section provides the following services for mechanical tests on rolling stock:

- Maintenance and provision of specialised measuring equipment.
- Develops specialised test methods when required.
- Calibrates measuring equipment against working standards.

The metrology section ensures in addition that systems are in place for the periodic calibration/verification of all Transnet measuring equipment, and that the calibration is traceable to National Standards in compliance with the Legal Metrology Act (Act No. 9 of 2014).

OVERHEAD CONDITION MONITORING SYSTEM (OCMS)

Electrically hauled trains collect power from the overhead line via a pantograph,

which is mounted on the roof of a locomotive. In order for Transnet Freight Rail to operate electrically hauled train services reliably, thereby ensuring a scheduled railway, it is essential that the risk of pantograph/overhead contact wire damage is eliminated or minimised. This requires that the geometric parameters (stagger and height) of the contact wire, and the dynamic parameters (vertical and longitudinal forces) of the overhead line conform to specification. The Technology Management department of Transnet Freight Rail developed an Overhead Condition Monitoring System, to monitor the condition of the 3kV DC, 25kVAC and 50kV AC overhead lines for conformance to specification. The measured and calculated parameters are:

- Vertical contact force.
- Longitudinal contact force.
- Stagger, calculated from the vertical contact force.
- Contact wire height.
- Contact wire gradient (slope), calculated from the contact wire height and distance travelled

The parameters of the overhead line are measured by means of a specially equipped measuring pantograph that is fitted to a locomotive when the measurements are performed. The overhead line equipment comprise of long lengths of wires that require many clamps of different types, to either join wires or interconnect wires, to ensure continuity of current flow in the wires. If the wires inside the clamps corrode, or if the clamps become loose, the wires burn off at the clamps due to overheating, which disrupts the train service. The GeoScout system is used to record video and thermal images, that are linked to GPS position for analysis of visual or thermal faults of the overhead line. The GeoScout system performs the following functions:

- Records up to 3 video streams which can be in the visible and/or infrared spectrum.
- Records GPS position.
- Provides immediate feedback to the operators on recording status.

The results of the of the Overhead Condition Monitoring system and the GeoScout system are given to the infrastructure maintenance section, in the form of a defect list, so that the defects can be repaired before a catastrophic failure occurs.

TEST COACH SUPPORT

The Technology Management Department has several test coaches available to conduct tests on trains in service. A test coach is coupled behind the first locomotive on a train and is used as a mobile laboratory during long duration on-track tests. The following are examples of typical long duration tests when a test coach is used:

- Tests prior to the introduction of a new train service to establish running times and train handling.
- Acceptance tests of a new type of locomotive before it is put into service.
- Measurements of the overhead line condition.

Test coaches provide on board accommodation for staff, so that measuring equipment functionality can be monitored, and measured data from the tests can be analysed. Each test coach has a built-in diesel power generator to provide 230V AC power for measuring equipment, laptop PC's, lighting and air conditioning. Two dedicated electric locomotives are available for use with a test coach for when on-track tests are performed, for which a train is not required.

The support that the RTDC provides to the test coaches and dedicated electric locomotives is with maintenance, repair, manufacture of specialised test rigs, and the supply of consumables.

This ensures that the test coaches and dedicated electric locomotives are maintained in good working order to achieve reliability, availability and safety when tests are conducted. RTDC is also the home base for when a test coach or dedicated electric locomotive is fitted with the required measuring equipment, prior to a test, or when equipment is removed after a test.

DYNAMIC TEST FACILITY (DTF)

Rolling stock components such as couplers and bogie frames, are subjected to cyclic loads when trains operate in service. The Dynamic Test Facility is used to subject these components to cyclic loads, to determine the fatigue life of new components, and is also used to determine the remaining fatigue life of components that have been in service. Knowing the fatigue life of a component such as a coupler on, for example, an iron ore wagon, determines at what stage the coupler must be replaced with a new one, so that in-service failure of couplers (and resulting train partings) can be prevented.

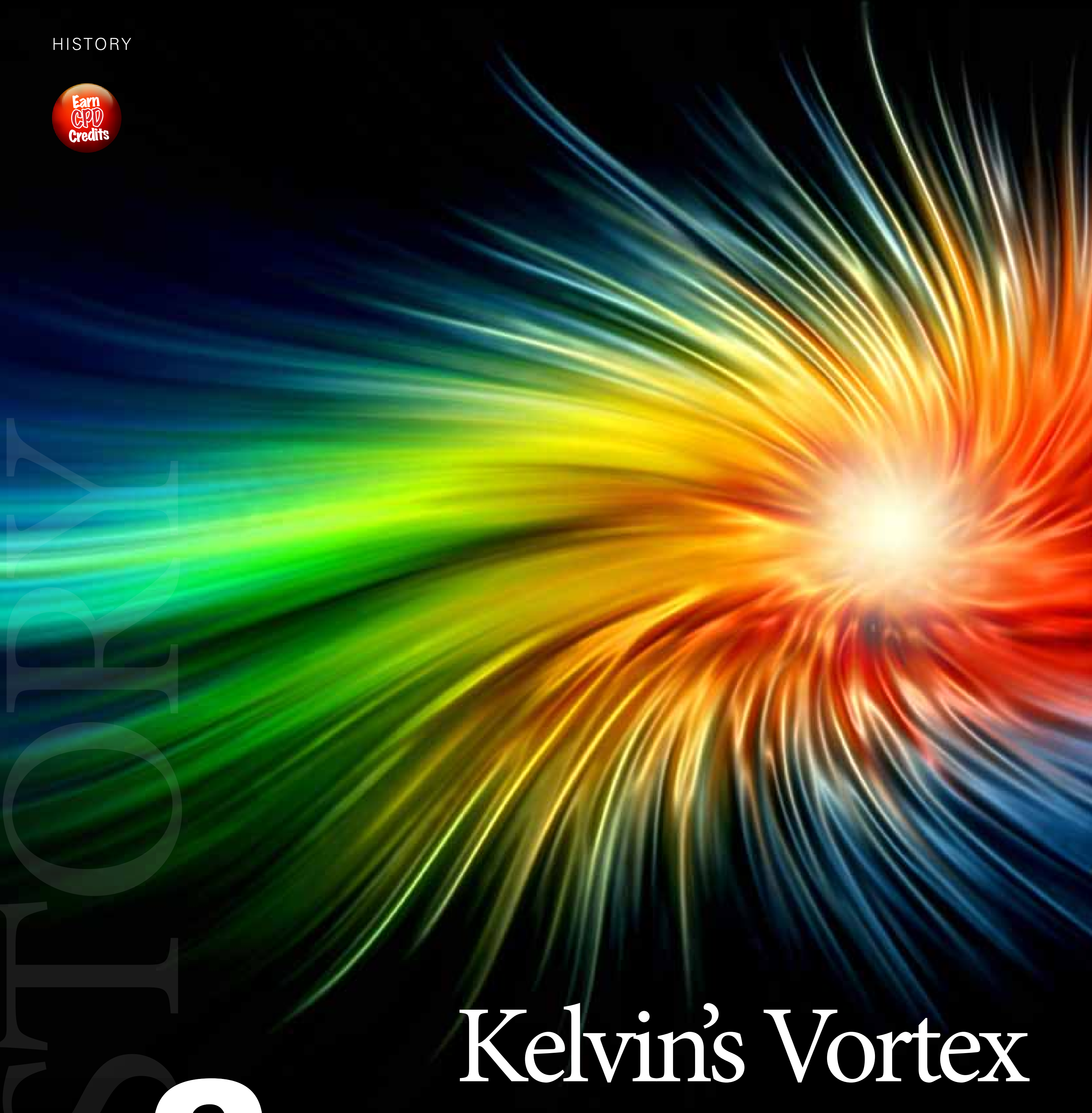
CONCLUSION

The visit was enjoyed by the Railway Chapter members and the presenters from the staff of RTDC. It provided food for thought, figuratively and literally, as can be seen from the picture.

ACKNOWLDGEMENTS

The authors thank Joseph Bonga and the staff of RTDC for their time and effort to make the visit a success. wn

Earn CPD Credits



Kelvin's Vortex

Sir William Thomson (1824-1907) – Mathematical physicist and engineer, was born in Belfast to Irish and Scottish parents. He did important work on the mathematical analysis of electricity, and the formulation of the first and second laws of thermodynamics.

He was knighted in 1866 by Queen Victoria for his work on the transatlantic telegraph project. He also did important work on the mariner's compass. He became known as Lord Kelvin when he was honoured in 1892 with the title 'First Baron Kelvin of Largs' for his contributions to thermodynamics. The SI unit of thermodynamic temperature has been named the 'kelvin' symbol K, in his honour. A brief biography of Lord Kelvin appeared in the November 2015 issue of **watt**now.

Atoms

We live in a universe of spiral vortices, from subatomic particles to the objects of the cosmos. The orbits of the planets trace spiral paths as the Sun orbits the galactic centre, and the stars of the galaxy trace spiral paths as the galaxy moves though the local galaxy group.
On a more down to earth scale we have all noticed the spiral vortex of water draining from a wash basin.

BY | D. BASSON

Leucippus and Democritus of ancient Greece advanced the idea that matter was made of indestructible particles, naming them ‘a-tom’, meaning ‘that which cannot be cut’. In 1808 chemist John Dalton postulated that for each chemical element there is a corresponding atom and that all else is made up by a combination of atoms. The atoms of the ancient Greeks were assumed to be the chemical elements of the Periodic Table, devised by Dmitri Ivanovich Mendeleev in 1869, and which were indivisible and indestructible. Several versions of the periodic table have been developed, but it is the eighteen column rectangular version that is to be seen as a wall poster in the science classroom. It was not suspected that the chemical element atoms were hugely complex structures, of several types of particles existing in hyper-dimensional space. The chemical atoms were indeed fundamental to chemistry, as their chemical properties would be lost if the atoms were fragmented.

Kelvin's Vortex Atoms

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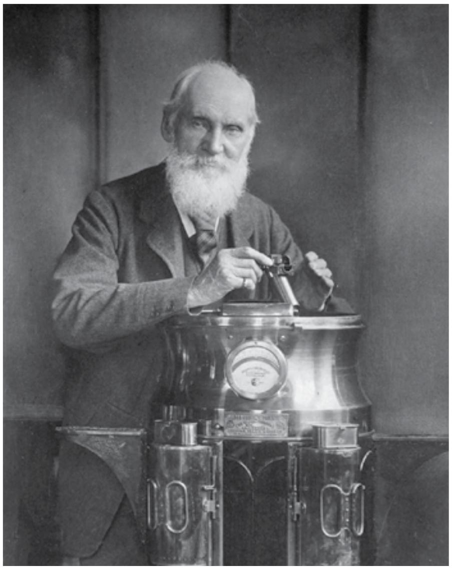


Sir William Thomson (1824-1907)

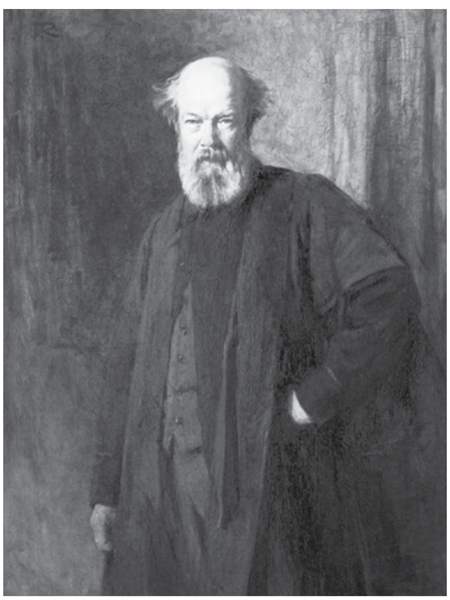
In 1867 Sir William Thomson made a first attempt at establishing a model of an atom. Its most striking properties would be its permanence and simplicity. Thomson was inspired by a paper written on vortices in 1858 by Helmholtz. This was translated into English by Peter Guthrie Tait, who showed Thomson some ingenious experiments with smoke rings to illustrate Helmholtz's ideas. Kelvin-Helmholtz instability can occur where there is velocity shear in a continuous fluid, which can be seen in clouds, the ocean, Saturn's bands and Jupiter's Red Spot.

Vortices showed remarkable stability in air and other fluids but afterwards dissipated. However in the perfectly non-viscous luminiferous ether it was presumed that they would remain permanently, as they do in superfluids. Superfluids have the remarkable ability to escape from an open container by creeping up the inside walls, and down the outside. In the following discussion the 'strings' are long circular vortices. A tornado is an example of a long and violent string vortex.

The word 'chiral', meaning handed, was first introduced into science by Lord Kelvin, as Professor of Natural Philosophy at the University of Glasgow from 1846-1899: *"I call any geometrical figure, or group of points, chiral, and say that it has chirality, if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself.*

In the early 1890s I initiated a discussion of the role of time reversal symmetry in optical activity and pointed out that time-even pseudoscalar observables are the hallmark of genuine chirality. This led me to propose the following new definition of chirality: True chirality is shown by systems existing in two distinct enantiomeric states that are interconverted by space inversion, but not by time reversal combined with any proper spatial rotation.

(In September 2016 research was announced for controlling the chirality of certain medicinal drugs. Left and right handed drug molecules can have different, and sometimes undesirable properties).



Peter GuthrieTait (1831-1901)

Peter GuthrieTait (1831-1901) was a Scottish mathematical physicist and a lifelong friend and scientific associate of Maxwell. He co-wrote a physics textbook with Kelvin. He took a profound interest in the knot theory of vortex atoms. The idea that atoms were knots in the luminiferous ether was immensely popular with Kirchhoff and other scientists of the time.

Tait did extensive work on vortices with knots of up to ten crossings. His work would lead to the development of knot theory as a branch of mathematical topology. Mathematical knots are quite different to those known to every sailor and Boy Scout. The strings are always closed loops which cannot be untied, but the knots can fall apart when viewed from higher dimensions.

Tait became a leading exponent on quaternions, writing two books on the subject. Quaternions, discovered by Hamilton in 1843, were indispensable to Maxwell's original electromagnetic theory. Quaternions are a four dimensional extension of two dimensional complex numbers, and are sometimes referred to as Hamilton numbers.

The Hamiltonian function developed in 1835 would become indispensable to Dirac's quantum mechanics a century later, and came into widespread use. Tait wrote a number of other books, and did much work on thermodynamics and thermoelectricity.

Intractable problems are sometimes called Gordian knots after Alexander the Great, who took no nonsense with the knot, and slashed it with his sword. In South Africa this kind of problem is sometimes referred to as: *" 'n turksvy van 'n probleem".*

A Gordian-knot

Physicist Ludwig Boltzmann (1844-1906) made major contributions to atomic theory and thermodynamics, despite many scientists of the time disputing the existence of atoms and molecules. His development of statistical mechanics, which explains and predicts how the properties of atoms determine the physical properties of matter, is regarded as one of his greatest achievements. Boltzmann was a tutor of Lise Meitner, discoverer of nuclear fission.

Henri Poincaré (1854-1912)

Henri Poincaré (1854-1912), scientist, mathematician and engineer, made huge advances in mathematical topology. The proof of his famous conjecture posed in 1904 would defy the efforts of the world's mathematicians for a century before it could become a theorem. He was one of the first mathematicians to attempt the three body orbiting problem and was awarded a prize for his major contribution to celestial mechanics. He was also one of the originators of the special theory of relativity. There is a brief history of mathematical topology in the January 2014 issue of **watt**now.

New research at the University of Bristol using computer models of wave chaos, has shown that three-dimensional tangled vortex filaments can in fact be knotted in many highly complex ways. Mark Dennis, Professor of Theoretical Physics in the School of Physics, remarked:
"Although the computer models were framed in the language of quantum waves, these results are expected to be completely general, suggesting a new understanding of the complexity of the three-dimensional optical and acoustic landscapes that surround us every day."

In 1896 Henri Becquerel elaborated on the work of the Curies and proposed that atoms had internal structure. In 1897, another Thomson, Sir Joseph John Thomson (1856-1940) working with cathode rays discovered electrons, charged particles smaller than atoms - a first step into the subatomic world. This was the first indication that the chemical atoms were not the same as the ultimate physical atoms.

Sir Joseph Thomson was an English physicist who was elected as a fellow of the Royal Society, and appointed to the Cavendish Professorship at Cambridge in 1884. He was awarded the 1906 Nobel Prize in Physics for his work on the conduction of electricity in gases. Seven of his students became Nobel Laureates, a record comparable only to that of Arnold Sommerfeld (1868-1951).

Developments in particle physics showing that the chemical element atoms had internal structure caused Lord Kelvin to despair of the atomic vortex theory:
"The vortex theory of the atom is only a dream. Itself unproven, it can prove nothing, and any speculations founded upon it are mere dreams about dreams."

In 1904, J.J. Thomson's "plum pudding model" became the most widely accepted explanation of atomic structure, supposing that the negatively charged electrons were embedded like raisins in a positively charged pudding.

Robert Millikan (1868-1953) was able to measure the charge of the electron in 1910. Ernest Rutherford (1871-1937) performed his famous gold foil experiment in 1910. He beamed charged particles at gold foil and to his astonishment some of the particles bounced back. From this he was able to deduce that atoms were mostly empty space with a nucleus occupying a tiny space at the centre and that the electrons were in orbit around the nucleus. This posed a dilemma: orbiting charged particles would radiate their energy and quickly collapse into the nucleus.

Rutherford proposed the name proton for the positively charged particles in the atomic nucleus. He also proposed the name neutron for a neutral particle in the

Kelvin's Vortex Atoms

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nucleus but it was only in 1932 that James Chadwick was able to prove that these neutral particles existed.

Niels Bohr (1885-1962)

Niels Bohr (1885-1962) proposed that the electrons behaved in quantum fashion in fixed orbits jumping from one orbit to another (quantum leap) when they absorbed or released energy.

The idea of orbiting electrons has given way to orbitals.
In quantum mechanics, an atomic orbital is a mathematical function that describes the wave-like behaviour of either one electron or a pair of electrons in an atom. This function can be used to calculate the probability of finding any electron of an atom in any specific region around the atom's nucleus. Despite the fact that orbiting atomic electrons is not a valid concept, this image is still used on logos and icons representing atomic matters. Whizzing electrons are more easily visualised than a mathematical probability function.

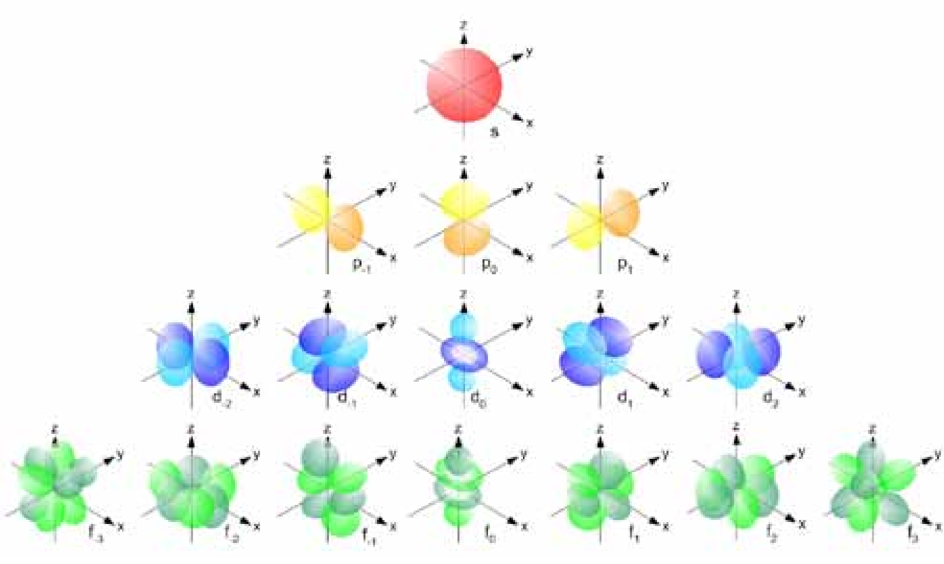
In 1921 German mathematician Theodor Kaluza and Swedish physicist Oskar Klein proposed adding a fifth dimension to the four dimensional Einstein-Minkowski space time continuum. This suggested that if the dimension were large enough and circular, a straight line drawn through the universe would meet itself end to end. If this dimension were curled up to infinitesimal size it would have remarkable consequences. In particular they showed that the effect of gravity in that very small fifth dimension would actually appear to us, from our larger-scale perspective, as electromagnetism.

Although Kaluza and Klein's theory seemed to unify the forces of electromagnetism and gravity, it wasn't widely accepted at the time. It was mathematically true but the concept of extra spatial dimensions seemed very strange. However some 60 years later this mathematical oddity provided a missing piece in the hunt for quantum gravity. String theory proposed that the fundamental components of matter are string-like rather than point-like. This provided a theory that could embrace the physics of the very small and very large, known as quantum gravity. Another remarkable outcome was that for string theory to be consistent, the number of space-time dimensions must equal 10 and the unseen extra dimensions are rolled up to infinitesimal size.

Eugenio Calabi and Shing-Tung Yau have made major advances in string theory with the Calabi-Yau topological manifold. Calabi–Yau manifolds are important in superstring theory as shapes that satisfy the requirement of space for the six "unseen" spatial dimensions of string theory.

Gabriele Veneziano conducted most of his postdoctoral scientific activities at CERN. His work with the Euler Beta and Gamma functions (c 1720) interpreted as a scattering amplitude would lead to his work in 1968 being regarded as the founding of string theory and quantum gravity. Joël Scherk, working with Eugene Cremmer and Bernard Julia, devised an eleven dimensional theory of supergravity, and proposed the mechanism of spontaneous compactification in quantum field theory.

Arguably, Superstring Theory was born in the summer of 1984, when Michael Green and John Schwartz finally established the consistency of a theory rich enough to



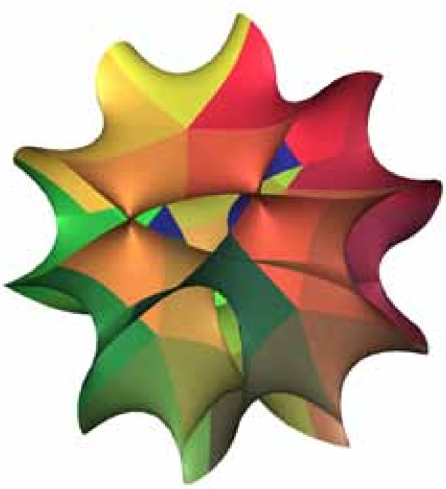
A selection of orbitals

encompass all known forces of nature. In 2009 Michael Green succeeded Prof. Stephen Hawking as Lucasian Professor of Mathematics at Cambridge.

In 1984, Edward Witten of the Institute for Advanced Study, Princeton, suggested that the five different versions of string theory might be describing the same thing seen from different perspectives. He proposed a unifying theory called "M-theory". M-theory brought the five string theories (string quintet) together by asserting that strings are really one-dimensional slices of a two-dimensional membrane vibrating in eleven dimensional space-time. The ultimate particles of matter existing as eleven dimensional space-time manifolds are commonly known as superstrings. Witten delivered his fast paced lecture "Index Theorems and Superstrings" to a 200 strong audience of scientists. No questions were asked. Witten was awarded the prestigious mathematics Fields Medal in 1990. Nobel prizes are not awarded for mathematics.

To the non-scientist, particle physics is a world of mind boggling mathematics and bewildering families of particles, some with lifetimes so short that they hardly exist. The layman can take comfort in the fact that the ordinary matter that we are made of requires only protons, neutrons and electrons, and the neutrons if isolated, decay into protons and electrons. The only members of the quark family required by protons and neutrons are the up-quark and down-quark.

It sometimes happens that scientists, artists, writers and musicians produce works of greater genius and insight than they are aware of. This was the case with Kelvin's vortex atoms. At the time, new discoveries



A representation of a typical Calabi Yau Manifold

and experiments made his theory seem a lost cause. It would take a century for brilliant advances in mathematical topology and theoretical physics to cause string theory to rise up as a phoenix from the ashes.

On 4 October 2016 the Royal Swedish Academy of Sciences announced that the 2016 Nobel Prize for Physics had been awarded to three British born scientists: Prof. David J. Thoughless, Dr. F. Duncan M. Haldane and Dr. J. Michael Kosterlitz for: *"Theoretical discoveries of topological phase transitions and topological phases of matter."*

The laureates used advanced mathematical methods to study unusual phases, or states, of matter, such as superconductors, superfluids and thin magnetic films. They overturned the theory that superconductivity and suprafluidity could not occur in thin layers. It was shown that electric current vortices in a thin film superconductor would link together, but would drift apart when the film came out of the superconducting state.

Nobel committee member Thors Hans Hansson used a cinnamon bun, a bagel and a pretzel to illustrate the topological difference between objects with zero, one and two holes to show the step-wise topological progress of conductance from superconductivity through to ohmic resistance.

Many topological phases are now known, not only in thin layers and threads, but also in ordinary three-dimensional materials. Over the last decade, this area has boosted frontline research in condensed matter physics, not least because of the hope that topological materials could be used in new generations of electronics and superconductors, or in future quantum computers. Current research is revealing the secrets of matter in the exotic worlds discovered by this year's Nobel Laureates.

At this time of year it is quite likely that a dramatization of Dickens' *"A Christmas Carol"* will be presented in the media.

On 19 December 1843, Charles Dickens' novella *"A Christmas Carol in Prose, Being a Ghost-Story of Christmas"* was published in London and has never gone out of print. This is the story of Ebenezer Scrooge and four ghosts - the ghost of his partner Marley and the ghosts of Christmases past, present and future.n The book was written at a time when the British were examining and exploring Christmas traditions from the past as well as new customs, such as Christmas cards, Christmas trees and Carol singing. The flaming Yule-log was another popular ancient, albeit pagan, custom of Nordic or Germanic origin. The Christmas dinner, replete with roast goose and plum pudding, was probably for most people the only lavish meal of the year.

Kelvin's Vortex Atoms

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The Christmas tree became fashionable in England when Queen Victoria married her German cousin Albert in 1840. The decorated evergreen tree tradition came from Germany where it was known as the Weihnachtsbaum, which had its origins in ancient times. Astonishing displays of Christmas decoration craft can be seen at Rothenburg and Oberammergau as well as down south in Melbourne.

Many objects have acquired Christmas significance: Holly leaves, berries, mistletoe, glass baubles, tinsel, candles, bells, angels, stars etc. The Christmas Pantomime became a very popular traditional Christmas entertainment. This comes to us from ancient Rome. The jovial faced Father Christmas in red arctic outfit has seen many transitions since the original Saint Nicholas of 4th century Turkey, taking on Scandinavian trappings and using reindeer for transport instead of horses. In Holland he became known as Sinterklaas and acquired a helper, Zwarte Piet. Probably the best known image of Father Christmas is the Coca-Cola Santa. Most of the Christmas customs seem to have very little to do with Christmas.

It is the ghost of Christmas past that we need to call up here, and take a flashback to London of 1895, when a magazine article by H.P. Blavatsky was published, showing and describing the ultimate particle of physical matter. The ultimate particle described in 1895, psychically observed and studied, is shocking. It shows the particle existing in two forms, differing only in chirality, like right hand and left hand screw threads, and representing positive and negative electric charge. The particle was described using its ancient Sanskrit name 'aahnoo'. We will continue using modern parlance as few, if

any readers will be familiar with Sanskrit terminology. The particle (superstring) consists of ten string loops twisted and linked together as an inseparable mathematical knot, or including the time dimension, existing as an eleven dimensional topological manifold. This is also a demonstration of the topology hairy ball problem which states that it is impossible to brush all the hair on a ball flat without causing cowlicks. Three of the string loops are shown thicker than the rest, suggesting that these represent the dimensions of three dimensional space, and the rest representing higher dimensions.

The strings were shown to be of extremely small multiple helixes (vortices) helixed to seven levels (reminiscent of incandescent lamp filaments), and the ultimate nature of the filaments, as strings of dimensionless points, or bubbles. (Could these be neutrinos?) The total number of points were estimated at 13,8 billion, which is not far removed from the ratio between neutrino mass and proton mass. It is tempting to suppose that the spacing of the points is of Planck length spacing (1,616 x 10^{-35} m) as this is the smallest possible physical dimension. Strangely, it was claimed that by breaking a filament the entire superstring would disappear, and by providing a suitable 'space' a new one would spontaneously appear out of nowhere. One can easily make a drawing of a three dimensional object on two dimensional paper but a representation of eleven dimensions is a tall order indeed. The investigators nevertheless did try to give a reasonable impression.

The theory of higher space dimensions claims that they are curled up to infinitesimal vortices, which presumably shows that the uniformity of the sizes of the various subatomic particles, is determined by the dimensionality of space. A huge investigation into the internal structures of chemical atoms and compounds was undertaken by C.W. Leadbeater and Annie Besant, as a part time activity from 1895 to 1908. Leadbeater was an English clergyman of widespread interests, and Annie was a larger-than-life social reformer of the early 20th century.

She fell foul of the Law when she tried to promote family planning in England, but was later acquitted of all charges. She was a close friend of the famous playwright George Bernard Shaw, who described his 'amazing Annie' as the best public speaker in England, and possibly all of Europe. She was able to assist Shaw to get started with his writing career. The relationship ended when Shaw fled following a proposal of marriage by Besant. One of Shaw's many plays, 'Pygmalion', became very famous as the musical stage performance and movie 'My Fair Lady'. A quote from Shaw: *"A life spent making mistakes is not only more honourable, but more useful than a life spent doing nothing"*.

The investigations into the subatomic world were undertaken using a special yoga technique learned from an Indian guru, which provided an observation faculty right down to the Planck length scale. They did not think that this ability was exceptional and that one day it might become quite commonplace. People claiming to be knowledgeable in these matters, warn that acquiring this ability prematurely, could be extremely dangerous for the person involved. The study of the hydrogen atom was as shocking as the superstring. It showed a proton enveloped in an orbital. The investigators were puzzled by the orbital describing it as a huge envelope surrounding a tiny nucleus. At the time, the Rutherford and Bohr models proposed an electron orbiting the proton nucleus as a discrete particle like a sun and planet system.

This concept has given way to the electron wave probability orbital envelope, in which the electron can appear anywhere without anything actually moving. The hydrogen proton nucleus was shown to contain three smaller entities, one negative and two positive, which conform to the discovery of quarks decades later in 1963. The three quarks were shown to each contain three electrically charged superstring manifolds. Curiously, the quarks were shown each having an orbital which would need to be of gamma wavelength size.

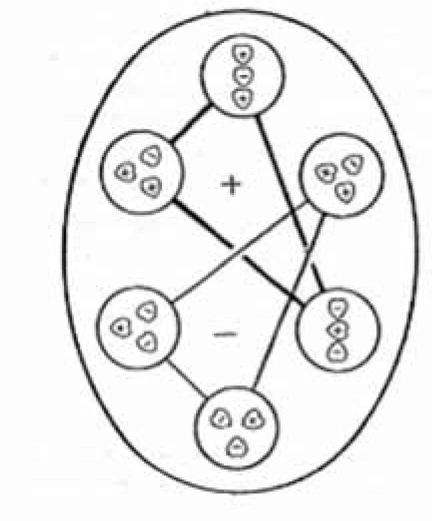
The drawing of the hydrogen nucleus included an antiproton, with all the charges of the proton components reversed. A possible explanation is that this is the result of Heisenberg uncertainty. The investigators had no way of knowing that arresting the motion and fixing the position of the proton was an impossible state of matter – presumably causing the appearance of the antiparticle. This drawing is not to scale – the orbital would appear huge compared to the nucleus.

A number of other quarks with various configurations of superstrings were also recorded.

A fundamental principle of the scientific method is that experiments must be fully and exactly repeatable. It is on this score that the psychic results fail miserably. Practically no-one has been able to repeat the atomic observations. At a later stage, psychic Geoffrey Hodson was asked to observe the electrons flowing in a cathode ray tube – a seemingly impossible task to observe particle/waves much smaller than atoms flowing at high speed in a vacuum.

He claimed to succeed in this by 'playing tricks with time'. His observation was that the electrons were similar to the quark superstrings, only smaller, and that they flowed along the tube in a spiral motion. This accords with zitterbewegung proposed by Schrödinger, working on Dirac theory in 1930, which for electrons gave a result of $1{,}6 \times 10^{21}$ radians per second. Self-magnetizing electric current vortices represent a huge study, from quantum level, up to the huge Birkeland currents and magnetic ropes of the solar system. Birkeland was fortunately able to consult mathematical genius Henri Poincaré for assistance with the abstruse mathematics required.

We can take leave of the psychic investigation here. A huge book was produced dealing with most of the periodic table elements as well as a large number of molecules. The molecules are shown with the atomic nuclei collapsed and merged together and having bizarre orbitals. The damage could have



Hydrogen Atom

been done by the arrest of particle motion conflicting with Heisenberg uncertainty.

Louis MacNeice CBE (1907-1963) was an Irish poet and playwright. He was part of the generation of the Auden group of poets and was widely appreciated by the public during his lifetime. He had a practical and down to earth take on the goings on of the spooky yoga science:

It's no go the Yogi-Man,
it's no go Blavatsky,
All we want is a bank balance
and a bit of skirt in a taxi.

It is quite reasonable and understandable, that scientists working in the rarefied stratosphere of ultra-advanced mathematics, would be disdainful of, or even outraged by, non-mathematical after-dinner parlour science. There is an example of despicable amateur science in the painting 'Experiment with an air pump' hanging in the London National Gallery.

The 'spooky atoms' of more than a century ago, continue to grow more enigmatic with each successive decade, and remain a teasing puzzle that will not go away. wn

Determination of the initial energy of photoelectrically released electrons

When determining the initial energies of electrons released by short wavelength light, errors of a diverse nature occur, which to date, in spite of many investigations over the past twelve years to determine these values, have not been successful, and their absolute magnitude has not been positively determined.

BY | H.J. VAN DER BIJL
15 APRIL 1913

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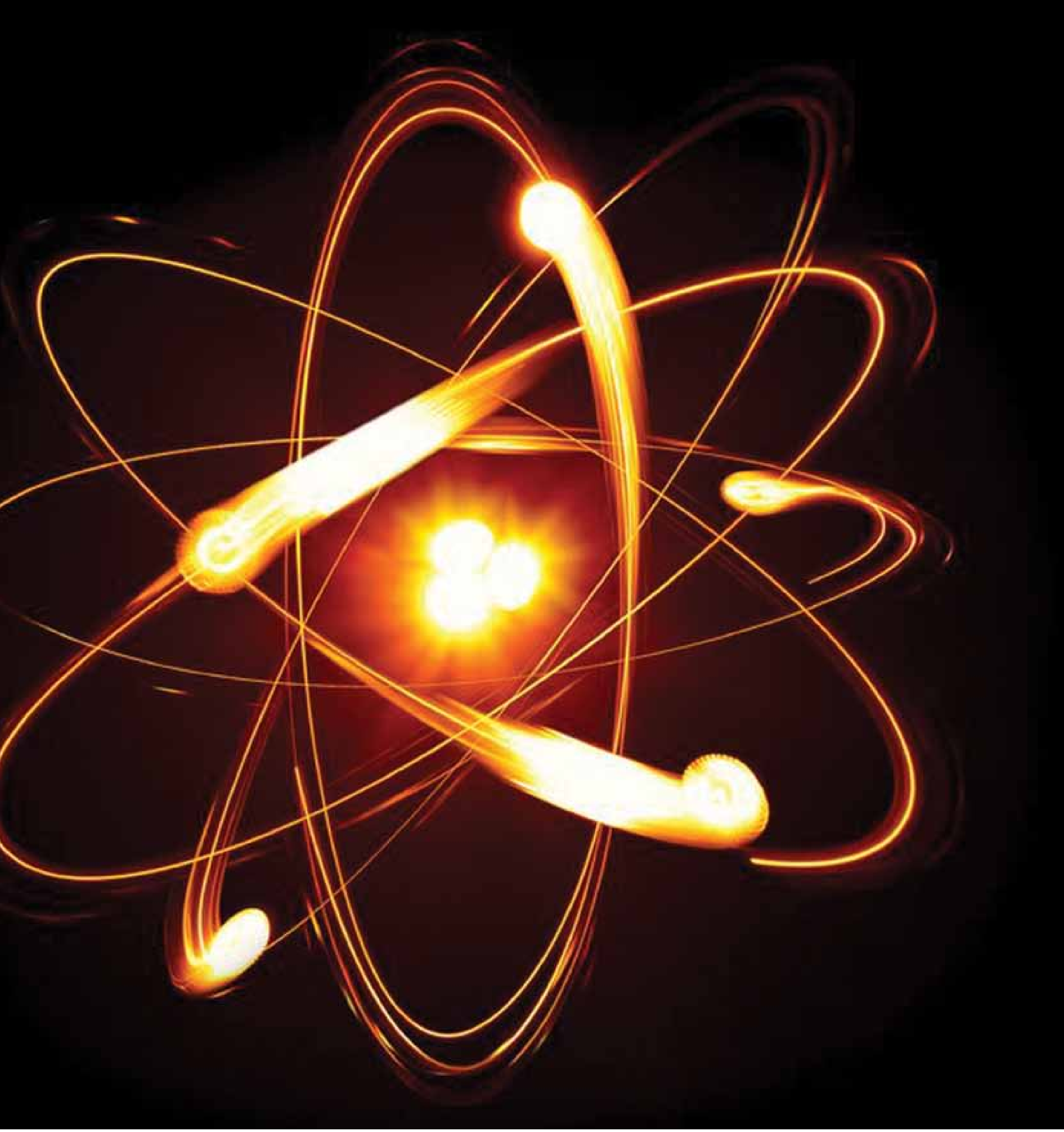
Translation from the original German into English by Hermann Broschk Tech Dip. B. Com. FSAIEE

Due to the unavoidable gas layer formation on metal surfaces, the surfaces are to be prepared or cleaned under vacuum. Von Baeyer and Gehrts for example tried to clean the surface by cathodic vaporisation and established that this resulted in the initial energy increasing.

Later experiments however illustrated that these higher values were incorrect due to discharges, since all authors had, up to this time, used discharges through the tube to test the vacuum. Thus the question raised was to what extent the glow discharges could have affected the initial energy. In fact Hermann found that, with the total absence of high voltage discharges, all metals investigated had a zero maximum initial energy. This makes it doubtful that an external influence could have given an incorrect initial result.

The high apparent initial energies which are created by the glow discharge are partially due to the direct result of changes in the contact potential. This effect has already been noticed by Gaede. These variations were illustrated by tests, which I carried out, on the influence of glow discharges.

It is not improbable that, due to the electric charges resulting from the high voltage discharges, perturbing fields are produced so that the observed variations in the contact potential are only partially apparent. Von Baeyer and Tool investigated the influence of glow-discharges on the contact potential. However



these measurements of the contact potential difference were carried out in a hydrogen atmosphere. Since available test results have shown that the contact potential can vary with the gas pressure, it is necessary to carry out the same measurements in a vacuum.

Herrmann scraped the metal surfaces in a vacuum. Others such as Klages, Kunz and Hughes produced surfaces in a vacuum. This process would ensure accurate results if they could be carried out in an absolute vacuum. However, even in the best vacuum conditions available nowadays, a large number of gas molecules remain and these molecules influence the surfaces of the substances being investigated. Thus it seems appropriate not to concentrate on the use of "clean" surfaces, but on the influence of the contact potential difference, which in fact provides the bigger danger when

Photoelectrically released electrons

continues from page 55

accurately determining the initial energies in a vacuum.

This deciding influence, with few exceptions, was not taken into account when determining the initial energy, although the necessity to introduce a correcting factor was not known for some time. Only recently Compton measured the contact potential difference of the plates being investigated. However this was carried out at atmospheric pressure and it is not certain if the values obtained can be used.

The reason for my investigation was to determine in how far these disturbing influences, which occur when determining the initial energy, could be the reason for the discrepancies in the results obtained by various other authors.

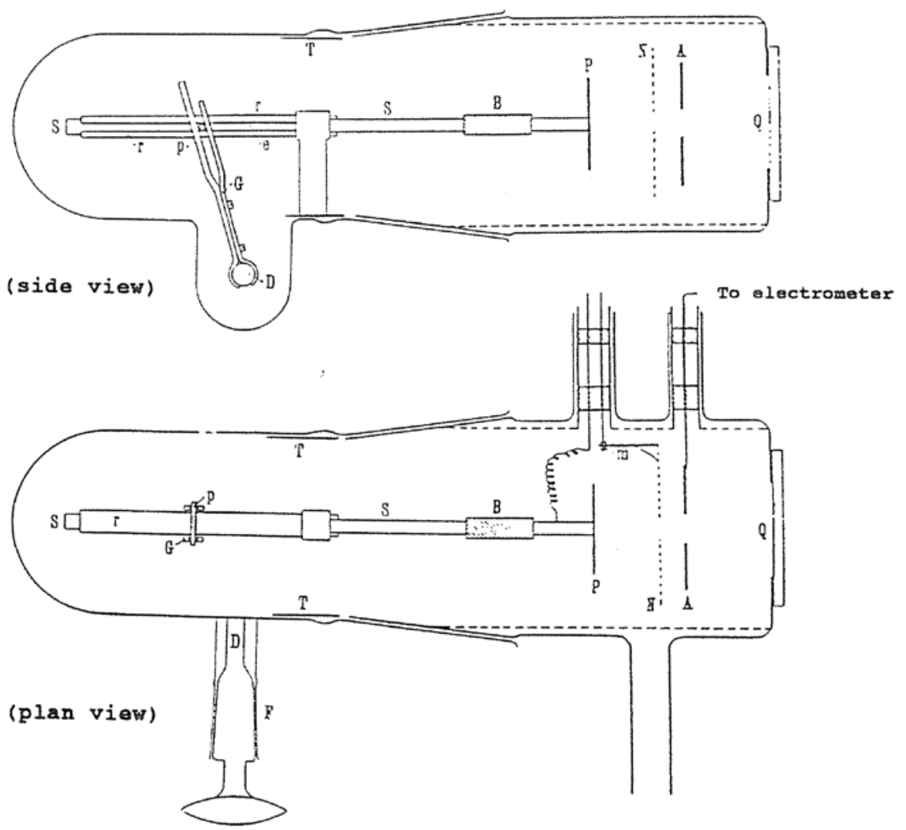


Fig 1

TEST ARRANGEMENT

For the measurement of the initial energy and contact potentials in a vacuum, the glass tube depicted in Fig. 1 was used. (The figure shows a side view and a plan view of the tube.) The tube was 26 cm long and 8 cm in diameter. *P* is the zinc plate being tested. The plate was scraped before being inserted into the tube. Plate *A* (the anode) was used to collect the electrons and was connected to an electrometer as shown. To avoid reflection of electrons, the usual practice of placing a brass grid *N* between *A* and *P*, connected to an auxiliary voltage, was used. These metal parts were mounted in the tube on an insulated amber rod. To investigate the effect of the auxiliary field on the initial velocity, the distance of the brass grid from *A* could be adjusted via the nut *m* (after opening the tube). The grid *N* and the plate *A* had an orifice through which the plate *P* could be exposed to light. To enable the ultraviolet rays to enter the tube a quartz plate *Q* was cemented to the front end of the tube.

The contact potential difference can be measured with the PELLAT method, provided the one plate is adjustable. To enable plate *P* to be moved parallel to itself it was connected by the amber insulation tube *B* to a long brass rod *S*. This rod was held in a brass tube *r* through which it could be horizontally adjusted. In addition the tube *r* had a slot *e* on both sides through which a pin *p* connected to the rod *S* could move horizontally. The tube *r* was supported by a spring ring *TT* which is supported in position against the wall of the glass tube. To enable the rod *S* and the plate *P* to be moved from outside the tube a brass fork *G* was used. This fork was connected to a glass rod *D* mounted in an earthed sleeve *F* which could be rotated from outside the tube. Using this arrangement plate *P* could be adjusted in relation to the grid. It should be noted that all moving metal parts were earthed. To provide electrostatic screening the test tube was encased by an earthed brass wire mesh screen. The external connections in roduced via the attached tubes were fed through earthed brass tubes.

An electrometer with cylindrical quadrants designed by Kleiner and provided with a Bronson resistance was used to measure the current. The sensitivity of the electrometer was initially provided by 1500 scale divisions per volt on a 2,5 m scale length, but for the dispersed light used in the experiment, was increased to 2000 divisions per volt.

The initial vacuum was produced with a Geryk oilpump. Further evacuation was carried out with carbon and liquid air.

The light from a mercury quartz lamp was dispersed by an optical quartz monochromator with a constant deviation prism. The lamp was positioned at the collimator, so that it was only necessary to rotate the collimator tube to set the various lines. The telescope and slit remained relatively fixed in relation to the test equipment. A quartz lens focussed the light slit onto plate P. This setting resulted in a visible blue line (436μμ). To calibrate the monochromator a fluorescent screen was used.

DISTRIBUTION OF THE INITIAL ENERGY

Influence of the auxiliary field

To avoid electron reflection by plate *A* (Fig. 1) a negatively charged grid *N* was inserted in front of plate *A*. The electrons emitted by *P* could thus be accelerated or retarded, so that the potential of *P* is not varied about zero but around the potential of *N*. By this method the energy distribution could be investigated.

The auxiliary field between *N* and *A* as stressed by Von Baeyer also influences the region between *N* and *P* and has an accelerating effect on the electrons. The auxiliary field thus not only prevents reflection but shifts the energy distribution curves in the direction of the retarding potentials (i.e. in the usual convention “to the left”).

A number of authors have tried to apply a correcting factor for the influence of the auxiliary field on the initial energy. Klages proposed that if a point on the curve could be determined without the influence of the auxiliary field, then the complete curve could be drawn in its correct position. This, however, as shown by the following aspects, does not apply to those electrons which impinge on the wires of the grid. Those with larger energy will cling more easily to the grid than others, due to their higher velocity requiring a stronger field to draw them through the openings of the grid. The curves for the weaker auxiliary fields must therefore have a steeper gradient than those of the stronger fields. I was able to also prove this experimentally. In addition, another factor plays a role which under certain circumstances can again operate in the opposite direction.

Influence of the divergence of the electron beam

Compton, who also investigated the influence of the auxiliary field on the distribution curves, found that the same linear shift occurred as with the grid voltage and noted that this result was apparently in contradiction to the tests carried out by Ladenburg and Markau who found that auxiliary voltages in excess of 50 volt had no influence on the curves anymore.

This contradiction can be explained by the greatly varying test configurations used. Furthermore, in the configuration used by Ladenburg and Markau, a condition existed which these authors apparently overlooked in their tests: the influence of the auxiliary field on the stream of electrons only applied to the case where no field existed between the grid and the exposed plate, and not for the whole curve. Since the distance between the exposed plate and the grid was very large (i.e. 6 cm), one can, even though an auxiliary voltage above 50 volt has no influence on the current for zero potential difference, not deduce that electron reflection is prevented by a voltage of 50 volt. Apparently even a weak field will already suffice to prevent electron reflection. The reason the current does not increase above 50 volt is the following. Electrons are emitted in all directions from the plate[1]. Due to the large distance between the plate and the grid only a fraction of the emitted electrons reach the grid, since the solid angle formed by the grid in relation to the exposed plate is small compared to 2π. Increasing the auxiliary field strength attracts electrons to the grid, and so increases the current. The current reaches a maximum as soon as the field is strong enough to attract all electrons emitted from the plate to the grid.

Another result is that the auxiliary voltage causes the gradients of the curves to become steeper, provided that it does exceed the limiting value determined by the dimensions of the test apparatus (50 volt in the test carried out by Ladenburg and Markau).

To test these theories, the curves shown in Fig. 2 were drawn. The auxiliary voltage was 40 volt and electron reflection does not come into the picture. All parameters were kept constant, with the exception that in curve *I* the exposed plate was approximately 5 mm from the grid and in curve *ll* about 20 mm. As can be seen the curves differ considerably but have the same maximum initial energy. The apparent high (cut-off) value of over 4 volt originates from the auxiliary field.

Influence of electron reflection

The influence of the electrons reflected by the anode A on the initial energy is still to be discussed. This refection has

Photoelectrically released electrons

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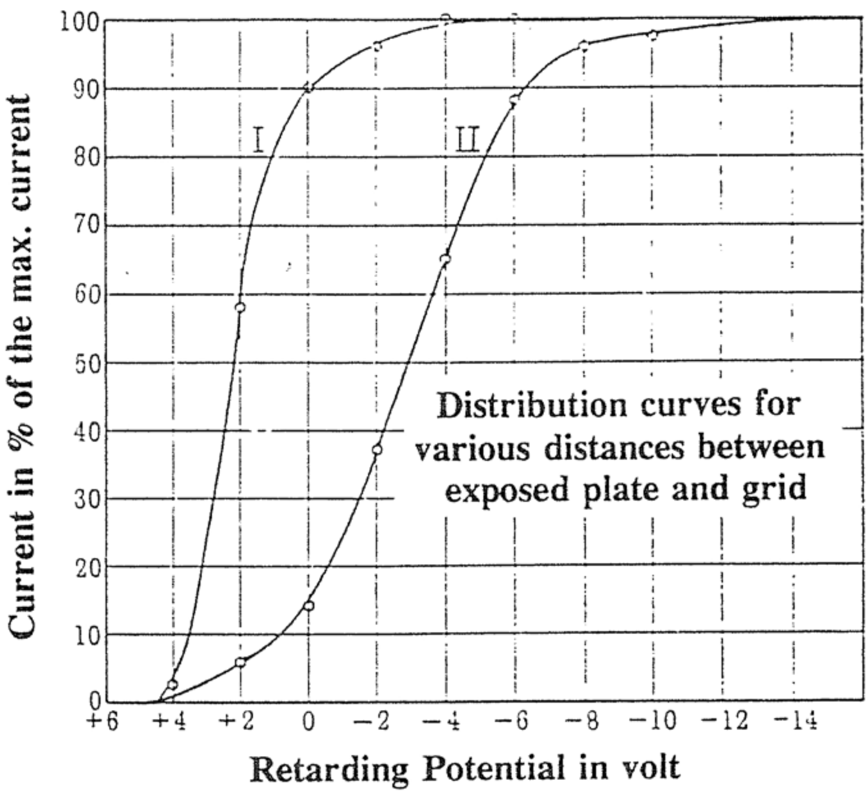

Fig 2

a similar effect as the divergence of the stream of electrons (curve **II**, Fig. 2) and can also influence the maximum energy. The auxiliary field between the grid and the anode is not strong enough to prevent the reflection of electrons at the anode. These electrons are travelling at a velocity *v* which is greater than the velocity v^1 which the field can impart to them.

We observe that the electrons which impinge on the wires of the grid attach themselves there since the weaker field between the grid and the anode is not strong enough to draw them through the grid. The remaining electrons that pass through the grid openings can be reflected by the anode since they approach with a velocity *v* which is greater than velocity v^1. If we consider the case in which all these electrons would be reflected then the anode would not receive a charge, even though the electrons leave the exposed plate (cathode) with considerable velocity.

I have introduced more detail in my discussions on the factors, which influence the deformation of the distribution curves, since far-reaching conclusions have already been drawn from the shape of the curves.

Thus the distribution curves were used to answer the questions as to where the lowest limit of the value of the initial energy is; whether it is zero for positive or negative values).

From the discussion above, one realises how difficult it is to answer questions about the absolute values of the initial energy.

INFLUENCE OF THE AUXILIARY FIELD ON THE MAXIMUM ENERGY

Since so many factors influence the shape of the distribution curves, I have, to enable me to obtain a reference point for the size of the initial energy, mainly focussed on the influence of the auxiliary field on this initial energy.

It is the applied excess voltage *v* of *P* over *N* (Fig. 1) that just suffices to attract back all emitted electrons. Due to the auxiliary field existing between *N* and *A*, a stray field is formed in the region *PN*, which exerts an accelerating effect on the primary electrons (i.e. occurring between *P* and *N*), and results in an increase in energy η of these electrons. The actual maximum energy can be calculated from

$$\eta = v - w$$

The value of *w* is obviously a function of the auxiliary field *E* between *N* and *A* [w = ø (*E*)], so that

$$v = \varnothing(E) + \eta$$

To determine the shape of the function ø experimentally, a number of tests were carried out. These illustrated that the apparent maximum energies have a linear relationship to the voltage applied to the grid.

Fig. 3 illustrates the values obtained for the tests of the maximum energies as a function of the auxiliary voltage. The curves I and II illustrate the results obtained for distances of 6,7 and 2,3 mm between anode *A* and grid *N* respectively.

If the apparent maximum energies are shown as a function of the field between *N* and *A* the curves **I** and **II** coincide. This was expected since the field and not the

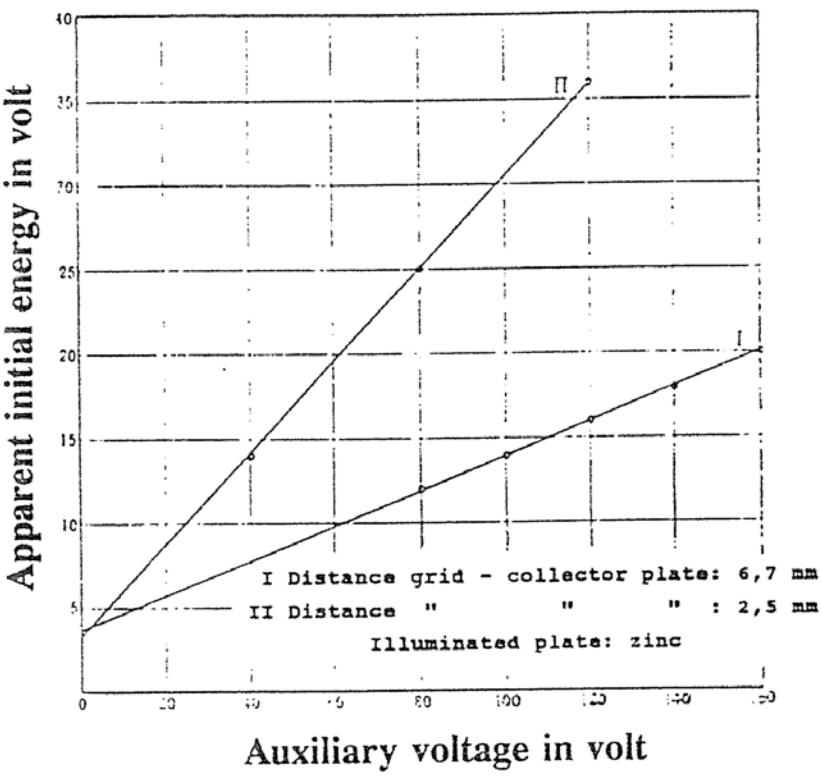

Fig 3

grid voltage was taken into account. The equation (2) thus is as follows:

$$v = {}^{k}/_{d}\; V + \eta$$

where *k* remains constant for the same grid. *d* is the distance between grid and anode, and *V* is the voltage difference between *N* and *A*. The corrected maximum energy η resulting from the perturbing effect of the auxiliary field is obtained from the intercept with the ordinate axis.

The curves illustrate that the auxiliary field can show deceptively high initial energies. This is, naturally, dependent on the dimensions of the grid and the anode. For these tests the dimensions were not advantageously chosen, to illustrate how high the influence of the auxiliary field could possibly be. The copper anode had the same diameter (47 mm) as the grid. In both the anode and the grid the apertures which allowed the passage of light were the same (9 mm) in diameter. Thus with these tests the edge effect of the field also played a part.

Additional tests were carried out by reducing the edge effect with an annular anode having an internal diameter of 18 mm and an external diameter of 35 mm. The grid diameter remained the same as previously used. Here again a linear dependency on the auxiliary field was observed. However the perturbing effect was much lower. For example, with an auxiliary voltage of 80 volt and a distance of approximately 3 mm between grid and anode, I observed an apparent maximum initial energy of 6 volt.

The curves in Fig. 3 show that the maximum energy corrected for the auxiliary field and taking into account the contact potential difference, which was set at 0,67 volt is approximately between 2 and 4 volt.

TESTS WITH MONOCHROMATIC LIGHT

In the following table the results of a number of tests using dispersed light are shown. A wavelength of 254 μμ was used. Both the anode and grid were brass and had slits of 5 mm and 3 mm wide and a length of 15 mm and 11 mm respectively, to allow the light beam to pass through. The cathode, which was again made from zinc, was scraped before inserting into the tube.

-58 volt on grid		-21 volt on grid	
Voltage between plate P and grid	Current	Voltage between plate P and grid	Current
-6	100	-4	100
-4	100	-2	100
0	98,8	0	85,7
+2	83,6	+2	24,6
+4	54,4	+4	3,75
+6	17,7		
+8	5,8		

Table I

Photoelectrically released electrons

continues from page 59

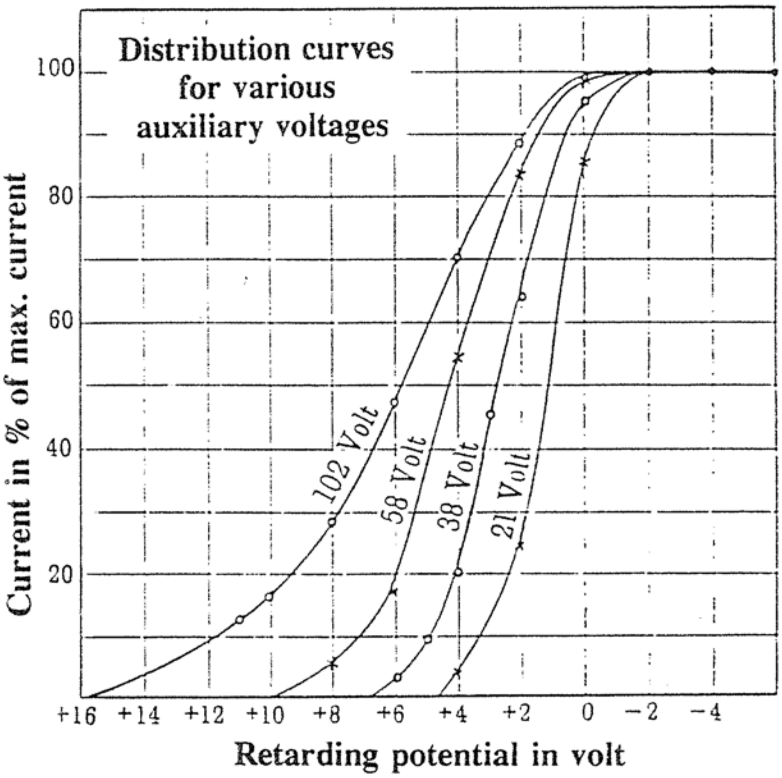

Fig 4

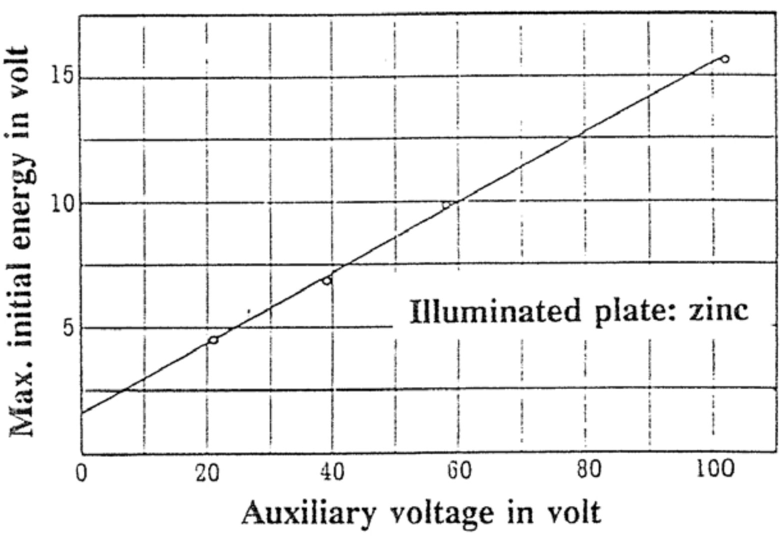

Fig 5

The current values in the table are given as a percentage of the maximum current.

The values obtained from four of these tests are shown graphically in Fig 4. The curves for higher auxiliary voltages do not have as steep a gradient as the others. This, as well as the condition that the difference in the gradient of the curves for smaller auxiliary voltages is less discernable, justifies the conclusions previously mentioned on page 335.

These curves illustrate that the maximum initial energy can only be determined when its dependence on the actual auxiliary field is established, and not for another energy value.

Fig. 5 illustrates the apparent maximum initial energies as a function of the auxiliary voltage. Since the contact potential difference between brass and zinc was -0,49 volt, this resulted in a maximum energy at 2,2 volt at the zinc cathode, for electrons released by light of wavelength 254 μμ.

It is thus evident that as a result of the auxiliary field, it is very difficult to accurately determine the initial energy. Firstly the field has the endency to flatten the curves, which makes it difficult to accurately determine the intercept on the voltage axis.

On the other hand, the auxiliary field may not be chosen too small, since then the influence of electron reflection will be noticeable. With a distance of c. 3 mm between grid and anode one can reduce the (auxiliary) voltage to 20 volt. As in the tests with dispersed light one can extrapolate (Fig. 5). However the above value of 2,2 volt is not necessarily highly accurate.

DETERMINATION OF THE CONTACT POTENTIAL DIFFERENCE

The following tests illustrated that it is necessary, when measuring the initial energies, to take note between tests of the contact potential difference in the tube itself. This can, under certain conditions, change dramatically. After a while, e.g. in vacuum, it will reach a constant value, so

that the determination of the initial energy can be easily made.

The contact potential difference in a vacuum can be determined as follows. The adjustable plate P (Fig. 1) is earthed and placed a small distance from the grid. Both remain connected to the electrometer. If plate P is removed the capacitance of the system is altered.

This change would be equal to the electrometer deflection a_1, which is a value of the existing contact potential difference k. If now a potential $-p$ is applied to the adjustable plate, and the test repeated, then the electrometer deflection a_2 equals the potential k-p^1)and the sensitivity ϵ can be calculated from

$$\epsilon = \frac{a_1 - a_2}{k - (k-p)} = \frac{a_1 - a_2}{p}$$

Also

$$\frac{a_1}{k} = \epsilon$$

so that the contact potential is

$$k = p\frac{a_1}{a_1 - a_2} \qquad 4$$

The following measurements, shown in Table II, carried out immediately after the tests, illustrate the accuracy of the method used. The contact potential differences (zinc-brass) shown in the third column were calculated from the previous formula.

The observations shown in the table were made directly after one another. To enable the adjustable plate to be placed at the exact distance from the grid every time an indicator was fitted to the ground glass rod F on the outside of the test apparatus.

Voltage on adjustable plate (zinc)	Deflection (mm)	Contact difference in volt (zinc-brass)
0 P = -0,384	a_1 = 63 a_2 = 13	+0,484
P = -0,576 0	a_2 = -11 a_1 = 61	+0,488
		mean: +0,486

Table II

THE GLOW DISCHARGE AND THE VARIATION OF THE CONTACT POTENTIAL

After carrying out the above measurements, the plates remained in the vacuum for five days. Thereafter the contact potential difference (zinc-brass) was measured and found to be +0,463 volt at a pressure of 0,04 mm.

The plates were then removed from the tube and exposed to the atmosphere for one hour, whereafter the zinc was electronegatively charged relative to the brass. The value changed so rapidly that it was not possible to measure it accurately. While evacuating, the contact potential was at a nearly definite value and the zinc slowly became electropositively charged in relation to the brass.

The following measurements were taken under various conditions over a three day period. The first measurement in the table (at 2 mm pressure) was taken 15 minutes after evacuation.

These tests illustrate that the contact potential varies only slightly in vacuum. As soon as the plate was exposed to atmospheric pressure, the zinc tended to become electronegatively charged in relation to the brass. During evacuation it reverts to the earlier value (between +0,4 and +0,5 volt). Due to the high voltage discharge the potential difference can be made either negative or positive according to the direction of the discharge. It is to be noted that once the discharge has occurred, a value between 0,3 and 0,4 volt is obtained after a while, instead of the 0,4 to 0,5 volt reached before. One can also see from this table that after a later (third) discharge, a higher value of +0,65 volt reducing to +0,37 volt after five hours (instead of settling between +0,4 and 0,5 volt) is attained. This is borne out by the fact that the potential difference rose from -0,96 to +0,32 volt after only two days. It thus appears that, besides the fast and large variations occuring as a result of discharges, there is a somewhat less discernible variation that only slowly returns to equilibrium.

It was noticed that the electrometer needle was not at rest during the discharge. This persisted for a few minutes.

It is not possible to be absolutely certain if we are dealing with an actual change in the contact potential, or if the oscillations are caused by charges that, due to a discharge stored on the walls of the test tube could have distorted the field between the plates.

Photoelectrically released electrons

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Date and Time	Pressure etc.	Contact differenc in volt (zinc-brass)
18 March 12.30h	2 mm	-0,01
1.10^h	0,065 mm	+0,01
1.35^h	carbon dipped in liquid air until	
2.35^h	....	+0,42
3.00^h	air released down to atm pressure	
3.05^h	....	+0,35
3.25^h	....	+0,28
3.40^h	evacuated	
4.00^h	liquefied air on	
4.25^h	....	+0,46
19 March 9.40^h	....	+0,51
11.10^h to 11.13^h	high voltage discharge introduced zinc plate, anode	
11.45^h	....	-0,32
12.20^h	....	-0,30
12.27^h to 12.35^h	discharge through zinc plate, anode	
12.42^h	....	+0,46
12.46^h to 12.53^h	the same discharge through zinc plate, anode	
1.00^h	....	+0,65
	left alone until	
5.40^h	....	+0,37
6.00^h to 6.06^h	discharge through zinc plate, anode	
6.15^h	....	-0,96
	left alone and measured the following day	
20 March 12.20^h	....	+0,04
21 March 12.20^h	....	+0,32

Table III

It appears that both these effects play a role, even though the interior of the tube was carefully electrostatically screened. However, it cannot be ruled out that charges clinging to the walls of the tube had an effect on either side of the earthed mesh which was fitted to the tube.

SUMMARY

The object of these experiments was to prove that the majority of the determinants of initial energies result from different fundamental aspects. In particular the following influences were investigated:

- the introduction of an auxiliary field to prevent electron reflection,
- the contact potential difference between the plate,
- the glow discharge variation.

The auxiliary field can, under certain circumstances, produce deceptively high initial energies (up to and above 40 volt). These have a linear relationship to the auxiliary field, and by extrapolation, the maximum initial energy at the zinc plate could be determined as approximately 2,2 volt for electrons released by light of wavelength 254 μμ·

It was shown that the energy distribution curves are influenced by so many factors that it is difficult to obtain their true form.

An arrangement was devised which enabled the contact potential difference in the test tube to be measured directly before and after the initial energies were determined. The contact potential remains fairly constant for a while, in a vacuum, and thus an accurate determination of the initial energies is possible. To do this an arrangement similar to that used by Richardson and Compton (op. cit.) is probably best suited.

However the contact potential difference in vacuum should be observed inbetween tests, which is also possible with this arrangement.

The potential difference existing between the plates can be varied by the high voltage discharge. These variations can be measured, but to date a comprehensive explanation as to the origin of the observed potential variations cannot be determined. This would have to be the objective of more detailed investigations. The author could not at this stage continue with the tests since he was leaving Germany. wn

Physics Institute of the Technical University, Dresden, April1913.

calendar

NOVEMBER | DECEMBER | JANUARY 2017

NOVEMBER 2016

9 - 10	Photovoltaic Solar Systems	Johannesburg	roberto@saiee.org.za
16	Power Transformer Unit Protection & Testing	Johannesburg	roberto@saiee.org.za
17	Power Transformer Power & Maintenance	Johannesburg	roberto@saiee.org.za
23 - 24	Leadership & Management Principles in Engineering	Johannesburg	roberto@saiee.org.za
23 - 24	Fixed Broadband Access Technologies	Johannesburg	roberto@saiee.org.za
24	National Student's Project Competition	Kwa-Zulu Natal	geyerg@saiee.org.za
30-1 Dec	Design of Economical Earthing Systems	Johannesburg	roberto@saiee.org.za

DECEMBER 2016

6 - 7	HV Circuit Breakers, Operating & Maintenance	Johannesburg	roberto@saiee.org.za

JANUARY 2017

30-1 Feb	SAUPEC Conference	Stellenbosch	geyerg@saiee.org.za

= CPD Courses

November

Movers, shakers and history-makers

COMPILED BY | JANE BUISSON-STREET
FSAIEE | PMIITPSA | FMIITSPA

1 NOVEMBER

1611 “The Tempest,” Shakespeare’s romantic comedy, was first presented at Whitehall Palace in London.

2 NOVEMBER

1960 Mary Leakey and her team discovered the first fossils of Homo habilis, an early human ancestor, at Olduvai Gorge, Tanzania. Homo habilis is thought to lived between 1.4 and 2.3 million years ago.

3 NOVEMBER

1929 The Marconi-Wright facsimile system was first demonstrated. Documents and images could be transmitted in just 3 minutes.

4 NOVEMBER

1846 Benjamin Franklin Palmer received a U.S. patent for the first artificial leg.

5 NOVEMBER

1935 “Monopoly” was introduced by Parker Brothers Company.

6 NOVEMBER

1989 The WordPerfect Corporation released version WordPerfect 5.1 for DOS. It was the first version to feature Mac-style pull-down menus.

7 NOVEMBER

1935 The Royal National Institute for the Blind issued the first “talking book,” using twelve inch discs.

8 NOVEMBER

1935 Experimental tv transmissions with 180 lines of resolution were broadcast on short wave from the Eiffel Tower in Paris, France.

9 NOVEMBER

2008 Miriam Makeba, South African singer and activist, died aged 76. She is, perhaps, best known for her song “Pata Pata”.

10 NOVEMBER

1961 Neil Armstrong (the first person to walk on the moon) set a new speed record speed in an X-15 rocket plane, at 6,587km/h.

11 NOVEMBER

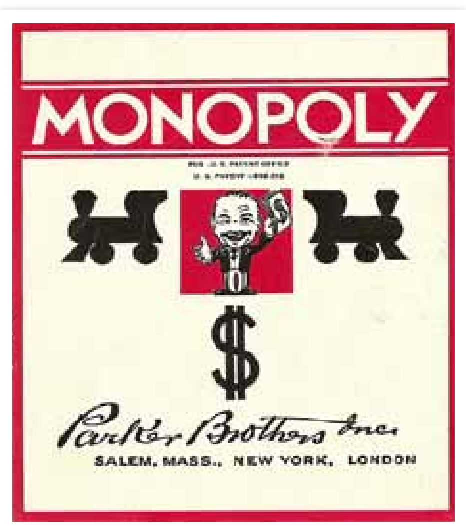
1887 Harrison Patent Knitting Machine Company made use of a photo in their advertisement in Manchester, England’s *"The Parrot"* newspaper. This was the first advertisement of its type.

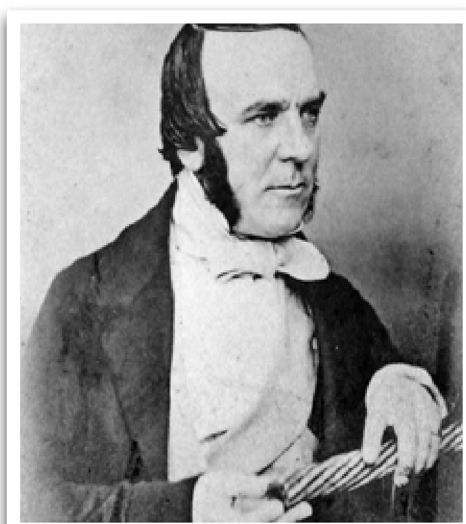
12 NOVEMBER

2000 Bill Gates demonstrated a functional prototype of a Tablet PC. Microsoft claimed *“the Tablet PC will represent the next major evolution in PC design and functionality.”* However, the Tablet PC initiative never really took off and it isn’t until Apple introduced the iPad in 2010 that tablet computing is widely adopted.

13 NOVEMBER

1851 John and Brett Watkins’s underwater telegraph, which ran between the Dover, UK and the French city, Calais opened for business, establishing a comms link between London and Paris.





14 NOVEMBER

1922 The BBC began broadcasting on medium wave, from Marconi House in London with the first newscast.

15 NOVEMBER

1971 Intel released the world's first commercial CPU on one chip *"a single-chip microprocessor"*, the 4004.

16 NOVEMBER

1982 Steven Jobs wrote a letter to the president of McIntosh Labs, requesting the right to use "Macintosh" as a brand name. The offer was rejected. Apple Computer finally received a license for the name Macintosh in March 1983.

17 NOVEMBER

2006 A British man was convicted of what was described as the country's first "web-rage" attack. He was sentenced to two and a half years in prison for assaulting a man he had exchanged insults with over the Internet.

18 NOVEMBER

1477 William Caxton issued his first dated printed book in England, Dictes or Sayengis of the Philosophres ("Sayings of the Philosophers"). Caxton produced ± 100 copies of the work.

19 NOVEMBER

1998 Vincent van Gogh's "Portrait of the Artist Without Beard" sold at auction for US$71.5 million.

20 NOVEMBER

1998 Sony unveils the Memory Stick card and memory card drive. An 8MB storage card measures 1.5 inches in length. The price was US$40.

21 NOVEMBER

1877 Thomas Edison announced his invention of the phonograph, a machine that could record and play sound.

22 NOVEMBER

1995 Pixar released Toy Story, the first feature-length film created using only computer-generated imagery.

23 NOVEMBER

2004 Blizzard Entertainment launched World of Warcraft, which is one of the most popular online games in history.

24 NOVEMBER

1991 Freddie Mercury, lead singer of Queen died aged 45, just one day after he publicly announced he was HIV positive.

25 NOVEMBER

2013 The Richards family in Canberra, Australia set the world record for having the most Christmas lights. They had over 500,000 lights around their home.

26 NOVEMBER

1976 Microsoft officially dropped the hyphen in Micro-soft and Microsoft became the trademark name.

27 NOVEMBER

1701 Anders Celsius, the inventor of the Celsius thermometer, was born in Sweden.

28 NOVEMBER

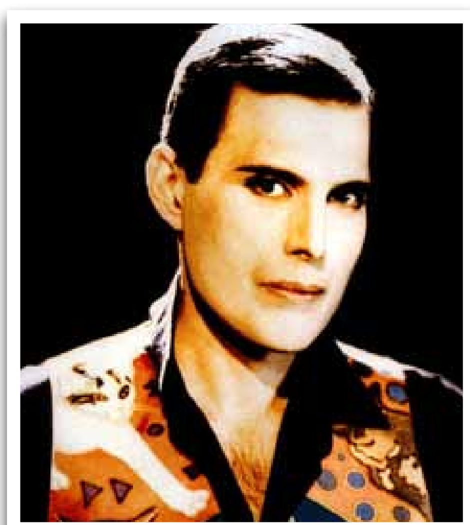
1582 In Stratford-upon-Avon, England, William Shakespeare and Anne Hathaway paid £40 bond for their marriage licence.

29 NOVEMBER

1881 Francis Blake received a patent for the carbon microphone he invented during 1877.

30 NOVEMBER

1982 Michael Jackson's second solo album, Thriller was released worldwide. It became the best-selling record album in history. wn



SAIEE CENTRES

Bloemfontein Centre

Chairman | Dr Ben Kotze

Postal Address | Univ. of Technology Free State Private Bag X20539 Bloemfontein 9300

T|051 507 3088 **E**|bkotze@cut.ac.za

Eastern Cape Centre

Chairman | Carl Hempel

Postal Address | PO Box 369 Port Elizabeth 6000

T|041 392 4254 **E**|chempel@mandelametro.gov.za

Gauteng Central Centre

Chairman | Maanda Ramutumbu

Postal Address | Eskom Enterprises Park, Corner Leeukop & Simba Road, Sunninghill

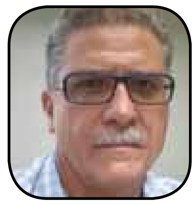
T|011 800 6356 **E**|RamutuM@eskom.co.za

Kwa-Zulu Natal Centre

Chairman | Vincent Tiedt

Postal Address | SMEC SA 2 The Crescent Westway Office Park Westville, 3629

T| 031 277 6686 **E**| vincent.tiedt@smec.com



Mpumalanga Centre

Chairman | Ludolph de Klerk

Postal Address | Proconics Headquarters Kiewiet street Secunda 2302

T|017 620 9698 **E**|ludolph.deklerk @proconics.co.za

Southern Cape Centre

Chairman | Johann Swanepoel

Postal Address | 1 Kingsley Close Genevafontein George 6529

T| 0448714925 **E**|jgfswanepoel@gmail.com

Vaal Centre

Chairman | Sicelo Kunene

Postal Address | PO Box 705, Park South, 1910

T|083 654 6627 **E**|bambolunye@gmail.com

Western Cape Centre

Chairman | Bruce Thomas

Postal Address | Water & Sanitation Building 3 Reyger Street Ndabeni

T|021 514 3651 **E**|bruce.thomas@capetown.gov.za