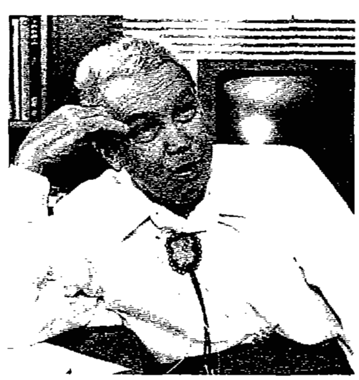
So what's to be done about it? One solution is to turn the computer into the asset it could become for attracting students to the study of electromagnetics by using it to provide a more insightful learning environment. This can be accomplished in two, related ways. First, the computer provides a problem-solving tool that yields essentially exact solutions to problems that were heretofore either not solveable, or only approximately solveable after lengthy mathematical manipulation. Second, even after solutions have been obtained, they may not lead to understanding the basic physical phenomana involved unless they can be appropriately visualized, which is where computer graphics can become invaluable. Either of these two possibilities alone could be significant, but taken together they promise exciting future prospects for the study of electromagnetics.

Computers have been making their way into education for the past twenty years or so. At first, their use was confined largely to the computations involved in thesis or other research. Later they were introduced into the undergraduate curriculum, and it has now become common for engineering majors to be required to take a programming course for graduation. At some schools, computers are being used in a more integrated and central way. For example, Peter Barber of Clarkson College has informed me that he has been teaching freshmen the Method of Moments. And Warren Stutzman of Virginia Polytechnic Institute reports that graphics-based computer teaching aids are being developed for the College of Engineering there. I am sure there are many other examples of computers and graphics finding their way into teaching. Please let me know of your activities or others that your are aware of in this area.

However computers are now being used in education, it seems certain that they will attain a more central role in the future. By combining the problem-solving and graphics capabilities of computers, it will be possible to develop intriguing new ways to teach abstract topics like electromagnetics, as well as to make other "more-down-to-earth" subjects more interesting too. For example, by giving a student real-time access to solutions and their graphical representations, it will be feasible to perform "computer experiments" which are more accurate and more complete than their real-life experimental counterparts. For simpler problems, the computations can be performed as needed, the scope of which will surely grow as computer technology continues to improve. Where the problems are more complex, the solutions can be stored using media such as floppy discs, hard disks, video tape, magnetic-video disks and laser-video disks. The computer can then be used to control the graphics display and to create an interactive environment for the student to ask "what if?" questions. To be most effective, this kind of learning aid will require not only solutions and graphic displays, but well-designed software to control the interaction process. Examples of this kind of approach can already be found, ranging from interactive-video tape and laser disks to real-time computations. I'll try to provide some examples in the next column.

I'll conclude by noting that this column has been typed using my new "Fat Mac" computer. This is my first experience with using computerized word processing, and I am finding it most enjoyable. Especially jazzy is the fact that I can change type size, font and style as well as the layout format. In the next column, I will also plan on providing further information on MacIntosh applications.

In Memory of Carl A. Wiley



Carl Atwood Wiley was born on December 30th, 1918, in Scranton, Pennsylvania. He died peacefully on April 20th, 1985, at his home in Westchester, California, from the ravages of a pulmonary disease for which no cure could be found and for which no certain diagnosis could be made.

Carl Wiley was perhaps better known to members of the IEEE Aerospace and Electronic Systems Society than to those of the Antennas and Propagation Society for his invention of what we now call Synthetic Aperture Radar (SAR). The patent he obtained, number 3,196,436 dated July 20th, 1965, bore the title "Pulsed Doppler Radar Methods and Means", and it showed no prior art. Carl, himself, did not refer to it as Synthetic Aperture Radar, but rather as Doppler Radar Beam Sharpening. The first such airborne radar, called DOUSER, was built and flight tested at Goodyear, Arizona in the years 1952-1953. If the late date on the patent seems surprising there is a good reason: the patent action was initially filed on August 13th, 1954 but it was placed under secrecy order number 449,559 on June 1st, 1955. The order remained in effect for ten years before the patent was actually granted on July 20th, 1965.

Continued on the following page.

Carl grew up in the stimulating atmosphere of a university town, Princeton, N.J., and he often remarked about the excellent library facilities there available to him. Very likely that early exposure had much to do with the shaping of his education for he became a voracious reader who delved into many areas of scientific thought, becoming expertly self-taught in physics as well as electrical and electronic engineering and allied disciplines, and acquiring a respectable knowledge in more remote fields such as crystallography and biology, to name just two. His formal education led him to the BS degree in Mathematics from Antioch College in White Sulphur Springs, Ohio in 1944 and he followed this with graduate course work through the Ohio State University Extension Program at Wright Field, Dayton, Ohio during the years 1946 to 1949. From 1941 to 1949 Carl rose from engineer in the Radio Direction Finding and Antenna Groups to become Section Chief of the Research Advancement Unit of the Air Force Aircraft Radiation Laboratory at Wright Field. It was there, in 1942, that he discovered the piezo-electric effect in barium titanate and observed that its dielectric constant was a function of DC bias. Incredibly, the laboratory director refused to file a patent claim on the former effect, but Carl did obtain a patent in 1949 dealing with oscillator tuning control using DC-biased, barium titanate capacitors. Much later, in 1956, the U.S. Government brought suit against two electronics companies who were making commercial use of barium titanate's piezo-electric properties. Eventually, in 1957, the government obtained a royalty-free license to use $BaTiO_4$ transducers (which by then had been patented by the commercial companies) and Carl was awarded what is known as a "junior patent position" for the work he had originally done in 1942.

Carl's horizons were indeed broad. During the last year of his terminal illness he worked to bring together ideas which had been in the back of his mind for something like thirty years; they concerned particle physics. I can vividly remember his excitement when he talked about this abstruse work and how he was convinced that his theory explained what physicists call vacuum-point scintillation and how it predicted the remarkable symmetry properties of those fundamental particle building blocks that are whimsically called quarks. His interest in particle physics and quantum mechanics must have been whetted at least as long ago as 1950, for it was in that year that he wrote an article for a popular science fiction magazine under the pseudonym Russell Saunders. Physicists will quickly see the hidden meaning, but for electrical engineers an explanation is in order. Russell-Saunders coupling is an interaction between the resultant orbital angular momentum of nuclear particles and their resultant spin. Thus, it differs from j-j coupling (j being the angular momentum quantum number) which is an interaction between the total angular momenta (orbital plus spin) of the individual particles. I am almost certain that Carl chose this esoteric pseudonym in emulation of a scientist-engineer whom he greatly admired, John R. Pierce of Bell Laboratories (now at Cal Tech) who himself had written science fiction using the name J. J. Coupling.

Carl's magazine article was not fiction; it was a sober and scientific analysis of sailing in space using solar radiation pressure as the drive. His original title was "Are the Clipper Ships Gone Forever?" When the article appeared in the May 1951 issue of Astounding Science Fiction Stories the title had been changed to "Clipper Ships of Space". What Carl showed was that it is possible, in the true sense of the word, to sail in space, to tack and to perform all maneuvers necessary to the making of a round trip to some point in the solar system. He chose the planet Mercury as an example. He knew that a "keel" was necessary, otherwise it would be possible only to "run before the wind", and he showed that the equivalent of the keel is the gravitational force of the sun or one of the planets. He also wrote "---as long as the ship experiences only central forces such as are produced by the gravitational field of the sun and the radiation from the sun, it will be unable to change its angular momentum. This is necessary if the ship is to arrive at the location of a planet with the same velocity as that possessed by the planet. Therefore, the ship must make a close approach to either the terminal planet or some other planet in order to change its angular momentum to the correct value required in order to reach the terminal planet with a velocity matched to that of the planet." He went on to give an example of how Venus can be reached from Earth by first making a hyperbolic passage around planet Mars. Thus, in this one article, Carl Wiley was the first to propose solar sailing as a practical means of space transportation, and the first to point out how the gravitational whip effect can be used to advantage in changing the course of a vehicle in space that is drifting without fuel. NASA's outer planetary probes have made good use of this whip effect. Carl was honored as keynote speaker at a Jet Propulsion Laboratory Symposium on the Solar Sail in 1977, at a time when the Yankee Clipper program to rendezvous with Halley's comet (which returns later this year) was under serious consideration.

On a personal note, I first met Carl Wiley when I joined his company, Wiley Electronics in Phoenix, Arizona in 1957. We continued our close association at Rockwell International in California for many years before Carl joined the Space and Communications Group of Hughes Aircraft Co. in El Segundo, CA., in 1978. It was there that he was able to put together the aperture synthesis and image reconstruction techniques of the radio astronomers with the techniques of microwave radiometry to achieve improved passive radar imaging. I was particularly happy to nominate Carl for Fellow grade in the IEEE, to which he was elected in 1979, and again to nominate him for the Aerospace and Electronic Systems Society's Pioneer Award which he won this year. He became a Life Fellow of the IEEE in 1984.

I have lost a close personal friend whose genius and versatility I shall always admire. His wife Jean and his two sons Leslie and Keith, have lost a loving husband and a caring father. Our profession, indeed the whole scientific-engineering community, has lost a prolific contributor. Who knows what new ideas might have sprung from his fertile mind had he been permitted to remain longer with us?

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