THE INVENTION OF TELEVISION

Harry Shelton

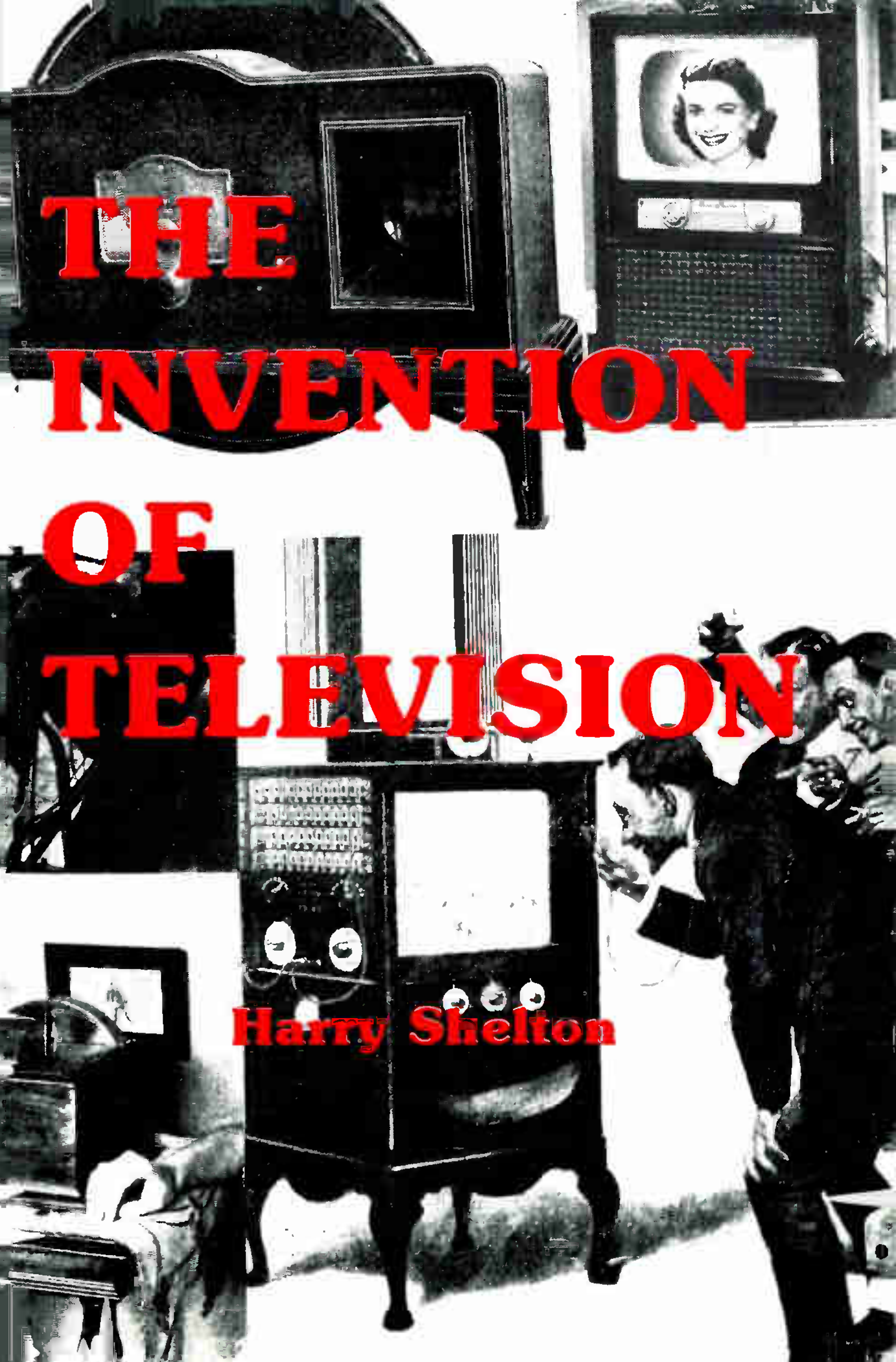

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Table of Contents

Table of Contents (cont.)

Introduction

Perhaps no single device invented by man has changed the world in which we live in so many ways as has the television. Its impact as a news, information, and entertainment medium has been felt virtually everywhere in the world. In fact, television has enabled us to go to every corner of the earth as well as many far removed from it--at least through pictures. Television and its kin have become an integral part of almost every human pursuit. Computer terminals "paint" pictures made of keystrokes and data bits. Live pictures are telecast from the moon by miniature cameras. Home video outfits tape record color pictures and sound--and play them back instantly. Security cameras protect stores and factories from thieves. And microprocessor controlled robots with video eyes weld cars together on assembly lines. But where did this device that has so markedly changed our lives come from? Who invented it? When was it invented? And why was it invented?

It is popularly believed that Jules Verne first alluded to the transmission of pictures and sound by electronic means in his novel, *Twenty Thousand Leagues Under The Sea*. However, this is not entirely true. No where in Verne's works does such a device appear, and none of his biographers--including his greatgrandson — credit him with proposing such a device. But Verne does indeed outline the fundamental principles of photoelec-rricity that eventually made image transmission possible: photoelectric emission, photovoltaic production, and photoconductivity.

In Verne's 1869 novel, Professor Aronnax, his trusted aide Conseil, and seaman Ned Land are washed overboard into the sea only to be rescued by the mysterious vessel that sank their ship. They find themselves aboard a submersible ship in which the antisocial Captain Nemo roams the ocean floor to escape a world he finds oppressive. His ship, the Nautilus, is a marvel of futuristic wizardry. Powered by electricity, the vessel used solar energy to recharge batteries which ran its electric motors. In this, Verne's vivid fiction, was explained the principles of photoelectricity, the ability of an electric current to create light and vice versa.

During a lull in Verne's whirlwind voyage, the Nautilus happened on an unusual undersea phenomena:

> *On the 16th of January, the Nautilus seemed becalmed, only a few yards beneath the surface of the waves. Her electric apparatus remained inactive, and her motionless screw left her to drift at the mercy of the currents. I supposed that the crew was occupied with interior repairs, rendered necessary by the violence of the mechanical movements of the machine.*
>
> *My companions and I then witnessed a curious spectacle. The hatches of the saloon were open, and as the beacon-light of the Nautilus was not in action, a dim obscurity reigned in the midst of the waters. I observed the state of the sea under these conditions, and the largest fish appeared to me no more than scarcely defined shadows, when the Nautilus found herself suddenly transported into full light. I thought at first that the beacon had been lighted, and was casting its electric radiance into the liquid mass. I was mistaken, and after a rapid survey, perceived my error.*
>
> *The Nautilus floated in the midst of a phosphorescent bed, which, in this obscurity, became quite dazzling. It was produced by myriads of luminous animalculae, whose brilliancy was increased as they glided over the metallic hull of the vessel. I was surprised by lightning in the midst of these luminous sheets, as though they had been rivulets of lead melted in an ardent furnace,*

or metallic masses brought to a white heat, so that, by force of contrast, certain portions of light appeared to cast a shade in the midst of the general ignition, from which all shade seemed banished. No; this was not the calm irradiation of our ordinary lighting. There was unusual life and vigour; this was truly living light....

Jules Verne--"Twenty Thousand Leagues Under The Sea."

What Verne described was the reaction of various sea creatures to the magnetic and electric fields exerted by the electrically powered submarine. Verne's living light was what we know as phosphorescence--or the ability of electricity to cause certain elements and compounds to glow with light. In this case, the fish glowed in the dark ocean, their brightness increased the closer they came to the electric field emitted by Nemo's submarine.

Verne relied heavily on information gleaned from technical journals and correspondence with the great scientists of the time to prognosticate what would someday be the basic mechanics of video transmission. The notion of intelligence being transmitted by wire was already commonplace in that time because of the German Soemmering's multiwire telegraph (invented 1809) and Samuel Morse's single wire telegraph (invented 1835). Scientist Alexandre Edmond Becquerel observed the ability of light to generate an electric current in 1839. So, by the late eighteen hundreds, the theory that pictures could be "sent" by wire or even through the air was already well known to the scientific community. What followed were years of painstaking study of the properties of the natural elements and their ability to conduct, resist, or react to electric currents that finally yielded the information necessary to actually construct a working television system. In 1884 Paul Nipkow, a student at Berlin University, patented the Nipkow Disk, a device which could break up a scene into small pieces so that it could be sent piece by piece through a wire to a similar device where the scene would be reconstructed. The disk was a wheel which was punctured radially with holes in a spiral so that, when spun, a field would be scanned at a high rate of speed. The light passing through the holes struck a selenium cell and thereby changed its current flow and voltage output. At the receiving end, a similar disk synchronized to the first with regard to spacing, rotation, speed, and position, reproduced the image via a lamp which grew brighter or dimmer depending on the voltage received from the pickup device. Nipkow's principles were sound, but technology hadn't advanced enough to make his invention practical. The reaction time of selenium was too slow to permit the transmission of live images. Many discoveries in the fields of chemistry and electronics had yet to be made before the transmission of pictures would become a reality; for, television was a compound invention, a combination of still photography, motion picture photography, radio, and telegraphy, which utilized the photoelectric effect of various chemical elements and compounds to reproduce pictures.

1

Television And Politics

Development of different television systems began in earnest in the 1920's by groups of scientists from three countries: Germany, Britain, and the United States. And because of the times in which the technology became available, development flourished or languished with the political fortunes of the countries where the research took place. In Hitler's Germany, the Fernseh Video-Telephone was used to televise the 1936 Munich Olympics, beaming almost live pictures to hotel lounges in the distant cities of Berlin and Leipzig. Hitler recognized the power of such devices to motivate and unify people. His government was the first to sponsor development of the magnetic tape recorder. During the early years of World War II, he used magnetic tape to deliver "personal" messages in areas that had been recently bombed by the Allies. Radio listeners, unable to tell that the program was recorded, were fortified by the Führer's reassurances because they assumed he was speaking in person from the local radio station.

Hitler also understood the value of motion pictures. Film cameras followed him everywhere, making him one of them most documented leaders of that time. Hitler used television to boost the morale of the Nazi wounded by telecasting sports and entertainment programs to army hospital wards.

World War II shut down Germany's television development, especially after the tide had turned in favor of the Allies. And after the war, the Germans were too preoccupied with the reconstruction of their decimated country to be concerned with the electronic novelty of the '30's.

In England, the radio industry was nationalized in its infancy with the vesting of total control over standards and practices delegated to the British Broadcasting Corporation. Scottish television pioneer John Logie Baird was at first denied a license to build his partly mechanical picture transmission system because the BBC wanted to maintain control of any type of broadcasting, and in 1925, they were not the least bit interested in developing television. Public pressure finally forced the BBC to experiment with a system, but they wavered between Baird's partly mechanical system and the all-electronic system that was being developed about that same time in the United States. The British were slow to realize that the future of television lay in the all-electronic systems invented by Farnsworth and Zworykin of the United States. Nevertheless, Baird continued development through the war. In 1941, during the German Blitz, he telecast color pictures of a paper mache' dummy named Eustace using three synchronized mechanical scanners to divide the image into color primaries. But mechanical television was destined for another purpose, and the race to establish a high-resolution direct pick-up television system passed the British by.

The television that we know today came about as the result of work by the Russian-born American Vladimir Kosma Zworykin and was made possible by American industry and the free enterprise system. In 1912, Zworykin attended Petrograd (now Leningrad) Institute of Technology. Under his professor, Boris Rosing, he learned the principles of mechanical picture dissection and reconstruction utilizing a Nipkow Disk and cathode ray tube. The project was abandoned after some time because Rosing came to the conclusion that such a system would never be practical for televising live scenes. In 1919, Zworykin immigrated to the U.S.

and returned to school to earn his Ph.D. in Physics. In 1920, he went to work for the Westinghouse Corporation, experimenting with photoelectric tubes. By 1923, he had demonstrated his first crude all-electronic system for televising pictures. His system utilized converted cathode ray oscilloscope tubes for both pickup and receiving devices, and his first transmission was no more than an "X". Westinghouse executives apparently did not believe Zworykin's device was worth developing because he soon left there to go to work for David Sarnoff and the Radio Corporation of America.

It was RCA, then, that was to bring the development of television from experiment to reality. RCA's President, David Sarnoff, hired Zworykin as Director of Electronic Research At RCA in 1929. During the thirties, Zworykin developed the iconoscope pickup tube, the first device able to pick up live scenes with brightness and clarity. Though not the final answer to telecasting pictures, Zworykin's iconoscope tube changed the trend in development from mechanical to electronic.

As happened in Germany, World War II put a temporary halt to television's growth as RCA turned its technological energies to building radios, radars, and snooperscopes for the Allies. When the war was won, however, the laboratories and factories were already in place, and television equipment construction became a priority for American electronic manufacturers. War weary Americans, enjoying enormous prosperity and hungry to buy all the things that had been rationed or unavailable during the war, created a seemingly insatiable demand for this new appliance. Thousands lined up to buy the toy that could bring the Dodgers, Milton Berle, and Sid Ceaser into their homes. America was in the right place at the right time, and thereby established itself as a leader in the development of television for decades.

What is Television?

If you polled people randomly, asking, "What is Television?", you would probably hear the replies; *The A-Team*, *Dynasty*, or Bill Cosby. Indeed, television owes much to the entertainment industry for its existence, but very likely her fathers never envisioned that their device to transmit pictures would be used so extensively for this "frivolous" purpose. Anyone who has ever enjoyed a television program is in debt to that unseen army of scientists and researchers who experimented with sparks and chemical compounds until they discovered the natural elements that could be harnessed to send pictures to remote places. The television you view in your home today is but one application of the science of image transmission. Broadcast television, the oldest and most well known relative of the video family, has many cousins, some closely related such as facsimile, and many distant relations such as the Snooperscope and Electron Microscope.

The transmission system used in the United States is essentially a VHF and UHF radio receiver which converts a detected radio-frequency signal into information which is used to reconstruct the image on a phosphorescent cathode ray tube. This system, however, is but one of many ways to send images to far places. Several designs were tried and discarded along the road to establishing a practical system. Many early methods of live picture transmission were later supplanted by superior technology while others found uses in other areas of the image transmission field.

It was, then, the CRT operated television receiver and electronic pick-up tube that became the standard for reproducing live pictures, an inevitability since the mid 1930's when the first production models appeared on the scene. But there are at least ten major systems which were at one time considered for use, or are now being used to transmit and reproduce live moving pictures. And there are as many variations within each of the systems as there are systems. In most of Europe, for example, 625 line/25 frames per second scanning is used while the United States, Canada, Mexico, and Japan use 525 lines/30 frames per second. Both systems use compatible color (the picture can be seen on a black and white set), but the method of adding color to these two systems differs.

Why so many different ways to send live pictures? In the early stages of television development, video researchers used mechanical devices to dissect and reassemble images. When an electronic means of performing this task proved faster and more reliable, these earlier systems were retired. Fully electronic television opened the door to many different variations in the rate and frequency of scanning lines. In the U.S., the 525 line/30 frame system was adopted because more channels could be licensed with the narrower spectrum bandwidth required by the 525 line system. The tradeoff was a slight loss of quality, as the higher scanning rate renders a sharper, more detailed picture. The Europeans didn't need as many channels, however, so they took advantage of the additional frequency space to transmit higher resolution pictures. On board the Apollo moon missions yet another method of adding color (known as Field Sequential Color) was used because at the time this system was lighter and smaller in size than the three-tube compatible color systems.

Nineteenth-century man conceived the device that could send pictures by wire, and it was in the image of the telegraph and telephone--an apparatus to originate signals (the pickup device) and a sister machine to view the image (the reproducer)--that the television was created. Very early in the Twentieth Century, multiple wire video transmission was conceived using an array of photoelectric tubes hooked to amplifiers that in turn drove discreet lamps arranged in the same pattern as the pick-up device. The darker and lighter parts of a scene fell on the discreet tubes, causing their corresponding lamps to glow or dim accordingly, thus reproducing an image (See figure 1). The obvious drawback of this device was the enormous number of wires needed to send a picture of any definition. The solution to the multiple wire problem was to divide the picture into small pieces, assign a voltage value to each one in accordance with its light value, and send them down the line one at a time. Like a photographic camera, a field was imaged on the flat surface of the pickup device where it was broken into bits and serially dispatched onto a line to the receiver. And like a photograph, the field would be reproduced on the monitoring device by reconstructing the serial bits. No matter what kind of system was used, faithful reproduction demanded that the receiver and reproducer be "locked" to each other, and so to the above requirements the concept of synchronization was added. It was within this framework that scientists designed their machines, whether mechanical or electronic.

In creating their designs, video engineers borrowed heavily from their counterparts in the motion picture industry. Video pick-up devices used the same kind of lenses as did movie cameras, and the concept of dividing the picture into discreet frames was likewise borrowed from the motion picture camera. At different times in television's development, motion pictures were used as an integral part of various picture transmission systems. One early system first recorded the picture on film and then scanned the film print for video transmission. Later, video transmissions were permanently recorded on film to be broadcasted at another time (kinescope recording). Early attempts at picture reproduction were based on projecting the picture on a screen as was done with motion picture projectors. Though they didn't become the most common system to be used, projection television has seen a renaissance in recent years and more units are being sold every year. Most extraordinary of all, however, is the return to the multiple light principal such as the liquid crystal Mitusubishi Diamond Vision screen in the Houston Astrodome and other large arenas which uses millions of addressable light refracting cells turned on by computer to display theater-sized color television pictures, large enough to be seen by sixty-thousand people.

The evolution of television is an interesting tale, that begins with a series of scientific discoveries in the Eighteenth and Nineteenth Centuries, gains momentum in the early 1920's and burgeons into a giant industry in the 1940's. Development can be said to have occurred in three stages: 1.) The early discoveries of physical and electrical phenomena; 2.) Primary development of television pick-up devices and receivers between the years of 1880 and 1930; and 3.) The realization of all-electronic television that led to widespread acceptance of the medium in the 1930's.

But television owes as much the debt of gratitude to showbusiness as it does to science. Had it not been for the Milton Berle's, Howdy Doody's, and Amos and Andy's, we might have a very different idea of television today. Commercial broadcasting became the sister industry which popularized the medium and fostered its growth. In its infancy, television relied heavily on the talents of Broadway and Hollywood to fill its airtime, and it was the profits from radio that built the equipment necessary to bring television to the masses. As radio before it, television caught the fancy of America, and the love affair goes on today. Broadcast television made way for cable television, and now television has become personalized with the advent of home satellite dishes and video recorders.

The span of time between man's first notion that pictures could be "sent" to the practical reality of television? Nine-hundred and fifty-seven years.

2

A Mystical Beginning

The notion of sending pictures far distances began quite inconspicuously on the plains of Saudi Arabia in the Tenth Century. Caravan riders, stopping for the night, inadvertently ripped a hole in one of their tents, allowing light from outside to fall on the opposite inside wall. To their amazement, the upside down and backwards image of a passing camel and driver appeared on the wall, and the idea of seeing a live image from a distant point cast upon a wall was discovered by man. The Arabian scholar Hassan ibn Hassan named the device the Camera Obscura in 989. And by 1267, western cultures learned of the camera from the philosopher-scientist Roger Bacon of England who wrote about it in his *Perspectiva* and *De Multiplicatione Specierum*. The first working model of a camera obscura on record was that of the Italian architect and sculptor Giambattista della Porta in 1569. Della Porta constructed several small versions of the camera and later converted one room of his villa into a giant camera by placing a convex lens in one of the walls. Guests were conducted into the room where they could watch the happenings in the next room undetected. It is said that della Porta used the device to spy on unsuspecting guests, many times with scandalous consequences.

Della Porta is oftentimes credited with the invention of the camera, and some of the credit is well deserved. It was he who first proposed the camera as a device whereby artists could trace the images of their subjects onto paper or canvas. The Italian went on to build a version using a concave mirror tilted at a forty-five degree angle to the aperture, thereby allowing the image to be viewed in its proper perspective.

Within the next five years, della Porta's models were improved upon many times by Daniel Barbaro who sharpened the camera images by using an adjustable focal length lens and diaphragm aperture. Sometime during 1600, Johannes Kepler, a mathematician in the Imperial Court of Austria, used a portable camera obscura designed by Robert Hooke of England. The camera was built into a tent wall for the purpose of viewing sunspots. In 1612, Jesuit priests also used a camera obscura connected to a telescope to study sunspots.

In the 1700's alchemists began to uncover the properties of the natural elements, including the ability of light to alter chemical compounds. Johann Heinrich Schulze found that a solution of silver salt on bone, wood, or paper turned black when exposed to light. Carl Scheele, a Swedish chemist, published research on the action of light on silver chlorides. His conclusion was that light caused the silver solution to turn black. He further proved that ultraviolet rays caused the silvers to blacken more rapidly, and his conclusions were supported by the later research of the German J.W. Ritter and the Britton Sir William Herschel who discovered ultraviolet and infrared rays respectively.

In 1773, Josiah Wedgwood, a manufacturer of pottery, porcelain and fine china, sought a method by which an image could be fixed permanently on china. One of his clients was Catherine the Great of Russia who commissioned his firm to decorate a set of china with scenes from famous homes and castles of England. Wedgwood had a friend purchase a camera obscura for him in London, and then he set about to 'burn' the images of famous homes onto the plates. He obtained less than the desired result. Meanwhile, his son, Thomas Wedgwood, studied the relationship between heat and light at the University of Edinburgh. In 1797, Thomas began collaborating with his friend, Sir Humphry Davy, a chemist and physicist. They experimented with various chemical compounds on paper, white leather, and glass. Using leaves and insect wings laid on plates coated with silver nitrate, they then exposed them to the sun. They were able to preserve the images, but not for very long.

Then, in the last half of the Eighteenth Century, a young Frenchman stepped onto the scene. Joseph Nicéphore Niepce was born the son of a Counselor to King Louis XVI of France. His family lost most of their wealth and landholdings in the French Revolution. Still, they managed to live in the manner to which they had become accustomed. As a youth, Nicéphore was fascinated by gadgets and machines, even building models of original inventions. When he reached manhood, he served in the military and then went into scientific research with his brother, Claude. In 1807, Claude and Nicéphore patented an engine for powering a boat. In 1816, Claude went to Paris to show his engine to prospective customers. It was there that he learned that a camera obscura could be had, and he bought one and sent it back to his brother. Nicéphore set up a shop in his attic and began taking images of the landscape using paper soaked in silver chloride. The images were recognizable though blurry, and the pictures faded before one day had passed. Then, he came up with an idea to make a positive print of the original plates so that the light and dark areas resumed their original places. He was able to fix more images and thereby perpetuate them, but the process was still far from perfect. In 1826, he ordered several camera obscuras from the Chevaliers, camera-makers of Paris. By chance, the artist Louis Mandé Daguerre entered the Chevealier shop while Niepce's discovery was being discussed. When Daguerre learned of Nicéphore's work, he wrote to him, asking to collaborate. Niepce did not immediately respond.

Daguerre, like Nicéphore, grew up in the court of King Louis XVI at Orleans. As a child he amazed and delighted his family, friends, and assorted courtiers with his ability to draw. At age thirteen, he apprenticed himself to an architect, and at sixteen, he studied with the noted scenic painter for the Paris Opera, E.M. Degotti. An apt student, Daguerre soon made a name for himself designing scenery for other Paris theaters.

A popular form of entertainment at the time was the viewing of panoramas and dioramas, three dimensional paintings or models which were seemingly animated by lighting effects. Daguerre formed his own company with another painter, Charles Bouton, and together they staged grand exhibitions of their dioramas accompanied by orchestra music. Their process involved the painting of two scenes on either side of a translucent screen. When illuminated with intermittent blinking lights, the effect of a moving picture was created.

Perhaps their most renowned work was the *Midnight Mass at St. Etienne-du-Mont*. The screen was nine feet wide and forty-five feet high. On one side of the screen was painted the empty church interior, and on the other, worshippers and clergy attending mass. By illuminating several candles behind the screen one at a time, the empty church appeared to fill with people, one by one. Their dioramas received rave reviews and were in demand everywhere, and Daguerre and Bouton travelled the continent and beyond, showing their work. In his spare time, however, Daguerre read all he could about chemical compounds to fix images permanently. His intention in studying this new technology was to find a method of making his moving pictures with actual images rather than painted ones. So absorbed became he in his work that Louis began to neglect his diorama building company and his family. His wife, an Englishwoman, threatened to leave him because of his inattention, but recanted when friends and associates supported his work. Though Niepce refused to collaborate with him, they did correspond, showing each other samples of their work without revealing their processes.

Then, Niepce ran short of working capital and agreed to cooperate with Daguerre, They signed a ten-year agreement to trade information and split the profits equally. Three years of work yielded an improved process using iodine to fix the images. More work was needed. In 1833, just four years into their contract, Niepce died at the age of 67. Niepce's son, Ididore, who had apprenticed himself to his father years before, inherited Nicéphore's share of the company.

In October of 1837, Daguerre stored some plates he thought ruined in a chemical storage cabinet. A few days later, when he opened the cupboard, he was astonished to find that the pictures were sharp and the image had not faded. Still, though, he didn't know what had caused the development and fixing. He placed several plates, each coated with a different substance, in the cupboard for several days. Once again he was surprised to find that all the plates held the image quite well. Cleaning out the cabinet, he found a bottle of mercury from which a few globules had leaked out. Thinking that he'd found the agent that fixed images on film, he experimented with the chemical by holding his exposed plates over a pot of heated mercury. Using a twenty minute exposure time and the mercury vapor, he was able to produce perfect monochrome pictures. Later he would learn that it was salt, not mercury that had fixed the pictures so well.

Daguerre then sought to dissolve his partnership with Isidore and thereby ensure that he would be the sole patent holder for the fixing of images. Isidore agreed to let him have the patent in return for one-half of the profits until their contract expired.

His invention became known as the Daguerreotype, and it made him famous. After giving his patent to the French government, he retired to a villa at Bry where he held court, receiving distinguished visitors from around the world. And without realizing it, he started a generation thinking about pictures, made with a camera, that could be made to show motion. Daguerre, then, was the first man to envision motion picture films, the forerunner of television.

3

From Sparks

The ancient Greeks first recorded their observations of the two basic properties of electricity, magnetism and static charge, ages before Christ. Certain black stones found in the Province of Magnesia in Asia Minor were found to be attracted to certain substances. The Greeks named the stones "magnetite" and the modern word magnet is derived from the Grecian name of those seemingly magical stones. The ancient Greeks also noticed that when sheep's wool was rubbed against amber, sparks were created. The Greeks, however, did not study these unusual discoveries. As with most other natural phenomena, they attributed the sparks and attracting stones to magic and made it a part of their lore.

The first recorded study of magnets and their properties was made by Petrus Peregrinus, a French physicist, in 1269. The people of Europe, caught in the muck of medieval civilization, clung to their superstitious beliefs, and no great interest in investigating the phenomena further was stirred.

In 1600, physician to Queen Elizabeth of England, William Gilbert, published *De Magnete*, a scientific explanation of magnetism. He devised an instrument called a Versorium, also known as an Electroscope. The Versorium consisted of a needle balanced on a pivot that measured the strength of the magnetic bodies placed close to it. Gilbert's study disproved the common belief that the stones were magic, and he is credited with changing the way men thought of magnetism for all time. Also around 1600, Otto von Guericke built the first electric friction machine. Consisting of a globe of sulphur, the ball sparked and crackled when rotated and rubbed by hand.

Advances in the understanding of the new phenomena of electricity increased greatly in the Eighteenth Century. In 1720, researchers Stephan Gray and Granville Wheler of England demonstrated that some substances conducted electricity while others did not. In 1730, the two scientists succeeded in conveying electricity on a silk thread a distance of 886 feet using a friction machine.

About that same time, scientist Charles Du Fay of France discovered that there were two kinds of electrical charges, positive and negative. In 1773, he developed an improved electroscope using pith balls suspended by conducting threads. Depending on the strength and polarity of the charge, the two balls would either attract or repel each other.

A Pomeranian, E. George von Kleist, and Pieter Van Musschenbroek of Leiden, both working independently, developed simple condensers consisting of sealed bottles of water with electrodes in the top. With the apparatus, they stored electrical charges indefinitely. The device was dubbed the Leyden Jar, and its use was demonstrated in the Court of Louis XV when seven-hundred monks holding hands--the two at the ends connected to terminals of the Leyden jar--jumped simultaneously in the air when administered a charge.

In 1774, Benjamin Franklin began experimenting with electricity. He proposed the one-fluid theory--that there were excesses and differences of a single electrical "fluid" rather than two "fluids" as proposed by students of Gray and Du Fay. While his theory of one "fluid" was incorrect, his idea of electron flow analogous to the flow of liquid was a concept that has endured to this day.

Other scientists of the day working on different theories contributed substantially to the clarification of electrical phenomena and its properties. In his famous Law of Gravity, Newton proposed that gravitational force was proportional to the inverse square of the distance between the two bodies. This furthered the investigation of charged bodies by Joseph Priestly in his study of such bodies in 1767. Priestly showed that if the force between charges varies as the inverse square of the distance, as in the case of gravity, then there is no net force on a charge placed anywhere inside a hollow charged conductor. Henry Cavendish proved Priestly's theory correct in 1772. However, Cavendish's work was not widely read until 1879 when James Clerk Maxwell of Scotland published his papers. Meanwhile, a Frenchman, Charles Augustine de Coulomb, undertook a study to clarify electrical forces in a quantative way. He established the Inverse Square Law for Charged Bodies in 1784. One year later, he demonstrated the Inverse Square Theory with both statically and magnetically charged bodies. More importantly, though, he developed a method of measuring the amount of work performed by an electrical current.

Towards the end of the Eighteenth Century, a chance discovery by the Italian Luigi Galvani advanced electrical studies and opened the doorway to greater understanding of the phenomena. While working in his laboratory, Galvani noticed that the severed leg of a frog twitched when in the presence of an electrostatic generator. Studying further, he found that the muscles could be made to contract when the nerves were connected to two different types of metal that were also in contact. Galvani misunderstood the reason for the reaction, thinking that the dismembered frog leg had caused the twitching. Later, he would learn that it was the saline solution in the frog's body parts reacting with the dissimilar metals that caused the contraction of the frog's leg. Another Italian, Alessandro Volta, used Galvani's principle to build the first voltaic pile (or battery) in 1799. His first battery consisted of a silver disk and a zinc disk separated by a brine-soaked cardboard spacer. Later he would stack the cells of silver, dielectric, and zinc in multiple layers to increase the voltage output.

Once the battery became available, electrical experimentation and study accelerated markedly. In 1820, Hans Christian Oersted of Copenhagen demonstrated the effect of an electrical current on a compass needle placed nearby, thereby proving that there was a direct connection between electrical and magnetic phenomena. Later in that same decade, Andre Marie Ampere discovered that two adjacent parallel wires carrying currents in the same direction repelled each other. Ampere made quantitative measurements using movable coils, and in doing so was able to investigate the laws that had been hypothesized by his predecessors. He called his electricity measuring device the Galvanometer in honor of Luigi Galvani. Consisting of a coil of wire surrounding a magnetic needle, the deflection of the needle out of the plane of the coil measured the current passing through the coil. A testament to Ampere's work today is the use of his name for the unit used in measuring electrical current.

As with Newton's Law of Gravity, another principle of physics, heat conduction in metal, was applied to electrical theory by George Simon Ohm. Physicists in the early 1800's heated one end of a metal rod and measured the amount of time it took for the heat to reach the other end. Fourier showed that the rate of heat flow depended on how rapidly the temperature changed with position--known as the temperature gradient--along the conducting body. Ohm postulated that a similar action occurred with electricity. Ohm's theory stated that when a solid conductor had different voltage potentials on opposite ends, charges drifted from one end to the other. The principle of a voltage potential determining the rate of flow divided by the resistance of the substance through which a current flowed was a necessary step in the mastering of electrical forces to do work. Ohm established the basic mathematical formulas that are used to this day to determine the resistance and current flow in electrical circuits.

Another key to the harnessing of electricity came in 1831 and was uncovered by Michael Faraday. It was known at the time that an electric current in a coil would cause that coil to become magnetized. Faraday wondered if a coil were placed in the field of a strong magnet if the reverse action would occur. Using a magnetized iron bar, Faraday was able to induce currents in a closed circuit tied to a galvanometer.

Then, in 1839, a Frenchman was to happen on the electrical phenomena that would make the televising of pictures possible, the photovoltaic cell. Alexandre E. Becquerel constructed a voltaic cell of two electrodes made of different metals that were immersed in an electrolyte of ferric chloride and alcohol. When sunlight fell on the cell, a slight voltage could be measured on the galvanometer. The cells, however, were unstable and the effect lasted only a few hours. Realizing that light caused current to flow in certain substances, scientists set about to test all the known elements for photoelectric emission. In 1876, W.G. Adams and R.E. Day observed the photovoltaic effect in solid selenium. Ultimately their discovery lead to the invention of the photographic light meter, which would become an important tool in the photographic and television systems that were later developed.

4

Light - The Source Of All Power On Earth

As in the case of the other natural phenomena, light also was the object of worship and study since the beginning of time. The Ancient Incas established the Sun as the center of the universe, and every aspect of their culture was tied to the rise and setting of that unreachable, flaming ball. They awakened to it, worked by it, perished when it stayed absent too long, and flourished when it came and stayed.

Beginning sometime during the Third Century B.C., Greek scientists undertook the study of mathematics, the elements, and the natural phenomena. The Greeks, using a new form of mathematics called geometry, were able to measure the distance to the Sun and Moon as well as the circumference of the Earth. The Greeks theorized that light and vision were a two-way, symbiotic interaction of eye, object, and light, where the eye radiated beams that bounced back from illuminated objects.

The Hindus likewise studied the celestial bodies. The Arabian scientist Alhazen proposed the seemingly obvious theory that light issued from luminous objects. At the time it represented a huge step forward in Man's understanding of the phenomenon of light.

The Renaissance in Europe brought about the advent of scientific study. The great thinkers of most every European country set about to define and describe all things on earth, including light. Leonardo Da Vinci, Galileo Galilei, and Rene Descartes all undertook the study of light. In 1637, Rene Descartes proposed the theory that light was a "luminiferous ether", an infinitely plastic medium that filled all space and transmitted light as a kind of pressure. Descartes' theory became the focus of study by other scientists in the years that followed.

On another front, Isaac Newton undertook the study of the nature of color. He defined white light as a mixture of all colors of light. He correctly identified the mechanism by which the perception of color was effected; that objects appear a certain color because they absorb or reflect certain colors of light. He published his findings before the Royal Society first in 1671, and every year afterward for several years. In his *Opticks*, first published in 1704, he detailed the functioning of light as we know it today. Newton's theory propounded the belief that light came in rays, and that the frequency of the ray determined the color. For reasons unknown, Newton never investigated the energy source that made these rays. The next step forward in the understanding of light would have to wait for Thomas Young of England and Augustin Fresnel of France to establish a detailed theory that accounted for the action of the sun and its effects. Their theory stated that light came in waves (which was later proven true), but their study never concerned itself with the nature or composition of these waves. At this juncture, light was measured in optical terms since electricy was yet to be applied to scientific study.

In the mid-Nineteenth Century, the two phenomena crossed paths. In 1861, the Scotsman James Clerk Maxwell observed that light had properties similar to electricity. Still referring to light as "the ether", Maxwell correctly identified light as a complex substance with a mechanism for producing rays. He set about to explain light using the laws of mechanics. Maxwell was able to show that there exists a type of electromagnetic field in light that separates itself from the charges and currents that gave it birth and then propels itself through space. Maxwell calculated that light waves travelled at 193,088 miles per second, an amazing difference of only 7,000 miles per second from what we now know the speed of light to be (186,300 miles per second). Later, other researchers would come to similar conclusions, thereby upholding Maxwell's findings.

In 1887, Heinrich Hertz stumbled onto photoelectricity when a crude attempt to transmit radio waves revealed that light affected the strength of the received waves. Reflected ultraviolet rays increased the power of the radio waves transmitted in Hertz's experimental equipment, and the connection between light and electricity was firmly established. This knowledge in hand, the scientists of the Twentieth Century were ready to understand light far better than it had ever been known before, knowledge that would ultimately allow Man to conquer it. What evolved was a comprehensive theory that accounted for every aspect of the phenomenon from the source of radiation to its effects on the Earth and its elements.

Perhaps overshadowed by his theories of relativity and atomic fission, Albert Einstein did considerable work in completing our knowledge of light. Upon discovering Maxwell's figures to be inaccurate, he reverted to Newton's theory that light came in pulsing rays. Einstein took Newton's theory one step further to state that the frequency of a light beam was proportional to its energy, and that when light struck objects, particularly metals, negatively charged electrons in the metal were dislodged. Adapting Max Planck's earlier equations, he wrote the formula $E=hv$, where "E" was energy, and "h" was the universal constant of proportionality known as Planck's Constant, and "v" was the frequency. In 1905, Einstein came to the conclusion that light rays were made up of discreet packets of energy, known as quanta (later as photons) and bombarded all matter at great velocities, dislodging electrons in varying degrees depending on the composition of the objects it struck. Ten years of work followed, in which time the theory was tested. By 1915, the scientific community exhausted every test that might have disproven Einstein's theory. No flaw could be found in his hypothesis.

Only one mystery in the definition and composition of light remained to be solved. How did two light beams cross paths without mixing into one color? In 1925, Quantum Theory was amended to state that light was a wave, and that this wave was invisible unless reflected by an object. Light existed as an invisible radiation.

Light as we know it today is a super-high frequency electromagnetic radiation having a wavelength of 10 to the -4th wavelengths per meter to 10 to the -8th wavelengths per meter, the visible portion of which is located at approximately 10 to the -6th wavelengths per meter. The color of light is determined by the frequency of the rays, and when objects are bombarded by these invisible rays, physical and chemical changes occur.

The puzzle solved, scientists everywhere began to experiment with light and detail its effects on the natural elements. That research, carried on for years by an army of men who never met, ultimately led to the invention of television.

5

Historians often take considerable license in crediting various inventions to individuals. This occurs for many reasons, the most common one being Nationalism. Russia, for instance, credits its own primary developers of inventions such as the Telegraph, Telephone, Phonograph, and Motion Picture Projector, to the persons who introduced the device in their country. Another reason why certain inventions are credited to individuals other than the true inventor is that historians oftentimes assign the honor of devising some new modern marvel to the first individual who made the device a commercial success. And, in the course of time, aided by the oversimplification of children's textbooks and popular literature, an invention becomes identified with the individual who made it popular, and the true inventor or discoverer goes unremembered. These are the likeliest reasons, but not the only ones. The reason fame eluded many great men of science was that they were uninterested in pursuing a particular invention or they were unable to obtain the necessary finances which would have made their invention a success. Success, in this case, is measured by the degree of acceptance of an invention in everyday life. The invention of radio as a means of communication took place in the 1830's by Joseph Henry of Princeton. But because of the aforementioned social, political, and economic conditions of that time, the marvel of Radio remained a scientific curiosity for more than sixty years.

Who Invented Radio?

Sometimes Guglielmo Marconi of Italy is referred to as the "Father of Radio". However, what Marconi should really be remembered for is his dramatic demonstration of transatlantic telegraph communications that caught the public's imagination around the turn of the Nineteenth Century. The technology to perform the herculean feat of sending messages through the "ether" had existed for over sixty years. But the Capitalists who could have taken the idea from paper to reality did not see any merit in Radio, probably a result of the Industrial Age still being in its infancy, and so the true inventors never saw their brainchildren become the indispensible entities we know them to be today. The true father of Radio was Joseph Henry, a Princeton Professor and later the founder of the Smithsonian Institution. It was he who first demonstrated the ability of radio waves to effect change at a remote point. Henry's transmitter consisted of a gigantic electrical coil, whose electromagnetism was used to ring a bell across the room. That took place in 1832, three years before Samuel F.B. Morse demonstrated his electrical telegraph system for Congress.

The phenomenon of radio waves effecting physical changes at a distance from their originating point was discovered in 1831. However, thirty-five years passed before any practical application was made of this principle, and when the discovery was made known to the public, it was not well received. The invention of radio began shortly after the properties of electromagnetism were uncovered by Michael Faraday and others in 1830.

Among them was an American, Joseph Henry, who originally came from Albany, New York. Henry's father, William Henry, died when Joseph was eight or nine, and the young Henry grew up in Galway, New York in the home of his mother's parents, the Alexanders of Saratoga County.

Born three years before the turn of the Nineteenth Century, Henry arrived on the scene just as the also young nation of the United State embarked on a momentous change of social course, from that of a colonial, agricultural economy to one of a world class industrial power. Joseph Henry, however, set out to become a man of art. Young Joseph discovered literature at age eight when, while playing near the town hall, he stumbled into the Galway Village Library. He took a keen interest in literature, reading novels, mostly of the romantic genré. And from his interest in literature, there was born an interest in the theater.

At an early age, Joseph went to work as a clerk in the store of a Mr. Broderick. Later he apprenticed himself to a silversmith, but when the smithy failed, Joseph found himself unemployed. At age fourteen, he joined a juvenile forensic and theatrical society called the Rostrum and began producing plays. His specialty was the creation of clever stage effects, which won him some minor acclaim. He was made president of the Society, and he threw his entire energy into showbusiness pursuits. Then, a minor illness confined him in bed for a few days. To while away the hours, he read, but not the romance novels he had enjoyed so much as a boy — but a science volume, *Lectures on Experimental Philosophy, Astronomy, and Chemistry*, by an English clergyman, G. Gregory. The volume pondered the great unanswered questions of mankind, asking how the natural forces of heat and light produced various effects on natural entities. Henry kept the book, and wrote the following note in the flyleaf:

> *"This book, by no means a profound work, has, under Providence, exerted a remarkable influence upon my life. It accidentally fell into my hands when I was about sixteen years old, and was the first work I ever read with attention. It opened to me a new world of thought and enjoyment; invested things before almost unnoticed with the highest interest; fixed my mind on the study of nature, and caused me to resolve at the time of reading it that I would immediately commence to devote my life to the acquisition of knowledge".*

Joseph, upon his return to the Society, tendered his resignation. He returned to school, where he absorbed every bit of knowledge the masters had to teach him. Then, working as a teacher in a country district school, he attended Albany Academy at night in order to continue his education. Later, he became a tutor to the sons of General Stephen Van Rensselaer, the patroon. Then he joined a surveying crew and helped chart parts of southern New York. Following his stint as a surveyor, he returned to Albany Academy as an assistant teacher. In 1828, he was appointed professor of mathematics there, and it was at this time he began his study of physical phenomena.

Teaching college in those times was not an easy job. Henry's lowly position demanded that he teach the youngest students for up to seven hours a day. Somehow, though, he still found time to perform his experiments in electromagnetism. In 1828, he described the application of the galvanic multiplier in the Albany Institute publication, *Transactions*. In 1831, he published his further investigations into electromagnetism in the *American Journal of Science and the Arts*, establishing himself as a leader in the field of electrical research.

Meanwhile, scientists in Europe and the United States were attempting to use these newly found powers of electromagnetism to send messages long distances. Some claimed it could not be done. However, In 1831, Henry indeed sent messages over a wire to a distant point using an electromagnetically rung bell as the sounding element. He soon was able to do the same without wires, inventing wireless telegraphy. All his idea lacked was the code which Samuel F.B. Morse later became so identified with when his single-wire telegraph and its dot and dash method became a reality later that same decade. Henry, however, did not pursue either the single-wire or wireless telegraph for two reasons. First, Henry was totally absorbed in scientific study, emersed in research of the natural phenomena. His goal was not to invent a device that would make the world a better place to live, but the pursuit of scientific knowledge for its own sake.

In 1832, Henry was offered a Professor's chair at Princeton University, which he gladly accepted. There, he carried on his experiments, publishing his discoveries, but never seeking patent protection. Consequently, it remained for others to develop his discoveries, and Joseph Henry went into the history books, not as the inventor of the telegraph and radio, but for other accomplishments. By Act of Congress, Henry's name was adopted as the unit of measurement used to denote the amount of inductance in an electrical circuit. Secondly, he became the first Secretary and guiding force behind the establishment of the Smithsonian Institution in Washington. He took up this pursuit in 1828, and no doubt the post of Secretary of the Smithsonian demanded most if not all of his time, leaving the telegraph and radio "on the shelf", waiting for someone else to step into the picture and bring them into practical use.

The Amazing Invention of Dr. Mahlon Loomis, Dentist

Here follows the original account by C. Francis Jenkins, coinventor of the theater motion picture projector and an early television system, of a Dentist, Dr. Mahlon Loomis, who apparently invented wireless telegraphy in 1865 but was unsuccessful in bringing it to the public.

While in 1832 Professor Joseph Henry discovered that electrical oscillations could be detected a considerable distance from the oscillators it remained for a dentist, Dr. Mahlon Loomis of Washington, D.C., to actually send the first radio messages. In 1865 he built an oscillating circuit, and connected it to a wire aerial supported in the air by a kite. One station was set up on the top of Bear Den Mountain, in Virginia, not very far from Washington; a duplicate station having been set up on top of Catoctin Spur, some fifteen miles distant.

In "Leslie's Weekly" (1868) Frank Leslie personally describes these "successful experiments in communication without the aid of wires."

Later (1869) a bill was introduced in the U.S. Congress to incorporate the Loomis Aerial Telegraph Company (though nobody would buy the stock, and it remained for others, years later, to reap the reward of radio broadcasting).

In speaking on the bill, Senator Conger *repeated, he said, the explanation that Dr. Loomis made to him that---*

> *"The system consists of causing electrical vibrations, or waves (from the kite wire aerial) to pass around the world, as upon the surface of some quiet lake into which a stone is cast one wave circlet follows another from the point of disturbance to the remotest shores; so that from any other mountain top upon the globe another conductor which shall receive the impressed vibration may be connected to an inductor which will mark the duration of such vibration, and indicate by an agreed system of notation, convertible into human language, the message of the operator at the point of first disturbance."--*
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> *From "Congressional Globe", Library Congress.**

Apparently, the United States was not ready for Loomis's marvel of science in 1868. Being the time of the end of the War Between the States, most Americans were too busy with more pressing concerns to even consider the possibilities of radio. This was the year the Transcontinental Railroad was completed and coast to coast telegraph communication was accomplished. The nation celebrated the linking of east and west. The railroads became the lifeline of the nation, and those with money to invest put their money into railroads. Radio was an invention that arrived before its time, and Loomis's device was shelved, awaiting another day and another inventor.

* C. Francis Jenkins, Vision by Radio, Radio Photographs, Radio Photograms. (Jenkins Laboratories. 1925), pp. 67, 68.

Guglielmo Marconi

The man who would sell radio to the world was to be an Italian, Guglielmo Marconi. The independently wealthy Marconi was the product of an Italian-English marriage, who was educated by private tutors at his parents' estate in Bologna. Without undertaking any formal program of study, Marconi set about to learn the principles of physics. He studied under Professor Vincenzo Rosa of Leghorn and Augusto Righi of the University of Bologna. Righi was a pioneer in the study of electromagnetic waves. In 1894, Guglielmo by chance picked up an electrical journal that featured an article describing the electromagnetic wave experiments of Heinrich Hertz. It was from this article that he conceived his invention using electromagnetic waves as a means of communication. He started work immediately at his home in Pontecchia. By 1895 he had succeeded in transmitting messages several hundred feet. Marconi realized that the distance was but a matter of producing his transmitter on a larger scale, and so he set about to market his idea to the public. He saw a great potential for wireless in ship to shore communication, so he moved his operations to England where the shipping trade was on a better footing. His transmitter was based on Hertz's design and he employed a device invented by Edouard Branly called a coherer as the detector in his receiver. He demonstrated his system to the General Staff of the British Army and Navy.

Although his wireless system was based on the work of others, Marconi also contributed two original ideas of his own. He used an earth ground at both transmitting and receiving devices, and he also conceived of the use of an aerial reaching upward into the sky and insulated from the ground so that the signal could radiate over ground structures which might otherwise block it.

By 1897 Marconi established a permanent station at The Needles on the Isles of Wight and at Bournemouth. Victoria, Queen of England, heard of Marconi's success and had a transmitter and receiver installed on the royal yacht, Osborne. Marconi turned his invention into a money making enterprise by charging for messages sent. These messages become known as Marconigrams, and within months ship owners flocked to have wireless equipment installed aboard their vessels.

In 1899, Marconi successfully transmitted messages across the English Channel, from the coast of France to the Cliffs of Dover, and the age of international radio communications began. Marconi was brought to the United States by the New York Herald, which used a Marconi transmitter aboard the steamship Ponce to flash reports from yacht races off the New Jersey coast.

In 1901, Marconi built a transmitter at Poldhu in the South of England, this one a hundred times more powerful than his previous versions. His intention was to send a message across the Atlantic. When it was finished, he went to St. John's, Newfoundland in November of that year to install a receiver. On December 12th, Marconi personally received the first transatlantic "wire" from Poldhu, England.

Radio came into its own when, on April 12, 1912, the luxury liner Titanic struck that now legendary iceberg and flashed her cry for help on the "wireless". That message was picked up by a young man in New York who would later play a key role in the development of all-electronic television, David Sarnoff. With Marconi's invention, Sarnoff ushered in a new age--instant news communication. The new medium demonstrated its usefulness in a way so astounding that it could no longer be denied. The Radio Age had at last arrived.

Marconi, though he did not know it, did something else in 1899 that would eventually play a role in the invention of television. He formed the Marconi Wireless Telegraph Company of America in November of that year. The Marconi Company would later become RCA, the pioneering company that would produce the first all-electronic television.

6

The Edison Effect

They called Thomas Alva Edison the Wizard of Menlo Park. A persevering Ohioan, he collected over one-thousand patents for electromechanical devices, including; the carbon telephone transmitter, multiplex telegraph, stock ticker, motion picture camera, and the phonograph. He is most remembered, though, as the man who invented the incandescent light bulb, a device that was destined to revolutionize society. In October of 1879, Edison made history when his charred bamboo fiber enclosed in an evacuated glass envelope burned for several days without going out. That day, without realizing it, Edison began a new era in electronics, the Vacuum Tube Age. The subsequent tests of his electric lamp showed that black particles adhered to the inside of the glass bulb directly opposite the negative side of the filament. Further experimentation proved that the carbon particles were given off only on the negative side of the filament, with none being radiated from the positive side. As with all of his previous observations, Edison noted this fact in his journal where it remained unstudied for years. Even though he was perhaps the most successful and prolific inventor of his time, Edison was not a scientist in the sense that he pursued knowledge of the natural phenomena for the sake of study alone. Rather, he was more interested in practical applications of already known elements and forces, and so it was left to others to study the effect and then apply this new knowledge. When his research was published, the phenomenon came to be known as the Edison Effect, and other scientists undertook studies to uncover the force that caused the particles to radiate from the negative terminal.

Edison's discovery made its way to England in the late 1890's by way of technical journals, where a consultant to the Edison Light Company of London, John Ambrose Fleming, took an interest in the black carbon particles. He tested every known element as a filament in his vacuumed bulb, looking for that element that would emit the most particles. Then he designed a tube which used a positively charged anode to catch the particles radiated from the filament. Fleming discovered that a great flow of electric current from the negative element to the positive element occurred when the voltage between the two elements differed greatly. In 1904, Fleming patented the Vacuum Tube Electric Valve (or Diode as it is known in the United States).

Another British Physicist, J.J. Thomson of England, discovered why Fleming's valve worked the way it did. He showed that the carbon particles were carried on negatively charged electrons. Once the relationship between electrons and voltaic potentials was established, a new world of study was opened to scientists. Wherever men studied physics, they were sending electric currents through a vacuum.

The logical next step came when the American inventor Lee DeForest added a third element to Fleming's electric valve, called the control grid. The additional element varied the amount of current flow through the valve. The practical applications of this new discovery were obvious, and DeForest's valve was quickly adapted to the amplification of sound. The Audion, as this new vacuum tube came to be known, was the long awaited answer to the problem of electrical amplification of telephone and radio communications. Earlier, the most powerful transmitters yielded only the weakest of signals, making cross-country telephony difficult and radiotelephone reception impossible. But with the advent of DeForest's Audion Tube, the telephone gained a stronger voice and radio in turn adapted voice transmission techniques for its own use.

One year after Edison patented his incandescent lamp, two German scientists, Julius Elster and Hans Geitel, developed the first vacuum phototube. Their invention came about as a result of research of the electrochemically positive elements of aluminum, magnesium, and zinc that determined them to be highly photoemissive (they give off electrons) when struck by light. Later, they used the even more photoemissive elements of potassium and sodium, amalgamated with mercury and enclosed in a vacuumed glass envelope. These Amalgamated Spheres, as they were known, had a short life, and could only be rejuvenated by a filtering process that removed the debilitating byproducts of oxidation in the atmosphere. In 1910, Elster and Geitel switched to hydride crystals of sodium and potassium suspended in hydrogen gas, which extended the life of the tube and eliminated the need for periodic replenishment and thereby invented the modern phototube which would become the heart of nearly all early television schemes.

Edison, who never envisioned what his incandescent lamp research would yield, was yet to play another role in the invention of television--Motion Pictures.

7

Sarnoff's Radio Music Box

There is a saying: "You can't get to there from here". That is where the world was in relation to television at the turn of the Twentieth Century. The phonograph, motion picture, and radio--three inventions that had not even existed ten years before--now were commonplace in American life. In 1906, however, radio was used mainly for point to point message transmission, a service relegated primarily to ship-to-shore and trans-atlantic communications. Crude mechanical television pictures were successfully generated in the laboratories of Max Dieckmann of Germany that same year, and in the early nineteen-hundred's it now remained for engineers and entrepreneurs to decide to what purpose to use these newly found marvels of modern science.

A turn of fate brought together a man of vision with the budding industry of radio. This man would turn the infant Radio in a new direction, one which would eventually spawn yet another industry, Broadcasting, an enterprize that would subsidize the development of television for four decades until it could support itself. That man was David Sarnoff, and the fateful event was the sinking of the luxury liner Titanic.

The man who would establish radio broadcasting, all-electronic television, and compatible color television began life inconspicuously in the Russian-Jewish community of Uzilan, which was near

Minsk, Russia. When David was four years old, his father left them to go to the United States. There he went to work, and when he saved enough money he sent for his family. In 1900, Sarnoff and his family entered the United States as millions of emigrants before them had, through Ellis Island in New York Harbor.

In 1906, Sarnoff's father died, and being the eldest son, David became the family provider. At fifteen, he took a job as a messenger for the Commercial Cable Company, a transatlantic wire telegraph service. Six months later, he departed Commercial Cable for the Marconi Wireless Telegraph Company of America where he became an office boy. This move proved to very fortuitous for Sarnoff and the world as well. Within twenty years, his ideas would establish radio broadcasting, television broadcasting, all-electronic television, and all-electronic color television, as well as numerous other electronic inventions. Achieving those goals, however, proved to be difficult for Sarnoff.

In his spare time, Sarnoff continued his studies, learning Morse Code. For his efforts he was rewarded with a job as a wireless operator at Sea Gage, New York. Sarnoff completed a course in electrical engineering at Pratte Institute. Following graduation, he worked as a marine telegraph operator on various ships.

Then came the job that would change Sarnoff's life--and the world. He became an operator for a Marconi station located on the top floor of Wanamaker's Department Store in New York City. On April 12th, 1912, Sarnoff was at the key when the momentous last message from the luxury liner Titanic crackled frantically in his headsets. Sarnoff stayed at his station for three days, relaying information between ships involved in the rescue and the rest of the world. By the time the dust from that celebrated tragedy settled, everyone in the world recognized the power of this new medium, and the name Sarnoff became synonymous with Radio.

From that day on, Sarnoff's success at Marconi was meteoric. He was made Radio Inspector and an instructor at the Marconi Institute. In 1914, he was promoted to Contract Manager. In 1915, he wrote a memo to the then Vice-President and General Manager of Marconi, Edward J. Nally. In it he proposed a "plan of development which would make radio a 'household utility' in the same sense as a piano or phonograph.....The receiver can be designed in the form of a simple 'Radio Music Box'; and arranged for several different wavelengths." Apparently, little stock was taken of his suggestion as the management of Marconi never acted on his plan.

In 1919, General Electric formed the Radio Corporation of America. As part of the deal, the assets of the Marconi Company were absorbed by the new company, this a political move designed to place control of this new medium solely in American hands---at least within its borders. Sarnoff was named Commercial Manager of the new Radio Corporation of America. Two years later, Sarnoff became General Manager and resurrected his "Radio Music Box" idea. Members of the board were still skeptical. To prove his theory, Sarnoff staged a demonstration, broadcasting the 1921 Dempsey-Cartier fight. The response to the fight was so tremendous, the Board quickly rethought its decision and began the manufacturing of radio transmitters and receivers. In yet another career advancement, Sarnoff was named Vice-President of the Radio Corporation of America.

To meet the growing demand for broadcast radio, other major electrical corporations such as AT&T, Westinghouse, and General Electric built radio stations as well, mostly in New York and Philadelphia. But programming costs were high, and to meet the growing need these four giants of the electronic industry joined together to form the National Broadcasting Company, a programming service based in New York City that would transmit radio programs over telephone lines throughout the country for broadcast by locally operated radio stations. By the mid-nineteen-twenties, stations were signing on in other cities such as Washington D.C., Boston, and Baltimore. In 1926, eleven years after Sarnoff first suggested the "Radio Music

Box", network radio broadcasting became a reality. Two "feeds" were available from NBC, the Red Network and the Blue Network, thus allowing for a variety of programs for listeners to choose from. One year later, 1927, a competing organization, the Columbia Broadcasting System, was formed by Columbia Records. And the craze was on.

The rise of broadcasting, the formation of the Radio Corporation of America, and the influence of David Sarnoff not only provided the world with many new electronic inventions, they also changed forever the way inventions were developed. Prior to this time, inventors, some working under the auspices of a University and others working independently, brought forth their brainchildren from back shed laboratories or modestly equipped university research facilities. But modern radiotelephone equipment was becoming increasingly complicated and therefore highly expensive to produce. It was necessary, therefore, for some great entity to fund the expensive experimentation and initial production costs to bring such products to the market. In Great Britain and several other European nations, the government stepped into this role, taking absolute control over the airwaves. But in the United States, where free enterprise was the law of the land, it was left to the private sector to finance the first radio transmitters and receivers. Up until the early years of Twentieth Century, no one had ever conceived that sporting events, dramas, and information could be disseminated through the air to virtually every human being on earth at once, but thirty years later, the practice was commonplace. The world at last had been introduced to Radio. And if sound could be sent through the air, why not pictures. In fact, television pictures had successfully been transmitted via Radio in the U.S., England, and Germany by 1927. This early form of television is covered in detail in later chapters.

Yet another invention appeared in the early Twentieth Century and became every bit as popular as Radio. The inventor described this new medium as "doing for the eyes what the phonograph does for the ears...." Thomas Edison was the inventor and the invention was the motion picture.

8

Pictures In A Box

The invention of motion pictures logically followed the mass acceptance of still photography. The idea of showing simulated motion, however, dates back to 1645 when a German Jesuit priest and scientist, Athanasius Kircher, demonstrated a device that projected succeeding hand-drawn transparencies on a screen. Called the Magia Catoptricia, Kircher's invention closely approximates the animated cartoons of today.

Peter Mark Roget, a medical doctor and famed author of the *Thesaurus of English Words and Phrases* made a study of pictures in motion in 1820, six years before Niepce and Daguerre came forth with their photographic developing and fixing process. Roget considered the possibilities of simulating motion after viewing a moving object through venetian blinds one day. To prove his point, he mounted drawings documenting the motion of an animal on the pages of a book. By flipping the pages, the effect of watching an image in motion was demonstrated. Roget presented his findings to the Royal Society, but no immediate practical inventions came out of his study.

Once photography came into practical reality in the 1830's, other inventors began looking for ways to exploit this new technology. One avenue taken by scientists was a method of reproducing photographs in natural color. Another was the simulation of binocular vision or creating the illusion of the third dimension. Yet another use was adapted to the new science--the study of motion by using a succession of still photographs. In both Europe and America, devices based on this newly discovered phenomena began to find their way into the homes of ordinary folk in the form of toys. Known as Zoetropes, they usually depicted the gait of a horse or the flight of a bird.

Leland Stanford, a railroad tycoon who founded the university that bears his name, subsidized the motion recording experiments of Eadweard Muybridge, an Englishman. In 1878, at Leland's farm in Palo Alto, Muybridge lined a stretch of track with twelve cameras spaced twenty-one inches apart. Trip wires were stretched across the track, and when the horses' hooves broke the wires, the pictures were taken. The result of his study was a device called the Zoopraxiscope. This device used a rotating drum with slots cut in it at intervals and the frames of still pictures pasted to the inside of the drum opposite the slots. Later, Muybridge continued his study of motion at the University of Pennsylvania. In February 1888, while lecturing in West Orange, New Jersey, Muybridge met with Thomas Edison in his laboratory where they discussed the problem of adding moving pictures to recorded sound. Edison indeed put together a device which printed microscopic pictures arranged on a disk alongside the accompanying circular record groove. The device failed for two reasons. The frames had to be microscopic in size to fit on a disk in any usable numbers. Also, they found it impossible to reproduce sound on a disk that had to be stopped and started forty-eight times a second, the number required to reproduce fluid motion. They quickly learned that this approach to sound film recording would never be practical. Coincidentally, that same year, George Eastman introduced the latest leap forward in still photography--roll film. Eastman's innovation allowed a picture to be taken, the film wound out of the aperture onto a holding spool, and then another picture taken right behind the first one. Previously, photography had been limited to only those who could afford the bulky equipment and expensive treated glass plates made famous by Daguerre. Eastman provided cameras, complete with a roll of film capable of taking ten pictures. He rented them for what now seems like a paltry sum of $1.00 a roll. When all the pictures were exposed, the user mailed the camera back to Eastman where the pictures were processed. Roll film made photography available to everyone, and immediately Edison saw how Eastman's film could be adapted to the photographing of live motion. Edison punched holes in the edge of Eastman's roll film at regular intervals. An eccentric cam and ratchet paw were used to alternately stop and then advance the film, positioning each frame for exposure. The film was then pulled past a revolving shutter with slits cut in it, creating successive frames of action one after another. The Kinetoscope camera took forty pictures a second and used film that was one and three-quarters of an inch wide. Four sprocket holes per inch were punched in the edge of the strip on either side.

In order to reproduce the pictures, Edison came up with a film band viewer also called the Kinetoscope, patented in 1891. An endless loop of film was pulled past the viewing port by a hand crank. The Kinetoscope viewer did not employ intermittent film advance as did the camera, which caused noticeable flicker because the aperture could only be open for the briefest part of the frame. Despite this flaw, Edison's invention was hailed as a modern miracle. Edison demonstrated his device to a delegation from the Women's Club of America convention who visited his laboratory, and news accounts of the day reported that the ladies were favorably impressed. The film showed an Edison employee bowing and waving. Edison later adapted Muybridge's pictures in yet another film. His need for fresh subject matter, however, prompted him to build a studio at his laboratory complex in West Orange.

In 1889, under the direction of his chief photographic expert, William Kennedy Laurie Dickson, Edison constructed a tarpaper shack with sliding roof panels that rested on a turntable mounted on axles with wheels. The structure could be spun completely around, allowing them to take advantage of the sunlight no matter what time of day it was. At the same time they eliminated the need for artificial light. Dickson recruited Edison employees as actors for his first films. Later, he would hire circus and variety performers as subjects for cinematic treatment.

In 1894, Edison opened his first Kinetoscope Parlor in New York. There, lined on either side of the hall were several viewing machines which could be operated for a nickel. The parlor was a smash success, prompting Edison to build nine-hundred Kinetoscopes over the next two years.

That same year, a new inventor came to the forefront of the technological world--C. Francis Jenkins. Jenkins, in 1894, attempted to reinvent Edison's Kinetoscope by substituting a revolving light bulb in place of Edison's revolving shutter. Though different enough to receive a U.S. Patent, it represented a step backward in the solution of motion picture taking and viewing problems. In partnership with Thomas Armat, a fellow student at the Bliss School of Electricity, Jenkins married Edison's viewer with what was commonly known as a Magic Lantern, a lamp backed with a reflector which effected a high concentration of light onto a relatively large surface. Like motion pictures, the Magic Lantern appeared first as a toy, a device which projected silhouettes of hand puppets on the wall where they appeared several times larger than they actually were. Eventually, the Magic Lantern was applied to the enlargement of still photographs. It logically followed that someone would adapt this principle of focused light to motion pictures as well. Jenkins and Armat entered into an agreement to develop such a device in 1895. Edison had already attempted large screen projection, but without success. Jenkins and Armat built a machine that same year, but it worked somewhat less than satisfactorily, according to Armat's own personal account of the era. Jenkins remembered it differently, claiming in letters to friends that the machine performed perfectly. Armat terminated his agreement with

Jenkins and then set out to redesign the pulldown and shutter mechanism. The result of his work was the Geneva Cross movement, the solution to the problem of illuminating a film for relatively long periods of rest for exposure and then a brief interval of blanking out the light while advancing to the next frame.

Armat successfully demonstrated his machine at the Cotton States Exposition in Atlanta, Georgia in 1895. The projector's maximum speed was twenty frames per second, so the Edison films that had been shot at forty frames per second ran in slow motion. The machine was never successful commercially, but it did manage to catch the imagination of the public, including executives of Edison's company.

More interesting, however, was the path taken by Jenkins. He was to become the first inventor to successfully broadcast television pictures using radio waves, though nearly thirty years would pass between his invention of the theater projector and that of his television system.

9

Whirling Disks--Flickering Images

Schemes to effect the transmission of images to distant places were suggested by scientists Bain in 1842 and Bakewell in 1847. Dubbed "seeing by electricity", their proposals established the principle of sequential picture element scanning (the orderly process of dissecting a picture into small pieces) that was the basis of early facsimile transmissions and ultimately the first principle of television -- that a picture could be sent over wires or through the air as a series of time-space voltage variations which could be sensed and reconstituted in exact replicate form. Other solutions to the problem of picture transmission were tried by scientists, however, before time-sequential picture element scanning methods were finally adopted to "see by electricity".

One such system was proposed by George R. Carey of Boston, Massachusetts, in 1875. His machine imitated the human eye, having a square grid of light sensitive selenium cells connected to a similar bank of electric lamps, each corresponding in horizontal and vertical position to their sister pickup cells and each pair connected by a discreet wire. Fundamentally, Carey's idea was sound, but it quickly became apparent that the number of wires necessary to send a picture of any appreciable definition precluded any widespread application of this system. However, this early picture transmission system would later find its niche in the illuminated sign industry in the form of travelling billboards.

In 1881, Shefford Bidwell of England successfully sent a photograph over a telegraph wire using synchronized, phonograph-like disks. The pickup disk was coated with a substance that conducted electricity in proportion to the light value of each picture element. The disk was swept by a pickup stylus similar to that of a phonograph, and a voltage value was derived from each picture element. The receiving machine exposed a synchronized photosensitive disk with light equivalent to that sensed on the pickup disk. When photographically developed, an exact replica of the original picture was reproduced. It was obvious, though, that live moving images could never be transmitted using such a device. Bidwell's machine represented a step forward in the solving of image transmission problems, but was quickly supplanted by the invention that would dominate television research for the next fifty years -- the Nipkow Disk.

Very little is known of the man who made the first crude transmission of live images possible. Paul Gottlieb Nipkow was a student at Berlin University in the 1880's. Based, no doubt, on the toy pinwheels that were popular with children in Europe at the time, Nipkow adapted the principle of the spiralled spinner to sweep out a field with a beam of light in an ordered, cyclical pattern. His device was a disk with a number of holes punched equidistant from each other around its circumference. Each hole was equally sized, and each succeeding hole was displaced further outward by the factor of the hole height. When spun rapidly through an aperture, the opaque disk became temporarily transparent even though only one hole was passing through the aperture at any one time. A selenium cell, located behind the aperture, would conduct a current proportional to the light reflected from each picture element. The current in turn, would drive a lamp mounted behind a sister disk which spun in precise synchronization with the pickup device, thereby reproducing the pattern. Unfortunately, selenium proved to be too slow acting to make the transmission of moving images, much less live images, possible. Some historians suggest that Nipkow built a model of his system, but no transmissions were ever made with his device. Nipkow received a German patent on his system, spawning a legion of imitators, all putting forth a variety of methods for picture transmission based on some method of image dissection.

Inventor Senlecq of France borrowed Carey's mosaic grid and added to it a synchronized distributor at both transmitter and receiver. Using a distributor system, the light value of each picture element was read in sequence and then transmitted one at a time to the receiving grid where the image was reconstructed. No prototype of this system was ever built.

In 1906, Professor Max Dieckmann of Germany patented "A Method for the Transmission of Written Material and Line Drawings by Means of Cathode Ray Tubes." He used Nipkow's Disk as his pickup device. His cathode ray tube reproducer was described as having "deflection modulation and magnetic deflection for both directions of scanning", which is essentially the method used for reproduction today. Dieckmann built and successfully transmitted by wire simple shapes in his laboratory. The success of Dieckmann's system was made possible by the advent of the vacuum phototube, a device capable of tracking the rapidly changing light levels presented by the scanner, but no practical application was immediately made of his invention.

In 1907, Boris Rosing, a lecturer at the St. Petersburg Institute of Technology, patented yet another method of dissecting a picture for sequential transmission. His scheme used two segmented mirror drums. The first drum was spun rapidly and the second disk rotated slowly in the opposite plane. By directing a beam of light onto the rotating mirrors, a flat rectangular field was scanned sequentially, left to right, top to bottom, and line by line. The light value reflected off the subject was picked up by a primitive photoelectric tube, and a fluorescent-screened cathode ray tube was used to display the reproduced images. In 1912, Rosing dropped his image transmission project after he determined that a mechanical device would never be practical for live image pickup. According to the official history of television as recorded by the Society of Motion Picture and Television Engineers, Rosing built a prototype, but it apparently was never demonstrated publicly. Rosing's contribution to the ultimate mastery of television, however, was to be far more substantial than this latest approach to mechanical picture dissection. Each year, Rosing selected a student to be his personal laboratory assistant. In 1912, he selected a twenty-year-old lad from Mourom, Russia named Vladimir Zworykin. The son of a prominent industrialist, Zworykin showed great aptitude for image transmission research, and soon mastered every aspect of Rosing's system. Little did Rosing know at the time that fifteen years hence Zworykin would successfully develop all-electronic television. In 1914, however, electronic image transmission efforts seemed at a standstill in St. Petersburg, and Zworykin departed Russia for Paris to study the phenomena of X-rays with Professor Paul Langevin. Once again, development of television waited for other inventors to bring it out of the laboratory and into practical use.

At this juncture, two new inventors stepped into the scene: Charles Francis Jenkins of Washington, D.C., and John Logie Baird of Scotland. Working independently of each other, the two began construction of practical television pickup and reproduction systems beginning sometime around 1910.

Charles Francis Jenkins was making his second thrust at picture transmission. In 1894 he had proposed a system already suggested by Senlecq of France. This system combined Carey's selenium cell grid with a synchronized distributor at both pickup and receiver. No prototype of that system was ever made, but Jenkins did later use the rotor distribution principle in one of his receivers.

Born to Quaker parents in rural Ohio just after the end of the Civil War, Jenkins was ripe to be plucked up by the Industrial Revolution. Self-described as a career bureaucrat who retired at age twenty-eight to become an inventor, Jenkins turned all of his energy to the invention of optical-electrical machines. Most of his inventions, however, were based on the ideas of predecessors or combinations of already existing inventions. In 1896 he had succeeded in co-inventing the Motion Picture Projector. It was his idea to marry the Magic Lantern to the Kinetoscope. However, virtually all of his other designs to reproduce motion pictures were inferior to those which already existed. Credited with sending the first Radiophoto, Jenkins had merely combined Bidwell's sequential scanning of a photograph with Marconi's wireless radio transmissions. His optical research, however, eventually did yield an innovation that ultimately resulted in a working television system. Jenkin's Prismatic Ring was yet another variation of Nipkow's Disk and Rosing's Mirror Drum. The ground glass plate employed a constantly narrowing plane angle of its radial dimension. When rotated and placed in the path of a light beam, the light would be focused into a narrow flat beam. As the plate was rotated, the ever decreasing angle of the glass caused the light beam to travel downward across a field. A similar plate, fixed at a ninety degree angle to the first and travelling at a speed several times that of the first would effect the sequential scanning of a field left to right, top to bottom.

Jenkins used a system based on the Prismatic Rings to transmit still photographs with great success in 1922. Then, having mastered the transmission of still pictures, he began seeking a method of transmitting motion pictures and live images. Whether by design or good fortune, Jenkins was allowed access to the U.S. Navy's experimental radio station, NOF, Washington. His system to transmit live pictures used fifteen frames of 48 lines each second. No provision to broadcast audio simultaneously with the pictures was made. However, at this period in history even motion pictures did not have sound so it is not surprising that he did not include an audio channel. His pickup apparatus consisted of four prismatic rings which threw the scanning beam of light onto the subject. Beyond the subject was a screen, and beyond that was the phototube. One original innovation introduced by Jenkins was the production of the amplitude modulated carrier by optical rather than electrical means. Jenkins, using a slotted disk that was spun at a predetermined rate in front of the pickup device, effected an amplitude modulated sinusoidal carrier wave ready for power amplification. Jenkins' apparatus indeed transmitted silhouettes with remarkable clarity. Films looked much better, but his system, called "Radiovision", lacked the ability to pick up live images with photographic clarity. Jenkins' demonstrated his video transmission system to government officials in his office in June of 1925 and it was reported on the front page of both of Washington's newspapers. Here follows the original account from the "Sunday Star" June 14, 1925:

> *"Radio vision," long the fantastic dream of science, became an accomplished fact yesterday afternoon, with Secretary of the Navy, Wilbur and other high government officials witnessing the feat.*
>
> *With the aid of a remarkable apparatus invented by the Washington scientist, C. Francis Jenkins, the Secretary of the Navy, Dr. George M. Burgess, director of the Bureau of Standards; Admiral D. W. Taylor, Capt. Paul Foley of the Naval Research Laboratory and others actually "saw" by radio an object act in motion several miles distant in front of a "radio eye" installed at the Naval Radio Station, NOF, Bellevue, D.C.*

Interest in Jenkins' Radiovision was piqued, especially after Jenkins promised that, soon, people might be able to watch a live performer in the same fashion they were accustomed to hearing them on the radio. Jenkins published the plans to construct a receiver, which he dubbed the "Radiovisor", in several amateur radio journals.

Being little more complicated than radios of that era, such a receiver could be constructed in a week for less than twenty-five dollars. Using the frequency band just above AM radio, his signal had a bandwidth of 100 kilocycles. Using this range of 4,900 to 5,000 kilocycles, Radiovision signals travelled much farther than video signals of today. Radio enthusiasts as far north as Massachusetts and as far west as Detroit built Radiovisors and received moving pictures in their homes. Regular broadcasts began on July 2, 1928. Jenkins used live actors and filmed presentations:

> *At this writing thousands of amateurs fascinatingly watch the pantomime picture in their receiver sets as dainty little Jans Marie performs tricks with her bouncing ball, Miss Constance hangs up her doll wash in a drying wind, and diminutive Jacqueline does athletic dances with her clever partner Master Fremont.*
>
> *Jenkins. Radiomovies, Radiovision, and Television. 1928.*

A craze was born, and the giant electrical manufacturers of the United States became interested in adapting these crude yet enchanting images to radio broadcasting which was then in its boom. In 1927 the Bell Telephone Laboratory developed a Nipkow inspired system in a two-way arrangement with an accompanying telephone link. Herbert Hoover, who was then Secretary of Commerce, made the opening remarks at their first transmission. Then came a vaudeville skit featuring a burlesque comic named A. Dolan who told Irish jokes and "darky" jokes in blackface on a telephone link between Washington, New Jersey, and New York City. The Radio Corporation of America and General Electric entered television in 1928. David Sarnoff, radio broadcasting's mentor, appeared on G.E.'s Schenectady station W2XCW, on its inaugural telecast. Sarnoff envisioned doing with television what he had done with radio in the past five years. Spinning Disk receivers went into production in that same year, selling for $75 each. What followed was a year of "firsts".

There was the first televised play, the first outdoor telecast, and the first televised political speech. The television programming at first was mostly radio with pictures. Words were spelled out on the screen and the packages of products were shown along with the message being broadcast simultaneously on radio. Close-ups of live actors, cards, or still pictures were sent. Outdoor scenes were filmed and then scanned for transmission. The receiver screens were three inches across, and the color, while monochromatic, was orangish-red. Set sales were brisk, prompting David Sarnoff to apply for a station license in New York. Sarnoff's Radio Corporation of America received permission from the Federal Radio Commission to operate W2XBS in New York City in the fall of 1928. The now legendary animated favorites Mickey Mouse and Felix the Cat became the first "stars" of RCA's station using yet another system based on Nipkow's Disk. Much of their popularity today can be attributed to the fact that Mickey Mouse and Felix the Cat, having large areas of light and dark with few halftones, were excellent subjects for transmission with this early system.

While television caught on quickly in the U.S., development went on at a somewhat slower rate in Europe. Pioneers in France, Germany, Holland, and Great Britain were at work designing and building television apparatus.

John Logie Baird of Scotland emerged with a working television system in 1922. He embarked on his quest to invent television after failing at a succession of enterprises which included paper sock manufacturing, fruit jam manufacturing in the West Indies, and a near disastrous attempt to invent a glass razor. After cutting himself severely, Baird gave up the idea and embarked upon research in the new field of electronic image transmission.

Baird set up makeshift apparatus in a rooming house and later a rented room in Queen's Arcade, Hastings sometime during 1922. He made his Nipkow inspired disks out of the cardboard top of a hatbox. The other parts of his machine were made of an army surplus telegraph, a tea chest, lenses, a fan motor, sealing wax, glue, darning needles, flash light batteries, valves (vacuum tubes), transformers, string, electrical wire, and wood. The disk's spindle was a darning needle and was spun by bobbins. He mounted the transmitting end of his system on a washbasin. The receiver was mounted on a tea chest nearby. Baird's work came to the attention of the public literally by accident. One day in the spring of 1923, he succeeded in transmitting shapes and letters on his crude system. That same day, Baird nearly electrocuted himself on his own machine. He was found unconscious by his landlord the next morning. When his landlord found out what the nature of Baird's experiments were, he evicted him immediately. Baird's accident and subsequent eviction made newspaper headlines which brought his work to the attention to the public. Because of the publicity, he was able to obtain financial backing, and with the money he built a much sturdier model of his system. However, when Baird attempted to demonstrate his brainchild in a London department store, it would not work. His backers deserted him. Baird, undaunted, started over from scratch with the financial help of some cousins in Glasgow. On October 2, 1925, he successfully televised over wires a faithful halftone view of a teenage boy named William Tayton. Baird plucked the boy out of a nearby office and paid him half a crown to pose in front of his pickup device. Baird demonstrated his pickup system to several members of the Royal Institution on January 27, 1926. An interesting historical footnote was written when one of the visiting Institution members caught his beard in Baird's machine. Once again, disaster was narrowly averted, and, later that same day, the gentleman was treated to look at himself on the latest marvel of the Industrial Age -- television.

Baird, like his counterparts in America, sought to make television the companion of radio, a pictorial information and entertainment medium. He approached the BBC about transmission of television programs. In Great Britain, the Radio industry was nationalized and private individuals could not broadcast radio programs. The BBC was not interested in entering the new field and rejected Baird's proposal. British subjects were outraged at the BBC's position and lobbied Parliament to permit television broadcasting. The BBC was ordered by Parliment to begin experimental transmissions. Using Baird's equipment, tests began September, 1929. Baird designed a variety of mechanical pickup and reproduction machines, most based on the Nipkow Disk and Rosing's Mirror Drum. The problem of capturing outdoor scenes with photographic clarity was overcome when engineers Hartley and Ives of Electrical Research Products (Company) interposed a film camera between the subject and the television scanning disk. This method employed a continuous loop of film that was exposed in a motion picture camera and then immediately conducted to a developing tank. Passage through the necessary chemicals took less than one minute because the negative could be scanned as easily as a positive print by inverting the signal voltage of the phototube. Then, the mechanical scanner would break each frame into serial bits for transmission as before. Baird adapted the intermediate film link to both sending and receiving stations, reconstituting the transmitted image on photographic film for projection on a theatre-sized screen.

Jenkins and Baird had succeeded in introducing television to the world, but technological advancements rendered their systems virtually obsolete from the day they began broadcasting. In England, the BBC signed off its experimental Baird mechanical transmissions in 1935. In August, 1936, they returned to the air using all-electronic television. Baird was hurt by their decision to drop his system, but he went on experimenting. In 1941, he successfully transmitted color pictures using synchronized color filter disks, an advance the new electronic method could not match.

In the United States, the Great Depression of 1929 sealed the fate of early television. Set sales slackened, and no new stations were built.

By 1930 all but one of the twenty-seven stations licensed to broadcast television programs had shut down their transmitters. The advent of an all-electronic means to transmit and receive high-resolution pictures signalled the real end of early television. The cost of all-electronic equipment was prohibitive, and for the next five years only RCA would continue to operate a television station.

10

The Electronic Eye

By 1930, mechanical pickup devices had been exploited to their maximum potential, and while adequate to reproduce live scenes when mated with an intermediate film link, advances in the art of vacuum tubes promised to make these earlier methods obsolete. This latest branch of electronic experimentation first rendered an experimental camera in the early twenties, but ten years would pass before such devices were perfected enough to outperform mechanical systems and another five years would pass before all-electronic video pickup would become the standard of the art.

Two such vacuum tubes were perfected in the late 1920's by different scientists in the United States: Philo T. Farnsworth of San Francisco and Vladimir Zworykin of New York. Though they worked independently of each other, their research took a similar course, which would later result in a long legal battle over the patent rights to the television pickup tube. Both scientists built systems based on methods suggested by A. A. Campbell Swinton of England in 1907. Swinton's method, which never reached the prototype stage, was called "Distant Electric Vision". In it, modified cathode ray tubes were used to both pick up and display live pictures. The first camera tube to find widespread practical application was the result of work by a Utah farm boy *cum* scientist, Philo T. Farnsworth.

In the early 1920's Farnsworth began television research in a San Francisco laboratory. Based on Swinton's proposal, Farnsworth produced his Image Dissector, a vacuum tube equipped with a photoemissive plate. A high velocity electron beam shot from the tube's cathode swept out an orderly scanning pattern of two-hundred lines, fifteen times each second. Changes in brightness of each picture element caused changes in the potential on the rectangular photoemissive plate. The negatively charged beam was changed in value according to the brightness of the picture elements. A detectable signal was sensed by the anode of the tube and amplified for transmission. Farnsworth's tube was a step in the right direction, but still was unable to pick up live scenes with photographic clarity. The high velocity beam dictated that large amounts of light were needed to render a usable signal level. Therefore his tube would only work under extremely intense illumination, making the Image Dissector less desirable for live pickup. In conjunction with Bell Laboratories, Farnsworth later adapted his Image Dissector to film pickup where it performed quite well. In an interesting twist, Farnsworth employed a mirror-drum reproducer based on Rosing's design because he also was unable to solve the beam focus problem inherent in cathode ray viewing tubes. His system, completed in 1927, was unique in that it was the only one in the United States ever to use electronic means for pickup and mechanical means for reconstitution. Development of a satisfactory cathode ray viewing tube proved to be one of the most exacting technological challenges ever to confront science.

The cathode ray television tube was a spinoff of an earlier invention, the oscilloscope, invented in 1903 under the name "Oscillograph" by Dr. C. F. Braun which used a fluorescent-screened vacuum cathode ray tube invented by William Crookes of England in 1878. The oscilloscope allowed electronic engineers to see the effects of various electronic circuits by displaying voltages in a specified time frame. Boris Rosing adapted

Braun's tube for a display device in his system built in 1911, but having yet to find the solution to beam focus, pictures obtained with his tube were very poor.

Although the cathode ray tube had been around for nearly twenty years, no one had yet successfully built one that could outperform already existing mechanical reproducers. Critical to the use of such a tube for video display was the decay time of the phosphor coated face. If the decay time was too short, the image would have an annoying flicker. And if the decay time was too long, successive frames would "paint" over the already glowing phosphor spots, causing the picture to "stick". The quest to adapt the cathode ray tube to television reception was undertaken by Vladimir K. Zworykin.

As a boy in Russia, Vladimir was something of a child prodigy. He showed an intense interest in science by apprenticing himself to his professors who in turn allowed him access to the school laboratory. His father, an influential industrialist in Mourom, sent Vladimir to the Institute of Technology at St. Petersburg to study the then new field of electronics. There, he enrolled in the class of Professor Boris Rosing. During this period, Rosing had filed patents for his partly mechanical television system. Rosing selected the apt Zworykin as his personal lab assistant, and under his tutelage, young Vladimir learned the principles of image transmission. In 1912, Rosing dropped his television project when he realized mechanical scanning methods were inherently limited. Zworykin, who had become extremely interested in electronic imaging, went on to Paris to study X-Rays under Paul Langevin at the College de France.

War interrupted Zworykin's studies abruptly in 1914 when he was drafted into the Russian Signal Corp. During his service, he learned the practical applications of radio. After the war, political unrest ripped the social and economic fabric of Russia, and Zworykin decided to flee his native land.

In 1919, he landed in New York with almost no money and speaking little English. He worked at odd jobs, and studied English in his spare time while looking for employment in the electronics industry. Ten months after he arrived in the United States, he landed a research assistant's position at Westinghouse Laboratories. One year later he left that job to work for an oil company on a project to effect the cracking of gasoline by electricity. Within eighteen months, he was back at Westinghouse working on an electronic means to transmit moving pictures. The Westinghouse Board of Directors appropriated money for Zworykin's image transmission system in 1922. One year later, Zworykin filed his first patent for the Iconoscope pickup tube. The Iconoscope (image viewer) used a low velocity beam and the electron storage principle to pick up live scenes with fine detail under average light. By 1924, Vladimir had built a prototype, but the cathode ray viewing tube was incapable of reproducing the fine detail of the Iconoscope. The Westinghouse executives were disappointed. Mechanical transmission methods had nearly matured, and the proposed cost of refining Zworykin's invention seemed astronomical.

Though no one knew it at the time, 1929 was the turning point in Zworykin's quest to perfect an all-electronic television system. Early in 1929, David Sarnoff of RCA hired Zworykin away from Westinghouse and put him to work building an all-electronic television prototype. That year, with the backing of RCA, Zworykin patented his Kinescope viewing tube which employed electrostatic beam focusing and fast decaying phosphors. He demonstrated his all-electronic system using the Iconoscope tube for pickup and the Kinescope tube as a receiver to the convention of the Institute of Radio Engineers in November of 1929. Even though this latest version of his system was much improved over earlier attempts, the live scenes still required high levels of illumination to effect a usable signal and the picture had a tendency to "stick" (an image would remain on the screen even after the camera had panned off--this actually a flaw of the camera). Given the economic circumstances of the time, it is not surprising that the corporate giants of the radio industry didn't rush to acclaim Zworykin's system. The stock market crash had happened only days before. The radio magnates knew implementation of Zworykin's system on a par with radio would require millions of dollars in capital investment with no certainty that enough sets could be sold to recover their costs. Only RCA committed their resources to development.

The RCA Television Project

January 3rd, 1930, two months after the Stock Market Crash of 1929, David Sarnoff was voted President of RCA. By the end of that same year, RCA began to feel the effects of the depression when radio set sales dropped off by over fifty-million dollars. In spite of the flagging economy, Sarnoff provided Zworykin with a laboratory, fabrication facilities, and technical assistants to build the complex system he had designed. After three years of work, Zworkin's system was ready to be tested in the field. Zworykin described the system in his book, Television: the Electronics of Image Transmission:

> *....These tests were carried out at Camden (New Jersey), using a video transmitter with a carrier frequency of 49 Megacycles. The accompanying sound was transmitted at 50 megacycles. The studio from which the picture signals originated was located about 1000 feet from the transmitter and connected to it by a coaxial line. Iconoscopes were used to pick up scenes both in the studio and out-of-doors. A scanning pattern of 240 lines made it possible to obtain a picture with good definition, but as the frame frequency was 24 cycles, without interlacing, flicker was quite noticeable.*
>
> *The following year the number of lines was increase to 343, and an interlaced pattern having a field frequency of 60 cycles and a repetition*

> *rate of 30 frames per second was adopted. The results of these tests were so satisfactory that it was decided to continue them in their (RCA's) New York City studio (probably 511 Fifth Avenue, the site of earlier RCA tests using a mechanical scanner)....*

On June 29th, 1936, experimental transmissions were made over RCA's channel from their station atop the Empire State Building. The pictures were beamed by microwave from a studio located in the recently completed NBC Radio City Studios at 30 Rockefeller Plaza in New York City. The studio took the essential form that we commonly see today, cameras on wheeled dollies controlled from a separate room by directors and engineers. One hundred receivers were placed in various locations throughout New York City and many modifications and refinements were made both to the transmission and reception equipment as more was learned about the new art.

On July 7th, 1936, David Sarnoff presided over his second inauguration of Television in a telecast which featured comedian Ed Wynn. No sets were offered for sale, however. The United States government had banned commercial television, and Sarnoff did not want to risk failure again by selling sets only to have nothing but test patterns to watch on them.

As the dollars slipped away without the realization of tangible results, Sarnoff kept the television dream alive with constant pleas before the RCA Board and the United States Federal Governnment. In 1935, he had announced that RCA would spend $1,000,000 to bring television into the homes of ordinary people. The cost of performing this feat, however, ran into ten times that figure before W2XBS went on the air with all-electronic transmissions. In order to keep interest in the new medium alive, Sarnoff held frequent demonstrations for the press, and in 1937 two mobile vans capable of sending live pictures to the studio from as far as twenty-five miles away were put into service.

Sarnoff envisioned Television as the visual counterpart of Radio, local stations broadcasting pictures from a single source by use of telephone lines between the studio of origin and the individual cities. To that end, American Telephone and Telegraph Company engineers designed a new type of cable to carry the superhigh frequencies necessary for high-definition transmission. Other companies, using RCA equipment, put stations on the air in other cities. Philco, the radio manufacturer, went on the air with its W3XE in 1937, linked to RCA's W2XBS by AT&T's cable. CBS, which had also ventured into mechanical television in the 1920's, reactivated its New York City station W2XAB. Allen B. DuMont, a former assistant of C. Francis Jenkins, announced plans to build television pickup, transmission, and reception equipment as well as establish a national network. General Electric likewise returned to the air with all-electronic transmissions in Schenectady. Programming was noncommercial, usually consisting of live coverage of political conventions or parades. Only one camera was used for these early telecasts, and commentary was sparse. Still, no sets were offered for sale.

Much disagreement surfaced over the standards to be used. The more lines used, the greater frequency space a channel would occupy. If broadcasters chose a higher line rate, fewer channels could be designated. Fewer channels meant fewer transmitters. The Radio Manufacturers Association set up a committee to coordinate the various makers of television equipment and formulate a single standard for all to follow. They recommended the line rate be increased to 441. Seven channels of six megacycles each were designated from 42 megacycles to 90 megacycles. In 1938 a new transmission method called Vestigial Sideband Filtering permitted much greater picture definition without increasing the bandwidth requirement. By 1939, RCA felt it was ready to place receivers on the market.

Sarnoff officially unveiled his Radio Manufacturers Assoication based television system at the 1939 New York World's Fair. Already established receivers in New York as well as several placed throughout the fairgrounds televised Sarnoff as he once again introduced television to the world. But some radio industry executives disagreed with the RCA's standards, and because of their inability to come to an agreement on the line rate, the FCC refused to license commercial stations. In order to resolve the manufacturers' dispute, the National Television Systems Committee was formed under the sponsorship of the RMA. The committee consisted of engineers from most of the major radio makers. Their goal was to select one final standard of transmission for all manufacturers. After several months of study, the NTSC committee submitted their recommendation to the FCC in March of 1940. In May of that year, the FCC adopted the NTSC 525 line, 30 frame system using vestigial sideband transmission on a six megacycle channel as the official television system of the United States. Commercial television broadcasting was set to begin in July, 1941. Sarnoff and the other radio manufacturers began preparing their factories for production. On May 27th, six weeks before commercial telecasting was to commence, President Roosevelt declared a national emergency because of the escalation of the war in Europe. All television licenses were suspended. America's radio factories were converted to build radio transmitters and receivers for the Allies. Sarnoff was drafted into the Army at the rank of General and placed in charge of military communications. The cameras and transmitters were turned off. The military equivalent of television was the infrared snooperscope, and Zworykin went to work on that. The television blackout in America would last three years.

In Europe, both England and Germany made the conversion to all-electronic pickup an reproduction in the mid-1930's. Baird shifted the emphasis of his work to reproducing faithful color, once again resorting to a whirling disk, this one ringed with color filters in sequence. Hitler's television crews televised the Munich Olympic Games using both the intermediate film system and the new all-electronic system simultaneously in August of 1936. The Reichs Rundfunk telecast the

Games to 28 viewing rooms in major German cities using three cameras operating out of two mobile vans. After the war broke out, Hitler used his television system to entertain the wounded. Receivers were placed in hospital wards where the troops were treated to musical extravaganzas and newsreel coverage of the war. Allied bombing put Hitler's Berlin television transmitter out of business on November 23, 1943. However, German controlled telecasts continued from a transmitter located atop the Eiffel Tower in Paris until August of 1944 when it was liberated by the Allies.

The end of World War II signalled the beginning of television on a large scale.

11

The Rise Of Television Networks

While the establishment and operation of television networks in Europe was undertaken by the governments of each nation, in the United States the government opted not to involve itself in the construction of television stations, limiting its role to that of regulating channel assignments and operating power. It was then left to American business to take the fledgling technology from scientific accomplishment to practical implementation. The cost of building and operating television stations was enormous, even in the mid-nineteen-forties. In the beginning, only the giant electronics manufacturers could afford the exorbitant price tag of station construction. RCA, Philco, General Electric, and DuMont built stations in the cities of New York, Philadelphia, Schenectady, and New York respectively. The Columbia Broadcasting System, a subsidiary of the Columbia Record Company, was the only non-electronic manufacturer to enter the field. Regardless of their origins, the one problem all the new networks had in common was programming. Hollywood, an obvious source of high-quality entertainment, wanted no part of the new medium. Movie executives perceived television as a threat to the motion picture industry, and the major studios refused to let their films be shown on television, that even in spite of the fact that some of the first stations to go on the air were owned by motion picture companies. At that time, the studios owned most of the theaters, and motion picture executives feared that television might siphon off part of their audiences. That left sports events and so-called "specials" (parades, political conventions, and breaking news stories such as fires, etc.) as the most readily available television subject matter. These events were good material for the camera, but hard for stations to find sponsors who would pay for their airing. Programmers wanted familiar characters and settings that viewers could return to day after day. Like radio before them, they wanted to build a pattern of daily or weekly viewing to ensure consistent audience ratings. Cast in the same mold as the radio networks a decade earlier, these services provided comedy and music programs featuring renowned performers carried by special telephone lines (and later microwave radio transmitters) to cities throughout the country where affiliated local stations would broadcast them. This proved to be a convenient arrangement for local station operators who were paid by the networks to carry their shows. These programs featured top Broadway and Vaudeville talent, acts that local stations would have been unable to offer their viewers on a regular basis. NBC Radio and CBS Radic were the first to venture into television programming, adapting their already successful formats of sportscasts, game shows, dramas, and musical programs from radio for presentation on the small screen.

NBC operated two radio networks, known as NBC Red and NBC Blue. In 1941, the newly renamed Federal Communications Commission ordered NBC to divest itself of one of its radio networks in the interest of future industry growth. NBC fought the ruling in the courts for two years. After exhausting every possible appeal, however, NBC was forced to sell its Blue Network. In October, 1943, Edward J. Noble purchased NBC Blue for eight million dollars. He renamed the network the American Broadcasting Company, and when ABC entered the television business in 1945, they became the fourth entity to mount such an operation behind NBC, CBS, and DuMont. Far from what we see on network television today, when the four major television companies began operations in earnest in 1945, programming consisted of perhaps two or three programs presented on one night of the week, with each network taking a different night. By 1947 NBC, CBS, and DuMont were programing shows on three or more nights a week, and viewers could choose from two or three shows in some time periods. NBC and CBS, who appeared to have the advantage over the others with their readymade stable of talent, were surprised when the relative newcomer DuMont won the first ratings sweep ever taken with *The Original Amateur Hour* hosted by Ted Mack. Meanwhile, ABC started its network service with a serious handicap because the wartime licensing freeze imposed by the FCC prevented them from owning even a single station to carry their programs. As an interim measure, ABC programmers used the facilities of General Electric and DuMont to produce their programs (the few they had).

Just as network television became popular, two stumbling blocks were thrown in its path. In January, 1945, James C. Petrillo, President of the American Federation of Musicians, placed a total ban on AFM members performing on television. Petrillo had earned a reputation as a tough negotiator in the late Thirties when he nearly crippled American radio with a prolonged musicians strike. He charged that the radio networks had signed musicians to low-paying contracts during the depression and then refused to share the wealth when prosperity returned. When television began, Petrillo refused to allow his musicians to perform on television until (as he put it in his own words), "We...find out first where TV's goin'!" Without live music, television lost one of its most potentially successful formats.

Another setback was delivered television broadcasting in 1948 when the Federal Communications Commission put a freeze on new station licenses. Because of the FCC's decision ten years before to allow only thirteen channels on the VHF band, stations on the same channel in adjacent communities were already interfering with each other. When the freeze was imposed on September 30, 1948, thirty-seven stations were in operation in twenty-one U.S. cities. Eighty-six stations previously approved were under construction, and the FCC moved to prevent the signal interference problem from worsening. The freeze, which was to have been imposed for a few months, lasted three and one-half years while Congress wrangled over which frequency band television should occupy and how best to convert to color. Despite the freeze, RCA alone sold three million sets in 1949 and seven million in 1950. By 1949, the four television networks were running a full week of prime-time programming, and for the first time since they began, television viewership matched radio listenership. In spite of these advances, television had yet to turn a profit. As an industry, American television lost $26 million in 1949. Industry leaders were not discouraged, however. They realized that once the ban was lifted, television would take its rightful place with the other entertainment media. Already, TV (as it was dubbed by the press) had produced its first generation of superstars. Jackie Gleason of DuMont, Arthur Godfrey of CBS, and Milton Berle of NBC became tremendously popular, seemingly overnight.

When the freeze on television station construction was lifted in 1951, broadcasters rushed to put their stations on the air, and consumers flocked to the stores to buy receivers. Americans were so thrilled at having TV in their homes, they would even watch a test pattern if nothing else was on. On September 4, 1951, coast-to-coast television network service was inaugurated. Ninety-four stations in fifty-two cities carried President Harry Truman's address to the opening session of the Japanese Peace Treaty Conference in San Francisco. For the first time since its beginning in the mid-nineteen-forties, network television showed a profit. By the end of that same year ninety-five percent of American homes were receiving network service. Some of the fledgling Broadcasters soon learned, however, that even America had its limits as economics and logistics thwarted their efforts to survive as program suppliers. Only two networks, NBC and CBS, were available everywhere because the cable could only accommodate two signals at a given time. ABC Television managed to hang on by using Kinescopes until a system of microwave relays could be built across the country. The DuMont network was unable to sustain their early programming successes without the coaxial cable and ceased network telecasts in 1955. Since, then, many organizations have attempted to establish the so-called "fourth network", but so far none have been able to successfully mount such a service in the traditional broadcasting mold as NBC, CBS, and ABC did in the nineteen-fifties.

1955 marked the end of entertainment programs on radio as audiences forsook their radios for television in the prime evening hours. Radio was able to survive as a music and news medium while virtually all comedy and drama programs moved to television. Ten years after network television began, Hollywood's attitude towards the new medium changed, and eventually movie producers learned how to exploit television for profit.

In spite of its successes, however, television faced other problems. There were too few channels available, and a viable color system needed to be instituted.

12

To fully understand the implication of implementing a color television system, it is necessary to describe the operation of its components. All colors perceived by the eye are combinations of the three primary colors of green, red, and blue. To transmit color spectrum values it is necessary to separate the picture into its basic color components. This can be done in several different ways. One method involves the scanning of entire fields in one color. Succeeding fields of red, green, and blue flashed rapidly before the eye meld into a chromatic picture. Another system uses a device known as a dichroic filter, which separates the light reflected from a scene into its primary components and images them on three discreet camera pickup tubes simultaneously. The color values are then transmitted to the receiver by somewhat the same means as monochrome pictures are and replicated on a tube that likewise is capable of displaying the three primaries superimposed on each other. The former system is called Field Sequential Color Television, and the latter is known as NTSC Compatible Color. Modern computer and optical techniques have since provided several other methods of color transmission and reception, but in 1945 Compatible Color and Field Sequential Color vied for acceptance as the official television system of the United States.

The Advent Of Color Television

By the end of the fourth decade of the Twentieth Century, television had secured for itself a foothold in the world. The peoples of Europe, Asia, and America were rapidly becoming accustomed to seeing news and entertainment on the small screen. In America, television became so popular that the revenues of the film companies fell off. The response of motion picture producers to this new medium was to begin making their films in color, thereby offering audiences entertainment television could not match. The technology to print color film and send color television transmissions was available by 1940. However, where in film no redesign of camera or projection equipment was necessary to show color films, television pickup and reception equipment designed to televise monochrome pictures required substantial modification to reproduce color.

The first laboratory color television transmissions of still pictures were made in 1928 by John Logie Baird in England using his Nipkow Disk based system with yet another spinning disk fixed in front of the first; this one ringed with red, green, and blue colored filters in sequence. In operation, succeeding fields were transmitted in values of the color primaries. At the receiver, the picture was reconstituted by using the same sort of colored filter wheel, yielding faithful color reproduction. Baird's system, while basically sound, lacked the ability to send moving color pictures, even those already on film. faithful color reproduction using this approach required that the scene not change for three fields. Even the slightest movement of an object in a scene would cause the edges of that object to have a hue change at its fringes because in the time that lapsed between fields, movement would present yet another scene to the Nipkow scanner. The color values perceived from the first field scanned would still remain at the time when the third field was being scanned, rendering a hue shift at the leading and trailing edges of any moving object. The faster the speed of the moving object, the wider the fringe spread. Despite this seemingly prohibitive flaw, engineers attempted to adapt the color filter wheel to all-electronic cameras in the forties -- and very nearly made the process known as Field Sequential Color Television the standard in the United States.

Another approach to color television was introduced by David Sarnoff's engineers at RCA with the unveiling of their Compatible Color Television System and the Tri-color Kinescope beginning in 1946. Compatible Color had some advantages over Field Sequential. The three color primaries were each scanned every field, so the color fringing was not a problem. Also, the pictures could be viewed on a black and white television without any modifications to the receiver. But the available pickup tubes (the Iconoscope and Image Orthicon) were difficult to control, causing the image to bleed on moving shots and stick on bright objects. The makers of these two systems, both beginning the mid-1940's, were destined to battle each other in the courts and before the public for a decade to have their system named the national standard.

In the 1940's, RCA held the undisputed lead in television development, and its sister organization, NBC, likewise had come to the fore as America's premier broadcaster in both radio and television. As a network, their stiffest competition came from a similar radio network headed by William Paley, the Columbia Broadcasting System. Paley lead CBS from near extinction in the late Twenties to rival NBC in its number of affiliate stations, stars under contract, and audience shares in the Forties. Every possible advantage was taken to lure listeners (and later viewers) to one or the other of the competing channels, and the race to establish color television in the United States became yet another battle in their quests for network superiority.

By 1943, both CBS and NBC had invented competent mechanical color television systems. Both companies used RCA monochrome Image Orthicon cameras with segmented color disks mounted to the front. The field frequency was increased to 144 (48 color frames). This reduced the color fringing problem, but introduced two new problems. The increased number of frames required more frequency space to carry the information when transmitted. Also, the pictures could not be seen on a set that was designed to paint 60 fields a second. RCA dropped Field Sequential Color as a realistic solution to the color problem in 1945 and turned its attention instead to an all-electronic means along the lines of earlier monochrome cameras.

CBS, however, continued to perfect their mechanical color transmission system. In 1944, CBS executive Paul W. Kesten suggested that the NTSC adopt Field Sequential Color Television on the UHF Band as the national standard. CBS had only one station, located in New York City, and officially still considered television as experimental. Since they had little capital invested in equipment, they stood to gain a better foothold in the industry if Field Sequential Color was adopted. However, RCA, General Electric, DuMont, and Philco had already invested substantial sums in their monochrome cameras and receivers and stood to lose money if they were forced to scrap all their existing equipment. A legal battle ensued, first with the FCC, later in the courts, and ultimately before the public. Sarnoff staged a demonstration of an all-electronic color system in October of 1946. The camera used three Image Orthicon tubes, the latest improvement in pickup tube technology. The picture was projected on a screen by three beam tubes. The Tri-color Kinescope had yet to be invented. The demonstration was restricted to still pictures. The Image Orthicon tube had the flaw of image lag. If the camera were pointed at an object for a period of time and then moved, the image would "stick" for a second or two and then fade. And since the three tubes seldom responded the same way to changes in light value, the colors bled on moving shots, especially under intense light. This flaw was every bit as detracting as the color fringing was in Field Sequential Color.

The FCC wisely decided to postpone making any decision on color, citing lack of technological accomplishment in either system. Hearings were held by the FCC in both 1945 and 1946 where CBS and NBC became adversaries in what amounted to a lawsuit to award patent rights and governmental sanction to either CBS's Field Sequential Color or RCA's Compatible Color.

Like monochrome before it, Compatible Color was to be all-electronic, dispensing with the bulky whirling disks. In their scheme, live scenes were split into their primary components by use of a reflecting mirror. Then each primary color was scanned by a pickup tube and transmitted. At the receiver, the three pictures would be superimposed over each other with beam projection tubes to faithfully reproduce the variations in hue and shadow. RCA's cause was greatly aided in 1945 with the introduction of the Image Orthicon pickup tube invented in their laboratory by scientists Rose, Weimer, and Law. The Image orthicon was more efficient, allowing a greater depth of field, and was able to operate with less light. The tube lent itself well to use in RCA's simultaneous color system. The demonstration using still pictures in 1946 was most likely responsible for the FCC postponing again its decision to choose a color standard.

All the while, CBS continued improving its field sequential system, and in 1947 they once again petitioned the FCC to adopt Field Sequential as the national standard. The FCC once again deferred their decision. Both groups continued work. The most notable accomplishment by either research team was the invention by Zworykin's engineers of the Tri-color Kinescope in 1950. Several designs of a receiving tube that could reproduce color pictures were tried and discarded before RCA settled on the colored dot matrix tube that is found in more than half of existing color television sets today. In their design, three beams carrying the color information were focused through a pie shaped mask with thousands of apertures punched in its surface onto a screen coated with colored phosphors laid out in a symmetrical pattern. The aperture prevented the beams from landing on the wrong phosphors, and a picture in faithful colors was reproduced. It is interesting to note that RCA tested another type of tube, using an aperture grill in place of the dot matrix screen, but ultimately discarded the idea. Years later, Sony of Japan would reinvent the aperture grill tube and produce some of the sharpest and brightest pictures ever.

Sarnoff showed off the Tri-color Kinescope to reporters in October, 1950. The pictures, though better than before, still had some minor flaws. The Image Orthicon lag problem had not been solved. Comet tails trailing moving (particularly bright) objects gave the pictures a blobby quality. The FCC apparently was unimpressed. That same month, they adopted CBS's Field Sequential Color System as the national standard. Sarnoff, who had invested $20 million of RCA shareholders' money in color development, filed a suit in Federal Court to enjoin CBS from instituting its system. After seven months of deliberation, the Supreme Court upheld CBS's system and Field Sequential Color Television became the official system of the United States.

The first telecast in Field Sequential Color originated from CBS's Grand Central Station Studio in New York at 4:30 p.m., Monday, June 25, 1951, featuring Arthur Godfrey as host. Thirty receivers equipped to receive field sequential color pictures were situated in various locations around New York City. The telecast was also carried on the CBS stations in Boston, Philadelphia, Baltimore, and Washington, but the program was seen by less than one-thousand people all totalled. Those with conventional black and white sets could not see the program at all, and by the next morning, it was apparent to everyone that Field Sequential Color was not going to take the world by storm. The United States was at war again, this time in Korea, and rationing of consumer goods had been reinstituted. The consumers weren't ready to junk their black and white models, and in effect said, "No!" to color television. In October, 1951, CBS shut down its field sequential cameras in the name of national emergency, but more likely the Korean Conflict provided a convenient excuse for network executives to drop a system that was not winning the support of the public.

Sarnoff stepped up his promotion of Compatible Color. Improvements in pickup tubes and the Tri-color Kinescope caught the attention of the National Television Systems Committee. Still far from perfect, Compatible Color offered the best solution to the institution of color on a mass basis because color programs could be viewed on existing black and white sets. On March 25, 1953, CBS officially bowed out of the color television system race, leaving the field wide open for RCA. Sarnoff again demonstrated the RCA system to the National Television Systems Committee who finally gave its endorsement. Sarnoff repetitioned the FCC to adopt RCA's system. On December 17, 1953, the FCC reversed its earlier ruling on color and made RCA-NTSC Color the national standard. Within a week, NBC was televising some holiday specials in color, including; *Amahl and the Night Visitors* and the *Tournament of Roses Parade*. CBS also began telecasting some programs in Compatible Color in 1954, but these color telecasts were seen in color by very few people. Less than 8,000 color sets were sold nationwide in the first half of 1954. ABC, who was still struggling to establish itself as the fourth television network, decided not to make the sizable investment necessary for color equipment until it was on a better financial footing. DuMont, whose fortunes had been sliding since 1950, never telecast any programs in color.

Though NTSC color fulfilled the all-important criteria of compatibility with existing receivers, it is not a system without flaws. Of necessity, the color portion of the signal is transmitted on the "back" of the monochrome signal on a carrier several times the frequency selected (3.579545 cycles per second). A crawling dot pattern can be seen travelling up the screen of monochrome sets if viewed closely. Also, objects characterized by a vertically or horizontally slatted geometric pattern have a tendency to ripple with rainbowlike colors when imaged in certain planes. The red phosphors in early tri-color kinescopes were actually colored more orange because the production of a true red phosphor was not achieved as early on as was the production of other colored phosphors. And because of the necessity to maintain a six-megahertz bandwidth, small objects having values of blue and green actually appear gray on the Tri-color Kinescope. Despite these drawbacks. the overall reproduction of color is vivid and bright, even when viewed in a well-lit room.

For reasons other than technical sophistication, the acceptance of color didn't come immediately. NBC was virtually alone in the color market up until 1958. Until then they were the only network with regularly scheduled color programming.

Color began to edge its way into the marketplace in the late 1950's. In 1959, other manufacturers began producing color sets, and receiver prices went down. Sales began to increase steadily. Consumers buying their second television sets were more inclined to buy color. By 1965, NBC was nearly all color, having only two programs on its schedule that were still shown in black and white. CBS was airing nearly half of its programming in color, and ABC phased in their color equipment in 1966. Twenty-three years after the first proposal for color television was made and thirteen years after NTSC color was adopted as the standard in America, color television became an established entity in the United States.

In Europe, state-operated television systems were slow to change over to color for several reasons. First, the nationalized television networks had no competition to outdo. Also, the system used in England and Italy (405 lines/25 frames) did not lend itself well to adding color as was done with NTSC Color. In 1969, the BBC began telecasting simultaneously on two systems--the old 405 line system and yet another version of color television called PAL (Phase Alternate Line) Color. PAL Color is superior to NTSC Color in every respect, having more lines of resolution and truer color reproduction. Yet another system using 819 lines/25 frames is in use in France and Russia. This system produces pictures far superior to NTSC Color and PAL Color, but requires almost twice the frequency bandwidth for transmission which makes its use in the United States prohibitive.

Field Sequential Color -- a different version than CBS's color in the 1950's -- later saw use on the Apollo spacecraft. Field Sequential cameras of that era weighed less than tri-color cameras, a prime consideration in space travel. Later, new signal and optical processing techniques made color pickup with one tube possible, obviating the need for spinning disks. In recent years semiconductor research has rendered new solid state video pickup and reproduction devices that promise to eliminate the need for vacuum tubes for television pickup and reception altogether.

13

Television Recording

The source material for historical clarification surrounding the first use of television recording devices is full of contradictions. Jackie Gleason, in his autobiography, How Sweet It Is, recollects that his CBS shows in 1952 were "taped", but this is hardly the case since the earliest experimental video tape recording was made on November 11, 1951 by Bing Crosby Enterprises, and this is not the method Gleason refers to when he writes about the methods used to save his telecasts. Gleason's early CBS programs were saved using a Kinescope recording, whereby the picture on a television monitor was photographed on motion picture film. The thirty-nine classic "Honeymooners" episodes that have been in syndicated release the past three decades were filmed using the DuMont Electronicam system, which made use of synchronized film cameras. The show was filmed before a live audience. The film was then developed, edited, and then telecast. Gleason refers to these recordings as being "filmed".

Television recording is nearly as old as television itself. British television pioneer, John Logie Baird, patented his Phonovision television recording system in 1927. His method was quite simple. The television signal was recorded onto a wax disk just as was done with sound recordings. Baird was able to record video using these means because his 30 line/12-1/2 frames per second picture did not exceed the frequency recording capabilities of disk transcription equipment. The playback pictures were poor in this system, even compared to "live" transmissions of the day, and was never used outside of Baird's laboratory.

While Baird pursued mechanical means to record television pictures, a man by the name of B. Rtcheouloff based his invention on the magnetic recording process invented by Vladimir Poulsen in 1898, but no prototype of Rtcheouloff's machine was ever built.

In 1927, television and film merged with an innovation by two English scientists, Hartley and Ives of Electrical Research Products Company, who proposed the idea of interposing a film camera between the subject and the television scanner. In one device, Hartley and Ives overcame two problems facing early television engineers. The first crude mechanical image pickup devices were unsuitable for live pickup but worked quite well when scanning film. By positioning a film camera between the subject and the scanner, this problem was eliminated. An added bonus of their design was that the film could be saved and reused later. Two versions of their device came into prominent use in Europe in the late 1920's and early 1930's. In the first version, the film was exposed, developed immediately, and then scanned for video transmission. Then the film was recoated and looped back to the camera gate to be exposed again. Another version of this system, however, merely saved the exposed film so that it could be retelecast later. These early methods were used by the BBC and Germany's Reichs-Rundfunk in the early 1930's, but became obsolete with the advent of electronic pickup tubes.

In the early 1900's researchers pursued yet another method of recording sound, this one using photographic film. The incoming sound waves were turned into electrical waves that were in turn used to drive a neon glow discharge lamp or mirror diaphragm which traced patterns corresponding to the amplitude and frequency onto moving photographic film. The same principle was applied to video recordings, but only a small bandwidth could be accommodated using these means and it was never seriously considered as a method of recording video.

The second generation of video recording devices took the form of the Kinescope Recording, which amounted to nothing more than a film camera mounted in front of a television monitor. The first attempts to "film" television pictures from a cathode ray tube were made in the United States in 1938. A sixteen millimeter, spring-wound camera operating at 16 frames per second was used to record live images. Due to the difference in frame rates, a black bar rolled through the frame where the open shutter of the motion picture camera photographed the blanking interval. The television screen is totally black approximately one-twentieth of every second, and it became apparent that the frame rates of the two would have to be matched before a usable record could be made. A television picture recording system was built for the United States Army Air Corp and Navy during World War II. Under the names *Project Ring* and *Project Block*, science fiction became science fact with the mounting of television cameras in the nosecones of guided missiles. These pictures were filmed at 4 to 8 frames per second.

The rise of network television in the United States spurred the industry to build sophisticated kinescope recording equipment capable of reproducing a video picture with the same brightness, contrast, and sharpness of the original. In 1948, Eastman Kodak introduced their Eastman Television Recorder. The system used a 1200 ft. magazine of 16mm film, and the shutter and film drive motors were driven by the television frame rate. Eastman cameras became the backbone of the American networks' recording operations, allowing prime-time programs to be shown at the same time on both the east and west coasts.

In 1950, Hollywood producer Jerry Fairbanks introduced another method of television recording dubbed the Multi-cam system. This system used three film cameras equipped with companion video cameras operating simultaneously. The director controlled the cameras from the booth just as was done with video-only cameras. But at the same time the film could be stopped for set changes or to correct a flubbed line. The Multi-cam was used to film Groucho Marx's *You Bet Your Life*, *I Love Lucy*, and countless other programs since then. With many refinements, the Multi-cam process is still in use today.

Paramount Pictures also built a television film recorder, this one having large-screen projection capabilities. The system was of the Intermediate Film type invented for use with mechanical scanners in the early 1930's. In this system, 35mm film was exposed to television frames, run through developing fluids, dried, and fed to the shutter of a theater projector. The time between scanning and projection was sixty-six seconds. Another unusual feature of this system is that the recording took place at the receiver (which happened to be in a theater).

In 1950, CBS Television pulled off a coup of sorts when they demonstrated color film recordings of their Field Sequential transmissions. The frame rate of CBS Field Sequential Color television was exactly two times that of sound film so the three color primaries were recorded on each frame before pulldown. If CBS Color ever had a chance to achieve acceptance, its compatibility to film represented a means whereby field sequential pictures could be transmitted on existing standards. That was not to be, however.

In the mid-1930's, magnetic recording had undergone development similar to that of television, except that magnetic recording research had chiefly concerned itself with audio. Almost totally ignored in the United States, the Europeans had been studying magnetic recording since the turn of the century and building machines since 1930. Vlademir (Vladimir) Poulsen of Denmark patented a magnetic recording system using a spool of wire in 1898. Very little development of Poulsen's machine took place until the 1930's, however. Adolph Hitler was very interested in developing magnetic recording along the same lines as motion pictures, radio, and television. Not only did the use of these sophisticated electronic devices further prove his belief in Aryan superiority, but provided him with valuable tools in his propaganda effort. During the war, portable radio stations equipped with Magnetophone tape playback machines were dispatched to towns that had been bombed. A speech by the Führer was broadcast. The Germans, believing they were hearing the Führer in person, were reassured.

Allied radiomen captured two such stations near the end of the war. They were impressed with the Magnetophon's ability to reproduce sound which was found to be far superior to any disk recording yet produced.

U.S. Army Signal Corp officer John Mullin brought the two Magnetophon recorders to San Francisco. There he modified the machines and then staged a demonstration for Bing Crosby. Crosby's first show of the 1947-48 season was recorded using the modified Magnetophon at the NBC/ABC studio complex in Hollywood. The program was recorded as it occurred. And when the show was over, Bing, his producers, and Mullin gathered around the machine to hear the results. They were astounded. The replay could not be distinguished from the live broadcast. Gone was the tinny artifacts that characterized wax disk recording. Bing agreed to back the development of the Magnetophon.

In order to produce machines, a factory was needed. Interestingly enough, another Russian immigrant, Alexander M. Ponitoff, arrived on the ever-broadening electronic communications scene at just the right time to provide the manufacturing and test facilities to build magnetic tape recorders. Ponitoff, like Zworykin and Sarnoff before him, was an engineer and had left Russia during the revolution to come to America. He migrated to San Francisco where he pursued the field of electronics. When World War II began, he landed a contract to build gyroscopes for B-25's. When the war was over, Crosby's organization went into partnership with Ponitoff to build magnetic audio tape recorders. The first machine was dubbed the Ampex 200 and went into service at ABC Radio in

January 1948 and, in various refined states, became an industry standard for twenty years.

Once the audio recorder became an established tool in Radio, it naturally followed that television engineers would develop similar machines to record pictures. By 1950, teams were at work at RCA, Ampex, and in Europe to develop such a recorder. The process of recording video motion pictures turned out to be more involved than that of sound. The frequencies employed in television signals were hundreds of times higher than those of sound. The principles of electromagnetic recording demanded that the higher the frequency, the faster the tape would have to travel to capture the frequency variations accurately. In 1950, Crosby Electronics, RCA, and the BBC all attempted video recording using modified audio recording machines outfitted with multiple heads and higher speed motors. These machines had a poor response to the broad band of television frequencies, however, and never made it out of the laboratory. The solution to video recording demanded a new and more efficient method of storing television signals. The answer came in yet another application of scanning, this time using a wide strip of magnetic tape passing over a revolving record transducer. The first patent for helical recording was awarded to Eduard Schueller of AEG (Germany) in 1936. Schueller invented the ring-shaped head that is still used in recording machines to this day. His machine was intended to compress or expand sound without changing the pitch and had nothing to do with the recording of video. In 1950, RCA engineer Earl Masterson applied for and received a patent for a helical scan videotape recorder, but RCA executives chose not to pursue his design. Serious problems involved in reproducing helical scan tapes prevented their immediate development. The inherent drag encountered in helical tape scanning caused the picture to wave like a flag aggravatingly at the top. The video of one television field was recorded over as much as six inches of tape, and it was apparent that even the slightest upset in the speed of the rotating head or the transport would cause the picture to break up.

In 1950, Alexander Ponitoff put together a six-man research team headed by Charles Ginsburg to solve the problems of video recording. The Ampex team's first effort resulted in a machine with a spinning head with three transducers situated equidistant around its circumference. A two-inch wide tape was wrapped around the arc of the spinning head. The tape travelled at 30 inches per second, making the head-to-tape speed approximately 2500 inches per second. The pictures reproduced on this machine were not of good enough quality to persuade Ponitoff to develop it any further. Another machine was built in 1953, this one equipped with four heads. The pictures were better than those of the three-head version, but still were incapable of reproducing fine detail. In 1955, Ginsburg and his team redesigned their machine to record video using the techniques of FM radio broadcasting. It was found that FM modulations were easily recorded on magnetic oxide-coated tape.

Impressed with the results, Ampex decided to demonstrate their new machine at the Convention of the National Association of Broadcasters. The original machine, dubbed the VRX-1000, was taken to the 1956 NAB convention in Chicago. The machine's only flaw at this time seemed to be the lack of a tape that could stand up to the high relative head to tape speed (1440 inches per second).

Engineers at 3M went to work developing a tape that could stand up to the stringent requirements of video recording. On the eve of the convention, they produced two reels of tape with the formula they believed would work satisfactorily. Dr. Wilfred Wetzle, head of the Videotape Project at 3M, hand-carried the tape to the convention. The new machine and this latest tape formula were demonstrated for the first time in March of 1956 and featured a (what else) commercial. A young lady made her pitch live on camera before the convention delegates. Then, the tape was rewound and played back. When it was finished, the broadcasters of the country jumped to their feet and applauded.

On November 30th, the first Ampex VR-1000 Videotape Recorder went into service at CBS television in Hollywood. The first program to be recorded was *Douglas Edwards and the News*, which was delayed for telecast at the same hour on the West Coast. In that same year, Ampex received orders for seventy-seven machines, and the era of videotape recording had begun.

Machines of that basic design are still in use today, but recently they have been all but supplanted by newer systems, mostly based on helical scanning. The problems inherent in helical scanning have been overcome by modern computer technology, namely Digital Time Base Correction. Using the high speed reading and writing capability of modern microprocessors, a picture can be stored in a memory as individual pixels and replayed in any time frame selected. Other innovations in recording techniques have reduced the size and expense of videotape. Beginning in 1975, videotape, long found only in broadcast stations, became available to the general public in the form of cassette recorders which could be operated by anyone. Units that are smaller and more sophisticated than Ampex's early machine now can be found in affluent homes around the world.

Another method of video recording came about as a result of laser research by Theodore H. Maiman of the United States in the late 1950's. Magnetic tape proved to be so fertile a ground for development, however, that laser recording remained largely ignored until the late 1970's when laser disk video playback machines for the home entertainment market were introduced. Laser disks are not as easily recorded as magnetic tapes, but render superior images and sound. Some day, laser and digital storage may supplant magnetic techniques as the primary means of recording pictures and sound.

It will be remembered that in the first third of the Twentieth Century, Man mastered the science of transmitting live images.

14

The Future Of Television

Television is being reinvented almost everyday. The end product of innumerable coinventions and subinventions has given ordinary folk in homes around the world the capability of televising and recording live images. The vacuum tube can be classed as the one device that made high-resolution live image transmission a technical accomplishment and eventually a commercial success, but the semiconductor, after nearly one-hundred years of development, has redefined the art almost entirely. The televisions of tomorrow will make those we watch today seem as fuzzy and jerky as 8 mm. home movies do now.

Television sets of the future will resemble a motion picture screen. Home screens will be as large as six feet across and will be capable of delivering 35mm. motion picture film quality images even in a brightly lit room. They may not even use a picture tube, but rather a multiple element liquid crystal display screen. LCD screens, such as the Mitsubishi Diamond Vision screens used in some major league ballparks around the country, are already finding their way into home units today. If these multiple element screens sound familiar, it is because they are a revival of the very first system of image transmission proposed by George Carey in 1875. Modern day computer techniques which allow each element to be addressed individually and updated many times a second made Carey's multiple element pick-up and display grids a workable idea--one hundred years after he proposed it.

The semiconductor pickup chip, developed by RCA in the late 1970's, has made total solid-state high-resolution television possible for the first time since its invention. The chips overcome many of the flaws of vacuum pickup tubes, and have found their way into home and industrial cameras already. Still, these chips (known as Charge Coupled Devices) require more development before they can be expected to perform as well as the latest wave of pickup tubes. Someday in the not-to-distant future, we will watch television pictures without the use of any vacuum tubes whatsoever.

Satellite dishes, VCR's, home video movies, and video games are now considered standard accessories in affluent homes. Where viewers fifteen years ago had the choice of three or four services, now they have their choice of thirty to fifty services. And the uses of television beyond entertainment are growing every day. Metropolitan schools are wired for video, allowing lecturers or films to be shown to thousands of students at one time. Robot subs scour the ocean floor where human eyes could never go. The reduction in cost of video cameras has made it possible to monitor our homes from our places of work via telephone, using a modified television camera and computer. The importance of the computer in the future uses of television cannot be underestimated. Microchip technology promises to make video equipment smaller, less power consuming, yet more reliable in the future.

Ironically, RCA, the company that was responsible for introducing radio broadcasting, all-electronic television, and all-electronic color television to the public, no longer manufactures broadcasting equipment. The field has been taken over by gads of independent companies, each specializing in one type of equipment. The Japanese seem to have had more impact on both the broadcasting and consumer market than any other group. Because of their introduction of portable equipment for electronic news gathering and home use over the past fifteen years, television has become an increasingly pervasive force.

Our lives have been redefined mightily in the past half century, and a lot of that reshaping has taken place because we have become an image conscious world. Critics have taken the art if not the science of television to task at times, blaming its portrayal of sex and violence for the seduction of our young. Though television has been the messenger that brought bad news, it has likewise brought us much good news. If for no other reason, television is the most important single device ever invented because it has allowed us to see ourselves as others see us.

The End

CHRONOLOGICAL LIST OF IMPORTANT DATES IN TELEVISION HISTORY

300 to 100 B.C.	Magnetism and Electricity are discovered by the Ancient Greeks.
989	Arabian scholar Hassan ibn Hassan describes the camera obscura.
1269	Petrus Peregrinus, a French physicist, publishes a study of magnets.
1569	Giambattista della Porta constructs a camera obscura.
1600	William Gilbert of England publishes "De Magnete" and invents the Versorium, a device to measure magnetism.
1645	Athanasius Kircher invents the Magia Catoptricia, a machine which projected hand-drawn pictures in motion.
1671	Sir Isaac Newton undertakes the study of light and color, detailing the action of light refraction and reflection as we know it today.
1746	Pieter Van Musschenbroek of Holland and E. George von Kleist of Pomerania, working independently, invent the Leyden Jar (Electrical Condenser).
1799 (1800)	Alessandro Volta of Italy invents the electric storage battery.
1809	Samuel T. von Soemmering of Germany invents the multiple-wire telegraph.
1819	The Galvanometer (Voltmeter) is invented by Johann S.C. Schweigger of Germany.
1822	Joseph N. Niepce of France invents photographic film and fixing solution.

1822 The Electric Motor is invented by Michael Faraday of England.

1824 The Electromagnet is invented by William Sturgeon of England.

1832 The Electric Generator is invented by Hippolyte Pixii of France.

1835 Samuel F.B. Morse invents a single-wire telegraph and code to send messages in the U.S..

1847 Louis J.M. Daguerre of France commercializes photography with Niepce's process, naming it the Daguerreotype.

1842 to 1847 Scientists Bain and Bakewell propose sequential scanning and photoelectric pickup of live scenes.

1872 Eadweard Muybridge and John D. Isaacs of the United States invent motion pictures.

1876 Alexander Graham Bell of the United States invents the telephone.

1877 Thomas Edison of the United States invents the phonograph.

1877 Thomas Edison invents the Microphone.

1878 William Crookes of England invents the Cathode Ray Tube.

1879 Thomas Edison invents the Incandescent Lamp.

1881 Shefford Bidwell of England invents the Wire-photo.

1881 Frederick Ives of the United States invents color photography.

1884 Paul Gottlieb Nipkow of Germany patents a radially slotted disk that can sequentially scan a scene.

Chronological List of Important Dates In Television History

1887 Emile Berliner of the United States invents the Gramophone (Disk Recording).

1894 C. Francis Jenkins of the United States proposes Telorama, a system to transmit pictures electrically using a light sensitive pickup grid.

1895 Julius Elster and Hans Geitel of Germany invent the Photoelectric Cell (gas tube).

1896 Guglielmo Marconi patents his radio transmitting and receiving system.

1899 Vlademir Poulsen of Denmark invents magnetic (wire) recording.

1899 Marconi forms the Marconi Wireless Company in the United States.

1900 A Continental writer coalelesces the work "television" from Greek and Latin roots.

1901 Peter C. Hewitt of the United States invents the Mercury Vapor Lamp.

1902 Reginald A. Fessenden of the United States invents Radio Telephony.

1903 C. F. Braun of Germany invents the Oscillograph, forerunner of the Oscilloscope.

1904 John A. Fleming of England invents the Vacuum Tube Diode.

1906 Professor Max Dieckmann of Germany builds a picture transmission system in his laboratory.

1909 The first broadcast radio transmissions are made in San Jose, California by Doc Herrold.

1910 Elster and Geitel of Germany perfect their Vacuum Phototube.

1911 A. A. Cambell Swinton of England proposes "Distant Electric Vision".

1912 Boris Rosing of Russia builds a prototype of a television system using a Nipkow scanner for pickup and two revolving mirror drums for display.

1918 Edwin H. Armstrong of the United States invents the Superhetrodyne Radio Receiver.

1920 KDKA airs the world's first scheduled broadcast from Philadelphia, Pennsylvania.

1921 The first home radio sets go on sale in the United States. RCA broadcasts the first sports event in the United States: the Dempsey-Cartier fight.

1922 C. Francis Jenkins sends photographs by wireless.

1923 Vladimir Zworykin of the United States patents the Iconoscope Video Pickup Tube.

1925 John Logie Baird demonstrates television transmission using a Nipkow-based system in England.

1925 C. Francis Jenkins successfully transmits motion pictures in halftone by radio using U.S. Navy radio station NOF in Washington, D.C..

1926 RCA, GE,AT&T and Westinghouse join together to form the National Broadcasting Company.

1927 Congress passes legislation creating the Federal Radio Commission, an agency to regulate channel assignments and transmitting power.

1927 Columbia Records institutes the Columbia Broadcasting System (CBS).

1927 Philo T. Farnsworth invents an electronic television pickup tube, the Image Dissector.

1928 Twenty-seven mechanical television stations go on the air in the United States. Within two years, only one, W2XBS in New York survives the depression of the 1930's.

Chronological List of Important Dates In Television History

1928 John Baird of England makes the first laboratory color transmissions of still pictures.

1928 Pfleumer patents magnetic tape.

1929 Vladimir Zworykin begins work on his all-electronic pickup and reception system with the financial backing of David Sarnoff's Radio Corporation of America. Later that same year, Zworykin patents the Kinescope Viewing Tube.

1929 to 1936 State operated television services begin in England, France, Holland, and Germany using mechanical means.

1932 RCA's David Sarnoff announces a $1,000,000 program to perfect all-electronic television. Forty-million dollars will be spent before television earns its first dime.

1934 Edwin H. Armstrong of the U.S. invents FM Radio Transmission.

1934 AEG of Germany demostrates the Magnetophon (Audio Tape Recording).

1936 NBC begins experimental telecasts using their new all-electronic television system in New York City. Programs originate from Radio City and are transmitted from the Empire State Building.

1936 State operated television in Germany telecasts the Munich Olympic Games using both mechanical and all-electronic means.

1936 The BBC discards Baird's mechanical system and signs on with all-electronic television.

1939 David Sarnoff introduces RCA's all-electronic television to the world at the New York World's Fair. Franklin Roosevelt becomes first U.S. President to be seen and heard on television. Commercial television is set to begin.

1940	Franklin Roosevelt bans commercial television because of the growing threat of war in Europe. Radio factories are converted to manufacture radios for the military. RCA demonstrates color television using mechanical means to the FCC.
1943	Network television begins with NBC transmitting sports telecasts to stations in New York and Philadelphia.
1943	The Federal Communications Commission orders NBC to divest itself of one of its Radio Networks. NBC Blue becomes the American Broadcasting Company.
1945	NBC, CBS, ABC, and DuMont begin television program services.
1946	RCA and CBS undertake research projects to perfect color television. RCA pursues all-electronic methods while CBS develops a partly mechanical system.
1947	John Bardeen, Walter H. Brattain, and William Shockley of Bell Laboratories invent the transistor.
1948	Kinescope recording on a large scale begins with the introduction of the Eastman Television Recorder.
1948	The growing number of television stations in the U.S. prompts the FCC to impose a freeze on granting license applications. The freeze last almost three years.
1950	Bing Crosby Electronics, RCA, and the BBC undertake research programs to perfect magnetic video recording.
1950	Zworykin unveils his Tri-color Kinescope Viewing Tube. The FCC, however,designates CBS Field Sequential Color as the national standard for color television. RCA files suit in Federal Court, but the FCC decision is upheld.

1951	The first Field Sequential Color telecast is made from CBS's Grand Central Station Studio in New York, featuring Arthur Godfrey. Within six months, however, the color equipment is dismantled.
1951	Coast-to-coast television network service begins in the United States.
1952	The FCC sets aside 242 channel allocations for public television.
1953	CBS bows out of color television development, and RCA again petitions the FCC, finally winning approval. Compatible Color telecasts on a limited basis begin soon afterward.
1955	The DuMont network, unable to obtain access to the transcontinental cable, goes out of business as a television network.
1955	Commercial television service begins in Britain.
1956	Ampex Corporation of California introduces the VR-1000 Videotape Recorder.
1961	Ampex and RCA introduce Color Video Tape Recorders.
1962	First trans-Atlantic satellite broadcast is made using Telstar 1.
1964	UHF tuners become standard equipment on U.S. manufactured television sets.
1965	CBS and ABC begin color programming on a regular basis.
1965	Sony introduces the first home video tape recorder, selling for $995.
1967 to 1969	PAL/SECAM television systems are introduced in Europe. By 1969, most Europeans make the conversion to color.

1968	Philips of Holland introduces the 1" Plumbicon Pickup Tube. Sony of Japan Introduces the Trinitron Picture Tube. CBS uses mini-cams to cover the Democratic and Republican Conventions.
1971	U Format video tape is introduced by Sony, TEAC, and JVC.
1972	Consolidated Video Systems introduces the Digital Time Base Corrector.
1972	Teletext (Closed Captions) experiments begin in the U.K..
1973	Ampex introduces the "A" Format 1" Videotape Recorder.
1974	The Microprocessor is married to broadcast equipment.
1975	Bosch of Germany introduces its "B" Format 1" Videotape Recorder.
1976	Sony introduces its "C" Format 1" Videotape Recorder.
1977	PBS begins national program delivery via satellite.
1978	NHK of Japan begins testing High-Definition television (1150 lines/30 frames).
1979 to 1980	The Constant Charge Device (CCD) image pickup chip is developed by RCA.
1979	Beta and VHS 1/2" videotape formats are introduced for the consumer/industrial market.
1986	The Nippon Electric Corporation (NEC) introduces a solid state high power Television Transmitter.
1987	NEC introduces a totally solid state digital memory capable of recording 34 seconds of color video with sound.

WORLD TELEVISION SYSTEMS: PAST, PRESENT, AND FUTURE

Name of Inventor Developer, and Nation of Origin	Date of Use	Scanning Rate/Method of Pickup and Display	Transmission Frequency Radio Channels Occupied
Dieckmann, Max; Ger.	1906	20 lines using a Nipkow Scanner and Cathode Ray Picture Tube	Experimental
Rosing, Boris; Russia	1907	Scan Rat Unk. Mirror Drum Pickup. Cathode Ray Display	Experimental
Jenkins, C.F.; U.S.	1925 to 1932	48 lines/15 F.P.S. Prismatic Disk Scanner. Nipkow Disk and Jenkins Slotted Drum Display	4900 to 5000 kc. (Utilized Naval Radio Station NOF, Washington, D.C.)
Alexanderson, Earnst; General Electric Corp.; U.S.	1928 to 1930	24 lines/Frame Rate Unk. Nipkow Pickup. Various Receive Devices Used	Transmission Freq. vary. used by WGY Radio, and twenty other U.S. Radio Station
Baird, J.L.; BBC; G.B.	1929 to 1932 (Demonstrated 1925).	30 lines/12-1/2 F.P.S. Nipkow Disk Intermittent Film Pickup. Various Display	Various
Zworykin, V.K.; R.C.A.; U.S.	1929 to 1932	60 lines/20 F.P.S. Nipkow Pickup Cathode Ray Tube Display	Various Utilizing W2XBS of NBC, W2XR, and others

WORLD TELEVISION SYSTEMS: PAST, PRESENT, AND FUTURE (CONT.)

Name of Inventor Developer, and Nation of Origin	Date of Use	Scanning Rate/Method of Pickup and Display	Transmission Frequency Radio Channels Occupied
Farnsworth, Philo. T. U.S.	1927 to 1932	200 lines/15 F.P.S. Image Dissector Pickup. Mirror Light Valve Reproducer (1922-27) Cathode Ray Tube Display (1927 to 1932)	Utilized AT&T Land Land Lines
Telefunken; Ger.	1929 to 1939	Line/Frame Rate Unk. Lens Drum Pickup of Film and Live Images. Mirror Drum (Early) Cathode Ray Tube Display (Later)	Land Line
Fernseh; Ger.	1929 to 1939	375 lines/25 F.P.S. Nipkow Lens Disk Film Scanner. Mirror Drum (Early) and Cathode Ray Tube Display (Later)	Land Line (Early), State Operated Radio (1932--)
Fernseh Video Telephone; Ger.	1929 to 1939	180 lines/25 F.P.S. Nipkow Lens Disk Flying Spot Scanner Pickup. Mirror Drum (Early) and Cathode Ray Tube Display	Land Line between Munich, Leipzig, and Berlin
Zworykin, V.K.; R.C.A.; U.S.	1932 to 1933	240 lines/24 F.P.S. Iconoscope Tube Pickup. Cathode Ray Tube Display	49mc Visual 40mc Aural
	1933 to 1940	343 lines/30 F.P.S. (Interlaced Scanning. Iconoscope Pickup. Cathode Ray Tube Display	49mc Visual 50mc Aural

	1938 to 1940	441 lines/30 F.P.S. (Interlaced Scanning). Iconoscope Pickup. Cathode Ray Tube Display	49mc Visual 50mc Aural 7 Channels of 6 mc from 42mc to 90mc
RCA/NTSC System Adopted by U.S. FCC	1940 to Present	525 lines/30 F.P.S. Various Pickup and Display Devices Used	7 Channels of 6 mc from 42 to 90mc Using Vestigial Sideband Transmission. Channels later expanded.
Marconi Corp; England, Italy	1936 to 1986	405 lines/25 F.P.S. Various Pickup Tubes and Cathode Ray Viewing Tubes Employed	5 mc channels on VHF Carriers in the U.K. and Italy.
EBU/Marconi Corp. BBC, RAI	1967 to Present	625 lines/25 F.P.S. Various Pickup Tubes and Display Devices Used	Various Channels of 7 or 8mc used in Eastern Europe, Western Europe, USSR, China, French Territories, France, and Luxembourg
SECAM System France	1967 to Present	819 lines/25 F.P.S. Various Pickup Tubes and Display Devices Used	Various Channels of 7 or 14 mc Used in France and Monaco
NHK; Japan	1978 to Present	1150 lines/30 F.P.S. Various Pickup and Display Devices Used	Experimental. Now being tested in Japan and the U.S.
EBU; Europe	1978 to Present	1150 lines/25 F.P.S. Various Pickup and Display Devices Used.	Experimental. Now being tested in Europe.

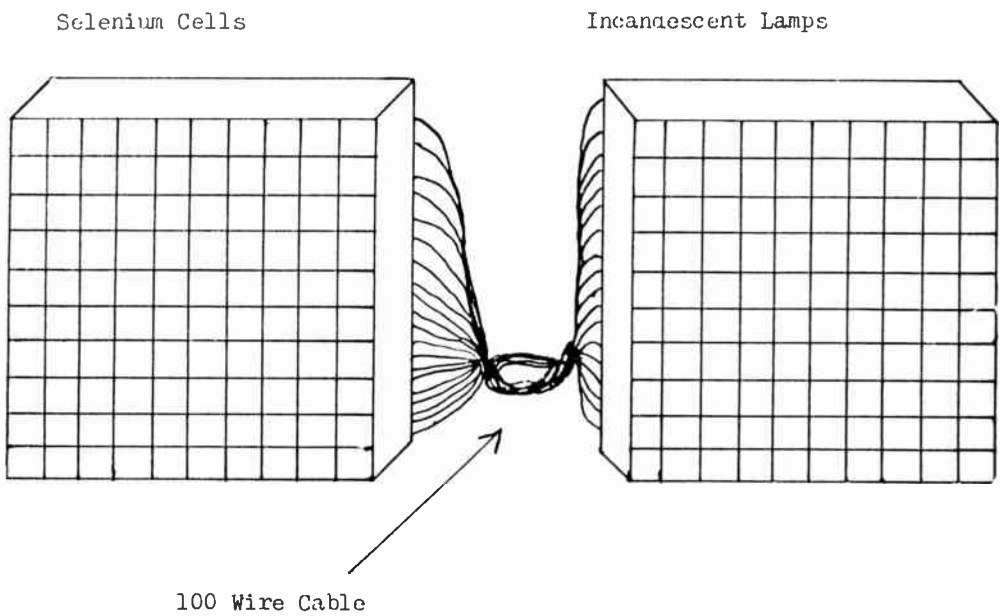


Figure 1.

George R. Carey of Boston, Massachusetts proposed this grid of selenium cells mated with a sister light grid for image display in 1875.

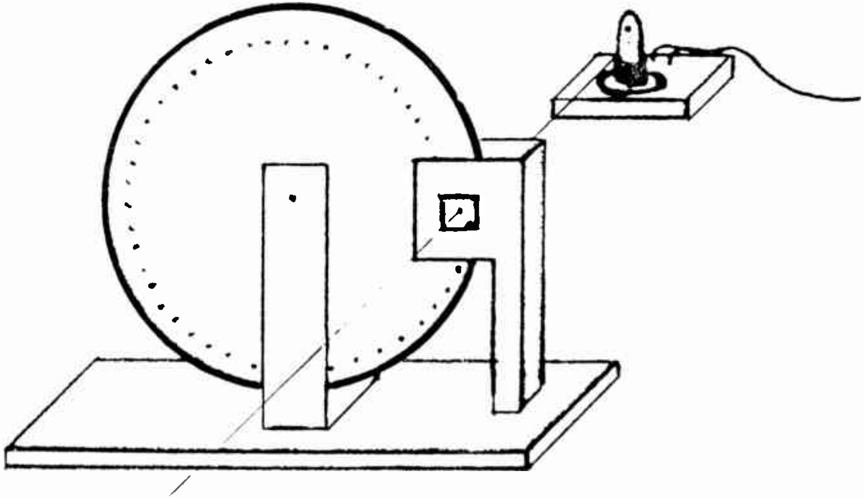
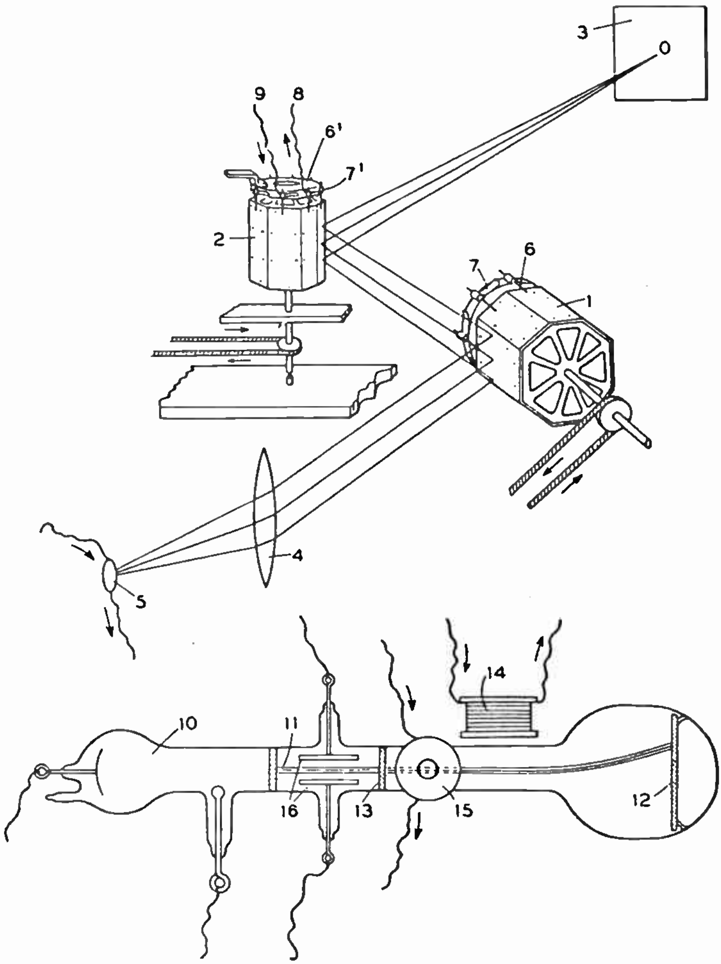
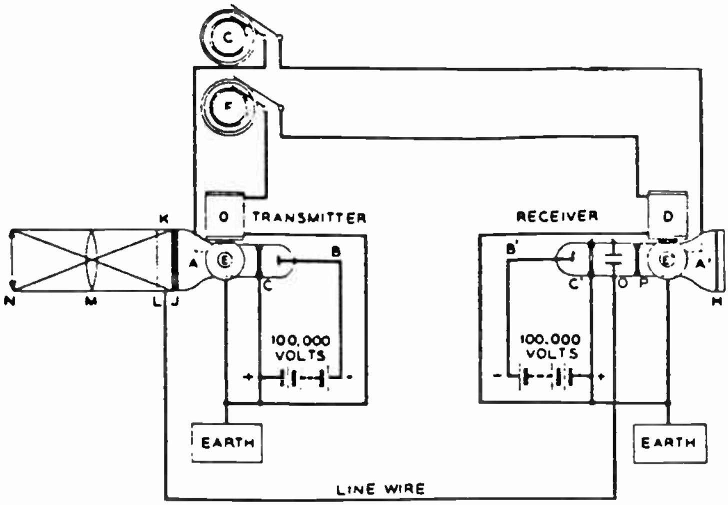


Figure 2.

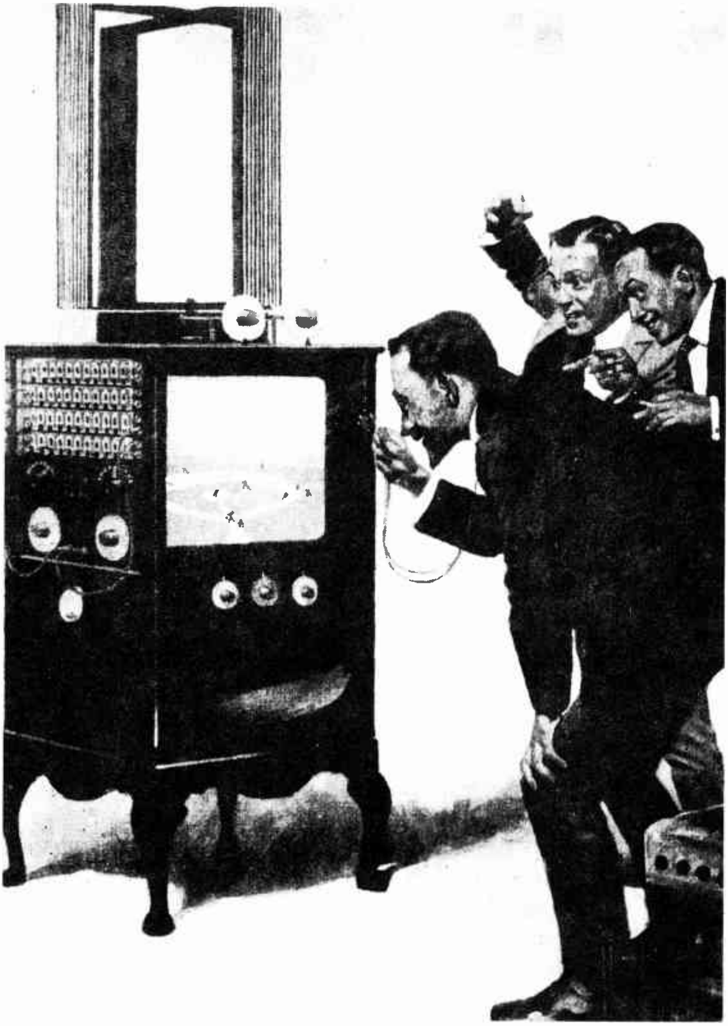
The Nipkow Disk. When spun rapidly, this device dissected a field into discreet bits whose light values could be used to drive a lamp at a similar receiving disk. Invented by Paul Nipkow of Germany, this device became a key component of many early television systems.



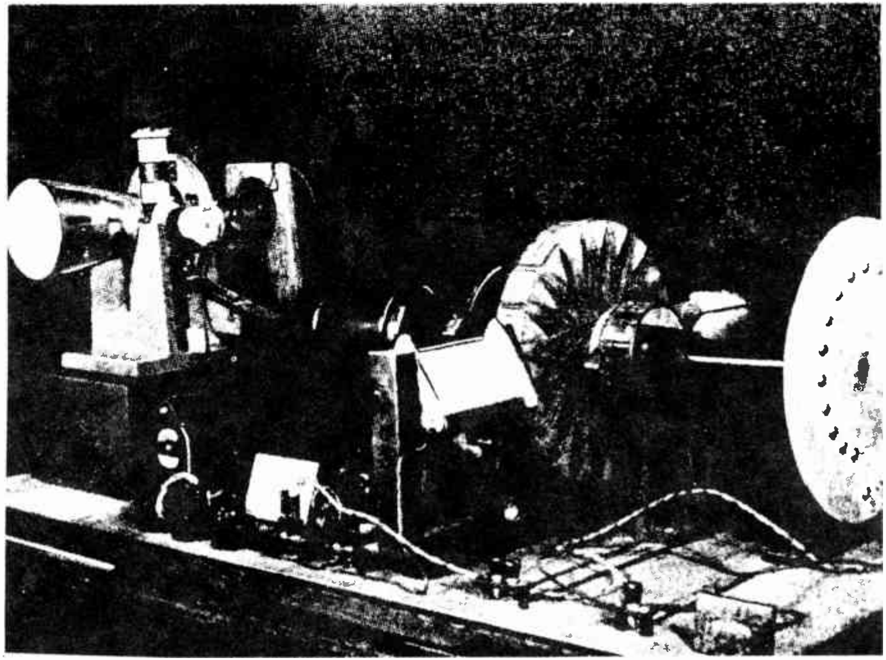
Rosing's Mirror Drum. Invented by Boris Rosing of Russia in 1907. This revolving mirror drum scheme was yet another approach to image dissection that was later incorporated into early television systems.



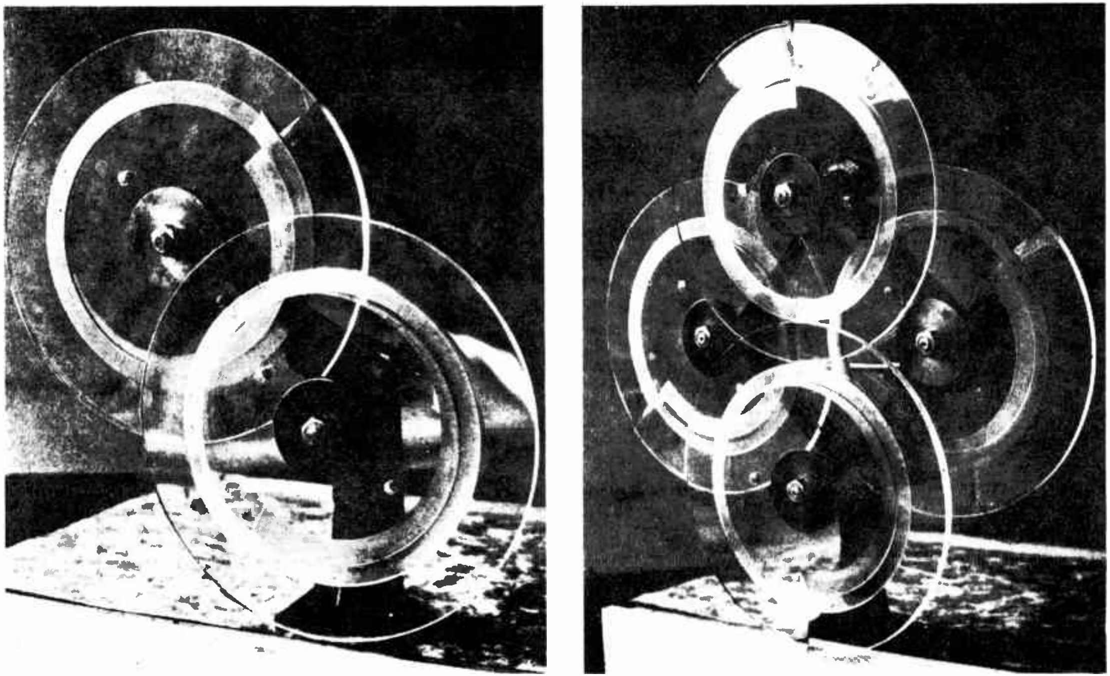
A. A. Campbell Swinton's scheme
for all-electronic pickup and display
proposed in 1911.



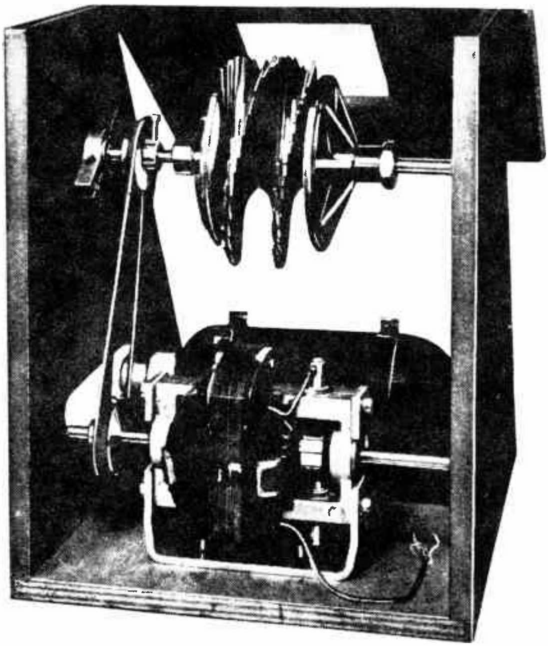
An artist's conception of "Teleorama", 1894.



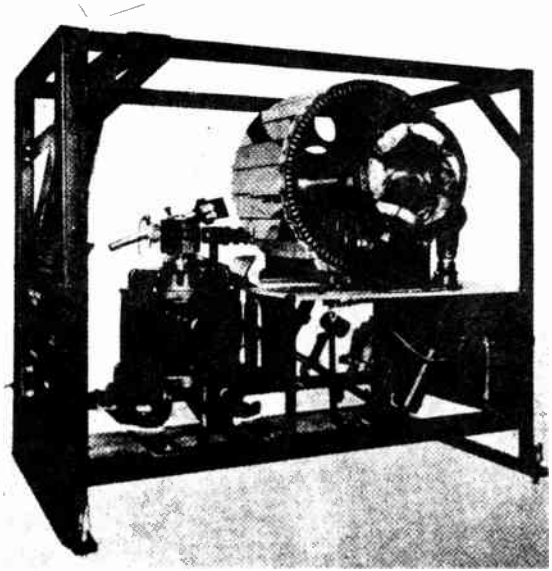
Max Dieckmann's experimental image transmission system. Invented in 1906, this device used a Nipkow Disk for pickup and a Cathode Ray Tube for display.

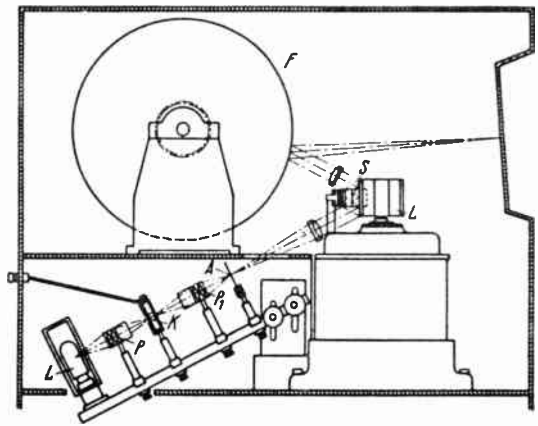


Jenkins' Prismatic Rings. These ground glass plates were the key components in this Radiovision Transmitter.

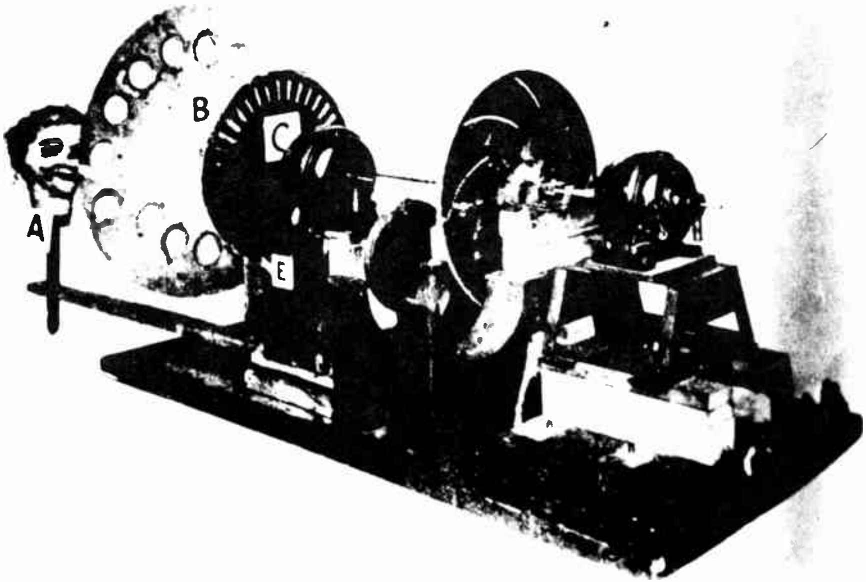


In Europe, this Mirror Screw receiver design was tried briefly as a display device in the late 1920's.

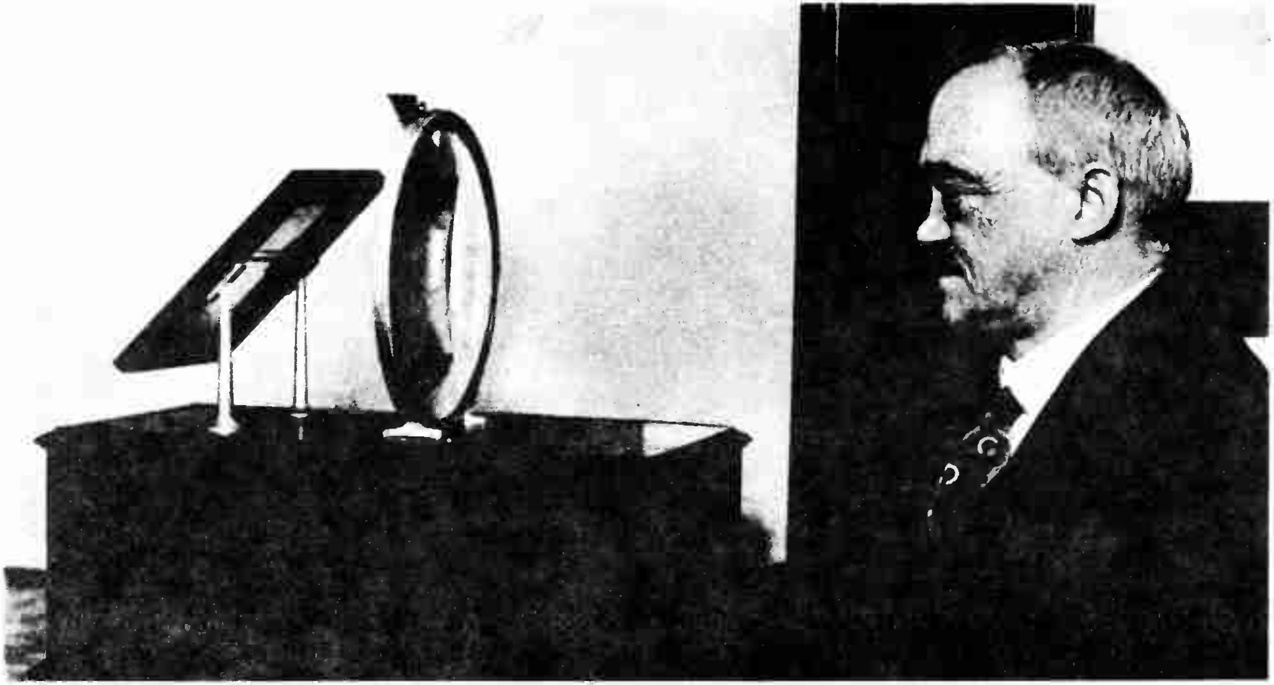




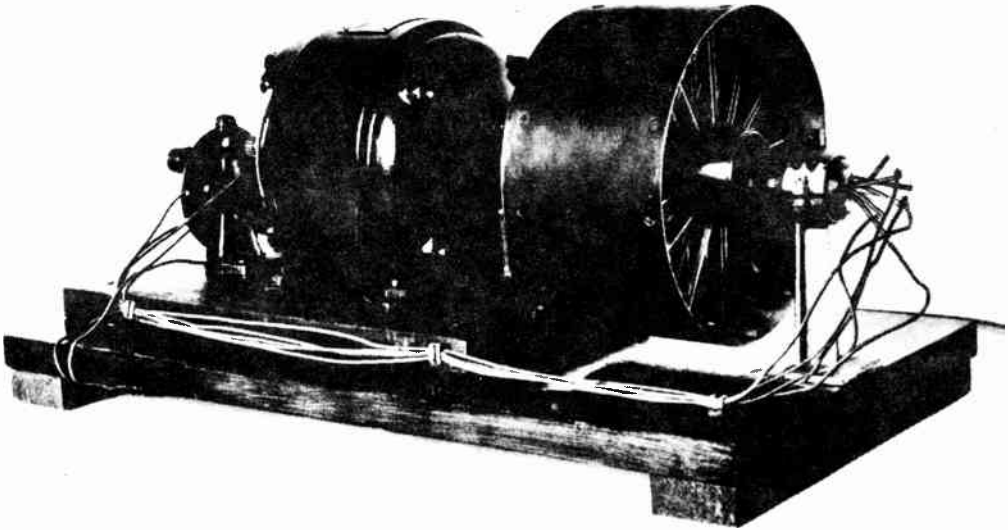
A Mirror Drum receiver used in Germany in the late 1920's and 1930's.



John Logie Baird's original television transmitter, built in 1922.

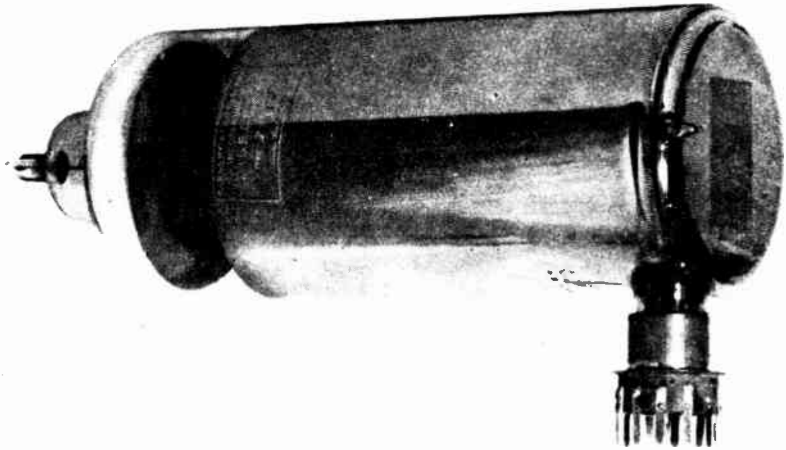


C. Francis Jenkins, the first American to send photographs by wireless and later the first man in the United States to send live television pictures using radio. Here he is shown viewing a "Radiovisor" of his own design.

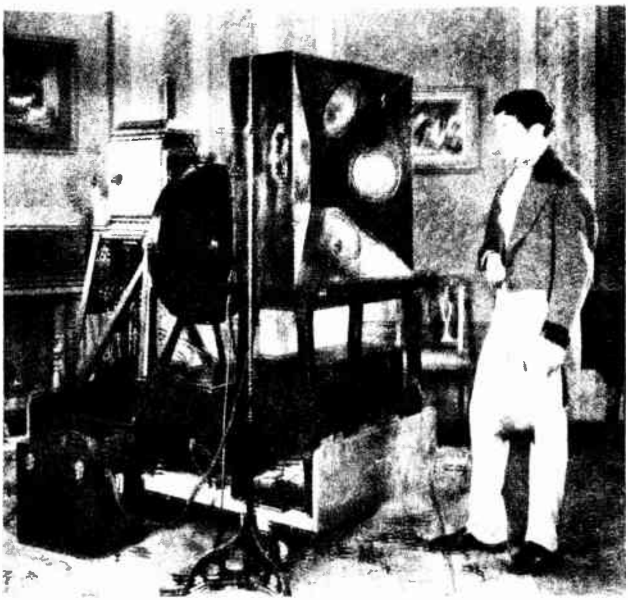


The "works" of a Jenkins Radiovisor which used a variation of Nipkow's Disk, the Drum Scanner.

Two ladies view silhouette images on C.F. Jenkins' Radiovisor (1925).



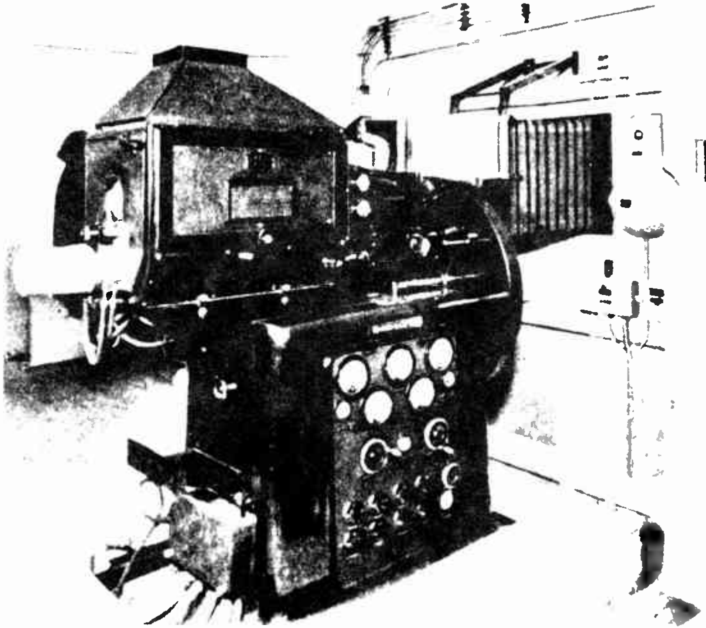
Farnsworth's Image Dissector. 1927.

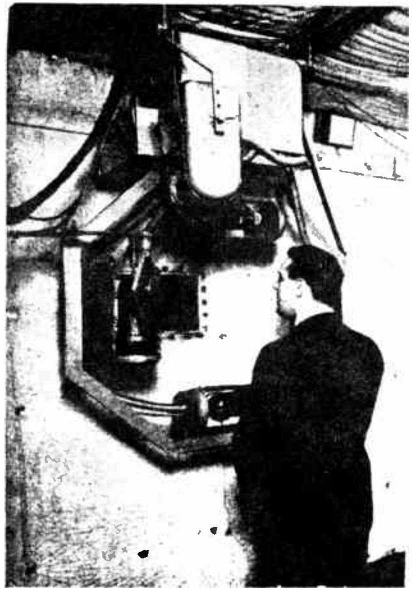


An actor poses in front of RCA-NBC's mechanical television camera (1927). Courtesy RCA/GE.

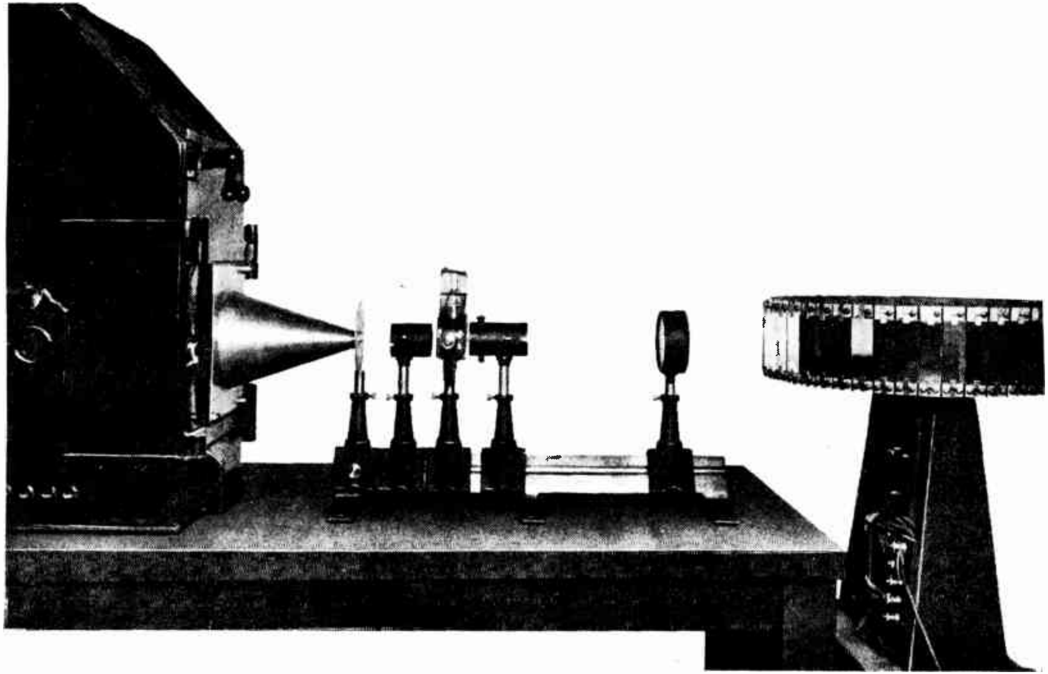
Mickey Mouse and Felix the Cat stand in front of RCA-NBC's mechanical television pickup(1927). Courtesy RCA/GE.

Actual monitor picture of Felix the Cat produced by RCA-NBC's mechanical television pickup (1927). Courtesy RCA/GE.

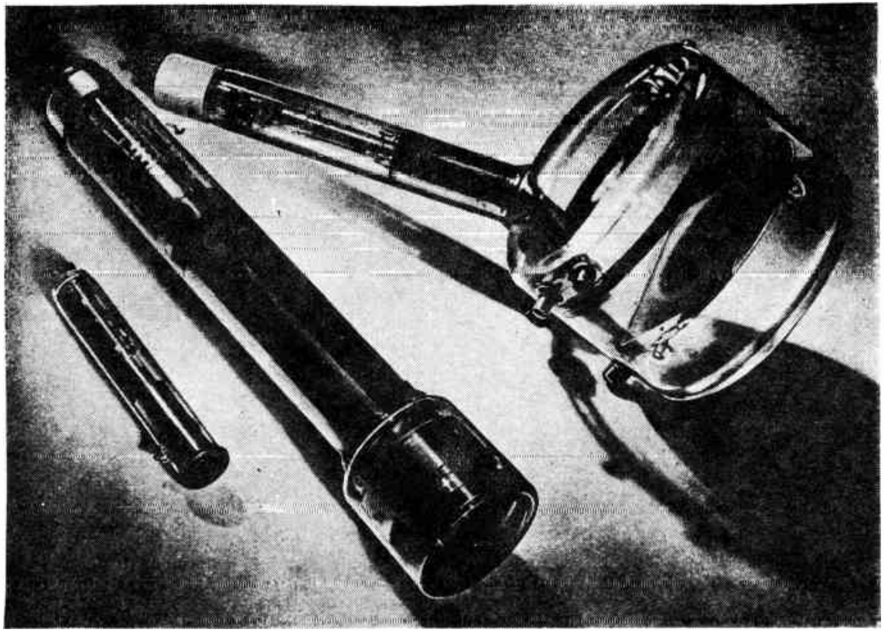




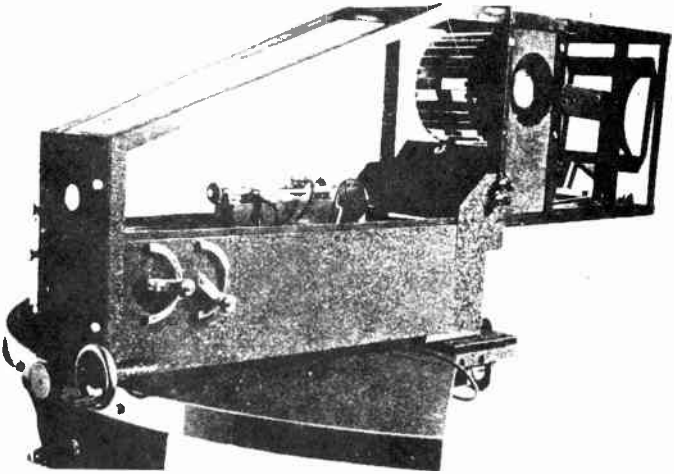
A Fernseh live scene pickup, known then as the Fernseh Video Telephone. Subjects in the adjacent room were scanned by an arc light projected through a Nipkow Disk. Circa 1928.



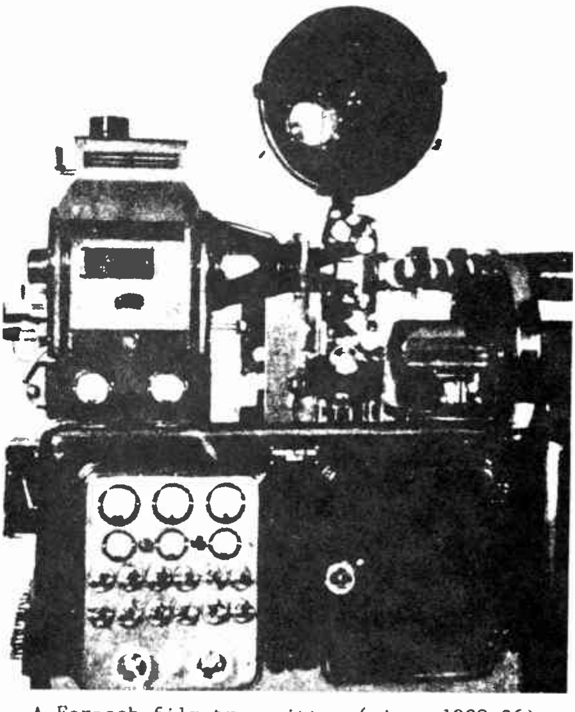
A Marconi Low Definition Mirror Drum Receiver. (Circa 1928).



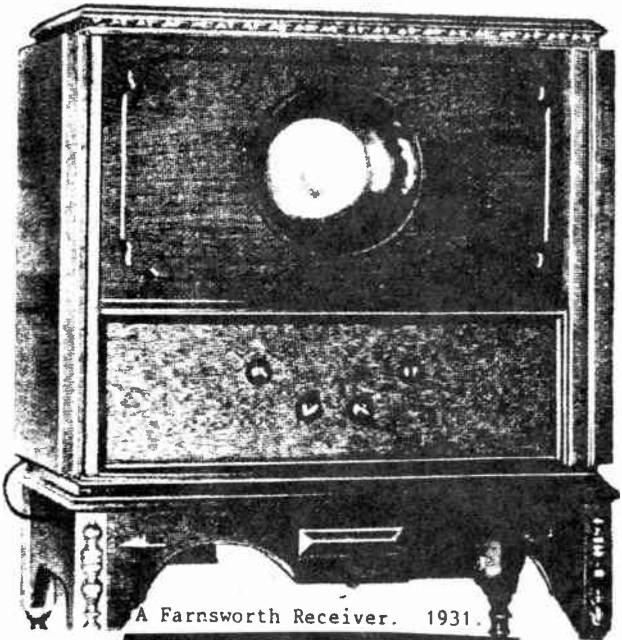
Three generations of pickup tubes: (from R to L)the Iconoscope, Image Orthicon, and Vidicon. Courtesy RCA/GE.



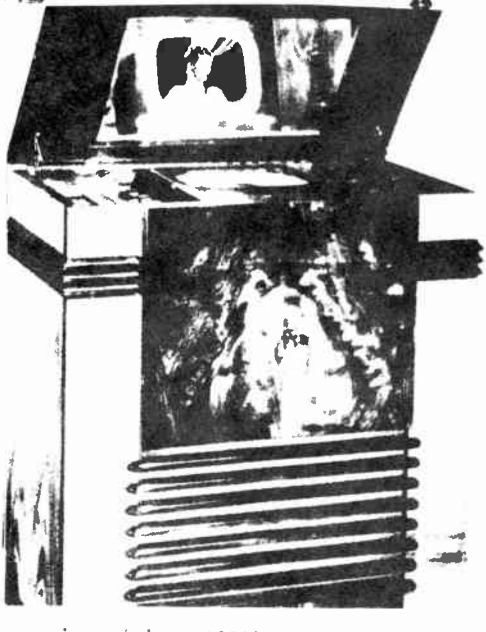
A Mirror Drum Pickup device of British manufacture.
(circa 1928).



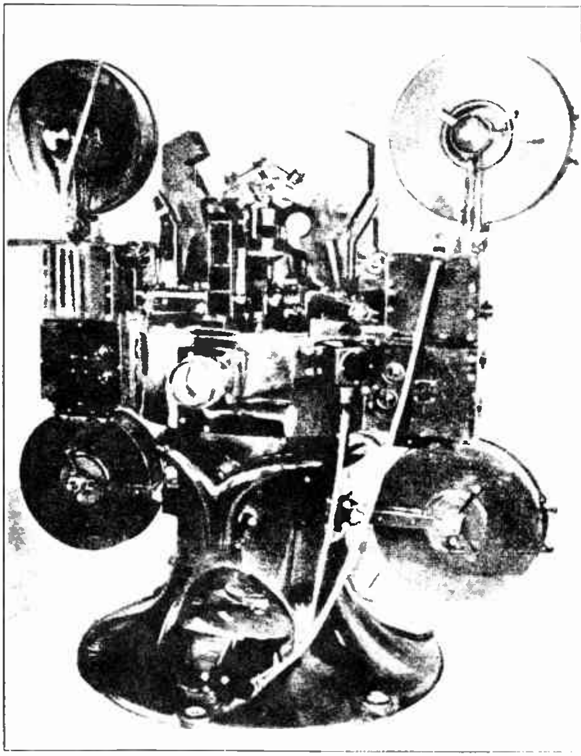
A Fernseh film transmitter (circa 1928-36).

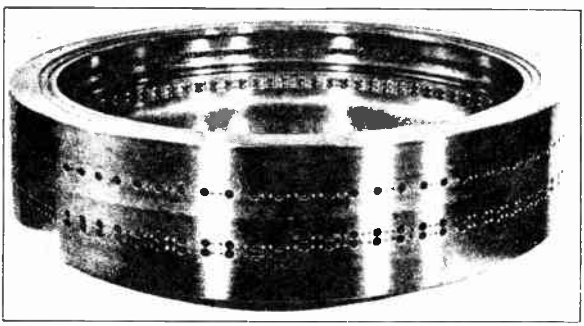


A Farnsworth Receiver. 1931.

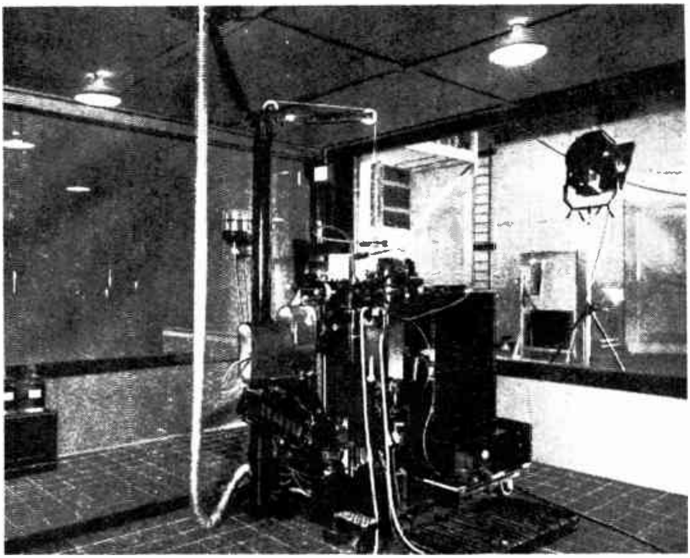


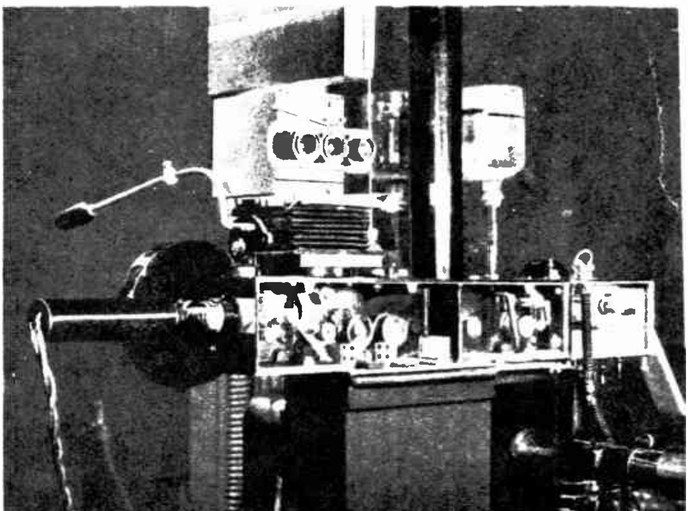
An RCA receiver (circa 1939). Courtesy of RCA/GE



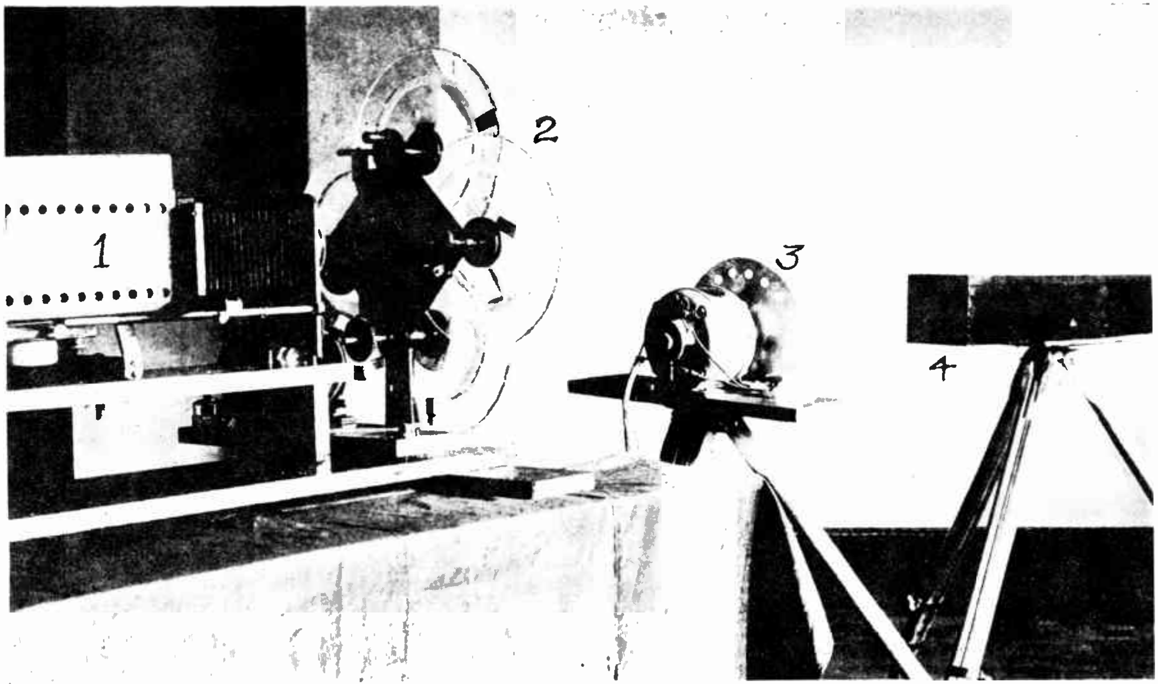


A Telefunken (German) film and live Lens Drum pickup (circa 1928-36). The Lens Drum had the advantage of producing straight rather than arced scan lines.

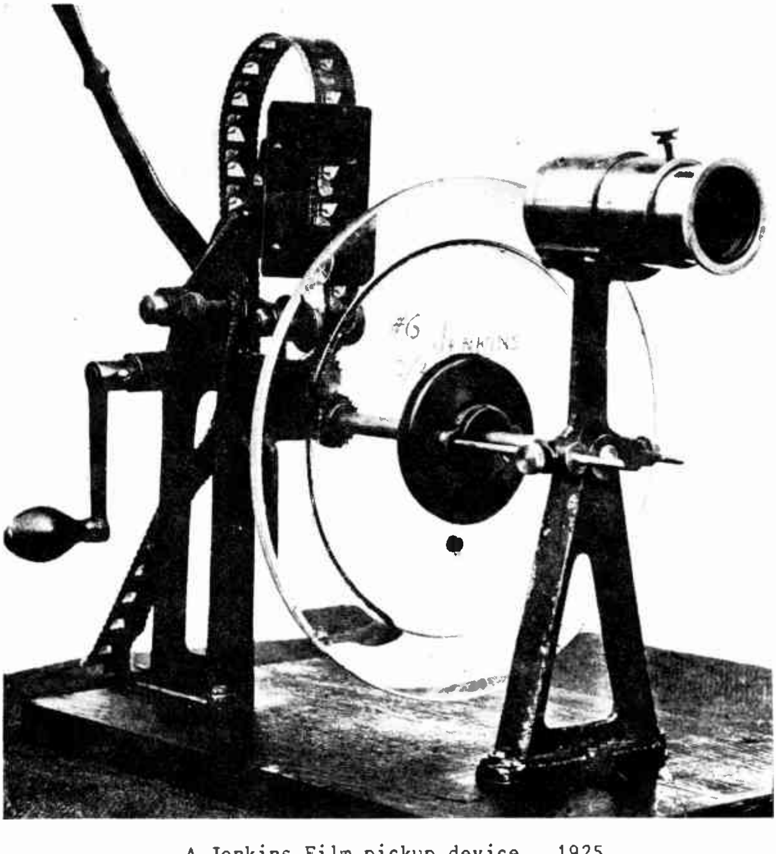




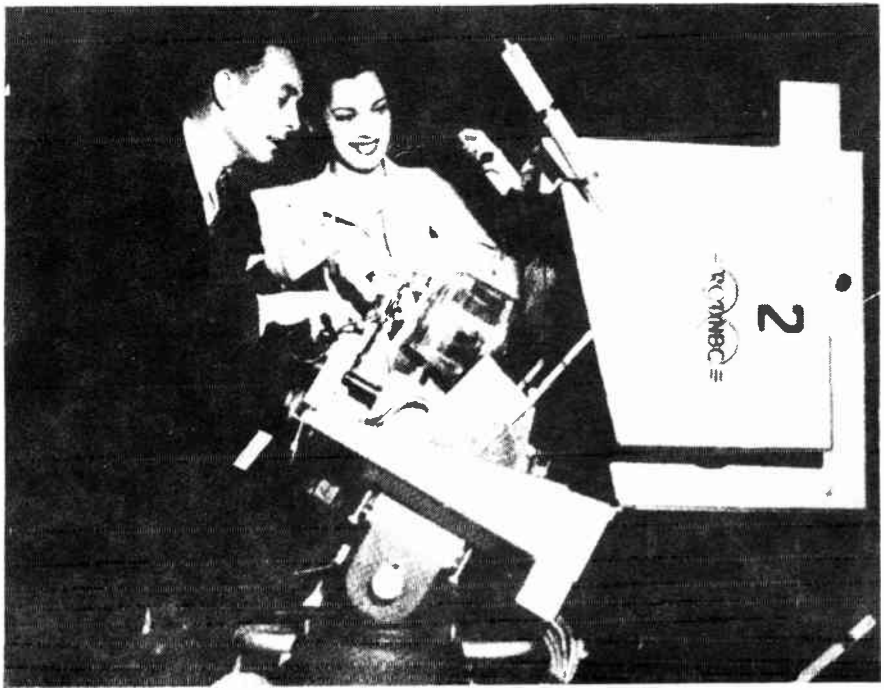
A Marconi Continuously Working Intermediate Film camera shown in a British studio. 1928-1935.



Jenkins' Radio Eye, 1925.

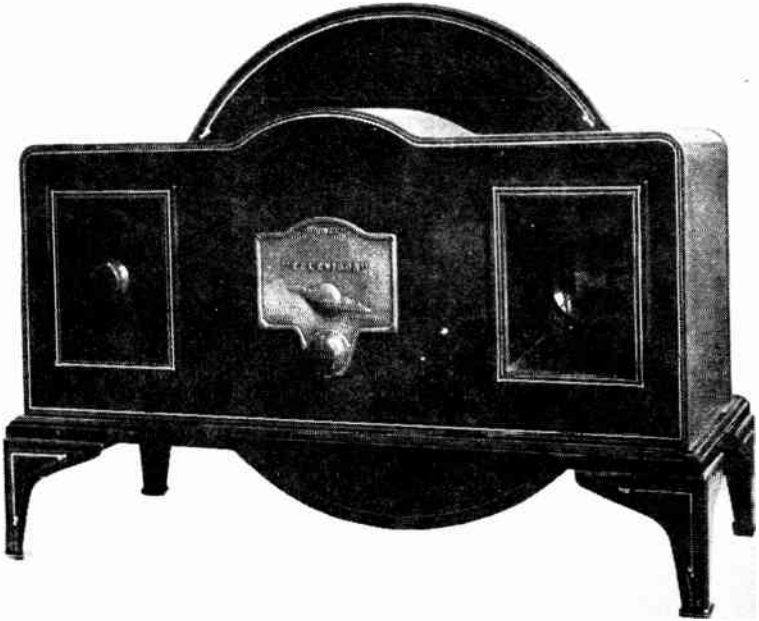


A Jenkins Film pickup device. 1925.

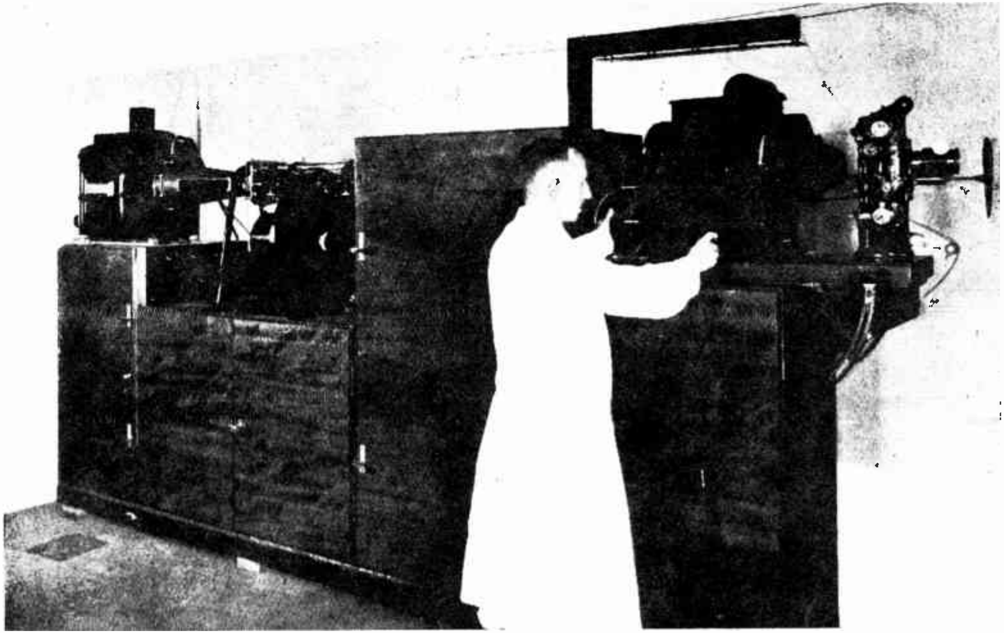


An RCA Iconoscope Camera (1936). Courtesy RCA/GE.

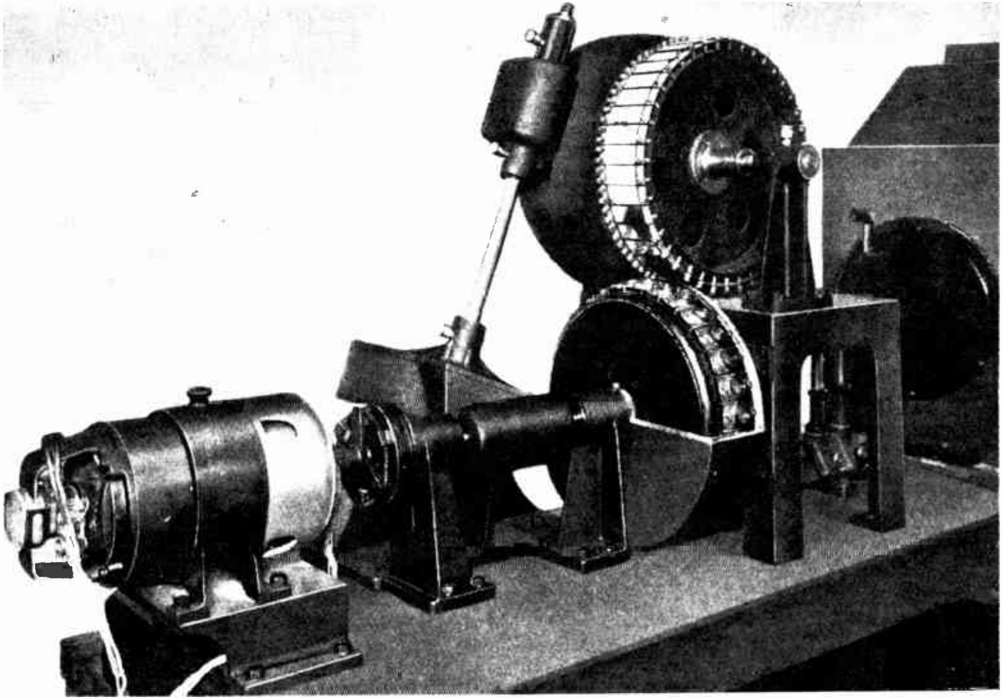
Vladimir Zworykin holding his Iconoscope tube.
Courtesy RCA/GE.



The "Televisor" was an early British receiver which used a Nipkow Disk.

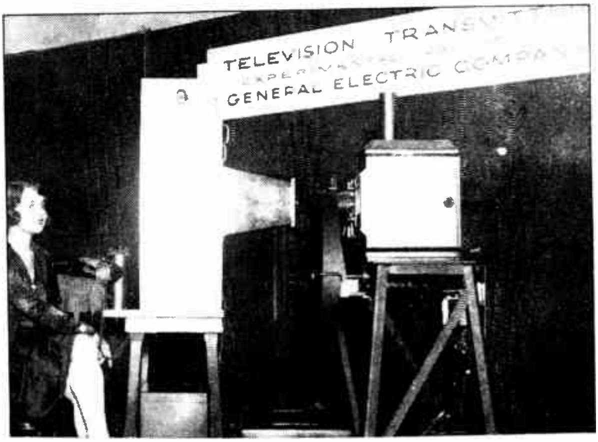


A Continuously Working Intermediate Film receiver. Broadcasts were received, converted into a video display, photographed by a motion picture camera, and then projected in a theater. 1928-1935.

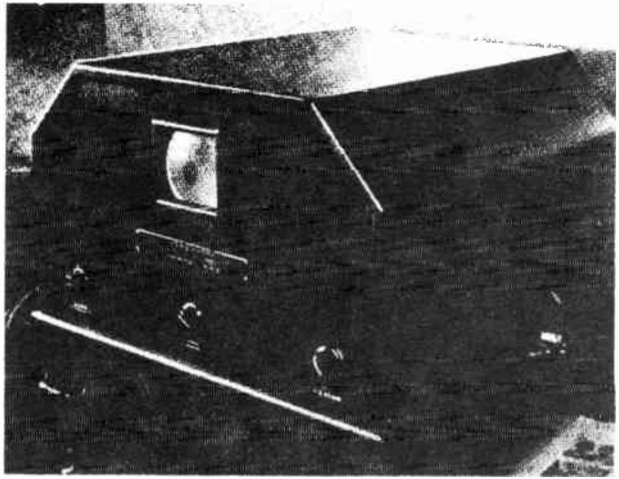


A Marconi 100 Line Mirror Drum Receiver. 1928.

John Logie Baird of Scotland, inventer of an early television system.



A demonstration of television in a department store (1928). Courtesy General Electric Corporation.



Photograph of a German Cathode Ray Tube Receiver and the set which made it. 1930.

David Sarnoff inaugrates television at the New York World's Fair, 1939. Courtesy of RCA/GE.

A Reichs-Runkfunk television remote truck equipped with an Intermediate Film Transmitter used between 1931 and 1940 in Germany.

A Dumont remote truck with cameras and microwave transmitter. 1950.

$200,000,000 entertainment…yours free on G-E

Jack Benny | Edgar Bergen | Bob Hope | Roberta Quinlan | Dave Garroway | Ken Murray | Jimmy Powers | Fred Waring

Look at the Difference!

(Above)—When interference or distance stands in the way, you may get pictures like this.

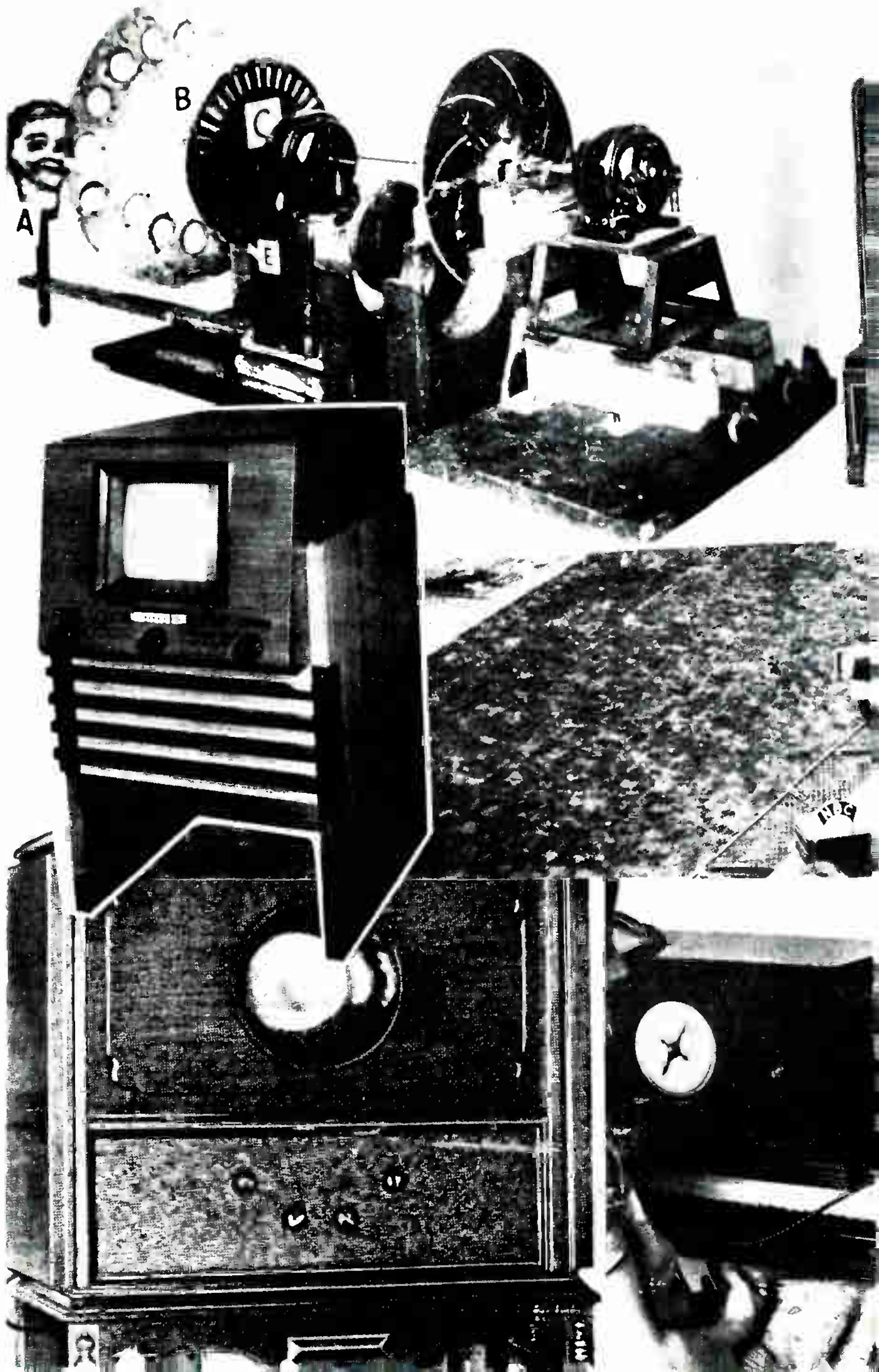
(Below)—With this great G E receiver, you can look to wonderful pictures like this.

G-E BLACK-DAYLITE TELEVISION

Overpowers interference …overrides distance too!

A 1951 magazine advertisement for General Electric televisions promises better reception in fringe areas. Courtesy General Electric Corporation.

Joseph Henry, the "Father" of Radio.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