WHAT'S IN A NAME

PART 4

Credit Where It's Due

by Greg Grant

" . . . Come sir, credit where it's due; most of the glory goes to YOU. . . " sang Colonel Pickering in 'My Fair Lady'. In the previous essay in this series, however, matters were frequently somewhat different.

Lingering in the background throughout the piece was the problem of litigation and the hassle such action causes. Did this help or hinder either technical progress or the fame and fortune of the individual inventors involved? In general, it seems, such matters tended to be governed by the choice of one's employer.

Meissner, Hartley, Round, Colpitts and Franklin all worked for what were undoubtedly the big battalions, such as Marconi, Bell Laboratories and Telefunken. All of these men were prolific inventors and all were credited with the inventions they made in the majority of cases, although the patents were usually held by the company. That meant that they could be defended vigorously – and usually were – when they needed to be.

How successful these companies were, and how well rewarded the individuals felt, can be judged from the fact that all of the former are still very much in business today and where the latter are concerned, a Meissner or Hartley oscillator remains just that.

Going it Alone

Edwin Armstrong and Lee de Forest, on the other hand, were classic loners, subjected to litigative challenges throughout much of their working lives.

Where the company men had their discoveries named after them, the loners – ironically – are remembered, if at all, by *what* they invented, such as the Triode Valve and the 'Superhet' receiver. No hint of whose brainchild it was at all!

It's easy to understand from this why certain men develop conspiracy theories, the belief, for example, that the legal profession – a field rotten with the restrictive practices it so condemns in others – would reason that challenging an individual would mean but one thing: a killing for lawyers, whatever the outcome. Armstrong, for example, seems to have been prone to such ideas.

Mix and Match

Yet there was – indeed still is – a third way of working as an inventor which, to my mind, gives more satisfaction perhaps than industry on its own and far less hassle than that suffered by the lone developer. It could be called 'Mix and Match', and consists of moving seamlessly between industry on the one hand and academe on the other. Two distinguished names in electronics did exactly this for most of their working lives, with great success.

Cause and Effect

The Swiss-German electronics engineer, Walter Schottky and the American electronic physicist, Clarence Zener, gave their names to both a Device and an Effect. Where the latter, ultimately, settled for academe, the former, eventually, decided on industry.

Born in Vincennes, Indiana, in 1905, Zener is one of those astonishing individuals who has mixed and matched for most of his lengthy and busy life.

He joined Westinghouse Research Laboratories in 1951, becoming their Director of Science before returning to academic life 15 years later, firstly as Dean of Scientific Research at Texas A&M University and then as Professor of Science at the Carnegie-Mellon University in Pittsburg.

At the latter, he became deeply interested in solar power, although he is universally known for his investigation of the diode called after him. Figure 1 shows the reverse voltage aspect of the Zener diode.

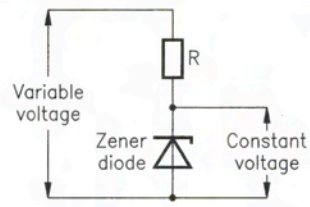


Figure 2. A practical voltage stabiliser circuit using a Zener diode.

Between points **A** and **B**, the current increases considerably. However, observe the voltage: it has increased hardly at all. This means that the Zener diode can maintain a voltage at a steady level despite increasing, or varying, levels of circuit current. In a word, it *stabilises* the voltage.

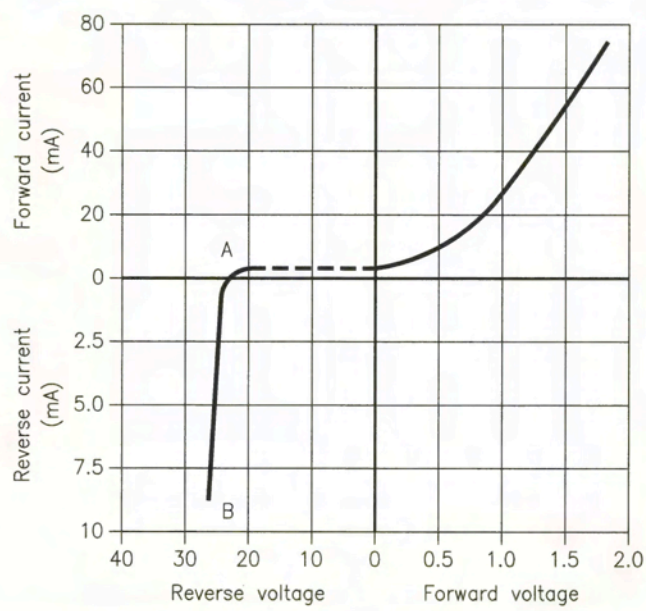
Figure 2 is a simplified, practical electronic circuit diagram of a voltage regulator or stabiliser board. Such circuits are near-universally used in modern communications equipment, electronic navigational aids for civil and military aircraft, many electronic measuring and control devices and, naturally, in that ubiquitous electronic totem of our time, the computer. The resistor **R** limits the reverse current through the diode to a safe level.

Avalanche!

Science and Technology, of course, are subject to advances and further developments in a manner all other fields are not, and so presently, the Zener Effect is thought to be due to Townsend Discharge rather than Zener current. Consequently, the device is also known as an Avalanche or Breakdown diode.

Townsend Avalanche, named after the British physicist, Sir John Townsend, is a multiplication process where a single charged particle, accelerated by a strong electrostatic field causes, through collision, a considerable increase in ionised particles. Townsend was the first scientist to calculate the charge on a single gaseous ion as far back as 1897, in the course of a most significant contribution to the theory of ionised gases.

Figure 1. The reverse voltage aspect of a Zener diode.



Schottky – The Noise Expert

Like Clarence Zener, the Swiss-German electronics engineer, Walter Schottky (1886-1976), has given his name to both a device and an effect. Like Zener too, he moved effortlessly between industry and academe, finally settling on the former.

The son of a university mathematics lecturer, Schottky graduated with a Ph.D from Berlin's Humboldt University in 1912. Two years later, he joined Siemens Research Laboratories and began working on the problem of noise in valve amplifiers.

At this time, a number of electronics engineers worldwide were attempting to improve valve manufacture, the better to ascertain the true parameters, and therefore, performance, of these devices. Many concentrated on such matters as improving the internal structure and its welding, whilst others concentrated on improving the vacuum by developing better vacuum pumps, which had hardly improved since Johann Geissler had invented the first effective modern pump in 1855.

Whilst he could see that such work could be very valuable, Schottky concentrated on the physics of noise, concluding that there were, in effect, two fundamental noise sources in valve amplifiers.

Firstly, there was the input circuit noise caused by random molecular movement in the wires and components, today known as Thermal Noise, and secondly, the noise caused by the valve itself, in particular, the random nature of the electron emission from the cathode and the differing velocities of these liberated electrons, now known as Shot Noise.

The current, i.e. the electrons, emitted or 'boiled off' from a valve's cathode depends in part on the cathode material's Work Function, in other words, the MINIMUM energy needed to transfer an electron from within the material to a point just outside the material's surface.

This is shown in Figure 3, where the cathode surface can be regarded as a 'Junction' between two dissimilar 'Substances', i.e., the metal and the vacuum.

In the course of his research, Schottky found that the Work Function could be reduced from its normal value as a result of the electric field at the cathode and the presence of image forces. This discovery is known as the Schottky Effect.

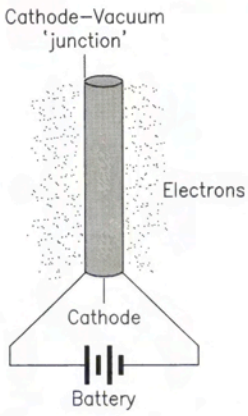


Figure 3. The cathode of a radio valve. The glass envelope has been omitted for clarity.

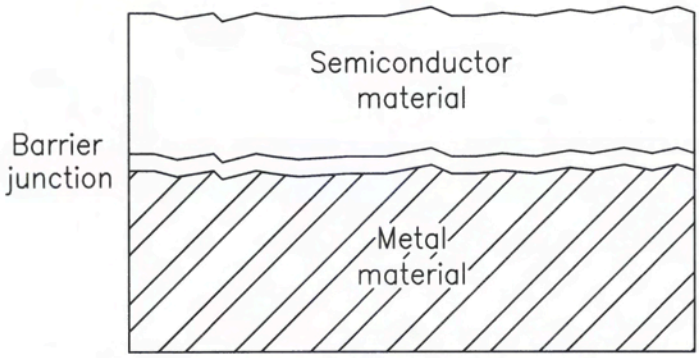


Figure 4. Diagram of a Schottky diode's construction. The barrier has been enlarged for clarity.

Three years after publishing his now-classic paper on noise in 1918, Schottky's colleague, C. A. Hartman carried out the earliest experiment to identify and measure Shot Noise.

In 1924, Schottky and Erwin Gerlach invented the Ribbon Microphone and its complement, the Ribbon Loudspeaker. Shortly, however, Schottky turned his formidable mind to semiconductors, in particular, metal-semiconductor devices, which were in fairly common use in radio engineering at this time.

After extensive research, Schottky published his Schottky Diffusion Theory of Current Flow in semiconductor diodes, from which, present-day understanding of such devices grew. Consequently, these devices are known among electronics engineers and technicians as Schottky diodes. Moreover, his Effect applied equally well to semiconductors as it did to thermionic valves.

If, as shown in Figure 4, we look on the metal-semiconductor junction as being essentially similar to the metal-vacuum 'junction' of a valve, the 'Barrier Lowering' in this case, whilst less than the reduction in Work Function in the valve example, nevertheless shows that the Schottky Effect is even more striking.

When Transistor-Transistor-Logic (TTL) was developed in the early 1960s, greatly speeding up computer operations, the principal component in this development was the Schottky Diode, which gave the computer industry Schottky TTL.

By *any* standards, it was a stunning achievement to have made outstanding contributions to both vacuum and semiconductor electronics. It was even more so to have influenced computer circuitry.

Wheatstone's Bridge?

Another brilliant individual who moved between his own companies and the academic world of his day – in his case the Professorship of Experimental Philosophy at King's College London – was Charles Wheatstone, whom we've already met.

Among his many other achievements, he initiated the use of electromagnets in electric generators and invented the Playfair Cypher. He was also one of the first British scientists to recognise the importance of Ohm's Law. Although his honours and awards were such that they supposedly filled a cubic-capacity trunk, he held one distinction he not only didn't earn, but in fact, did everything possible to ensure that its originator received the credit for. You see, the one device Charles Wheatstone did NOT invent was the Wheatstone Bridge.

In 1833, the British mathematician, Samuel Hunter Christie, developed the 'Bridge' principle of measuring resistance. A decade or so later, Wheatstone concluded that electrical measurement had to be put on a far firmer footing, especially the fundamental units of current, resistance and voltage.

Using Georg Ohm's recent development, Wheatstone made a standard resistance and created his own measurement units. In the course of this work, he also made use of Christie's 'Bridge' technique, illustrated in Figure 5, and gave Christie full credit for his invention.

Despite this endorsement, the sort *any* inventor would have been delighted with coming, as it did, from one of the greatest scientists of the day, it was Wheatstone's name that prevailed. And to this day, it still does, by and large. Why?

Well, authoritative works like the *Encyclopedia Britannica* certainly don't help. Even in its latest edition, it continues to perpetrate the myth in, it has to be said, a somewhat sly way. This reference work's view of the affair is that Wheatstone manufactured the bridge at Christie's instigation and then popularised its use.

That smacks not so much of hedging your bets, more of avoiding litigation! ELECTRONICS

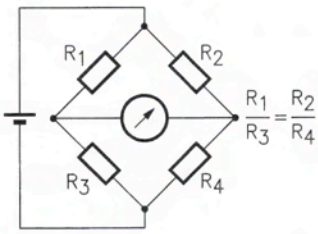


Figure 5. Christie's 'Bridge' technique for measuring resistance.