EARLY PHILADELPHIA TELEVISION

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I joined the Philco television group in September, 1934 after resigning as Chief Engineer of XENT, a 65 kw radio station on the Mexican border. Most of the group had previously been at RCA Camden, and included A.F.Murray, Phillip Kunkle, John Duncan, and Harry Branson. Frank J. Bingley was formerly with John L. Baird of U.K. in the early days of mechanical television. Mr Murray was the director of the group, reporting to Wm. Grimditch, V.P. Engineering at Philco Radio and Television Corp.

A complete TV control-room was in operation but the only signal source was from 35mm sound film. The projector had been modified to give 30 frames/sec at standard projection speed. Altho the system was electronic at 345 lines, the synchronizing pulses were generated by a mechanical disc. The timing of the horizontal pulses was made more uniform by means of regenerative electronic circuitry.

The Iconoscope pickup-tube and the monitor picture-tubes were made in the tube laboratory, since they could not be purchased from RCA at the time. Sam Essig had just joined the group and had been working for Zworykin when they discovered how to form the tiny discrete islands needed to make the Iconoscope feasible. The phosphors for the picture-tube screens were also made in the tube laboratory by a young electrical engineer. The parts/million impurity requirement was beyond the capability of contemporary chemistry. Tiny amounts of contaminants could produce the "pink underwear" color so detested by Mr. Grimditch.

One of my first assignments was to get the W3XE television transmitter working. It had been constructed during Philo T. Farnsworth's time (1931-1933) at Philco and included some interesting features. Multiple-plate variable capacitors had been machined from solid blocks of brass and then gold-plated. The high-voltage power-supply used a half-wave voltage-doubling circuit and had terrible regulation. The half-wave dipole antenna and open-wire transmission-line were mounted on a massive wooden tower made from 6 x 6 inch beams. I had a few anxious moments trying to repair the antenna system. I obtained a commercial radio-telephone operator's license and became the station's chief engineer.

The original W3XE transmitter was modified to investigate the feasibility of a new method of amplitude modulation. A single type-852 vacuum tube final rf amplifier delivered about 100 watts at 50 mhz to a quarter-wave vertical antenna above a copper sheet ground plane on the roof of the transmitter room. A quarter-wave transmission-line was then connected across the rf output line at a point one quarter wave from the rf amplifier tank circuit. When the remote end of the quarter-wave line was shorted, full output was sent to the antenna. Likewise, when the remote end was left open-circuited, the rf output fell to zero. The output could be "modulated" by connecting a variety of carbon resistors across the remote end of the "modulator line".

A second type-852 vacuum tube was next connected across the remote end of the modulator line to act as a variable resistance, controllable by the video signal applied to the grid. Tests confirmed that the little transmitter was indeed broadcasting a television signal. Studies indicated that this novel modulation scheme should be suitable for high-definition television and have an overall efficiency greater than that obtainable with either grid-bias or Class A plate modulation.

A patent application was filed and later granted for this transmission-line modulation method. As a matter of interest, this was my first patent, and the application was prepared by D.B. Smith, a young engineer who later represented Philco on the National Television Systems Committee (NTSC).

A new more powerful transmitter was next built using the new modulation method. The rf generator consisted simply of two type-846 water-cooled vacuum tubes as a push-pull oscillator. They were mounted in the upper ends of large brass tubes, forming the "organ-pipe" plate tank circuit. The grid tank consisted of a pair of smaller diameter tubes extending out horizontally. The dc power was supplied from a 5kv rectifier power-supply. The rf power output was fed to a pair of balanced 75 ohm coaxial transmission-lines.

The transmission-line modulator consisted of four Eimac type-450TL vacuum tubes arranged in parallel push-pull and connected to the rf output line junction through an open-wire transmission line. The length of this line was carefully adjusted to an electrical quarter-wavelength with the modulator tubes non-conducting. The transmitter output in this case was essentially zero since the modulator line presented a short circuit at the junction with the output line. Also, the short-circuited junction impedance was transformed to an open circuit at the tank circuit a quarter-wavelength away. In effect, the output line was disconnected from the tank.

The modulator grids were directly coupled to a direct-coupled 2 stage amplifier whose frequency response extended from zero to 5 mhz. An additional amplifier stage could be inserted to reverse the polarity of modulation for experimental tests. A 500 ft solid copper coaxial line brought the video signal from the control room on the 5th floor up to the transmitter room on the 8th floor.

The transmitter delivered a carrier power of 1000 watts at 50 mhz and was capable of linear modulation to over 80 percent. The frequency was manually adjustable and was continually checked with a heterodyne frequency monitor. Very little change in oscillator frequency took place during modulation, as could be observed using a square wave video signal. This relatively good frequency stability is believed due to the almost constant rf tank voltage during transmission-line modulation. An Invar high-Q circuit was later installed to minimize long-term frequency drift.

The modulated rf output was directly observed on an oscilloscope connected across the output line. The output of a 200 watt fm sound transmitter was combined with that of the main tansmitter thru a "notch" filter consisting of a half-wave long circuit tapped slightly off center. The above installation was used at W3XE until 1941.

The unique transmission-line modulation method was described in a paper presented at the Rochester Fall Meeting of the IRE in November, 1937. Also unique was the fact that this was the first paper ever presented by Philco. I was also invited to present the paper before IRE Sections in New York, Washington,DC, Philadelphia, and Emporium, PA. The paper concluded with a demonstration using a 200 mhz transmitter using a pair of type-834 vacuum tubes as an oscillator and another pair as transmission-line modulators. A small lamp connected across the antenna terminals indicated output. Modulation was clearly indicated by an appreciable brightening of the lamp. The demonstration unit had been built by a brilliant young engineer, Norman H. Young,Jr.

During the demonstration the frequency of the modulating signal was progressively increased through dc, 1000 hz, 1.5 mhz, 5 mhz, 10 mhz and 20 mhz. A Philco all-wave receiver at one side of the platform was used to measure the higher modulating frequencies. The demonstration was ceremoniously ended at 20 mhz since that was the frequency limit of the receiver!

An unexpected compliment to the Rochester presentation was contained in a letter from W.R.G.Baker of General Electric to Mr. Grimditch requesting permission for a visit by his transmitter engineers to Philco to discuss the new circuit in more detail. The General Electric television station WRGB, located at Schenectady,NY, was named after Mr. Baker. On another occasion, many years later, I was having lunch with a famous British engineer. Suddenly he stood up and asked me if I were the Parker who invented transmission-line modulation? He seemed to feel that the basic principle was used in practically every radar TR circuit ever made.

The original wooden antenna structure had been replaced with a 110 ft steel tower, giving a total height above ground of 210 ft. A bi-directional broad-band antenna was developed consisting of four half-wave dipoles arranged in a "cube". A series of quarter-wave lines transformed the impedances of the center-fed dipoles to match that of a pair of balanced coaxial lines from the transmitter. The design procedure made use of mutual impedance relations between radiators as described by Geo. H. Brown in an early IRE article. Mr. Brown later became a Vice President of RCA.

Actually, there were two cube antenna systems, one horizontally polarized, and the other for radiating vertically polarized signals. Sometimes they were interchanged weekly during experimental investigations. This caused some consternation with a few bars who had television receivers trying to show football games to their customers. The final antenna system used was non-directional and employed both an E-W and a N-S horizontally polarized cube antenna. The two antennas were fed to give a 90 degree phase shift. This quadrature connection resulted in a much better broad-band impedance behavior than either of the antenna systems alone.

The antenna development work needed an impedance meter to operate at 50 mhz,--not available on the market at the time. One was developed using one rf microammeter as a voltmeter and a second one as a shunted ammeter. A variable capacitor enabled the measurement of the reactance component of the impedance. This "instrument" was also helpful in the later single sideband filter development work.

Single side-band transmission interest was inspired by the assignment in 1936 of a series of 6 mhz channels for television. The sound carrier frequency was to be higher than that of the picture carrier in each channel. For maximum picture bandwidth (and definition) the picture carrier should be as close as feasible to the sound carrier of the lower adjacent channel. The design objective selected was a high-pass filter with the cutoff frequency set at 50.25 mhz and the first "infinite" attenuation point at 50.00 mhz, where the adjacent sound carrier could be located. This should provide a video bandwidth in excess of 5 mhz.

A pair of filters was designed using m-derived lumped-constant theory. Five sections were used, with half-sections at the ends to match the impedance of the coaxial lines feeding the antenna. The series elements were actual lumped capacitors but the series-resonant shunt elements were simulated by resonant coaxial lines. The characteristic impedance of these lines was adjusted to match both the reactance and the reactance-slope of the prototype lumped circuits over the desired rf band. Some of the lines used .25 in diameter center conductors inside copper tubing several inches in diameter and several feet long. In order to achieve high attenuation in the stop-band it was found important that the junctions of the coaxial lines with the adjacent capacitors be as compact as possible to prevent currents from bypassing the junctions.

The SSB filter response was measured using a Boonton Microvolter as a signal generator and a modified auto-radio as field-strength meter. For measurements of attenuation in the 70-80 db range a procedure was used much like the old "audiometer" method of comparing signal levels. The receiver rf frequency was swept back and forth over a narrow range while the signal generator level was slowly lowered until the audible "swish" in the receiver just disappeared. Measurements could be reproduced by this method to within 1 db! The transmitter side-band response was also observed by locating the field-strength meter one mile away. Single frequencies in the 0-5 mhz band were used to modulate the transmitter. The resulting upper and lower side-frequencies were then tuned in as separate signals and their amplitudes measured. As expected, the lower side band was essentially absent, the strongest lower side-frequency being about 30 db below a typical side-frequency in the upper side-band.

However, when a television video signal was used for modulation the received picture was hardly recognizable! Delay distortion was the suspected cause, probably as the result of the relatively steep (.25 mhz) cutoff. Measurement of the relative delay over the 5 mhz video band consisted in finding the slope of the phase-shift vs frequency curve. The phase shift was first determined by comparing the phase of a received video frequency with that sent out of the control room as the frequency was slowly increased from 60 hz to 5 mhz. Phase intervals of 180 degrees could be accurately measured by observing the nulls and maximums of the sum of the two signals. Total phase shifts of thousands of degrees were measured over the 5 mhz band! The corresponding delay distortion amounted to several microseconds.

A 19 section bridged-tee video network was designed to correct the delay distortion by pre-distorting the video signal going to the modulator of the transmitter. The design called for some of the sections to use negative values of inductance! This presented a problem until a solution was found in a book by A.T. Star, a U.K. author. Negative inductance elements can be simulated by using mutual inductance. The correcting network was mounted in a metal box with 19 compartments to isolate the sections. When a television video signal was passed through the network the picture became unrecognizable, but after also being transmitted and received an excellent picture resulted! Theory is wonderful!

The above SSB system was later re-designed to increase the separation between the picture carrier and the adjacent sound carrier to 1.25 mhz. Economical television receivers for home use could not be built for the .25 mhz system. The resulting usable video band-width thus decreased from 5 mhz to 4 mhz.

A detailed analysis of a filter design was required because the actual response may differ considerably from that predicted by m-derived filter theory. One of the reasons for the difference is that the iterative impedance of the network over the pass band is not constant at the nominal design impedance. This is especially true at frequencies within 10 percent of the cutoff frequency where the filter operates. A young engineer, Wm. O. Reed, was hired to help with the analysis work. He had taken courses in graduate school on the subject and had numerous tables for calculating mismatch loss etc. On one occasion as he was analyzing a design, I was checking the response by simply calculating the phasors along the chain network, starting from the load end. He was barely started by the time I had finished. He never used his tables and charts after that!

With W3XE on the air again it became necessary to develop receivers. My assistant with the early transmitter work, Chas. Stec, and I moved down to the 5th floor to start a group building television receivers. The first sets were quite bulky with twenty or more vacuum tubes and heavy power supplies. The picture tube was mounted vertically and was viewed by means of a sloping mirror in the cabinet lid. An array of numerous knobs controlled tuning, deflection, and size of picture. The first set went to my home to monitor the transmissions from W3XE. The next was installed at the home of Mr. Grimditch. Typically, any new Philco radio being developed was taken to his home for a shakedown run, along with its development engineer. After several such critical shakedowns the set was usually considered ready for the market. Other television sets went to Philco executives or were used for demonstrations.

Continuous rf tuning was used, altho only W3XE was receivable in the Philadelphia area at the time. Detent tuning of individual channels was considered but thought to be ahead of it's time. The intermediate frequency response was tailored for operation using the vestigial sideband system, with the picture carrier half way up the sloping response. In this system the lower video frequencies are transmitted double sideband, while the higher video frequencies are transmitted single sideband. During this receiver development a young engineer, Wm. Bradley, discussed a new design approach with me (over the lunch table). His method involved poles and zeros and was quite novel at the time. Bradley then mounted some rubber sheeting on a frame and lowered it over a series of vertical pencil stubs, adjusting their location and height until the slope and height of the sheet suited him. He then converted the physical dimensions to inductance and capacitance values. Another group built an if amplifier using these values. This amplifier had the best performance achieved up to that time!

Several innovations in picture tube design were tried at Philco. A "bent gun" design was used to reduce the tendency for screen ion spot caused by material other than electrons reaching the screen. Picture tubes having a rectangular screen and a metal envelope were made in a cooperative effort with Hygrade Sylvania. The project was abandoned because of difficult stress problems in the structure. A special tube was also built for research purposes having the gun parts consisting of precisely ground graphite cylinders so arranged as to maintain exact axial alignment in spite of temperature fluctuations. The resulting spot on the screen was the most perfect ever seen, being free from the usual flare and other aberrations. This tube was designed by L.P.Garner, with whom I had been associated in the early days of mechanical television in Chicago. Garner later left Philco to join Zworykin's staff at RCA for the development of high-power vhf transmitting tubes. Picture tubes were also built for projection onto a reflecting screen. In a much later development, a lenticular screen was produced which allowed a good picture to be viewed with direct sunlight striking the screen!

Early "studio" programs originated in the space next to the control room with a single Iconoscope camera and a couple of flood lights. This space was on the fifth floor of the Philco factory and the audio rumble was intolerable. A new studio was built using the "room within a room" principle with the concrete floor slab floating on a bed of coil springs. Provision was made for two cameras and several banks of incandescent flood lamps. Quiet ventilation was a necessity, and consisted of an air conditioning unit in an adjacent room, low velocity vents, and a connecting duct loaded with sound absorbing material. Engineers ran the cameras, manned the control room, and constructed flats and scenery, along with their other duties. Much of the studio construction and operation was under the direction of A. H. Brolly, previously Chief Engineer for Farnsworth. Facilities for televising 16 mm movie film and still slides were also added.

Most of the studio presentations consisted of variety shows and plays by amateur dramatic groups. The plays had already been presented in little theaters but a couple of evening rehearsals were usually needed to map out camera positions and to determine actor grouping more suited to television. The amateur performers were "paid" by presenting them with candid photos taken during the show. The 5x7 inch photos were masked to resemble television pictures. The photo work was done in the basement of R.E.Waggener, one of the engineers. His basement was also used as a machine shop and tube laboratory during a strike at the Philco plant. The lathe was the same one I had used to make mechanical television receiver parts in 1931!.

Programming was greatly enhanced by the hiring of a full time Program Director, Nick Alexander. The television department secretary frequently acted as "script girl", giving cues to the director regarding camera changes etc. An elaborate Xmas show required a main set showing the inside of a church, and half a dozen smaller sets scattered around the studio. The main set was drawn by Brolly by following an image of a Xmas greeting card projected onto the blank flats. The perspective was so realistic that the Executive V.P. came back to the studio the next day to see how we could get such a deep set inside the studio! The organ used for the program was an old reed organ borrowed from the Good Will Industries. A commercial type vacuum cleaner in the next room and connected by a hose through the wall substituted for the usual foot pumping. The cast included wives and children of the television department. Another show included Girl Scouts and Brownies.

The W3XE programs also included a variety of remote pickups, such as the 1940 Republican National Convention, the Philadelphia Mummer's Parade, Ice Follies, the University of Pennsylvania home football games, and other sports events.

Some of these remote pickups required elaborate preparations, such as a 300 mhz transmitter in a room built on top of Convention Hall to relay the program to receiving equipment located at the Philco plant about 12 mi away in North Philadelphia. A feature of the receiver was means to shave off the incoming syncronizing signals and reinsert new ones. The design and construction of the equipment used for remotes was under the direction of Frank J. Bingley. The convention facilities included a camera platform attached to the left hand balcony and a control room under the balcony. NBC occupied a similar platform attached to the right hand balcony. Their control facilities were contained in a large motor bus parked along side Convention Hall. The NBC television signal was then transmitted to New York via coaxial cable. Orthicon pickup tubes became available for remote cameras shortly following the 1940 Republican National Convention.

I was privileged to witness a Bell Laboratories demonstration of the New York-Philadelphia coaxial cable in 1937. Excellent high definition pictures were transmitted and viewed on a picture tube several feet long, designed to minimize any deflection distortion. Beam modulation was by varying the width of the rectangular scanning spot. We had also been invited to visit the NBC studio and remote pickup facilities in New York. A high point of this visit was having lunch with an RCA V.P. in the Rainbow Room atop the RCA building. The NBC television transmitter was located a few blocks away on top of the Empire State Building.

The installation for the football games consisted of camera platforms at the 20 yard lines and a large control room under the South stand of Franklin Field. Monitors in the control room permitted the director to select appropriate camera shots. A camera was also provided in the control room for individual interviews. Cameras back at the main studio could be selected to present the scoreboard and other statistics of the game during time-outs. The audio signal was sent back to the studio over regular telephone lines. Separate order wires allowed communication between the director and the main studio as well as with assistants on the sidelines of the playing field. The video signal from the control room was sent to the 300 mhz relay transmitter atop Convention Hall over a solid copper coaxial line several hundred feet long. Some of this distance was along a railway traversed by electric trains. When a train would go by the television signal was completely ruined by the strong signal induced in the coaxial line! The telephone company came to our rescue by furnishing a video wire circuit using a standard cable pair with special equalizers and booster amplifiers. We observed that the cable pair was connected between the grid and floating cathode of the input stage of the terminating amplifier to minimize interference from even mode signals. When our own amplifier was changed to a similar circuit the copper coaxial line also worked fine, with no interference from the trains.

A video wire circuit was also installed between remote end was adjusted to just cancel out the polarity and amplitude of the transient. Needless to say, the picture quality at other receiving locations suffered.

At one time the same channel was assigned to both W3XE and a television station located in New York City on the erroneous assumption that vhf signals do not propagate beyond the line of sight. As I expected, the interference was intolerable, especially about midway between New York and Philadelphia. Not expected, however, were letters from "flat earth" believers who interpreted the results as proving that the earth is not round after all!

Not all demonstrations were over the air. One particular one involved the troup of show girls from the New York stage show "Hell's a Poppin'". I acted as "interviewer" of individual girls before the camera,--quite an experience! Mrs. Parker and I later attended the show and went back stage afterward to talk with Olson and Johnson, the producers.

Another series of demonstrations consisted of a Philco "roadshow" presented at department stores in a number of midwest cities. The Iconoscope camera was run by Chas. Stec, while the receivers were manned by Norman Young. A.F. Murray was in charge. A compact (for it's time) synchronizing generator had been built by Rufus Applegarth. The unit measured about 8 by 17 inches, and included a low powered radio transmitter. I was put in charge of the Philco television department by Mr. Grimditch in Mr. Murray's absence and remained in charge when he resigned.

A serious attempt was made early in 1941 by the National Television Standards Committee to set standards for U.S. television. To assist the effort, Philco conducted a number of tests as to number of scanning lines, more reliable synchronizing, and polarity of transmission. Various line numbers were tested from 441 to 625 lines before recommending the 525 lines finally standardized for the U.S. The W3XE transmitter was completely rebuilt to permit am or fm modulation of either picture or synchronizing, or both. Frequency modulation was accomplished in a reactance tuned oscillator at about the 10 watt level and at a fraction of the final carrier frequency. A series of doublers, triplers, and amplifier stages raised the power to the 1 kw level. Grid bias modulation of the rf output stage was used for amplitude modulation. Care was needed in the adjustment of the intermediate stages to achieve pure frequency modulation, free of any spurious am. Instantaneous selection of various modulation combinations was possible for demonstration purposes. The construction of this rather sophisticated transmitter was under the direction of Bingley.

One combination to produce augmented synchronization used am negative modulation (increased carrier amplitude for synch pulses), and then during synch intervals, an upward shift in the carrier frequency of about a mhz. This shift brought the carrier up on the flat portion of the receiver response with the result that the synch pulse amplitude was

Convention Hall and a sports arena several miles away. The first sports event happened to be professional wrestling. Our engineers, familiar only with college wrestling, were amazed at the show! Televising the Ice Follies presented an interesting challenge. One camera was mounted on a platform located near the roof of the arena, looking almost straight down. The Mitchell camera tripod was anchored to the platform to prevent falling. Considerable strength was required to maneuver the camera to follow the fast skating. Some of the ice show scenes were dimly lighted and difficult to pick up. A 16 mm film of the entire show was run at the main studio during the performance to provide a backup for the dark scenes. The accuracy of timing between the film and the live show was amazing! A switchover could be made at any time without being noticed.

Preparation for televising the Philadelphia Mummer's Parade presented some unusual problems. The elevated camera platform extended out from the North side of City Hall. The control equipment was located inside in the city council chamber (on plywood sheets to protect the carpets). The 300 mhz relay transmitter was located in the metal hat of a statue of Wm. Penn on top of the building tower. In Philadelphia no buildings are allowed to be taller than Wm. Penn's hat. No appreciable ac power was available in the building so that cables had to be run from a point under the street, through a tunnel, up the elevator shaft, and over the roof to the council chamber! Power cables also had to be pulled up the elevator shaft to the transmitter.

Another interesting situation developed when we attempted to televise the Annual Boat show held next door to Convention Hall. I had difficulty starting up the transmitter for the evening show. It had been snowing all day and the antenna array was covered with ice and sleet. The man called in to clean off the ice refused to climb the tower because the weight of the ice had buckled the tower!

Demonstrations were part of the life of early television. One important demonstration was held at the Franklin Institute in downtown Philadelphia in 1936, and represented the first on-the-air showing of a 441 line picture and single side band transmission. The picture quality was excellent and seemed to greatly impress R. D. Kell and other engineers from RCA (our competitors). Kell had worked with mechanical television in 1927 while at General Electric. Ghost images and other defects peculiar to the receiver location had been "corrected" by pre-distorting the video signal at the transmitter. The frequency response of the overall system was measured and any sharp peaks or dips carefully noted. A single peak, identified with a decaying repeat image in the picture, was compensated for by inserting a properly proportioned RLC tuned-circuit in series with the plate coupling resistor of the modulator amplifier. A single after-image in the picture was corrected by inserting a length of two conductor lamp cord in the coupling circuit. The length of the lamp cord matched the delay of the after-image while a variable resistor connected across the doubled over the normal value, with a corresponding promise of improvement in synchronizing stability.

A demonstration for the Federal Communications Commission, the National Television Systems Committee, and the news media was held at the Huntingdon Valley Country Club, some 20 miles from the transmitter. It was winter and a severe snowstorm caused the limousines on the way from the railroad station to get stuck in the snowdrifts. I remember sitting in the rear seat next to a Life Magazine photographer for several hours before being rescued. (The newsmen played poker all night at the club). The next day the effect of various numbers of lines was demonstrated as well as other features. However, the demonstration of augmented synchronizing was a complete flop! A ghost image of the horizontal synch pulse occurred in the center of the picture. It was extra strong and at a frequency different from that of the carrier by about a mhz. The result was a severe "herringbone" or "watered silk" pattern, completely ruining the normal picture. Successful synch augmentation would seem to require a transmission path completely free from reflections from buildings or other causes of ghost images.

The setting of television standards was further complicated by the possibility of color television. A demonstration of a "field sequential" system in September 1940 by the Columbia Broadcasting System used 343 lines and a rotating color disc. The results were judged as only fair, and the system was completely incompatible with existing electronic television. Experiments at Philco with such a field sequential system led to the same conclusion.

Standards were finally agreed upon and U.S. television was made "commercial" as of July 1, 1941, using 525 lines and 30 frames per second (interlaced), as recommended by Philco. The experimental license W3XE was replaced by a commercial license with the call letters WPTZ. Philco later sold WPTZ to a Philadelphia broadcast station. I resigned from Philco in October 1941 to take a position with the U.S. Government during World War II. After the war I joined L.P.Garner at RCA to develop a line of super-power transmitting tubes.