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AND FROM MCFARLAND

The History of Television, 1942 to 2000
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The History of Television, 1880 to 1941

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Chapter 10

The London Television Service: 1936–1939

On January 15, 1936, H.G. Lubszynski of EMI applied for three important patents. One was for an image iconoscope with added secondary emission. Another was for a camera tube that used several target electrodes. But his most important patent disclosed means for having the electron beam approach the screen to be scanned substantially "normally," i.e., at an angle of 15 degrees or less. It had been found that the current collected from a screen was dependent not only on its potential but very much upon the angle of incidence of the beam. It was recommended that the electrons be traveling at a comparatively low speed in order not to gain too high a lateral velocity.

By this time, efforts to produce a low velocity electron beam had shown that perpendicular landing of the beam was a necessity in order to have a flat field. It appears that as the angle of the beam increased, the beam lost much of its power and caused gradual fading of the image. Lubszynski's patent was very important, for it was the first step taken to produce a camera tube using a low velocity electron beam in order to eliminate the various harmful effects of a high velocity beam striking a target. These included "tilt and bend" (the uneven shading over the surface of the mosaic) and the copious secondary emission from the high velocity scanning beam.[1]

The work of Arturo Castellani was described in January 1936. Mr. Castellani was director of SAFAR (Societa Anomina Fabbricazione Apparecchi Radiofonici) in Italy. He had developed a television camera using his new camera tube, called the Telepantoscope.

Basically it was a form of Iconoscope with an electron beam that scanned a photoelectric mosaic. However, the electron beam scanned only a single line horizontally. A rotating mirror drum was used for the vertical movement of picture. The mirror drum had a synchronizing disc on it to ensure perfect synchronization. For film transmission, the mirror drum was dispensed with, using the continuous movement of the film for the vertical component.

The tube was small enough to be installed in a camera about the same size as an ordinary movie camera. It was claimed that Mr. Castellani had first displayed television equipment at the Radio Show in Milan in 1930.[2]

In February 1936 Dr. Zworykin gave a lecture on electron multipliers. He described his work on a new "electron image" tube. This tube could be used to produce a visible image from both the ultraviolet and infrared portions of the light spectrum. It operated by having a translucent photocathode made of a microscopic layer of platinum sputtered on a glass or quartz plate. A thin layer of oxidized silver would be reacted with cesium vapor, forming a sensitive photosensitive surface. Light from the scene would strike this layer and would cause electrons to be emitted from the other side. These would be concentrated by means of several electrical anodes which would focus the electrons onto a fluorescent screen. By means of this tube, examination of living specimens under infrared light was made possible. Or, it was claimed, it could be used to see through fog, smoke or darkness. A demonstration of the tube with motion pictures was given at the lecture.[3]

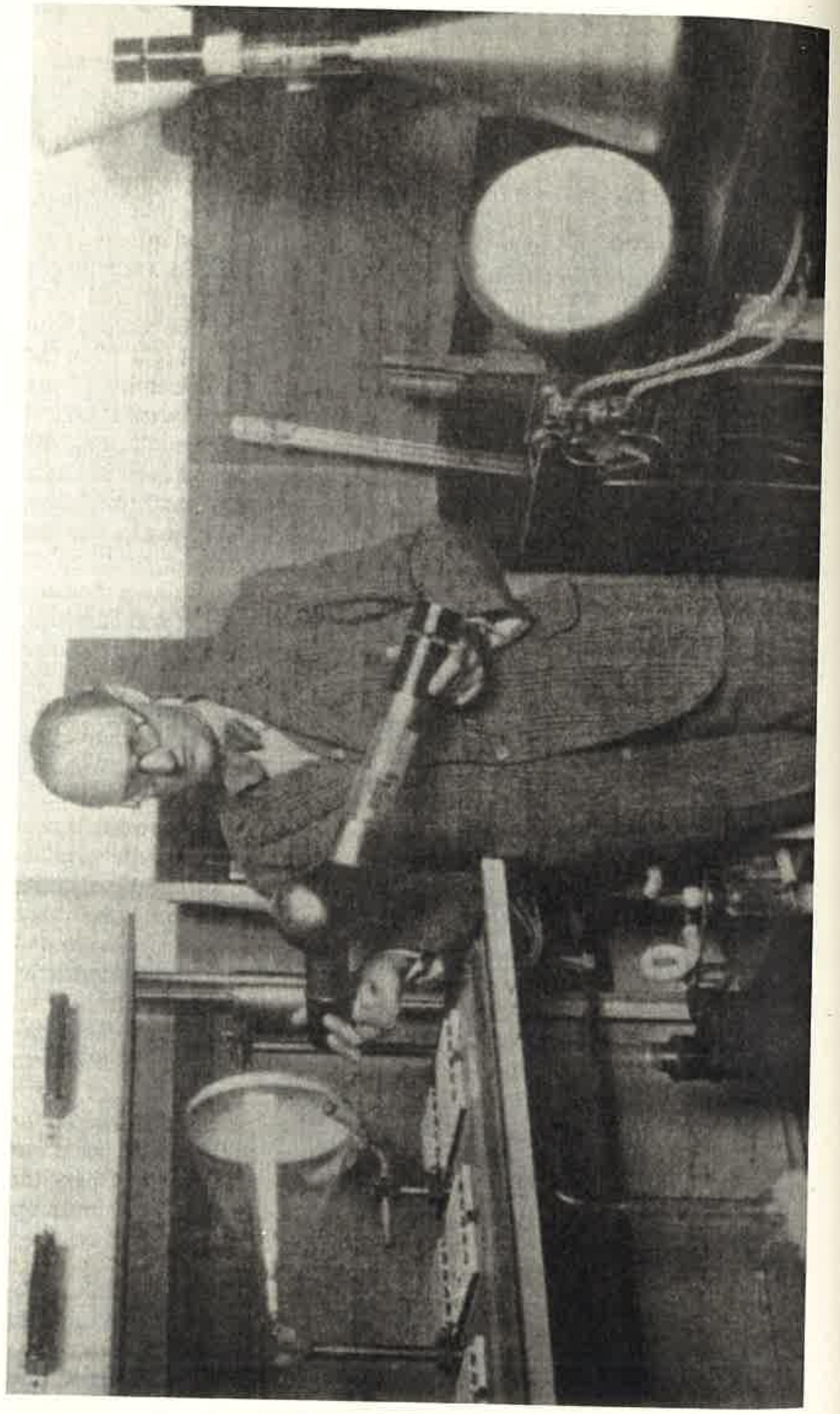
At this time in 1936 there were many difficulties in setting up the London Television Service. Relations between Baird Television and Marconi-EMI were very strained. Neither company would allow the other to know what it was doing. Terence C. Macnamara was in charge of planning the new station. Douglas C. Birkenshaw, engineer in charge at the Alexandra Palace, had the difficult task of keeping peace between the companies. They had come to no agreement regarding a standard form of license regarding their television patents.[4]

The early plans of the Baird Company included (1) the spot-light process, (2) the electron (Farnsworth) camera, (3) the use of the intermediate film process and (4) a mechanical film scanner using a Nipkow disc similar to that of the intermediate film process.

The Spotlight Studio used a disc scanner running at 6,000 rpm and having four spirals, each of 60 holes. Each spiral was brought into use by means of a further shutter disc revolving at 15,000 rpm. The large disc, which was enclosed in a vacuum, was rotated by means of a 100-cycle, 3-phase synchronous motor of ½ horsepower. The small disc was driven by a 1/20-horsepower, 50-cycle, 3-phase motor.

The light source was a large arc consuming 120 amperes. Owing to the intense heat generated by an arc of this power, the scanning gate was water-cooled. The reflected light was picked up by 4 large photocells of the multiplier type whose positions were adjustable. A cathode ray monitor was provided in the spotlight projection room.

The electron camera studio was equipped with two experimental electron cameras whose associated apparatus was housed in a further adjacently situated subcontrol room. One of the cameras was mounted on a movable run truck and the other on a tripod. The scanning currents and other supplies for these cameras were all generated in the subcontrol room



and sent to each camera by a composite cable. The camera outputs were amplified in head amplifiers and the output passed back along a composite cable to the subcontrol room. Intercamera fading was carried out in this control room, and the single output passed to the central control room.

The intermediate film process had a special camera using 17.5mm film (half of 35mm) which after being photographed was quickly developed, washed, fixed, and washed again. The film was scanned while still wet. The film was run through an underwater gate through which was directed a beam of light from a 60-ampere arc. The disc was driven by a ½-horsepower, 3-phase motor, with the disc being enclosed in a vacuum. It ran at 6,000 rpm and contained 60 holes arranged on the circumference of a circle. The light from the disc was sent to a photocell of the multiplier type and then passed through a series of amplifiers to the central control room. The sound was recorded on the film so that it was in sync with the picture when it was projected some 65 seconds later.

Two identical sets of Telecine equipment were installed for the transmission of 35mm motion picture film. The film was driven under continuous motion by a modified film projector and after illumination by a 60-ampere lamp was scanned by a disc unit similar to that of the intermediate film apparatus. There were means for a rapid changeover of both sound and vision from the output of one projector to another. Each of these picture sources was connected to the central control room, where they were all monitored and sent to the transmitter via a concentric cable. Transmission was the Baird standard of 240 lines sequential at 25 frames/sec.[5]

The Marconi-EMI system was built around the "Emitron" camera tube. This was Marconi-EMI's trade name for its version of the Iconoscope. There were six cameras all told. Four of the cameras were built into the Marconi-EMI studio. Camera 1 was usually in the center of the studio on a mobile truck. Cameras 2 and 3 might cover the scene from alternative viewpoints, while camera 4 was usually reserved for announcers or captions. The other two cameras were fed motion picture film from conventional 35mm film projectors. Sound was picked up by a moving coil microphone suspended from a boom, while an orchestra was covered by a ribbon microphone, and two other microphones were available as needed.

The Emitron cameras included an Emitron camera tube, an optical lens system and viewfinders, and a head amplifier. The optical system consisted of a matched pair of lenses, either 6.5 inch f/3 for normal use, or 12-inch focal length lenses at f/4.5, the width of the mosaic being some 4.75 inches. Automatic compensation for parallax was provided at all distances.

The signals from the various cameras were sent to a "fading and monitoring mixer," where any signal could be sent out for transmission

Opposite: Arturo Castellani and his Telepantoscope camera tube.

over the air, or sent to a second channel where it could be previewed before being used. There was even a third channel, used as either a spare or a means for transmitting film signals while rehearsing a live program. There was no instantaneous switching of pictures, only a means for slowly mixing from one channel to another (which did allow superimpositions).

An elaborate system of correcting the "tilt and bend" signals were incorporated in the system as well as the necessary controls for controlling the focusing beam and its electrical gain and adjusting the size of the picture. Picture transmission was on the Marconi-EMI standard of 405 lines interlaced two-to-one at 25 frames. This was the most advanced television system in the world at the time.[6]

On April 9, 1936, John L. Baird of Baird Television Ltd. applied for a patent for a color television method. It was a simple method of setting a rotating color wheel with three filters (red, green and blue) in front of a cathode ray tube so that each filter was viewed when its color was being transmitted. The use of only two filters was mentioned as well as the projection of the images through the filters onto a viewing screen.[7]

During the months of April and May of 1936, V. Jones of Baird Television Ltd. applied for several patents on various forms of electronic camera tubes. Baird Television was doing much research into electronic camera tubes in order to offset the advantage that Marconi-EMI had. Much effort was made to improve the Farnsworth Electron Camera. In spite of the fact that it was working quite well in the United States, Baird Television had very bad luck with it. For reasons which have never been explained, it never could produce reasonable pictures for Baird in England. As a result, it was sparingly used in the demonstrations at the Alexandra Palace according to Tony Bridgewater.[8]

The promise of a high definition service in England spurred much activity in the United States. RCA gave a demonstration of its system to the press on April 24, 1936, from Camden, N.J. This was the first demonstration given by RCA since May 17, 1932. It was of a 343-line, 30-frame interlaced system. The Empire State transmitter went back on the air on June 29, 1936. It was also a 343-line picture. However, it was not until July 7, 1939, that the pictures were considered "worth showing." This was the occasion of a demonstration of the RCA television system at Radio City for an assembly of RCA licensees. It was revealed that three receiving sets were in operation in the area but that within a short time more than 100 sets would be distributed at scattered outposts.[9]

In Los Angeles, the Don Lee Broadcasting System under Harry Lubcke had completed the design and construction of a high definition system. It was a 300-line, 24-frame sequential system. There was no interlacing due to the fact that the Los Angeles area was served by both 50- and 60-cycle power. Public demonstrations were held daily beginning on June 4, 1936.[10]

On June 15, 1936, a new set of television standards was presented to the Federal Communications Commission by the Television Committee of

the RMA. They recommended a channel width of 6 mc, the use of between 440 and 450 lines at 60 fields interlaced, with spacing of the picture and sound carriers of approximately 3.25 mc. The use of negative picture polarity, with the sound carrier above the picture carrier was recommended, as was space to provide for seven channels between 42 mc and 90 mc. Three items were left for future discussion: (1) the use of vertical or horizontal polarization of transmission, (2) transmission of the DC component, and (3) maximum percentage of modulation.[11]

The Philco Radio and Television Corporation had also carried out a series of tests on 345-line, 30-frame interlaced pictures with sound on 54.25 mc and vision on 51 mc. Picture modulation was 2.5 mc and it was claimed that a special type of modulator had been developed. Philco was asking for a 6 mc total channel width.

On June 18, 1936, Philco started a series of "regular" programs, and a special demonstration was given to the press on August 11, 1936. The test of both film and "live" television (a mock prize fight from the roof of the plant) was staged under the direction of Albert F. Murray. It was noted that there was little difference in the pictures off the air or from concentric cable.[12]

Farnsworth Television had also improved its equipment. A new experimental television studio had been equipped with several Farnsworth cameras, for both "live" and film use. By this time, the "live" camera was quite compact, weighing some 75 pounds, being only $10 \times 12 \times 15$ inches wide. It even included a lens disc mounted with 4 lenses for varying focus. It was claimed that the overall sensitivity of camera was such that 40 foot-candles was sufficient for satisfactory television pictures!

Farnsworth Television was transmitting on 343 lines at 30 frames interlaced. It was announced that a new television station was being built in North Philadelphia. It intended to operate with the picture at 62.75 mc and the sound at 68 mc with a 2.5 mc bandwidth.[13]

On June 25, 1936, L. Klatzow of EMI applied for a patent for a method of coating the mosaic screen of an Iconoscope with silver after it has been assembled in the tube. Means were described so that the screen could be tested until satisfactory performance was achieved.[14]

Dr. C.B. Joliffe of RCA mentioned in June 1936 the possibility that for television transmission a portion of one side-band could be eliminated and more space be available for broadcasting. Until this time, most television broadcasting had been accomplished as double side-band with two symmetrical sides, it being obvious that the second side-band was redundant.[15]

It had long since been found that the received television picture was improved when the receiver had been slightly detuned. Von Ardenne had reported on this phenomenon earlier, and RCA stated that they, too, had noticed its results but claimed that at a modulation frequency of some 500 kc doubling the bandwidth did not make a great deal of difference.

However, with the greater bandwidths now being used, experiments were being made to take advantage of this feature. There were no difficulties when the carrier was one edge of the overall selectivity curve. This method also reduced the number of stages in the i-f system of the receiver. It also stated that if one side-band could be suppressed at the transmitter, it would result in considerable savings in channel bandwidth requirements. It was reported on November 29, 1936, that field tests were being pursued by W.J. Poch and D.W. Epstein of the RCA Laboratories.[16]

There was a report of a private demonstration of the new Scophony television system in July 1936. A "Junior" receiver was demonstrated with a picture some 8 inches by 10 inches on 240 lines at 25 pictures/sec. It was claimed that the definition was remarkably good. Another demonstration was given of a picture some 5 feet by 5 feet, while a third screen of some 13 feet by 10 feet was in the process of being set up.

More details of the new Scophony system were released. It used a new method of "light control" beam convertor and "split focus." The light control was a method of simultaneous projection whereby as many as fifty or one hundred apertures were operating at one time. This resulted in increased brightness. There was mention of supersonic waves in a liquid column which were modulated and caused to stand still by the use of a rotating mirror drum. The use of "split focus" was an optical arrangement of crossed cylindrical lenses which caused a beam of light to be focused in two separate planes, thus producing more light with reduced size of the moving parts.[17]

The Eleventh Olympic Games were held in Berlin, Germany, in July/August 1936. This was covered by television for the first time in history. The coverage was by the German Post Office (DRP), which was using Iconoscope cameras furnished by Telefunken. The Post Office had three Iconoscope cameras, two covering the main areas and the third at the swimming pool. One of the cameras was equipped with lenses of 250 mm (10 inches), 900 mm (35.5 inches) and 1600 mm (63 inches) in order to cover all of the events. The Post Office was also using several intermediate film trucks.

Fernseh also provided equipment for the games. They had a Farnsworth electron camera which "delivered very sharp signals, free from interference components, but only in very bright weather." Fernseh also furnished an outside broadcast van using the intermediate film system, which had the advantage of mobility and could take pictures in almost any weather.

The games were transmitted to Berlin, where they were viewed mainly in some 25 "television parlors" and theaters, as well as in the Olympic Village. Transmission was on 180 lines at 25 pictures/sec. Unfortunately, it was reported that the reception was rather poor, the whole screen shook and "the eye strain being considerable . . . many didn't stay for the remainder of the afternoon events."[18]

Radio Olympia opened in London on Wednesday, August 26, 1936. It featured television transmissions for the first time. Television broadcasting from the Alexandra Palace was scheduled daily from noon to 1:30 and from 4:30 to 6:00. Three brands of receivers were displayed: Bush Radio (manufactured for Baird Television Ltd.), the Marconiphone Company, and H.M.V. combined sound and vision receivers. All sets were to operate on both the Baird and Marconi-EMI standards.

Baird Television won the toss of a coin and started the first day's transmissions. There were many "live" pickups, but the bulk of programming seems to have been excerpts of motion pictures and newsreels of the day. There were many breakdowns of equipment and it was even claimed that there were overt acts of sabotage. Baird Television staged another of its "firsts" by taking a Baird television receiver up in an airplane and receiving pictures from the Alexandra Palace.

However, it was agreed that the show was successful and that it did whet public interest in receivers and a demand for the same. At the end of the show, it was announced that the programs from the Alexandra Palace would be suspended for some four or five weeks until a regular service would begin.[19]

The 1936 Berlin Radio Exhibition was held after the Olympic Games from August 28 to September 6, 1936. While the official German television standard was 180 lines at 25 frames/sequential, most of the exhibits were being exhibited on a 375-line standard at 50 fields/interlaced scanning.

Fernseh showed an electron camera of the Farnsworth type that had been used at the Olympic Games. This camera was operating at 180 lines and the "pictures were very pleasant." Fernseh also displayed a 375-line film transmitter using a Nipkow disc. It was claimed that the best pictures at the exhibition came from this apparatus. Fernseh had just delivered a second intermediate film transmitter to the German Post Office and had supplied a spot-light transmitter to be used in a two-way television system.

Telefunken was using Iconoscope camera tubes for all their equipment including film projection. They displayed a 7 by 9-inch television receiver. They also had a small theater where they projected pictures some 3 by 3½ feet. Loewe Radio showed a regular receiver as well as a projection type with a picture size of 16 by 20 inches on a ground glass screen. Lorenz displayed a receiver with a 7 by 9-inch picture.

Tekade showed the only mechanical receiver, which had a double mirror screw with a lens drum and an arc lamp modulated by a Kerr cell. The pictures were reasonably good with fair brightness.

Missing from this exhibit was the intermediate film receiver of Fernseh. (According to one source, it was in London and was going to be used by Baird Television for a large screen demonstration at the Dominion Theatre. This demonstration never took place.) Also missing were the Karolus large screen lamp bulb screens and any of the television equipment of Manfred von Ardenne. A demonstration of the Berlin-Leipzig Television Telephone was given in the Exhibition Hall.[20]

In Japan, it was reported that the Japan Broadcasting Corporation (NHK) was going to do extensive research in television in order to make possible direct viewing of the 1940 Olympic Games, which were to be held in Tokyo, Japan. The experiments were to be directed by Dr. K. Takayanagi of the Hamamatsu Engineering College, who had been released from his duties at that Institution.[21]

The opening of the London Television Service was scheduled for November 2, 1936. A coin was tossed to see which system would open the service, and Baird Television won. At 3:30 the service was started with speeches by R.C. Norman, chairman of the BBC; Major Tryon, the postmaster-general; Lord Selsdon; and Sir Harry Greer, the chairman of Baird Television. The speeches were followed by some light entertainment. It was reported that John Logie Baird was present but was not invited to take part in the ceremonies.

A half-hour later, the program was repeated on the Marconi-EMI Television system with a speech by Alfred Clark, the chairman of Marconi-EMI. The trials were on. One comment on the opening day was that the EMI transmission was "faultless," a portent of things to come. The television service started that day was to continue (with a few minor interruptions) for the next few years. Only World War II could bring it to a halt.

However, the Baird system was in trouble from the beginning. It was apparent that it could not hold out for long. The spot-light studio, operating in near darkness, was hopelessly out of date; the intermediate film system was very dependent on a huge supply of water, sometimes running out of it and halting operations. The Farnsworth electron camera, still in a developmental state in England, was presenting problems. It was used for a few programs but, due to low sensitivity (noise) and poor geometry, was soon withdrawn.[22]

The final blow to the Baird Company was a disastrous fire at the Crystal Palace on November 30, 1936, which destroyed its research laboratories.[23] That the Baird system was to be soundly defeated was soon apparent. This defeat was preordained, but circumstances were such that since Baird Television had a powerful press behind it and EMI had been so secretive about its work, a government decision in EMI's behalf would have provoked a row of immense proportions. However, the trials continued until the end of 1936.

On November 5, 1936, Alda V. Bedford and Knut J. Magnusson of the Radio Corporation applied for a patent for a television camera apparatus. It was for a complete camera including double optics for the operator and camera tube. It also included a pedestal on wheels for mobility and means for raising and lowering the camera head. It was the prototype for the television camera used by RCA for the next 5 to 7 years.

In November 1936 the Research Laboratory of N.V. Philips, Gloeilampenfabrieken, Eindhoven, Holland, described a complete Iconoscope camera system. As it was experimental, it could be used on a great variety of line frequencies from 90 lines at 50 frames sequential to 405 lines at 25 frames/interlaced. In addition to the "live" camera, a complete film chain using an Iconoscope was displayed. This marks the beginning of the Philips interest in electronic television.[25]

On December 7, 1936, Baird Television gave a demonstration of large screen television at the Dominion Theatre in London. It was a mechanical system that produced a picture some 8 feet by 6 feet with a minimum of flicker. (This same system was again demonstrated on January 4, 1937.) It was later revealed that this system used spot-light scanning with a mirror drum in conjunction with a slotted disk. The pictures were of 120 lines at 17 frames/sec. It used a form of interlaced scanning to reduce flicker. The transmitter was on the third floor of the theatre and all transmission was closed-circuit. At the receiver, the light from a high intensity lamp was modulated by a Kerr cell. A mirror drum with a slotted disc reconstituted the picture.[26]

The trials between Baird Television and Marconi-EMI were coming to an end some three months after they had begun. On February 4, 1937, the BBC announced that they had chosen the Marconi-EMI system over that of Baird Television, Ltd.

From February 8, 1937, on, the 405-line standard only would be telecast from the Alexandra Palace. Three reasons were given for this choice: (1) the superior quality due to the high definition, (2) much less flicker due to interlacing and (3) the greater scope for development offered by the Emitron camera. It was promised that these standards would not be substantially altered before the end of 1938. Actually, the victory of Marconi-EMI gave the London Television Service a set of standards that would serve them well for almost fifty years.[27]

In January 1937, both Farnsworth Television and RCA promised that they would soon be using the new unofficial RMA 441-line standard. However, the first demonstration on 441 lines in the United States was given by the Philco Radio and Television Corporation on February 11, 1937. It was claimed that the pictures offered 30 percent more clarity than comparable 345-line pictures. In addition, Philco claimed that it was introducing high fidelity television as it was using a modulation frequency of 4.5 mc, which meant that Philco was transmitting over 680 picture elements per line—and only 588 elements were necessary to create equal horizontal to vertical resolution. Details of a new transmitter modulator were not revealed except to state that one side-band was attenuated. At the receiver, a "quasi-single side-band" reception system was used. The head end circuits were "detuned" so that the i-f band-pass region was centered over the unattenuated sideband.[28]

On March 31, 1937, Standard Telephone & Cables, Ltd., applied for a patent for a video playback machine using magnetized tape. This tape passed through a gap in a yoke surrounding a cathode ray tube. Inside this tube an electron beam modulated by the television signal was made to pass between a gap, which then transferred its signal to the yoke through which the magnetic tape was traveling.

For playback, when the tape passed through the gap, it caused variations in the circuit, which then entered the tube, causing the electron beam to be modulated. This beam then struck a target, which caused variations in the output current of the device.[29]

The new Farnsworth Studios in Wyndmoor, Pennsylvania, were operating in May 1937. Both film and live pickups were shown. In fact, the "live" studios using Farnsworth cameras seemed to be using about the same amount of lighting as those using Iconoscope cameras. It appeared that the Farnsworth cameras needed about 150/170 footcandles for studio lighting, while the Iconoscope cameras used about 100 footcandles. In either case, this was quite bright and made for very hot television studios.

Motion picture film projection was able to provide some 200 footcandles, which was more than adequate for both camera tubes. But whereas the Image Dissector was able to project clear, distinct pictures, the Iconoscope film projection was bothered with shading problems that produced smudgy, blotched pictures. As a result, there was renewed interest into film projection using dissectors or Nipkow discs.[30]

It was reported in May 1937 that television equipment built by RCA Victor was expected to reach Moscow that month for use in a television center erected in Moscow. Other centers were to be constructed in Leningrad and Kiev and use equipment built in Soviet factories.[31]

On May 12, 1937, at the Twelfth Annual I.R.E. Convention in New York City, RCA demonstrated a new method of large screen television using a tube developed by Dr. R.R. Law of the RCA Harrison, N.J., laboratories. The tube, called a projection kinescope, was some 18 inches long and projected an image some 1½ inches by 2¼ inches onto its fluorescent screen. It was able to project an image as large as 3 by 4 feet. While the demonstration was impressive, it was claimed that it was not for home use, but would be confined to the laboratory.[32]

Also at this convention, a paper was read on the "Theory and Performance of the Iconoscope." It was proven that as a storage device, the Iconoscope had very low efficiency, between 5 to 10 percent. This low efficiency was caused by the redistribution of secondary electrons produced by the beam and the fact that small fields draw away the photoelectrons from the mosaic. A phenomenon known as "line sensitivity" was discussed. It referred to the fact that the line ahead of the scanning beam was subject to a strong positive field and consequently had high photoelectric efficiency.

The article mentioned two methods for increasing the sensitivity of the Iconoscope. The first was by the use of secondary emission signal multipliers and a low capacitance mosaic. The second made use of secondary emission image intensification, which could be accomplished by allowing an electron image produced in some form of image tube to fall

on a mosaic constructed in such a way that the elements extend through the mosaic. This was one technique employed in the new "image iconoscope."[33]

Also on May 12, 1937, the BBC telecast the coronation of George VI from a position in Hyde Park Corner in London. This was the first outside broadcast using the newly adopted Marconi-EMI television system. Three cameras fed their pictures to a van, from which they were sent by a special coaxial cable to the Alexandra Palace.[34]

The 1937 Television Exhibition in London opened on June 10 at the Science Museum. The exhibition featured a Cossor film scanner, which provided television signals when the Alexandra Palace was off the air. It used a cathode ray tube to produce an unmodulated raster. The film was run between it and a photocell to produce the video signal. This signal was amplified and mixed with sync pulses and fed to the various receivers. This system was similar to the 1931 von Ardenne film projector.

Baird Television Ltd. demonstrated a version of their old 30-line television system and showed the latest model of the Farnsworth electron image camera. Other exhibits included those of Scophony and its large screen mechanical scanners. There were samples of coaxial cable from Standard Telephone & Cables, Ltd., similar to that installed between London and Birmingham in 1936.

EMI displayed one of its outside broadcast vehicles as well as the latest type of Emitron camera. The vehicle, which really was a traveling control room, was rather large, being some 27 feet long, 7 feet wide and over 10 feet high and weighing some 9 tons. Inside the vehicle was all of the equipment required to operate three Emitron cameras and the necessary sound equipment. Each camera had 1,000 feet of multi-core cable to allow it to operate away from the vehicle. There was complete control room scanning and amplifying equipment including the use of a fader as well as two visual monitors. Up to six microphones could be fed to an audio mixer, where an audio signal could be sent by land-line to the Alexandra Palace.

This van was to be accompanied by a second similar vehicle with an ultra-shortwave vision transmitter built into it. It operated in the region of 64 mc and delivered a power of 1,000 watts at peak picture white modulation to a special antenna. Finally, there was a third vehicle that supplied the electric power for both the other units. This complete outside broadcast unit was the prototype for all future remote trucks.

In addition, EMI displayed a "working" model of the television camera of Campbell Swinton, which had been built in the EMI laboratories. Unfortunately, there is no information available as how it was constructed or operated. Only a photograph is available. This exhibit was in line with EMI's contention that the Emitron camera tube was based on the writings of Campbell Swinton and not necessarily those of Dr. Zworykin.[35]

EMI also displayed a working model of a photoconductive tube by H.

Miller and J.W. Strange. In a later paper, Miller and Strange described their efforts to produce a practical camera tube using the photoconductive effect. Several patents had been taken out, but they disclosed that up to now no one had succeeded in producing a transmitter using the photoconductive effect. (Obviously, they were not yet aware of the progress being made in the Bell Telephone Laboratories by Hofele and Gray.)

After extensive experiments, zinc selenide had turned out to be the most sensitive material tested, and a tube was constructed using it. It produced sharp pictures, the conductivity along the surface being negligible. Miller and Strange mentioned that similar work on photoconductive tubes was being done by Harley Iams and Albert Rose of RCA and Max Knoll and Fritz Schröter of Telefunken.[36]

In July 1937, the tennis matches at Wimbledon were televised by means of the mobile outside broadcast unit of the BBC. The games were transmitted on ultra-shortwaves twelve miles to the Alexandra Palace. This was the first time that any outside event had been televised without a cable link. Another first for the London Television Service![37]

On July 22, 1937, Farnsworth Television and the American Telephone and Telegraph Company signed an agreement whereby each had the privilege of using the other's patents. This was quite a feather in Farnsworth's cap. It meant that AT&T had finally recognized the value of his work in television. This agreement had taken place after some four months of examination by the Bell Telephone Laboratories to analyze the 150 Farnsworth patents and submit a formal report. The agreement was nonexclusive; both were free to license other parties.[38]

Harley Iams had been joined by Dr. Albert Rose in the laboratories of the RCA Manufacturing Company at Harrison, N.J. They reported on their work on camera tubes in August 1937. It included research on tubes with light sensitive targets such as the Iconoscope, which were photoemissive; on targets made of cuprous oxide on copper, which were photovoltaic; and on targets made of aluminum oxide (Al_2O_3) or zirconium oxide (ZrO_2), which were photoconductive. Targets made of selenium were also tried but with rather poor results.

They had found the most sensitive targets were those in which an electron picture was focused upon a scanned, secondary electron emissive target. The scanning and picture projection might be separated by using a two-sided target. Coupling between the two sides was obtained by conducting plugs through the target. This was a two-sided form of the image Iconoscope. It was noted that work on this kind of tube had begun in 1933 coincident with that of Hans Lubszynski of EMI. Iams and Rose claimed that this general design offered considerable hope for the future as the operating sensitivity was high and the optical arrangement convenient.[39]

The Berlin Radio Exhibition was held from July 30 to August 8, 1937. Fernseh A.G. did not display the Farnsworth Image Dissector at this time. It was claimed that in spite of secondary electron multiplication, it was not sufficiently sensitive for general work. However, Fernseh displayed two types of Iconoscope cameras. One was a large camera for studio work with the viewfinder lenses mounted over the taking lenses as in the RCA camera. It had lenses of f/1.8 with a focal length of 18 cm. The other was a smaller camera with f/1.5 lenses side by side similar to the Emitron camera. The pictures had good definition, and the halftone values were very good.

All of the demonstrations were on 441 lines at 50 fields/interlaced. Fernseh displayed its intermediate film transmitter, which did use the Farnsworth Image Dissector as a film scanner. Fernseh also showed a Nipkow disc film transmitter running in a vacuum. It was claimed that this last equipment produced the best pictures at the show. It appears that there had been complaints that pictures from motion picture film from the Alexandra Palace were marred by dark and light patches.

Telefunken had on display two Iconoscope cameras set up in a studio. It also demonstrated a television "public address system" using a cathode ray spot-light transmitter. This system used a high brightness cathode ray tube as a light source and projected its picture on a large 5 by 6-foot screen, which was also produced by cathode ray projection. It operated on 147 lines, interlaced scanning. It was claimed that the amount of flood light on the speaker required in order to televise with an electron camera was very many times in excess of the illumination projected on the speaker when using spot-light transmission.

The German Post Office also had a demonstration studio with Iconoscope cameras and a mechanical film transmitter of the Nipkow disc type that transmitted extremely good pictures. Both Loewe Radio and Lorenz demonstrated 441-line Nipkow disc film transmitters. It was reported that the German government was in no hurry to start an extensive program service and that it was probable that no developments would take place on the commercial side for the next two years.[40]

Radio Olympia was held from August 25 to September 4, 1937, and consisted mostly of displays of home television receivers. There were 14 small theatres displaying sets from 14 manufacturers. Most were regular direct-viewing screens except for H.M.V., which had a 10 by 8-inch reflected picture, and Philips, which had a projected 20 by 16-inch picture. It was reported that the performance of the sets varied from "very good, outstanding brilliance" for a Baird T12 receiver, to "poor definition" for a Pye 4045, Major 1 receiver.

Scophony Ltd. did not give a demonstration, claiming that because of the considerable amount of irregular timing and phase shifting of the television signal from the Alexandra Palace, it was quite difficult for receivers (of the Scophony type) that possessed mechanical inertia to operate satisfactorily.[41]

However, that was a very minor criticism of the London Television Service. Arriving in a constant stream, visitors from the United States were astounded by (1) the uniform high quality of the pictures, (2) the regularly scheduled programs and (3) the coverage of outside events. Some of the comments made at the time were "an operative system giving good stable pictures of acceptable detail, brilliance and interest"; "stability, freedom from faulty sync and a wide contrast range"; and "of remarkable contrast and detail; exactly like a movie." A real tribute to Isaac Shoenberg and the engineers of Marconi-EMI.

The programming was variable, ranging from short dramatic skits to comedy, lectures, newsreels and of course film cartoons. The major criticism was for the film transmissions from the Emitron cameras with their "shading" problems.[42]

Receiving sets were on sale for a very high price at the time, from $300 to $800, and as a result only a very limited number of sets (fewer than 3,000) found their way into homes around London.

The Columbia Broadcasting System announced that it was going to build studios in Grand Central Terminal in New York City. They claimed that they were experimenting with 441-line pictures using a film scanner with continuous motion projected onto a Farnsworth Image Dissector tube with a 9-stage electron multiplier.[43]

In September 1937 Dr. Peter Goldmark, the chief television engineer for the Columbia Broadcasting System, reported that the BBC was already using a new "electric camera," which had been rendered panchromatic to a fair degree. EMI was now using Emitron camera tubes, using the new Klatzow method of finalizing treatment of the mosaic with silver to get rid of the excessive infrared response that was so typical of the cesium-silver-oxide mosaics being used at the time.

In addition, Dr. Goldmark reported on a new television camera about ten times more sensitive than any in use. He was referring to the new "Super Emitron" camera tube of Hans Lubszynski and Sidney Rodda, which was used for the first time in November 1937. This was an advanced form of image Iconoscope.[44]

The Super Emitron tube worked in the following manner: the scene to be televised was optically focused onto a continuous transparent photocathode surface, and the electron image so generated resembled that obtained with the Image Dissector tube. This electron image was electrostatically accelerated towards the secondary emission mosaic (which was not photosensitive) and at the same time was electromagnetically focused by a coil.

The charges stored in this manner on the mosaic were greater than in the ordinary Iconoscope for two reasons: (1) the continuous photocathode was more sensitive than a regular mosaic and (2) five or more electrons left the mosaic for every primary electron incidental on it. Hence it was as much as ten times more sensitive than the ordinary Iconoscope. In addition to the increased photosensitivity, the size of the optical picture on the photocathode surface was smaller than the ordinary mosaic, and shorter focal length lenses could be used for more depth of focus.

At first, this new tube suffered from some serious electrical and optical distortions. Among them were curvature of field, pincushion and "S" distortion. However, these problems were slowly solved, while the tube's

increased sensitivity was an important asset for covering outdoor events. The first use of the new Super Emitron camera was the coverage of the "Cenotaph" ceremony in London on November 11, 1937.[45]

The Bell Telephone Company had long been working on a coaxial cable system, and on November 9, 1937, it transmitted the first television pictures between New York City and Philadelphia. It used a 1 mc wide, coaxial system. The pictures were originated from a 6-foot steel mechanical disc scanner operating on 240 lines at 24 frames/sec. The image from the motion picture film passed continuously in front of 240 high speed lenses set in a circle on the disc.

The light from the film went to a phototube containing an electron multiplier. The output of the multiplier was applied to a double modulator, which raised the entire spectrum about 100 kc. Thus the region between 0 and 100 kc was available for the sound channel and sync pulses. Sync pulses were obtained optically from special holes drilled in the scanning disc and were transmitted on a separate channel. The picture signal was equalized and corrected for phase distortion by means of repeaters every ten miles over the coaxial line.

The pictures were reproduced on a conventional cathode ray receiver using a green screen. It was claimed that the pictures were comparable in quality to the 441-line interlaced pictures being shown in New York and Philadelphia.[46]

RCA was projecting motion picture film using an Iconoscope. The use of interlacing at 60 fields/sec complicated the process. The projector had a special intermittent with a ratio of 3:2 that allowed the first frame to be scanned three times at 1/20 second while the second frame was scanned two times at 1/30 second, thus averaging 1/24 second each. A special shutter admitted light only during the vertical blanking period, which created a charge-picture on the mosaic that remained until scanned. While this solved the film speed problem, it appears that the picture quality was not as good as that produced by the Image Dissector or Nipkow disc.[47]

On November 9, 1937, the Philco Television Corporation announced that it was using a new transmitter modulator developed by W.N. Parker with a range of nearly 5 mc using one side-band. Reception was by use of a quasi-single side-band receiver.[48]

The new large screen Scophony system was demonstrated in London at British Industries House on December 8, 1937. It was claimed that "the pictures were crisp, flickerless and bright enough to be seen in comfort by everyone." Certain adjustments had been made to the television signal from the Alexandra Palace that allowed the Scophony receiver to follow its signal with no difficulty. A picture was projected onto a large screen (six feet by five feet) as well as a home receiver providing a two-foot-square picture.[49]

Also on December 8, 1937, a large screen television demonstration was given at the Palais Theatre in Kent by Baird Television. The picture, some eight feet by six feet, was of a regular program of the BBC from the

Alexandra Palace. However, Baird Television stated that it planned to provide its own programming from the Crystal Palace.

The projection equipment consisted of a special picture tube that formed a small bright picture some two inches square, which was then projected by a lens of large aperture onto the screen. It was announced that Gaumont-British Pictures Corporation intended to equip some fifteen theatres in the London area with large screen television equipment.[50]

It was reported on December 12, 1937, that the first mobile unit for NBC Television was presented to Radio City. It consisted of two motor vans. The first one consisted of the complete pickup apparatus including cameras, sync generators, rectifiers, amplifiers for blanking and deflection and line amplifiers. This van carried two Iconoscope cameras, which were connected by several hundred feet of coaxial cable. The sound equipment included several parabolic microphones.

The second van, connected by 500 feet of coaxial cable, contained a complete microwave relay transmitter. The vision transmitter operated on 177,000 kc and was connected to a special directional aerial. It was expected to have a range of some 25 miles and to be in operation early in 1938.[51]

Allen B. DuMont applied for a patent for a system of communication on January 11, 1938, whereby the transmitter (camera) and receiver (viewing screen) were in the same glass envelope. It was planned to have a single beam sweep across a photosensitive surface and then a fluorescent screen. By means of electronic switching, it would be possible to both send and receive pictures from the same apparatus.[52]

On January 17, 1938 (also on April 30 and June 1), Georges Valensi applied for a patent for a color system using a single channel. He described means for combining signals (both monochrome and color) into a single channel so that a reduction in bandwidth was accomplished.[53]

The work of G. Krawinkel, W. Kronjager and H. Salow of Berlin-Templehof on a storage television pickup tube with a semiconducting dielectric was reported in January 1938. They discussed the possible replacement of a nonconducting target layer (such as mica) by a semiconducting one (i.e., slightly conducting glass) which should give higher field strengths at the target.[54]

G. Braude (in Russia) applied for a patent for a camera tube using a semiconducting two-sided target on February 3, 1938. The patent called for a thin dielectric plate that had a certain amount of leakage. An image was to be projected onto the photosensitive side of the plate through a transparent electrode "A" (mesh screen) and was to be scanned on the back side of the plate by an electron beam. The light from the scene produced photoelectrons on the photosensitive side of the mosaic element, which were transferred to the mesh screen, which could be placed on the directive plate. This would be discharged by the action of the electron beam scanning the back of the plate and become the picture signal.

It was possible to use an electron image (such as in the image

Iconoscope) that passed through the mesh screen to a semitransparent mosaic, which was not photosensitive. It was later claimed that such a mosaic was realized and tested. This use of a thin dielectric plate with controlled leakage was an important step forward toward the goal of a practical two-sided target.[55]

On February 4, 1938, John L. Baird gave a demonstration of color television at the Dominion Theatre in London. The television transmission was by wireless from the South Tower of the Crystal Palace. The picture was 120 lines. Transmission and reception were by means of a mirror drum with 20 mirrors revolving at 6,000 rpm. These mirrors reflect the scene to be transmitted through a lens with 12 concentric slots at different distances from its periphery. By this means the field given by the 20-line drum is interlaced six times to give a 120-line picture repeated twice for each revolution of the disc. Each of the slots was covered with a light filter, blue-green and red being used alternately, the effect of this being to transmit lines of the picture corresponding to a blue-green image and a red image. Light from a high intensity arc lamp was concentrated on the moving aperture in the disc and yielded sufficient light to fill a screen 12 feet by 9 feet. Results indicated that the picture was still experimental and one should not be critical of its "imperfections." This appears to be the first demonstration of large screen color television by wireless. Another Baird first. The program consisted of live pickups, colored slides and a colored cartoon.[56]

In February 1938 the Allen B. DuMont Laboratories announced that they had developed a television system which could transmit pictures without synchronizing signals. By reducing the number of frames to 15 per second, they claimed they could cut the television bandwidth in half. As a result, they were transmitting 441-line pictures at 15 frames/sec interlaced 4:1.

It was planned to use double sawtooth scanning: from left to right and right to left horizontally, and at the same time from top to bottom and bottom to top vertically, to eliminate the need for synchronizing signals. The waveforms of the vertical and horizontal scanning voltages were used as modulating signals on an auxiliary carrier. After demodulation and amplification at the receiver, the waveform was then used directly as a sweep voltage for the receiving cathode ray tube.

It was asserted that a flickerless, 441-line image was produced, even though only 15 frames/sec were being transmitted. The audio was sent on a subcarrier of 25,000 cycles with a channel some 266 kc wide. It was claimed that this method saved some 2 megacycles in bandwidth.[57]

On March 29, 1938, the Farnsworth Company announced a new motion picture projector for television using a continuous movement devised by Harry S. Bamford. It used two lens discs, each carrying a total of 24 lenses and rotating in opposite directions. The projector was so synchronized with the scanning system of the dissector tube, that alternate frames were scanned two and three times respectively, providing an interlaced picture. It was claimed that the pictures had "unusually good contrast and definition."[58]

In April 1938 there was a report on high definition pictures from Fernseh A.G., using a film projector with a Farnsworth Image Dissector tube incorporating an electron-multiplier type of phototube. These were 441-line images interlaced 2:1 at 50 fields/sec. Pictures from this projector were thrown onto a screen some 6½ feet wide (2 meters) by a special projection-type cathode ray tube.[59]

On May 28, 1938, Peter Goldmark of CBS applied for a patent for a motion picture film projector with a plurality of lenses so that only one at a time was used to project an image onto an Image Dissector tube.[60]

Philo Farnsworth described a storage type of camera tube in May 1938. In this tube, it was claimed, the image was amplified before scanning. The tube consisted of an image grid, a signal screen and a cathode ray gun within the tube. The image grid was made up of a thin sheet of suitable metal, perforated with approximately 160,000 holes to the square inch. On the side towards the window of the tube was deposited an insulating substance, and upon this insulator were deposited numberless small islands of photoelectrically active material. The signal screen was a comparatively fine mesh of wire in front of the image grid.

Due to the action of the light from the scene, an electrostatic charge image was set up on the image grid. The electron gun projected a fine high velocity beam of electrons on the metal side of the image grid, and secondary electrons were produced at the point of impact of the beam. These electrons were drawn through the holes in the screen by the positive action of the photo islands on the opposite side. This resulted in amplification since far more electrons were produced per picture element. Almost all of the electrons were collected by an anode, although a small amount might be collected by the photoislands. A tube of this type was introduced by Philo Farnsworth in November 1938 at the fall meeting of the IRE. It was later claimed that this Farnsworth image amplifier tube had been operated in the laboratory with scenes having only 2 or 3 candles/square foot.

It was mentioned that this principle could also be used as a normal dissector tube. In this case, the back of the storage screen was coated with photosensitive material, which if flooded from a uniform light source produced photoelectrons. These photoelectrons were subject to the same triode action. However, in this case an amplified electron image was formed, which was scanned across an aperture as in the standard dissector tube.[61]

The Television Committee of the RMA, under acting chairman Albert F. Murray, approved a new set of American television standards on June 3, 1938. This included a 441-line frequency so that the synchronizing generator could be simplified ($3 \times 3 \times 7 \times 7$ as integers) at 60 fields interlaced. Other specifications included a 4:3 aspect ratio, negative picture modulation, horizontal polarization, a constant black (DC) level and the adoption of the serrated type of vertical sync pulses with additional equalizing pulses.

The advent of single side-band operation led to a separation of some 4.5 mc between picture and sound, rather than 3.25 mc, for greater picture detail. It was claimed that the Philco experimental television transmitter W3XE in Philadelphia was already transmitting signals according to the new proposed RMA standards in July 1938.[62]

Baird Television had installed a large screen cathode ray projection unit in the Tatler Theatre, Charing Cross Road. The device was used to project pictures some six feet by eight feet across. A public demonstration was given on June 9, 1938, of the "Trooping of the Colours."[63]

In London, the London Television Service was telecasting three times daily. There were transmissions at 12 noon, 3:00 P.M. and at 9:00 in the evening. In addition, the outside broadcast units were covering a wide variety of outdoor events, including boxing in April, the Whitney Cup Polo Match and Chelsea Flower Show in May, "Trooping of the Colours" from Whitehall, the Lords Test Match and the Derby in June, Wimbledon and cricket in July of 1938.[64]

In spite of the artistic and technical success of the London Television Service the sale of sets was quite low. It was decided that Radio Olympia, to be held on August 24–September 3, 1938, would have at least 20 set manufacturers with television as the main attraction. Alexandra Palace would be broadcasting some five or six hours daily during the exhibition. There was a statement that unless there was a boost in the sales of sets, the second television transmitter at either Birmingham or Manchester would not likely be built.[65]

At the Thirteenth Annual Convention of the IRE, held in New York City from June 16–18, 1938, many papers of interest were presented. They ranged from papers on single side-band transmission, multi-stage electron multipliers, to "The Image Iconoscope" by Harley Iams, George Morton and V.K. Zworykin. These latter three reported that their work had been parallel with that of EMI and others and their tube operated on the same principles. It was claimed that the Image Iconoscope was some six to ten times more sensitive than the Iconoscope which needed at least 1,000 to 2,000 footcandles for good operation.[66]

However, RCA was not really interested in the Image Iconoscope in spite of its advantages over the Iconoscope. Harley Iams and Albert Rose were hard at work in the RCA Laboratories on a camera tube using low velocity electron beam scanning. Iams had applied for a patent on May 31, 1938, in which the target transferred its pattern to a photoelectric screen by means of a magnetic field. This target was discharged by the action of a flying spot cathode ray tube. Thus, since only low velocity electrons were discharged, no "dark spot" signals were produced.

On July 30, 1938, Albert Rose of RCA applied for a patent that proposed to use a low velocity electron beam for scanning a translucent mosaic target. The electrons not reaching the target were returned by a different path to a collecting electrode in front of the electron gun. The television signal could be taken either from the signal plate or from the electrode, where it could be amplified by an electron multiplier. The entire tube was immersed in a magnetic field from a coil, and scanning was by a magnetic coil for vertical deflection and electrostatic plates for horizontal deflection.[67]

On September 12, 1938, Albert Rose and Harley Iams of RCA described their work on low velocity scanning beam tubes. The article mentioned the importance of a uniform axial magnetic field which would keep the beam well focused and substantially in its normal path as it approached the target.

It also mentioned that it was desirable to have the low velocity beam approach the target at a consistent angle of incidence for improved operations. Another requisite was relatively high beam currents (about two microamperes).

A description of two tubes using the relatively simple photoelectric beam (flying spot scanning from a cathode ray tube) was given. The first used a two-sided target (as described in the September 23, 1937, application of Rose and of the application of Iams of May 31, 1938) using a photocathode and a single-sided mosaic at right angles.

Photos of the experimental tubes were shown. The first type used a two-sided target and cathode ray tube scanning. This tube demonstrated the improvements to be expected in signal strength, operating efficiency and dark spot control from low velocity scanning. In the other tube, photoelectrons released from the mosaic were collected by the scanning electrode instead of a separate collector electrode.

In addition, and of more importance, two tubes using "thermionic-beam" scanning were described. Two tubes were built, one using electrostatic horizontal and vertical deflection and the other using electrostatic horizontal but magnetic vertical deflection. A one-sided, photosensitive mosaic with a translucent signal plate was used, the optical image being projected on the mosaic through the signal plate.

It was claimed that both tubes were able to resolve at least 100 lines per inch on the mosaic, the transmitted picture having very little spurious shading and relatively high signal strength. An operating efficiency of 71 percent was calculated. The article concluded that while many problems had been solved, much additional work remained for the purpose of determining optimum designs.[68] The Iconoscope continued to be the "standard" studio tube both in the United States and Europe, with the Super Emitron (Image Iconoscope) being used out-of-doors by the BBC in London.

On July 12, 1938, Dr. Werner Flechsig of Fernseh GmbH applied for a patent on a color picture tube. This tube proposed to use three beams (each representing a basic color) which deflected simultaneously to a screen containing color producing phosphors. In front of the screen and between the electron guns was situated a grid screen that allowed each beam to reach only its own color. Thus it would be possible to project a simultaneous color picture using the grid as a means of color separation.[69]

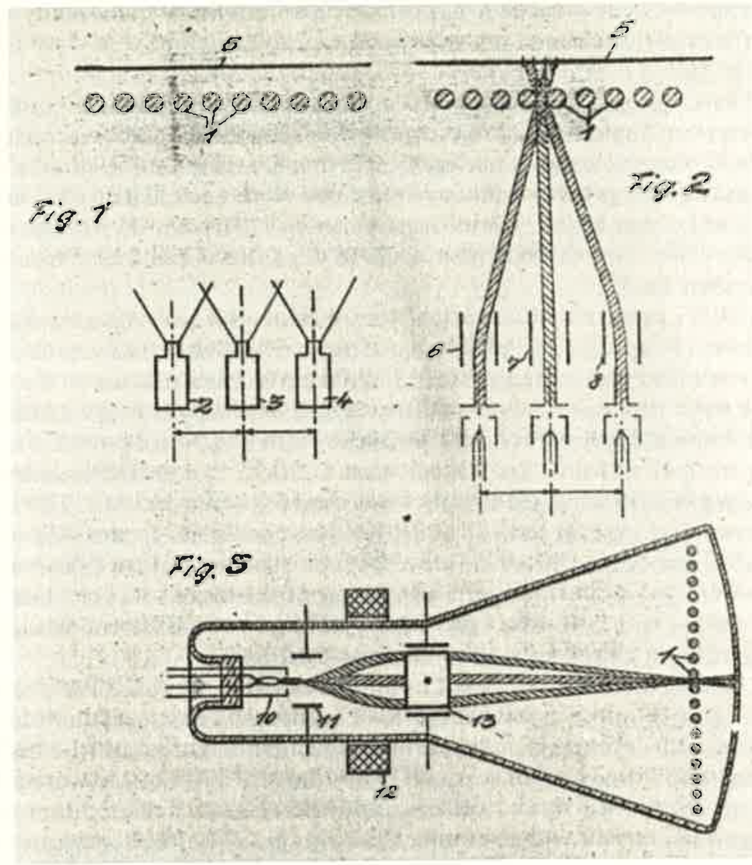


Diagram from Werner Flechsig's color picture tube patent (applied for, 1938; issued 1943).

The Berlin Radio Exhibition opened August 5, 1938. All demonstrations were given on the new 441-line standard. Fernseh demonstrated a large screen projector, 10 by 12 feet, and a home receiver with a picture some 8 by 9½ inches to cost about £35 or £40 on October 1, 1938. An upright set with a 16-inch tube was displayed as well as a home-type projection receiver with a picture 14 by 16 inches. Fernseh had both a mechanical 441-line disc transmitter and a film transmitter using Image Dissector tubes which gave excellent pictures, quite free from shading errors.

Telefunken was now using an Arcadia (made by Mechau) type of motion film projector. This used optical compensation in the form of a series of moving mirrors with continuous film movement. It was being used with either the Iconoscope camera tube or the flying spot (cathode ray tube) scanner. They demonstrated a 2-foot picture tube, which gave quite a brilliant black and white image. In addition, they also displayed a projection-type set with a 16 by 20-inch screen for home use. Finally, there were three projectors in the exhibition hall showing pictures some 5 by 6 feet in size.

The German Post Office had a complete television station in a portable van that could transmit pictures while in motion. In addition, a crude form of color television was displayed from special motion picture film, by means of a projector having two color components. The tube screen itself was red and blue. It was demonstrated at 180 lines at 25 frames, and as there were two colors with a color disc, there was bad flicker at a 12½-cycle rate.[70]

D.W. Epstein of RCA applied for a patent on a television recording method on September 30, 1938. It was for a device that would convert the 24-frame film speed so as to record 30-frame television pictures. This was to be done with a special intermittent which would record field 1 and field 2, and lose the first part of field 3 while the film was pulled down. It would then record all of field 4 and the first part of field 5. It would then lose the last part of field 5 while the shutter was closed for film pulldown. Then the process would repeat itself. Thus it would be possible to record 30-frame (60-field) television pictures onto 24-frame motion picture film was a minimum loss of information. The timing of the shutter was quite important, and a major difficulty was in the joining of two different fields, i.e., the last line of field 3 with the first line of field 5.[71]

On September 30, 1938, the London Television Service covered the arrival of British prime minister Neville Chamberlain's return from Munich by means of its outside broadcast unit. Chamberlain brought with him his message of "Peace in Our Time!" The Marconi-EMI outside broadcast unit was there with three cameras and the necessary microphones and covered the arrival and ceremonies following it. The "live" program was sent by radio-relay to London, where it was broadcast from the Alexandra Palace.

This coverage was called "the most striking of all" by the *London Times*, which stated that it had "a quality of history in the making which no other outside broadcast has equalled." The *Times* continued, "To see these events as they take place is something different in kind from a newsreel after the event; it has a particular thrill and would alone make the possession of a set worth while." This broadcast appears to have been the first actual broadcast by television of a major news event as it was actually happening. It was one of the highlights of the 1938 season of the London Television Service and would not be equalled for many years.[72]

RCA announced on November 6, 1938, that it had come to an agreement with Harry R. Lubcke, director of television for the Don Lee Television System. RCA had purchased certain patents and methods of Mr. Lubcke pertaining to synchronization methods and apparatus.[73]

It was reported on December 21, 1938, that Dr. V.K. Zworykin had been granted his patent, USA 2,141,059, after some 15 years in the Patent Office. This occurred after the Patent Office tribunals had decided against

him; a District of Columbia court of appeals had finally reversed them. This patent, originally filed on December 29, 1923, was involved in no fewer than 11 interferences between the original application and the final version. It had twice been before the United States court of appeals and had been in litigation for some 12 years.[74]

Actually Dr. Zworykin's 1925 patent application, USA Patent No. 1,691,324 (issued in 1928), would have given him the priority he wished, as it had more promise; it mentioned both the use of discrete globules and the use of a fine mesh screen in place of aluminum foil. But the patent departments at both Westinghouse Electric and RCA insisted that the 1923 application be given the earliest priority.

The case before the court of appeals was to be decided on only one issue: the construction of the photocell. If the 1923 filing showed an application disclosing a photosensitive plate of a specific construction, then Zworykin was entitled to the award of priority. This was the argument of Zworykin's lawyers.

The only question in controversy was whether the potassium of the photoelectric element was in the form of elemental areas and whether it was new matter in the 1923 application. If it was, Zworykin was entitled to make the claims in his 1923 application, and Zworykin was the first inventor. On November 2, 1938, the court of appeals ruled to grant Zworykin his patent. It was issued to Westinghouse Electric and Manufacturing Company.[75]

Having won this case, Dr. Zworykin applied for another patent on November 26, 1938, which was essentially the same as the December 29, 1923, application but included a new "Fig. 6." This figure showed a typical single-sided front surface Iconoscope. There were only two claims, and they referred to the action of an electrical condenser being connected to an electrical circuit in series with a second insulating gap, with an electrical circuit being adapted to effectively utilize a discharge from said condenser. This patent was also assigned to Westinghouse Electric and Manufacturing Company of East Pittsburgh.[76]

In addition, Dr. Zworykin reapplied for another patent on December 20, 1938, that had been originally filed on May 1, 1930, and had not yet been granted. It, too, added a new figure, which showed a typical single-sided front surface Iconoscope. The claims primarily concerned an image screen consisting of a plurality of insulation-supported conductive elements having electrically separated surfaces responsive to radiant energy, and means for deflecting a beam and causing it to scan said conductive elements. This patent was also issued to Westinghouse. This series of patents thus gave Dr. Zworykin and Westinghouse complete control of the Iconoscope.[77]

On December 30, 1938, RCA applied for a patent for an optical projection system using a cathode ray tube. It applied Schmidt optics in the form of a large convex spherical mirror facing the tube. This mirror acted to converge and reduce the spherical aberration and coma of the image.

It was claimed that it provided an optical system with an aperture ratio of f/0.6 or greater.[78]

The RMA Television Committee made a decision concerning Standard T-115 regarding single side-band transmission on January 19, 1939. In this standard, both side-bands were generated and one side-band removed by filters in the antenna transmission line. This was a very important advance as it allowed a maximum of picture detail while conserving broadcast bandwidth. It was too late for the BBC in London to adopt single side-band transmission, as their standards had been set in 1936, and they had to continue use of double side-band modulation.[79]

RCA reported in February 1939 that it had been recording, from the face of a cathode ray tube, television pictures of images transmitted by the BBC in London. RCA showed a four-minute film of images received at Riverhead, N.Y., by their film recording equipment. The images were unsteady and not sharp, although at times they were clear enough that one could recognize the announcer as Jasmine Bligh. As far as is known, this is the first American recording of images from the face of a cathode ray tube, and it certainly sets a record for the long-distance recording of television images.[80]

On February 14, 1939, RCA gave a demonstration of their large screen television projector at the Waldorf-Astoria in New York City. Pictures some four by six feet were shown.[81]

The Boon-Danaher prizefight was telecast on February 29, 1939, to two theatres in London and proved to be a huge success. As a result, Gaumont-British (the Ostrer company that owned Baird Television) announced that they were going to install theatre television equipment in some 350 theatres. At this time, the large screen television system of Baird Television Ltd. was being demonstrated on a 9 by 12-foot screen at the Gaumont-British office in New York City.[82]

On May 24, 1939, EMI gave a demonstration of its new large screen television projector at its theatre in Hayes, Middlesex, England. The image, as seen on a 15 by 12½-foot screen, was "comparable with ordinary film standards." The occasion was the annual running of the Derby.[83]

Philco Radio and Television Corporation gave a demonstration of its new "portable" television transmitter to a group of radio dealers in New York City on March 7, 1939. It was self-contained, with a camera, mounted on top of a box, that weighed some 420 pounds. It had a complete transmitter operating on RMA standards with a power of less than 1 watt that had a range of some 175 feet. It was not for sale but was being used for further research and study.[84]

Also in March 1939 General Electric stated that it planned to operate a television relay station in the Helderberg Mountains around Schenectady, N.Y. General Electric had not been very active in the field of television since its divorce from RCA in late 1932. However, with the advent of commercial television in the United States, General Electric had embarked on a development program and was going to build a television transmitter,

David Sarnoff at the New York World's Fair, April 20, 1939, speaking before an NBC Iconoscope camera. His image was sent to the Empire State transmitter and rebroadcast.

television receivers and especially television cameras of its own design. General Electric was planning to transmit television signals from Schenectady to Troy and Albany, N.Y.[85]

The RCA/NBC television transmitter in the Empire State Building was being overhauled to conform with the newly adopted RMA standards, including a single side-band filter. It was being readied for the opening of the World's Fair in New York City in the spring of 1939.

Six American manufacturers announced plans to have television receivers on sale by May 1, 1939. They were the American Television Corporation, Andrea Radio Corporation, Allen B. DuMont Laboratories, General Electric, Philco Radio and Television Corporation and the RCA Manufacturing Company of Camden, N.J. Farnsworth Television and Radio Corporation stated that they were going to raise several million dollars so as to be able to manufacture television receivers. Andrea Radio claimed that it was the first to put television sets on sale using the new 441-line standards.[86]

David Sarnoff appeared before an NBC Iconoscope camera on April 20, 1939 (prior to the opening of the World's Fair) and dedicated the RCA exhibit. This was claimed to be the first time that pictures from the TeleMobile (RCA's portable van) were sent to the Empire State transmitter and rebroadcast. The RCA exhibit included a large screen projector and a "flask" receiver, which had a large picture tube (some 18 by 24 inches) with front viewing and had a brightness of highlights of 40 candles/square foot. It also contained a complete 16mm film projection chain and provided space for the TeleMobile.[87]

For David Sarnoff, this was the realization of some eleven years of planning. His original idea, late in 1928, to have a television system operating in the United States by 1932 had long been delayed. A five-year plan had turned into an eleven-year reality. Very few people in 1928 had foreseen the depression or how long it would last. In fact, in 1939 the world was still suffering from its effects.

Television in the United States made its formal debut on Sunday, April 30, 1939, with the telecasting of a speech by President Franklin D. Roosevelt at the opening of the World's Fair in New York City. The images were sent to receivers placed at strategic locations. It was claimed that the pictures were clear and steady.[88]

The time seemed to be ripe for a commercial television system in the United States. The introduction of the new television system did not seem to hurt the sale of radio sets at all. However, the sales of new television sets were very slow and disappointing. Following the lead of the BBC in London, RCA/NBC now embarked on a long series of special events in order to stimulate interest in the new medium. There were outside broadcasts of the Columbia/Princeton baseball game on May 17, 1939; the Six-Day bike race on May 16–22, 1939; the Baer-Nova prizefight on June 1, 1939; and the parade in honor of King George VI and Queen Elizabeth on June 11, 1939. All of these events were covered with a single camera.[89]

On June 1, 1939, a new high quality mechanical film scanner was described by the General Electric Company of England. It had an apertured (Nipkow) disc running in a vacuum. It used continuously moving film illuminated by a split optical system to eliminate flicker, with a mechanism to compensate for film shrinkage. Synchronizing signals were also produced by holes in the disc. This was another solution to the problem of poor film transmission by the Iconoscope.[90]

Harley Iams and Albert Rose of RCA Manufacturing Company publicly revealed details of their new low velocity scanning beam camera tube to the New York section of the IRE on June 7, 1939. This pickup tube was called the Orthicon, an abbreviation of Orthiconoscope. The name was derived from the fact that the curve between input light and output current was a straight line. It was claimed that no shading problems were present.

The tube was described as being some 20 inches long and 4 inches in diameter. The image plate was some 2 by 2½ inches wide. Picture resolution was claimed to be some 400 to 700 lines. Sensitivity was supposed to be some 10 to 20 times that of the Iconoscope. On July 23, 1939, it was reported that the Orthicon was in the final stage of development and would be ready for broadcast by the first of next year.[91]

On July 27, 1939, John L. Baird gave the first demonstration of a color television system using a cathode ray tube. The pictures were

transmitted from the South Tower of the Crystal Palace, a distance of two miles to Mr. Baird's home and laboratories in Crescent Wood Road in Sydenham.

The scanning device was a revolving drum with 34 facets in conjunction with a color disk which caused the spot of light to be interlaced three times so as to give a complete picture of 102 lines. This was completed 16⅔ times a second, each line of light being passed to a photocell which translated the light into electrical impulses. A flying spot system projected its light through a stationary slit, behind which revolved a scanning disc. Each slot in the scanning disc was covered with a color filter, the first slot red, the next blue-green and so forth. The mirror drum revolved at 6,000 rpm while the scanning disc revolved at 500 rpm.

At the receiver, a color filter was rotated in front of the cathode ray tube in a manner that presented the proper blue-green or red filter in synchronization with the transmitter, producing a full-color picture. The image was projected through a lens onto a three-foot white paper screen. It was reported that "flesh tints came through well, blue and red brightest, but scarlet tended to have an orange tint. Definition was not as good as in black and white television."[92]

The Sixteenth (and last) Berlin Radio Exhibition opened on July 28, 1939. (The next show was to be in Cologne in 1940.) The main feature of the exhibition was a "standard" television receiver designed as a joint effort of Fernseh A.G., Telefunken, Lorenz, Loewe, and TeKaDe. It was a rather small table model with a picture some 19.5 cm by 22.5 cm in size. It was to be available for some £ 32.10s ($137). It featured a new, square, flat-faced picture tube and had only some 15 valves.

There were supposed to be exhibits of large screen television by Dr. Karolus and Telefunken. However, the Karolus projector developed problems and was never shown, and the Telefunken projector was on display for two days only and was withdrawn.[93]

In July 1939, the *Journal of Applied Physics* published an issue devoted to television. It included articles by David Sarnoff, Knox McIlwain, Pierre Mertz, Peter Goldmark, and E.W. Engstrom. The article by McIlwain, a "Survey of Television Pick-up Devices," was quite revealing. It indicated that a study of the sensitivities of the two competing camera tubes, the Iconoscope and Image Dissector, were not as far apart as had been indicated. The Iconoscope needed at least 100 candles/square foot and could transmit a usable picture at 10–15 candles/square foot. The image dissector needed 150–170 candles/square foot as a minimum and could give a recognizable picture with an average illumination of 4 footcandles! However, it was conceded that the Image Dissector was useful for outdoor pickup under only the most favorable conditions.[94]

The annual Radio Exhibition at Olympia was opened on August 23, 1939, with a speech from the Alexandra Palace by Sir Stephen Tallents, the public relations officer of the BBC. This was the first time an exhibition was opened by television. Again there was heavy emphasis on television, with models from HMV, Baird Television Company, GEC, Scophony and Ferranti. As a result, it was announced that some 500 sets a week were being sold in the London area.[95]

But this success was to be short-lived, for with the beginning of World War II in Europe, the BBC television station at the Alexandra Palace was closed down on September 1, 1939—one of the first casualties of the war. The station had been ordered shut down at noon with no advance warning. Some 23,000 television sets had been sold since the station's opening in November 1936, and they were now rendered useless for the duration of the war. It was rumored that the high cost of operating the London Television Service was the primary reason for the early closing of the Alexandra Palace![96]

The television system in the United States continued to improve. As a great portion of the technical research had been done by the Radio Corporation, it was important for RCA to come to terms with its competitors. RCA had been buying up most of the important patents concerning camera and receiving tubes. In addition, there were certain circuits that were necessary in a television system. Many of these were owned by Philo Farnsworth. As a result, RCA had to come to an agreement with him.

Philo Farnsworth had signed agreements with Philco (1931), Baird and Fernseh (1934), and the American Telephone & Telegraph Company (1937). In September 1939 an agreement was reached between Farnsworth and RCA. It was signed by Otto Schairer of the Radio Corporation of America and E.A. Nicholas of the Farnsworth Television and Radio Corporation. Nicholas was the former head of the Licensing Division of RCA. It was the first time that RCA had a contract to pay continuing royalties for the use of patents. The agreement was announced on October 2, 1939. This agreement was a tremendous victory for Philo Farnsworth and represented full recognition of his valuable contributions to the field of television.[97]

In Los Angeles, the Don Lee television station W6XAO, which had been operating at 300 lines sequential at 24 frames on frequencies of 45 megacycles for vision and 49.75 megacycles for sound, was shut down during the summer of 1939 in order to convert over to the new RMA 441-line, single side-band operation. Early in November 1939, W6XAO went back on the air. At this time, RCA, General Electric, Gilfillan Brothers and Stewart-Warner placed television receivers on the market in the Los Angeles area. It was announced that Don Lee Television had ordered portable television field equipment from RCA to be delivered by mid-December.[98]

On October 17, 1939, the Radio Corporation was celebrating the twentieth anniversary of its founding. A special program was sent from the Empire State television transmitter to an aircraft equipped with a receiver. The end of the telecast showed the plane landing at North Beach Airport, so that observers in the plane could see themselves landing.[99]

Farnsworth Television, which did not have an exhibit at the World's

Fair in New York City, did have a traveling exhibit that was in Seattle, Washington, during the first week of November 1939. The unit featured a "live" Farnsworth electron camera which was used in demonstrations.[100]

On November 8, 1939, the Ges. zur Forderung der Forschung auf dem Gebiete der Technischen Physik and der Eidgenoissischen Technichen Hochschule (the Swiss Institute of Technology) of Zurich, Switzerland, filed for a patent for a large screen television projector. It had a light-modulating screen that was to be locally deformed by the cathode ray beam. This mosaic screen was to be a layer of oil, or a mixture of gum and oil, or gum, gelatine, synthetic resin, etc.

Light from an independent source was to go through a series of lenses, a reflector and a lens to a modulating screen. Light reflected from the back of undeformed parts of the modulating screen was shut off by a reflector; but light affected by the deformed parts of the modulating screen passed the reflector and was directed by a lens system to form an image on a screen. This device was planned to project television pictures with sufficient light intensity to fill a large screen.[101]

The FCC adopted new rules regulating broadcasting on November 29, 1939. Two classes of stations were set up: Class 1, broadcasting on an unscheduled experimental basis, and Class 2, to offer a scheduled public program service using limited commercial operation. The FCC refused to set up any standards for transmission, mistakenly inferring that each manufacturer would use the standard it liked best. It was apparent that there was much dissension among the smaller manufacturers, and on December 22, 1939, the FCC decided to call a hearing on standards and related matters early in 1940.[102]

In December 1939 Scophony described for the first time a new camera tube called the Diavisor. It used principles patented by A. Rosenthal. The camera tube encased an image screen consisting of an alkali halide crystal mounted on a signal plate. A cathode ray beam scanned the surface of the crystal. The luminous energy of the image served as an exciting radiation, the crystal having been previously prepared to produce color centers. The cathode ray beam served as the quenching radiation.

The crystal stored an amount of energy corresponding to the intensity of the light upon it. This energy was freed by the action of the scanning beam when most of the quenching radiation freed electrons from the volume element of the crystal. This energy went to a resistance across which the picture signals were developed. A camera tube using an electron image was also described as using a light beam that was deflected by mechanical means.[103]

During this period, television had progressed from a purely experimental medium to a full-fledged commercial venture. The London Television Service, which had opened in 1936, had set a standard of excellence that was not to be matched anywhere for many years.

Television systems were getting more reliable, with better (more sensitive) cameras, and receivers with larger and brighter screens. It appeared that a commercial television service in the United States would be introduced in 1939 as soon as certain problems could be solved. However, there was much unhappiness among the smaller manufacturers and the FCC was loathe to set standards. Elsewhere throughout the world, television was being given low priority as the nations prepared to go to war.

Chapter 11

The First NTSC: 1940–41

On January 1, 1940, the Don Lee television station in Los Angeles, California, telecast the Rose Bowl Parade from Pasadena. This was accomplished using the two new portable television cameras recently acquired from RCA. The weather was overcast with considerable rain. The television signal was relayed nine miles from Pasadena to W6XAO, where it was transmitted to the Los Angeles area.[1]

Public hearings by the FCC beginning on January 15, 1940, indicated a break in the ranks of the television industry in regards to the standards (or lack thereof) in the United States. Both the Philco Corporation and DuMont Television sought to make changes. Philco wished to go to 605 lines at 24 frames/sec. DuMont desired a flexible system using 625 lines at 15 frames/sec. The Zenith Radio Corporation claimed that television was not ready for the public. In addition, Major Edwin Armstrong put forth the case for FM broadcasting, charging that RCA was trying to block the growth of his invention by all possible means. This shocked the new FCC chairman, James L. Fly, who ruled that the matter of permanent allocation would have to be held up until FM's needs were met.[2]

Members of the FCC, led by Chairman Fly, inspected the television station of RCA/NBC in New York and the new General Electric station W2XB in Schenectady, N.Y. They then visited the Allen B. DuMont Laboratories and were given demonstrations of television on both the RMA and DuMont standards.[3]

On February 5, 1940, they visited the RCA manufacturing plant in Camden, N.J., and were shown several new Iconoscope camera tubes. They witnessed a demonstration of large-screen television as well as a comparative test of 24-frame vs. 30-frame television.

They were also given a "demonstration" of color television. According to one source, it was a "simulated" three-color system utilizing three separate transmission channels using a system of mirrors for composition of the aggregate image. Another source claimed that it was a two-color flying spot system combined optically on a single screen. At any rate, it was the first indication that RCA was engaging in research into color television.[4]

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