PROCEEDINGS OF

THE RADIO CLUB OF AMERICA, INC.

Founded 1909, New York, U.S.A.

Spring 1996

From KFKB to XERA, the Story of a Super-Power Station

Also in this Issue:

THE RADIO CLUB OF AMERICA, INC.

Founded 1909, New York, U.S.A.

Headquarters office: 1620 Route 22, Union, NJ 07083. Tel. 908-687-3090; Fax 908-687-0977.

Proceedings of The Radio Club of America Volume 70, Number 1 Spring 1996

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Cover: KFKB received this prize as the "World's Most Popular Radio Station" in 1930.

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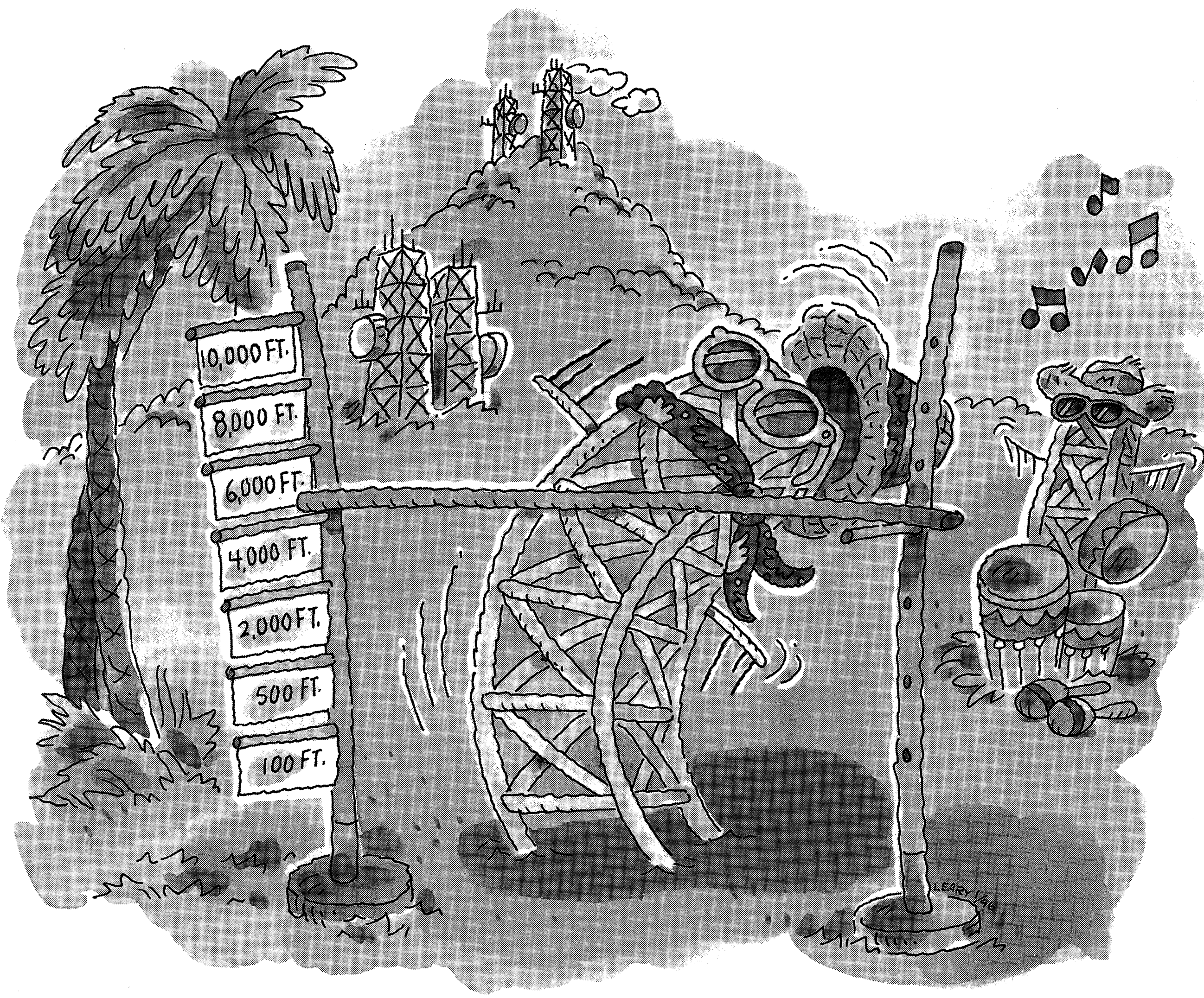

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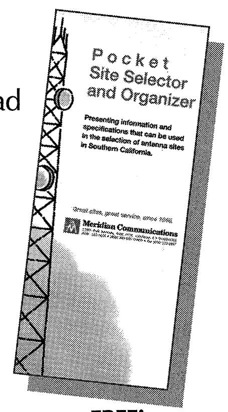

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Editorial Comment

By Don Bishop, *Proceedings* Editor

▶ *Planning* — Under the leadership of President Emeritus Mal Gurian, the Long Range Planning Committee continues to define priorities for achieving long-term goals. Among its goals, the committee has recommended the following priorities: improve membership services; increase the membership of the Club; design a program for corporate funding; and increase and improve the scholarship program.

One particular change that the planning committee recommended was adopted by the board of directors in June—the addition of two more membership categories. Now, in addition to Life and Regular members, the Club will have Student and Retired members. Adjustments will be made to the membership dues schedule to reflect this change, which will become effective Jan. 1, 1997. These changes are intended to encourage people to join at a younger age and to make it easier for retired members to retain their membership.

▶ *Member sponsorship* — For many years, membership application forms have specified that prospective new members must be sponsored by two current members. To help the number of members to grow, the board of directors voted to relax the two-member sponsorship requirement. A new version of the membership application will reflect this change, which was initiated by the planning committee. Neither the Constitution nor the By-laws requires sponsorship of membership applicants, so making the change is easy.

▶ *Official address* — Sometimes Club members report difficulty in finding the right people in the various committees to handle their inquiries. Thanks to our contract with Meredith & Henry, the Club now has a new official address: 1620 Route 22, Union, NJ 07083. The telephone number is 908-687-3090, and the fax number is 908-687-0977. The office is staffed during regular business hours.

Be advised that unless mail sent to a Club member via the official address is marked "personal," the headquarters staff will read it to determine how best to handle the correspondence it contains. The headquarters staff is prepared to process any inquiries.

To make it easier to reach me regarding the *Proceedings* or other matters, I've listed my postal and e-mail addresses and my phone and fax numbers on the table of contents page.

▶ *Nominations* — This is the time of year when the Nominations & Elections Committee sets about finding candidates for the board of directors and the offices of vice president, vice president/counsel, vice president/co-counsel, treasurer and secretary.

Candidates may be nominated by the executive committee (which normally accepts the recommendations of the nominations committee) or by petition. The names of the nominations committee members are (in alphabetical order): William Endress (co-chairman), Frank A. Gunther (chairman), Gilbert Houck, Fred Link

Continued on page 52

From the Birth to the Demise of Super-Power Station XERA

By Durell M. Roth

In 1938, broadcast engineer James O. Weldon designed and installed a 500,000-watt, medium-wave, transmitter with a two-element directional antenna at radio station XERA in Villa Acuna, Mexico. Two years after the installation, Weldon wrote a detailed description of the 500-kilowatt amplifier and associated equipment, but until his death in 1993 the paper remained unpublished. Because the station was unique in terms of design, power level, and the international political atmosphere in which it operated, I felt it was important to edit and expand Weldon's work to include such historical information as photographs and program schedules that were not contained in the original document. This, therefore, is the story of XERA, owned and operated by John R. Brinkley M.D. At that time, XERA was the most powerful medium-wave station in North America.

KFKB Broadcasting Association, Inc.

Milford, Kansas

Power, 5,000 watts. Wave Length, 285.5 meters. Frequency, 1050 kilocycles.

Hours of Broadcast: Each week day from 5:00 a.m. to 7:00 p.m.

Sundays from 8:00 a.m. to 9:00 a.m. and 12:00 noon to 7:00 p.m.

DAILY SCHEDULE

5:00	to	5:30	a.m.	Hauserman and Cook.
5:30	to	6:00	a.m.	Health Lecture by announcer.
6:00	to	7:00	a.m.	Bob Larkan and his Music Makers.
7:00	to	7:30	a.m.	Hints to Good Health by announcer.
7:30	to	8:00	a.m.	Bob Larkan and his Music Makers.
8:00	to	8:30	a.m.	Prof. Bert.
8:30	to	9:00	a.m.	Old time entertainers.
9:00	to	9:30	a.m.	Markets, weather, cash grain. Hauserman and Cook.
9:30	to	10:00	a.m.	Medical Question Box.
10:00	to	11:00	a.m.	Special Features.
11:00	to	12:30	noon	Steve Love and his orchestra.
12:30	to	1:00	p.m.	Health Talk by Dr. Brinkley.
1:00	to	2:00	p.m.	Special Features.
2:00	to	2:30	p.m.	Dutch Hauserman and Cook.
2:30	to	3:00	p.m.	Medical Question Box.
3:00	to	4:00	p.m.	Bob Larkan and his Music Makers.
4:00	to	4:30	p.m.	Uncle Sam and Dutch Hauserman.
4:30	to	5:45	p.m.	Arthur Pizinger and his orchestra.
5:45	to	6:00	p.m.	Tell Me A Story Lady.
6:00	to	6:15	p.m.	Prof. Bert, French language instruction.
6:15	to	6:30	p.m.	Orchestra.
6:30	to	7:00	p.m.	Dr. Brinkley.

Schedule changes weekly but hours of broadcast are fixed.

Figure 1. KFKB daily program schedule from the Souvenir Album of KFKB published January 1930.

The story of XERA begins in 1917, in the small town of Milford, Kansas. Dr. Brinkley and his wife, Minnie, moved there after responding to Milford's request for a physician. They made their home and doctor's office in the rear of an abandoned drug store and stocked the shelves with patent medicines. Brinkley didn't stay a small-town physician long, though. He developed two controversial surgical procedures that gained him international fame: one which corrected impotency and another that cured prostate inflammation. His practice grew rapidly, and Brinkley soon built a new hospital. Although controversial, the procedures were popular; and in early 1923, Brinkley was summoned to California to perform surgery on the managing editor of the *Los Angeles Times*. While there he visited the paper's radio station, KHJ, one of the first stations in the area. Announcers reported the progress of the editor's recovery daily over the station, and Brinkley thought that radio would be a good way to inform and entertain his own patients while they recuperated. When he returned to Milford, he applied for a license to operate such a station in Kansas. On September 20, 1923, permission was granted to operate the first commercial station in Kansas, KFKB. Brinkley hired Weldon as chief engineer and nicknamed the station "The Sunshine Station in the Heart of the Nation." The KFKB studios and transmitter were in a one-story brick building dwarfed by the two three-hundred foot towers that supported the station's multiwire flat-top antenna. The original transmitter was a modulated oscillator operating on a frequency of 1,050 kilocycles. Weldon converted the station to a class-B linear system and increased its power to 5,000 watts.

Brinkley's medical and broadcasting business became successful beyond all expectations. In 1929, KFKB won a gold cup as the most popular radio station in the world. The daily schedule shows the diverse programming that contributed to its overall appeal (See Figure 1 on page 24).

With an expanding patient load and 10,000 letters directed to him at the station each day, Dr. Brinkley was not able to answer all of his mail. To alleviate the problem he started a new program, "The Medical Question Box," broadcast twice daily, in which he answered listeners' letters, offered them medical advice, and suggested one or more of his numbered medications as a possible cure for their ailments.

The American Medical Association (AMA), however, frowned on Brinkley's questionable techniques and chastised him for his on-the-air practice of medicine. When the KFKB license came up for renewal, the Federal Radio Commission (FRC) refused, with the admonition that the world's most popular radio station was not serving in the public interest. KFKB continued to operate under appeal of the FRC's ruling until Brinkley sold the station for $90,000 and applied to the Mexican authorities for a permit to build a broadcasting station somewhere along the Texas-Mexico border.

In early 1931, the Mexican authorities granted permission to build XER near Villa Acuna, Mexico, just across the Rio Grande form Del Rio, Texas. In late spring of that year construction began on the 50,000-watt "Sunshine Station Between the Nations" (Fowler 23-24).

Weldon and another engineer, Will Branch, began construction of the XER transmitter in Fort Worth, Texas, in mid-1931. When the broadcasting site was ready, the equipment was transported to Villa Acuna, Mexico, where the construction was completed. Weldon and Branch moved to Del Rio to oversee the final construction of XER, but the Brinkleys remained in Milford to supervise the Brinkley hospital and set up remote studios to broadcast, via phone line, over the border station. In the interview with Weldon, video taped in February 1993, he discussed the development of XER and remarked that he remembered the line from Milford as being nearly high-fidelity.

On October 21, 1931, XER began regular broadcasting on the mid-channel frequency of 735 kilocycles, with programs originating from both Milford and Villa Acuna. The primary target area of XER, and other high-power border stations, was both the United States and Canada. The stations, therefore, depended on the night-time medium-wave skip to reach their audience and adopted a dusk-to-dawn schedule for their normal broadcasting hours. The schedule worked not only to the financial advantage of the stations, but also aided their maintenance and modification efforts because the work could be done during the daylight hours when the stations were off the air.

The original XER transmitter used a 50-kw linear r-f power amplifier consisting of six Western Electric (W.E.) 232A tubes operating in a class-B, push-pull, parallel circuit. The antenna was a flat-top, approximately 24 feet long by 8 feet wide, suspended between two 300-foot towers. The ground plane for the antenna consisted of parallel wires laid three feet apart and soldered to collector ribbons for connecting to the remainder of the ground system.

XER was an immediate success. In an April 1932 letter to Dr. Brinkley, station manager H.L. Munal attached a statement of income and expenses for the first six months of operation which showed a profit of more than $48,000 (Munal 2). Brinkley reported, over XER, the national success of his Milford-based medical practice and made frequent private plane trips to Del Rio to oversee his expanding radio business.

The First Power Increase

In mid-1932, Weldon increased the transmitter output power to 65 kw by adding two tubes to the class-B amplifier, thus making a total of eight W.E. 232A's. He also modified the antenna system by adding a parasitic reflector that increased the station's signal to the north by approximately three decibels. To install the reflector, engineers erected a third tower forming an equilateral triangle with the other two and installed messenger cables to support the reflector.

The driven element and passive reflector were installed approximately ninety electrical-degrees apart. The system formed a cardioid pattern that provided maximum signal over a 180-degree section in the northern half of the coverage area. The reflector increased the station's ground-wave signal to about 300 miles and its sky-wave signal beyond 1,000 miles. The territory within the 300 to 1,000 mile area was served by high-angle radiation and was not affected by the reflector. Writing in a December 1932 letter to Brinkley, Weldon reported an antenna current in the new system of 42 amperes with carrier only and 55 amperes on modulation peaks. He installed a ground system identical to that of the driven element under the reflector and connected the two systems to form one large ground plane.

Making Plans for 500,000 Watts

Even as early as 1932, the engineering staff made plans to increase the station's power to 500,000 watts using a transmitter with a class-C final amplifier and high-level modulation. But when considering power in the 500-kilowatt range, the increased physical size and weight as well as the cost of parts like transformers, tubes, and generators became major factors in designing the new transmitter for XER. Weldon wrote in a December 2, 1932, letter to Brinkley that the power transformer for such a system weighed 32,000 pounds and that the filament generators alone would cost about $15,000 each. When all parts, including spares, building expansion, power supply line, and arrangements with the power company were considered, the total estimated cost was $150,000 (Weldon 3-4).

Weldon originally planned to build a new class-C final and push-pull class-B modulator using ten RCA type UV-862 tubes, four in the modulator and six in the final amplifier. With this configuration he could use the existing transmitter and modulator to drive the new equipment. Although this system was never constructed, equipment modifications were made that would accommodate some type of future power increase.

In spring 1933, Weldon made extensive modifications in the station's power supply. He replaced the original mercury-vapor rectifiers with a pair of six-phase, mercury-arc rectifiers manufactured by Brown-Boveri Co. of Switzerland. Each rectifier system was grid-controlled and had a rating of 1,800 kilowatts or 100 amperes at 18,000 volts. The six-phase system, contained in a steel cylinder, is described by S.R. Durand in his paper for the

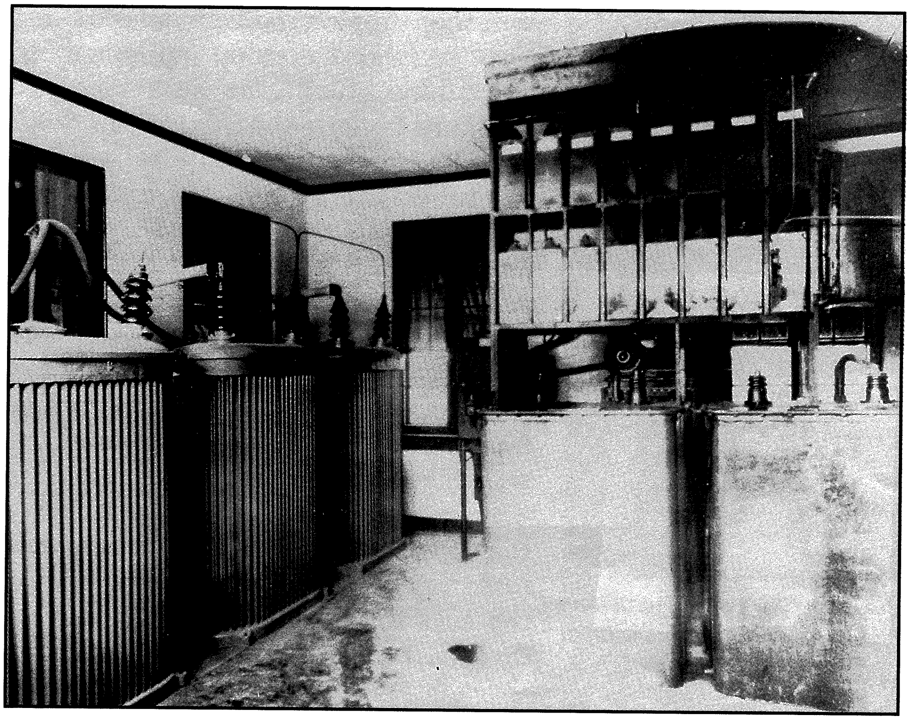

Figure 2. A portion of the power supply for the 180-kw station showing the filter capacitors in the upper right of the figure, and the filter chokes in the lower right foreground. Power transformers are along the left wall.

except for a single positive pulse, which was supplied once during each input cycle. By adjusting the phase position of the positive pulse relative to the positive half-cycle on each anode, Weldon made the power supply output voltage continuously variable from 9,000 to 18,000 volts. The positive pulses were supplied by a synchronous-motor commutation system, and the phase position of the pulses was adjusted by rotating the phase of the motor supply voltage. Two 100-volt motor-generator sets, one for each rectifier, supplied the grid voltage, and a Bakelite shaft-coupler isolated one of the generators from the 9,000-volt potential difference between the rectifier cylinders.

Institute of Radio Engineers as being approximately 3 feet in diameter, 5 feet high, and weighing 1,000 pounds.

Figure 2 above shows the new filter chokes, filter capacitors, and high-voltage transformers that were installed as part of the power supply modifications. The main transformer, manufactured by American Transformer Co., was fed from the 11,000 volt high-line through a motor-operated, high-speed, oil circuit breaker with an interrupting capacity of 100,000 KVA. The transformer had two six-phase secondaries, each supplying one of the Brown-Boveri rectifiers. Each of the six-phase systems supplied 9,000 volts, and the two were connected in series for a maximum output of 18,000 volts.

The output voltage of each six-phase rectifier could be set to any value by applying an arc-delay control voltage to each of the rectifier's six grids. Using this feature, each controlled grid of the rectifier on the 18,000-volt side was supplied with negative voltage,

In case of backfire in the rectifiers, high-speed relays would reverse the polarity of their grid potential and thus interrupt the arc. The backfire would case within one-half cycle after the grids became negative, and the system would return to normal within eight to ten cycles.

Auxiliary equipment associated with each of the rectifiers included a high-vacuum and a low-vacuum pump, ignition and excitation set, water system to cool the high-vacuum pump, a cathode and condensing dome for each rectifier cylinder, and an interlocking protection system.

The Second Power Increase

After completing the power supply, Weldon modified the transmitter to increase its output power to 180 kilowatts. He changed the original final amplifier, eight W.E. 232A tubes, from class-B linear to class-C, and built

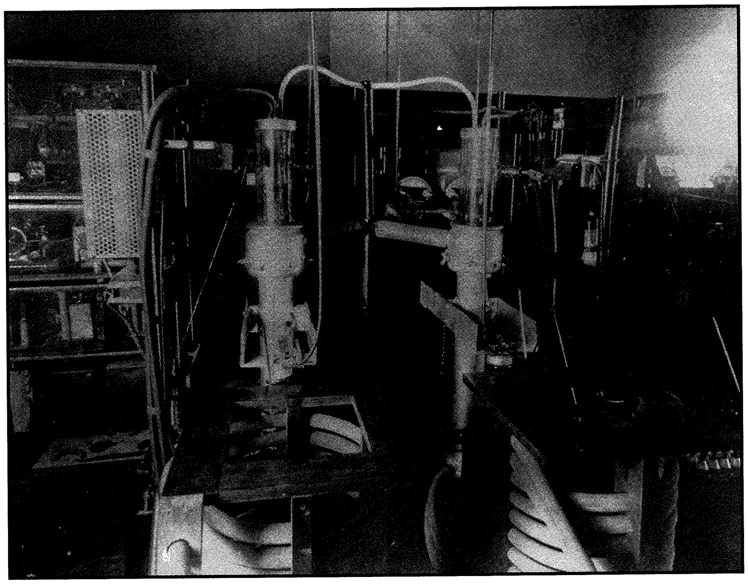

Figure 3. Part of the modulator for the 180-kw transmitter showing two of the modulator tubes, cooling-water coils and associated equipment. The front panel of the modulator is barely visible in the background.

a new modulator for the system. Writing in his paper about the 500-kw transmitter, Weldon described the new modulator as, "...a class-B modulator, using four RCA type UV-862 tubes. . . with modulating transformer, and condenser, and with parallel feed modulation reactors. . ." (3). A modulator driver containing two 848 tubes in a push-pull circuit was fed by a speech amplifier using a pair of 849 tubes, also operating in push-pull. The plate voltage for the audio and r-f driver tubes was the 9,000 volts obtained between the two series-connected rectifiers. A separate filter system was used for this lead. Two of the RCA UV-862 modulator tubes, cooling water coils, and associated equipment are shown in Figure 3. The resonating capacitor and coil that formed the push-pull output tank circuit for the eight W.E. 232A's in the final amplifier are shown in Figure 4. The coil, wound on a dried maple-wood form, had ceramic blocks in the grooves to hold the turns. The small coil in the foreground is the link that coupled the transmission line to impedance-matching equipment in the antenna tuning house.

Figure 5 shows the control panels for the 180-kw transmitter. The modulator tubes are behind the third and fourth panels from the left, and the power amplifier tubes are behind the eighth and ninth panels. The tank circuit for the final amplifier is on the other side of the wall in the far right of the Figure and is fed through the two feed-through insulators visible on the wall. The two panels to the right of the main panel contain controls that move the capacitor plates for fine tuning the tank circuit, and the meter in the top center of the left panel monitors the r-f tank current.

The Antenna System and Tuning Equipment

Figure 6 shows the coil and capacitor arrangement inside the antenna tuning house

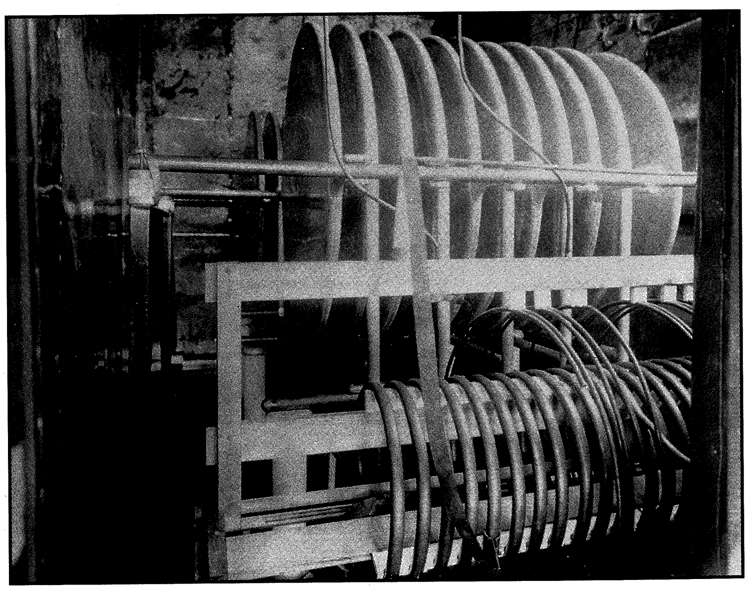

Figure 4. Tank circuit of the 180-kw final amplifier showing the resonating capacitor and part of the tank coil. The ceramic blocks within grooves to hold the truns are visibile inside the coil above and below the Maple-wood form. The small tubing in the foreground is the ouput link that drives the transmission line.

below the driven element of the array. The capacitors in the foreground are part of the push-pull tank for terminating the balanced line from the transmitter. The capacitor in the background is for series-tuning the antenna and is connected to the feed-line through the insulated bushing on the wall above the capacitor. The coil for the system is barely visible below the series-tuning capacitor. Each capacitor plate is constructed with two spun-aluminum plates, riveted at the center and sealed on the edges. Each plate is six feet in diameter and two inches thick. The transmission line from the final amplifier entered the tuning house from behind the camera.

While the station operated with a transmitter power of 65 kw, the antenna system functioned without major problems. During that time, however, the weather had begun to cause

Figure 5. Control panels for the 180-kw station. The modulator tubes in Figure 3 are behind the third and fourth panels from the left, and the power amplifier tubes are behind the eighth and ninth panels. The tank circuit in Figure 4 is on the other side of the wall at the far right in the figure. The plate leads connect to the tank circuit through the feed-through insulators that are visibile on the wall.

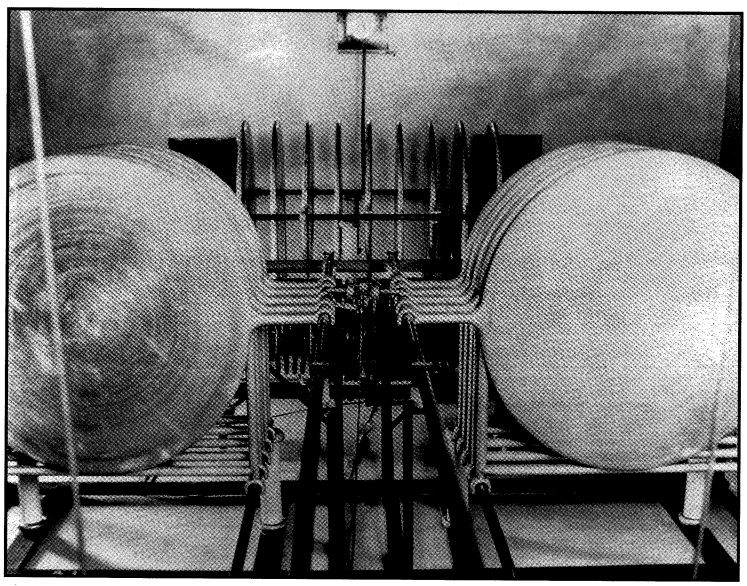

Figure 6. Resonating capacitors in the antenna turning house below the driven element of the array. The capacitors in the foreground are for resonating the push-pull tank that terminates the transmission line from the transmitter. In the background is the series-tuning capacitor for the antenna that connects to the feed-line through the insulated bushing on the wall just above the capacitor assembly. Each capacitor plate is six feet in diameter and two inches thick.

oxidation on the surface of the multiconductor lead-in cable. The oxidation increased the wire-to-wire resistance causing extensive heating of the lead-in when the power was increased to 180 kilowatts. A personal correspondence with Weldon in May 1989, finds that when operation at 180 kw started, the lower fifty feet of the half-inch copper cable feed line to the antenna became so hot that it turned black (1). He corrected the problem by slipping a five-eighths-inch diameter copper tube over the cable and connecting them at the top of the feed line. The larger outer diameter of the tubing provided a smooth, low-resistance conductor with sufficient surface area for current distribution and allowed the feed system to operate normally. With this arrangement the radiation resistance of the array measured 13 ohms, and the antenna current was about 118 amperes. Although an exact date is not known, soon after the power increase to 180 kilowatts, engineering personnel converted the antenna system from a passive array to a phased array, with little or no effect on the radiation pattern.

The antenna system, however, was still not without problems. Writing in his paper, Weldon described one of the more potentially disastrous occurrences: "When the energy was divided and supplied to both antennas in proper ratio to give equal currents, these antennas were satisfactory. However, on one occasion all the energy was fed to a single antenna and corona discharge at the top and for perhaps fifty feet down the vertical lead was rather severe. Arc-overs across three, two-foot strain insulators, in series to the supporting messenger cables were experienced on some occasions" (23). Of course, this was not the normal operating mode of the antenna, and no arc-covers occurred when using the conventional hoop-up. It did indicate, however, that if a higher power transmitter were to be used, the station would require an antenna with greater capacitance to lower the r-f potential at the top of the array. Weldon eventually replaced the system with a new antenna (discussed later) when he increased the transmitter power to 500 kilowatts.

Brinkley Relocates in Texas

After Weldon corrected the feed-line overheating and developed a stable phasing system for the two antennas, the station operated without significant problems. Brinkley broadcast his lectures daily, made electrical transcriptions for re-broadcast, and frequently commuted to the border to supervise his broadcasting business. On a return trip to Milford, he discovered that one of his employees had started a rival clinic and was offering the Brinkley treatments for a substantially lower cost. Justifiably angered, Brinkley announced over XER that he had refined his surgical techniques for treating impotency and developed a new procedure for shrinking enlarged prostates. The Brinkley Hospital would also move to Del Rio he said, citing as justification the escalating cost of remote phone lines and commuting between the two cities.

In late October 1933, a caravan of thirty families of Brinkley employees plus trucks filled with hospital and office equipment began the journey to the Texas-Mexico border. Doctor, Mrs. Brinkley, and their son, John, followed a few days later by private plane and became permanent residents of Del Rio.

Brinkley rented three floors of the Roswell Hotel for his hospital and the entire basement for X-ray and laboratory facilities. He set up new remote studios for broadcasting over XER and bought a Spanish-style house on 16 acres just outside Del Rio. He soon enlarged his new home to accommodate a three-story pipe organ in the music room, and added a swimming pool, lush gardens with meandering walkways, and electrically operated fountains.

Brinkley loved Del Rio, and his business breathed economic life into the community during the depths of the Depression. He touted the recuperative powers of his new city over XER, citing the year-round warmth, fresh air, and the excitement of romantic Old Mexico. Del Rio, Brinkley quipped, was the place ". . . where summer spends the winter" (Fowler 40).

An increasing patient load for Brinkley meant more dollars for businesses on both sides of the border. Not everyone, however, was pleased with Brinkley, and plans were being implemented by the Mexican government to close XER. After initially granting Brinkley permission to broadcast in English, the Mexican authorities recanted the agreement and issued fines against XER. The fines were allegedly for violating Mexican laws by broadcasting in English from a remote location and continually breaching Department regulations in the content of the transmissions. On February 24, 1934, Federal troops from the Department of Communications closed the Sunshine Station.

While the station was off the air, Brinkley bought time on other border stations and on his old KFKB in Milford. Two months after closing XER, however, the Mexican Supreme Court ruled in favor of Dr. Brinkley and allowed the station to resume broadcasting. By the time of the court ruling, Weldon had changed the station's frequency to comply with new international regulations adopted by Mexico, and in April "The Sunshine Station Between the Nations" was reborn as XERA. The station now operated on a new frequency of 840 kilocycles, and the regular nightly broadcasts continued at 180 kilowatts until early 1938.

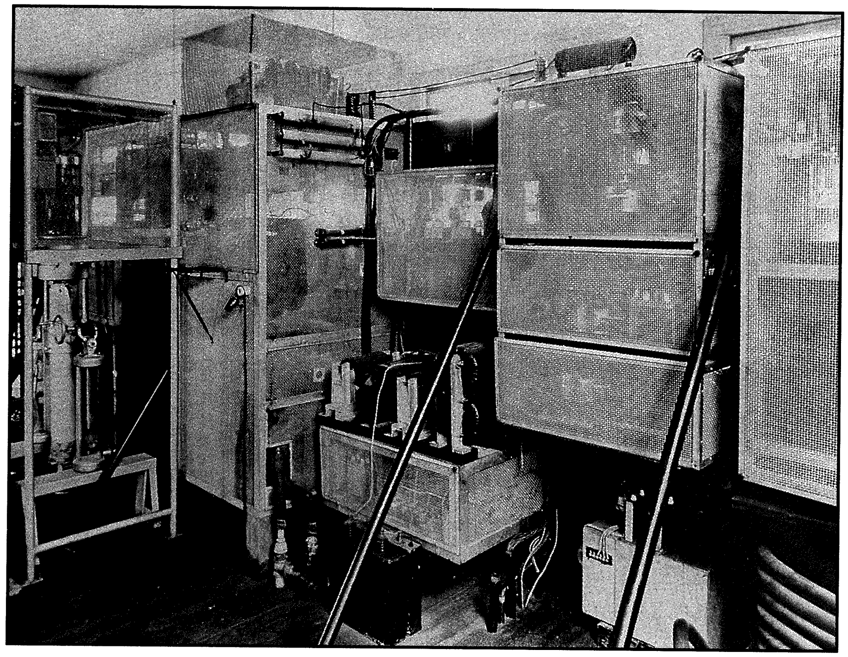

Figure 7. A portion of the modulator of the 180-kw transmitter.

Just after the first of the year, Brinkley decided to increase the station's power to 500,000 watts. In an effort to accomplish the increase in the most efficient manner, the station management developed a four-step plan to meet specific objectives. First, there could be no program interruptions during installation and change-over to the new equipment. Second, the new high-power equipment had to be in operation by early September, allowing slightly over eight months for design, construction, installation and adjustment. Third, as much of the existing equipment as possible had to be used in the new system. Fourth, since sufficient space was not available, an addition to the building had to be designed and built before the new equipment could be constructed.

To accomplish these objectives, Weldon began an in-depth study of published material relating to high-power work which had been done both in the United States and Europe on experimental and commercial equipment. Correspondence between Weldon and Brinkley in early 1930 shows that he initially planned to use some kind of a high-level modulation system. Later, however, he built 50-kilowatt transmitters for stations XEW in Mexico City and XEAW in Renosa, Mexico, using a new amplification system designed by W.H. Doherty. Weldon found the system to be more efficient than the conventional class-C amplifier and, therefore, more suitable for high-power applications (Doherty). Writing in his paper on the 500,000-watt transmitter, Weldon said that ". . . the most logical design for such a high-power transmitter lay in the use of the Doherty system of amplification" (5).

Having decided to use a Doherty amplifier, his choice of tubes was made easier by the development, in late 1937, of the Western Electric type 320A tube with a peak-power rating of 250 kilowatts. Until then, no tube had a peak-power rating greater than 100kw, but with the 320A, a 500,000-watt Doherty could be built using only eight tubes instead of 20 or more that would have previously been required.

In addressing the need to use as much of the existing equipment as possible, Weldon designed a system using the present transmitter, with modifications, as a driver for the Doherty amplifier. A new room was added to the transmitter building to house the 500-kw

Characteristic and Operating Data
320A Vacuum Tube

GENERAL

The 320A vacuum tube is a three element water-cooled tube designed for use as an oscillator, modulator or amplifier at the higher power levels and high frequencies.

Nominal filament voltage	35 volts
Nominal filament current	435 amperes, single phase or dc
Average thermionic emission	90 amperes

Average characteristics with a plate potential of 18,000 volts and a plate current of 8 amperes:

Amplifier factor	30
Plate resistance	965 ohms
Grid to plate transconductance	31,100 micromhos

OPERATING LIMITS

Maximum modulated direct plate voltage	12,500 volts
Maximum non-modulated direct plate voltage	18,000 volts
Maximum alternating plate voltage r-m-s	20,000 volts
Maximum direct plate current	15 amperes
Maximum plate dissipation	150,000 watts
Maximum grid dissipation	2,000 watts

Figure 8. Operating characteristics for Western Electric type 320A vacuum tube. Four of these tubes were used in each of the 250-kw Doherty amplifiers at XERA.

unit, its 50-kw r-f driver, and bias rectifiers. The room, constructed adjacent to the existing control room, was thirty by thirty feet with a full basement.

After completing the addition to the transmitter building, workers removed the wall separating the new structure from the old control room, and engineers began construction of the 500-kilowatt amplifier and its 50-kilowatt driver. In mid-July, with the 50-kw unit nearing completion, Weldon reduced the transmitter power from 180 kilowatts to about 80 kilowatts. He then removed two of the UV-862 modulator tubes and their sockets and used them to complete the new driver. The station remained on the air at 80 kilowatts for the nightly broadcasts until testing of the 50-kw unit had been completed.

The New 50-kilowatt Modulated Driver

The 50-kw driver consisted of two RCA UV-862 tubes, parallel-connected, in a tuned-grid-tuned-plate circuit. The amplifier occupied a space 48-inches wide by 54-inches deep directly behind its control panel. Plate voltage for the amplifier came from the 18,000 volt supply and the filament voltage from a d-c motor-generator in the basement. Two compressed-gas capacitors in a "double-ended" circuit formed the tunable portion of the plate tank and provided r-f energy for neutralization.

To begin testing the new amplifier, Weldon disconnected the old class-C system and reduced the output of its exciter to about half power. Then using a three-quarter inch diameter concentric transmission line, technicians coupled the output of the exciter directly to the grid tank circuit of the 50-kw unit. Weldon obtained audio for modulating the new amplifier from the push-pull 848 tubes, previously used as the audio driver for the now-disconnected class-B modulator. He coupled the secondary of the output transformer from the push-pull stage with a 50-mfd dc-blocking capacitor to the grid lead of the UV-862 amplifier tubes. Two audio chokes connected in a T-filter arrangement provided audio isolation from the bias supply. By carefully designing the input circuits of the 50-kilowatt system, Weldon achieved a near-perfect impedance match to the audio transformer. The grid tank circuit presented a 600-ohm load in parallel with a 200-ohm resistive load across the transformer for an audio-input impedance of 150 ohms. Being much lower than any other load

Figure 9. Gold cup awarded to KFKB in 1930 as the World's Most Popular Radio Station.

in the modulator, the 150-ohm impedance created a flat audio-frequency response with minimum phase distortion. The d-c output of an r-f rectifier in the 500-kw unit served as signal voltage for inverse-feedback control of the audio system, and transformer coupling throughout the high-power audio chain provided the necessary impedance matching and phasing within that feedback loop. The loop contained two transformers, but with the transformer technology of the time only 12 DB of feedback could be obtained. Although the feedback level was adequate for the initial start up of the 500-kw amplifier, the system was modified later to increase the amount of feedback in order to further decrease any audio phase distortion.

During the initial testing of the 50-kilowatt unit, a spurious oscillation or "singing" occurred as a result of the tuned-grid-tuned-plate circuit arrangement used in the amplifier. Weldon inserted a small inductor in the grid lead of the UV-862 tubes that detuned the circuit at the frequency of the oscillation and allowed the amplifier to function normally.

For a period of several weeks, the station broadcast the nightly programs at 50,000 watts. Since the station only operated during the night-time hours, all of the necessary equipment modifications for the 500-kw system were made during the day, when the station was off the air. Engineers installed a switching arrangement that allowed the 50-kw modulated driver to be alternately connected to either the new amplifier for testing or to the antenna for the nightly broadcasts.

More Power Supply Modifications

The power supply components and most of the r-f equipment had adequate power ratings for use with the 500-kw amplifier. Weldon, however, re-connected the power supply filter chokes and filter capacitors in order to accommodate the increased current requirements. The six-phase Brown-Boveri rectifiers were more than adequate for the new equipment; but the filter chokes, as connected, did not have sufficient current capacity. Each of the chokes had dual ratings and were re-connected in parallel to double their current capacity, which reduced the total inductance to one-fourth of the original value. To compensate for the reduced inductance, Weldon connected the audio reactors, which he had removed from the old class-C r-f amplifier, in series with the other filter chokes for a total inductance of 2.25 Henrys. As an economic measure imposed by management, technicians constructed a filter-capacitor assembly for the power supply consisting of the modulation capacitor from the old class-B modulator and additional capacitor units for a total of 70 microfarads. The capacitor assembly together with the 2.25 Henry inductance provided an L-C filter resonant frequency of slightly less than 13 cycles. While not adequate

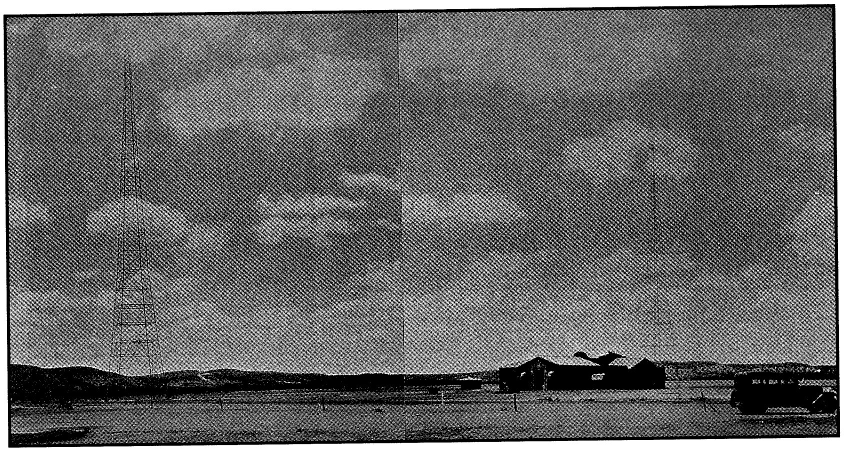

Figure 10. XER before the antenna was installed.

for the lowest audio frequencies, the 13-cycle filter did provide sufficient power-supply stability to begin testing of the 500-kilowatt amplifier.

The 500,000 Watt Amplifier

The 500-kilowatt amplifier consisted of two 250-kilowatt Doherty amplifiers that were operated in parallel to obtain 500,000 watts. Both of the Doherty units used four of the newly developed W.E. 320A tubes, each tube having a peak power rating of 250,000 watts.

Engineers made initial tuning adjustments in the amplifiers on August 1, 1938, using an r-f bridge to obtain coarse settings of all the resonant circuits. When power was applied to the first Doherty amplifier, a "singing" oscillation occurred that caused excessive plate current and opened the circuit breaker. To eliminate the oscillation, Weldon added additional mica capacitors, which he borrowed form the other amplifier, to increase the KVA/KW ratio of the grid-tank circuit. Because capacitors had been removed form the second amplifier, Weldon postponed the testing of the 500-kw system until additional parts could be obtained. During that time, however, engineers tested each of the Doherty amplifiers individually at a carrier output power of up to 320,000 watts. As part of the test, each amplifier was modulated at eighty percent with a single audio tone. On about August 10, XERA, The Sunshine Station Between the Nations, began regular nightly broadcasts using one of the Doherty units operating at an output power of 270,000 watts with 100-percent modulation.

When testing of the parallel operation for 500 kilowatts began, another spurious oscillation occurred at a frequency of 1370 kc. The oscillation resulted from the two pairs of Number 2 audio peak tubes acting as a push-pull oscillator when the output of each amplifier was paralleled. While troubleshooting the system, Weldon discovered that, at 1370 kilocycles, a high-impedance, resonant, push-pull circuit was presented as a plate load to the audio peak tubes and that the distributed capacity of connecting lines to the grid tuning equipment functioned like a resonant push-pull tank at that frequency in the grid circuit. Together, these conditions caused the two units to operate as a high-power oscillator instead of an amplifier. He eliminated the problem by adding a three-turn damping coil in each grid lead to de-tune the tank at 1370 kilocycles. The coils were temporary, however, as any change in the tank tuning would require their re-adjustment. Later, when additional parts were available, each coil was replaced with a five-ohm resistor. The resistors presented a total of ten ohms to the oscillation in the tank, but only five ohms in the r-f drive lead to the amplifier. The ten-ohm impedance eliminated the oscillation with a negligible effect on the regulation of the r-f drive signal.

During a test at 500 kilowatts, the inadequacy of the 13-cycle power supply filter became apparent. While modulating the transmitter at 100 percent with a 50-cycle tone, Weldon discovered an audio voltage in excess of 3,000 volts across the 70-mfd power supply output capacitor. This voltage, alternately added to and subtracted from the plate voltage of the power-amplifier tubes, caused severe audio distortion and unnecessary stress on the new W.E. 320A tubes. As a stop-gap measure, he installed a high-pass audio filter with a roll-off of −6 db at 30 cycles. The filter was used until the recommended 120-mfd capacitor could be installed.

On September 15, 1938, XERA began regular nightly broadcasting with a 100-percent modulated carrier output power of 520,000 watts. With the 3 db gain in the antenna, XERA had an effective radiated power of slightly more than 1,000,000 watts. Dr. Brinkley boasted that he owned "...the world's most powerful broadcasting station" (Fowler 45).

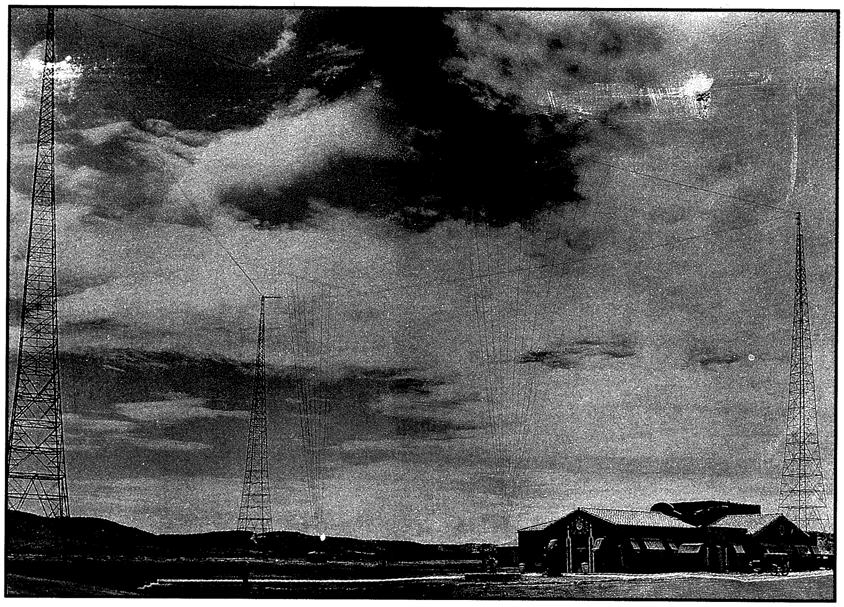

Figure 11. Station XER with the two-element flat-top antenna system that engineers installed while the station was operating at 65kw. The array had a forward gain of slightly more than 3 db and provided the station with an effective radiated power of more than 130kw to the north of the transmitting site. The flat-top portion of the system is not visible in the photograph; however, the group of wires nearer the building are the down-leads for the driven element of the array.

By skillfully designing the XERA equipment, Weldon accomplished a nearly impossible task; in less than eight months he had designed, constructed, tested, and put into operation the 500,000-watt station. He had used all but four parts from the existing transmitter, and he completed the entire project without program interruptions. After the power increase from 180 kw to 500 kw, the only parts of the old transmitter to be discarded were two tube sockets, one of the class-C stage assemblies and one high-level modulation transformer.

Touring the 500,000 Watt Amplifier[1]

Engineers positioned the control panel for the 500-kilowatt transmitter just inside the new room, facing the old operating position. Constructed of steel and glass office partition-material, the twenty-seven-foot-long panel spanned nearly the entire width of the new control room, with individual panels directly in front of the associated equipment.

Facing the new control board, one had a clear view of the complete in-line system of panels. A 48-inch wide panel in the center contained the controls for the 50-kilowatt modulated driver, and a door adjacent to each side of the panel provided access to the driver and one of the 250-kw amplifiers. A set of panels adjacent to the left access door contained the controls for one of the Doherty amplifiers, and an identical set of panels adjacent to the right access door formed the control system for the other Doherty unit. On the far right end of the main control system, stood a separate control panel for the bias rectifiers and filament starting circuits.

An array of eleven meters formed the first section of the monitoring panel for each Doherty unit. Included in this array was a plate-current meter for each of the four tubes and total plate-current meter for

[1]Photographs of the 500-kw system are not available.

the unit; a grid-current meter for each pair of tubes and an r-f tank current meter for each of the two grid-tank circuits; a filament-voltage meter that could be connected to any of the four tubes by a rotary switch and a time-meter for recording filament operating time. Four plate-current overload relays, each with an indicating flag, composed the second portion of the monitoring area. When plate-current overload occurred, one or more of the relays closed a 24-volt battery trip-circuit which in turn opened the high-speed oil-type circuit breaker to shut down the amplifier. When the relay closed, it set the indicating flag to show which of the four tubes had been drawing excessive current.

The controlling section of the panel for each Doherty amplifier contained an assortment of knobs, toggle-switches, and push-buttons for adjusting specific parameters of that unit. Among these were controls for adjusting the filament voltage for each of the four amplifier tubes and the 18,000-volt plate supply. Two push-buttons in the control area either removed the amplifier from service or re-connected it into service, as required. A system of shafts and gears allowed load impedance and grid-tank/plate-tank tuning adjustments to be made from the control panel.

By entering the amplifier compartment through either of the front panel access doors, one had a clear view of the Western Electric 320A power tubes. All eight tubes stood in a straight line, seven feet behind and parallel to the front panel, spanning its entire twenty-seven foot length. The four tubes to the left of the driver composed the 250-kilowatt amplifier, Number 1, and the four to the right composed the 250-kilowatt amplifier, Number 2.

In his paper on the 500,000-watt transmitter, Weldon described the functional placement of each amplifier tube: "In each 250-kilowatt amplifier, the two tubes farthest away from the driver stage are the "Number 1" or carrier tubes and the two tubes nearer to the driver stage are the "Number 2" or modulation peak tubes of the Doherty system. The 250-kilowatt units are identical in every detail and the following description applies to either" (11).

Each 250-kilowatt amplifier contained four of the Western Electric 320A tubes; two tubes connected in parallel for the carrier amplifier and two connected in parallel for the audio peak amplifier. A 17.5 KVA filament transformer and induction-voltage regulator hung on the basement ceiling directly below each of the tubes. The transformers supplied single-phase a-c power to the filament of the associated tube, with the filaments of each pair being supplied 90-degrees out of phase. A system of shafts and gears allowed adjustment of the voltage regulators from the control panel located on the floor above.

Cabinets mounted at floor level and eighteen inches behind the 320A tubes contained the grid inductors, mica condensers, and variable condensers for adjusting the grid-circuit phasing and tuning. An air duct mounted directly above the cabinets extended the full length of the two amplifiers and then extended outside the building. The duct served as housing and cooling system for the grid-load resistors in each Doherty amplifier. The resistors generated approximately thirty kilowatts of heat, and air supplied by a blower in the basement removed the heat at each end of the system.

Weldon designed the grid-tank circuit for the Number 1 and Number 2 tubes as a "built-out" or "double-ended" circuit, so that neutralizing voltage could be obtained from the built-out end of the tank. The neutralizing condensers consisted of a group of mica units, with a small, air-insulated variable condenser connected in parallel for trimming. The trimming condenser was located above the air duct and connected to the plate-blocking condensers at that point. In his paper Weldon said that he found this method of neutralizing unsatisfactory because any adjustment of the tank condensers could result in the need to re-adjust the neutralizing condenser. "Although instability never developed as a result of changing adjustments of the grid tuning without re-neutralizing, it was made a routine to recheck neutralization after such adjustments and practically always a slight readjustment was found necessary" (Weldon 14).

At the center of the air system containing the grid-load resistors, the duct extended forward toward the front panel. Here the duct functioned as a conduit for the wires that connected the driver through a phase-shift network condenser to the input circuits of the Number 1 tubes. In the center of the duct engineers installed part of the isolation system that disconnected either or both of the 250-kw units form the driver amplifier.

Compressed-gas condensers mounted on the floor of the amplifier compartment, behind the grid equipment cabinets, resonated the amplifier output circuits. A system of shafts and gears allowed the condensers to be adjusted from the front panel. As an economy measure the station management required that compressed air, rather than dry nitrogen, be used to operate the condensers. Under normal conditions this method proved to be more economical; however, in his paper on the high efficiency transmitter, Weldon noted that it "...has a disadvantage in that oxygen is present in the condenser tanks to support combustion in case of an internal arc over." As a precaution, safety gaps were installed across each condenser; but Weldon also noted that "...conditions may develop wherein these do not provide protection" (14, 15).

To help prevent moisture condensation in the air lines, and thus in the condensers, a ten-foot vertical pipe was run from the compressor tank. This allowed any moisture that condensed in the line to drain back into the tank. Engineers removed the moisture daily by opening a drain cock at the bottom of the tank. To test the efficiency of the system, and to check on the danger of moisture condensation in the condensers, Weldon left the drain cock closed for several months until the tank became half-full of water. At random intervals during that time, some of the condensers were opened and found to be completely dry. Weldon, however, states in his paper that "...in general, the weather conditions prevailing in the locality where the transmitter is situated present lower humidity values than may normally be expected in most parts of the country. Although no difficulties have been experienced in this case, the use of air is not to be recommended above the use of dry nitrogen" (15). Weldon used a 300-psi compressor as an air source to operate the condensers, and a pressure switch controlled the compressor and maintained a line pressure between 250 and 255 psi.

Directly above the compressed-gas tuning condensers, a shielded cabinet containing the plate phase-shift networks and output tank coils associated with the tuning condensers spanned the length of both amplifiers. This cabinet had a steel and aluminum frame and used copper sheets to form separate internal compartments.

Above the output-inductance cabinets another air duct, attached to the ceiling, ran the full length of the control panel and then out of the building. In addition to functioning as a hot-air exhaust, the duct served as a housing for the 18,000-volt supply lead, which entered the system near the center and connected directly to the driver plate-choke. Before the driver choke, the high-voltage line went through two contacts of the isolation system and then to the individual plate-current limiting resistors of the two Doherty amplifiers. Another air duct mounted directly above the 320A tubes contained the limiting resistors, each positioned above the associated tube. The duct spanned the full length of the two amplifiers and functioned as the cooling system to remove the heat generated by more than 13 kilowatts of power radiated from the resistors. A blower in the basement supplied air at the center of the duct and the heat was removed from the system through an external exhaust at each end of the building.

A feed-through bushing carried the 18,000 volts from the limiting resistor to the plate r-f choke for each of the eight 320A tubes. The chokes were mounted vertically on top of each tube assembly. In his paper Weldon describes the chokes as having been wound with number ten wire on a seven-inch diameter, three-foot-long Bakelite form. Every twentieth turn was firmly attached to the form to prevent the turns from piling up due to heating or magnetic force which might be caused by high plate current (16).

At the rear of the amplifier, engineers positioned the two T networks used for matching the output circuits of the 250-kilowatt amplifiers. The output leads of the networks connected, through the contacts of an isolation switch, to a dual-impedance T network in the basement. Weldon describes the T network as consisting of two inductive series elements and one capacitive shunt element. Each element had leads connected to contacts of the isolation switch in order to adjust the impedance match to the final amplifier (17).

The Isolation System

Weldon designed this system so that it would automatically isolate either or both of the Doherty amplifiers when an electrical fault occurred. As part of the isolation procedure the switching system adjusted load impedances and re-routed signal paths as necessary to keep the station on the air while repairs were made to the isolated equipment.

On the control panel of each amplifier, a switch labeled "Automatic" or "Manual" set the operating mode of the isolation system for that unit. In the manual mode an operator had to initiate an isolation sequence, but in automatic, when an electrical problem occurred, the system removed that amplifier from the air without operator intervention. A two-position switch on the control panel set the time required to disconnect a specific unit. In the "Instantaneous" mode isolation procedures occurred immediately, but in the "Delayed" mode two interruptions within one minute were required to isolate an amplifier.

The isolation switch selected specific taps on the dual-impedance T network that fed the antenna in order to alter the load impedance presented to the amplifier output circuits. Under normal operating conditions the network presented an impedance between 50 and 60 ohms to the 500-kilowatt amplifier. When one of the Doherty amplifiers had been disconnected, however, the system readjusted the network and presented an impedance between 100 and 120 ohms for operating at 250 kilowatts. In the event that both amplifiers were isolated at the same time, the system would automatically connect the 50-kilowatt modulated driver to the transmission line through a separate network. Engineers only used this feature during initial adjustments and eventually removed it from the system. Although not used during the first year of broadcasting at 500-kilowatts, the feature that removed either of the Doherty amplifiers from service became a prominent part of the system during a period of financial instability at the station. During that time Weldon operated the station at 250-kilowatts as an economic measure and used the feature daily to alternate the amplifiers.

In addition to the preceding actions, the isolation switch performed the following functions in a single operation (Weldon, 18-20):

1. Disconnected the 18-kilovolt supply and grounded the high-voltage positive terminal of the isolated unit.
2. Disconnected the grid-drive lead and substituted resistance loading so that the driver-stage load remained unchanged.
3. Opened the 500-volt bias supply and grounded the 500-volt bias terminal of the isolated unit.
4. Opened the 1,200-volt bias supply and grounded the 1,200-volt bias terminal of the isolated unit.
5. Applied a short-circuit across the door switches of the isolated unit so that this unit could be entered without interrupting the plate and bias supplies to the other unit.

6. Applied a short-circuit across the filament time-delay circuit and the plate-interlock relay so that the filament voltage of that unit could be removed without interrupting the plate voltage supply to the other unit.

7. Applied plate voltage to the other unit when the isolating operation was complete.

When an electrical fault occurred, the time required for the isolation system to perform the preceding functions and return the operating portion of the transmitter to the air was less than two seconds. "The mechanism of this switching system is driven," Weldon wrote, "by the slow speed shaft of ratio-motors, one motor controlling the switching for each of the units. Interlocking prevents operation of the switch while the rectifier oil circuit breaker is closed and also prevents the circuit breaker closing while the isolation or re-connecting is in progress" (18).

The Cooling System

A system of porcelain pipes hung on the ceiling of the basement by stand-off insulators supplied distilled cooling water to the tubes in the amplifier on the floor above. In his paper Weldon described the hookup of the water system to the 320A tubes of the 500-kilowatt amplifier: "A two inch pipe brings water to the pair of 'Number 1' tubes with their jackets in parallel. Their outlet water passes through suitable lengths of porcelain pipe to the jackets of the 'Number 2' tubes and from them through 28 feet of porcelain to the outlet manifold" (19). Water circulated at a rate of sixty gallons per minute through each of the 320A tubes.

Weldon used coils of porcelain pipe to supply water for cooling the 848 and 863 tubes in the lower-power stages. A similar system using a one and one-half-inch diameter porcelain pipe supplied water, from the same source, to the 50-kilowatt driver. Each tube assembly had a water cutoff valve to interrupt the supply water and another valve to drain the water jacket when it was necessary to remove a tube.

Two 3,000-gallon cypress-wood tanks served as storage for the distilled water that circulated through the system. A 25-horsepower, 3,600-RPM centrifugal pump circulated the water through a closed loop that included all the water-cooled tubes and a heat exchanger. The hot raw water form the exchanger was cooled in a fifty-by-sixty-five-foot pond through a system of ten spray nozzles.

The Bias Supply

A power supply using six UV-872A rectifier tubes in a three-phase, half-wave, double Y connection supplied the bias for the Number 2 tubes of each amplifier. The system supplied 1,200 volts at 7.5 amperes. The motor-generator that supplied bias for the Number 1 tubes is described by Weldon in his paper as being "...separately excited so that in case of an arc over within one of the tubes, from plate to grid, the plate voltage will not cause reversal of the polarity of the machine [motor-generator]" (22). A standard single-phase, full-wave rectifier supplied the bias voltage for the 50-kilowatt modulated driver.

The 500-kilowatt Antenna

Until the fall of 1938, when the testing of the 500,000-watt amplifier began, all of the antennas used at the station were variations of a multi-wire flat-top system. When operation with the 500,000-watt amplifier began, brilliant corona would, at times, appear on the flat-top and over about 50 feet of the down leads. Weldon stated that the corona 'talked' so loud that you could hear the Doctor's voice on the main street in downtown Villa Acuna (Correspondence 27 May 1989). The corona caused audio distortion on modulation peaks greater than 75 percent, but both problems were corrected when Weldon installed the new antenna system for the 500-kilowatt transmitter. The new antenna had higher capacitance than the old one, which prevented corona from forming on the array.

A sixteen-wire tapered cage 36-feet in diameter at the top and 3-feet in diameter at the bottom constituted each element of the new antenna. Using a 1,000-cycle bridge, Weldon measured the capacitance-to-ground of the new system as being 2.6 times greater than the old one. With a 100-percent-modulated 540-kilowatt signal applied to the new array, no visible or audible corona was present on the system. Figure 12 is a photograph of XERA with the new cage antenna. Someone apparently tried to enhance the antenna wires, which were barely visible in the original picture; and although the enhancement is obviously poor, the photograph does show the general appearance of the 500,000-watt system.

In his paper on the transmitter Weldon describes the phasing and coupling equipment for the antennas as having inductors made of large-diameter copper tubing and supported by 10-inch stand-off insulators attached to each alternate turn. The resonating condensers were a series of air-insulated aluminum plates, two inches thick and five feet in diameter, similar to those used in the 180-kilowatt amplifier. The output of the transmitter was connected to the phasing equipment by a 75-ohm concentric transmission line made of a two-inch diameter copper inner conductor and a seven-inch diameter copper outer conductor. The line was sealed and kept at a constant air pressure of 20 psi. Under normal operating conditions, r-f current in the line measured approximately 83 amperes or slightly less than 520,000 watts. A three-conductor, unbalanced, open-wire line connected the phasing circuits of the reflector and the driven element.

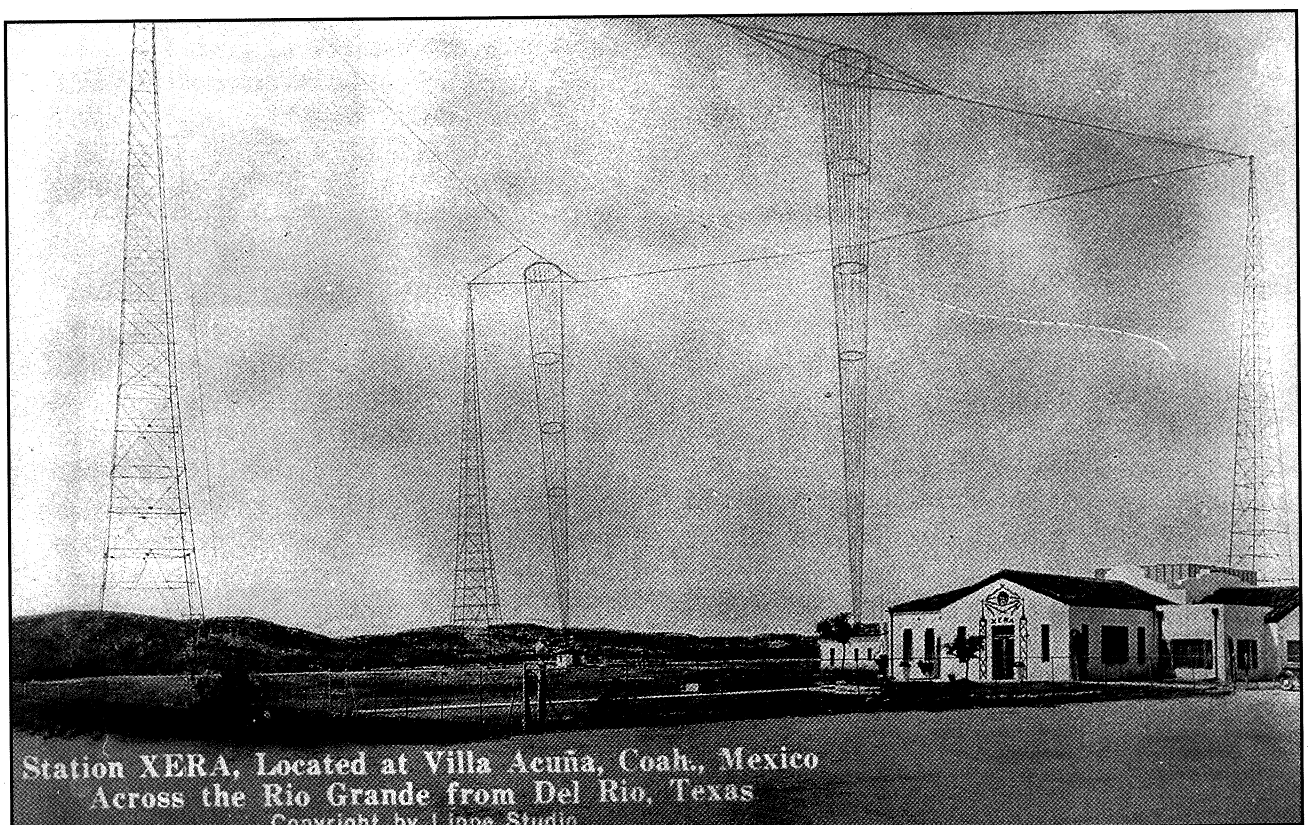

Figure 12. XERA with the cage antenna used with the 500-kw transmitter. The wires of the cage and flat-top, which were barely visible in the original picture, have been poorly enhanced by someone, but the photograph still shows the nature of the system.

While operating the station at 500,000 watts, engineers made field-strength measurements in the 180-degree maximum-signal area to the north of the transmitting site. In his paper on the transmitter, Weldon said that when converted to "fundamental strength" the measurements showed 6.65 volts at a distance of one mile. Additionally, he reported that this figure agreed closely with the predicted strength for 1,000,000 watts of power in an antenna one quarter wave high, and would be the expected strength from the directive system with a transmitter output power of slightly more than 500 kilowatts (28).

As described earlier, the ground system for the flattop antennas consisted of an array of parallel wires laid out on a grid. When the new antennas were installed, engineers overlaid the old system with a set of 120-half-wave radials spaced at three-degree intervals. They installed one such system under each element of the antenna and connected the two systems at points where the radial wires crossed.

Figure 13. XERA designer, James O. Weldon, next to one of the 250 kw Western Electric 320A tubes at his company, Continental Electronics, in Dallas.

Lightning Protection

The antenna and equipment was protected from lightning and other flashovers by a system described by Poppele, Cunningham, and Kishpaugh in their August 1936 paper published in the *Proceedings of the Institute of Radio Engineers*. They describe the protection system as "...a device which functions to remove the carrier for an instant succeeding a flashover in any part of the circuit" (1074). The detection part of the circuit depended on the grid and plate voltages, in the final amplifier, being proportional in magnitude but opposite in phase when the amplifier is in normal operation. To form the detector circuit, two reactors were connected between the grid and plate circuits and their common point connected, through a detector, to ground. With the reactance of each coil critically adjusted and the system operating normally, the output of the detector remained zero. When lightning or other flashovers occurred in the antenna system, however, the grid-to-plate phase and/or magnitude relationship became unbalanced and the detector output increased to a level that operated a relay. The relay removed the carrier by interrupting the plate supply voltage to a buffer amplifier just after the crystal oscillator. According to Poppele, "...plate voltage is restored after a delay of approximately a fourth of a second, which permits the arc to clear in the antenna system with an almost unnoticeable interruption of the program" (1074).

Overall Specifications

Table I lists the overall specifications for the XERA 500,000-watt system. It should be noted, however, that the second harmonic level of −72 db below the 500-kilowatt carrier was not satisfactory, and Weldon reported in his paper that the design would allow the use of several methods of reducing the level further. One such method, he said, would be the use of a quarter-wave concentric harmonic shunt connected in the matching network (28). Even though the value of the harmonic signal

Table 1. Overall Specifications for the XERA 500,000 Watt System

Plate Voltage on 320A final tubes:	18,000 volts
Plate current (no modulation):	45 amperes
Plate input power:	810,000 watts
Output power to antenna:	500,000 watts
Second harmonic:	−73 db below 500-kw carrier
Efficiency (Doherty amplifier only):	approx. 61%
Maximum power demand:	1,340,000 watts*
Overall station efficiency:	approx. 37%
Audio frequency response:	30-30,000 cycles plus or minus 1 db

*Using an integrating demand watt meter. Includes transmitter power, building lights, and loss on one mile of 11,000 volt power lines from the U.S. side of border.

remained above one millivolt at a distance of one mile, it caused no interference and engineers made no attempt to reduce it further. Measurements of other harmonics showed their levels to be well within good engineering practice.

Closing XERA

XERA operated at 500,000-watts until early summer 1941. Two years earlier Mexico had ratified the provisions of an international agreement with the United States that cleared the way for action against all controversial border broadcasters. In late spring 1941, the newly elected President of Mexico ordered the expropriation of XERA, saying that the station was controlled by foreigners and that it had transmitted "...news broadcasts unsuitable for the new world..." (Border Radio, 44). In early July *Federales* closed XERA.

In an attempt to revive the station, Dr. Brinkley flew to Mexico City for an ill-fated conference with the Mexican authorities. On his return trip to Del Rio, Brinkley suffered a heart attack from which he never fully recovered, and on July 21, 1941, Mexican authorities began dismantling XERA. During the next year his health continued to deteriorate, and on May 26, 1942, he had a second heart attack and died.

After removing the equipment from Brinkley's station, the Mexican authorities installed the XERA transmitter at station XEX in Mexico City. It is not known if the transmitter was ever put on the air or whether any portion of the station still exists. One of the Western Electric 320A final tubes, however, did find its way to Weldon's company, Continental Electronics, in Dallas and is currently on display in the lobby.

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The AN/APS-42 radar

By Frederick G. Suffield, P.E.

The AN/APS-42 radar was the first post-war airborne radar ordered by the military. It was initially procured by the Navy Bureau of Aeronautics in a combined development and production contract for 100 radars for Navy transport aircraft. The Air Force, after considering a procurement of another radar, decided to join forces with the Navy and transferred funds to BuAer. Later, the Coast Guard transferred funds to BuAer for a small quantity of the radar for its aircraft. The AN/APS-42 radar was intended for the transport-type aircraft such as the DC-4, DC-6 and C-97. The Air Force ended up with a much greater number than the Navy. The radar also went into the Strategic Air "Command Post" airplanes, C-97, at the request of General Curtis LeMay.

About the same time as the initial AN/APS-42 contract was issued, BuAer contracted with American Airlines for research in weather radars. Under this contract, a specially instrumented Convair 240 was flown into thunderstorms in an attempt to correlate radar observations with the actual weather (hail, turbulence and rainfall). One outcome of this research was the development of the "iso-echo contour circuitry," which was incorporated into the AN/APS-42. This permitted display of dangerous thunderstorms and the areas of most intense disturbances.

In theory, little new development was required for the AN/APS-42, thus permitting a combined development/production contract. In the real world, this theory was flawed, and the production schedule created enormous problems for the

Boeing KC-97L "Stratofreighter."

designers and the production people, e.g., the purchase of production quantities of critical and expensive components before the design was frozen and the complete radar was tested. The original specification weight of 140 pounds might have been met if the development had been done first and if the production ordering had not started until after complete testing. However, with the production schedule driving the program, there was no realistic chance that the final design would come close to the original specification weight.

The AN/APS-42 radar did make history. It was the first radar to be installed in presidential aircraft, the *Independence* for President Truman and the *Columbine* for President Eisenhower. Also, it was an important navigational device for aircraft using the Thule, Greenland, Navy base with its perpetual fog and storms, and perhaps most importantly, to help aircraft in the Berlin airlift get into Berlin despite Russian jammers and other attempts to break the airlift. News that the AN/APS-42 was helping to keep the Berlin airlift alive was a big morale lift for everyone who played a role in the development and production of the radar.

The initial contract was placed with the Houston Corporation, west Los Angeles, California, a company with no track record with the BuAer Procurement Agency as a production or development source. The major radar manufacturers were busy converting from war-time production to commercial products. The Houston Corporation had no radar experience and little electronic experience, and none of the engineers had a recognized position in radar design. The company was primarily a mechanical production place, not an electronic design or production house. The major products were automatic 16mm and 35mm film-processing equipment, machine shop subcontracts, and some injection-molded parts. During the latter part of WWII, the company had done some electroform components on a subcontract basis. The company was owned by H. H. Helbush, who had purchased it after WWII. The original designer of the film processing equipment, Hub Houston, was still with the company as chief designer.

A small group of local engineers, seeing the request for a bid for the radar, convinced the Houston Corporation to submit a bid, and the low, fixed-price bid won.

Some time after the award was made, BuAer assigned James W. Grodsky as project engineer. When the Air Force transferred funds to BuAer, Jack Limoli of AMC was assigned as the Air Force project engineer, and then Lt. Curt Kelley was assigned by the Coast Guard as its project officer.

The original specification, 16 R 75 (AER), was dated 1 Feb. 47. Subsequent revised issues were dated 3 May 48 and 15 Aug. 48, and finally were replaced with MIL-R-6987.

The rapidly mounting expenses due to labor charges and parts procurement, with little real results as to visible equipment, caused Helbush to question the activity. He had been receiving glowing accounts from his people, yet he had a feeling that things were not right, and since this contract was strictly production, without money for development, disaster appeared to be inevitable. He discussed this with Hub Houston, who suggested that the author of this paper, known to him from a wartime visit to the Los Angeles area, was doing consulting work and was possibly available. At their request, both Aubry Vose and I visited the facility and toured the plant, the laboratory and the production shop and viewed the work under way on radar-related items.

We could see some problems, and we mentioned them to Helbush, but we also noted that a more in-depth study was necessary. We suggested a six-week consulting contract to examine the work in detail and to establish the eventual production test plan and procedures. This would give us the access and ability to ask questions in detail throughout the plant.

We started work examining the initial design and final designs, as well as the procurement of components. In addition, we requested the production planning and production test plans, but they were never found.

After about two weeks, we went to see Helbush and suggested that he really did not need to fund the consulting contract for the full six weeks, as it was apparent that he had a real problem. This was explained in detail to him. His reaction was that he had suspected problems, and he wanted us to continue on and take charge of the program. It took a while to convince us to accept his offer, but after establishing several conditions, we accepted. First would be a more detailed study of the program status, and then a meeting with the Navy to "lay the factual cards upon the table." The exact status of the program was covered, as well as noting that the Navy had not visited the plant frequently enough to ascertain the real status of the program. At this meeting, the recovery plan was to be detailed. Several of the engineers were to be replaced with more capable persons. A revised monthly report was to be issued to the Navy, as the file copies of the existing reports were totally incorrect. Additional engineers with proven experience in radar design were to be added. Personnel with the experience in production test and quality control, as well as a writer for the required manual, were to be added.

Helbush agreed, and we started to work the following day.

Once the first changes within the engineering department at the plant were under way, the plan for the meeting in Washington was detailed. At the meeting in Washington, we very frankly outlined the problems, and we covered the steps planned to bring the program under control. It was stated that within six to nine months, redesigned equipment would be in the Type Test, and that the radar would meet the overall weight as well as the performance requirements.

The organizational changes were outlined. Several engineers were contacted, ones both Vose and I had worked with at Westinghouse, and job offers were made. The lure of California helped the task greatly!

As the Houston Corporation did not have the Type Test facilities (shock, vibration, altitude and temperature), preliminary arrangements were made to allow the use of the Type Test facilities at the Naval Electronics Laboratory at Point Loma in San Diego.

The team returned to California with a better feeling about the program and a full appreciation as to the magnitude of the task facing us. While we were in the East, Vose remained in the plant and coordinated the technical activities as well as redesigned the receiver.

An item that became the driver for the major change in the program management at the Houston Corporation was the total weight of the radar.

The specification 16R75(AER) called for a weight, installed, with shock mounts and cables, of a maximum of 140 pounds.

The estimated weight of the radar, if it had been completed using the design in progress, would have been about 300 pounds.

Very large, premature investments had been made in the procurement of transformers and chokes, and most had been received in the plant. However, the power supply designs were not complete as the circuits were still in a state of flux. Not only was the ordering premature, but the transformers were obtained from Los Angeles suppliers who had little knowledge of the low-weight, 400-cycle design necessary for airborne equipment. On top of that, all the items received were sealed-can designs with the added weight of the filling compound. A source for the all-important pulse transformer for the magnetron had yet to be located. Of all the transformer companies in the area, only one was interested in undertaking the pulse transformer, and all of its experience was in audio, door bell and neon sign items! Because of their willingness

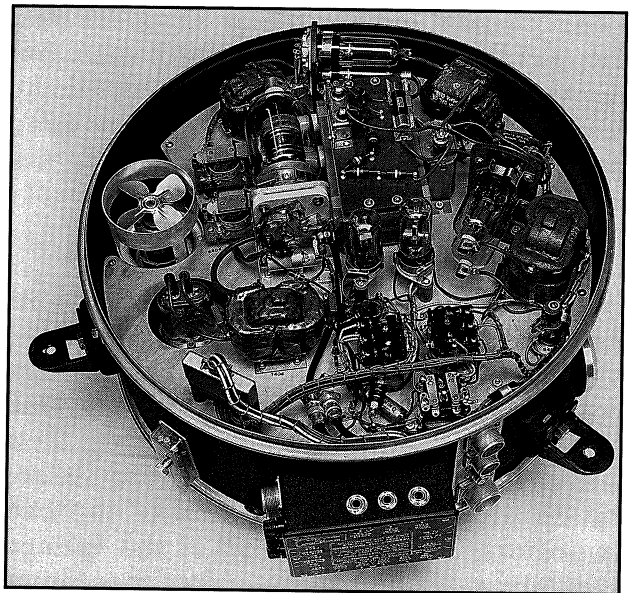

Photo 2. AN/APS-42 receiver-transmitter high-voltage side, showing the lightweight transformers.

to learn and because Vose worked with them day and night, the company's employees managed to learn how to make successful pulse transformers. Vose had to demonstrate the application of Type "C" cores and the use of Fosterite insulation.

Because the weight of the iron core items originally selected was about half of the total radar weight, and because the manufacturers would not take them back, all had to be scrapped.

For the stabilizing of the antenna, several items had been ordered and were in stock, but the actual design of the antenna system was still not complete. A stock of Bendix gyros and servo amplifiers existed, and due to the tremendous cost involved, every effort had to be directed toward using them to save the cost to the Houston Corporation should scrapping be the route selected.

The design for the deflection circuits for the Indicator and the rotating deflection coil for the 5-inch cathode-ray tube was not complete. Two sources were immediately contacted for the components, the D.E. Makepeace Company for the slip rings and John Howe for the insulated bearings, using pyrex glass balls and bronze races, items that he had developed for the Westinghouse during WWII.

Technical specifications

The AN/APS-42 radar operated at the 'X' band, ±55Mc. of 9,375Mc. It could also be set to receive radar beacons at 9,310Mc. The transmitting magnetron was the 2J55. Reception of both radar and beacon returns was via a 3db noise figure, 60Mc. pre-amp feeding the 60Mc. I.F. strip. Bandwidth could be switched from wide to narrow to match the transmitted pulse widths of 0.75 microsecond at 800 cycles per second, 2.25 microseconds at 300 cycles per second for beacon use, and 5.0 microseconds at 200 cycles per second for long-range search and weather detection. To maintain the dissipation of the magnetron within JAN-1A limits, the power input for the 5-microsecond pulse was slightly reduced. The antenna had a 360° scan and could be switched by a wiring change to cover a 240° sector scan, with the 120° sector scan selectable from the control unit. The scan rates were automatically selected to be 45° RPM for close-in scan and 15 RPM for long-range search. Power requirements for the

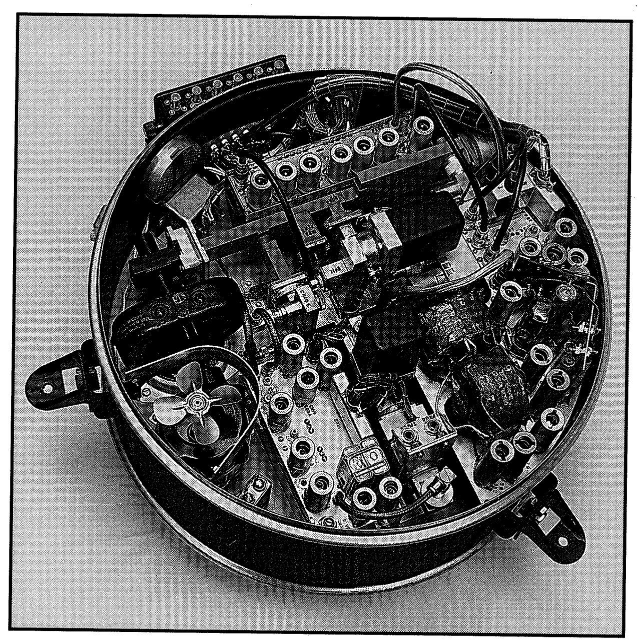

Photo 3. Receiver transmitter.

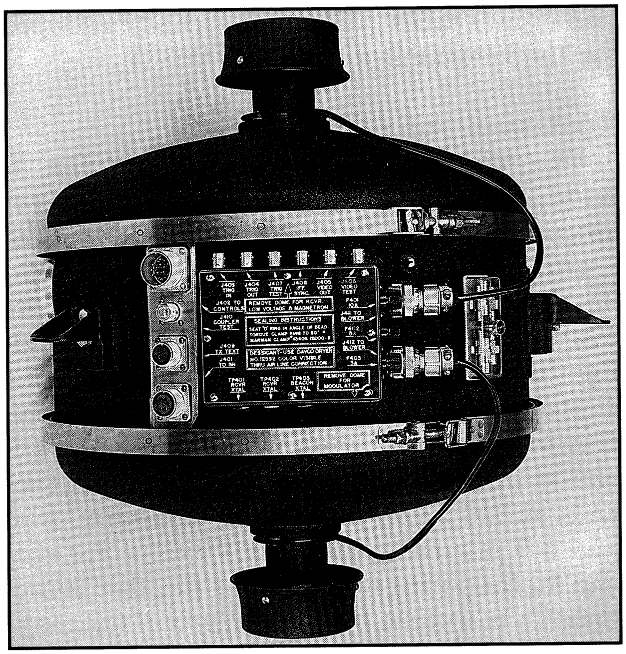

Photo 4. AN/APS-42 receiver-transmitter.

radar were single-phase, 400 cycles, 115 volts at 1.0 kilowatt, and 28 volts dc at 2 amperes for the control relays. Total weight was 173 pounds.

The major elements of the radar were:

• *Receiver-Transmitter-RT-156/APS-42*

This 24-inch diameter and 15-inch high cylindrical can held the pulse modulator, magnetron, waveguide duplexer, mixer and directional coupler, local oscillator Klystrons (one for radar frequency and one for beacon frequency), a beacon reference cavity, automatic frequency control chassis, 60Mc. pre-amp, power supply and control units and fuses and relays. Both sides of the chassis were usually visible for service.

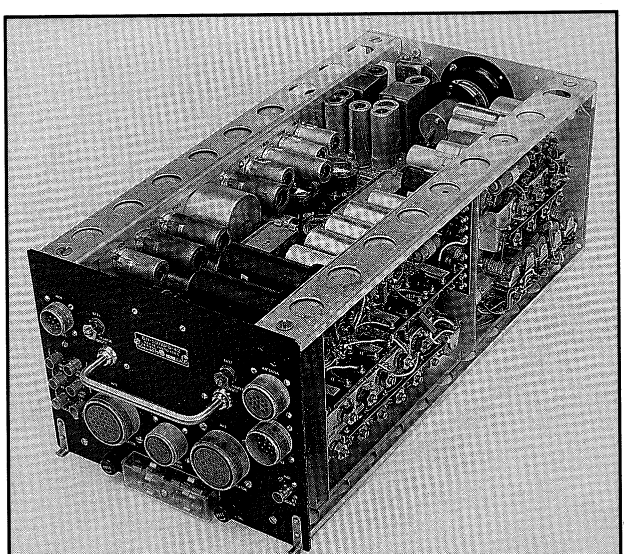

Photo 5. Synchronizer.

• *Synchronizer SN-59/APS-42*

This 20-inch by 10-inch by 7½-inch unit held the power supply elements for the lower voltages for all vacuum tubes, and had six compact plug-in sub-chasses as follows: One sub-chasis contained a 60Mc. I.F. strip. Two sub-chasses servo-amplifiers driving the rotating deflection coils in each of the two indicators. Another held all of the voltage regulating circuits, range-maker generators and the video mixers. One more sub-chassis contained the master trigger generator, the delay circuits and the sector control circuits. The last subchassis holds the sweep amplifiers, sweep driver and intensity gate circuits. A small axial flow blower supplied cooling air for the compact unit. The small subchassis allowed easy troubleshooting and repair.

• *Range Azimuth Indicator IP-35/APS-42*

This cylindrical housing, 6½-inch in diameter and 14 inches long, housed the 5-inch cathode-ray tube, a 5FP7, a video amplifier stage, a sealed high-voltage supply for the

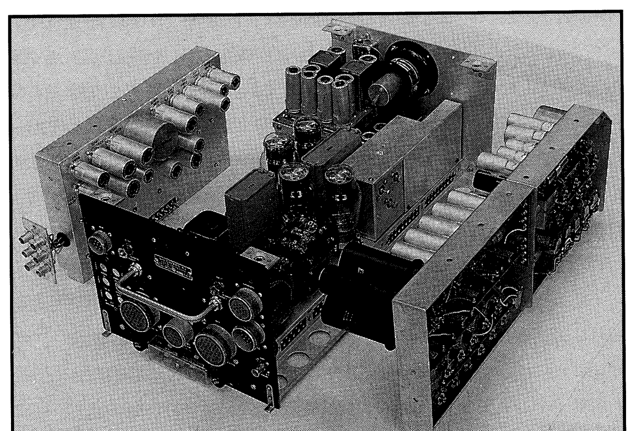

Photo 6. Designed for ease of manufacture and service.

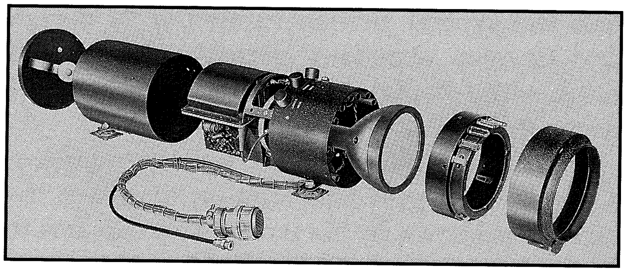

Photo 7. Range/azimuth indicator.

cathode-ray tube and indicator lamps showing the range markers being displayed. Two indicators went with each AN/APS-42, and either one or both could be operated, depending upon the aircraft installation.

Antenna AS-428/APS-42

This complex unit was designed to mount within the DC-4 nose radome, ahead of station 14, as well as in larger aircraft. The antenna scanned a 360° area at either 15 or 45 RPM, and by a simple wiring change—a selectable sector scan—the wiring change selected 120° or 240° sector. In addition, the control panel allowed tilting the reflector above or below the horizontal, selection of a pencil beam of about 5.5° or a fan-shaped beam giving nearly equal energy return for mapping and navigational aid. The antenna could be locked to the aircraft attitude in the vertical plane or stabilized via a self-contained gyro in the roll plane. A modification would allow roll and pitch stabilization within 1° up to 25°. The fan-shaped beam for mapping was generated by use of a reflecting surface contoured to produce the desired fan-shaped beam, and comprised of a series of stiff wire elements about ½-inch apart. This small, lightweight assembly was mounted on the antenna reflector, and beam changes to pencil from fan-shape were accomplished by rotating the reflector. With only a 90° rotation of the reflector, the beam changed shape to pencil beam with the wires now out of the phase with the microwave signal. The stabilization information is derived from the Electronic Control Amplifier AM-252/APS-42.

The control unit

The control unit provided the pilot the following:

RANGE	5,10,30,100,225, Time Delay, (Nautical Miles)
FUNCTION	Off, Standby, Search, Beacon, Weather
PATTERN	Pencil, Cosecant Squared (Obstacle-Mapping)
TUNING	Automatic, Manual
GAIN	Receiver Gain
STABILIZATION	On-Off
SCAN	Off, Sector, Full
TILT	Up-Down
TILT METER	Meter calibrated in tilt increments
SWEEP DELAY	Selection of any 30 nautical mile section
ANTI-CLUTTER	Off, FTC, FTC & IAGC (Fast Time Constant Instantaneous Automatic Gain Control
SENSITIVITY TIME CONTROL	On-Off

With the Berlin airlift starting, and with the increased world tension, the military believed that establishing a second source for the AN/APS-42 radar would be a good idea. The military selected the DuMont Company, and J. Hal Reid was selected as project engineer. He made several trips to the West Coast and proved to be a very competent engineer and very easy to get along with. However, after about six months, the lure of the West got to him, and he obtained a position with Convair in San Diego, where he also did an exceptional job. As

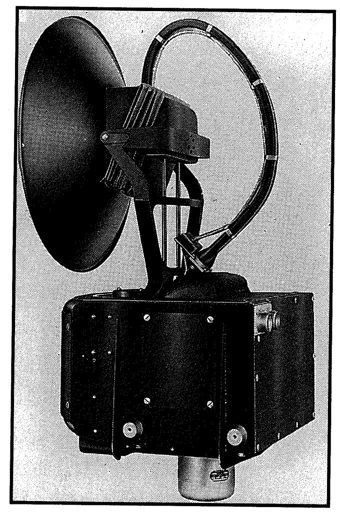

Photo 8. Antenna.

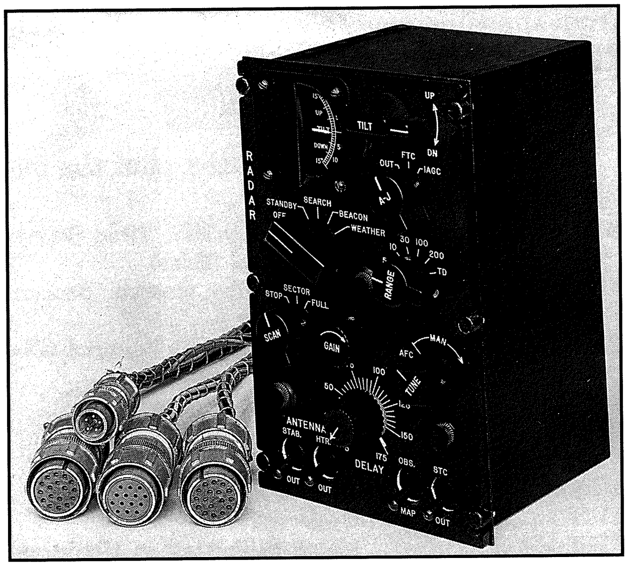

Photo 9. AN/APS-42 control unit.

further insurance, the military selected a third source, the Bendix Pacific Company in Van Nuys, California. It assigned Don Gehlke as project engineer, another fine man and a personal friend of mine. Again, there was excellent cooperation with the two sources.

The engineering team

As is true with so many details that get lost as they fade into history, the engineers who did so much to bring the AN/APS-42 radar to production are soon forgotten. Thus as part of the history, one must give credit to as many as one can recall.

Aubrey Vose, with whom I had worked since 1939 at the New York Worlds Fair in the Westinghouse exhibit, deserves the credit for the yeoman's job of shepherding the technical design through many problems.

John Alexander, who started as a lab technician with no microwave experience, not only used hard work and his exceptional ability to observe and solve problems in the microwave mixer and duplexer, but he designed, set up, and operated an antenna range with pattern recording equipment. With that, he designed the antenna reflector that gave an excellent Csc2 pattern. He moved to TRW Systems, where he has done an outstanding job.

Maurice Franco, an engineer from England, had the typical British capability to design and develop excellent circuits, and he did much of the display area. He went to Lockheed Aircraft Co.

Don Lanctot was another British engineer, a mechanical specialist and an excellent designer, as shown by his many contributions to the antenna stabilization system.

John Love brought a large measure of stability to the reliability portion of the mechanical designs as well as the general structure.

Clare Monroe joined us from Westinghouse, where Vose and I had many years of close familiarity with his capability both in design as well as technical personnel management. He did his usual great job.

Ed Smuckler was one of the original Houston engineers who we retained, and he handled much of the technical documentation and some of the circuit design. He was a prime interface with Frank Lyon in the maintenance Manual work. He moved to TRW Systems and, sadly, passed away before I could contact him relative to his recollections of the program. A very good man and a fine person.

Herbert Kroft came from Westinghouse in the East and established the Quality Control

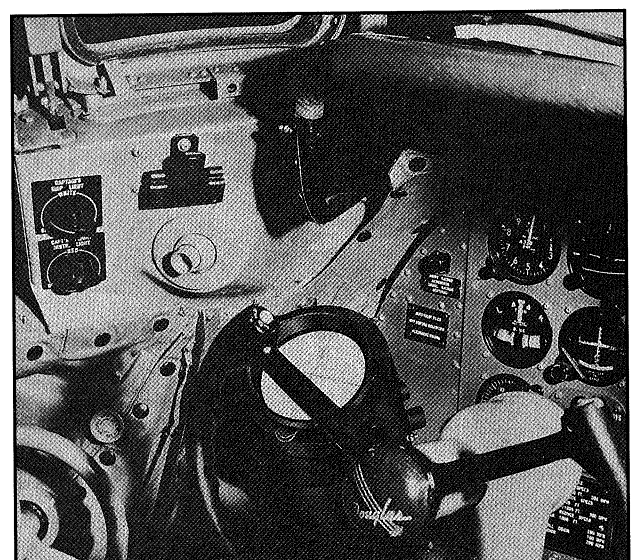

Photo 10. AN/APS-42 indicator in cockpit.

Continued on page 56

1995 RCA Banquet and 86th Anniversary Dinner

By Jane Bryant, *Proceedings* Editor

The Radio Club of America Banquet and Annual Awards Presentation on Nov. 17, 1995, at the New York Athletic Club was highlighted by guest speaker Marchesa Elettra Marconi, Princess Giovanelli, daughter of Guglielmo Marconi. She talked about memories of her father, including how well-known and respected he was throughout the world. "His dream was to cross the Atlantic with his invention—wireless," she said. The full text of her speech follows on page 34.

On the awards side of the event, 26 members were elevated to the grade of Fellow. Michael C. Trahos served as the respondent for the new Fellows. His response appears on page 38. Other award recipients include Jai P. Bhagat, the Sarnoff Citation; Carl E. Smith, the Jack Poppele Broadcast Award; Max C. DeHenseler, the Ralph Batcher Award; Edward Dervishian, the Lee de Forest Award; David E. Weisman, the Special Services Award; Archibald Doty, Jr., the Barry Goldwater Amateur Radio Award; and Gilbert R. Houck, the President's Award.

At the Technical Symposium, moderated by Ray Trott, Club members heard presentations from Ray Minichiello on the technical achievements of Marconi; Lauren McQueen on the receipt of an honorary degree from the Popov Scientific Society in St. Petersburg, Russia; Durell M. Roth on the history of radio station XERA—see related article on page 00; and Bruce Kelly on the 1BCG Revival.

Our complete Banquet and Awards coverage follows.

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86th ANNIVERSARY DINNER
&
AWARDS PRESENTATION
NOVEMBER 17, 1995


The Radio Club of America
1909
19

Commemorating the 100th Anniversary of Marconi's First Wireless Communication

By Princess Elettra Marconi Giovanelli

The following is the text of the banquet's keynote speech.

I was so looking forward to meeting you. I am here with my son, Prince Guglielmo, and I am very moved and very happy. I would like to speak with each of you personally.

My name is Elettra. My father called his yacht, his beautiful yacht, *Elettra,* for the electric waves. Then he made his experiments aboard the yacht. He loved the sea. He loved his yacht. And when I was born, he called me Elettra like his yacht.

So I am very happy to have this name, because, like my father, I love the sea, and I remember with my name my father and his experiments 'til the last day of his life.

This year, as we all know, is the centenary of my father's invention. He was 21. He started at 16 when he heard of the existence of electric waves, the

At the conclusion of Princess Giovanelli's speech, Raymond Minichiello, P.E. (M), presented her with a plaque enscribed as follows: "Radio Club of America. Presented to Princess Elettra Marconi Giovanelli, commemorating the 100th anniversary of the first transmission of a wireless signal by Guglielmo Marconi, father of wireless. 86th anniversary banquet, New York, New York, Nov. 17, 1995."

Hertzian waves. He had this inspiration that he would use them to communicate, to transmit without wires.

He started alone on books. He followed lectures, but he always was alone, by himself, in his villa Grifone, and there he succeeded. Only his mother believed in him. He was very strong will-powered.

He sent his brother, Alfonso, and a peasant, and said, "If you hear the signal across the hill, you shoot the gun." And he heard the shot of the gun, and the whole world heard it, because the radio, the wireless, started at that moment.

He went to England because, as you know, Italy didn't understand. With his mother, my wonderful grandmother, Anne Jameson, they went to London. The head of the post office, Sir William Priest, said, "Stay with us, young man. Your invention is very useful for England and for all the Commonwealth."

He made many experiments and transmissions, always at longer distances. His dream was to cross the Atlantic with his transmission, wireless. He chose Cornwall. Cornwall is the first place where I went with my son, Guglielmo, in January this year. There, the people remember my father and treasure his memory. They have lots of pieces of his radio station where he built in Poldhu. And this wonderful atmosphere.

From Cornwall, we went to India, to New Delhi. There, too, they gave me a very warm welcome. They knew everything about my father, even better than in other countries sometimes. I was very surprised.

Then I went to Belgium, to Brussels. They have a great admiration for my father, too.

Then to Canada. It was the first time I went to Canada, and I fell in love with Canada. They say, "Marconi, he invented the radio here in our country, Canada, because he received for the first time the signal across the Atlantic, and he was there. He was in Newfoundland." Through the balloons and then the kites, his antenna received the message from Poldhu, from Cornwall.

I really loved all the people there because, for them, Marconi, Cape Breton, became important. So many people worked in the radio stations of Cable Head, of the Marconi towers. The country was transformed from the farming—there was just fields—to industries, so it became quite rich.

My father was quite grateful to Canada, because Canada helped him even financially. Well, he had already founded the Marconi Company in England, and then he founded another Marconi Company in Canada. The Canadian government helped him because they wanted him to develop radio and to give the possibility to such an isolated country like Canada to have the possibility of transmitting with radio and also for the ship at sea.

Then, Ireland. We went to Ireland. There was the same ship. A beautiful ship, an Italian ship, who, from Canada, went to Clifton, with a beautiful exhibition on board of wireless sets, photographs and the story of my father. They gave me also a very warm welcome, the Irish. They said, "Oh, he is Irish. He would have never invented the radio if he hadn't Irish blood." So I felt very happy, very proud, because I know that my grandmother, she helped him morally so much. I think it is quite right.

Then I went with my son to London, and then I went alone to Brazil, because there as the experiment of my father who lit up the lights of the statue of Jesus Christ of the Corcovado mountain from the villa Condotti in Rome. It's our house in Rome.

Guglielmo, my son, repeated the experiment. He pushed the key, and with electric waves, he lit up the lights on top of the Corcovado. And I was in Rio de Janeiro. Everything worked out beautifully. The people there were so loving. They admired my father so much, and they were so wonderful with me. Brazil has been very generous.

Then we went together to Sri Lanka. There was another ship. It was another Italian ship, with a beautiful exhibition on board. And the Singalese have been very enthusiastic about my father.

After that to Singapore, who is being very important. They remember my father in Sri Lanka and also in Singapore. He went with my mother in 1933 when they went round the world. Singapore, my father was always saying to my mother, it was the most important. It would have been a great development of telecommunication for the future. It is true, because I found Singapore really strong with radio and telecommunication. They remember his lecture that he made in 1933, and they said that it was a wonderful lecture at the university.

After that, we went to Australia, Sydney, and I wish to remember that in 1930, my father, from the yacht *Elettra,* on board, he pressed the key. The electric waves lit up the lights of Sydney's town hall. My mother was close to him, and he heard from the other side the voice of Mr. Fiske, who said, "All right, wonderful." It was 11 o'clock in the morning in Italy, and it was eight o'clock at night. All the lights were on. It was marvelous. We went to Australia. We saw all of our Australian friends that we love very much. We have been five times in Australia, and it has always been very exciting for me and for my son, Guglielmo.

There was also very important Marconi Club that there are 17,000 members. It is the most important club in Sydney. There is a soccer team who is called Marconi Soccer Team, and it wins all the time.

Then we stopped in New Zealand in Auckland. They gave us a wonderful welcome. They remembered very well when I went with my mother on board of the big liner *Guglielmo Marconi.* My mother was the godmother of the ship. We went round the world. It was—it went from Italy to Australia. It was a great success.

Then we went to Argentina, to Buenos Aires. There to South America, that so enormous distances, that they all loved my father.

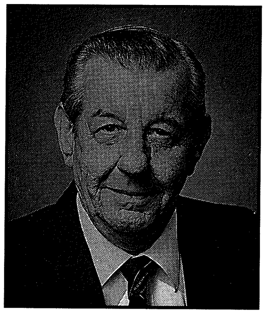
Then from there we went to London because there was the issue of the beautiful stamp at the Royal Post Office. We had a wonderful time with all the people that had known my father, remembered my father, and after that he, in all the hearts of the people who had so much benefits from him because they always remembered that all of his experiments and his invention, the radio, the development of the radio, he aimed always because he wanted to save people at sea, he wanted to save the human lives. He wanted to improve the life of everybody.

Now I would like to remember my beautiful mother, that she left us one year ago. Her wish has always been to publish her memoirs because she wrote a diary when my father was alive to remember the places where they were visiting and so his experiments on board of the yacht *Elettra*. She wanted to write them, and she wanted to be present, but now she gave me the responsibility to have them published before in Italian, because she wrote in Italian. The preface will be by Nobel prize-winner Carlo Rubbia, who was, like my father, the winner of a Nobel prize in 1909.

And then I will have now the responsibility to have it translated in English. So I will come and present it here in New York, of course, because my mother wanted me very much to have it in English because my father worked all the time in English-speaking countries. He crossed the Atlantic 87 times, always by sea, and always for his work. The last time was

Continued on page 39

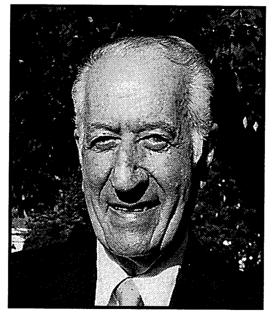
HONORS AND AWARDS 1995



THE PRESIDENT'S AWARD

Gilbert R. Houck

Awarded in appreciation for outstanding service to the Radio Club of America, Inc.



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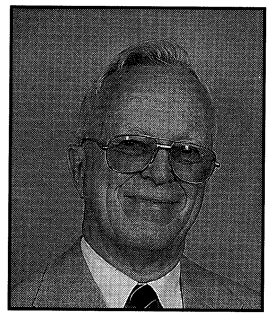
Edward Dervishian, P.E.

Awarded in recognition of his support of the de Forest Pioneers and his significant contributions to the advancement of radio communications.

THE SPECIAL SERVICES AWARD

David E. Weisman, Esq.

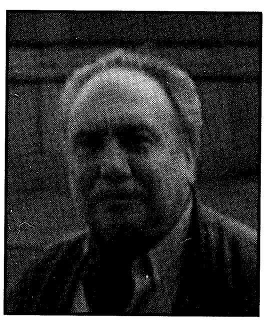
Awarded for devoted attention and legal assistance to the Radio Club of America, Inc.



THE BARRY M. GOLDWATER AWARD

Archibald C. Doty, Jr.

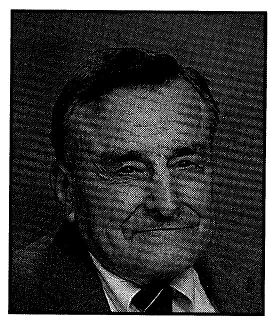
Awarded for intensive study of amateur radio antenna systems.



THE RALPH BATCHER MEMORIAL AWARD

Max C. deHenseler, Sc.D.

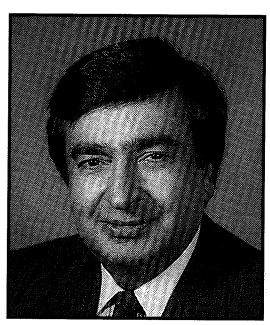
Awarded for dedication to worldwide radio and television history.



THE JACK POPPELE BROADCAST AWARD

Carl E. Smith, P.E.

Awarded for pioneer contributions to the design of broadcast antenna systems.



THE SARNOFF CITATION

Jai P. Bhagat, P.E.

Awarded for major contributions to the advancement of mobile telecommunications.

Response for Fellows

By Michael C. Trahos, D.O., N.C.E., C.E.T.

President Morissey, Princess Marconi-Giovanelli, ladies and gentlemen, good evening. It is with great honor that I stand before you as the respondent for the 1995 Fellows of the Radio Club of America.

The 1995 Fellows represent a broad diversity of the telecommunications field. This diversification exists because of the deep foundation established by the long-standing members of this society and for which stretches back on and beyond the first consolidated 1938 rules and regulations of the Federal Communications Commission (FCC).

Shortly after the enactment of the Communications Act of 1934, the FCC adopted its first 14 parts of the then new Title 47 of the Code of Federal Regulations. This society played a major role in the nurturing and development of these various new radio services, which included the Standard (Part 3) and Non-Standard (Part 4) Broadcast, Experimental Radio (Part 5), Fixed Public Radio (Part 6), Coastal Radio (Part 7), Ship Radio with Telegraphy (Part 8), Aviation (Part 9), Emergency Radio (public safety) (Part 10), Miscellaneous Radio (non-public safety and commercial) (Part 11), Amateur Radio (Part 12) and Commercial Radio Operator (Part 13) Services. As a physician and telecommunications specialist dealing with the rendition and delivery of medical and emergency services, I say that this society's foundation and contributions are no better exemplified than in the public safety sector.

All of you can recall that fateful day in Oklahoma City, Oklahoma, when the federal building was destroyed by an act of senseless violence. With the photographs and news coverage that emerged from the disaster scene, our hearts went out to the victims and their families.

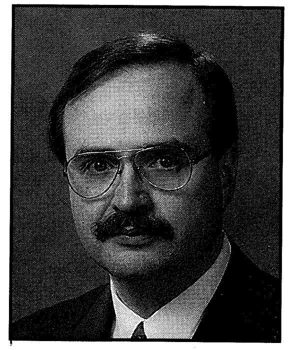
Many within this society, I am sure, felt helpless and wondered what they could do for these victims. But in truth, if it were not for the members of this society, in conjunction with industry and the FCC, many of the victims that did survive the devastation may not have.

When the Oklahoma blast occurred, the city's disaster response network went into effect. The command and control functions where totally dependent on the elaborate communications infrastructure already in place. That communications infrastructure, in reality, exists as the direct result of the cumulative hard work and ingenuity of the membership of this society and industry, ranging from the time of Guglielmo Marconi's first wireless transmission to today's development and implementation of the digital communications technology.

Yes, we were all saddened by the lives that were lost. But this society should be proud of the lives that were saved in this, as well as many other past, present, and future disasters yet to come. For it is this society, through its members' small and large evolutionary contributions to radio, that was instrumental in helping to save the lives and shorten the suffering of the many victims of the Oklahoma City bombing and have made the prompt delivery and rendition of emergency and medical services to the American public the best of all nations.

The 1995 Fellows hereby gratefully accept the honor this society bestows upon us this evening. We do this with our sincerest gratitude. And it is with enormous dignity and respect that we proudly stand on the shoulders of the greats of radio, you the membership, with the intent of not only continuing this organization's legacy, but with the desire of making the Radio Club of America the most renowned radio communications society in the world.

Thank you.



Michael C. Trahos, D.O., N.C.E., C.E.T. is a member of the National Association of Radio & Telecommunications Engineers, the American Society of Certified Engineering Technicians, APCO and REACT.

Marconi...continued from page 36

when he went round the world. He came back from the other side.

This is the book. This is a beautiful photograph of my father and my mother. Then there will be many photographs inside that nobody has seen yet. And then also manuscripts and also letters that my father wrote to my mother. There was a great love. They never left each other. My mother, she remained 57 years a widow. She was beautiful, but she never wanted to marry again because she was so much in love with my father.

This is all I have in my heart now. I am sure that you will help me even to find the right editor because I think that here in America in New York is the best place in the world. So I will come back again with my son Guglielmo, and we shall be very close to each other like my father was always close to the Radio Club.

I am sure that many who have been members were friends of my father. When he was coming here, he was speaking at a banquet like tonight. I have photographs of him speaking at these banquets. So he is with us, my father, tonight.

XERA...continued from page 22

Munal, H.L. Letter to Dr. Brinkley. 10 October, 1932. Author's collection.

Munal, H.L. Letter to Dr. Brinkley. 25 April, 1932. Author's collection.

Munal, H.L. Letter to J.W. Adamson. 7 October, 1932. Author's collection.

Nixon, Ruby. Personal video tape interview. 19 April 1990. Author's collection.

Poppele, J.R., Cunningham, F.W., and Kishpaugh, A.W. "Design and Equipment of a Fifty-kilowatt Broadcast Station for WOR." *Proceedings of the Institute of Radio Engineers* 24.8 (1936) 1063-1081.

Resler, Ansel Harlan. *The Impact of John R.*

Continued on page 63

Grants-In-Aid Committee report

By Kenneth M. Miller

On Nov. 17, 1995, the board of directors approved the Grants-In-Aid (GIA) committee's recommendation to establish 13 financial aid grants totaling $11,500 to 10 organizations.

The source of these funds is the interest earned from the investment of more than $150,000 in our GIA capital pool.

The club's constitution states that the club shall provide a scholarship fund for needy and worthy students pursuing the study of radio communications. And once again we carefully reviewed the requests for financial aid as provided for in the club's constitution.

In fulfillment of this objective, grants were approved for the following 10 organizations:

From the GIA General fund to: Southern Methodist, Capital College, Polytech University, Steven's Institute of Technology, Virginia Polytechnic Institute, Georgia Institute of Technology and the Embry-Riddle University.

From the Poppele, Grebe and General GIA Funds to: the Foundation for Amateur Radio.

From the Poppele Fund to: the Ranken Technical College.

From the Finch Fund to: the University of Cincinnati.

Each of these 10 organizations has in place procedures to award 100% of our grants to individual specific college students in need of financial assistance in paying their tuition.

We give special recognition to the generous donations provided by the family of Jack Poppele who have contributed thousands of dollars to our Grants-In-Aid program, spanning many years, in memory of their father, Jack Poppele.

In addition, special recognition goes to the Celwave Division of Radio Frequency Systems, Marlboro, New Jersey, a large manufacturer of communications antennas. For the past four years, Celwave has sponsored athletic activities at the International Wireless Communications Expo (IWCE) in Las Vegas, Nevada, with the proceeds being donated to our club's GIA program in the amount of $6,831, including $2,000 in 1995. These contributions and those of many others are what have made this program one of the finest and most successful in the electronics industry.

The year 1995 proved to be another successful year for this important activity in our organization. As a result, the total dollar amount of our grants to those organizations that will receive our financial aid assistance in 1996 will exceed the grants provided for last year.

Kenneth M. Miller (LF), K6IR, is a club director and chairman of the Grants-In-Aid Committee.

Squelch

By John E. Balint

... a poor player
That struts and frets his hour upon the stage
And then is heard no more ...
Macbeth

Before all we "poor players" in the development of mobile radio exit the stage, it might be good for one of us to tell the story of its birth and early development.

What Finch was to facsimile, DuMont to the oscilloscope and television, Fred M. Link was to mobile radio—or "Police Radio" as it was known in the beginning.

When I went to work for Link Radio in the spring of 1937, I was employee number 13. We shared the fourth floor of a loft in downtown New York on 17th Street near 6th Avenue with William P. Lear. Lear had an obsession with providing small aircraft with radio transmitters that would fit into the standard aircraft instrument opening.

Link had just bought the Bosch police radio receiver rights, and we were making shortwave receivers—just above the broadcast band. There was no "production line" as such. Some of the boys made some chassis using a small shear, a 4-foot brake and a kick punch for socket holes. That was our "machine shop." The chassis were sent out for plating, and when they came back, several of us were given a schematic, and we wired the sets one at a time. A back corner with a large fan was the "paint booth" where the outer wraparound was painted.

While this was our "product," there were a number of other jobs going on that Link rounded up for immediate cash flow. (I heard that just before I came to work, the boys were sent out to find home-radio repair jobs to bring in some cash. I knew the route well, having rung many doorbells myself!)

Of the other 12 employees, I remember only a few. There was Fred Budelman who was the chief engineer and the genius who gave us the technical guidance for the contributions that we made to the radio art. William Fingerle Jr. had recently graduated from M.I.T., but he knew how to work with his hands, too. Paul Wandelt (W2AU) was our resident comic who specialized in practical jokes. He also turned out mobile transmitters when he wasn't curing warts by having the unsuspecting "patient" place the wart against a rat-tail file plugged into the transmitter antenna socket while Paul keyed the transmitter on from the mike held behind his back! It worked, too! Herby Schiezel was reputed to be the fastest wireman in New York. Fred Mielchen was our "metal shop." There was Robert C. Ferrar, with whom I had gone to school and who had gotten me the job. He left Link soon after and went to I.T.T. After the war, they sent him to Japan to reorganize the Japanese electronics industry. He certainly did a bang-up job! Then there was Billy Wu, who wandered in and out during his masters studies at M.I.T. He was the son of the then-mayor of Shanghai and later Chang Kai Shek's foreign minister. Billy was known many years later as a principal at Panoramics. During his brief sojourn with us, he made many valuable contributions to the art of FM communications. Billy was primarily a theoretician, and I was a pragmatist. We became good friends, and he often took me to good Chinese restaurants where he ordered, and we argued as we ate.

I remember the first time when he taught me to use chopsticks, I was so engrossed in our discussion while eating that I didn't notice my hand. At the end of the meal, my hand was so cramped from the unaccustomed use that I thought it would fall off!

Townsend W. McCoun was dabbling with large coils and fixed capacitors in a back room. He later designed most of the early carrier current equipment for General Electric. Mac had a great sense of humor, and it was a riot to hear him tell how he had knocked down our mayor La Guardia three times. Mac was long and lanky, and La Guardia was built like a bowling ball and was always rushing in and out of buildings. On three occasions, Mac happened to be in the way, and I never did understand why Mac was not the one to be bowled over!

Jobs were scarce during the depression of the thirties, and I was working as fast and as carefully as I could to keep mine. One day, while I thought I was doing pretty well, I noticed two figures marching toward me—Fred Link with Fred Budelman behind him. There was a quality to their gait that telegraphed trouble. As they came nearer, Fred Link stuck out an accusing finger at me and asked, "Can you type?" I managed to stammer an affirmative. (I had done a lot of translation work and typed fairly well.) It seemed that a quotation had to be placed in the mail that day, and there was too much for our secretary, "Snooky," to handle alone. Either my typing was very automatic or the recuperative powers of youth allowed me to stop shaking enough to help.

When my friend Bob Ferrar decided to go to I.T.T., I inherited a job he had been working on. Link had a subcontract from Lear to build the transmitter that was to go on the largest flying boat ever made that the Glen Martin plant in Baltimore was building for the Russians. During the next six months, I was finishing up the transmitter and going on all the test flights on Chesapeake Bay. The first time the plane flew was the first time I had been in the air, too!

During the winter of 1937, Fred Budelman had designed a receiver for the 30 to 40 Mc band that didn't have much sensitivity but was starting to use these higher frequencies. It was a companion to the 15-watt AM mobile transmitter that was among the first two-way police radios. He was also experimenting with a super-regenerative receiver that promised to have much more sensitivity if it could be made to work at these "high" frequencies.

(Frequencies will be referred to as Mc [megacycles] and Kc [kilocycles]; to refer to them as hertz would be an anachronism.)

Early in 1938, the FCC was beginning to wonder about the frequency stability of these new "police radio" transmitters. They asked Link if we could design a frequency measuring device that would be simple to use and inexpensive enough for them to mandate. Budelman had an idea of using a crystal oscillator on a subharmonic of the transmitter frequency and a variable oscillator that could be calibrated against the crystal and measure the transmitter frequency by beating against it. He outlined the idea and possible shape of the device to me, and I designed the meter using the components and tools at hand. It worked so well that the FCC ruled that all transmitters had to be checked at least twice yearly.

It must be remembered that "crystal control" in those days depended on crystals that were individually ground for each circuit, and there was little guarantee that they would hold frequency. Each time we had a new application, Miller came over from New Jersey with his block of glass, bag of fine valve-grinding compound and bottle of carbon tetrachloride and ground a crystal in the set in which it was to be used.

The radio engineer for the Atlantic City police department was named Joe Dempsey (how can one forget the name!), and Joe was a reserve officer at Fort Monmouth. The Signal Corps at the Fort was experimenting with radio echo at over 100 Mc but had no way of accurately measuring frequency. They "guestimated" with Lecher wires. Joe took his Link frequency meter out to Sandy Hook where the super-secret experiments were held and found that our variable oscillator had enough harmonics to be very usable at these frequencies. I remember the trip to Sandy Hook by motorboat and the stacks of Yagi antennas and rings of paralleled "acorn" tubes that were the only active elements for higher frequencies in those days. That is how our Link Police Frequency Meter became the standard radar frequency meters BC438 and BC439 during the war.

I know that we had radar at Pearl Harbor because during the September preceding the attack in December of 1941, I worked over the Labor Day weekend to calibrate twenty-five frequency meters while a pilot sat in the lobby waiting to fly them to San Francisco and then to Hawaii.

A group of us used to go out to lunch together. While returning to work one day, I think I had the greatest thrill of my professional career. Budelman asked me, "How would you like to do some real pioneering work? Quasi-optic rays! Thirty megacycles!" That is how I got into two-way radio! (Yes, *Reference Data for Radio Engineers* or the "I.T.T. Bible," as we called it, in its first edition of 1943, refers to the frequencies around 30 to 50 megacycles as "Quasi-Optic Region.")

I moved into my "cage," a screen room that had been built into one corner of the front room of the loft. I could not have foreseen that it would be my "home" for most of the war until the whole building was taken over by Link Radio, and the engineering as well as the executive departments were moved up to the fifth floor, and I got a new screen room in 1944.

The super-regenerative receiver was our immediate task. It had a detector, a stage of audio amplification, a relay amplifier tube and an audio output stage. The super-regen generates a loud hiss, like the FM inter-carrier noise, that is silenced when a carrier is received. To provide silencing when no signal was present, the higher frequencies of the hiss were rectified and integrated over a five-second period in what I called a "rubber-band" circuit. A double diode tube rectified the noise and, when a threshold voltage was reached, a triode operated a relay to disconnect the loudspeaker. The moment of silence when a carrier was received, caused the "rubber-band" to instantly reset, as it did during the silences between syllables in the speech message, to hold the relay tube cut off and the loudspeaker on. The five-second time was set by a slider resistor in each receiver.

Almost all of the apartments in New York City were heated with steam radiators. The radiators were equipped with venting valves that would release the cold air in the pipes each time the steam was fired up. The valves emitted a hiss just like the super-regen receivers. After a day of receiver testing and slider resistor setting, when I went home at night and the radiator started to vent, I would automatically count "one and, two and, three ..." until I realized I was no longer at work adjusting the slider resistors for five seconds!

The super-regen receivers worked quite well up to about 32 Mc, but it was a real effort to get them up higher. With the tubes we had to work with, "picking up dimes with boxing gloves" was an apt metaphor. I did manage to get the receivers working up to 39 Mc, but it was by selecting components—quite a practical procedure considering that we didn't sell that many, and I think my salary by then was up to $17 a week!

Some time during the winter of 1938, we had a visit from a tall lean man in a long black overcoat, black suit, white shirt with a string tie and steel-rimmed glasses. He was an electrical engineering professor from Connecticut State College and had been commissioned by the Connecticut State Police to explore the possibilities of a state-wide police radio system. The man was Dan Noble. He had some discussion with his academic colleague, Major Armstrong, at Columbia University, and they thought that frequency modulation would have some advantages. He naturally came to us as the best designer of mobile two-way radios. There were many conferences and a flood of letters from Dan Noble to Fred Budelman. I remember when Fred got a letter from Dan one day, he remarked, "He pitches, and I keep batting them down!"

Soon Fred and Bill Fingerle were off in a corner breadboarding an FM transmitter that had a crystal oscillator, two phase-shift amplifiers and an audio amplifier to make a phase-shift modulator that could be multiplied up in frequency to get 15 Kc swing at full modulation. At the same time, Billy Wu was breadboarding a receiver with a Foster-Seely discriminator, a circuit known for some time and the detector that Armstrong was using. When it looked like the breadboard would work, I was given the receiver to whip into shape by making a producible unit. The receiver was a double-superheterodyne with a first intermediate frequency of 5 Mc and a second of 456 Kc. Both oscillators were crystal-controlled with the first crystal on a subharmonic of the signal frequency (minus 5 Kc) and the second on 4544 Kc. There were two limiters on 456 Kc followed by the double-diode discriminator and audio amplifiers.

With the amount of gain we had in the receiver, the intercarrier hiss was just as much of a problem as with the super-regen receivers. But now we had a limiter grid current to work with, and we didn't have to integrate the noise for more than half a second or so to silence the receiver. It was also evident that we needed a variable control to disable the silencing and allow reception in weak-signal areas. While previous receivers had just a volume control and on-off switch on the control unit, we had another control for the intercarrier noise suppression. Engraving the word "Volume" over a knob was no problem, but what to call the other control? Fred Budelman called several of us into his office and pointed out that it was not practical to engrave "Intercarrier Noise Control" over a knob, and we needed a good label. I immediately suggested the word "squelch." This came quite naturally considering I had been listening to that awful hiss for a couple of years by then! The word stuck, and I must admit that I still feel a sense of pride when I see "my word" in taxicabs in Hong Kong, Singapore, New Delhi, etc., not to mention its applicable definition in *Webster's Unabridged Dictionary*!

About this time, Sylvania had introduced its "Loctal" tubes. They were a glass tube with a metal base that had a metal center pin with an indentation around the bottom that mated with a spring-loaded ridge on the socket. The metal base had small openings around each thin wire element pin. This construction provided excellent base shielding, lower socket capacitance and allowed greater gain at higher frequencies than the heavy-pinned metal tubes in common use. Our first FM units were built with the Loctal tubes. As Sylvania created new tube types, it gave them to us to test. When I saw Fred Budelman coming toward my screen room kicking a tube along the floor, I knew I had a new tube type to play with. This was our shock test!

After the mobile transmitters were designed, it was a simple matter to put them on a rack chassis, add a 250-watt power amplifier and create base stations. So Connecticut was the first state to get complete statewide two-way FM radio coverage. Shortly afterward, Dan Noble joined Motorola, and the company became our strongest competitor after the war.

Good news travels almost as fast as bad news, so in the spring of 1940, we received a visit from a captain in the one and only "mechanized cavalry" division, later to become the "First Armored Division." He was Captain Grant Williams, the radio officer for the division. He had heard about the Connecticut state project and, since the low-frequency tank radios gave very poor performance, he wondered if the 30 to 40 Mc FM sets would do better. He had $3,000 in his maintenance budget, and the division was bringing six tanks to Madison Square Garden for the Horse Show ("mechanized cavalry"!), and could we build something that would fit in place of one of the ammunition racks, handle five communications channels and be installed while the tanks were at the Horse Show—for $3,000—for six tanks—in two months?

Little did we know that this kind of impossible assignment was to be our lot for the next five years!

The sets were ready and installed during

The Lucite Tie Rack

Our chief engineer, Fred Budelman, lived next door to a DuPont engineer who had something to do with creating Lucite. I don't know if DuPont ever found a use for the product other than art deco lamps made of round and flat pieces of the transparent material, but Fred brought some half-inch rods to work to see what we could use it for. At the time, Link Radio and Bill Lear shared a loft on 17th street in lower Manhattan. Lear had a "Q" meter that we all used, and I think it might have gone up as high as 100 Mc (not MHz at that time). We tried to wind some coils on the Lucite rod and found that there was no difference between the Q of air-wound coils and those wound on the Lucite rod at the highest frequencies we could measure. The Lucite also machined quite well, could be drilled and tapped at one end for mounting and grooved to hold the spread windings. So we had found an ideal coilform. We promptly used it for all our coils that tuned above 30 Mc. The police-band frequency meters that at Fort Monmouth were found to have great harmonics into the radar frequency range and that later, during WW2, became the BC438 and BC439, were the first beneficiaries of the new coils.

I took home a couple of feet of the half-inch rod and made a tie rack of it that hung on the back of my closet door. It was not very practical because the ties slid off the slick Lucite rod every time the closet door was opened or closed. But it was probably the only Lucite tie rack in the world, and I was determined to stick with it!

During the first or second year of our entry into WW2, the brain trust at Princeton University had an idea for testing fighter airplanes. The idea, briefly, was to plaster a test plane with strain gauges, multiplex the output of the gauges into a radio transmitter, take the plane as high as a bomber could carry it and let it dive into the ocean at "terminal velocity" (whatever that meant). Meanwhile, a receiver on the ground (or sea) would receive and record the output of the strain gauges which could then be analyzed to build a safer fighter plane. The system had to be on 75 Mc FM, of course, and we at Link Radio who had developed a reputation for doing odd projects in FM were the ones to build it. The specifications for the transmitter-to-receiver link called for less than one percent overall distortion. This was necessary to prevent crosstalk among the strain gauge signals which would have made a chop suey of the data.

In those days, one percent distortion was about the lowest one could measure. Besides, with both the transmitter and the receiver forming the path, it seemed like a chicken-and-egg situation. Was the distortion in the transmitter to begin with, or was it generated in the receiver?

Up to this time, our FM detector, a Foster Seely discriminator operating at 456 Kc, was designed to recover a ±15 Kc swing with good efficiency and inaudible distortion. But the amount of data needed a ±75 Kc swing.

Armstrong came to our rescue by telling us that he had a receiver with less-than-measurable distortion, and we could adjust our transmitter against it. This would solve half of the chicken-and-egg problem. (Armstrong seemed to take an interest in everything we did with FM, perhaps to make sure we treated his baby right. Sometimes I suspected that he steered the difficult projects our way to expand the use of FM.)

I packed the transmitter and a fistful of resistors in a box and took the subway to 116th Street and went to my well-known haunt in the basement of the E.E. lab at Columbia. The lab assistants had the "distortionless receiver" ready for me, and we began the tiresome task of adjusting the transmitter for the necessary pass band. Without oscilloscopes and sweep-frequency generators, this entailed feeding the transmitter with an audio input that caused a ±75 Kc swing as determined by the "null method" and then adjusting the coupling and loading of each interstage transformer for the required pass band until the "distortionless receiver" indicated that we had it right.

Never one to reinvent the wheel and eager to borrow any wisdom I could, I looked into the "distortionless receiver." Much to my dismay, I found that the discriminator was fed by a power amplifier in order to recover sufficient audio! I had no provisions in my receiver for a power amplifier. A discriminator transformer consists of a primary and a center-tapped secondary winding. Their discriminator had three coils the Horse Show, and the tank crews were familiar with them by the time of the famous North Carolina Maneuvers that preceded our entry into the war. Fred Budelman went to the maneuvers with a 250-watt base station, which he had to tune with a mess knife (he forgot his screwdriver) and reported that the tank crews were having a grand time communicating from gullies that had been dead spots with their old radios. Actually, the team that was supposed to lose the war, the FM radio-equipped tanks, won the war because of their perfect communication. The result of this was a shakeup in the army's thinking on mobile communication, and Grant Williams was sent to staff school to become a major.

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wound on the usual cardboard bobbins with the secondary on two bobbins close above and below the primary. I think there was only one outfit in New York City that had a universal coil winding machine, and it had wound the coils for Columbia. I telephoned the outfit then and there and ordered a few identical coils to try to make my discriminator. I asked that they be wound to slip over a half-inch form.

Several days later, when the coils arrived, I duplicated Armstrong's discriminator and began to investigate its frequency response. I soon discovered the secret of its low distortion. It was so over-coupled, with peaks several hundred kilocycles apart, that of course it had no discernible distortion over the narrow portion of its band that was used for ±75 Kc swing. But, by the same token, the slope was so flat that it had practically no audio recovery, hence the need for a power amplifier to feed it! (For those not familiar with the characteristics of the Foster Seely discriminator, imagine a graph with a zero in the center of both the X and Y coordinates and a graph of a steeply sloping letter "S" with its center at X and Y zero. The X axis would be the ± frequency swing, and the Y axis would be the recovered audio. The object is to make the diagonal of the "S" as straight as possible so that the frequency swing results in a linear audio recovery while making the slope of the line as steep as possible for efficient audio recovery.)

Of course the coil bobbins had been slipped over our standard Lucite rod, and their spacing could be adjusted for optimum coupling. The setup we had to use was to feed an audio signal into the now precise transmitter, adjust the frequency swing to ±75 Kc, adjust the discriminator coil spacing and resistor loading, null out the distortion analyzer and read out the residue distortion on a Ballantine audio meter! This involved endless trial, removal of the shield can, readjustment, replacement of the can and remeasurement. We found that indeed, we could get acceptable audio level with a standard receiver pentode instead of a power tube driving the discriminator and distortion that was too low to measure with our analyzer. The only fly in the ointment was that the coil bobbins had to be spaced so exactly with relation to each other that it raised the mechanical problem of keeping them in place on the Lucite rod.

The pressure of creating new developments in radio with the urgency of the war sometimes led to some bizarre nightmares. A friend of mine whose work was similar to mine told me that he too often found the solutions to problems in his dreams but forgot them in the morning. It was just as well, he said, because he remembered one of the dreams once, and the solution he had dreamed that was ridiculous! Perhaps this was a way our subconscious preserved our sanity under the pressure.

The problem of securing the coil bobbins to the Lucite must have been preying on my mind when I awoke in the middle of the night and asked my wife where she kept her nail polish. My bride of two months must have thought that I had really flipped to ask for nail polish in the middle of the night! After she told me, I went to the closet where my Lucite tie rack was hung and put a few dabs of nail polish on the rod and told my wife to go back to sleep which I, too, did promptly. She told me later that she wasn't sure whether to get up and run home to her mother at this point! In the morning, the first thing I did was to go to my Lucite tie rack and check out the nail polish. I was delighted to find that it had bonded to the Lucite, and I had found my perfect adhesive! (Of course I explained everything to my bride.)

So, while I held the coil bobbins exactly in place on the Lucite rod, my beautiful blonde lab assistant daubed them in with nail polish.

I don't know whether the dive-to-destruction technique ever resulted in better fighter planes. But nail polish became our standard company adhesive. During the war, when any adhesive had to be procured with a priority rating and yards of red tape, we could buy all the nail polish we wanted at the local five-and-dime for 10 cents a bottle. Soon, all seven floors of our loft building had a bottle of nail polish within easy reach. Years later, when one of the receivers that had the IF coils fastened with nail polish got caught in a flood of my basement, I found the adhesion perfect after the polish had been applied at least 10 years previously!

The Lucite rod didn't make a very good tie rack, but in combination with nail polish, it made an excellent coil form!

—John E. Balint

History overtook us, and by the time our armored forces were to be sent to face Rommel in North Africa, the only good mobile radios were our civilian FM sets. They were built on a simple inverted pan chassis with an aluminum wraparound: separate transmitters and receivers mounted on a sort of common subbase and painted a very unmilitary hammertone gray! We went into "mass production," turning out about five sets a day. My little screen room had two full-time receiver final-test and alignment workers. Paul Wandelt got only one assistant for the transmitters since they were much simpler to test.

The relatively non-rigid construction of the sets had some merit. I remember that we received photographs from North Africa of shot-up tanks and halftracks with the caption, "We take out the radios and put them in new tanks, and they keep on working!"

Bill Lear had moved out of the loft a couple of years earlier, so we had the entire fourth floor and soon acquired the third, fifth and sixth floors as well. Bill Fingerle took over the sixth floor for the manufacture of fixed stations.

The fixed stations were housed in rack cabinets of various heights that held from three to six chassis interconnected with a wiring harness consisting of a bundle of wires terminating in connectors that plugged into each chassis. There was a group of blind boys that

'Seal skins' in radio

Everybody should have a Hungarian friend. They are like paprika in the goulash of our circle of acquaintances. Most of us pursue the even tenor of our ways. Hungarians have Adventures. And they tell you about them with enthusiasm.

I was finishing dinner in one of my favorite inexpensive New York restaurants when Alex Nagy came in and rushed over to my table. "I got a job in a "seal-skin studio!" he gushed excitedly in his heavily Hungarian-accented English. Getting a job in 1939 was really something to get excited over. His enthusiasm gave the impression that he had been made a vice president or something, but I surmised that his employer was probably a one-man operation in need of an assistant.

Alex insisted that as soon as I finished my dinner, he would take me up to the "studio" and show me the beautiful things they were making. By this time, I was puzzled about seal-skins in a "studio," but I was whisked down to the subway—Alex even insisted on putting the nickel in the turnstile for me—and we soon got off at eighth street in the Village and made our way to a loft building. I was impressed that Alex had a key, not only to the front door, but to the "studio" door as well. When we got to the "studio" door, I read the sign on the glass, "Acme Silk Screen Studio." So "silk screen" had become "seal-skin" in Alex's Hungarian accent!

Alex showed me around and explained how printing was done by having a silk mesh stretched over a wooden frame. The pores of the silk were blocked with a gelatin coating except where the printing was to be. The frame was registered over the copy, and a thick paint was squeegeed through the unblocked pores of the silk onto the copy to produce the printing. I had never heard of the process before or even thought of how the multi-colored posters in the shop windows were made.

I admired the artwork of the various prints and congratulated Alex on his new job. Since I was not much into art, the technique was interesting but not anything I was ever likely to use. We parted at the subway station on 14th Street where I again congratulated Alex on finding a job. He took the local uptown, and I took the express to 116th Street.

Shortly after we got into WW2, we got our first "production quantity" order for some 50 radio base stations for the Air Corps. They were 3-foot-tall rack cabinets with three cadmium-plated chassis of the usual inverted cake-pan type. They were the transmitter power supply, the transmitter and the receiver. All the tube sockets, transformers, etc., on the top of the chassis had to be MIL SPEC marked. Previously, we used rubber ink stamps to identify the tube types at each socket, but the number of markings on our "production quantity" seemed like an endless task.

Somebody thought up the idea of putting a bunch of rubber stamps in the bottom of a box and lowering the chassis onto them.

It made a mess.

Eventually, I heard about the problem. When I saw the ridiculous rubber stamp box, I remembered Alex and his "seal-skins" and explained the process to our chief engineer, Fred Budelman. He had never heard of the process but, since he had thought up the rubber stamp idea, he was glad to palm off the problem. I was immediately appointed to solve the whole marking business!

Alex had long since volunteered into the infantry, fabricated these harnesses. One of them had some eyesight, and he translated the schematic drawings into Braille for the others who quickly memorized them. The reels of different colored wires were always placed in the same position, and each of the boys had a board with nail pegs to route the wires into the required configuration. When all the wires were assembled, they were "laced" (tied with cord) into shape, ready for soldering the plugs on the wire ends. It was always amazing to see this group work. Their hands flew from wire reel to pegboard while they chattered about everything under the sun. And they never made a mistake! If something malfunctioned during final test, we were always sure that the fault was not in the cables!

With the advent of "mass productions" and the military requirement that all replaceable parts had to be labeled, we ran into a problem. It had been relatively easy to rubber-stamp things in small quantity, but when we had *fifty* base stations to produce, the problem had to be faced. Some years previously, a friend of mine had gotten a job in a silk screen studio. He showed me around the plant one evening and explained the process. Since I was little interested in the art of printing at the time, I forgot about it. Now, I remembered, and wondered if that could be the answer to our marking problem. Consulting the Yellow Pages, I found a silk screen studio a few blocks away

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saying he was not going to be an enemy alien. So I consulted the Yellow Pages and found a silk-screen studio about six blocks from our plant. With a sample receiver chassis under my arm, I visited the place and found that it really had some ingenious devices. It was even printing on little round glass medicine ampules that rolled under the screen. I knew I had come to the right place. When the silk screener understood our problem, it said that the only question it had was finding a paint that would stick to the cadmium-plated surface of the chassis, but it was sure it could find an ink that would work. (After all, paints had been made for thousands of years.)

I left the chassis with the company to make a frame and jig, and the the company gave me a transparent celluloid for the art work from which it would make the gelatin by a photo process. The company agreed that it would not only furnish all the necessary equipment and supplies but also train our people in doing the screening. Our drafting genius, George Conner, knocked out the lettering on the celluloid in no time and sent it to the company.

Two days later, the silk screeners showed up with jig, frame, ink, solvent, rags and a big pile of old newspapers. We cleared off a large table for them while our sheet-metal boys brought up the chassis.

In less than ten minutes, they had all 50 chassis perfectly marked!

Of course, there had been no training so three or four of our production girls were immediately appointed the "Silk-Screen" department, the markings were wiped off the finished chassis and the girls were indoctrinated one by one. The whole plant watched this miraculous procedure, and even the boss, Fred Link, came out to watch. It was all we could do to stop the girls from wiping off the chassis again and again for another round of printing!

Cleaning up the screen and other parts by repeatedly dousing them with solvent over the old newspapers was the tedious part of the job, but the girls had had their fun.

So silk screening became our standard marking technique, and we had frames and jigs and squeegees, large and small, in a closet in the production department.

A few months later, we had a joint military project with Western Electric, and some of us went to New Jersey to visit its plant. I remember a large bright hall with rows of tables and girls doing various assembly operations on the radio equipment.

We came to one group whose task it was to mark the assemblies. Each girl had a small glass plate on which she put a blob of ink which she rolled out with a rubber roller. Then she picked up a rubber stamp, inked it on the glass and applied it to the assembly. Of course, half the time—specially with us watching—the mark was smeared and had to be wiped off and the whole procedure repeated.

We asked our hosts if they had heard of silk screening. Of course they had not, and we proudly explained how we didn't use rubber stamps anymore! They were really interested, and we gave them the name and address of "our" silk screener. They must have gone there the next day because within a few months, the technique had spread throughout the industry. Even the expensive process of engraving front-panel markings gave way to silk screen printing.

And that is how Alex's "seal-skin" technique got started in the radio industry. As Alex would say, "There is an old Hungarian proverb:

"'It's easy to get used to a good thing!'"

—John E. Balint

and paid them a visit. When I outlined the problem and they showed me how they were printing on little glass medicine vials that involved rotating the vials while printing, I knew I had a winner.

They agreed that for $50 they would make a screen from our art work, a jig for holding the chassis, furnish a squeegee, a quart of paint and a training demonstration at our plant. To say that the scheme was a success is an understatement. The skilled demonstrator worked so fast that the 50 chassis had to be wiped down several times so they could be redone to provide training for the girls who would handle the process! Soon after this, we visited Western Electric for some coordination, and we saw the girls applying markings by inking a plate, picking up the ink on a rubber stamp, marking the part and wiping it off if it was not quite right! Of course we told their executives about "our" marking process and gave them the address of "our" silk screen studio. This is how the art of silk screen proliferated in the radio industry.

Since we had developed a reputation for handling special communications projects quickly, we had a steady flow of rush jobs during the war. We had a regular contact assigned to us by the Navy, and he appeared from time to time much to my dismay because it always meant that I would have to work two—sometimes three—days without rest to create something that had never been done before, while he waited to take it away!

There was the time that the German U-boats were threatening our east coast harbors. The Navy had some battery-powered transmitters with very low power that it could install with microphones on the harbor buoys to listen for the submarines, but they needed a very sensitive receiver to monitor them. Of course it was to be built with the standard JAN (Joint Army and Navy) tube types which were only the metal variety.

After 36 hours without sleep, I finally told our Navy contact (expletives deleted) that if he got permission to use the Loctal tubes, I would have the receiver ready for him in eight hours. In the meantime, I was going to go home and sleep for eight hours. When I got back, he had the permission, and he got his receiver. That is how the type 7W7 and 7C7 Loctal tubes got on the JAN list and, I suppose, how the Germans were scared away from our harbors. His visits were not all bad though. He was a pipeline to us of all the current jokes from Washington, and we gave him the New York jokes to take back to Washington.

Another interesting Navy project was our FM "ten-channel" set. This was to be the answer to the Japanese kamikaze attacks on our ships in the Pacific. The idea was to build drone planes that were essentially flying torpedoes, control them from a "mother" plane and dive them on the Japanese navy. For control of the drone planes, they needed to receive 10 commands or relay closures. Hence the "ten-channel" name. We turned out a good number of these sets, but with war time secrecy, we never did learn how the scheme worked.

Our high-frequency expertise had now encompassed the 75 Mc range and broadband reception. One night, after a frustrating day of trying to get some amplification at these higher frequencies, I thought of the transmitter I had built for Bill Lear and the link coupling that was used between some of the stages. This seemed like a great way to get a tuned plate and grid circuit without combining the gigantic output and input tube capacitances. When I tried it the next day, it worked wonders and became one of our standard tricks.

One use of the higher frequency and broadband sets was for telemetering stress information from newly designed aircraft that were dropped from a plane and dived to destruction. Since this information was in analogue form, i.e., audio frequency blocks, it was important to have very low distortion to prevent crosstalk among measurement data. Measuring even one percent distortion with the equipment then available was quite a trick, much less designing a transmitter and receiver link with that little distortion.

Fortunately, Armstrong had a receiver that he claimed had less than one percent distortion, so that was our starting point to bandpass the transmitter for low distortion and then duplicate his discriminator for the receiver. Unfortunately, we found that his discriminator achieved its low distortion by being so broadband and inefficient that it took a power tube to drive it. We managed a modification that was within reason, but each coil had to be hand-tweaked with a distortion analyzer.

Western Electric had designed a copy of our original FM "tank radio," and it was being mass produced. They had fancy push-button frequency selection, and the hardware contained some very nice castings. But, when some were needed for a special mission, Western Electric brought six or 10 of them to us for "customizing"—increasing the transmitter power output and the receiver sensitivity. (Of course, we were never told what they were for.)

Some time in 1942, Grant Williams appeared again. He had come out of staff school a major and was put in charge of organizing the radio communication for the European invasion that everyone knew had to come. The problem that he presented was that this war, unlike previous wars, was going to be highly mobile, and point-to-point radio communication had to replace the old wired telephone.

Western Electric had standard military switchboards that it interconnected with its "spiral four" cable—a cable that handled a multiplexed signal of four simultaneous telephone conversations. What was needed was a radio link that would replace the spiral four cable from the telephone switchboard, transmit the telephone data over a distance of up to 70 miles and feed it back into another telephone switchboard. It had to be portable of course and easy to set up quickly.

We decided on frequencies around 75 Mc and a frequency swing of 75 Kc to give us the optimum deviation ratio of five to one of the 15 Kc audio signal from the telephone switchboard. We coordinated with Bell Labs and Western Electric on input and output requirements and provided for use of the setup as an automatic repeater station for longer hops. We included all the "bells and whistles" that could be foreseen as useful. The transmitter had 50 watts output power and could feed a 250-watt power amplifier. A telescoping antenna mast with block and tackle, guy ropes, stakes and clamps to hold a four-element yagi antenna were all our responsibility to design. This became our largest project by far, and Fred Link took over the entire six floors of the loft building, and we were truly in mass production. A second production plant was set up near Chicago for reasons of strategic diversification, but we had nothing to do with that. The system went into the field under the names of ANTRAC 1 for the 50-watt system and ANTRAC 2 for the 250-watt system.

Jimmy Campbell was a good radio man who had been one of the final-test and alignment boys in my screen room when we started the tank radios. He was my assistant in designing the ANTRAC receiver and did most of the legwork.

All of these military projects had to be documented, and voluminous instruction manuals had to be constructed for each of them. There was, of course, a military instruction manual on how to write instruction manuals in the acceptable third-person-singular with words of one syllable or less whenever possible. All the rules were included that would emasculate anybody's literary style. It turned out that among the entire engineering staff, only two of us could write acceptable English: Fred Budelman and I. This meant that he and I usually worked six days a week and wrote instruction books on Sunday. George Connor's drafting department had now become the technical manual department with about four to six draftsmen. It was fortunate for us that George's meticulous attention to detail made him an excellent proofreader who caught every variation from the proscribed style and punctuation. The manual for the ANTRAC 1 and the ANTRAC 2, for example, was about an inch thick!

And so our struggle up the frequency spectrum to 75 Mc, and by 1945 to the newly assigned 150 Mc two-way band, produced the radios that made some contribution to winning the second World War. I don't know how Fred Link and the others who worked hard in the lab, the machine shop and the production line feel, but I believe that if our contribution resulted in victory and the end of the war coming a day, a week or a month earlier than it would have without us, then we certainly saved many, many lives, not only among our own soldiers, but, by helping to hasten the Japanese surrender too (yes, we had our radios on the Manhattan Project even though we didn't know what they did!), we saved countless lives throughout the world. That makes me believe that we justified our existence!

AUTHOR'S NOTE:

This story is part history and part biography. Some of the dates are absolutely correct, while others are only my best recollection. The reason for some uncertainty is that my notebooks remained in my parents' attic when I moved from New York to Oregon and still remained there when my parents moved to California. But the picture is accurate as a whole. That's the way it was when radio was more of an art than a science.

If any people or events were not properly credited, blame it on my poor memory rather than any intentional omission.

John E. Balint
November 1986
Eugene, Oregon

Editorial comment...continued from page 3

(counsel), Jerry Minter (counsel) and Eric Stoll. If you want to volunteer to the nominations committee as a possible candidate, you can get in touch with one of the committee members directly or via the Club's official address.

You can find information about the petition method for nominating a candidate in the Constitution & By-laws, which you'll find on page 111 of the 1994 membership directory. I'm always glad to help with petitions, so if you want to, you can get in touch with me for assistance.

▶ *Executive secretary* — Howard Henry, who is with the Club's management company, Meredith & Henry, has been named executive secretary, replacing Club member Ronald Formella.

Ron took care of a lot of tasks for the Club, both during his tenure as executive secretary and before. His most direct connection with my Club work had to do with the *Proceedings.* Ron's the one who has been hauling printed copies of the magazines, directories and other special publications home from the printer, stuffing envelopes, affixing mailing labels, and hauling them once again to the post office. Thank you, Ron, for helping with the *Proceedings* and all those other details of Club operations.

And welcome aboard to Howard and the staff at Meredith & Henry who will be taking on many of the responsibilities previously handled by Ron. I don't know about the magazine-hauling, though. Ron had a pickup truck. I'm not sure what Howard drives.

▶ *Fellows and awards* — The board of directors has elevated 20 members to the membership status of Fellow, and seven members have been named to receive awards. As much as I wish I could tell you who they are—I can't. It's the Club president's prerogative to be the first to notify the new Fellows and award recipients, and I can't risk their seeing their names here before Tom Amoscato tells them. Watch for their names in the next issue of the Club newsletter.

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A meeting with Princess Elettra Marconi-Giovanelli

By Kenneth M. Miller

The following relates to my recent meeting with Princess Elettra Marconi-Giovanelli, the daughter of Guglielmo Marconi. Incidentally, Guglielmo Marconi named his daughter Elettra after the name of his yacht, *Elettra*. She proved to be a very interesting and delightful lady. Elettra Marconi holds the Italian title of "Marchesa." This title is the Italian woman's equivalent of the male title of "Marchese" held by her father. My evening spent with the Princess was a very timely encounter since 1996 is being celebrated internationally worldwide as the 100th (centennial) anniversary of Marconi's early wireless transmissions.

Italian princess Elettra Marconi-Giovanelli, daughter of radio pioneer Guglielmo Marconi of Bologna, Italy, and Grants-in-Aid committee chairman and club director Kenneth M. Miller (LF), K6IR, of Rockville, Maryland, at the 1995 club banquet.

Guglielmo Marconi was born on 25 April 1874 near Bologna, Italy. His father was Guiseppe Marconi of Bologna, a rather dignified chap of adequate means, whose second marriage in 1864 to a keen-witted Irish lady, Anna Jameson, yielded two offspring, Alfonso and Guglielmo, who were tutored on the parental estate. Incidentally, Anna's father, Andrew Jameson, was widely known regarding his whiskey distillery in Dublin. Anyhow, Anna went to Bologna to study music and fell in love with Guiseppe.

Then, in 1894, Guglielmo Marconi found himself reading an obituary of Heinrich Hertz, the discoverer of Hertzian waves, now known as radio waves. Marconi's imagination was set in motion, and he devised an apparatus to transmit coded signals more than a mile. This led to Marconi's traveling to England 100 years ago in 1896 and taking out a patent, which was the first ever granted for a system of wireless telegraphy.

It is interesting to note that one of the first practical applications of wireless communications took place almost a hundred years ago in 1898, when Marconi followed the Kingston Regatta in a tugboat and transmitted race results in code to the offices of a Dublin newspaper. In the following year, 1899, the value of wireless transmissions was demonstrated when the *East Goodwin Sands* lightship was rammed in a fog and assistance was summoned by the wireless.

In 1901, an event took place that is controversial to this day. At the time, many scientists believed radio waves traveled only in straight lines. Marconi disputed this view and was convinced that the long (low-frequency) radio waves he employed would follow the curvature of the earth. So on the 12th of December 1901, he claims to have received the letter "S" signals employing a kite-supported antenna at St. Johns, Newfoundland, that originated 2,000 miles across the Atlantic Ocean at the southwest tip of England in Poldhu.

Marconi continued to explore the immense arena of radio frequency generation and reception until his death. In 1912, he lost the use of his right eye in an automobile accident.

In 1929, he was created a "marchese," the rank of nobleman above count, by the Italian government. And his daughter today holds the title of "marchesa" (princess).

Well, many words. But it was so interesting to learn so much of the history of one of the great pioneers who played an interesting role in the history of wireless communications. As I mentioned, his daughter underscored what a bright lady she is as she recalled memories of her travels around our globe with her father as he was widely acclaimed.

Kenneth M. Miller is a life member of the Radio Club of America, a director in the Radio Club of America and chairman of RCA's Grants-in-Aid Committee.

Radar...continued from page 30

and Inspection Departments.

Last on the list, but a most valuable person, also from Westinghouse, was Frank Lyon, who prepared the instruction and maintenance manuals and handled many of the documentation tasks.

Other key people in the program activity included Alice Brady, the Navy contract negotiator who always won! Fred Sachs of the Naval Air Development Center, another key individual, had trouble believing that John Alexander's antenna patterns were as good as they tested! And, Johnny Garmston, the Navy Mustang, participated in most of the early test flights.

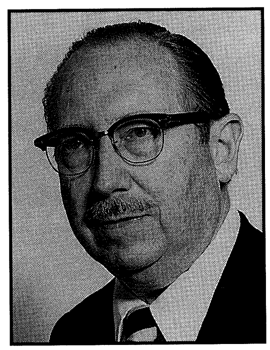
Once it was clear that the program was under way and met the specifications, several corporations looked at the opportunity to buy the program from the Houston Corporation. One of these was the RCA Corporation, which wanted to get into the airborne radar field. RCA managers watched the tests and acceptance of the units and made an offer to Helbush. This was in parallel with the Fearless Camera Company interest in the purchase of the automatic film-processing portion of the Houston Corporation. With the opportunity to sell both halves of the corporation, Helbush accepted both offers, and RCA moved some people into the plant.

The equipment had passed Type Test and entered production by the time the RCA people arrived, and after a month or so, someone in the public relations area of RCA released to *Aviation Week* an article claiming that RCA had "saved" the Houston radar program. An immediate demand by the Houston attorney, Helbush and myself was made to *Aviation Week* to ensure that the engineers who had spent so many hours on the development of the radar would not be cast as failures. *Aviation Week* printed a partial retraction of the erroneous claim.

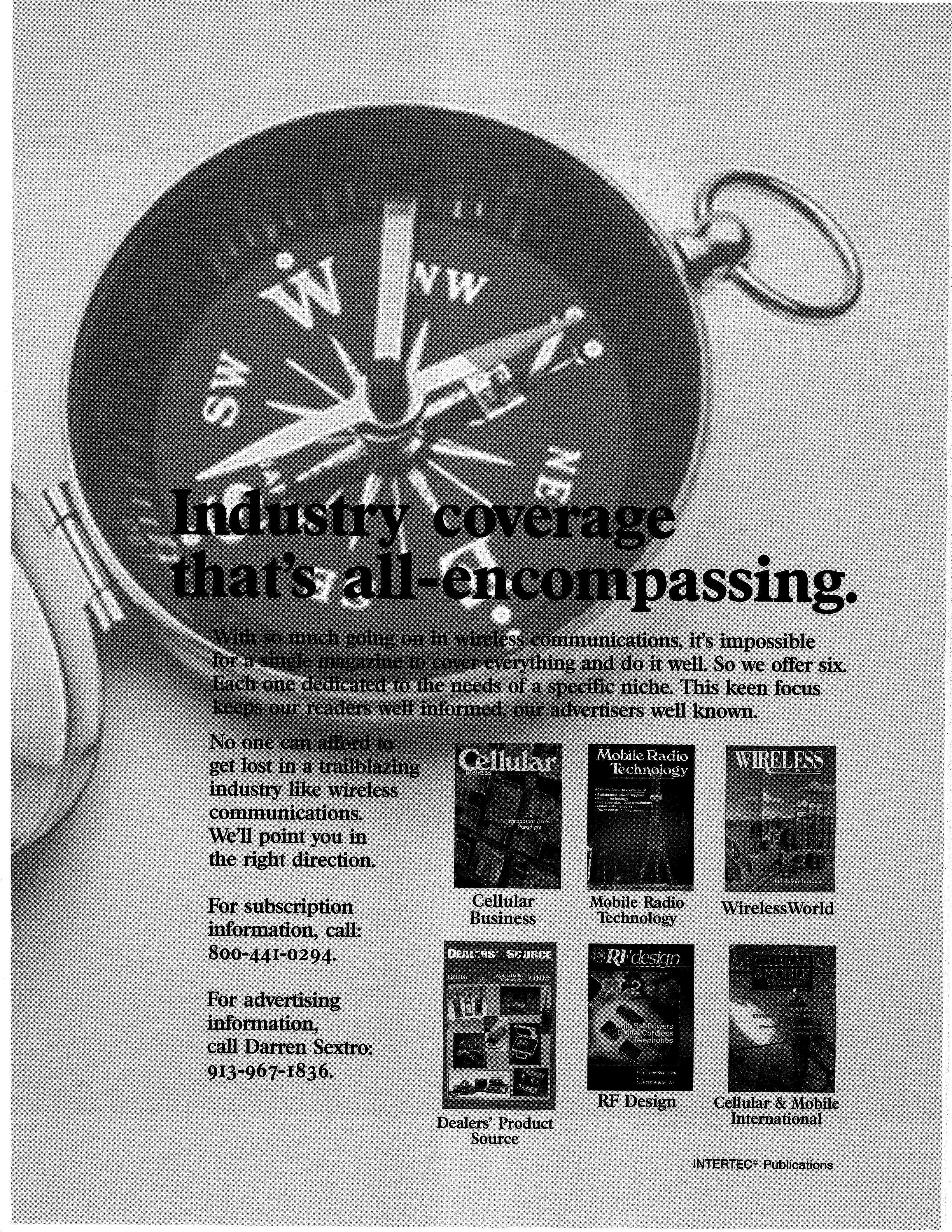
With the installation of the radar into the Strategic Air Command Airborne Command Post C-97 aircraft, the installation into President Truman's DC-6 and the fleet/installation in C-97 aircraft, followed by the installation in President Eisenhower's aircraft, the engineers who worked so hard for so many months had good reason to be proud.

So little remains in the form of documentation, and the original team of engineers has scattered to the four winds or passed away. It was my belief that, for the historical record and as a tribute to the engineering team, that this document should be produced.

Much credit for the information in this paper must be given to Aubry Vose for his information and to Jimmy Grodsky for his many inputs.



Frederick G. Suffield, P.E., is a Fellow in the Radio Club of America, a Fellow of IEEE and a recipient of the IEEE Centennial Medal. He is the former director of Region 6 of IEEE, and he hold patents in radar and related fields.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TREASURER'S REPORT FOR FISCAL YEAR 1995

(October 1, 1994 – September 30, 1995)

REVENUES

Dues Collected & Applied	$14,570
Other Member Fees	1,100
Sections Operations - net	94
Banquet - net	2,364
Advertising Sales	7,761
Pins & Plaques Sales	1,685
Interest on General Funds	2,674
Publications Sales & Misc.	550
TOTAL Revenues	$30,798

EXPENSES

Publications	
Printing & Supplies	$9,601
Mailing Expenses	2,891
Meeting Expenses	5,442
Office Expenses	
Printing & Stationery	1,147
Postage	1,529
Office & Computer Expenses	287
Executive Secy & Other Admin Fees	6,300
Legal & Accounting	1,100
Pins & Plaques - net	1,854
Miscellaneous	77
TOTAL Expenses	$30,228
NET Revenues less Expenses	$570
Other Adjustments (net) (see note -->)	$30,397
NET Increase in Fund Balance	$30,967

BALANCE SHEET

ASSETS

Inventory & Receivables	$5,641
Section & Banquet Funds	22,958
Cash in Bank - Operating	32,874
Investments - Securities	68,595
GNMA Certificates	46,376
Fed Home Loan Mtge	53,075
Fed Natl Mtge Assn	30,038
Putnam Fund	41,288
TOTAL Assets	$300,844

LIABILITIES

Prepaid Dues	$10,718
Prepaid Banquet Tix - 95 Banquet	0
Prepaid Advertising	0
Fund Balances:	
Scholarship Funds - Principal	157,395
For Distribution	13,238
General Funds - Oprt'g Balance	50,127
Reserve for Oprt'g Deficits	18,857
Life Member Fund	23,631
Legacy Fund	8,780
Other Assets & Liab - Net	18,099
TOTAL Liabilities	$300,844

N.B. Other adjustments include contributions to funds, scholarships and grants awarded, earnings on funds and changes in values of investments. Interest rate sensitive investments increased in value by $19,169 during the fiscal year.

SCHOLARSHIPS & GRANTS FUND

	Capital	Available for Distribution	Totals
Opening Balance Oct. 1, 1994	$152,905	$12,306	$165,211
Contributions	4,490		
Interest Earned		11,582	
Scholarships & Grants Awarded		(10,650)	
Ending Balance Sept. 30, 1995	$157,395	$13,238	$170,633

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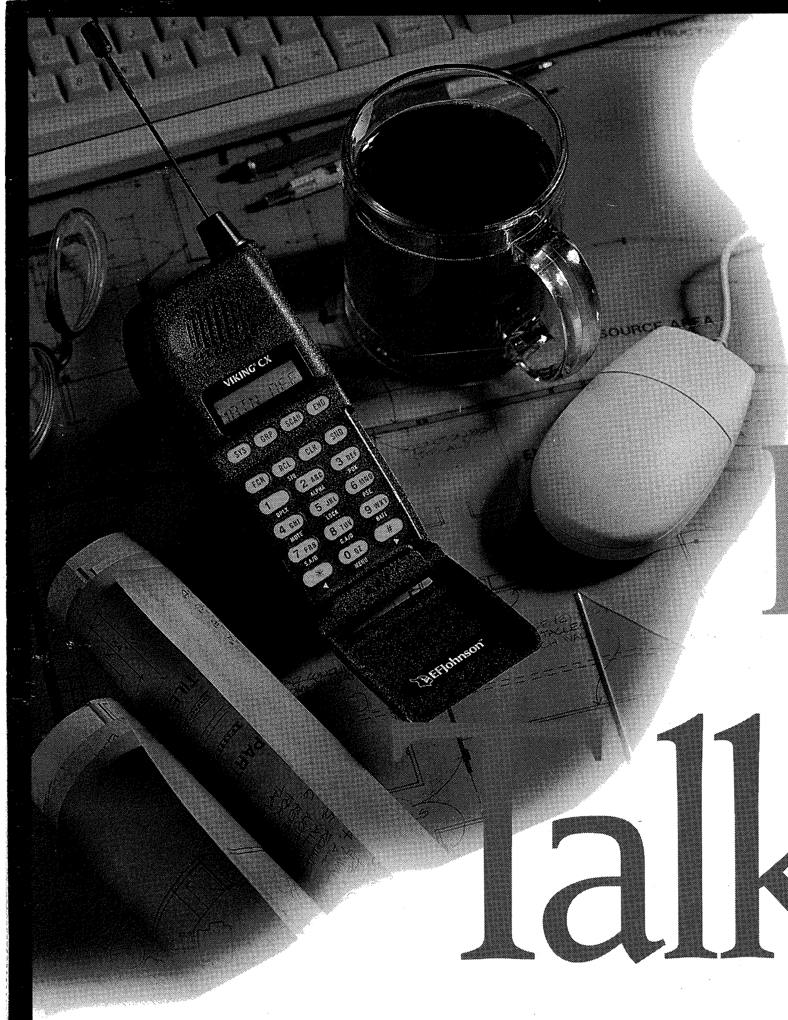

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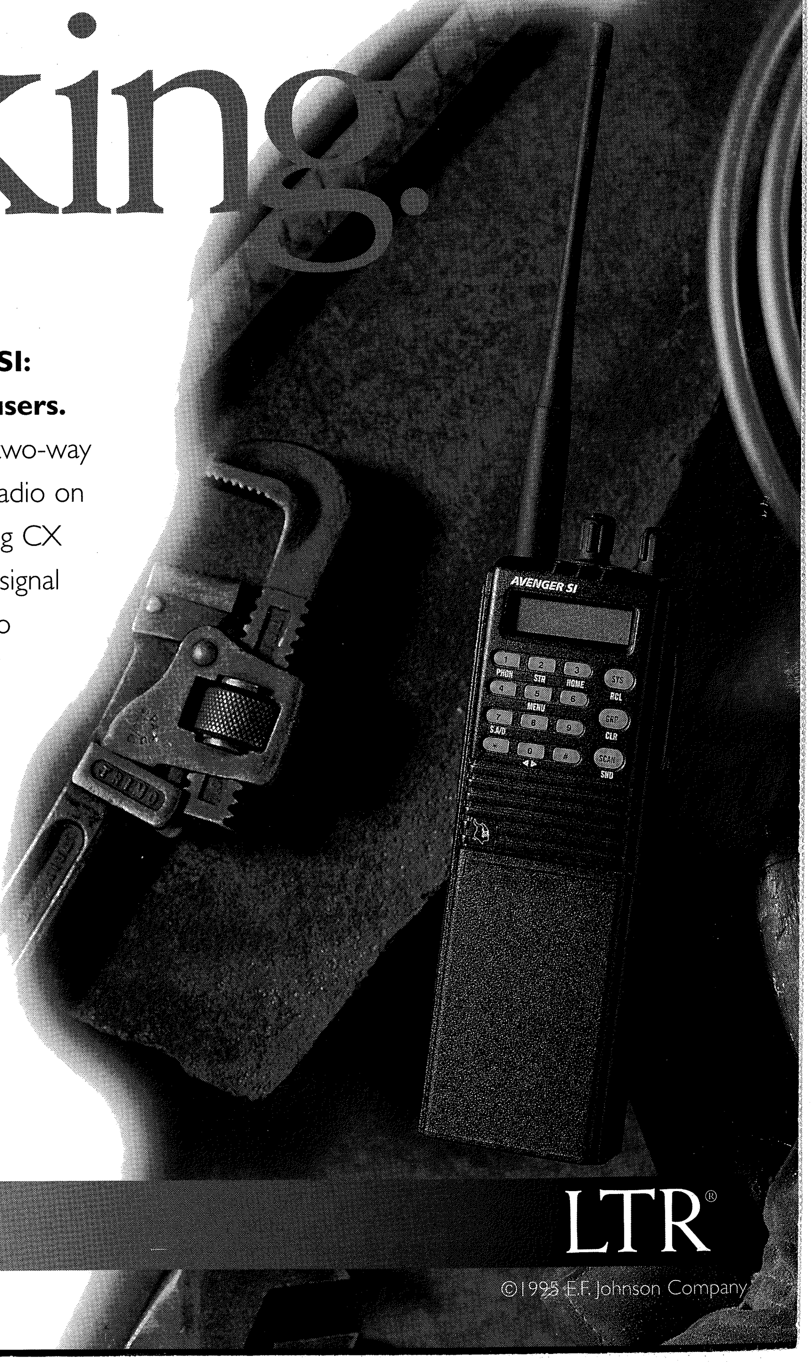

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