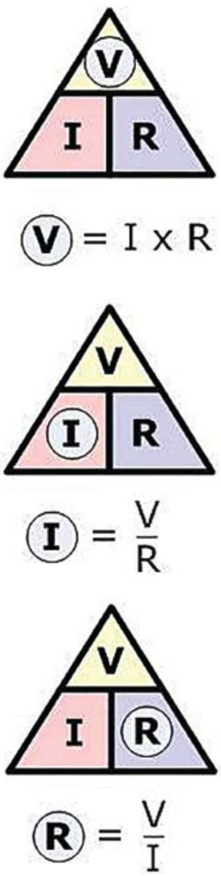
THIS IS THE EIGHTH IN A SERIES OF ARTICLES THAT EXPLORE THE HISTORY OF SCIENCE AND ENGINEERING.

One way in which this history has been preserved is in the names of the scientific units that we commonly use. Those units will serve as starting points for these articles as we explore "Why do we call it a...?"

OHMS LAW DIAGRAM



WHY DO WE CALL IT AN...

OHM

By: ***Lyle D. Feisel**, Ph.D., P.E. (Ret.), Iowa Alpha '61*

When you first started to learn about electricity, what was the first law or equation you encountered? If I were a gambling man, I would wager that it was Ohm's Law. This is a simple equation that says the voltage across a resistor, measured in volts, is equal to the current through the resistor, measured in amperes, times the resistance of the resistor, measured in ohms. Resistance is determined from the dimensions of the resistor and the resistivity of the material from which it is made.

As we see it today, Ohm's Law is a straightforward linear relationship, about as simple as you can get. There were, however, some tortuous twists and turns in the development of that equation and there were, at first, much more complicated versions. The driver — I almost said "conductor" — through this complex journey was the German physicist Georg Ohm (1789-1854), for whom, obviously, the unit of resistance is named. And no, that's not a misprint; Georg is not supposed to have an *e* on the end.

Georg Simon Ohm was born on 16 March, 1789, in Erlangen in the Kingdom of Bavaria, which is now a part of Germany. Ohm's father, Johann, was a locksmith and apparently had acquired a reasonably good education by essentially educating himself. He provided a basic background in science and philosophy for his children, enough for Georg to enroll in the Erlangen Gymnasium or high school where, apparently, the addition to his education was minimal. The city was then, and is now, a college town and in 1805, at the age of 16, Ohm matriculated in Erlangen University. His tenure at the university was brief and inglorious, lasting only three semesters. According to one account, his time there was devoted more to dancing, billiards, and ice skating (!) than the pursuit of knowledge, and his father said, "Enough is enough. Out you go." Of course, he said it in German.

While Ohm may not have been a sterling student, he acquired enough knowledge — or at least the credentials — to qualify him for a job teaching at a school in Switzerland where he started in 1806. He spent five years in Switzerland, teaching at the school and as a private tutor, and then returned to Erlangen University. Apparently, Ohm had spent his spare time in Switzerland studying the writings of the leading scientists of the day. In so doing, he learned enough that he was able, in short order, to pass the appropriate examinations and be awarded the Doctor of Philosophy degree.

Then, as now, the Ph.D. degree was the ticket to a university teaching position. It didn't seem to work for Ohm, however, and while he tried to get a job in a university, he was destined to spend some twenty years teaching at lesser institutions such as high schools and the German military school. He was fortunate, however, in that one of these schools, the Jesuit Gymnasium in Cologne where he taught from 1818-26, had excellent laboratory facilities. It was here where Ohm did much of his important experimental work and began publishing his results.

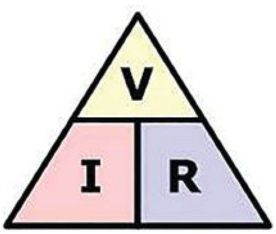
It is interesting to look at the state of knowledge of electricity and magnetism during this period. Prior to 1800, all experiments had been conducted using static electricity. The concept of electric current — a constant flow of electrical "fluid" — did not exist until Alessandro Volta invented the pile or battery in 1800. And while many scientists believed there was some relationship between electricity and magnetism, the effect of electromagnetism was not observed until 1820. Finally, the phenomenon of thermoelectricity —the generation of an electric current when a junction of two dissimilar metals is heated — was first reported in 1822. What was *not* known, at least not in a quantitative sense, was how an external circuit affected the output of a source of electricity. Ohm, as much a mathematician as a physicist, set out to explore that relationship and express it mathematically.

When talking about the challenges faced by our scientific forerunners, I often say something like, "They couldn't just go to the laboratory and pull a voltmeter and an ammeter off the shelf." Well, it turns out that in, say, 1822, that wasn't strictly the case. A good laboratory would have an electroscope; this was a device that consisted of two pith balls or two gold leaves that repelled each other and deflected when attached to a source of charge. The amount of deflection was a measure of the electric potential (voltage) of that source. The lab would also have what later became known as a galvanometer, a device that measured the force exerted on a magnet by a coil of wire connected to an electrical source. The force, of course, was proportional to what we now call current. Voila! A voltmeter (sort of) and an ammeter (sort of).

For Ohm's primary and most famous experiment, all he really needed was a voltaic pile, some kind of galvanometer, and a coil of wire. Using the galvanometer, he established a base force (current) by essentially shorting the battery with a heavy wire. That current would have been determined by what we now call the internal resistance of the battery. He then inserted into the circuit thin wires (0.025" diameter) of varying length and measured the *reduction* in force as the wire length was increased. When these data were plotted, they produced a curve that Ohm roughly approximated with this equation:

$$V = K\log(1+x)$$

where V is the reduction in force (i.e., current, I continue to remind you), K is a constant, and x is the length of the wire in the circuit. This, then, was the original version of Ohm's Law. Obviously, this is not the Ohm's Law we have come to know and love, but it was the best description of the state of knowledge at the time.



Ohms Law Diagram

In 1827, Ohm took leave from the gymnasium in Cologne and spent a year in Berlin. There he wrote his *magnum opus*, "Mathematical Consideration of The Galvanic Circuit." This very mathematical treatise (available on Google Books) presents both mathematical and descriptive discussions of electric circuits. In it, Ohm reworks some of his earlier data and derives the equation, V=IR, that we know so well.

One would think that such a simple result would have been accepted and, indeed, celebrated. Such was not the case, however. Ohm had his detractors and was subjected to various degrees of criticism and contumely before he and his work were formally recognized. Indeed, ever since he received his Ph.D. in 1811, he sought appointment as a professor in a recognized university but remained frustrated. He achieved some measure of success in 1833 when he joined the faculty of the Technische Hochschule in Nuremburg; still not a university, but much more prestigious than his previous appointments. The institution is now named the Nuremburg Institute of Technology Georg Simon Ohm. Its logo, fittingly, is the Greek letter Ω, which is, of course, the symbol for the ohm, the SI unit of resistance.

While at Nuremburg, Ohm finally received the honors he sought and deserved. He was awarded the Copley Medal from the Royal Society of London and was made a corresponding member of the academies of Berlin, Turin, and Bavaria.

Finally, in 1849, Ohm was appointed Full Professor at the University of Munich where he remained until he died on 6 July, 1854. While many scientists of the 19th century sensed that there was a relationship between electric tension (voltage) and force (current), it was Georg Simon Ohm who, through reason, experiment, and mathematical analysis, determined the details of that relationship. And that's why we call an ohm an ohm.