# The Future of Our Country: Technology

## The History of Dr. James West

## At The Johns Hopkins University

By Jonathan Respress

History of African Americans at the Johns Hopkins University Project

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"The big difference between science and other professions is that you never know what tomorrow may bring. Every day is unique and different."

*- Dr. James E. West*

## I. Introduction

Throughout the 20th century, the United States of America has observed a distinct change in the racial make-up of physicians, specialists, scientists, researchers, and inventors. Gradually, Blacks began to account for a large number of these positions in the United States of America. They found ways to educate themselves in their own institutions and rise above America's societal oppressions in order to acquire excellent education. Blacks ventured forth into the field of engineering and excelled in each of its fields despite the segregation in their everyday lives. During the late 1940s and 1950s, hundreds of Black men and women were heading for various institutions of higher learning. There, they would receive the education and training that they needed in order to care for people and improve technology, especially those from their own cultural background. One such individual was Dr. James West. He, like thousands of other engineers, dedicated his life's work to the advancement of technology, but also to the improvement of sound quality, providing state-of-the-art acoustics for people of all colors.

Unlike the people of the times, science was colorblind. More than virtually any other profession, one was judged by what one discovered. Technology was and still is our country's future. For James West, science and technology are what defined him. With nearly 50 U.S. and

200 foreign patents, West revolutionized the telephone and recording industries with the invention of the electret microphone. He's published a lifetime of work, focused on the intricacies of sound, electricity, and polymers. West said, "It's nice to know that the work I've done has improved the quality of life."

## II. Early Life

Dr. West was born James Edward Maceo West on February 10, 1931 in the town of Farmville, Virginia, about an hour's drive west of Richmond. His family was not poor, but they still had to deal with the American disease of the times: racism. Over the years, his father, Samuel Edward West, managed many businesses, including a funeral home owner, B & O Railroad porter, and insurance salesman. His mother was a teacher, who later worked at Langley Air Force Base during the Joseph McCarthy era. She lost her job because of her involvement in the National Association for the Advancement of Colored People (NAACP), contradictory to the McCarthy way. As a well educated Black family in the South, West's parents believed that learning should focus on the professions that were open to African- Americans at the time: law, medicine, teaching, and the church.

## III. Education and Early Adulthood

When he graduated from high school, West first enrolled as a pre-medical student at Hampton University in Virginia during the late 1940s. Eventually, he transferred from Hampton to Temple University in Pennsylvania and switched his major to solid state physics. His parents were not pleased with his decision, and as a result, immediately stopped all of their financial support. "I knew that I had to live my life and do what I liked to do," he stated. "If you do what you like to do,

you will do a great job. You will have that much more desire and devotion. I chose acoustics because I was more knowledgeable about it."

During his college years at Temple, there were still forms of racism in the North, different from but also similar to the South. West experienced it from all directions, including students and faculty at the time. He felt that he received less attention than he deserved, so he forced himself into study groups to prove his worth and always picked the hardest problems to solve. West would also go further than his mother in the African American civil liberties movement, attending Black Panthers meetings at Temple. He also became a fan of Trotsky. "I became more immersed in racist attitudes toward black people," he says. "Living in Philadelphia, I saw a whole different perspective from the standpoint of poverty and the deplorable situations in which some people are forced to survive. I lost confidence in the system." In regards to scholarships and internships, he did not receive the same information as the other students. So, he read bulletin boards and applied to the positions and awards, putting in extra effort. Finally one day, Bell Laboratories gave him the opportunity to join their staff; this opportunity would change the rest of his life.

West found satisfaction in science. Hired at Bell Labs as an intern in the 1950s, he was one of the few African Americans who worked at the firm and quickly became a lover of science. Yet, because of his anti-authoritarian politics, he also would eventually challenge the corporate culture. West wanted the company to retain its emphasis on research, not profit, and he was known for sending company CEOs pointed memos, requesting meetings, and even approaching a top executive on an airline flight to talk about where the company should focus its energy. Over the years, West says, he received proper recognition from the community and Bell Labs. As members of the Bell Labs research team, scientists like West did not personally profit from their inventions. That didn't matter. Money wasn't his goal. "Being allowed to do what I wanted to had been worth

far more than I ever imagined. The pursuit of knowledge and expansion of knowledge is really a privilege."

West's focus on science led to the invention that would charge his career forever. In the mid-1950s, a group of psychoacousticians (psychologists interested in sound) wanted to understand the performance of the human ear, West remembers. The question: What sort of time delay between two pulses is required for the ear to hear two separate sounds? (They later found out that it is 15 milliseconds). But to answer the question, they needed a linear transducer — a microphone and earphone — with a broad frequency to efficiently convert electrical energy into sound pressure, and vice versa. They needed a Delta function, a very sharp pulse.

Among other inadequacies, the microphones of the day could not produce enough sound pressure for such precise measurements. These condenser microphones also required an unwieldy battery power source. So West, then in the second year of his PhD and an intern in Bell Labs' acoustics research department in Murray Hill, New Jersey, was asked to help tackle the problem. West and a fellow researcher, Gerhard Sessler, built an earphone which handled the problems by using a solid dielectric condenser microphone, a dielectric being a substance that can prevent the flow of electricity and store electrostatic energy. The transducer, which used a polymer foil with a metal layer on top, was sensitive enough to create two quick pulses, the Delta function mentioned earlier. But, it still required a 500-volt battery. The microphones also lost sensitivity over time, and thus were not commercially produced.

Through further reading, West learned that to improve the lifetime of the microphone, he needed to reverse the polarity of the battery periodically to keep the charge from neutralizing and eventually reducing. DC, or direct current, voltage was necessary because without, second generation harmonics were produced. They needed a change in capacitance because of the application of an AC (alternate current) signal. In a battery, chemical energy is converted into electrical energy. Every battery is filled with a certain chemical called an electroylite fluid and two different types of metal. The two different types of metal have different electrical properties, and one is connected to the negative end of the battery and the other to the positive end. Both of these metals react differently to the electroylite fluid and the metal connected to the negative terminal gains electrons and becomes negatively charged while the piece of metal connected to the positive terminal looses electrons and becomes positively charged. While the battery remains unconnected the electrons on the negative terminal cannot reach the positive terminal. If the two terminals of the battery are connected together electrons are then able to pass long the wire from the negative terminal to the positive terminal to attempt to balance the electrical charge. As the electrons move through the wire they loose energy and this energy turns into heat. Since the energy that the electrons have comes from chemical energy in the electroylite eventually the chemical energy runs out and the battery becomes flat. This is a direct current.

"If I had to reverse the polarity of the battery, that meant that something internal was happening," he says. Then, in the process of reversing the 500-volt battery, the leads to the microphone shorted out, and he and Sessler got a very loud signal. At that point, the microphone started transferring sound without power from the battery. That meant the charge was continuous. How did this happen?

## IV. Bell Laboratories: The Discovery

The answer to the question was a word that West had never heard: electret.

"My life really changed at that point," he says. "Understanding this phenomenon became the single purpose in my life. I made an effort to understand everything I could about electrets. Discovery is the best high I've ever had," he says. "It's extremely euphoric. It's true that there is very little new in nature, but we can discover more and more about nature."

The Bell Telephone Company was very impressed with his and bought Berliner's microphone patent for $50,000. In 1878, David Edward Hughes invented the carbon microphone, the earliest model of the various carbon microphones now in use. With the invention of the radio, new broadcasting microphones were created, including the ribbon microphone. “I quickly became an expert on the issue,” stated Dr. West.

In 1964, Bell Laboratories researchers James West and Gerhard Sessler received patent no. 3,118,022 for the electroacoustic transducer, an electret microphone. It offered better reliability, precision, cost, and size, transforming the microphone industry. During the 1970's, dynamic and condenser microphones were developed, allowing lower sound level sensitivity and clearer sound recording.

As West learned, the study of electrets had been around for hundreds of years. His earliest reference was an English scientist named Stephen Gray who wrote a paper, in 1732, which detailed the long-lasting attractive power of dielectrics. At the time, electrets were of organic materials such as carnauba wax. It was a very complicated science. In Faraday’s rules, there was

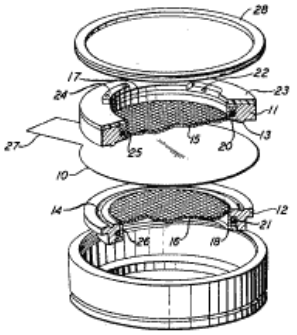
a fear that this technology was only usable for teaching electrostatics. Gray generated this static electricity with these materials by heating the wax, then cooling the melts in iron ladles. Various scientists later tested the properties of electret substances; which was eventually defined as a material that retains its electric polarization after being subjected to a strong electric field. By applying the 500 volts across the earphone over a period of time, the researchers had quasi-permanently charged, or polarized, the microphone, using the polymer, Mylar. Yet, the lifetime of the charge lasted only six months.

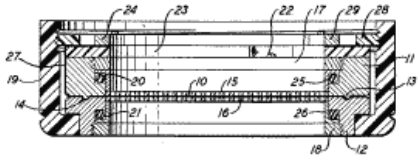
The challenge was to decipher the right mixture of plastics. West and Sessler went to materials science researchers at Bell Labs to discuss the polymers that they were working on. They tried to understand the trapping mechanism; they later found Teflon to be the best because of its use of SIO2. Teflon had been developed more than a decade earlier by chemist Roy J. Plunkett, and its properties were still being tested. In 1964, West and Sessler published a paper showing that Teflon retained a charge with minimal decay. "We found that, under careful conditions, we could inject a real charge into Teflon, and we extrapolated lifetimes in the hundreds of years," West says. The new and all important feature was the defined, stable charging of the dielectric, making it an electret.

In a practical sense, the innovation allowed the development of microphones and other devices that could maintain sensitivity and remain charged over a long period of time. There was no longer a need for costly batteries. "The difference between the standard condenser and electret microphones was that we replaced the battery with a charge that is embedded in a thin polymer foil," West explains. The microphones were tiny, resembling the size of a shirt button, and would be applied to telephones and other devices beginning in 1968. At first, Bell Labs was not confident in the new technology. They did not believe that this new technology could compete with the low cost

of the 56-cent carbon microphones of the day. To their dismay, the foil electret microphone's high performance features — broad frequency, low noise, light weight, and high sensitivity — still cost less, at 10 cents per microphone today.

The technology of electrets has gone far beyond the telephone receiver into such areas as medicine and space technology. Among its many applications, West values the electret's role in the hearing aid. Microphones in early hearing aids were heavy, and the vibration sensitivity was high. "Before, it was impossible for people to leave their hearing aid on when they walked; the vibration was tremendous," West says. "Now people can wear hearing aids all the time." As a another application during the Vietnam War, electret microphones were linked to FM transmitters, and the jungles seeded with the devices to track the movements of the Viet Cong. "Even today, the electret microphone is found in any modern war, especially in communication equipment such as radios or satellite phones," says West.





In groundbreaking research in the late 1980s, West and colleagues at Cornell University and Bell Labs, including Busch-Vishniac (former Dean of JHU Engineering), used an electret transducer with a wide frequency to take sophisticated blood pressure readings. In the past, these readings were only possible through invasive pressure recordings (in which a catheter is usually inserted in the artery). The researchers also discovered a new algorithm that accurately described the systolic and diastolic points found in blood pressure readings.

The technology is still in the research stage, but it shows tremendous potential. "What I hope is that further studies will allow us to be able to determine the performance of the cardiovascular system non-invasively, with a simple device that you could strap on," West says. With more sensitive and accurate blood pressure cuffs, doctors could more easily evaluate a person's blood pressure cycle to detect, for example, artery-clogging plaque.

Another motivator, he says, is the fact that heart disease and hypertension rates are higher among African Americans. "Heart conditions are basically the silent killers," says West, who hopes to work with researchers at the School of Medicine and elsewhere at Hopkins to develop such a device. "This is a dream of mine. There are no smoke stacks at Hopkins. If someone wants to know about acoustics, it is my obligation to pass on my knowledge."

## VI. Breaking Down the Barriers at Hopkins and Recap of Life

After his retirement from Bell Labs in 2001, West decided that he was not finished. "One thing was clear: I'd had a great life in research. It wasn't broken, so why fix it?" he says. "I scheduled interviews with various top universities; Johns Hopkins ended up being my decision."

As a result of this decision, West joined the faculty of the Whiting School of Engineering at The Johns Hopkins University. He is currently serving as a research professor in the Department of Electrical and Computer Engineering and also as the Chairman for the University's Diversity Council. "I discovered that Johns Hopkins was a lot like Bell Labs, where the doors were always open and we were free to collaborate with researchers in other disciplines," he says. "I like the fact that I won't be locked into one small niche here. I wanted to be in an environment that allowed 360 degrees of vision." His arrival at Hopkins marks the latest step in his remarkable career, which

began after he chose to ignore his parents' views and to pursue physics. As mentioned earlier, his parents were very disappointed in his decision to abandon medicine. "In those days in the South,

the only professional jobs that seemed to be open to a black man were a teacher, a preacher, a doctor or a lawyer," says West. “My father introduced me to three black men who had earned doctorates in chemistry and physics. The best jobs they could find were at the post office. My father said I was taking the long road toward working at the post office."

Despite discouragement, West pursued his goal, eventually producing the electret microphone as described earlier. All of the microphones currently produced are based on West’s and his partner’s principles developed years ago. West spent more than four decades with Bell Labs, building upon this research and obtaining more than 200 U.S. and foreign patents. West also has authored and contributed to more than 100 technical papers and several books on acoustics, solid- state physics and materials science.

His achievements have led to numerous professional honors. In 1998, West was elected to the National Academy of Engineering. A year later, he was inducted into the National Inventors Hall of Fame. He is a fellow of the Institute of Electrical and Electronics Engineers and the Acoustical Society of America, and has served as president of the latter organization. He has received the Golden Torch Award of the National Society of Black Engineers and the Silver Medal in Engineering Acoustics from the Acoustical Society of America. Next year, he will receive Gold Medal in Engineering Acoustics. In 1997, the New Jersey Institute of Technology awarded West an honorary doctor of science degree.

Ilene Busch-Vishniac, former dean of the Whiting School and lab assistant at Bell Labs, encouraged West to continue his research at Johns Hopkins. His contributions to modern technology, she says, should not be underestimated. "Jim is one of the two inventors of the polymer electret microphone," says the ex-dean, whose research field is also acoustics. "This microphone is now in virtually every telephone in the world, in all of the hearing aids and in many portable tape recorders. The last estimate I saw suggested that over a billion electret microphones are produced worldwide per year, all thanks to Jim and his collaborator Gerhard Sessler."

Busch-Vishniac, who has collaborated on projects with West, adds, "Jim's real talents lie in his uncanny ability to connect with people. He is a terrific listener, a wonderful mentor, a fabulous matchmaker, connecting people who should know one another but don't. Many of the contacts I have made throughout my career, and many of my research successes, I owe to working with Jim and to introductions he made."[1]

Although his Johns Hopkins appointment is in the Department of Electrical and Computer Engineering, West engages in joint research with faculty members in mechanical engineering, materials science and biomedical engineering. West has helped to develop medical devices, including a noninvasive method of picking up critical sounds from the cardiovascular system.

Today, West is active in programs aimed at encouraging more minorities and women to enter the fields of science, technology and engineering. He plans to help recruit more minority and women faculty members and students to Johns Hopkins. His research projects will include efforts to improve teleconferencing technology by transmitting stereophonic sound over the Internet and

[1] Headlines@Hopkins.http://www.jhu.edu/news_info/news/home03/jan03/west.html

developing a point charge in VLSI circuits with former co-worker Howard Catz. Above all, West says he has no desire to slow down. "My hobby is my work," he says. "I have the best of both worlds because I love what I do."

## VII. Recognition: Achievement and Appointments

West is a member of the National Academy of Engineering; a Fellow, and past President, and past member of the Executive Council of Acoustical Society of America (1998-2001), and a Fellow of the IEEE.

West is a member of the Board of Directors of The National Inventors Hall of Fame, a member of the National Academy of Engineering's Committee on Diversity in the Engineering Workforce and a member of the Scientific Advisory Committee of The International Symposium on Electrets.

West is the recipient of the Callinan Award (1970), sponsored by the Electrochemical Society of America, the Senior Award (1970), sponsored by the IEEE Group on Acoustics, the Lewis Howard Latimer Light Switch and Socket Award (1989), sponsored by the National Patent Law Association, the George R. Stibitz Trophy, sponsored by the Third Annual AT&T Patent Award (1993), and the New Jersey Inventor of the Year for 1995. He received The Acoustical Society of America's Silver Medal in Engineering Acoustics (1995), an honorary Doctor of Science degree from New Jersey Institute of Technology (1997).He received the Golden Torch Award (1998) sponsored by the National Society of Black Engineers, the Industrial Research Institutes 1998 Achievement Award, and The Ronald H. Brown American Innovator Award (1999). In 2002 he was The Audio Engineering Society Richard C. Heyser Memorial Lecturer. West was awarded the Lewis Howard Latimer 2003 achievement award, and the JOHN WILLIAM STRUTT, 3rd Baron of Rayleigh 2003

Award, presented by the Mexican Institute of Acoustics. One of his early publications has been chosen as a ``Benchmark" publication by the Acoustical Society of America. [2]

## VIII. Reflection

West is a "dedicated, restless scientist, always on the run for new discoveries."

His name may not be common to most, but every time a phone rings, the developed technology of James E. West is likely to be involved. During a distinguished private- industry career spanning more than 40 years, West co- invented the reliable yet inexpensive electret microphone used in most telephones, tape recorders and other important devices.

West's arrival at Johns Hopkins marked the latest step in a remarkable career that began soon after he chose to ignore his parents' well-meaning advice. West spent more than four decades with Bell Labs, building upon this research and obtaining more than 200 U.S. and foreign patents, has also authored or contributed to more than 100 technical papers and several books on acoustics, solid-state physics and materials science.

His achievements have led to numerous professional honors and his pioneering research on charge storage and transport in polymers (the electrical analogy of a permanent magnet) led to the development of electret transducers for sound recording and voice communication. Almost 90% of all microphones built today are based on the principles first published by West in the early

[2] West, James. “Modern Electret Microphones and Their Applications.” Heyser Memorial Lecture. Taken from the Audio Engineering Society.

1960s. This simple but rugged transducer is the heart of most new telephones currently manufactured.

WORKS CITED

1. Picture 1 taken from Lucent Technologies
2. Picture 2 taken from
3. Picture 3 taken from Johns Hopkins Magazine
4. Picture 4 taken from Teacher's Online Guide: Acoustical Engineering
5. Picture 5 taken from About.com/inventors
6. Picture 6 taken from Audio Engineering Society
7. Picture 7 taken from http://www.prism-magazine.org/dec00/ilene/ilene.cfm
8. Picture 7 taken from Johns Hopkins Magazine
9. Information and Selected Quotes provided by the taped interview of Dr. West by Jonathan Respress on November 17, 2005.