Circa 1923 at the studios of KFI, Los Angeles.

Fred Allen and Portland Hoffa.

The technology which has been refined in broadcast engineering evolved over years of research and experimentation by scientists in search of technological achievement which often seemed as sturdy as a glass antenna.

The developments spanned the globe and arrived, step by step, piece by piece, through the span of time: wireless transmission; radio; television; multiplex broadcasting; color television; multiplex television sound (developed, but not yet marketed); broadcast automation, and then beyond to laboratory experiments including the possibility of wide-screen television transmission, perhaps, even, to three-dimensional transmission.

Joseph Henry, an American, was astounded when he found he could electrify needles by an "electrical discharge" of a machine he had devised before the turn of the 20th century. He had "transmitted" this discharge from as far as 30 ft. away and knew that "something" was in the air. Shortly thereafter, James Clark Maxwell, in England, was to provide his own experiments advancing his theory about electromagnetic waves.

It was Heinrich Hertz who demonstrated that these waves could be sent through space at the speed of light and that an intercepting wire system could capture those waves at a position remote from the source. The waves became known as "Hertzian" waves; the interceptor apparatus became known as the "Hertzian" loop.

Edouhard Branly, a Frenchman, had developed an interceptor, called a "coherer" because when Branly filled a test tube with metal filings and subjected them to electromagnetic waves, the filings cohered only to be broken apart when Branly tapped on the test tube. He would "break the circuit" with his tapping. By the addition of an automatic tapper, attached to the tube, impulses could be cohered and decohered to the Morse code of dots and dashes.

In 1896 Guglielmo Marconi put this concept to work, developing a telegraph key to make and break the circuit. That year he patented the device; the following year he set up the Marconi Wireless Telegraph Co. Marconi grounded half of his aerial and set up the other half protruding into the air. He called this his "antenna". The first device sent signals only two miles, then by improving Branly's coherer by adding nickel and silver, he was able to transmit mesages 18 miles and soon

THE GOLDEN AGE BROADCAST TECHNOLOGY

STAN KRAFT

messages were being sent across the English channel.

Meanwhile an American, Lee DeForest, had invented an electrolytic decoherer. DeForest, just out of Yale, and a good publicity man about his discoveries, contacted the Publishers Press Association in 1901 and secured a reporting contract allowing him to cover the International yacht races. Marconi and other inventors knew of DeForest's attempt to prove that his wireless system was better so they "set up shop" at the sporting event and so jammed up the electrical waves with their transmissions that DeForest suffered a humilating defeat. But such was the case that noone covering the race on wireless could get their messages out. The failure was shared by all.

Publicity Value

Theordore Roosevelt was incensed by the stories of the competitive attack against DeForest and he asked the American if he would demonstrate his equipment to the U.S. Navy. The installation of wireless equipment aboard ship proved that signals could be sent between ships and from ship to shore. DeForest saw to it that his invention was well publicized and the New York *Times* dispatched him to cover the Russo-Japanese war for them; the London *Times* followed suit. With the world's two leading newspapers behind DeForest, the publicity value not only increased DeForest's prestige, it also whipped up enthusiasm for wireless transmission. By 1903, newspapers were being printed at sea from dispatches being sent from shore.

It was the Canadian Reginald Fessenden who made the first great step forward in the transmission of voice. In December, 1900, Fessenden quietly developed a spark transmitter which sent his voice "through the air" to be picked up by astonished wireless telegraph operators. The voice was poor in quality, but there was no doubt it was voice. In May, 1901, Fessenden developed his "alternator," a high-frequency dynamo, and secured a patent for "transmission and reproduction of words and other audible signals." The following year, Fessenden developed his own electrolytic detector, a miniature light bulb containing a platinum wire, one end of which was sunk deep into a nitric acid solution, changing the pulsating waves into a continuous wave.

Fessenden found out about an ingenious concept which had been devised but not tested by Italian Nicola Tesla. Teaming with Charles Steinmetz at General Electric, he built his first high-frequency alternator and then took up where Tesla left off. With the Tesla conceived, Fessenden produced system, electric impulses were sent out in a curve traveling out in all directions forming an "ethereal bridge" allowing the vocal sounds to get through.

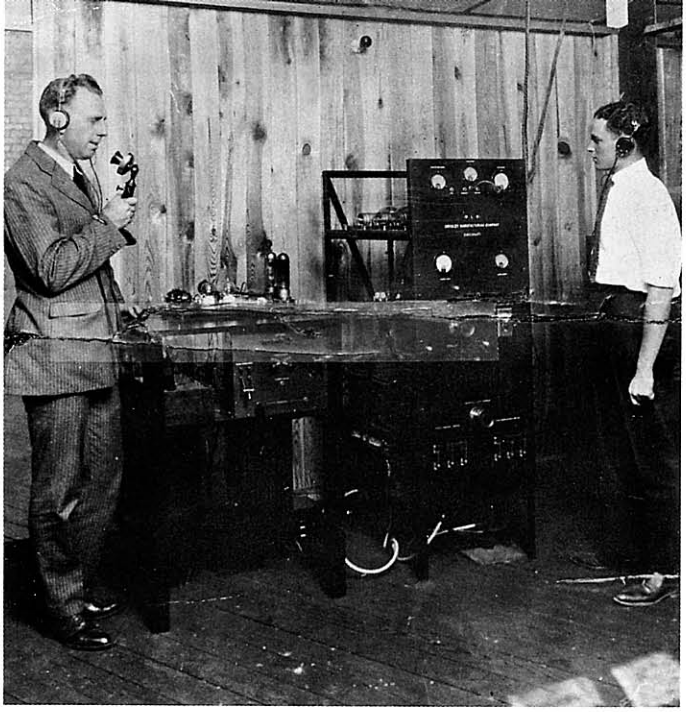
In 1906, at GE, E.F.W. Alexanderson teamed with Fessenden to build an alternator that was 7½ times more powerful than Fessenden's first instrument, to provide 75,000 cycles.

By this time, Fessenden had made his first-all radio broadcast, a program of music and speech heard along the East Coast from his lab in Brant Rock, Mass. all the way to Virginia. He accomplished this by coming up with another invention, the heterodyne concept, which eliminated the coherer system. It operated by joint operation of two alternating currents, one coming from the transmitter, the other from the receiver, with one layer joined to the top of the other layer forming a third layer that controlled static and was more sensitive.

Fessenden's discoveries were publicized — by all news sources. DeForest attempted to steal Fessenden's thunder. Fessenden was being called "the greatest wireless inventor, greater than Marconi" by the distinguished scientist Elihu Thompson. DeForest introduced the three-electrode vacuum tube, the "Audion" which was used as a detector *and* an amplifier which detected the radio waves and then gave them a burst of power so that they could be received loud and clear. His patent, secured in 1907, featured a sealed filament, a square of platinum for a plate, and a nickel grid. Through this development, long distance communication became a true possibility.

DeForest, again more publicity minded than Fessenden, made a successful demonstration of his invention aboard a yacht, leading the U.S. Navy to require radiotelephony on all of its vessels which cruised around the world in 1908.

In 1910, the *S.S. Republic* sank, and Congress enacted a radio act making it illegal for any passenger ship carrying more than 50 persons aboard traveling a distance of 200 miles from port to port to not have wireless equipment on board. Two years later, the sinking of the *S.S. Titanic* — simply because a neighboring ship was not manning its wireless receiver at the



Powel Crosley Jr., left, and Dorman Isreal, right, and 500 watt Crosley transmitter — late 1922.

time — required a fulltime radio man aboard ship. And wireless equipment had to be on board and in use no matter the distance from shore.

DeForest was not satisfied. He saw radio as a means for entertainment for the public, as well as news. He gained world-wide attention by broadcasting atop the Eiffel Tower and in 1910 had already played upon the vanity of the Metropolitan Opera star Enrico Caruso to have him and his cast broadcast an opera on radio "for all of the world to hear." In 1915, through his invention, he was able to set up radiophone communication between Arlington, Va. and Paris AND Honolulu. This only 11 years after the demonstration of wireless won a gold medal at the St. Louis Exposition of 1904.

No history of broadcast engineering can ignore the significant step made by Edwin Howard Armstrong, an officer in the signal corps whom many believe to be the greatest American inventor since Thomas Edison. Armstrong developed the circuits for use with the "Audion" tube which offered tremendous amplification of weak signals and greatly diffused the howls which used to come from the transmitter when continuous oscilation came about. Armstrong also modified Fessenden's heterodyne concept to produce the superhetereodyne system which eliminated the need for a long antenna and gave the sets a selectivity the receivers never had before. Armstrong went on to devise the concept of fm radio.

Armstrong's experiments were based on the then-already accepted theories. He knew that in amplitude modulation broadcasting the sound waves produced voltages in the speech amplifier and modulator circuitry which varied the strength of the radio-frequency carrier. Through his experiments Armstrong was able to maintain the strength of the carrier wave and his modulation changed the frequency of the carrier.

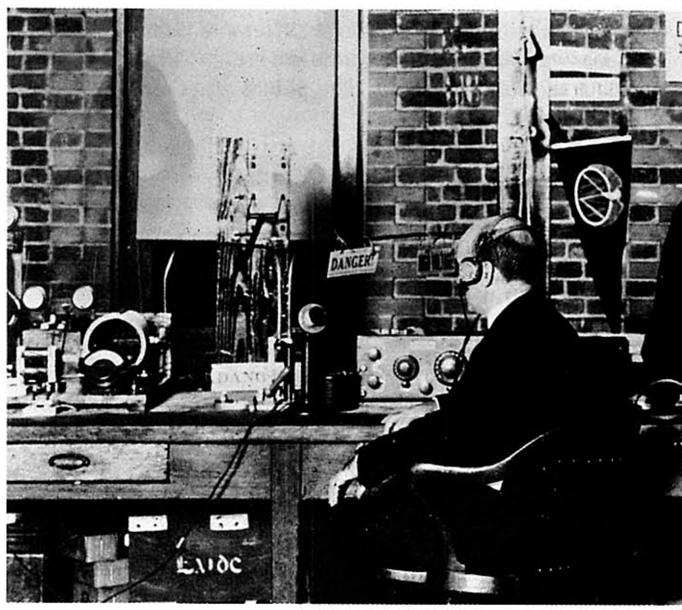
Through his developments he was able to produce sounds which did not depend on the 60 to 5,000 cycles of AM, but widened their scope so that his system covered the range of 30 (at the low end) to as high as 15,000 cycles (at the high end). The deep bass which was not possible to achieve in AM became strongly present, as were the high treble sounds, also previously lost through AM broadcasts.

Armstrong realized that his fm transmitter, because it operates on a very high frequency, had less transmission distance than am, no more, usually than 40 miles, standard today for fm stations. But therewere benefits: clearer, more pronounced sound — and because the sound entering the microphone of the transmitter does not produce changes in the amplitude of the carrier wave in the antenna, no static could be produced.

By working on the superheterodyne principle, a radio-frequency mixer, a substantial high-frequency oscillator and a radio-frequency amplifer which offered a broadly tuned factor was necessary. The wide-band amplifier was a vital component because of the 200 kc. frequency band.

There was another development in the installation of a *discriminator* instead of the usual second detector used in the AM system. This discriminator's job is to convert radio-frequency deviations produced by the audio modulator at the transmitter back to audio currents in the receiver's output circuit, which are then amplified and sent to the speakers. At the receiver, a *limiter* is installed which is a form of radio-amplifier circuit offering a low plate voltage and grid condenser bias allowing the tubes to saturate so that the voltage peaks on the grid make no like peaks in the plate current. Since the plate voltage is low (appr. 75 volts) the tube easily saturates when a strong signal is on the grid. The limiter delivers a radio frequency of uniform amplitude to the discriminator and while the ordinary am receiver deals with changes in amplitude, the frequency-modulation receiver operates on changes in frequency. The limiter delivers a radio frequency of uniform amplitude to the discriminator.

Although such refinements in FM broadcasting and transmitting took place over the years, Armstrong's initial steps brought him international acclaim. Already, radio engineering schools opened widely across the nation. A Radio International Conference had been staged in London in 1912 and two



One of America's first remote broadcasts, 1921, an improvised studio at the New York Electrical Show in the 71st Regiment Armory. Maj. J. Andrew White, standing center, program manager of RCA's first radio station, WDY, Roselle Park, N.J.

years later, the Institute of Radio Engineers had been formed. By 1915, wireless engineers, by connecting the 300 thermionic valves, had succeeded in transmitting speech across the Atlantic to Paris. All of this was history by the time Armstrong became involved in his fm experiments.

Dr. Michael I. Pupin, professor of electrical engineering at Columbia University, was already involved in his own refinements in broadcast transmission — and openly encouraging his students to enter the profession of broadcast technology. Hugo Gernsbach, a New York publisher, launched *Radio Amateur News* in July, 1919, which became the first "100 percent radio magazine" and encouraged interest in broadcasting. "I predict an astounding growth of the art in the next 10 years," he stated in his first editorial. "Marvelous inventions will be made in radio during the next decade — unbelievable now."

Alexanderson, a Swede, developed a multistage radio-frequency magnetic amplifer which acted as a "harnessing link" between antenna and microphone. Marconi, almost forgotten, asked Alexanderson to install a unit at his New Brunswick station where the "link" increased the power output ten times! The Radio Corporation of America, the then-merchandising arm for General Electric, asked Alexanderson to join them. He later became chief engineer at that company.

The War Years

During the war years, a Westinghouse station was on the air as a link between the armies of England and the United States. The station was the forerunner to the first commercially operated radio station in the United States, KDKA, Pittsburgh, Pa. which began fulltime broadcasting in 1920.

It was an invention of General H.C. Dunwoody which brought radio its first international burst of popularity. General Dunwoody invented the crystal set.

The crystal detector did not come factory-built until the 1920s were under way; people had to build their own. Parts and construction were fairly simple. You needed an antenna and a ground and connection to receive energy from passing radio waves carried—and you needed a detector. The antenna

was a bare or insulated wire from 50-100 feet in length, twisting one end around a limb of a tree or around a nail punctured into a neighboring building. A porcelain insulator was purchased and placed between one end of the wire and a tree, another insulator between the other end of the wire and the house where the signals were to be received. An insulator was used to keep the wire running into the room from the antenna from coming into contact with the house as it passed to the set. A ground connection was also attached from the set to a radiator or water pipe by means of a clamp.

For the crystal, a galena or silicon crystal was mounted in an alloy placed in a small metal cup. No wires were soldered to the cup since that might have destroyed the sensitivity of the crystal. Even hot water could melt the alloy.

A piece of fine wire, called a cat whisker, was used so that the point of the wire touched the crystal to find a sensitive spot. Attaching the antenna wire to the outer side of one of the crystal detector clips and the ground wire to the other clip, finally, attaching the earphones to the inner side of the clips, set up the unit. Moving the cat whisker lightly over the crystal brought in the sound of the station.

Innovations Seen

There were to be developed many innovations in crystal detectors. In a 1922 edition of *Radio Amateur News*, Gernsbach wrote: "*Judging from the number of different types of crystal detectors on the market at the present time, it would seem that there is no room for further improvement, as there are some exceptional designs. Of the recent types, the general trend seems to be towards the enclosed type of detector which, as we know, has many advantages over the old type of dust collector. Fred S. Hoover of New York has developed one which has as its chief features the provision made for reaching every part of the crystal employed in the apparatus with an extremely fine adjustment which is at the time rapid and rugged. The cat whisker contact is made of silver. The upper knob and rod control minute movement of the contact. That is, a twist of the knob hits every part of the crystal within the point. The lower knob controls the pressure of the coil and crystal.*"

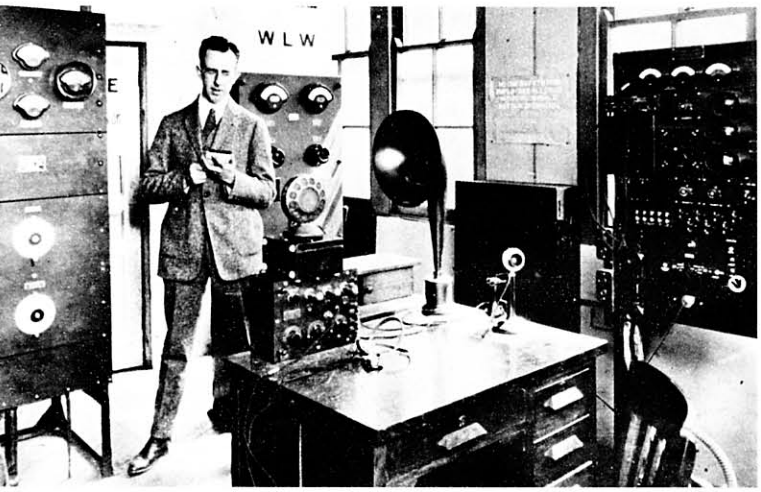
Most community stores were not selling radio parts. Mail order was the prime way for amateurs to buy their equipment. Many companies filled the needs from lower Manhattan, at the waterfront where the biggest buyers of radio gear were located, the men aboard the ships. In lower Manhattan, the area of Church and Chambers street became known as Radio Row, a name which remained until the late 1960s when the area was torn apart by bulldozers.

Although General Dunwoody's concept of the crystal detector proved substantial to the development of radio interest, he believed in—and, indeed, created, detector sets which used relatively expensive carborundum crystals which served as a valve in supressing the waves coming from the antenna, converting them to those waves which could be heard in the earphones. It was Greenleaf Pickard, however, who discovered the rectifying properties of silicon. This brought down the cost of the crystal detector. Pickard, who operated a receiving station in Otter Cliffs, Me. as early as 1905, devised a system of aerial connection that sharply reduced outside interference. He was a relatively obscure inventor until he brought some of his findings to the Institute of Radio Engineers in which in which he outlined some of his developments over the years. In 1929, his paper "Static Elimination of Directional Reception" brought him justifiable honors.

By 1929, radio had moved to earphone-less superheterodyne models and a number of companies moved in to try and capture the growing market. DeForest Radio Company was not the principal supplier of "Audion" tubes but there were other companies, General Electric and Westinghouse among them, giving DeForest a run for its money. In that year, the first Radio World's Fair was held at Madison Square Garden and it was here that parts manufacturers as well as complete unit manufacturers displayed their products, some just out of the workshop, each one claiming innovations. National Carbon Company moved beyond its supplying of Eveready batteries into manufacture of radio sets; names such as Atwater-Kent, Crosley, Brandes and Kolster, Silver, Zenith, Hammarlund, Majestic, Sparton, Champion Radio Tubes, and others fought for attention. The home receiver became a way of life. "Ham" operator enthusiasm soared and numerous magazines of interest only to them continued to be published. The professional broadcast engineer was a firm reality by 1929 and many had (by then) years of experience behind them. One of the "pioneers" was a brilliant young engineer who was hired in 1915 to install and operate a wireless system for the John Wanamaker Department Stores. The company had set up its transmitting station as an inexpensive way to keep communication between the company's New York and Philadelphia outlets. The engineer: David Sarnoff, founder of the Radio Corporation of America.

Interest in amateur broadcasting gained along with general radio, but less with the public than anticipated, who found listening, rather than transmitting, much more appealing. But that amateur radio began to grow in scope rather than in intensity is a matter of record.

There was a time when broadcast radio and wireless transmission did team up for tremendous publicity. The year: 1930 *The Literary Digest* was looking for a daily news commentator to fill the shoes of the gravel-voiced reporter Floyd Gibbons. The publication hired smooth talking, professional lecturer



Powel Crosley Jr. dedicating new 500 watt Western Electric Transmitter — April 11, 1923.

and world travel, the former Princeton University professor Lowell Thomas and he was set to broadcast over the newly-formed Columbia Broadcasting System. This was to be the first daily commentary on radio for the earliest (1923) commentator, H.V. Kaltenborn, only broadcast twice a week over the RCA (now NBC) Network. Thomas' success and popularity were immediate. Thomas knew radio, but not from anything except a wireless system. When Admiral Richard E. Byrd was making his expedition to Antartica's "Little America," Thomas, anchored to the microphone in New York, told of daily reports he had been receiving by means of wireless, at a station owned by Mackey Radio, subsidiary of Postal Telegraph. The publicity given to Postal Telegraph infuriated their competitor's board chairman Newcomb Carlton, of Western Union. It was 1938 and Carlton made an astounding offer: to transmit any and all messages to Lowell Thomas free of charge from any listener of Thomas's broadcast who wanted to send one. A whopping 265,654 Western Union telegrams poured in. Carlton's Western Union gained much publicity in its battle with Postal Telegraph. Curiously, Marconi's wireless system, which had been sending "Marconigrams" since 1907 was by then forgotten. But Lowell Thomas was not. In 1970, at the

Chief engineer, Joe Whitehouse with 1925 Western Electric 5 kw transmitter.

convention of the National Association of Broadcasters, he was named "a true pioneer" for his continuous broadcasting over 40 years.

The broadcast engineer, both amateur "ham" operator and professional was consistently on the lookout for new equipment. Some companies, like the Sleeper Radio Corp. continued to provide the engineers with "new" developments such as these which were advertised in April, 1922's *Radio & Model Engineering:*

> AIR CONDENSER MEETS ALL REQUIREMENTS
>
> What do you require of a variable air condensor? Or have you stopped to think just what you should require? The following specifications will serve as a guide in judging the merits of a condensor:
>
> Electrical features: Insulation of such material and design to produce a minimum power factor, high ratio of maximum to minimum capacity, negligible resistance in the leads.
>
> Mechanical features: Small in size, easy to mount, convenient terminals, permanent construction, smooth bearings, self-retaining movable plates.
>
> Bearing these factors in mind, consider the condensors illustrated. There is no moulded composition or "mud" employed, but sheet stock which will give the low power factor of 0.7%. The capacity ratio on the 0.0025 mfd. condensor is 20 to 1, and on the 0.000 mfd. size 75 to 1 over the useful portion of the scale. Usual types have a ratio of 4 to 1 and 10 to 1 for the two sizes, respectively. As for connections, on the stationary plates the resistance is zero, and only 7 milli-ohms on the movable plates.
>
> As for the mechanical construction, the G.A. standardized condensors can be worked in because of their compact design. The end plates are 3½" long and 2½ wide and the extreme width with the variable plates out, 3"., etc."

Other names moved in, including General Electric, the Philadelphia Radio Corporation (Philco), Radio Corporation of

America. Western Electric began to produce the first console transmitters and broadcasting equipment. Acoustical control became a paramount problem in broadcasting but radio stations had not as yet found definitive ways to improve their lot, and those who did kept their information a secret lest a competitive station take hold and transmit equally good sound.

By the mid-30s, however, Western Electric and Bell Laboratories seemed to be confining their experiments and developments to the telephone and to the coaxial cable, a development which would have far reaching effects in the later growth of television. Television was already in the development stage in the late twenties and General Electric began broadcasts in television over its broadcast outlet in Schenectedy, N.Y. over WGY-TV. In 1929, a Television Society was formed in London and published a journal, "Television" which purported to teach the engineer how to build his own receiver.

History of Television

England's Sir William Crookes's discovery of cathode rays in 1876 and two years later his development of the photoelectric cell, a device which altered the intensity of color variations to corresponding electrical energy was a spearhead to the development of television. A few years later, Paul Nipkow began experiments, as did Karl Braun, both of Germany. Nipkow devised a perforated spiral disc based on the theory of the persistence of vision; Braun had developed the oscilloscope displaying the variations of AC current in a vacuum tube. But it was Germany's Albert Einstein who first seemed to be convinced that a picture could be converted by electrical impulses.

Telegraphers who had been working with selinium found that selinium gave off increased power in transmitting electrical impulses when exposed to light; as early as 1875 a "Telectroscope" had been devised using this selinium as an operating device. There were other inventors who felt that "seeing by telegraph" was in the future and took out patents based on theories they had created. One of these was Alexander Graham Bell, inventor of the telephone.

Working on Nipkow's principle, but in his own unique way, America's C. Francis Jenkins used a scanning system of prisms for deflecting light beams and transmitted a still picture of President Warren G. Harding by telegraph from Washington D.C. to Philadelphia. This was in the early 1920s but this "miracle" was outdone in 1928 by John Baird of Scotland who developed his own system of mechanical scanning—and he transmitted a picture across the Atlantic ocean!

Bell Labs took it from there. Herbert Ives, who had been instrumental in the development of the wirephoto, televised President Hoover to an audience 300 miles away while the president was "transmitting" in Washington, D.C. Ives also presented the Speakerphone, still not yet nationally marketed, wherein a speaker would talk to another person seeing the person while he was talking. Television had arrived.

Alexanderson, still experimenting with broadcast transmission, then entered into television technology. In 1930, he presented a theatre demonstration of a television transmission on a 7-foot screen, using a perforated scanning disc and high frequency neon lamps. What the theatre audience saw was an orchestra performing in his laboratory some seven miles away. The images were unclear, but there was *was* a definite correlation in sound and picture, proving television could be more than a laboratory experiment; it could be as big a commercial force as radio.

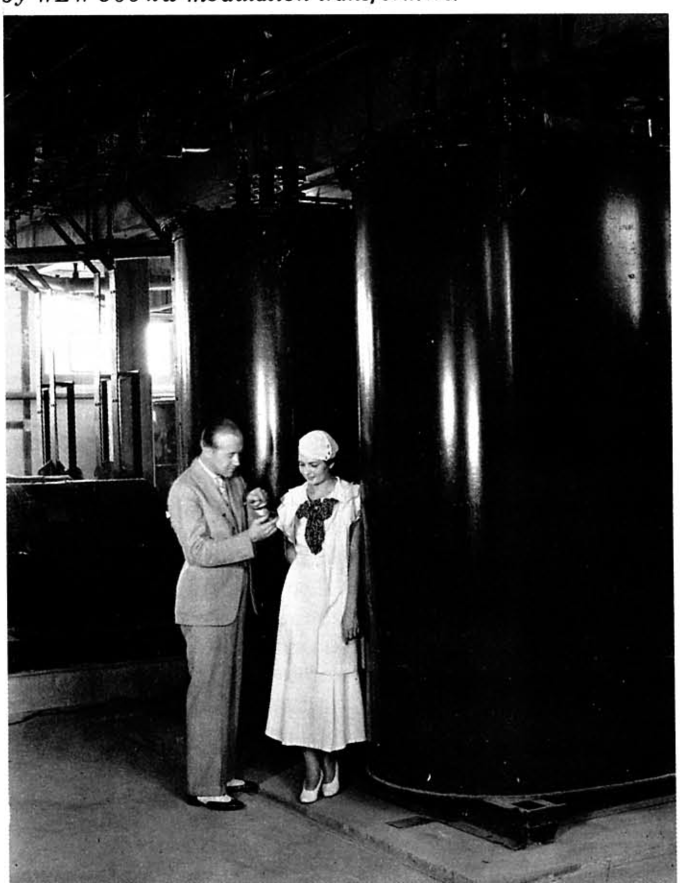
Vladmir K. Zworkin, working for Westinghouse and later RCA, began to improve upon the system. He developed the iconoscope which became the eye of the television camera. This device scanned the images and converted the images to electrical values working with a cathode ray tube which contained a mosaic plate performing the functions of the photoelectric cell. In addition, he devised an electronic "gun" which replaced the mechanical scanner. Philo T. Farnsworth also developed a system at this time which replaced the mechanical scanner and produced several stages of amplification as well. With Farnsworth's scanner, electronic images raced across the screen so fast that the picture turned fairly clear. By the mid-1930s, it was Farnsworth's system which was accepted by the broadcast industry.

RCA's David Sarnoff had long been interested in television and in 1935 RCA installed a transmitter atop the Empire State Building. Allen B. Dumont improved the tubes in use and introduced the first commercial television receiver. Through his development, pictures became more precise through what was termed "electrostatic deflection." By 1939, television transmission had truly arrived and Franklin D. Roosevelt demonstrated it at the New York World's Fair speaking before an RCA camera and broadcasting over the National Broadcasting Company's "system". When the war ended, Bell Laboratories completed their work on the coaxial cable for transmission.

The coaxial cable became a transmission line in which one conductor completely surrounded the other, the two being coaxial and separated by a continuous-solid dielectric or by kielectric spacers. Scientists at Bell found that such a line had no external field and was not susceptible to external field from other sources. Therefore, through such developments pictures could be transmitted, could be sent across the nation, without being subjected to interference by electricity in motion, or a magnetically charged atmosphere.

By 1948, with television successfully launched and in progress thanks to regular programming of the Columbia Broadcasting System, the National Broadcasting System and by the DuMont Network (The American Broadcasting System, once a

Band leader Lloyd Shafer and singer Honey Adams standing by WLW 500 kw modulation transformers.



Television history in the making: David Sarnoff, then president of RCA, stood before television cameras and dedicated RCA's pavilion at the 1939 New York World's Fair.

part of NBC, came later) television was already established.

In that year, however, a new development by Bell Laboratories scientists was to make huge inroads: the transistor.

Drs. Walter H. Brattain, Dr. John Bardeen and Dr. William Shockley won the Nobel Prize for the development of a slab of germanium with three connections to it.

The crystalline and atomic structures of germanium and silicon were discovered long before by metallurgists and chemists—and methods were devised wherein these materials could be supplied in their pure state. The point-contact diode, a glass tube-like unit containing two connection wires, is larger than the transistor. The development of both the diodes and the transistors eliminated the need for the two and three element vacuum tubes in receivers at a fraction of their size and weight. Silicon diodes, operating at higher temperatures than germanium diodes were found to offer even greater space and weight savings.

With the development of the transistor and diode, broadcast technology appeared to be cresting. The Japanese electronic industry began to develop its own strategic force toward the development of products utilizing the transistor and diode. Mitsubishi Electric Company, Tokyo, the foremost Japanese electronics firm, began to mass-produce transistorized circuitry in its radio receivers. The two-transistor radio appeared on the market by the thousands in 1960.

From 1948-1960, there seemed to be no uniform way in which to produce transistors. Much of the problem lay in the hands of manufacturers who were too concerned with making devices for spacecraft and computers to pay much attention to transistorized broadcasting. The space-oriented transistors had serious limitation of frequency responses in the upper audio ranges. While this didn't seem to matter too much in the case of portable radios, it proved disturbing to audio engineers seeking high quality in their equipment.

Compared with tubes, transistors had the advantages: they drew less power and developed less heat; took less time for warm-up; did not alter in characteristics with age; and supposedly, didn't wear out. Unlike the tube, the transistor does not produce erratic noises when exposed to vibration and proved extremely non-microphonic and sturdier to some hard knocks. Best of all, they proved hum-free.

However, although the development of the transistor and the diode was already a reality, it was some time before the different circuits were created, circuits which worked differently from tubes. Many of the earlier transistors were knocked out when volume was increased, and slight changes in temperature could alter some characteristics of the earlier transistors. It took four transistors to do the job of one tube. By 1964, however, circuitry had been refined and the transistors seemed to be developed fully to higher degrees of acceptability. In 1964, audio engineers, queried on the development of transistorized circuitry seemyd to agree that what the transistor gained in clarity, it lost in producing sound of warmth and tonal coloration.

Manufacturers answered the call, to some extent, by producing units with "presence controls"—producing a range of frequencies or pitches that give impact to the sound being heard. When a "bump" is introduced in the frequency response, a boost in the end of frequencies between 2,000 and 3,000 cycles per second appears, adding presence to the sound, perhaps a singer, allowing the singer's voice to move out in front of the accompanying instruments. The strings took on more guttiness, winds more brilliance, the brass had more bite. Transistorized circuitry in combination with the presence controls were then introduced to the broadcasting station and high-fidelity transmission was achieved.

Presence controls also began to appear on high-fidelity receivers as the component market began to open up. Engineers debated the value of presence, to what degree, when, how often should it be introduced into the mix. It was generally accepted, however, that a continuously variable degree control might be necessary to afford a swing from a flat position to +3 or 4 db of bump. This would, they said, require a second control, a simple switch which would offer three positions maximizing the bump at 2250,2500 and 2750 cycles per second. Personal choice continues to determine the right sound.

Another major development completely reoriented the broadcast industry and has done much, in combination with transistor and diode, to make the engineer's lot more functional and easier: magnetic tape recording. Ironically, the tape recorder, a boon to broadcasting engineers, is a constant threat for replacement of those engineers through automation.

Magnetic recording began with the discovery by Valdemar Poulsen of Denmark in 1898 who patented the first magnetic recording device after devising the system five years earlier.

Poulsen's device took the Grand Prize when he demonstrated it at the Paris Exposition of 1900 using wire as the recording medium. Although it did record and did playback, the absence of an amplifier system made the end result fairly inaudible. By 1903, the system had become of interest to various inventors and a company, The American Telegraphon Co. was founded in that year, but folded soon after. However, Poulsen patented a method of DC biasing in 1907 which brought about an enhanced playback effect for recording.

The primary interest in recording was then, and is to a great extent today, for use in dictation. In 1912 when Lee DeForest invented the vacuum tube, the recording interest began to improve because amplifiers were now being built and AC biasing began to work in combination to provide satisfactory—although crude by our standards—recordings. It was Kurt Stille of Germany who became the "Henry Ford" of recording just as Poulsen was known later as the "Thomas Edison". Stille talked some backers into marketing recording devices by setting up a patent holding company which would sell rights to those who wanted to make and sell the machines. By the

1920s a number of wire dictation machines were being sold throughout Europe—including the first machine to use a magazine loading principle.

Recorders were produced in a various array including one called the Blattnerphone, which used steel tape. Blattner saw the possibilities of tape recording as being the answer to recording and had heard of a possibility of using powdered magnetic materials rather then steel as the conductor for voice and sound, but proceeded no further with it. Blattner went to England to try to convince the film studios that sound could be added to film by means of an accompanying steel tape.

In 1927, the man who had made the suggestion about powdered magnetic coating, Pfleumer, began experiments in this direction. Coating cloth tape with powdered magnetic materials he found that sound could be recorded this way although the powder would fly just as soon as it would pass through the head. However, his experiments encouraged two German firms to continue the experiments, AEG producing the machine and I.G. Farben the tapes. But by 1931, no progress had really been made; recording was possible, but a steel tape seemed to be the only answer.

S.J. Begun of Brush Development Co. was next in the marketplace with his Lorenz machine in Germany. Begun emigrated to the United States in 1935 to continue his experiments.

The Germans, however, were vitally interested in tape recording and the AEG-Farben developments continued, culminating with the introduction of the German Magnetophon in 1935 which used plastic tape instead of steel. Bell Laboratories were well aware of the developments in tape recording and in 1935 had developed a steel tape recording machine, going so far as to develop the first stereo recorder, shown at the New York World's Fair of 1939—the same time that RCA had presented its development of television.

The stereo machine used two steel tapes which had been wound on the same reel but which separated and passed over two heads. Bell used a hard steel called Vicalloy which was extremely expensive — $1.50 a foot. Although Bell seemed to steal the thunder, Brush Development's Begun was continuing his experiments with what he called "The Soundmirror."

In the United States, Marvin Camras became associated with Armour Research Foundation and he, teaming Armour with General Electric Company, developed a wire recorder. Begun, however, received a research and development contract from the navy for his machine, which would use tape instead of wire. Begun developed a machine which had a recording time of only one minute on an endless tape. Continuing his experiments, he brought out a paper tape which interested Bell Labs; the $1.50 per foot price of Vicalloy was prohibitive. Begun also made a coating for wire tape and leased his developments to Webster Electric Company which introduced to the marketplace the first Webcor tape recorder in 1943.

In September, 1944, Begun convinced Minnesota Mining and Manufacturing Co. to help him develop a thin tape with a coating of ferromagnetic powder on it. 3M took it from there and Dr. Ralph Oace began a series of experiments which proved difficult since they were making a tape for which no recorder had been invented — as yet. Finding the right binder became the biggest problem since there was no test equipment to work with either, but by 1946 3M's Robert Westbee, heading up an r & d team, began to devise a series of test machines to work with a satisfactory binder. Begun later was able to introduce his own unit, the Brush Soundmirror, which used its own paper backed tape with a black-oxide coating.

In 1946, a number of companies came on the market with wire recorders including Magnecord which was formed to produce such equipment for the broadcast and recording field.

Gene Rider, left, and Charles Collingwood with film embossing recorder. 1944. CBS London office.

John S. Boyers, later with Bell Sound Systems, Russ Tinkham, later with Ampex, C.G. Barker, and J.L. Landon were the founders of the firm, Tinkham had been with Armour as had been Barker. They introduced their SD-1 unit in 1946 and later introduced the Audiad which incorporated a simple tape drive of about six ips. in combination with an AC-DC amplifier. They were started by closing an external circuit which would stop when a hole in the tape passed a contact shoe. The storage device was an elongated box. However, trouble soon ensued as the machines ran so hot they melted the binder used in the paper based tapes. In 1950, Magnecord introduced its famed PT-6 reel-to-reel plastic tape recorder at the NAB Show in Los Angeles. Within three days, $45,000 worth of business had been written, almost double its gross business the year before.

Experiments by Magnecord focused on at what speed the tape should progress. At first, the sound film speed of 18 in. per second was devised, but then a German Magnetophone was brought back from Europe operating a 77 centimeters per second (app. 30 in. per second). The NAB asked for a half of that speed and 15 ips was then the standard for broadcasting.

The German experiments with the Magnetophone were revealed after the war. One unit being used on Frankfort radio went out at 10,000 cycles and boasted very clean sound. John T. Mullin, who came across the unit, photographed the instruction manuals of the Magnetophone and found that the frequency range of the machines could be lengthened to 15,000 cycles—using coated Luvitherm tape. When Mullin returned he had assembled the machines with about 50 reels of tape he had secured and demonstrated them before the Institute of Recording Engineers. After that demonstration, Mullin was visited by Alex Poniatoff, Myron Stolaroff, Harold Lindsay and Charles McHarry—electric motors manufacturers who were looking for a new product to be sold under the Ampex Electric Co. banner. Mullin joined the company as consultant. Ampex was now in the recorder business.

3M, however, was interested in the recording tape and recognized that superior sound could only come through a superior oxide. Dr. W.W. Wetzel, who headed up the physics section of 3M's Central Research division, noticed that the

German tapes had low output, poor response at short wave lengths and had variable speed requirements. A tape lab was formed under M.C. Hegdal to devise coatings. By 1947, Brush's black-oxide tape had been the breakthrough item, but in that year Bing Crosby Enterprises began to consult Mullin about tape recording. Crosby had been seeking an end solution to tedious rerecording of his records and had been using transcription recordings for his Bing Crosby radio show. Later, Crosby sent his transcription recordings to Col. Richard H. Ranger who by then had introduced his Rangertone tape recorder in New York. Crosby realized that his broadcast transcriptions had lost quality in the re-recordings for duplicate transcription records. By piping the transcription of the Crosby broadcast from WJZ in New York over a telephone line to Ranger, the Colonel recorded the takes and some three weeks later the disc takes had been put together to furnish a finished program. Col. Ranger promised them that the broadcast would be duplicated in one day.

Within two months after the experiment, Crosby shows were being tape spliced together by Mullin in Hollywood as the birth of tape recorded broadcasting began.

Meanwhile 3m's experiments had paid dividends. A new red oxide tape had been produced on a platic binding offering 15,000 cycles per second frequency not at 15 ips but at 7½ ips. By the time 3M was ready to seek a patent, Armour's Camras was already seeking a patent for his similar oxide. In 1948, Ampex introduced its new red oxide tape.

By 1949, a number of new companies had entered the field to market tape recorders and it was at this time that Audio Devices became organized to market red oxide formulations with both paper and plastic based foundations. Audio Devices introduced a lubricant to its tapes and saw to it that there was a uniformity of quality in its product. By 1950, J. Herbert Orr introduced Irish tape—plastic with red oxide coating. Orr had been a signal corpsman who had liberated German tape equipment.

Ten years after Bell Labs had introduced stereo recordings, the Magnecord Co. introduced its own version, a three-head assembly with a spacing of 1-5/16 inches between the heads. This was later converted to 1¼ inch. In 1953, the Magnetic Tape Recording Industry Association was formed. One year later, Reeves Soundcraft brought out its 1-mil Plus 50 Mylar based tape for extended play, 3M introduced its 1-mil acetate base extended play tape. Three years later, Audio Devices introduced its low print-through tape and sales mushroomed: 110,000 tape and wire recorders sold in 1950, 100,000 more in 1951, since wire had been dropped in 1952, 100,000 tape recorders, in 1953, 200,000 and by 1954, 225,000. In 1955, the broadcast industry made a complete conversion to tape recording and of the 360,000 units sold, 60,000 were costing better than $500 each. By 1956, the figures ranged above 400,000 tape recorders.

There have been many developments through the years, but the interest in amateur broadcasting has never waned. As a matter of fact, with the emergence of the Citizen's Band receivers, it is now possible for the amateur radio fancier to broadcast without being registered with the Federal Communications Commission. While the CB band has been used for truck communication and ship-to-shore reception, it is still a hobby for those who simply want to talk.

Amateur equipment has been refined over the years until integrated circuitry and transistorized solid-state equipment has become the generally accepted way of life in the field. Many "hams", however, continue to stay close to the tube-operated equipment far longer than those interested in recievers. In many foreign countries and indeed, in many cities, long-life tubes are still doing the job in the face of modern engineering developments. Nostalgia, no doubt, plays a great deal in such consideration. Old engineers die hard.

Up-To-Date

In March, 1970, around the time Lowell Thomas was getting his award from the NAB in Chicago, a "ham" operator made contact with South Africa from his base in California. The voice asked the American if he would act as a standby for the National Aeronautic and Space Agency. The astronauts on Apollo 13 had not been able to land on the moon because of technical difficulties and were now heading back to earth. "Will you act as a standby for NASA?" the voice repeated.

"I don't know anybody in NASA," said the "Ham."

"Don't worry," said the voice from South Africa," we'll take care of that." And indeed, the California amateur operator turned in a professional performance acting as a communications point for the United States. The turn of the century and the space age had teamed up for a few exciting hours.

One of the early theories of radio waves has also come into view in the space age with the development of the radio telescope. It has recently been discovered that stars give out radio waves, waves which can be heard on Earth.

In the book *The 21st Century*, by Fred Warshovsky, it is stated that astronomical laboratories are investigating the concept of radio waves being radiated from the stars. Says Sir Bernard Lovell of the Jodrell Bank in England, "With the radio telescope we are penetrating so far in space that we're studying the epochs of time which take us back many thousands of millions of years and we're studying the universe—not as it is now. at this moment—but as it was in regions of time where it was possibly in an entirely different state, where it may have been closer to its early condition or evolution in origin."

Radio waves are said to travel at the rate of light waves, the pioneer theory still proven correct. Their waves are longer and can pass, say the astronomers, through the barriers of stellar dust and gas which block out the light waves. Through the radio telescope, more than 100 star-radio sources have been found and logged at Cambridge University in England. These have been labled 3C-147,3C-273, etc. The effort is now being made to uncover many more stars thought to be transmitting radio waves to Earth.

"Extraordinary Thing"

In Australia, astronomer Cyril Hazard noted that as the moon moved in front of a star labled 3C-273, the radio waves of the star were cut off! Coordinates were furnished by Hazard to Dr. Allan Sandage at Mt. Palomar Observatory for study. "It's an extraordinary thing," states Sir Lovell, "to have this great fortune of living in an age which is witness to the development of these two techniques, the space probe and the radio telescope. And each of these is having the same kind of impact on astronomy that the telescope had in the age of Galileo three and a half centuries ago."

Broadcasting on earth, as it is in space, continues to grow as technological improvement continues to grow. It seems that 1970 is still only the beginning. When Lowell Thomas's 40 years of broadcasting can name him a "true pioneer," when each man's small contribution becomes large in the jigsaw puzzle of life, then those pioneers of today, those broadcast engineers who will come on the scene with their own unique developments, their own special papers of the year 1970, may indeed prove that broadcast technology is in reality, only the beginning of a greater life ahead. ■