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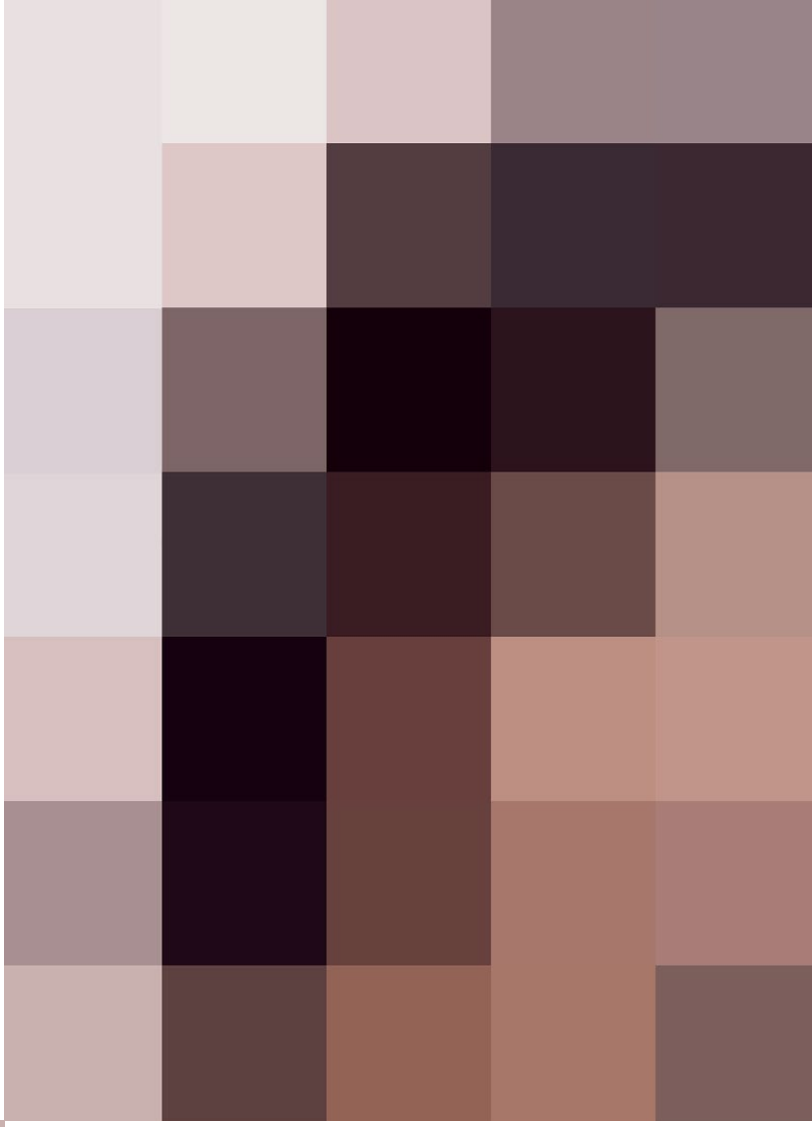

HIDDEN INVENTORS

20 EUROPEAN INVENTORS YOU SHOULD KNOW

Foreword from Eva Maydell

**MEMBER OF THE EUROPEAN PARLIAMENT,
EUROPEAN PEOPLE'S PARTY,
HIDDEN INVENTORS AMBASSADOR**

Europe has a long-established tradition of invention and it is exactly this ingenuity which remains at the centre of innovation today. European inventors are pioneering world-changing advancements across a vast range of sectors. We celebrate those creations; however, little attention is given to how these inventions came to be or the brilliant bright individuals behind these disruptive achievements.

Looking ahead, it is now more crucial than ever before to consider how inventiveness can assist our recovery from the unprecedented COVID-19 pandemic and fuel the digital and green transformation of our industries. I commend ThinkYoung and Ericsson for partnering on the Hidden Inventors campaign, putting the spotlight on the potential of innovation in shaping the future of Europe.

This book presents profiles of 20 Hidden European Inventors. Twenty examples of Europe's greatest minds. Their achievements have drastically transformed our daily lives for the better, yet the inventors themselves remain unknown to the wider public. That is why this book gives them the individual and collective recognition they deserve.

By increasing exposure to innovation, this campaign and book endeavour to encourage and empower our youth to embrace their own 'hidden inventor' within and to reach their full potential. In showcasing these 20 brilliant European inventors – who come from diverse backgrounds and cover a range of fields – we hope to highlight that anyone can be an inventor. Europe's excellent legacy of innovation must live on in future generations.

Importantly, this campaign also seeks to advance policies that will foster Europe's innovation, competitiveness, and resilience in an ever-changing world. Ensuring robust protection of intellectual property rights, for example, is fundamental to create an environment in which innovators from all backgrounds are incentivised and can flourish.

Moreover, this book emphasises that Europe's economic and social system relies on innovation. European patents bring in €5.7 trillion, and 90% of EU trade with the rest of the world comes from industries with strong intellectual property rights. Ensuring that the right policies are in place for inventors will encourage investments in research and entrepreneurship as well as help European industries remain globally competitive. This in turn will enable Europe to continue leading the way on innovation.

As a Member of the European Parliament and a tech optimist, I am proud to support the Hidden Inventors campaign and its role in fostering Europe, one that is characterised by ingenuity, while tackling the big challenges we face. I also recognise the key role inventors play in our society and supporting them with the freedom to create is vital.

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Contents

Executive Summary

ThinkYoung and **Ericsson** have joined together to showcase Europe's Hidden Inventors. The aim is to celebrate their passion, drive, and ingenuity – and to highlight their work pioneering and pushing the boundaries of what was thought possible in each of their sectors and industries. Whether it is Bluetooth, the LCD screen, or contact lenses, we often overlook how these inventions came about – or the brilliant people who brought them to life.

With this in mind, this booklet profiles inventors to give the people behind the inventions the recognition they deserve. Additionally, the profiles aim to help encourage and foster the next generation of inventors who will play a crucial role in tackling some of the biggest societal challenges of today and the future.

The booklet presents an overview of 20 brilliant European inventors who might not be recognised by the wider public, even if we benefit from their creations on a daily basis. The inventors included come from diverse backgrounds and nationalities, and cover fields ranging from connectivity and mobile telephony, to electrical engineering, computing, data compression and even medicine.

The inspiring inventors shown in this booklet, and the **#HiddenInventors** campaign on the whole, also seek to advance the debate on the EU's commitment to continued innovation and R&D in Europe, as well as protecting the rights of inventors.

Now it is up to each of us to inspire the next generation of inventors who will change the technology we use daily, open up new worlds of possibility, and tackle current and future societal challenges. Ensuring the right policies are in place to promote fair competition and resilience is crucial. Alongside this, exposure to innovation must be increased – making sure people from all over Europe are encouraged to reach their potential, regardless of their background. The next inventor revolutionising how we send files, communicate with one another, access information, or even save lives could be one of us.

Europe has a strong and long-standing footprint in innovative ideas, and looking forward, we must capitalise on this legacy through a sustainable ecosystem which will enable European ingenuity to thrive for the benefit of our society.

European Innovation Today and Tomorrow

Europe's Culture of Innovation

European history is characterised by innovation, invention, and progression. Producing some of the most celebrated and gamechanging breakthroughs the world has seen, Europe has pioneered advancements across a whole host of different fields and sectors. These range from new ways to see and view the world, to art and design, politics, law and philosophy - and inventions we never before thought possible in science, technology, engineering, and mathematics. The birthplace of the Renaissance, the Scientific Revolution and the Enlightenment, Europe pushed forward not only intellectual curiosity, but also entrepreneurial and commercial innovation.[1]

From the multiple inventions key to the Industrial Revolution, to blockbuster inventions like the jet engine, the computer, the World Wide Web, the television, and even the printing press, Europe has truly been at the forefront of global innovation throughout its history.[2] This history of ingenuity has created household names like Isaac Newton, Alan Turing, Johann Gutenberg, Leonardo da Vinci, Marie Curie, Nikola Tesla, Sir Tim Berners-Lee – the list goes on.

Promoting Future Innovation

Innovation is fundamental to Europe's economic and social system, and looking to the future, it will be crucial for responding to and tackling the social challenges we currently face.[3] These include the COVID-19 recovery, fostering green and technological transformation of all branches of industry and building a competitive economy based on cutting-edge technologies. To ensure progress and growth, policies need to enforce and promote the right environment for innovation to flourish. In order to build on the tradition of invention in Europe, and ensure this is geared towards tackling the current and future social challenges we face, policymakers must be innovative themselves, ensuring that inventors' rights are effectively protected when faced with the new challenges posed by an increasingly global economy.[4]

Support from policymakers could range from increasing levels of exposure to innovation to preventing gaps in innovation based on education level, socioeconomic status, race, or gender. Showcasing how innovation can be achieved and promoting role models to inspire the next generation are also steps that could help cultivate the groundbreaking inventors of the future.[5]

Protecting Inventors and Innovation

The transition from an inventor with a new and out-of-the-box idea to a world-wide product we use every day can be a complicated one. A groundbreaking invention needs to be patented. Either the inventor or an entrepreneur can then endeavour to create a product making use of that invention, placing it on the market. This drives the creation of new companies, and these sometimes scale up into multinational organisations. The last piece of the puzzle – helping entrepreneurs, startups, and businesses – has been a focal point for EU policymakers for a while. Europe's startup scene is thriving, and investments in European tech are currently at a record high. Early-stage startups are better financed than ever before, and in 2019, tech saw a 21% increase in funding from 2017.[6]

As patent applications are on the rise in Europe, our policymakers must make sure to uphold strong protection of intellectual property rights (IPR). In 2019, the European Patent Office received over 181,000 applications – up by 4% compared to 2018.[7] This shows that levels of innovation are booming. European patents bring in €5.7 trillion[8], and 90% of EU trade with the rest of the world comes from industries with strong intellectual property rights. This contributes 82 million jobs to Europe.[9] In short, Europe is a region whose prosperity is linked with IP rights. Protecting them will be crucial to ensuring that European industries remain globally competitive and continue leading the way in the development of key technologies like 5G, particularly as the region recovers from the Covid-19 crisis and sets targets for a greener and more digital economy.

The path from idea to new product or technology can be long and costly, with years of R&D behind each invention. IPR and patents have become a vital strategic asset for many European inventors. From big companies to SMEs, to research institutes and universities which focus on R&D rather than the direct commercialisation of products – an increasing number of European inventors critically rely on IPR and patent licensing to sustain their activities. A major driving force behind both this booklet and the Hidden Inventors campaign is to remind EU policymakers that inventors are key and supporting them with the freedom to create and innovate is crucial.

Europe's Current Inventors

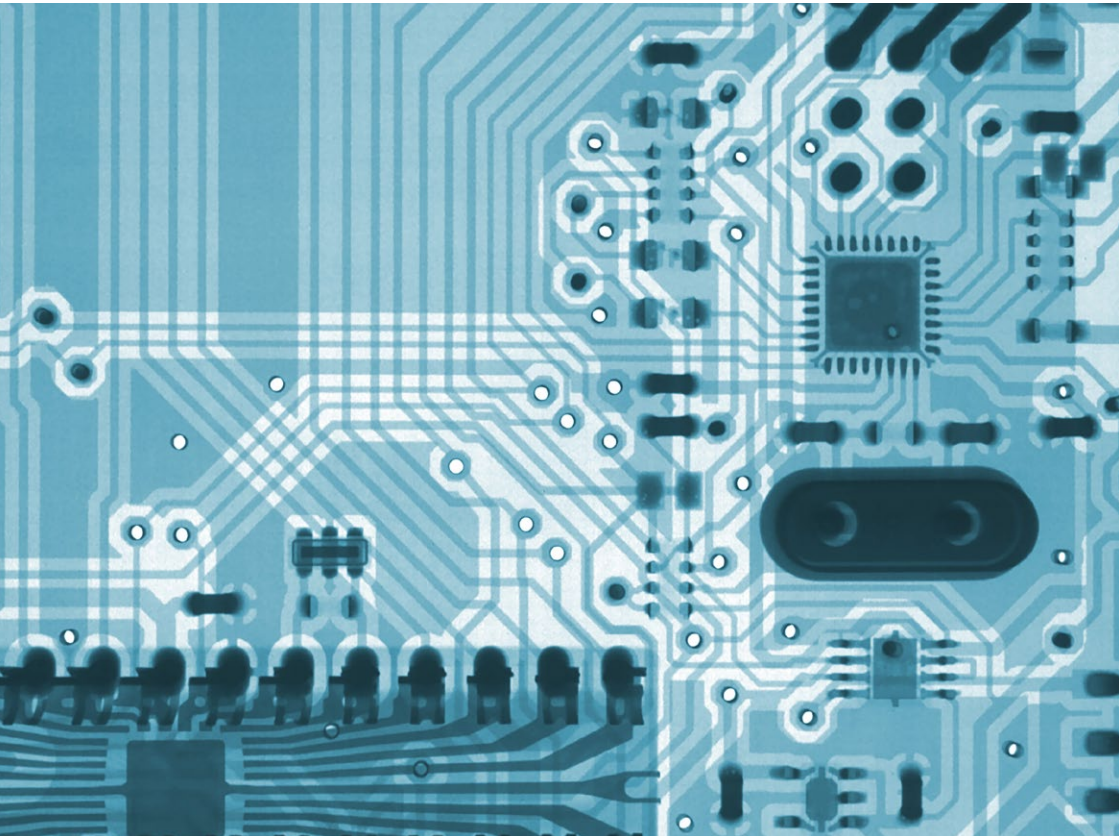
Behind the innovation process are people, and more specifically, people with a talent and passion for discovery, creativity, and solving problems. Not all of the inspiring individuals and teams that have come up with truly ground breaking inventions have become household names. Yet, they have either individually or collectively

come up with many of the inventions or driven the technology that we use every day.

With this in mind, the following booklet intends to celebrate the creativity, technical prowess, and scientific skills of the 'Hidden Inventors' who have made such a crucial contribution to our everyday lives.

Take a look through, see the names, and learn the stories of the European inventors who have pioneered the technology we take for granted today and pushed the boundaries of what was thought possible.

After all, for European inventors to thrive in the years to come, we must celebrate its most brilliant minds today.



Sophie Wilson

INVENTOR OF THE MICROCOMPUTER

Nationality: British
Birth Year: 1957
Education: University of Cambridge
Sector: Computer Science/Technology
Company: Acorn Computers Ltd.

Inventions

- Acorn System 1
- BBC Micro
- Acorn RISC Machine
- ARM Processor

Background & Early Life

Born in Leeds, England, Sophie Wilson decided to study computer science and mathematics at the University of Cambridge in 1975. While at university, she worked on her first system for a company based in Harrogate. The 'cow-feeder' project was used by farmers to regulate cow feed and became the basis for her next inventions in computer technology.[10]

Early Inventions

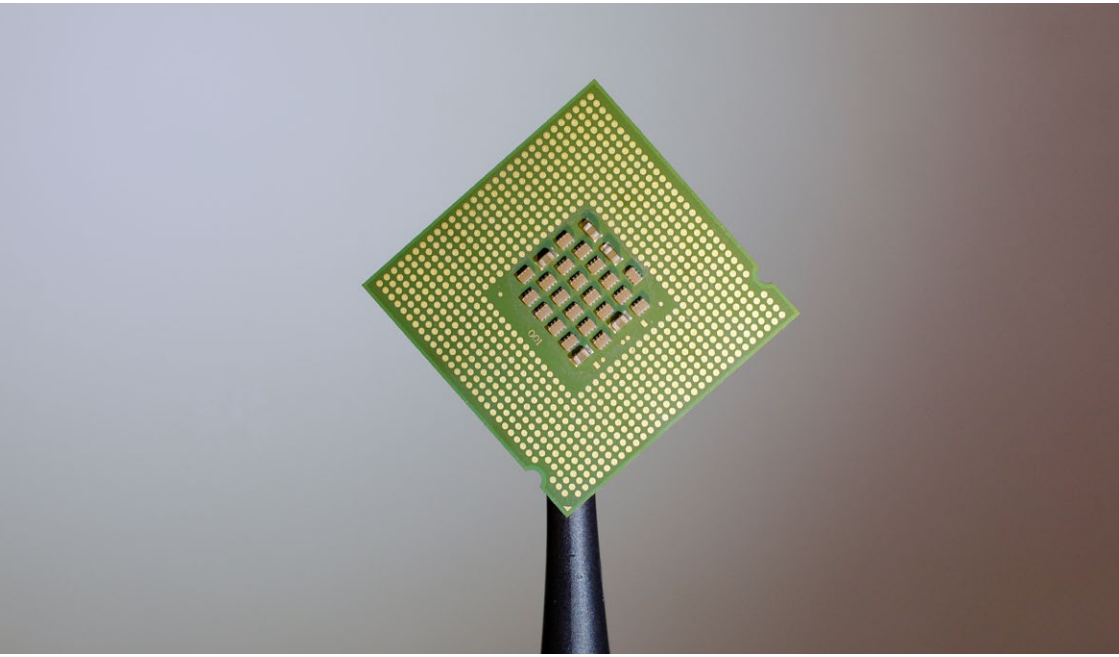
Between 1980 and 1981, Sophie designed the BBC Microcomputer while working with Acorn, a British company specialising in computers. The idea was to develop an affordable personal computer for the BBC's Computer Literacy Project.[11] A public awareness and education campaign set up by the government and the BBC, the project also taught viewers how to program, and chronicled a decade of information technology.[12] Sophie and her colleague Steve Furber jointly designed the hardware, while Sophie oversaw the software development with contributors including Paul Bond, Jon Thackray and David Seal for the operating system (OS). She also wrote the programming language used, based on requirements from the BBC and programmer Richard Russell. Control of the project was shared between Acorn (Chris Turner, Steve Furber and Hermann Hauser) and the BBC Literacy team. Overall, it was a huge success: with an original sales target of just 12,000, over 1 million units were sold by 1989.[13]

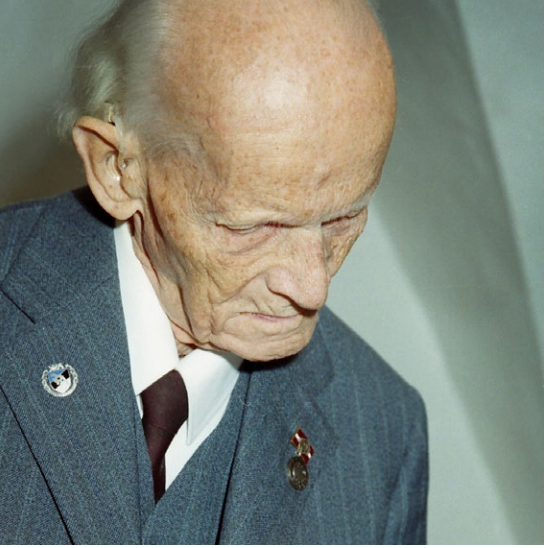
From Young Inventor to Global Pioneer

After the BBC Micro's success, Acorn took a bold approach. Sophie and Steve Furber set out to create their own Central Processing Unit (CPU). They wanted it to be smaller, faster, and better than the commonly used 6502 processor. From this, the development of the Acorn RISC Machine (ARM) instruction set was started in 1983, and the processor was finalised and working in April 1985. A milestone in computing, it drastically reduced the number of instructions needed to finish tasks using Reduced Instruction Set Computing (RISC). This meant ARM1 was a tiny, low-power, and efficient CPU using 25,000 transistors.[14]

Impact & Legacy

Today, Sophie Wilson's inventions are used in thousands of day-to-day products including mobile phones, tablets, digital televisions, and even video and computer games.[15] Their benefit has been huge – reducing the power needed to operate these devices while maximising their performance.[16] To date, over 160 billion ARM-powered chips have been shipped, while the average yearly shipments of ARM-based chips over the past three years is over 20 billion per year.[17]





Walter Zapp

INVENTOR OF THE MINIATURE CAMERA

Nationality: Latvian
Birth Year: 1905
Education: Self-educated
Sector: Optical Engineering
Company: Minox GmbH

Inventions

- Minox Riga/Minox A1
- Minox Sub-Miniature Camera

Background & Early Life

Born in Riga, Latvia, Zapp was interested in cameras and photography from an early age. A self-described 'weakling', at 17 he began to wonder if cameras could be made smaller while carrying around large and heavy wooden ones during his time as a 17-year-old art photography apprentice in Tallinn, Estonia.[18]

Camera Prototypes

In the 1930s, Zapp came up with the idea of a camera that was both small enough to fit in the palm of your hand, while also able to take high-quality photographs.[19] His ambition was to create a camera accessible to everyone, even those with only a small amount of photography knowledge. In 1936 he created the first prototype of the camera out of wood.[20] His efforts eventually paid off, resulting in the first working miniature camera that could fit in the palm of a hand. Production began in the Latvian factory VEF, with the camera arriving on the market in 1938.[21] For photographers of the time, it was barely recognisable as a camera: it had a silver body of stainless steel and could capture objects just 20cm away.[22]

From Miniature Camera to Spy Camera

Because of its revolutionary size, the camera became highly sought after by generations of spies and intelligence agencies – a development that Zapp himself is known to have been unhappy

with.[23] During World War II the camera became so popular, intelligence agencies couldn't get hold of enough of them. The close-focusing lens of the camera meant it was perfect for covert uses like surveillance and document copying. This association with espionage continued throughout the Cold War.

Impact & Legacy

Since its creation, more than 1 million of the miniature cameras have been sold. Minox, the company founded by Zapp, continues to revolutionise the camera, producing a wide range of 8 by 11mm subminiature cameras. Walter Zapp's ideas and innovations in photography and optical instruments have meant he is widely seen as one of the great visionaries of the industry.

Peter Landrock

INVENTOR OF ELECTRONIC ENCRYPTION CODES

Nationality: Danish
Birth Year: 1948
Education: University of Aarhus, University of Chicago
Sector: Cryptography/Mathematics
Company/Affiliation: Cryptomathic, International Association for Cryptologic Research

Invention

- Encryption codes for electronic data transfer

Background & Early Life

Born in Horsens, Denmark, Peter graduated in maths and physics in 1972 from the University of Aarhus. He then completed a PhD in mathematics at the University of Chicago in the US in 1974 before returning to Denmark to become an Associate Professor at the University of Aarhus.

Realising the Potential of Computer Codes

While at the University of Aarhus, Peter became fascinated with the computer revolution, code breaking, and as a result the commercial potential of computer codes.[24] In 1984 he started working in data security and brought together one of the leading data security research teams in Europe at the time.[25]

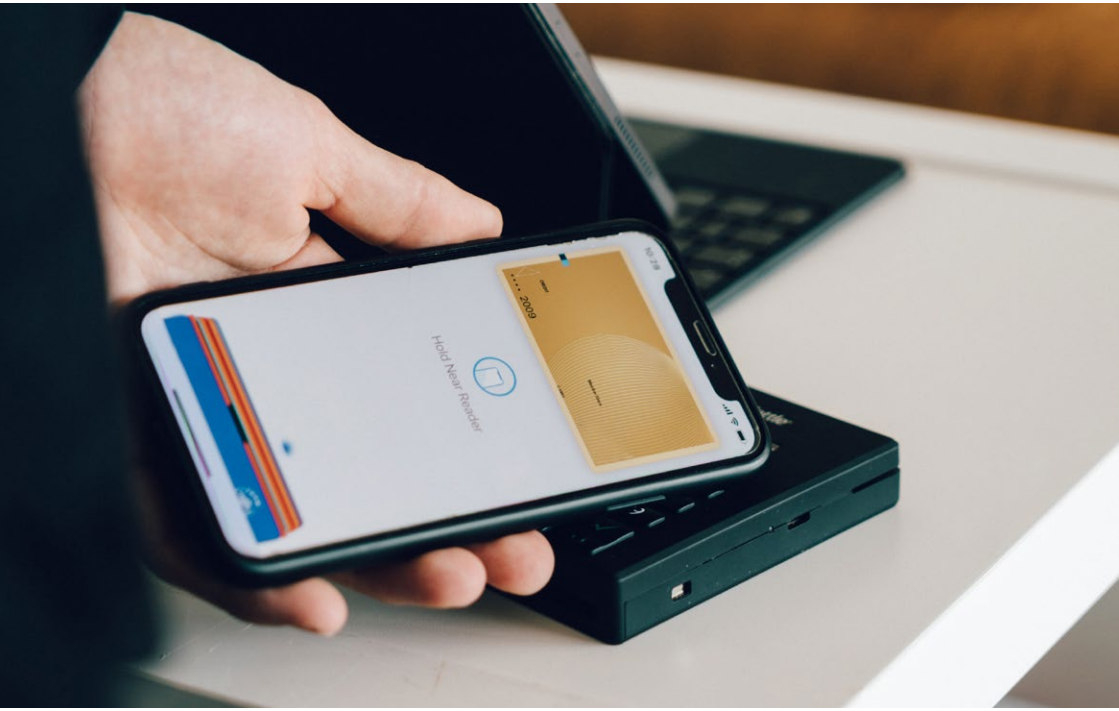
Academia to Entrepreneur and 'Chip and PIN' Creator

Alongside Ivan Damgård and Jørgen Brandt, Peter founded Cryptomathic in 1986. However, it was his work with the Isaac Newton Institute programme at the University of Cambridge on Cryptology and Coding Theory that inspired him to focus specifically on commercialising cryptographic algorithms.[26] Ahead of their time – well before online banking or shopping and even before the World Wide Web – Peter and the team focussed extensively on the practical aspects of key management and authentication.[27] Their first customers were financial insti-

tutions, where they designed digital methods to protect financial documents and information. They revolutionised the lock and key principle in digital format. For bank cards, the lock is the card's 'public key' (a long sequence of zeros and ones stored in the bank's database), while the corresponding 'private' key is stored only in the card's chip. Therefore when a payment is authorised, the chip digitally signs the transaction.[28] Their groundbreaking cryptography has since been applied to contactless payments, electronic passports, secure servers and even used for voting online.[29]

Impact & Legacy

Currently, over 100 million bank clients in Europe use internet banking relying on the trusted data encryption methods founded by Peter and his team. Despite being a relatively small company, the technology created by Cryptomathic is found in billions of mobile phones, and the algorithms are used to create hundreds of millions of bank cards yearly. The company is currently one of the world leaders in security solutions across various sectors.



Emilio Herrera Linares

INVENTOR OF THE SPACE SUIT

Nationality: Spanish
Birth Year: 1879
Education: Academy of Military Engineering of Guadalajara
Sector: Aeronautics
Company/Affiliation: Spanish Military, Spanish Royal Academy of Sciences

Invention

- Stratonautical Space Suit

Background & Early Life

Emilio Herrera Linares was born in Granada, Spain in 1879, into a family of the enlightened bourgeoisie. From his childhood he was fascinated by aviation and aerostatics, mainly due to the influence of his father (a military man by profession), and the novels of Jules Verne.[30] After finishing secondary school, he began studying architecture, although dropped out at 17 to enrol in the Academy of Military Engineering of Guadalajara.[31] The Academy was presided over at that time by the pioneer of the new field of aerostatics, Pedro Vives Vich. In 1914, Emilio made headlines in Europe as part of the first group of Spanish military aviators to fly over the Strait of Gibraltar by plane.[32]

Inventing the Precursor to the Modern Space Suit

Linares designed the stratonautical space suit in 1935 to be used during a flight to the stratosphere – about 20 kilometres above sea level. The flight was scheduled for 1936 by means of an open basket balloon. The stratonautical space suit contained two layers: a hermetic inner suit made of rubberised silk, covered with an articulated metal frame with accordion-like folds. This allowed for the mobility of moving parts like the arms and legs. It was equipped with a helmet where the visor contained three layers of glass: one shockproof, one with an ultraviolet filter, and an opaque infrared exterior.

A Dream Not to Be

In the end, the inaugural flight never took place due to the outbreak of the Spanish Civil War in July 1936.[33] Emilio, who served on the anti-Francoist side, fled to France in 1939, and passed away in Geneva in 1967. The suit would have been the first fully functional pressurised suit in history, although it was never worn in real conditions.

Impact & Legacy

Emilio's invention, an unprecedented feat at its time, would go on to inspire NASA to create the space suits of its astronauts over 30 years later, including those that would be worn by the crew of the Apollo 11 mission to the Moon in 1969. In posthumous gratitude for his work, Neil Armstrong himself, on his return to Earth, gave a moon rock to one of Emilio's collaborators, Manuel Casajust Rodríguez.[34]

Kornelis ('Kees') A. Schouhamer Immink

INVENTOR OF THE CD

Nationality: Dutch
Birth Year: 1946
Education: Rotterdam Polytechnic, Eindhoven University of Technology
Sector: Audio & Electrical Engineering
Company: Philips, Turing Machines Inc.

Inventions

- Compact Disc (CD)
- DVD and Blu-ray Disc

Background & Early Life

Born in Rotterdam, The Netherlands, Kees graduated with a degree from Rotterdam Polytechnic in 1967. In 1968, he began working at the Philips Research Labs in Eindhoven, where within a few years, the research effort that would eventually become compact-disc technology got under way.[35] He later went on to obtain a master's degree in electrical engineering, and then a PhD in 1985 at the Eindhoven University of Technology.

The Video and Laser Discs: An Unsuccessful Beginning

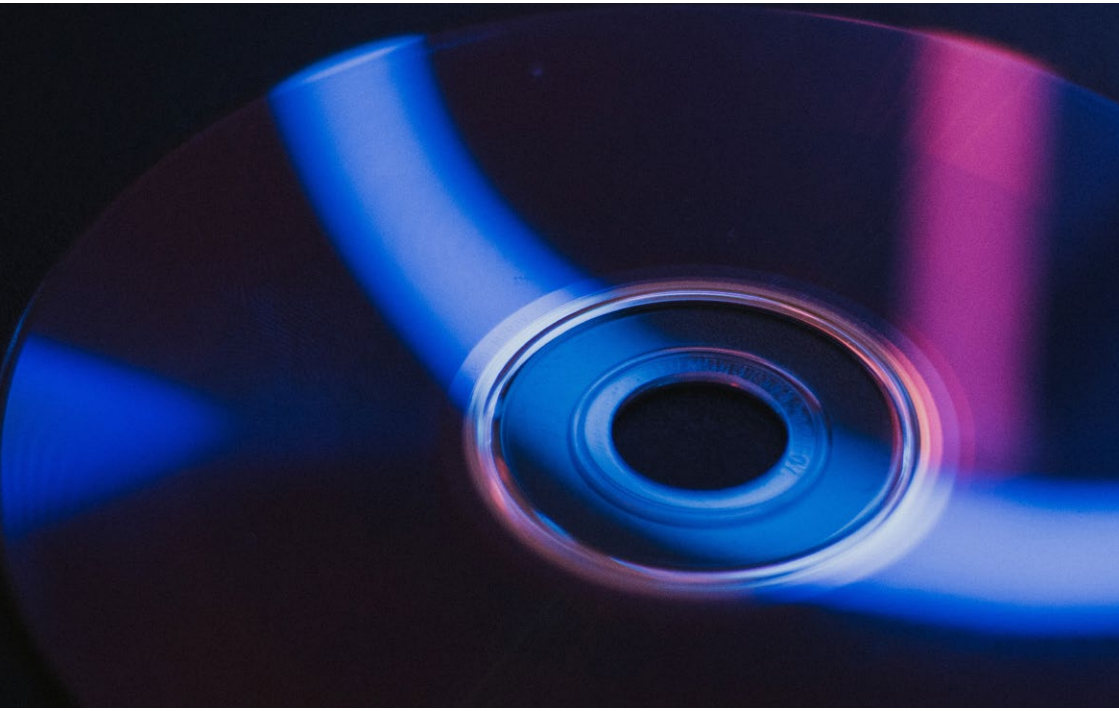
In 1973, he began working on the videodisc in the Optics group of Philips Research. Launched in 1975, it was a 30cm optical disc that could store 60 minutes of video content - essentially a huge, heavy, and unreliable early DVD. While it technically worked, it was a "monumental marketing failure".[36] At the time, Philips was using the same technology for an audio-only disc. They created a prototype in 1976, while Sony did the same a year later. In 1979 they decided to join forces to create a world audio disc standard. Working for the next few years between Tokyo and Eindhoven, they settled for an original launch date in November 1982, which was then split into a two-step launch with the first in Japan, and the second globally in March 1983.[37]

Creating the Code that Fixed the Compact Disc Revolution

Immink came up with an ingenious coding system called Eight-to-Fourteen Modulation (EFM). By breaking down binary code into shorter blocks, they could be read more easily. CDs and their successors (DVDs, CD-ROMs, Blu-ray) consist of plastic discs that are read by small lasers. Data is fed into a master recorder, which engraves a digital spiral of tiny pits onto a polished glass master disc. Both the pits and the areas between them (called the lands) represent the 1s and 0s of digital data.[38] For DVDs, Immink invented a new code, which was called EFM plus.

Impact & Legacy

The invention of the CD led to the subsequent development of CD-ROMs, DVDs, and Blu-ray. They revolutionised the computer, music and entertainment industries – with CDs alone selling billions of copies since 1989 and achieving a revenue of over €4.7 billion. They were the first portable format for high-quality audio and video digital recordings, while CD-ROMs offered significantly more storage space than the average computer hard drive at the time, giving people access to countless computer programmes.



Claude Berrou

INVENTOR OF TURBO CODES

Nationality: French
Birth Year: 1951
Education: Grenoble INP
Sector: Electrical Engineering/Communications
Company/Affiliation: Télécom Bretagne

Invention

- Turbo Codes

Background & Early Life

Claude Berrou was born in Penmarc'h (Finistère) in France. Following his early education in Brest, Berrou completed a two–year preparatory programme and was accepted into one of the prestigious 'Grandes Écoles' specialising in graduate-level studies. In 1975, he completed his engineering diploma at the Grenoble Institute of Technology (ENSERG).[40]

Information Encoding

After completing his graduate studies, Berrou was recruited by France Télécom to help set up the École Nationale Supérieure des Télécommunications de Bretagne (now Télécom Bretagne) in 1978.[41] Berrou's early work ranged from the physics of transistors to circuit architecture and metrology, the study of measurement. He investigated the use of algorithms extensively before turning his attention to the theory of information encoding.

From Self-Described 'Average at Everything' to Solving a 40-Year Puzzle

In 1986, Berrou became the head of the integrated circuit laboratory. Working on encoding techniques in telecommunications alongside the digital communication specialist Alain Glavieux, he began to wonder why scientists were overlooking the concept of feedback in electronics.[42] This basic question would turn into a groundbreaking discovery.

In 1993, Berrou made the incredible claim that they had come up with a coding method that could transfer data twice as fast as any other code, and almost to the theoretical maximum known as the Shannon Limit.[43] These Turbo Codes became a revolutionary form of error-correction coding. When information is broadcasted over distance, it changes due to obstacles or reflections.
The Turbo Code theory fixes this by simultaneously encoding the information in two ways at the broadcaster level, and then decoding them in tandem. This gradually fine-tunes the data or information being broadcasted and corrects more errors.

Impact & Legacy

Berrou and Glavieux paved the way for advances now widely used in satellite and radio communications, high-speed networks and mobile telephony. In 2003, the European Space Agency launched SMART-1, the first space probe with data transmission powered by Turbo Codes. NASA also used them in their Mars Reconnaissance Orbiter.[44]

Karlheinz Brandenburg

INVENTOR OF THE MP3 FORMAT

Nationality: German
Birth Year: 1954
Education: Friedrich-Alexander University, Erlangen-Nuremberg
Sector: Audio & Electrical Engineering
Company: Fraunhofer Institute

Inventions

- MPEG-1 Audio Layer 3 (MP3)
- Optimum Coding in the Frequency Domain (OCF)

Background & Early Life

Karlheinz Brandenburg was born in Erlangen, Germany. He studied electrical engineering and mathematics at Friedrich-Alexander University, Erlangen-Nuremberg, graduating in 1982. He then went on to pursue his PhD in 1989, focussing on digital audio coding.[45]

Challenging the Impossible

While completing his thesis, Brandenburg's advisor – Professor Dieter Seitzer – had applied for a patent to transfer music files through a phone line while preserving the audio quality. This was rejected on the basis that impossible ideas cannot be patented. At the time this was an understandable position – sending this much 'raw' information on the internet was not possible, and music files had their sound quality reduced.[46] Step in Brandenburg, who was given the task of achieving the impossible.

The "Father of MP3": Laying the Foundations

The results of his thesis laid the groundwork for what would become the MP3 standard. While working as an assistant professor, he continued his research with scientists from the Fraunhofer Institute for Integrated Circuits, where they improved the audio compression algorithm he had designed called optimum coding in the frequency domain (OCF). Exploiting the limitations of human hearing, the MP3

format borrowed aspects of psycho-acoustics – a process he worked on with Jim Johnston from AT&T Bell Laboratories. This meant files could be compressed by removing the frequencies the human ear can't hear.[47] This, coupled with placing audio data into numbers and then scaling down their size by rounding them up, meant MP3s could keep their sound quality as high as possible while reducing their file size. The biggest challenge came when compressing "Suzanne Vega's 'Tom's Diner' a capella".[48] Brandenburg notes that the simplicity of the song made it one of the most difficult to compress while keeping the quality intact. By 1992 the MP3 was a reality, but the big breakthrough came in 1995 when they decided the internet was the best way to market the technology and find its users.[49]

Impact & Legacy

MP3 technology was truly transformative, taking over CDs as the industry standard for music distribution and paving the way for industry giants and streaming services like Apple Music, Spotify, and SoundCloud, to name a few.

Elvira Fortunato

INVENTOR OF PAPER-BASED MICROCHIPS

Nationality: Portuguese
Birth Year: 1964
Education: New University of Lisbon
Sector: Electronics/Material Research
Company/Affiliation: Materials Research Center (CENIMAT/i3N), New University of Lisbon, YDreams

Invention

- Paper-based microchips and transistors

Background & Early Life

Born in Almada, Portugal, Elvira completed a degree in Materials Science and Physics at the New University of Lisbon in 1987, and then a PhD in Microelectronics and Optoelectronics in 1995. A childhood fan of science fiction, Elvira focussed on exploring the potential of microelectronics.

The Paper Electronics Concept

Working alongside Professor Rodrigo Martins, Elvira began to explore the potential of paper in electronics. Before their breakthrough, inventing paper-based semiconductors seemed an impossible task as transistors required silicon and other chemicals to conduct, store and block electric currents. The breakthrough came when they coated paper sheets with semiconductors made of oxides of zinc, gallium and indium, which, when connected through a layer of aluminium, allowed paper to replace silicon as a functional component.[50]

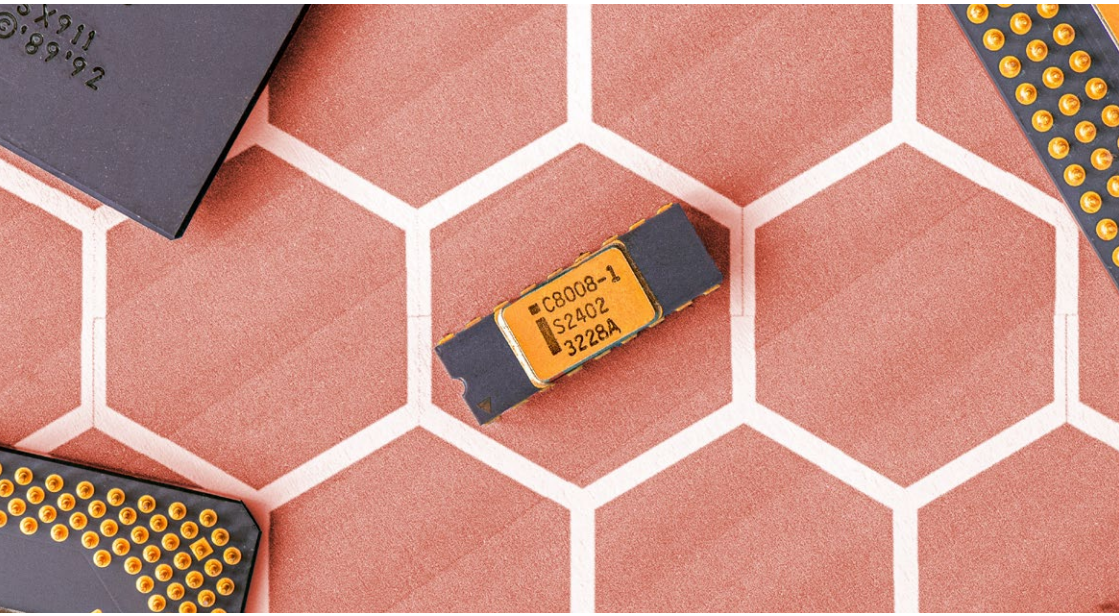
Using Paper Microchips for an Environmentally Friendly Future

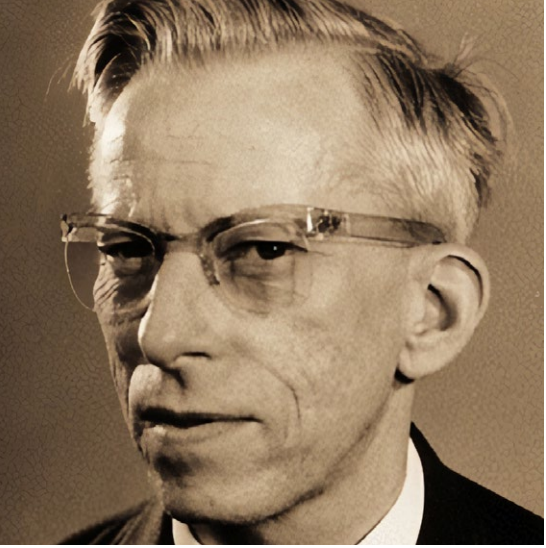
Producing normal microchips uses electronics-grade silicon. This is both a very expensive material to use and has a negative impact on the environment due to greenhouse gas emissions. The invention, therefore, was a 'blue-sky' moment – opening up new markets for disposable objects with microchip intelligence,

allowing smart devices to be discarded and recycled after use.[51] While the general idea was not to completely replace silicon transistors, this could become a solution for many applications.[52]

Impact & Legacy

It is widely noted that the future potential for paper-based microchips is huge. From bringing 'smart' computer technology to new areas of daily life, to pushing forward a new generation of inexpensive and recyclable devices, these will likely play a big role in future digital technologies and the Internet of Things (IoT).[53] The technology also paved the way for devices not invented at the time, including animated newspapers and billboards, self-updating food labels, business cards, radio–frequency identification (RFID) tags, and much more. Elvira is now one of the top pioneers in microelectronics and pushes for linking research with the market. Looking forward it is estimated that paper-based transistors in the smart electronic packaging market could reach a value of €1.51 billion by 2022, while paper-based microelectronics could be worth €10.56 billion by 2021. For her pioneering work, Fortunato won the Horizon Impact Award 2020, which celebrates and recognises EU- funded projects with a positive societal impact.[54]





Otto Wichterle

INVENTOR OF THE SOFT CONTACT LENS

Nationality: Czech
Birth Year: 1913
Education: Czech Technical University of Prague
Sector: Chemical Technology
Company: Bat'a Shoe Company

Inventions

- Silon
- pHEMA
- Soft Contact Lens

Background & Early Life

Born in Prostejov, in what was then Czechoslovakia, in 1913, Otto set his sights on a scientific career instead of working in his father's successful farm machinery factory. Following high school, he went on to study chemistry and complete his doctoral thesis in 1939 at the Czech Technical University in Prague.[55]

A Politically "Unreliable Person"

Following Nazi Germany's invasion and annexation of Czechoslovakia, Wichterle was unable to continue his university research. However, he was able to continue his investigations into the chemistry of plastics at the Bat'a Shoe Company, where he developed the procedure to make a synthetic called Silon. After World War II he returned to the Czech Technical University. Up until 1958, he was the dean of the Institute for Chemical Technology in Prague and worked on dozens of patents for polymer materials. However, rising political tensions meant he was removed from his job by the Communist Party, following a political purge by Czechoslovakia's leadership.

From Kids Toy to Billion-Dollar Industry Changer

Prior to his firing, he had been working on creating a material suitable for permanent contact with living tissues. The end result was hydrogel poly-hydroxyethyl methacrylate (pHEMA) - a gel capable

Impact & Legacy

of absorbing and retaining moisture. He began tinkering with its use in contact lenses, and on Christmas Eve in 1961, he assembled the first 'contact lense machine' in the kitchen of his family home, made of a children's toy construction Erector Set, bicycle parts, and an old phonograph.[56] He went on to create the basics of the spin-casting process now used to make soft contact lenses.[57]

His inventions changed the way people around the world see. Before his ingenuity, contact lenses were made of hard plastic, making them expensive, difficult to produce, and often uncomfortable. The material he pioneered saw little change for over 30 years, until silicone-hydrogel contact lenses were introduced.[58] This achievement earned him a title of "the father of the soft contact lens". Today hundreds of millions of people use contact lenses daily, showcasing the truly gamechanging nature of Wichterle's invention.

Benedetto Vigna

INVENTOR OF THE 3D MOTION SENSOR

Nationality: Italian
Birth Year: 1969
Education: University of Pisa
Sector: Chemical Technology
Company: STMicroelectronics, Italian Scientific Research Center

Invention

- 3D Motion Sensor

Background & Early Life

Born in Potenza, Italy, Benedetto Vigna studied Subnuclear Physics at the University of Pisa. Following short stints at the European Synchrotron Radiation Facility in Grenoble and the Max Planck Institute in Germany working on X-ray lasers, he joined the Research and Development Lab at STMicroelectronics (ST) in 1995.[59]

MEMS Research: Challenging the Competition

Microelectromechanical systems (MEMS) are systems that integrate sensors with microchips. This means information is captured and processed before the appropriate action takes place.[60] In 1996, only one paper had been written on acceleration sensors for automotive applications and it was from STMicroelecronic's competition. To change this, Vigna was asked to start ST's MEMS activities and start developing his own systems. Taking the role enthusiastically, Vigna dreamed of being the first MEMS supplier in the consumer market.

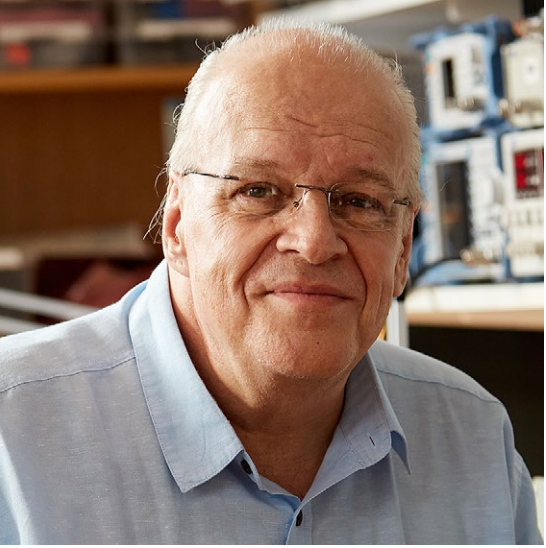
Adding a Real World (3D) Dimension

At the time motion sensors were being used mostly in car airbags, but their broader use still had a long way to go. Step in Vigna, who dedicated his efforts to bringing down their size and cost. In 2001, ST developed an inexpensive sensor capable of detecting motion in 3D.[61] Not only did Vigna miniaturise MEMS to

a never-seen-before scale, but he also created a completely new kind of system – one able to interpret the movements of the real world through a third dimension. This opened up a world of possibilities for everyday consumer products. Nintendo jumped on this, and in 2006 launched the Wii using motion control from inexpensive sensors from Vigna and his team.

Impact & Legacy

Today, MEMS are supplied in the consumer, industrial, automotive, and even healthcare markets. In the gaming world, the Nintendo Wii became the best-selling video game system globally in 2010, showcasing the huge potential of MEMS. Currently, the components are used in smartphones, GPS devices, computers, and medical and scientific equipment. The company now has over 50,000 employees, revenues of approximately €9 billion, and Vigna's research team has developed into a €140 million division.[62]



Lars Liljeryd

INVENTOR OF DIGITAL AUDIO COMPRESSION STANDARDS

Nationality: Swedish
Birth Year: 1951
Sector: Audio & Electrical Engineering
Company: Stocktronics, Dolby Laboratories

Inventions

- Spectral Band Replication (SBR)
- Deep-Diver Communication System

Background & Early Life

Born in Stockholm, Sweden, Lars Liljeryd grew up with a fondness for radio and electronics. As early as 10 years old, he began tinkering with radio receivers and built a series of them for his friends.[63]

A Passion for all Things Music

Liljeryd's love of electronics was coupled with his passion for music. A self-labelled 'rebel', he started playing the drums, joined his first band at 13, and started building stereos and loudspeakers from any salvaged parts he could find. He managed to combine his keen eye for experimenting with electronics with his music, touring with his band 'Shades-of-Blue' when he was 16. By 1971 he had set up his own business called Stocktronics rebuilding Hammond organs. He even went on to get a number one music hit in Sweden, and to create various sound-based inventions including a deep-diver communication system for the offshore oil industry, which became mandatory for diving operations deeper than 180 meters in the oil fields of the North Sea.[64]

Shrinking Sound to Modernise an Industry

The perfect culmination of Liljeryd's many talents, he completely revolutionised how audio files are compressed. Instead of cutting out parts of an audio file like the other methods available (MP3 and Advanced Audio Coding), he realised it

was not necessary to transmit all parts of the file. Instead, he found that only the lower frequencies were essential, which could then be used to reconstruct the higher frequencies at the receiving end.[65] Called Spectral Band Replication (SBR), its efficiency and high fidelity took the world by storm, quickly winning over mobile phone, internet, and satellite broadcasting companies. Soon after it was supported by the likes of Adobe Flash Player and Apple iTunes.[66] It hit the market in 2002 as part of the MPEG High-Efficiency Advanced Audio Coding standard (HE-AAC).

Impact & Legacy

Liljeryd's ideas have resulted in people across the globe being able to enjoy higher-quality sound more easily and more affordably. The convenient audio streaming, storage, and playback that we are so familiar with today would not be possible without the world's most popular digital audio compression codecs.[67] These are now the standard for over 6 billion devices across the globe.

Mária Telkes

INVENTOR OF SOLAR ENERGY STORAGE

Nationality: Hungarian/American
Birth Year: 1900
Education: University of Budapest
Sector: Solar Energy
Company: Cryo-Therm, US Office of Scientific Research & Development, MIT

Inventions

- Solar Heating Systems
- Solar Water Distilling System

Background & Early Life

Born in Budapest in what was then Austria-Hungary, Mária studied physical chemistry at the University of Budapest, earning a B.A. degree in 1920, followed by a PhD in 1924. She then moved to the US where, while working for the Cleveland Clinic Foundation as a biophysicist, she helped to create a device that recorded brain waves.[68]

Using the Power of the Sun

It was at the Massachusetts Institute of Technology (MIT) that Mária began her prolific research on the potential of solar energy. She worked on thermoelectric devices powered by the sun as part of the Solar Energy Conversion Project, searching for new and innovative ways of capturing and deploying solar energy. During World War II, she created one of her most important inventions: a solar distiller that was able to vaporise seawater and turn it into drinking water.[69] This quickly became a staple in the military's emergency medical kits, saving the lives of countless pilots and sailors who were shot down.[70]

From MIT to the Dover Sun House

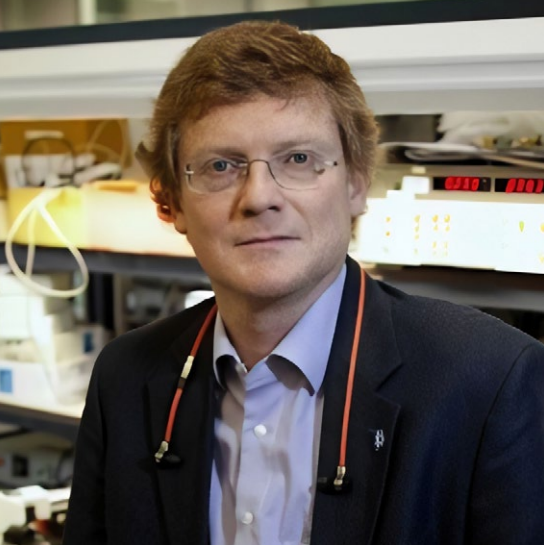
Teaming up with architect Eleanor Raymond and sponsored by Amelia Peabody, Telkes was tasked with designing a solar heating system for the Dover Sun House. This was to be an experimental house designed to showcase

solar energy. Her system captured and stored solar energy chemically through the crystallisation of a sodium sulfate solution.[71] Completed in 1948 in Massachusetts, the house worked for over two years before the chemical reaction used ran out.

Impact & Legacy

Quoted as saying "sunlight will be used as a source of energy sooner or later. Why wait?", Mária's groundbreaking research on solar energy has led to her nicknames of 'sun queen' and the 'mother of the solar home'.[72] Despite solar power taking a while to gain popularity, her work laid the foundations of what we know as solar power today.

Devoting her career to the energy of the sun, she invented one of the first solar heating and solar water distilling systems. Following the Dover Sun House experiment, Telkes continued focussing her career on solar innovations, creating solar stoves, heaters, and coming up with solar materials for space programmes. Over the course of her career, she was awarded over 20 patents for her inventions.



Jaap Haartsen

INVENTOR OF BLUETOOTH

Nationality: Dutch
Birth Year: 1963
Education: Delft University of Technology
Sector: Electrical Engineering/ Communications
Company: Ericsson, Haartsen New Ventures B.V.

Invention

Bluetooth Wireless Technology

Background & Early Life

Born in The Hague, The Netherlands, Jaap studied at Delft University of Technology, where he gained an M.S. in electrical engineering. After a brief stint working for Siemens in the Hague, and Philips in Eindhoven, he received his PhD in 1990 from the same university. Shortly after, he was hired by Nils Rydbeck, and moved to the US to join the newly created Ericsson-GE mobile phone division in North Carolina.[73]

Wireless Communications

In 1994 Jaap moved to the Ericsson division in Lund, Sweden.[74] Rydbeck had given him a new challenge: to work on a short-range radio link between a cellular phone and a nearby electronic device.[75] The mission was to add new capabilities to mobile phones.[76]

Changing the Way the World Sends Files

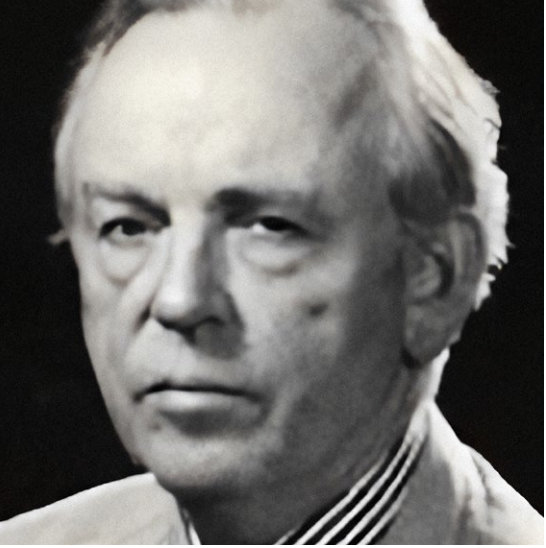
Jaap came up with the idea of using frequency hopping in 1994. This laid the foundations for Bluetooth, a revolutionary technology connecting electronic gadgets at short range with no cables. In 1995, Sven Mattisson, an expert in radio implementations, joined the Ericsson division in Lund, working on the hardware development. The Bluetooth solution meant that two devices could communicate with one another by switching radio frequencies, in sync, over 1600 times per

second. With 79 frequencies available, this meant the likelihood of other devices using the frequency and disrupting the communication between the two devices was extremely low.[77]

In 1997, Örjan Johansson helped drive the business around the concept, creating an ecosystem with other companies which became the Bluetooth Special Interest Group. In 1999, the first specifications were released, and in 2000 Ericsson launched its first Bluetooth product: a wireless voice headset.[78]

Impact & Legacy

Bluetooth has revolutionised not only the way electronic devices connect with one another, but also how individuals share files, connect, and communicate. If you use wireless headphones or speakers, pair gaming controllers, or use an external keyboard, you are using the technology Jaap introduced to the world.



Frank Pantridge

INVENTOR OF THE PORTABLE DEFIBRILLATOR

Nationality: Northern Irish
Birth Year: 1916
Education: Queen's University, Belfast, University of Michigan
Sector: Medicine
Company: Royal Victoria Hospital, Queen's University, Belfast

Invention

- Portable Defibrillator

Background & Early Life

James Francis Pantridge was born on the outskirts of Hillsborough, County Down, Northern Ireland. He completed his medical studies in 1939 at Queen's University in Belfast. When World War II broke out, he voluntarily joined the army and was sent to the Far East as the medical officer of an infantry battalion. In 1942 he was captured in Singapore and spent the rest of his time as a prisoner of war working on the Siam-Burma Railway.[79]
At the end of the war, Frank received a scholarship to the University of Michigan and studied under cardiologist Dr. F.N. Wilson.

Responding to the Rise in Coronary Heart Disease

Returning to Northern Ireland in 1950, Pantridge discovered that most coronary deaths were caused by ventricular fibrillation within one hour of the onset of symptoms, and usually before the patient was able to reach a hospital.[80] In an effort to stop this from happening, he came up with the idea of a 'portable' defibrillator. At the time defibrillators were only available in hospitals and relied on being connected to the electricity supply of the building.

The 'Father of Emergency Medicine'

With the help of Dr John Geddes, Pantridge's approach was to take a discarded ambulance and power the

defibrillator by two 12-volt car batteries through a static invertor. The first version installed in 1966 was incredibly heavy, weighing in at 70kg. While mobile coronary care was quickly and passionately taken up in North America, it took longer to be used in Great Britain. Pantridge continued to innovate, introducing the first truly portable defibrillator in 1968, weighing roughly the same as a newborn baby, and the concept of the automatic defibrillator, which he conceived in 1976 on a train between Ghent and Amsterdam.[81]

Impact & Legacy

Modern-day versions of the original defibrillator are now used countless times every single day, all over the world. They save an incalculable number of lives annually and are an essential part of emergency response in ambulances.[82] As a result, it is safe to say that Pantridge transformed emergency medicine and paramedic services across the globe.

Martin Schadt

INVENTOR OF THE LIQUID CRYSTAL DISPLAY (LCD) SCREEN

Nationality: Swiss
Birth Year: 1938
Education: University of Basel
Sector: Electronic Display Technology
Company: Omega, Hoffman-La Roche, Rolic Ltd

Inventions

- LCD Technology
- OLED
- Twisted Nematic Effect (TN)

Background & Early Life

Born in Liestal, Switzerland, Martin went on to study experimental physics at the University of Basel. After earning a PhD in 1967, he moved to Canada to do a two-year fellowship at the National Research Council.[83] Once completed, he went on to work for the watch company Omega in 1970.

Between a Liquid and a Solid

It was during his time with Omega when Martin came across research being conducted by the company F. Hofmann-La Roche looking into liquid crystals. These are materials that change shape like a liquid, but have the same characteristics as a solid. Combining his natural interest in different types of science, the research covered physics, organic materials, and electro-optics.[84]

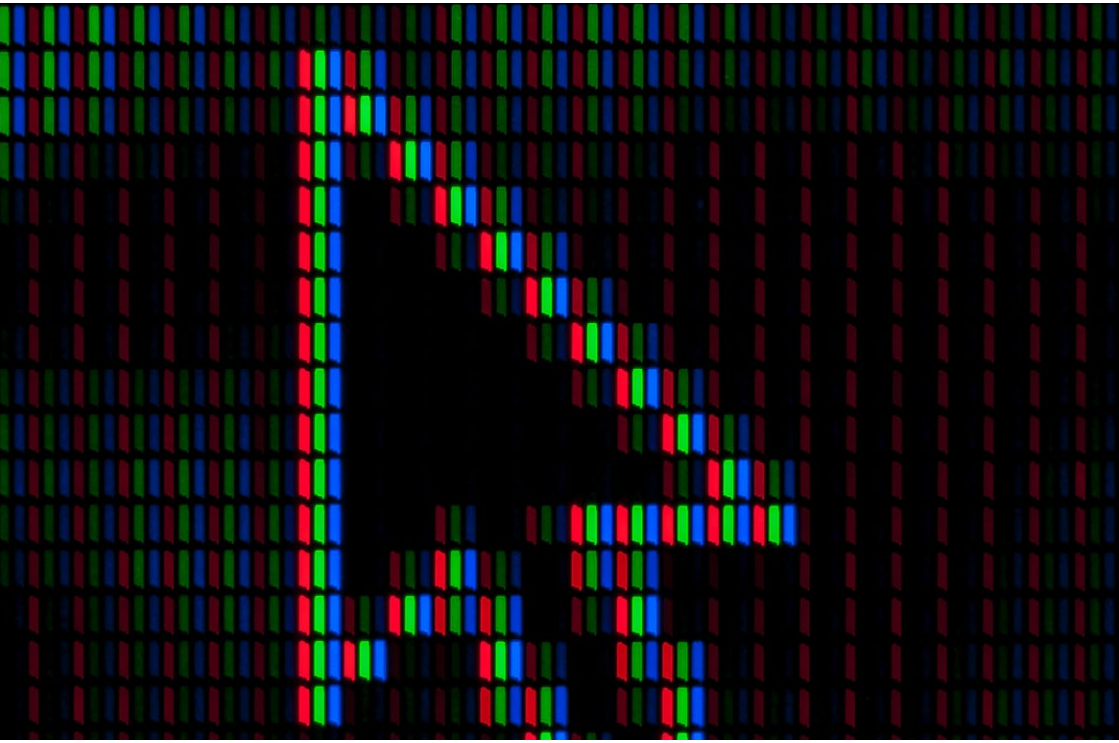
From Liquid Crystals to Colour Displays

The big breakthrough came when he began testing the theories of his colleague, Wolfgang Helfrich. Schadt designed and implemented tests to investigate if liquid crystal molecules could be 'unwound' to create a change in how they appear. He discovered that jolting liquid crystals with electricity caused their spiral molecular structures to unwind, which resulted in the molecules no longer being transparent.[85] By 'sandwiching' a layer of crystals between two plastic plates, he realised that these non-transparent

crystals could make visible shapes, like those used to display numbers in digital watches and calculators. When he also discovered that only a few volts were needed to interrupt light transmission and that this could happen with a battery, the true impact of his discovery became clear. [86]

Impact & Legacy

LCD technology has been truly groundbreaking, not only forever changing how we watch motion pictures, television, use our computers or play video games, but also for being a fundamental development that generated revenues of more than €130 billion in 2016.[87] Gone are the days of bulky screens and dated TV sets – the ever-brighter colours, larger and flatter screens, and flat panel displays with tiny pixels we enjoy today are all a direct result of Martin Schadt's state-of-the-art inventions.



Marta Karczewicz

INVENTOR OF ADVANCED DATA COMPRESSION

Nationality: Polish
Education: Tampere University
Sector: Electrical Engineering/Data Compression
Company: Nokia, Qualcomm

Inventions

- Advances in Data Compression
- Deblocking Filter

Background & Early Life

Born in Poland, Marta Karczewicz grew up with a passion for STEM and solving difficult problems. She finished among the top ten at the national Mathematical Olympiad, helping to both secure her place at university and receive a grant from Nokia to continue her studies.[88]
She went on to study information technology at Tampere University in Finland, where she completed her Masters and her PhD in 1994 and 1997.

A Future Focussed Outlook

With the freedom to design parts of the course at Tampere University, Marta focussed her efforts on image processing, statistics, and modelling. This allowed her to work at the same time on challenging projects at Nokia. Seeing huge potential moving forward, she decided to investigate video compression, laying the foundations for her pioneering future work.

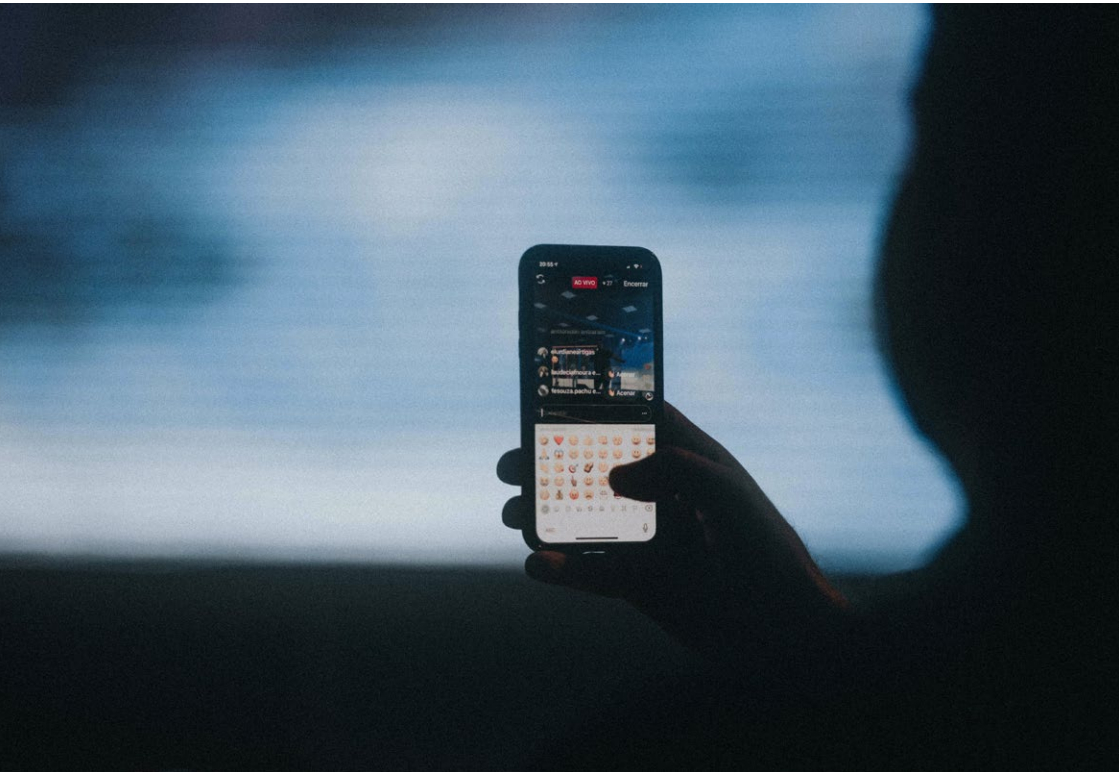
Making Information Simple: Advanced Video Coding (AVC)

Karczewicz went on to develop key components of AVC, the most widely used video codec for distributing video content globally. The technology compresses the video by reducing repeated information and exploiting the similarities between the frames in a video.[89] One of the key inventions was the deblocking filter. Used in set-top boxes, it examines pixels and

Impact & Legacy

smoothens sharp variations. This reduces the size of the file while ensuring the quality remains.[90] In just two decades, Karczewicz's inventions have meant that video files have become compressed by a factor of 1,000 – far surpassing the quality present in DVDs. This, in turn, has given rise to modern entertainment giants like Netflix, and given people the freedom to watch videos and films on mobile devices while on the move and communicate in real-time using video conferencing applications.[91]

Because of Marta's ingenuity, whenever you are streaming a video you are likely to be using a standard that she helped to create. Her efforts have transformed the video entertainment industry, making video streaming possible on laptops and mobile phones.



Federico Faggin

INVENTOR OF THE MICROPROCESSOR CHIP

Nationality: Italian/American
Birth Year: 1941
Education: University of Padua
Sector: Computer Science/Technology
Company/Affiliation: Olivetti, Fairchild Semiconductor, Intel, Zilog Corporation

Inventions

- Silicon Gate Technology
- Microprocessor Chips (Intel 4004/ Intel 8080/Z80)

Background & Early Life

Federico Faggin was born in Vicenza, Italy, in 1941. His father was a prolific scholar who authored numerous academic books. While attending technical high school Faggin developed a fascination for modern computing. Before going on to complete a PhD in Physics at the University of Padua in 1965, he worked for the Italian computer manufacturer Olivetti, where at the age of 19 he designed his first rudimentary desktop computer.[92]

Becoming the 'Father of the Microchip'

He moved to California in 1968, originally relocating to work for Fairchild Semiconductor. Here, he led the development of the original silicon gate technology and developed the first metal-on-silicon integrated circuit.[93] This self-aligned gate process technology used silicon as the gate electrode, instead of aluminium. Thanks to this new technology an entire processor containing numerous transistors could fit in a single chip.[94] However, fitting an entire Central Processing Unit (CPU) onto a single chip was yet to come.

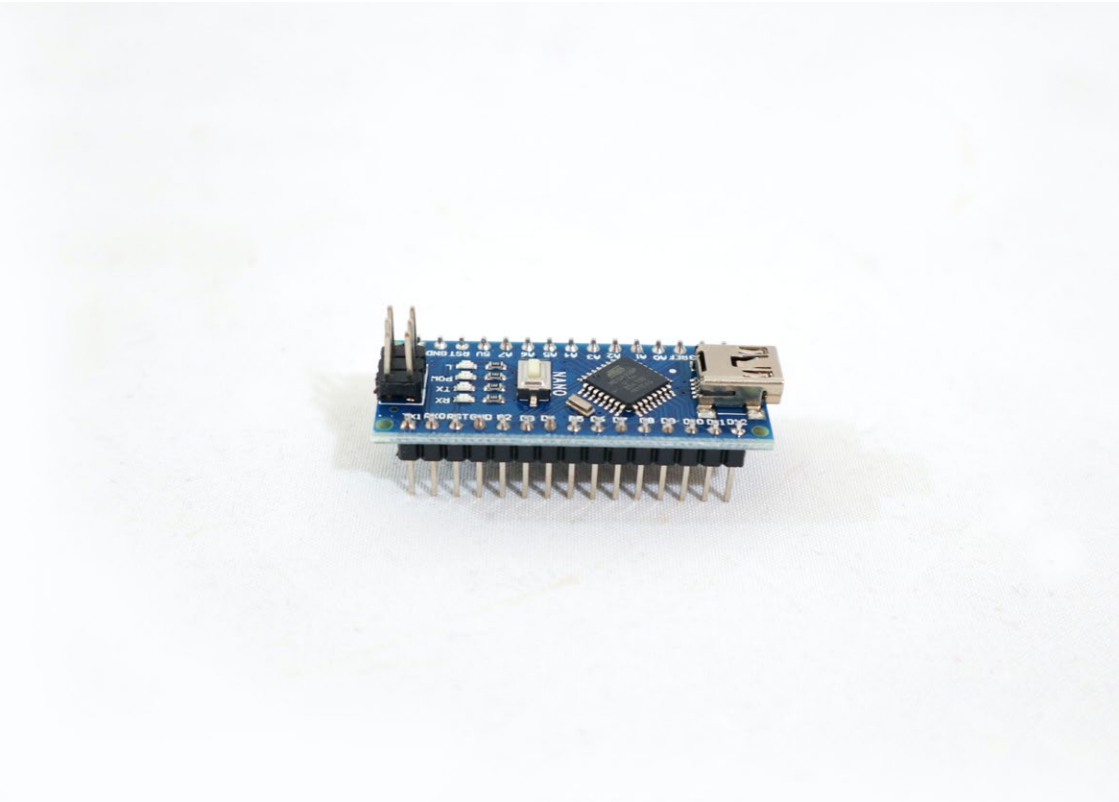
Fitting an Entire Central Processing Unit on a Single Chip

In 1970, he joined Intel Corporation. With the vision of creating a single chip to perform the functions normally requiring numerous chips, Faggin led the development of the world's first microprocessor,

the Intel 4004. In 1971, the first version was shipped to Japan and became a commercial reality. Not stopping there, he went on to create the first high performance 8-bit microprocessor, the Intel 8080.[95] In 1974 he set up his own company, Zilog, and went on to create the Z80 microprocessor, sellling over one billion and remaining in production for over 20 years.

Impact & Legacy

Microprocessors have allowed processing units to be incorporated into compact spaces such as modern PCs and smartphones – radically transforming the way people work, learn, and interact with each other. Microprocessors are now present in virtually all electronic items, from traffic lights to TVs and personal computers. It's therefore no exaggeration to say that Faggin's work represents one of the most important series of inventions in the 20th century.



Cornelis Drebbel

INVENTOR OF THE FIRST SUBMARINE

Nationality: Dutch
Birth Year: 1572
Sector: Engineering
Company: Royal Society

Inventions

- First Submarine
- Perpetual Motion Machine
- Mercury Thermostat

Background & Early Life

Born in the Dutch city of Alkmaar in 1572, Cornelis was the apprentice of the painter and engraver Hendrick Goltzius – a common occupation in the Netherlands at the time. This was when he was introduced to alchemy, which was the medieval version of chemistry and experimenting with materials.[96] This sparked a passion for inventing things that would lead to his eventual relocation outside of the Netherlands.

From Alchemy to Inventions

In 1604, Drebbel made his way to England. He had attracted the interest of the new King of England, James I, who was fascinated by explorers, theologians, economists, and alchemists and extended invitations to them to showcase their discoveries.[97] It was at the English court where Drebbel's name would gain traction. This was down to his Perpetual Motion Machine – a clock capable of telling the time, date, and season by using changes in atmospheric pressure to create motion.

The First Navigable Submarine

While working for the Royal Navy, Drebbel began toying with the idea of an underwater rowboat. This idea came to life in 1620, in the form of a wooden submarine or 'diving boat' propelled by oars and sealed from the water by a greased leather covering. It travelled the River Thames at

a depth of approximately 4.5m.[98] While much is unknown about how it worked, accounts suggest under the rowers' seats were pigskin bladders, connected to pipes on the outside. Ropes were used to tie the empty bladders and to dive below water; the rope was then untied and the bladders filled with water. Drebbel went on to build two more versions of the submarine. The final version was able to carry 16 people and stay under water for 3 hours – an achievement so great it was shown to the King.[99]

Impact & Legacy

Drebbel's work has contributed to the long history of inventors exploring what can be achieved in the water. As with many great inventors of the past, Drebbel would not receive significant recognition for his work until after his death. Despite receiving little fame or fortune, in 2001 a replica of his design was built for a BBC show by Mark Edwards.[100]

Carles Puente

INVENTOR OF THE FRACTAL ANTENNA

Nationality: Spanish
Birth Year: 1968
Education: Universitat Politècnica de Catalunya, Barcelona-Tech (UPC), University of Illinois (UIUC)
Sector: Telecommunications
Company/Affiliation: UPC, Fractus Antennas

Invention

- Fractal-Based Antennae

Background & Early Life

Carles Puente was born in 1968 in Badalona, Catalonia, Spain. In the 1990s, while still a student at the Universitat Politècnica de Catalunya, Barcelona-Tech (UPC), he had the idea of using fractals to design multiband antennas and aspired to become a scientist and a researcher. He is currently a Technology and Patent management professor at the UPC and a co-founder and Vice-President of Innovation at Fractus Antennas.[101] He holds an M.Sc. degree from the University of Illinios at Urbana-Champaign in the United States, and a Telecommunications Engineering and a PhD degree from the UPC.

Making Phone Antennas Invisible and More Powerful

In the 1990s, 2G mobile phones had external antennas, which delivered few features beyond placing phone calls, and featured a stubby, pull-out antenna. During his studies, Carles developed his first ideas to improve mobile phone antennas with the aim of shrinking their size (so they could be concealed inside the phone) while increasing broadcast capabilities to the new 3G frequency bands and beyond. While completing his PhD, Puente worked at the faculty of Electromagnetic and Photonic Engineering on pioneering developments of fractal technology in both antennas and microwave devices.[102]

The Fractal-Based Antennae Revolution

He began this challenging endeavour without initially receiving any financial support for his research.[103] In 1995, Puente and his team (including co-inventors Carmen Borja, Jaume Anguera, Jordi Soler, Rafael Pous and others) invented the fractal antenna and its derivatives. A major achievement at the time: thanks to fractal technologies, antennas were able to disappear from the surface of the phone. The name of the technology comes from fractal patterns, which defy common geometry rules and often include multiple small copies of themselves. This allows for coiling long antennas into the phones. Despite its size reduction, the fractal-based antenna is extremely efficient and broadcasts radio waves on varying frequencies.[104] This way, a single antenna can be used for multiple standards all together, starting with 2G, 3G, 4G, 5G and Wifi, Bluetooth and GPS.

Impact & Legacy

Carles' invention paved the way for the "Internet anywhere" revolution,[105] which relies on integrated and multipurpose antennas. When comparing the size and capacity of phones in the 1990s with 21st century devices, the impact of fractal antennas is unquestionable. Thanks to fractal antennas, a sleek, seamless appearance of mobile phones is compatible with a long range connectivity at a high-speed.

Salvino D'Armate

INVENTOR OF THE EYEGLASSES

Nationality: Italian
Birth Year: 1258
Sector: Optics

Invention

- Eyeglasses

Background & Early Life

Salvino D'Armate was born and raised in Florence, Italy, in the 13th Century. Because of the timeframe, his life is somewhat of a mystery outside of his contributions to optics. At the time, the science behind lenses was poorly understood. However, early versions of reading tools had been devised somewhere between 1000 and 1250 A.D. Called the 'reading stone', these tools were made of concave pieces of glass and were thought to be used predominantly by monks, who were the most likely to be able to read at that time.[106]

Disks for the Eyes

The first eyeglasses are thought to have been made around 1284. The frames had no arms and were unable to sit on the face freely – this was an evolution not seen for another 300 years. Instead, the glasses sat on top of the wearer's nose, and were held in place by hand. They had frames made of metal or bone, and the lenses were made out of quartz – one of the most easily found minerals at the time.[107] The earliest lenses were convex, and so bulged outwards in the middle, and were only capable of helping correct farsightedness.

Shrouded in Uncertainty

Despite D'Armate being credited with the invention, various sources have suggested either an earlier origin or

credit Italian monk Alessandro Della Spina as the inventor.[108] To this day there is no common acceptance of who was the original inventor of these early eyeglasses; however, they almost certainly originated from Italy between 1280 and 1300.[109] We know this because they began to appear in artwork, including in Tommaso da Modena's painting of Cardinal Hugo of Provence.

Despite the historical controversy, the history of eyeglasses showcases the often complex evolution of ingenuity and invention – and how time shapes what we are accustomed to today. Italy proves to be in one form or another the birthplace of glasses, leading to their development across the globe – ranging from the creation of the first frames with ear hooks in 1727 by Edward Scarlett, to the first bifocal lenses devised by Benjamin Franklin in 1794.[110]

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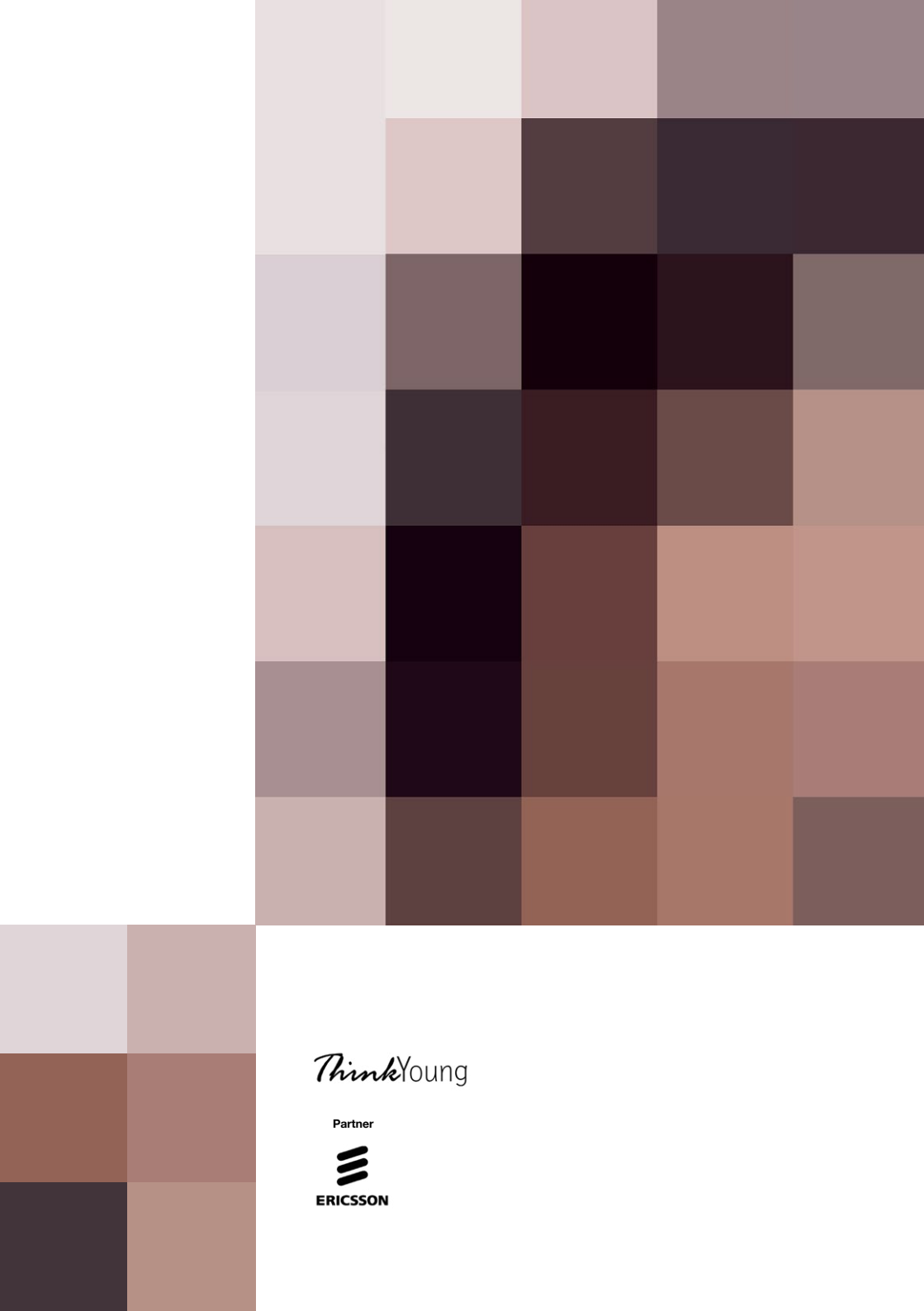

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