The end of an era:

Sydney's last DC power main switched off

by NEVILLE WILLIAMS

Recently, the Sydney County Council turned off the last remaining DC power main, serving Sydney's central business area. The supply had been maintained for just over 81 years but its ultimate phasing out came a neat century after the historic AC/DC confrontation in the USA between the competing interests of Westinghouse and Edison.

Nowadays, because of greater overall economy and versatility, the vast majority of domestic supply mains throughout the world provide consumers with alternating current (AC). The nominal RMS voltage and frequency per phase is most commonly either 117V at 60Hz (American continent, Japan, Taiwan, parts of Asia & Africa) or 240V at 50Hz (Europe, Australia, NZ, Oceania, parts of Asia, Africa).

However, while what was once known as "alternate" current dates back to the original rotating electric generators, it hasn't always been in such a dominant position. This would have been evident to anyone who followed the series of articles in EA from September to November '83, entitled "The inventive genius of Nikola Tesla". As indicated, DC gained a strong lead in the 1890's, before people like Tesla and Westinghouse intervened.

Destined to become a leading proponent of AC technology, Tesla was still a relatively unknown European student/engineer when, in 1879, the American inventor, Thomas Alva Edison, created a whole new scenario with the first really viable incandescent light bulb, using a carbonised filament.

The basic idea was also being investigated by Swan and others in the UK but, with access to better facilities, including vacuum and de-gassing equipment, Edison was able to work his way systematically through cotton, jute, bast, manilla and hemp fibres, before finally settling on bamboo threads as the most suitable source material for carbon filaments.

Electric lighting would no longer be dependent on the optically harsh and temperamental arc.

Realising that incandescent lamps could open the way to a share of the highly profitable lighting market, currently dominated by the gas industry, Edison immediately turned his attention to the ways and means of generating and distributing electricity to power them.

In September, 1882, he opened the Pearl Street (New York) steam driven power station, with 59 household subscribers, providing them with a 110V DC supply — the first of many such systems to be installed in major American cities.

This view shows the main DC sub-station in Clarence Street as it existed during the 1930s.

Renewed interest in AC

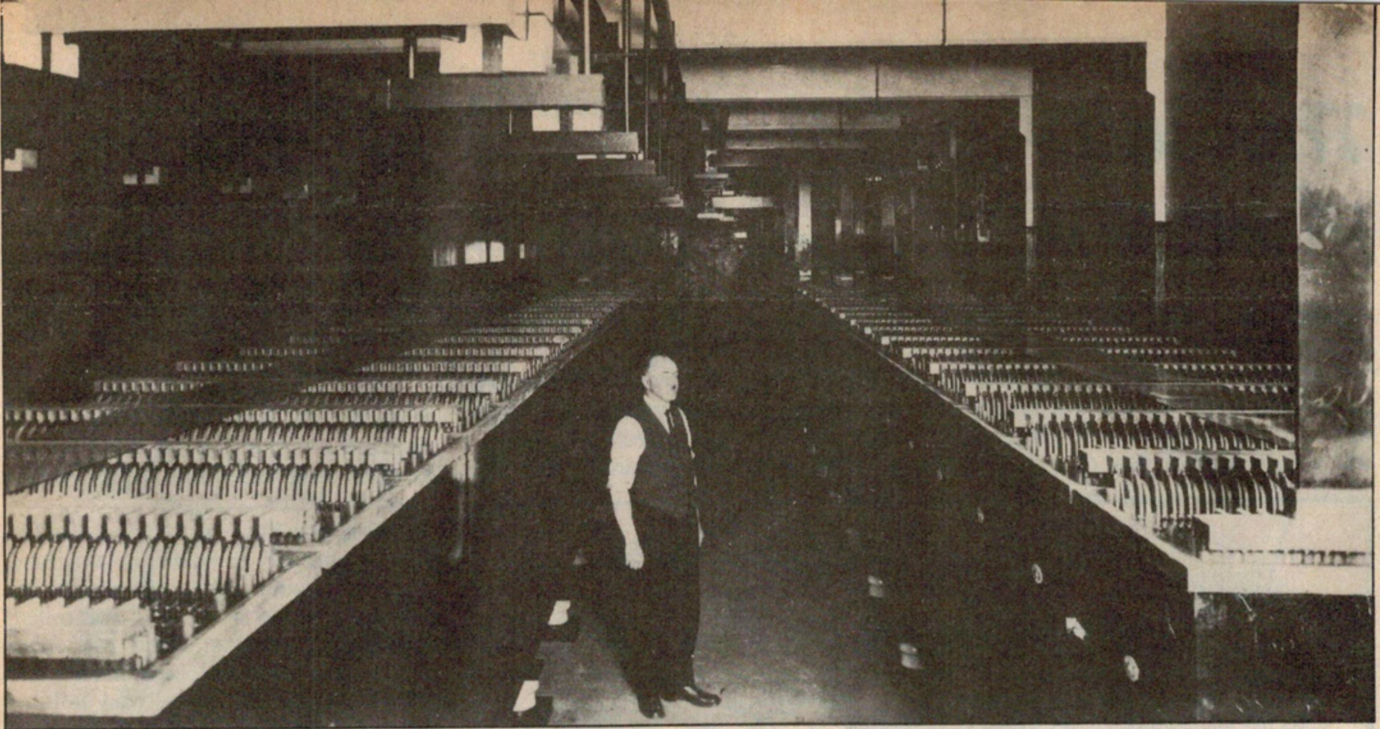
In the meantime, however, the Croatian-born Nikola Tesla had been patiently expanding the concept of AC-based (alternating current) electric power systems but, finding little support for his ideas in Europe, he sailed to America and secured a position with Edison. Perhaps not surprisingly, the association between the two was short-lived and Tesla was left to his own meagre resources.

Despite this initial setback, he managed to document and patent the essential features of a complete AC system in 1887, which duly came to the attention of George Westinghouse, inventor, industrialist and gas tycoon.

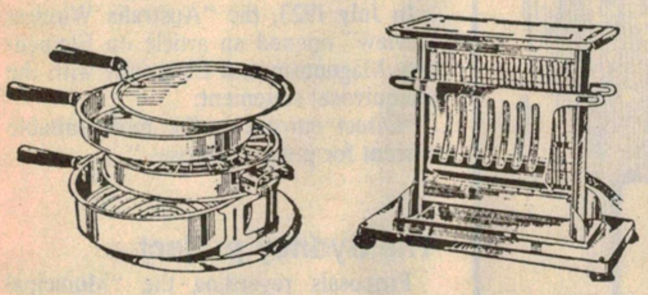
With an eye to the future, Westinghouse had just founded the Westinghouse Electric Company and had become personally intrigued by the idea of an AC-based supply, reticulated at high voltage (and low current) but with step-down transformers to serve local areas.

He forsaw that this would get around the line resistance problems which Edison was by then encountering, as his DC systems expanded, with anything up to 30V variations in the nominal 110V supply, depending on the load current and the consumer's remoteness from the power station.

Westinghouse signed a licence agreement with Tesla in 1888, causing Edison to resort to extravagant, even bizarre, propaganda intended to highlight the "dangers" of the AC system, in an unsuccessful effort to discredit the poten-



These battery banks were used to buffer load variations and occupied an entire floor of the sub-station.



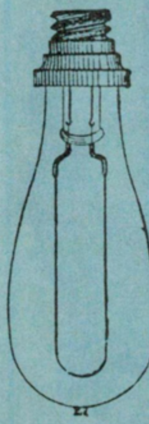
A "modern" electric griller and upright toaster, 1921 style, again normally suitable for use on either AC or DC.

How Edison lamps were made:

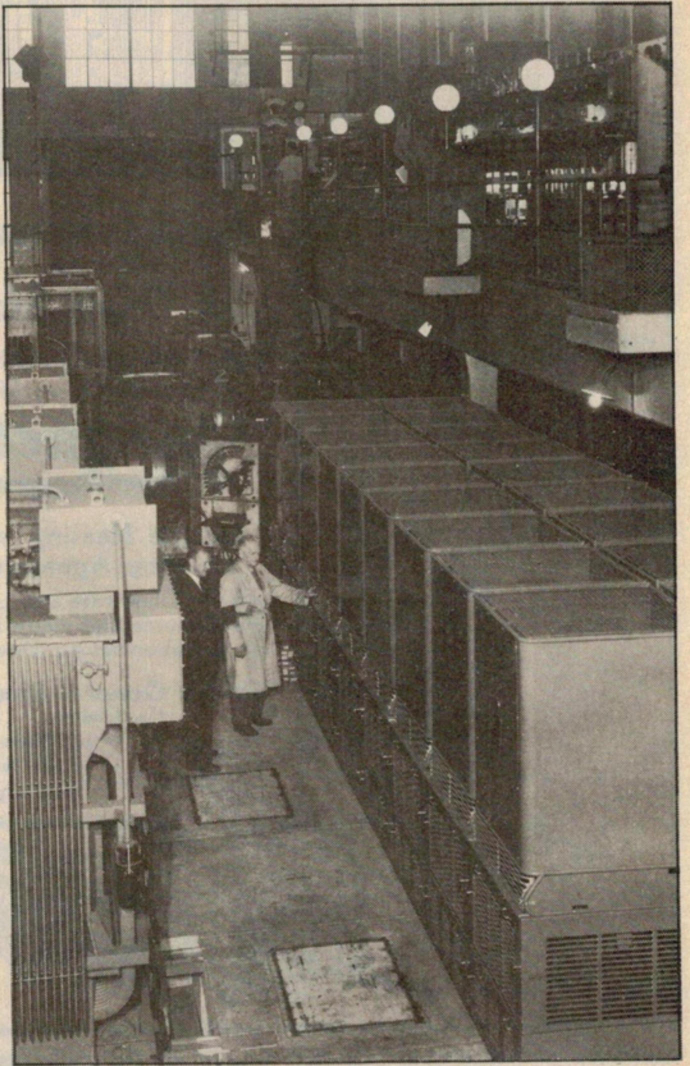
A bamboo rod is cut to the length required, divested of its hard soliceous coat, and split into six pieces, each one of which is reduced in thickness until its diameter is not much greater than a horsehair.

Each thread of bamboo is then placed in a mould formed by cutting a U-shaped depression in a plate of nickel, another plate of the same metal covering it over. The mould is then placed in a muffle, and is subjected to such a heat that the horseshoe shaped fibre is carbonised.

It is then placed in a glass bulb in connection with an air pump, the two ends of the horse-shoe carbon wire are fastened to platinum wires, which are sealed into the glass, and the ends of these wires form conductors for the electric current.



(From Cassell's "Science for All", published 100 years ago.)



These mercury arc rectifiers and transformers replaced the original motor-generator sets. Note the original switchboard on the upper gallery.

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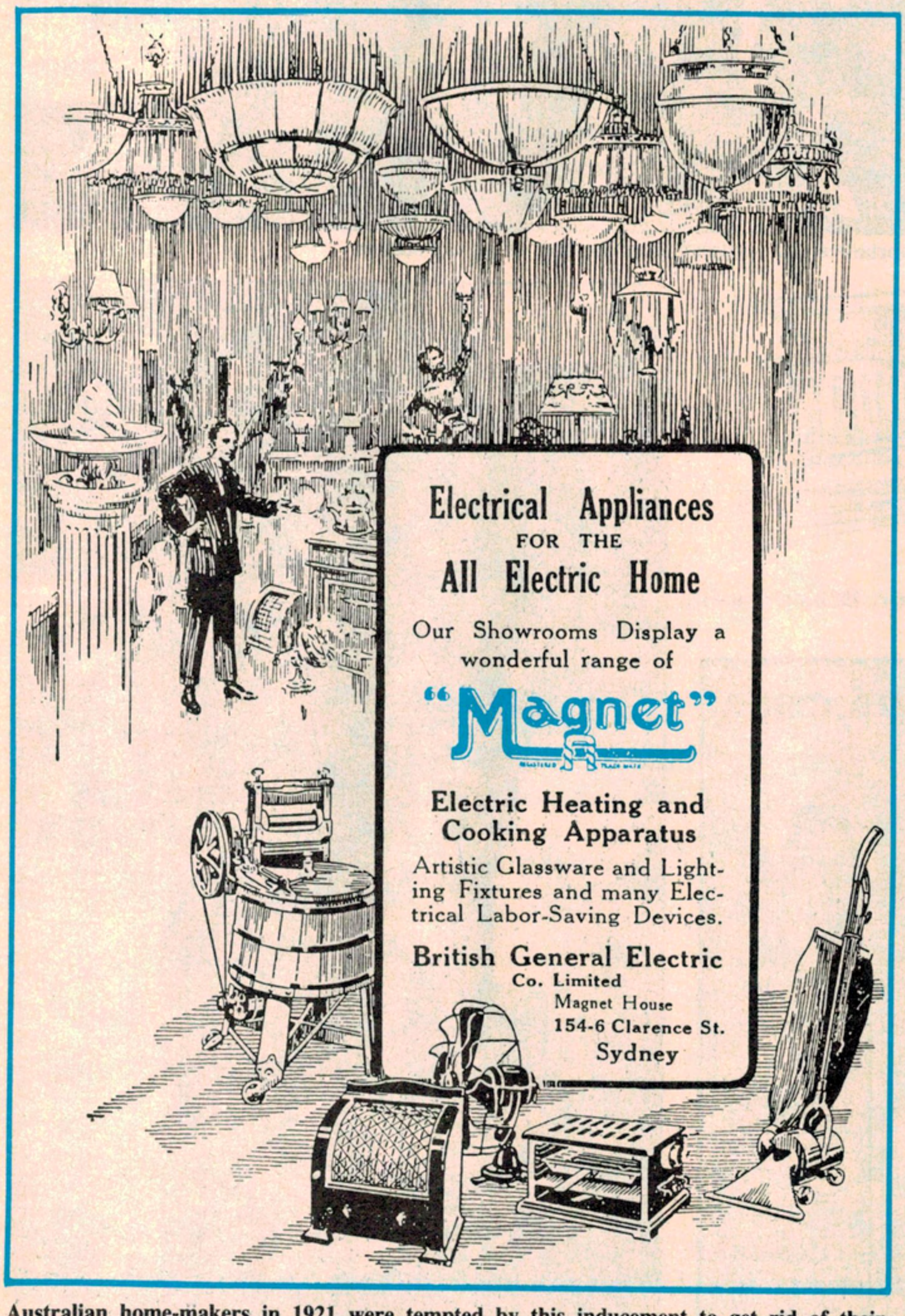
tial threat to his own DC technology.

Said Edison: "Just as certain as death, Westinghouse will kill a customer within six months after he puts in a system of any size. He has got a new thing and it will require a great deal of experimenting to get it working practically. It will never be free from danger".

AC on the move

In 1893, Westinghouse won a milestone contract to power the huge Columbian Exposition, which was to spread over an area of 16 hectares and consume more power, at the time, than the entire city of Chicago.

This was followed by contracts to harness energy from Niagara Falls with an ambitious AC hydro-electric system — contracts ultimately shared with the General Electric Company, which had reluctantly been forced to acknowledge the superiority of AC for the project.



Australian home-makers in 1921 were tempted by this inducement to get rid of their kerosene lamps, washtubs, wood fires and brooms, and to equip with the very latest in Magnet brand electric appliances, most of them AC/DC compatible. What, no radio, TV or hifi? (From "Sea, Land & Air" magazine).

AC technology was clearly on the march but, with many major centres in the USA, by this time, deeply involved with DC systems, there could be no abrupt turnabout and a mix of DC and AC mains was perpetuated way beyond the turn of the century.

In fact, even in the '30s and '40s, the ubiquitous RCA Receiving Tube Manuals were still carrying details of recommended valve types and typical designs for 117V AC/DC receivers.

Behind the lingering support for DC mains, especially in industrial situations, was the greater ease with which DC motors could be set up and controlled. Lighting and heating could use either source and electronic equipment, with its affinity for AC mains, did not become a consideration until at least the mid '20s.

In July 1923, the "Australia Wireless Review" opened an article on Elementary Magnetism and Electricity with the unequivocal statement:

"Direct current is the most suitable current for power purposes."

The Sydney project

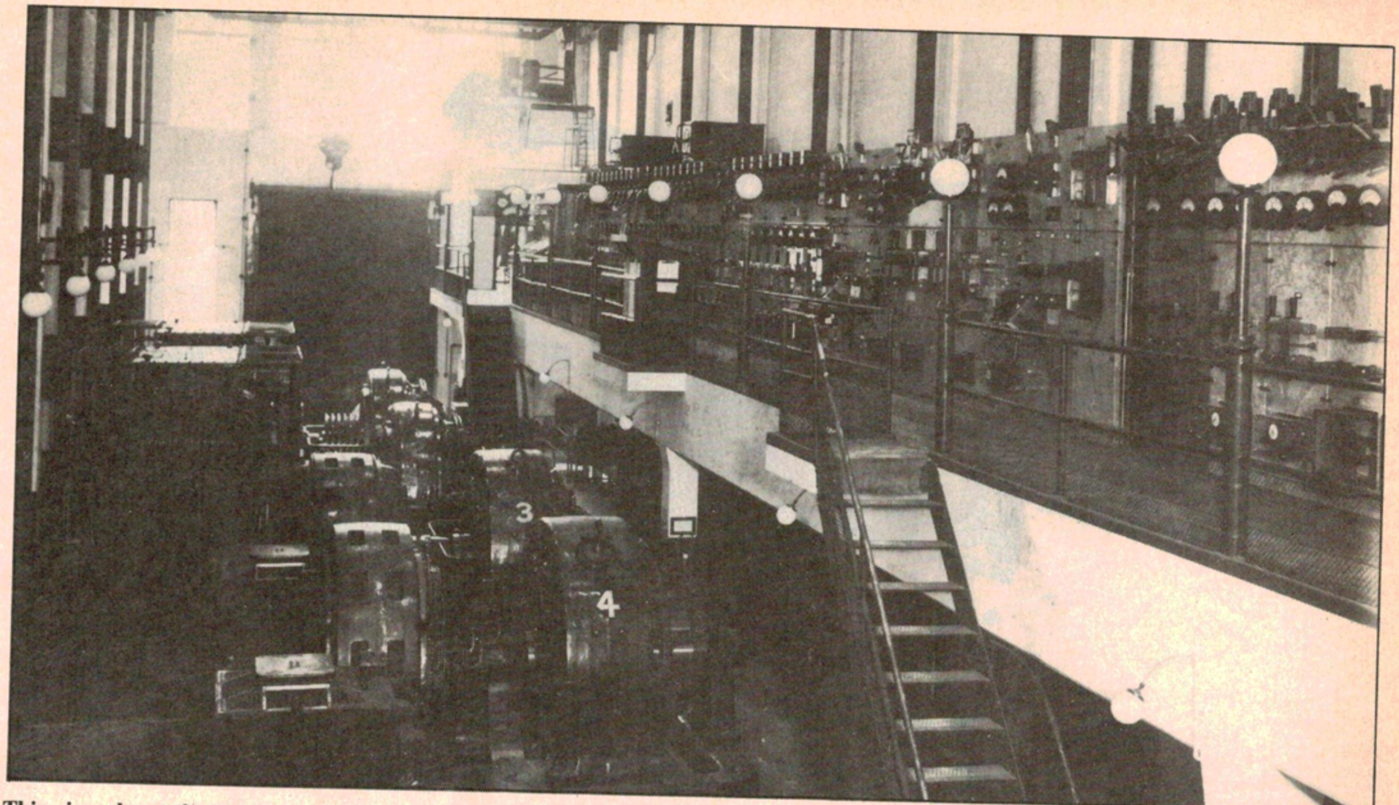
Proposals regarding the "Municipal Council of Sydney's Electricity Undertaking" extend back to the early 1880's — approximating the opening date of Edison's original Pearl Street power station.

The basic concept was to provide electric power for the central business area of Sydney — an area which involved a high concentration of commercial and industrial activities, with a potential role for electric motors powering everything from lifts and hoists to factory and workshop machinery.

So it was not surprising, when the worthy councillors sought the advice of Edison, Swan (by then, his British associate) and others, that they should decide in favour of an Edison style, 3-wire DC system.

However, to minimise the effects of mains resistance, they selected a higher voltage: +240V and −240V relative to a common earth return conductor. Subscribers could be connected to one pair of mains for a 240V DC supply, or have access to the full 480V DC for high-power requirements.

The system became a reality in July of 1904, with electric street lights operating from a power station in nearby Pyrmont. And, as planned, the DC mains soon



This view shows the original motor-generator sets in the Clarence Street sub-station, before their replacement by the mercury arc rectifiers and transformers.

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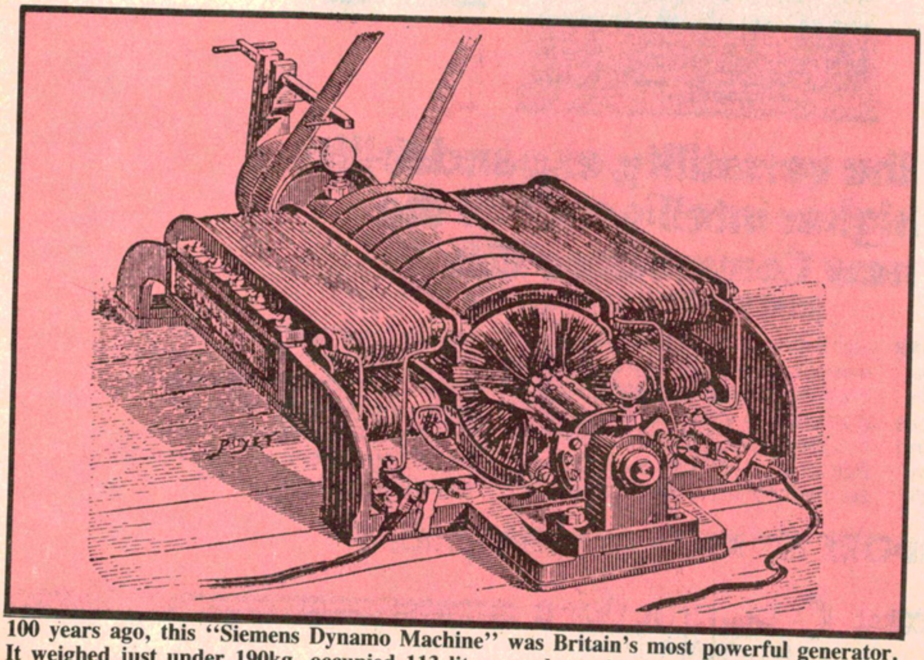
found their way into commercial and factory premises throughout the central business area.

In due course, as the versatility and economy of the AC system became more apparent, the DC system was deliberately restricted to the central business area, and subsequent expansion, in both service and generating capacity, was confined to AC technology.

Then, as increasing AC resources became available, the job of supplying the inner city DC network was taken over by a network of regional sub-stations equipped with large rotary converters — single rotor machines driven by AC from distant power stations and delivering DC to the local mains.



100 years ago, this "Siemens Dynamo Machine" was Britain's most powerful generator. It weighed just under 190kg, occupied 113 litres, and provided the Lizard lighthouse in Cornwall with a 3,620 candlepower etc.

Typical DC sub-station

The 0.5 megawatt rotary converters were designed to produce ±250V DC (or 500V) overall at up to 1000A apiece. Across the line was a huge bank of storage cells, each cell measuring about one cubic metre, with the battery bank occupying a complete floor of the large sub-station. By day it would buffer variations in the load; late at night, the rotary equipment would often be shut down.

The basic converter and battery system was designed to feed 250V DC to each line, allowing a 10V margin for voltage drop.

However, associated with the main supply were special "buck and boost" rotary converters, capable of delivering ±10V at up to 1000A each. By controlling the field system current and polarity, the output could be added to or subtracted from the line voltage, to maintain it at 250V under a variety of load conditions.

With the emergence of high power

electronic technology, the rotary machinery and batteries were, in turn, replaced by special transformers providing 12-phase AC input to multi-anode mercury arc rectifiers which, with resonant filters, could produce relatively clean DC.

As a consumer . . .

I knew nothing of all this when, fresh from the country, I obtained my first job as an assembler and wirer with Reliance Radio. It was a new venture — I was their first bench-hand — set up in an old building, demolished later to make way for the AWA head office in York Street.

My introduction to DC mains came when I was shown the ancient wiring and power points and warned that, on no account, was any ordinary radio or test equipment to be plugged into them. The result would be blown fuses and/or a blown power transformer and a very angry employer!

I was then taken down into a dungeon-like basement and shown a small rotary converter whining away in the gloom and turning DC mains power into 240V AC at 50Hz. I was to learn later that both figures were approximate only and that just so many receivers could be tested or demonstrated at the one time.

Even at best, radio reception still had its problems, arising partly from hash produced by the converter itself and partly from the horrendous interference level on the DC mains. After all, every single motor on the mains used a commutator and, fifty years ago, sensitivity about hash suppression was not all that evident.

A rather more dramatic introduction to DC mains followed a few days later, when one of the overhead light globes failed. It was a fairly large globe — about 150W — hung from a porcelain "rose" on the wooden ceiling by a metre or so of twisted, cotton-covered rubber flex.

As the filament parted, it set up an arc between the support wires, which proceeded to track up through the glass base into the bayonet holder, then through that to the flex, thereafter heading up towards the wooden ceiling like a miniature fireball. That was when somebody hit the switch.

I had seen for myself the ability of DC mains to maintain an arc, once started.

Tea . . . DC style

But that wasn't quite as salutory as the experience of a fellow wirer who attempted, one day, to "boil a billy" using an "immersion heater" — a spiral tube with an internally insulated element, fitted with a couple of metres of twin lamp flex and a bayonet adaptor, and plugged into a lamp socket.

Why would anyone be using such a potentially hazardous contrivance?

This was fifty years ago, remember, when a large proportion of suburban homes had two power points, at most, which could be English style 3-pin round, 2-pin round, American 2-pin flat or even the new fangled Australian 3-pin flat! Any number of gadgets, including the new radio set could end up being plugged into a lamp socket with a little help from a 2-way bayonet adaptor.

Indeed, the men delivering and installing new radio sets encouraged us to despatch them with unterminated power leads, so that they could more easily fit whatever plug proved necessary on arrival. So there was nothing startling about the immersion heater.

The trouble was that the would-be tea maker forgot about the DC supply and simply unplugged the bayonet adaptor with the power still switched on. There was a sizzle and an arc, and he ended up with a handful of fire and smoke!

Somewhat more bizarre was the tale, related to me recently by an engineer friend, concerning a group of tea makers in a small city office, set up by the electronics company from which he recently retired.

They equipped themselves with an electric jug of now unremembered vintage, with an ordinary open element. It worked apparently normally on the DC mains but, in rather short order, they all went down with some mysterious malady. It was ultimately traced, he said, to a toxic effect caused by a product of electrolysis, resulting from the DC supply.

It was a new one on me!

AC/DC receivers

But my pet hate was undoubtedly DC or AC/DC receivers, for the most part made and sold for use in the adjacent central city area. It generally fell to my lot to test and/or service them.

Being designed to operate without a mains power transformer, there had to be a direct conductive path between the mains and the internal signal circuitry. Even the normally innocuous valve heater wiring was "live", being a series string fed directly from the mains through a large and very hot resistor or a current regulator (barretter) tube.

In some models, the chassis was also "live"; in others, it was connected to the mains through a bypass capacitor of $0.1\mu F$ more. And, when operating from earth-positive DC mains, all the normally "earthy" circuitry had to be at −250V for the receiver to operate!

The owners of these rather unpleasant receivers were suitably isolated from them by all-round cabinet work and an interlocking mains plug, but technicians and servicemen had no such protection.

DC or AC/DC receivers designed for 117V mains weren't so bad, because the voltages were modest and the heater series resistor commonly of low enough value and wattage to be incorporated in the mains power cord. But whereas an accident with 117V can be embarrassing and unpleasant, a similar inadvertence with 240V could be decidedly fatal!

It was a fate that I managed to avoid but I was not the least bit sorry to read that, as a guest of the present Sydney City Council, Mrs Lorraine Ashby had switched off that longstanding reason to perpetuate transformerless radio sets — one that had been activated, 81 years earlier by her grandmother, Lady Mayoress Amy Sarah Lees!

Have former customers of the SCC been left lamenting? Not really; the phasing out process has been quite gradual and, with today's technology, there is no special problem for a customer who still needs DC, to produce it on the spot from polyphase AC.

I am indebted to a former EA staff member, Norman Marks, for his recollections of the Kent/Clarence St, DC sub-station, in which he served part of his apprenticeship in 1944.

Electric lighting in the UK

The principle public installations of the incandescent system in this country have been in the Savoy Theatre, London, which is entirely lighted by Swan lamps; at the International Fisheries Exhibition, 1883, where more than one thousand were seen on one circuit; at Holborn Viaduct, which thoroughfare, with houses adjoining, has been lighted by Edison's lamps; and at the Electrical Exhibition at the Crystal palace, where the suitability of the system for both public and private use was most successfully demonstrated. To Edison must always attach the credit of having been the first to serve entire streets with a supply of electricity in lieu of gas.

(From "Science for All" published 100 years ago by Cassell & Co Ltd, London).