The genius of George Westinghouse

Few inventors have had as much impact on the world as George Westinghouse. He invented the air brake that made possible the rapid development of the railroads; succeeded in launching AC power distribution against all odds; devised a method by which natural gas could be used on a large scale; and invented the automotive shock absorber.

by J. L. ELKHORNE

They called him "crazy George".

Young George Westinghouse surely represented the idea of the thin borderline between genius and insanity. Subject to violent fits of temper, he raged at any obstacle, and at times beat his head against the wall until it was bloody.

His fearsome reputation grew amongst his peers and one day a smaller boy made the mistake of calling George crazy to his face. The difference in size was as nothing to George — he beat the smaller boy to the ground. When George's father heard about this disgraceful conduct, he marched his wayward son to the woodshed for some traditional discipline. Firm muscles applied a stout switch, and with the first blow, it broke. Crying from fear and shame, George nonetheless pointed out that a leather strap hanging on the wall would be a better instrument, as it wouldn't break.

Such a statement made his father realize that normal punishment was not the answer for young George. In later years George Westinghouse appeared to be quiet and calm, to those who did not know him well — but only absolute self-control kept his temper even. That he was able to master his own nature is a tribute to a father's guidance and wisdom.

The elder Westinghouse owned an agricultural machine factory and thought George might keep out of trouble if he stayed busy. The plan worked only too well — George enjoyed spending so much time learning about the machinery that his schoolwork suffered. Finally, his father told him: "No more than two hours a day, here, and only if your grades are good."

Then one of George's teachers helped him with additional tutoring, but also recognised that George's active mind needed outside interests. He encouraged the lad to both study hard and continue to learn as much as he could about the factory.

In 1858, at twelve years of age, George became an employee in his father's business, earning two dollars a week. The senior Westinghouse saw to it that his son was treated as just another apprentice, rather than "the owner's son". The son began active work in the shop as a sweeper and machine wiper.

One sweltering, humid Saturday, Mr. Westinghouse had agreed to let his men have the afternoon off, when a rush order was received. The factory owner knew he had to keep his word, but he also knew he had a business to run. He felt it only fair to assign the preliminary work to the lowest ranking employee, even though that happened to be his son.

Young George had anticipated a fine afternoon of swimming and a picnic. Instead, he was sorely disappointed. He determined then that if he ever owned a factory, he would give his men every Saturday afternoon off, with full pay.

While he congratulated himself at such good intentions, an idea flashed into his mind. The many lengths of pipe he had to cut as threshing machine parts could be done quickly — he would use steam power to help him! All he had to do was chuck the pipe into a lathe driven from the engine and, as the pipe turned, apply the hacksaw. The results were as good as the concept. In less than an hour, the afternoon's work was done!

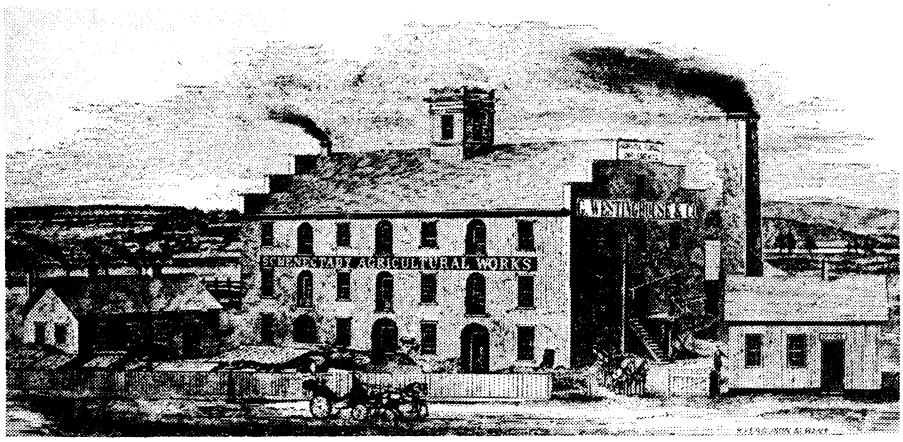
George fairly flew home to get his swimming suit. When his father saw the elated boy running through the yard, he found it hard to believe that the work had really been done. He had to go to the shop to see for himself.

George Westinghouse's first "invention" set the pattern for his life. His searching mind saw a wealth of invention, a new world of machine techniques that could make life easier for men.

His first real invention resulted from dissatisfaction with the reciprocating steam engines in his father's factory. He developed a design for a crude rotary engine, or turbine. Before he built a working model, however, the Civil War broke out and George enlisted in the army, with his parent's consent, at the age of seventeen.

In less than a year, he applied for and received a transfer to the Navy, since his mechanical training would be of greater use there. He had the opportunity to build a model of his rotary engine because, ironically, he spent the last two years of the war far from battle. In 1865 came the first real tragedy of his life — his elder brother, Albert, was killed in Louisiana.

On June 15 of that year, returning home on the train, George suddenly found himself pitched violently to the floor. Unhurt but curious, he left the coach to find out what had happened and spent the next two hours helping the train's crew get a derailed tender back onto the tracks. When he learned that such incidents happened all too frequently, his quick mind conceived a portable set of rails which could be placed so that the locomotive could pull the derailed car back onto the permanent rail.



Where George Westinghouse learned his trade — the factory of the elder Westinghouse in Schenectady, New York. The factory started in 1856.

Once home, he told his father of the rotary engine idea and got his father's assistance in filling out the patent application. In November, he received the patent award, the first of over 300 he would accrue during an active life.

George then attended Union College at his parent's wish, a plan they had had for Albert, but academic life was not to his liking. He found he could spend no time on inventions like the rerailer, and he further had to spend time on foreign languages, which were a complete mystery to him. At Christmas, the president of the college summoned George to an interview, admitted that he was brilliant, but said that he was not cut out for college life.

Further discussions with George's father indicated that continued study there would be inadvisable. The young man had determined that he wanted to be an inventor, a creator of new things. Now, to prove to himself and the rest of the world that he could succeed at something, he desperately spent all his spare time working on the rerailer.

Finally, George completed his design, incorporating such revolutionary concepts for the time as the use of cast steel over cast iron. His father advanced him enough money to finance patent costs, but declined to invest in the project. George found two backers, but not only did they demand that he assign the patent to a partnership they would form, they insisted he had to act as salesman for the new firm.

His first sale took less than ten minutes. Superintendent Towne of the Chicago, Burlington and Quincy Railroad said, "The diagrams did the selling." Towne became his first customer and a worthwhile friend.

Just as his career had begun with a train journey, so the young inventor now met the girl who would become his wife — in a railroad coach. He married her in August, 1867. Shortly after the wedding, George and his bride paid a friendly call at Superintendent Towne's home in Chicago. While wives became acquainted, the two men strolled into the study. The executive offered the young inventor a cigar and some advice.

"What railroading needs most, George, is a reliable system of braking."

"What's wrong with today's method, sir?" George asked.

"The human element. Time lag. A brakeman receives a signal from the engine and cranks a handwheel on his car."

George considered this and replied, "And the brakemen sometimes have to work several cars, don't they?"

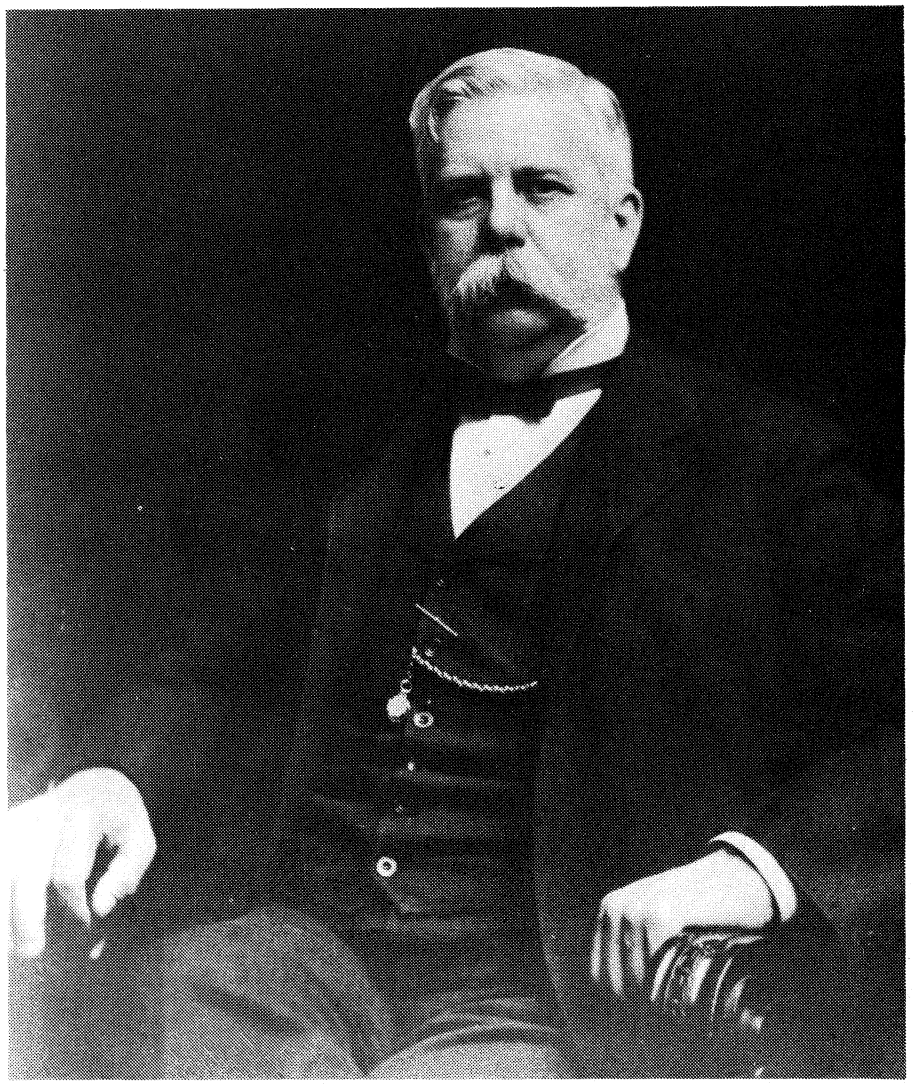
"Yes. It's a bad system. Too many men lose their lives that way. Wrecks still happen. If you could come up with a reliable mechanical system, you'd make a fortune, Westinghouse."

George smiled.

"No, I mean it," the older man said. "Good brakes would mean that we could run longer trains safely, our operating costs would be less, and corresponding freight rates would go down. Countless people would be indebted to you."

"I'll certainly think about it, Mr. Towne."

George did think about it. Plan after plan was imagined and discarded. Then another man approached Towne with a method. His technique was identical to one idea George had discarded. Experimental apparatus involving a complicated windlass mechanism was fitted to CB & Q's crack passenger train, and George Westinghouse received an invitation to the trial run. His rival's windlass broke the third time the brakes were applied.



George Westinghouse, inventor and industrial genius.

George worked on the problem with renewed energy, resolving to succeed where another had failed. Weeks went by in which George built a miniature train, weeks of constant experimentation and refitting. First he tried steam, readily available from the locomotive, but discovered that there was a time lag in running the steam from the engine to the last car. He also found that condensation could take place, rendering the system not only useless, but dangerous.

Then he hit on the idea of using compressed air. The pump to compress the air was steam-driven.

With success within his grasp — and a fortune to be made — George's business partners tried to increase the profits of their small firm by getting rid of George. They refused to even pay a license fee for the Westinghouse rerailer patent. George threatened to sue if they infringed. A few weeks later, the greedy villains argued amongst themselves; the ill-fated company went out of business.

At this point, the young husband needed work. A Pittsburgh foundry company offered to produce his rerailer, employ him as a salesman, and also pay a royalty for the patent rights. George left Marguerite, his wife, with his parents while he was on the road. In New York, he closed an order with the New York Central Railroad. He also tried to interest NYC in the compressed air braking system but received only bureaucratic excuses. The men who ordered the rerailer, which was tried and proven, didn't want to get involved.

Other railroad men he'd tried to interest in the air brake system had rejected it. Most could not understand the principle. Some few who thought there could be something in it were not willing to undertake the expense of fitting out a train with experimental apparatus.

George Westinghouse then did something daring. He personally confronted Commodore Vanderbilt, the hundred-million-dollar head of the New York Central, in his headquarters and demanded an interview. Such brash behaviour shocked the important executive but he was too amazed to refuse. The following day, when George explained his theory and showed the magnate the drawings, Vanderbilt numbered himself among those who refused to see the truth.

"You're trying to harness the wind and use it to stop a train. It can't work!"

The disappointed inventor was escorted from the office swiftly. Although he had failed with Vanderbilt, he still received a good commission on the NYC sale of rerailers, so when he returned to Pittsburgh he sent for Marguerite. One evening, while they were

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entertaining, George grumbled about his invention's lack of success. A friend, Ralph Baggaley, offered to put up the money to have the air brake apparatus built. The two men made contact with the Pennsylvania Railroad but time dragged on and the PRR failed to respond.

One day, a man came to their door.

"I'm W. W. Card, Superintendent of the Panhandle Railroad and I've heard about your brake system. I think we'll give it a try."

Within a week, Card had gotten permission for trials. "We'll place a train at your disposal," he told them, "but you'll have to bear the cost of installation. And if there's any damage, it's your responsibility."

A dangerous gamble, the pair thought, but if they succeeded, the risk would be worthwhile. They decided they could get by if they did most of the mechanical work themselves. When their task was completed, only ten dollars remained in their treasury. If the device failed, no one would give them another chance.

The test run of the modified train started with an air of celebration. A round of confident speeches preceded the event. Superintendent Card and a number of railroad officials boarded the passenger coaches. Westinghouse, however, rode in the locomotive with Dan Tate, the engineer.

As they pulled out of the Pittsburgh yards and opened the loco up, they anticipated only a routine test of the new apparatus. Still picking up speed, they rounded a bend to confront a sight which put Dan Tate's heart in his throat — a horse-drawn wagon straddled the tracks.

The sudden appearance of the train bearing down on them panicked the horses, who lurched forward, tossing the wagon driver onto the tracks. Without a second thought, Tate grasped the air brake lever and tugged it downward with all his strength. Pandemonium reigned amongst the officials in the passenger coaches, unaware of the problem in their path. The wheels screeched against rails hot in the sun and the train slid to a stop only a few feet from the dazed wagonman.

In seconds the railroad officials had rushed forward, demanding to know what had gone wrong. When they learned the truth, they declared that the brake had proved itself beyond question.

Three months later, in July 1869, the Westinghouse Air Brake Corporation was formed. Card and Baggaley numbered themselves amongst the board of directors. Twenty-three-year-old George Westinghouse was selected as president of the new company. Knowing that people prefer to be shown a new thing rather than told of it, he arranged for a train fitted with his air brake system to tour the country. This nationwide display generated great deal of public interest which, in turn, moved the more conservative railroad tycoons into adopting it.

The air brake was an excellent design. From the steam-driven pump in the locomotive, air pipes were rigged under each car. Flexibile couplings joined cars, and there was an automatic valve in the coupling to prevent the escape of compressed air when a car was detached from the train. A fitting from the main air line led to a piston affair under the car, which forced the brake shoes onto the wheels.

Once actuated, to release the brake, the engineer bled the air from the main pipe by means of a valve. Not much time passed before the fledgling company saw handsome profits coming in. Then George had an even better idea.

Instead of operating the brakes to stop the train, he reasoned, they should arrange the system so that the brakes were normally set, and use the compressed air system to hold the shoes away from the wheels. This created a fail-safe system. If an air hose broke, the shoe would slam into contact, preventing the car from becoming a rolling juggernaut.

The improved system found ready acceptance. Good as it was, though, it did not have the speed of control which would stop a fifty-car fast freight train with reliability and without cargo damage. George set about modifying the entire system, enlarging the air feedlines, improving the valves and greatly enhancing operating speed. Rather than talk to numerous railroad men about the latest improvement, he decided it would be more efficient to undertake the testing himself.

He had a fifty-car freight train fitted with the new system, at an expense of $200,000, incurring the wrath of Baggaley and the other company directors. Even though they called it the "most expensive train ride in history", they went along on the trial run. George placed a glass of water on the caboose floor and when the brakes were applied, the fifty-car fast freight came to a stop in two-and-a-half seconds, with so little jar that the glass of water did not spill. Further tests showed that the massive train could be stopped from 30kph in less than 60 metres.

W. W. Card witnessed this fabululous performance also; little time passed before the new, improved air brake had once again revolutionized railroading.

Ironically, now that trains could be longer and travel at increased speeds, new dangers presented themselves. The science of traffic control lagged behind mechanical progress. Signalling was still rudimentary. More, larger and faster trains meant more difficulties in despatching.

Westinghouse met the challenge with a complete electro-pneumatic signal system, the design reaching completion in 1880. As usual, there were no takers until someone had proved it. George was forced to organise a new company, the Union Switch and Signal Co., in 1881. He once again had to gamble, as growth was quite slow and the new plant required enormous capital. The Pennsylvania Railroad placed one of the first orders, which was a good sign, but years passed before this necessary safety concept gained full acceptance.

With the challenge of an interlocking signal system conquered — at least technologically — George looked for new horizons. Natural gas, one of nature's untapped wonders in that day, became the next endeavour. George, who knew next to nothing about geology, did not let that stop him. He reasoned that natural gas wells, with output in commercial quantities would be a wonderful new energy source for industry. Committing himself to the project completely, as he always did, George ordered a well dug on the grounds of "Solitude", his own estate in a Pittsburgh suburb. A walking beam engine running night and day jarred the quiet of his grand home and his neighbour's peace of mind.

Despite complaint, the well was brought in, one of the finest ever seen. Now that he had tapped nature's new secret, it remained to solve the problems of how best to handle it. Gas under pressure held great danger. But George designed a double-pipe conduit system, with safety valves and other safeguards.

By 1884, he had convinced the Pittsburgh City Council of the advantages of this new energy. He offered to provide gas free for certain public services, such as street lighting, and to provide the use of his pipeline to other gas producers at a nominal charge.

With another success behind him, Westinghouse reached out for another challenge and found himself involved in one of the strangest wars of the nineteenth century — the "battle of the currents".

He had seen the successful incandescent lamp of Thomas Edison, and he had heard rumours of a better electrical system than the direct current plants springing up throughout the country. DC distribution required sub-stations every mile or so, because of power losses in the transmission lines.

Even so, those adjacent to a powerhouse had about 130 volts available, which used up the lamps of that era all to soon. At the distant end of the line, however, the voltage was down to about 90 volts, giving electric illumination little better than candles. Despite its limitations, Edison had invested some two million dollars in DC power in New York City.

Westinghouse learned that infant theory of alternating current claimed much greater efficiency in transmission. Theoretical claims stood for little when weighed against the problems, though. A practical motor running on AC was needed and there were those who said it was impossible, "as the positive and negative would cancel each other". The new idea also came up against men who wished to protect their existing investment in DC plant and those who feared the unknown.

George Westinghouse held no fear. He bought the patent rights to an English invention, the Gaulard-Gibbs transformer. One of his engineers returned with an example; they found it was little more than a laboratory curiosity. George set about designing an efficient transformer himself — it took three weeks. At the end of 1885, he, his brother Herman, and a group of associates organised another new corporation, the Westinghouse Electric Company. Other business matters kept him occupied until the latter part of 1887, when news of a remarkable patent application reached him.

Then, in 1888, George Westinghouse, visionary industrialist, met Nikola Tesla, scientific genius and a discoverer himself of basic principles. Tesla, a Croatian, had received an excellent education in Europe as a mechanical engineer. He had developed a theory of alternating current distribution and use in 1882 — and built a two-phase motor to prove its efficiency — but could not interest staid Europeans in the concept.

In 1884, he decided to try his fortunes in the New World. After his arrival in New York, he worked for Thomas Edison but the two argued about AC and finally about a bonus Tesla had expected, and the two parted company. For over a year, Tesla worked at odd jobs and as a labourer. The United States was undergoing an economic crisis, suitable jobs were not plentiful, and besides, everyone knew that Edison had said Tesla was a bad 'un.

Fortunately, he met two men willing to take a chance on his ideas. They advanced some funds, he bought materials and built his working models. He filed for a patent on his system in October, 1887. Instead of the single patent he expected on what to him was a unified, coherent system, he received 40 patents covering basic apparatus. The key to his practical system resided in the concept of the "rotating magnetic field" which made the first AC motor possible.

Tesla pointed out that all generators and motors created and used alternating currents internally, but the commutator principle handled the currents external to the machines in a direct fashion. During school days, he had noted the sparking of the commutator as a sign of inefficiency — why not do away with it entirely? It remained for the genius of Tesla to conceive of the rotating field, which had no physical connection with the armature, but which would pull it along in synchronization.

Tesla's induction system made many things which are now taken for granted possible, such as good, cheap electric clocks, practical single and multi-phase motors, and true long haul distribution. He also patented the use of oil insulation, a number of basic principles of transformer construction, condensers, regulators, and other useful devices. Before his life's work had ended, he had over 700 patents to his credit.

Nikola Tesla had always known the value of his idea, but even he was surprised when Westinghouse appeared and said, "I will give you one million dollars for the use of your AC patents." Even in the face of that remarkable sum, he asked for a royalty based on the equipment produced. Westinghouse, knowing he was still getting a bargain, agreed.

Once the word had spread that Westinghouse and Tesla had joined forces, the "battle of the currents" began in earnest. The direct current faction, fearing for their investment, set about to defeat the combine. AC was too dangerous, they claimed. A propaganda war resulted.

Edison proceeded to electrocute cats and dogs with AC on Sunday afternoons, for the edification of the public. One of his confederates lost his grip on a dog during one demonstration and himself fell on the plates, which were fed by a 1-kilovolt generator. While he did not die, the experience remained with him. He described the sensation as that of "an immense rough file thrust through the quivering fibres of the body."

Since Edison was paying twenty-five cents a head for the animal victims, it is said the pet population of West Orange, N.J. was nearly decimated.

A "former" laboratory assistant of Edison's, H.P. Brown, succeeded in lobbying for a bill to provide for the use of electricity as a means of capital punishment in New York State. For a time, it looked as though "To Westinghouse" would be the new slang term for execution. Brown demonstrated, on dogs, that electrocution by AC "was instantaneous, painless, humane and left no disfiguring marks." To add insult to injury, when the bill was passed, Brown, by now a consultant to the state, authorized the purchase of three Westinghouse generators to be installed at Sing Sing Prison. When Westinghouse learned the intended use of his equipment, he protested — only to be told that DC generators could hardly provide the high voltages necessary for such work.

Edison wrote: "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."

He also published an article in which he stated: "I have not failed to seek practical demonstration . . . I have taken life — not human life — in the belief that the end justified the means."

Yet, some authorities claimed that workmen on DC systems throughout the country were fatally injured at the rate of a man a month. In an interview, Westinghouse said of thirty distribution accidents he had studied, sixteen came from DC and none where his equipment was in use.

On August 6, 1890, convicted wife murderer William Kemmler made history as the first man to be executed by electrocution. Twice! In a secret ceremony, the condemned man was strapped into the chair. The switch was thrown but Kemmler did not receive a lethal shock. He was taken to his cell, adjustments were made, and the execution repeated. The New York Times called it "an awful spectacle, much worse than hanging".

Westinghouse countered this setback by winning the contract to light the New York World's Fair of 1893, the Columbian Exposition. Countless thousands of people marvelled at the new system and the equipment on exhibition in the Manufacturers' Building.

Nikola Tesla, riding on the crest of an inventive wave which lasted half a century, had developed startling new concepts in alternating current. In his own exhibition, he nightly demonstrated that AC per se was not dangerous. After an hour of scientific "magic" with high frequency currents, he capped his performance by passing one million volts "through" his body to melt a copper disc by the touch of his outstretched hand.

Impressed by this dynamic duo, public opinion went in their favour. By 1895, the two had won and completed the contract for the Niagara Falls power station. The original two-phase generators were later rebuilt for three-phase operation and were still in use as late as 1959. The initial 15,000 horsepower developed at Niagara Falls could not meet the demands of energy-hungry industry and seven more units were installed.

Cheap, plentiful electric power put aluminium refining on a sound basis and enabled a giant artificial abrasive industry to be realized. In a year, the city of Buffalo, New York saw its first AC transmission line. Edison's General Electric Company had long since capitulated and purchased a licensing agreement to manufacture AC apparatus.

Westinghouse, in his eagerness to put the nation on an alternating current basis, had attracted a large amount of necessary, outside capital. He had had to seek enormous loans and still needed money. Pittsburgh bankers, not satisfied with his handling of the business — he "spent too much on research" — demanded a general manager of their own choosing. Westinghouse told them what they could do with their manager; the loan was refused. He then managed to secure a loan from New York banking interests with no such provisos. During this struggle, the board of directors refused to honour the royalty agreement with Tesla and ordered Westinghouse to find a way out.

The entrepreneur laid the problem before the inventor who had become his friend. Tesla knew the success of his AC system lay in getting it into operation on a vast scale. More interested in scientific and engineering accomplishments than in material wealth, he tore up the contract. The claim is made, but cannot be substantiated, that the piece of paper could have been worth 12 million dollars.

In 1938, Tesla gave a speech in which he said that "George Westinghouse was, in my opinion, the only man on this globe who could take my alternating-current system under the circumstances then existing and win the battle against prejudice and money power. He was a pioneer of imposing stature, one of the world's true noblemen of whom America may well be proud and to whom humanity owes an immense debt of gratitude."

This debt of gratitude gained bitter payment. In 1907, America suffered another financial crisis. An independent company like Westinghouse Electric found itself surrounded by the wolves who stood to profit by its decline. They brought pressure to bear to have the loans foreclosed. Westinghouse took steps to protect his investors, putting the company into receivership and working with bankers to reorganize the firm. A new chairman of the board was appointed, a man who opposed Westinghouse's "radical" policies like the treatment of his workers, and his strong commitment to research.

In 1909, although the company had become sound and solvent once again, Westinghouse was forced into retirement. The firm he had given birth to rejected him.

George Westinghouse, in his lifetime, sponsored many unusual ideas about the handling of his employees. He initiated planned communities for the families of his workers. The model town, Wilmerding, Pennsylvania, was the prime example. Westinghouse initiated a plan for worker's compensation for sickness or injury, and medical facilities were provided for his men and their families.

Harking back to his childhood decision, he had started a policy of a half-day off with pay on Saturday and he kept employees on the payroll at times when the board of directors would have laid them off, leaving them to the mercy of creditors. Yet he abhorred the idea of charity.

Though Westinghouse had relinquished control of Westinghouse Electric, he still reigned at the Air Brake Company. In his sixties, he could not accept the idea of idleness. Ironically, another idea came to him at this time by being again thrown out of a seat. The "horseless carriage" he'd bought was poorly sprung. So, in one afternoon, he invented the shock absorber, making yet another use of compressed air. In 1910, the Westinghouse Air Spring Company was organized, its products becoming basic to all automobiles.

On March 12, 1914, the man who had made so many changes in the world died in his sleep. He was sixty-eight. His final resting place is Arlington National Cemetery.