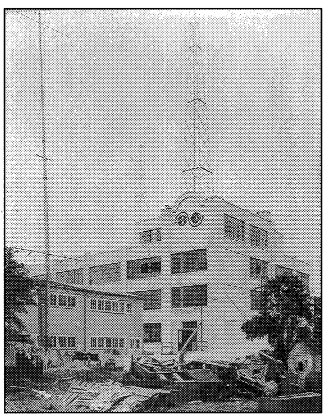
PROCEEDINGS OF

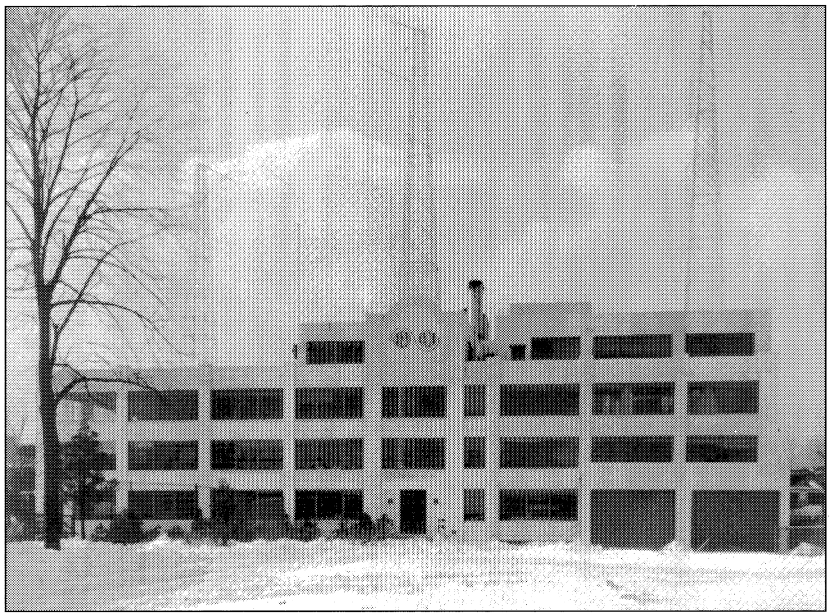
THE RADIO CLUB OF AMERICA, INC.

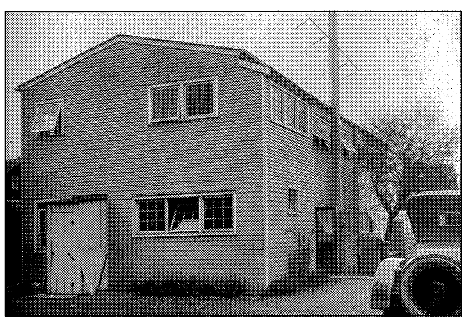
Founded 1909, New York, U.S.A.

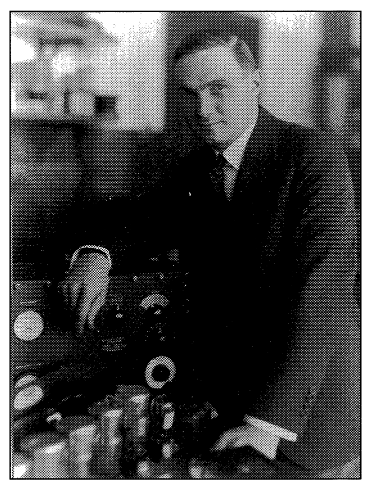
November 1994

Grebe Radio ...









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In This Issue:

Think of it as a mobile "workstation" that delivers everything on the menu.

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All the essentials you need to get the most from your system. Excellent Tx/Rx specs in lowband, VHF, UHF and 800 MHz models. 22 or 99 channels. Up to 110 Watts. 10 Watt external audio. TOT. BCLO. 41 tone and 83 digital squelch codes. Fast 40 channels/second priority scan.

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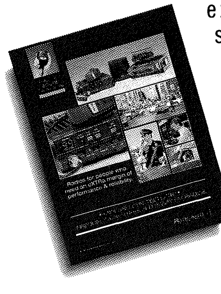

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Proceedings of The Radio Club of America Volume 68, Number 2 November 1994

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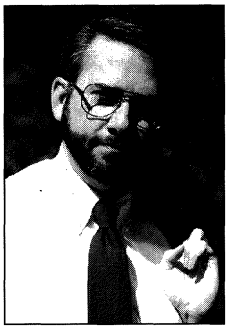


Editorial Comment

By Don Bishop

Stuart F. Meyer

Stu Meyer, W2GHK, passed away on May 21, when he collapsed from a heart attack.

He helped to guide the Radio Club of America as a director from 1972 to 1975, as executive vice president from 1976 to 1992, and then as president in 1993. He served on many of the Club's committees, and emceed the annual communications symposium and banquet for many years. He was generous with his time and effort on behalf of the Radio Club of America. He received the Club's President's Award in 1983, the Fred M. Link Award in 1988 and the Henri Busignies Memorial Award in 1992.

Stu belonged to about every radio organization that I do, and more besides, so I saw him frequently at trade shows, IEEE meetings and gatherings of amateur radio operators, in addition to Radio Club functions. He served as an advisor to the commercial magazine where I work.

In a lifetime that mixed radio communications as an avocation and an occupation, Stu built his first radio in 1930 and a television in 1932. He received an amateur radio license in 1933. Well-known among radio amateurs, Stu managed the exchange of confirmation post cards (QSLs) for many foreign amateurs as a QSL manager. He was chief engineer and later president of an amateur radio equipment manufacturer, Hammarlund Manufacturing Company. He served as president of the Quarter Century Wireless Association, an amateur radio organization.

After five years of active duty, the U.S. Navy discharged Stu as an aviation chief radio technician in October 1945. He had served mostly as a radio operator on destroyer and sub-chaser duty during World War II.

Stu began a 50-year association with the Club's president emeritus, Fred M. Link, when he joined Link Radio in 1945 to work on receiver design. He met Lottie, the woman who was to become his wife, at Link Radio. He left the company in 1947 to go into business on his own, and rejoined the company in 1950 as a project engineer, later becoming chief engineer in charge of production of the commercial and government sections. Fred sold his company, which later was liquidated, and Stu became the engineering manager of the Allen B. DuMont Laboratories' Land Mobile Division from 1953 to 1961. Fred was the division's operations manager from 1954 to 1959.

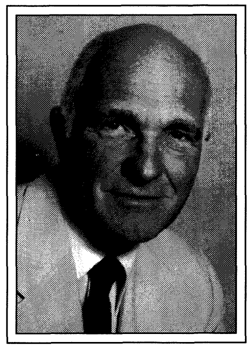
Stu continued in manufacturing as chief engineer and president with Hammarlund from 1961 to 1966, then with Aerotron as executive vice president from 1966 to 1971, when he became manager of government relations for Radio Corporation of America until 1975. He continued his government relations work for manufacturers until he died, representing E. F. Johnson Company until 1986 and Ericsson GE Mobile Communications thereafter.

I became acquainted with Stu in 1983 and began a business association with him in 1986. I admired his tenacity when he sometimes found himself championing minority viewpoints, and I appreciated the support and encouragement he gave me when I faced some difficult challenges. Thanks for being a good friend, Stu. All your fellow Radio Club members and friends in amateur and commercial radio will miss you. We all send our heartfelt sympathies to Lottie.

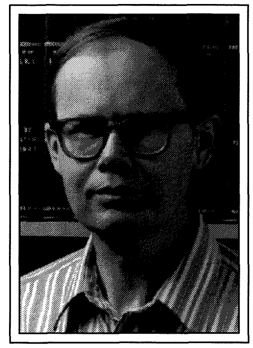
(continued on page 60)

Alfred H. Grebe, 1895-1935

By Alan Douglas
and Alfred H. Grebe Jr.



Grebe Jr.



Douglas

The history of Grebe Radio manufacturing and broadcasting is short. It spans only 25 years: from 1907, when Alfred Henry Grebe was 12 and began making simple receivers for friends, to 1932, when, at age 37, he saw the Great Depression bring on the collapse of the market for his premium-quality radio receivers and the bankruptcy of his company. (See photo 1 on next page.) In 1935, a complication to a previous internal injury sent Grebe into emergency surgery. A post-operative embolism formed that resulted in a fatal coronary thrombosis a few months after his 40th birthday.

The formative years

Grebe was born in 1895 at Richmond Hill, Long Island, New York, the son of Henry Grebe (born in Darmstadt, Germany) and Anna Marie Krick Grebe (born in Brooklyn, New York, of German parents).

Grebe's father was a horticulturist who ran his business from greenhouses on the family property. Later, his son's radio factory would occupy part of the greenhouse site, ultimately giving way to a three-story, poured-concrete manufacturing and broadcasting structure. (See photos on the cover.)

Grebe began making wireless apparatus two years after his father's death in 1905. Years later, he was quoted in the newspapers as having said, "When I was first bitten by the radio bug people thought only fools paid any attention to radio. I was warned by friends, relatives and others that I was wasting my time. But, with my mother's permission, I converted her parlor into an office and used part of the kitchen for some of my machinery. My mother was very patient and allowed me to clutter up the house and yard with my wireless."

At 14, he converted a greenhouse tool shed into a "radio shack." Here, Grebe began to practice his radio art seriously. A photograph of the radio "rig" shows his early attention to detail. All components were arranged "just so" and interconnected with the precision of a craftsman. "Haywiring" was not his style.

Grebe's policy of perfection at perfectionist's prices was not able to survive the pressure of the Great Depression.

Grebe's radio shack also served as a meeting place for boys who shared his interest in radio. Many of them later worked for Grebe or went on to careers in radio, including Roy Squires, Frank Squires, Ralph Barber, Clifford Goette (amateur radio call sign 2JU), Walter Roche (2TH), Ralph Sayres (2LH), George Rhodes and Richard Egolf (2LE).

So great was Grebe's curiosity and interest, he cared little for the constraints of public school. After graduating from grade school PS 88 in Jamaica, Long Island, New York, he attended the Jamaica Training School for a short time and then took courses at the Marconi Radio Institute in New York City.

Grebe made up his mind that if he wanted to learn more about wireless he would have to go to sea, where shipboard radio was considered to be important for navigation and emergency communications. He worked as an operator for United

Jerry B. Minter (LF) assisted in the preparation of this article.

Wireless on ships of various lines including the Panama Railroad and Clyde lines. His first voyage was to Portland, Maine: another voyage on *Cherokee* took him to Turks Island in the Bahamas. When United Wireless folded in July 1912 and was absorbed by Marconi, Grebe became associated with Telefunken and shipped on the British tramp tanker *Saranac* to India. The *Saranac* was the first British vessel outfitted with Telefunken radio equipment.

For a short time, Grebe was an operator at the Sayville, Long Island, New York, station of the Atlantic Communication Company, which, like Telefunken, was German-owned. During 1913 and 1914, Grebe installed 27 stations for Telefunken. His diary recorded that in San Francisco he "Finished all the ships in due time. Worked day and night on most of the ships. Finished *Adorna* with only one helper in 23 hours of actual work." In Seattle, his young man's frustration over delayed baggage is described in his 1913 diary:

> Aug. 22: *Went down to Electric Boat Company and saw the wireless stuff. Wavemeter and trunk haven't arrived yet.*
>
> Aug 23: *Still waiting for baggage.*
>
> Aug 24: *Going half crazy ... baggage still not here.*
>
> Aug 25: *Sunday, and no word about baggage, yet. Don't know what to tell the Electric Boat Company.*
>
> Aug 26: *Sweating blood ... waiting for baggage.*
>
> 5 p.m.: *Baggage arrived. Finished up tests in afternoon and expect to leave for New York in evening.*

The outbreak of war ended Telefunken's American business. Grebe joined Kilbourne & Clark, installing 14 stations in 1916. The following year, he worked for Emil Simon, installing wireless sets in French submarine chasers. He supervised the final assembly and testing of U.S. Navy submarine chaser receivers at Simon's subcontractor on Long Island, the Metropolitan Electric Company.

Manufacturing

Grebe's long-time friend, Ralph Sayres, recalled in a 1954 letter: "About 1913, I was helping Alfred install complete wireless equipment on the sailing steamer *Roosevelt*, a Peary polar expedition ship. Grebe was an able mechanic, as well as being possessed of a keen, imaginative mind." Every six months or so, between voyages, Alfred would remain ashore in his shop to make radio apparatus for anyone who wanted it. He started a small mail-order business. In three months ashore, he was able to fill all the orders that came his way.

The apparatus being made by Grebe included an efficient detector. Louis G. Pacent, the retail manager of Manhattan Electric Supply Company (MESCO), featured the apparatus in the MESCO retail store. Grebe also advertised his detectors in the few amateur radio periodicals being published in those days. In August 1916, he began advertising regenerative radio receivers that were made under the first "amateur and experimental" license granted by Howard Armstrong. Sales were extremely small in the short period before the amateur radio was shut down by the federal government in April 1917 because of World War I, but Alfred Grebe had found his calling.

With the experience gained with Emil Simon and at Metropolitan Electric Company, Grebe was able to plan his own manufacturing company after the war. Besides experience, he brought with him from Simon's organization Douglas Rigney, who became his vice president of advertising and publicity. A.H. Grebe & Co., Inc., was incorporated on Dec. 17, 1919. The incorporators and directors were Alfred H. Grebe, Louis G. Pacent and Douglas Rigney. Product planning had been going on at least since March, despite the continuing ban on amateur radio operation. (Amateur

Photo 1. Alfred H. Grebe in his radio manufacturing facility. Notice the General Radio signal generator.

Photo 2. The CR-9 regenerative model was announced in August 1921. Later that year, broadcasting began to capture the public's fancy, especially as reception improved during wintertime. Grebe was at the right place at the right time.

Photo 3. The CR-9 has two stages of audio amplification and is able to drive a horn loudspeaker.

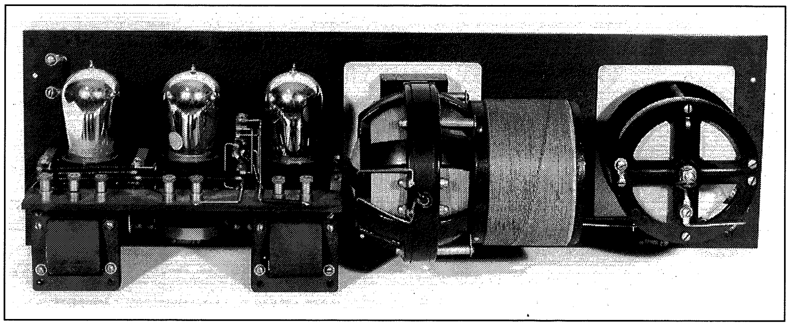
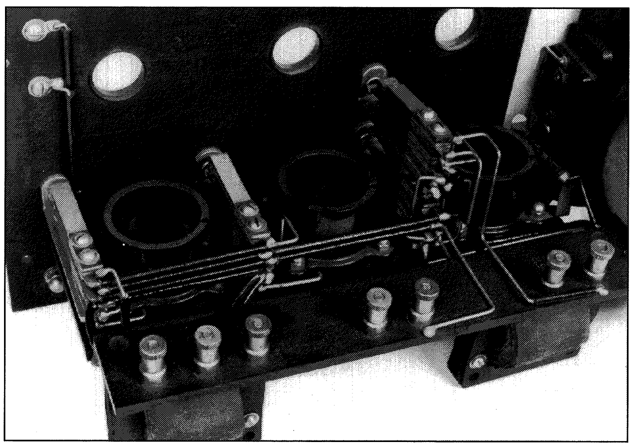


Photo 4. This closeup shows the tube socket arrangement and holes in the front panel that allow users to see the glow of the tube filaments.



radio reception was authorized in April; transmission was authorized in November after re-licensing took place.)

While most manufacturers went after the "pie in the sky" of commercial wireless, Grebe wanted only the amateur business. Nevertheless, he made his equipment meet the high standards of commercial quality. For the ham who could afford it, Grebe gear was the best available.

Then came radio broadcasting to the general public. Such broadcasting had been going on sporadically since the teens, but it began to capture the public's fancy in 1921 — particularly toward the end of the year when reception improved during wintertime. Suddenly the amateur-receiver makers were swamped with orders, and the lucky few with radio models in production became leaders in a whole new industry. Grebe was at the right place at the right time. The "CR-9," a regenerative model with two stages of audio amplification, was announced in August. (See Photos 2, 3 and 4.) It was an excellent performer that was able to drive a horn loudspeaker. Price was of little concern. Anything on dealers' shelves would sell. Grebe's fortunes skyrocketed. With his wooden factory building bursting at the seams, he kept production going while erecting a three-story, poured-concrete structure on the rest of the family property. The new structure was doubled in size in 1925.

By hiring some of the best engineering talent available (such as P.D. Lowell, from the Bureau of Standards) and encouraging them to produce the best radio possible, Grebe did the impossible: He repeated his success of the "CR-9" without using the regenerative circuit. The result was the MU-1 Synchrophase receiver. (See Photos 5, 6 and 7, next page.) Westinghouse and RCA, companies that now owned the Armstrong regeneration patent, were making life as difficult for their licensees as they could in hopes of driving them out of business. Most companies responded by adopting the tuned-radio-frequency (TRF) receiver circuit arrangement that was, for the time being, free of patent restrictions. Hazeltine devised a way of stabilizing the TRF, giving his Neutrodyne licensees an edge for a year or two. But Grebe came up with an even better arrangement: physically small tuning capacitors and radio-frequency (RF) coils with little external field; very careful placement of wiring; and capacitive neutralization (over which Hazeltine eventually won an infringement suit). The combination, with impeccable workmanship, was unbeatable.

Unfortunately, it was unbeatable even by Grebe himself. Up to this point, in 1925, competing in the radio industry was like shooting fish in a barrel. All radios were quite expensive; a $130 CR-9 or a $155

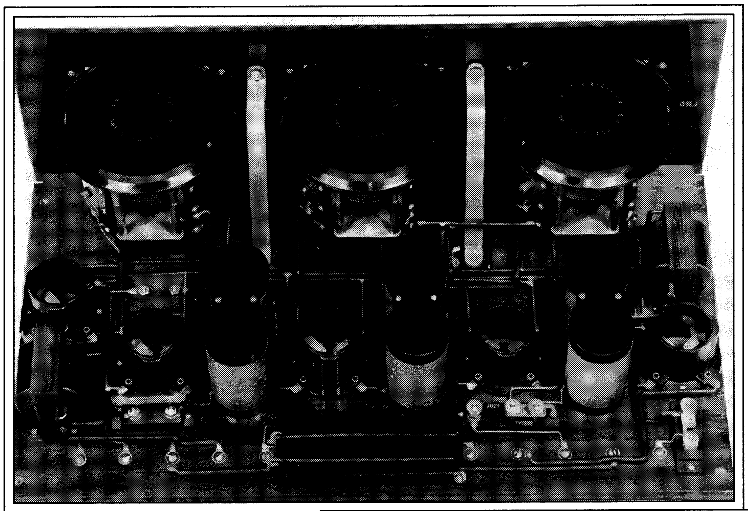
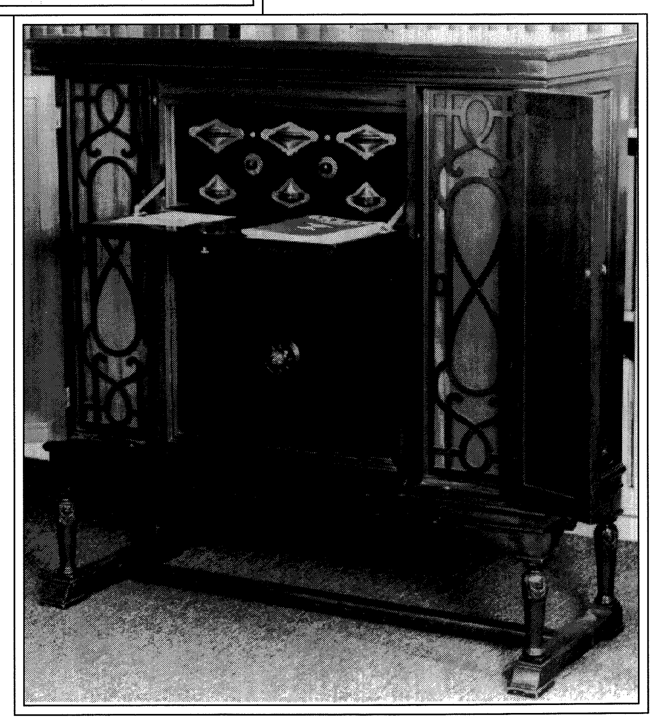


Photo 5. The MU-1 uses physically small tuning capacitors and RF coils with little external field; very careful placement of wiring; and capacitive neutralization (over which Hazeltine eventually won an infringement suit). The combination, with impeccable workmanship, was unbeatable.

Photo 6. Grebe repeated the success of the CR-9 receiver without using the regenerative circuit. The MU-1 Synchrophase receiver uses a tuned-radio-frequency (TRF) circuit.

Photo 7. In addition to the tabletop model, the Synchrophase receiver was made available as a console.



Synchrophase was not at much of a disadvantage to lower-priced models. But when production geniuses such as Powel Crosley and A. Atwater Kent got going, Grebe's policy of perfection at perfectionist's prices was not able to survive the pressure of the Great Depression. He probably would have found his niche, as did Stromberg-Carlson, and undoubtedly would have been a leader in the high-fidelity movement. His Synchrophase Seven was designed with flat audio response to 8 kHz — in 1927! But he lacked the resources to survive the early Great Depression years. In 1932, he was looking to the future of television and formed Grebe Radio & Television Company. But, bad medical luck struck him down as he was staging his comeback.

Broadcasting

In September 1924, station WAHG began broadcasting. The studio, along with the sales offices, was at Steinway Hall in New York City, and the transmitter was at the factory where antenna towers were placed atop the building. In late 1926, another transmitter was built on Rockaway Boulevard, near what is now JFK International Airport.

Grebe formed the Atlantic Broadcasting Corporation and, after a week off the air during the relocation to the new transmitter site, WAHG reappeared as WABC on Dec. 17, 1926. The *New York Telegram* of Nov. 27 noted, under the headline, "Grebe to the Front": "WAHG is soon to become a powerful factor in the local broadcast situation, we've been informed ... going to tremendous power and a remote control system that will handle programs from more points than any other station in the country. Great stuff!" Other portable stations licensed to Grebe (WGMU, land mobile; and WRMU, marine mobile)

(continued on page 16)

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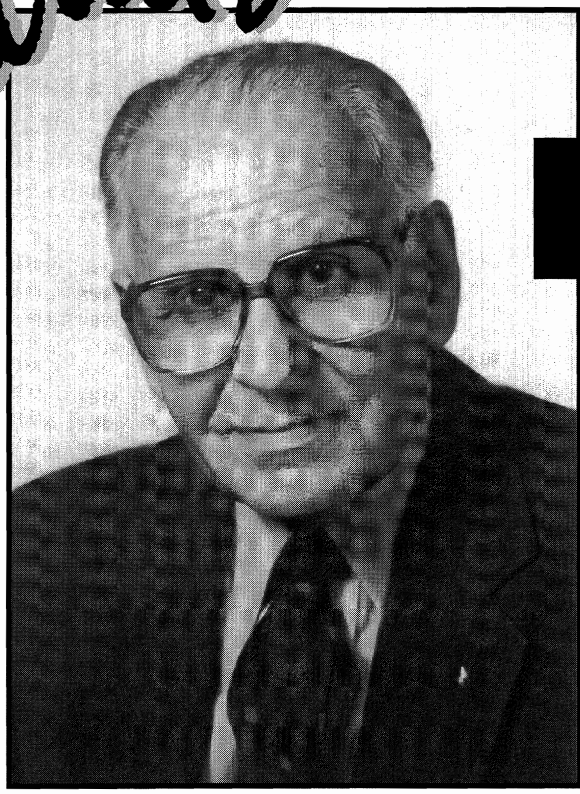

President Emeritus, Radio Club of America
Industry Consultant, Intertec Publishing

Fred Link

for all you've contributed to our industry, the Radio Club of America and our lives.

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From your fellow radio club members at *Mobile Radio Technology, Cellular Business, Cellular & Mobile International* and *Wireless World* magazines.

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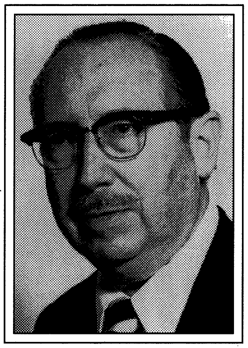


The AN/APS-6 Radar

By Frederick G. Suffield, P.E.

"There was not a night that went by that we did not give thanks for the intercept radar that our Grumman Hellcat airplanes were equipped with," so stated retired Navy Capt. Hawley Russell, who was the commander of one of the first night-fighter squadrons in the Pacific during World War II, in a meeting with the author in 1979. (See Photo 1.)

In late 1942, Grumman was starting production of the F6F Hellcat fighter aircraft. The Navy realized that a night-fighter version would be required. Originally, Sperry was placed under contract to build the AIA radar. The total quantity was 456 sets, with 274 flying in the F6F-3N aircraft and the remainder as spare, test and training sets. Due to problems, the Navy wanted to complete the contracts for the AIA by March 1944 and phase-in the newer AN/APS-6 radar. The Navy had seen the need for a new antenna type and made the specification a part of the AN/APS-6 specification.

[A] small team of young engineers, by dedication and many long hours, completed the design, test and release-to-production of the first AN/APS-6 radars within six months.

Originally, the Navy went to Westinghouse in Baltimore with the request for them to review the AIA program and see where they could help. This division of Westinghouse had long been a supplier to the Navy and was well-known for its excellent quality and reliability.

A team of Westinghouse engineers went to the Radiation Laboratory in Boston where they spent more than a week examining of the AIA components, the MIT Radiation Lab work and the existing antenna and modulator. Their visit included discussions with Radiation Lab employees and Navy employees and staff. They actually started some of the necessary redesign work while in their Boston hotel.

This small team of young engineers, by dedication and many long hours, completed the design, test and release-to-production of the first of the AN/APS-6 radars within six months.

Prior to this time, work had been initiated both in Baltimore and at the Westinghouse Research Laboratory in Pittsburgh on microwave mixers, pulse transformers and crystals.

The radar was to scan a 120° cone-shaped volume ahead of the aircraft flight path in selected ranges of five, 25 and 65 miles for radar search, with the maximum range extended to 100 miles for radar beacon. When within one-half mile of a selected target, the set could be switched to the *gun aim* mode for accurate aim-and-fire of the six 50-caliber aircraft guns.

Production

In late 1943, Grumman was producing about 75 F6F aircraft per week. Of these, initially 50 were scheduled to be F6F-5N fighters with the AN/APS-6 radar, starting in late March 1944. Because Grumman wanted at least a month's lead-time of production radars on hand prior to starting installation, the company thus required the first 50 of the Westinghouse units by March 1, 1944.

Starting with the 50 units per week, the production rate increased until VJ day. Not only were the units for installa-

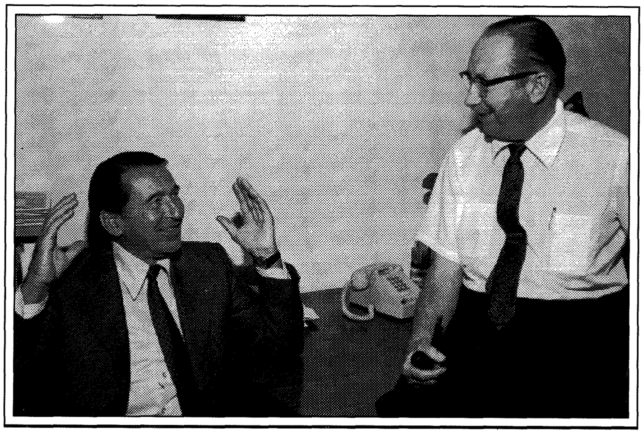


Photo 1. *"There was not a night that went by that we did not give thanks for the intercept radar that our Grumman Hellcat airplanes were equipped with," retired Navy Capt. Hawley Russell (left) told the author in 1979. Hawley was the commander of one of the first night-fighter squadrons in the Pacific during World War II.*

tion in the F6F aircraft, but additional units were required for training, testing, Navy Labs and Link trainers. In addition, as was common with American equipment, some were shipped to the British.

In that Westinghouse had promised the Navy that they would commence delivery six months after the start-up date, the early work with the Research Lab working with the Baltimore Electronics Division was a major step in meeting delivery.

Another step toward accelerating delivery was the release-of-drawings to the model shop for the initial six test-and-development models in parallel with the release-of-drawings to production. This was a risk, but it paid off in saved time. However, it entailed quite a bit of action by the engineers with the changes as determined from the six models being sent in the form of changes to the production shop almost daily.

In parallel with production was the training of the test employees and the development and fabrication of the necessary test equipment.

Constant coordination between Westinghouse engineers and Grumman, Navy BuAer, Navy Test facilities, Link Aviation (for the trainers), Dalmo Victor (for the antenna), Stromberg Carlson (for the modulator), the Radiation Lab and others was required.

Taking into account the aircraft produced, the spare sets and spare parts, the units for training, test and field installations, several thousand AN/APS-6 radars were produced.

Specifications

In contrast with today's six-foot-high stack of papers to define a radar, the Navy specification RE-9088 for the basic radar AN/APS-6 consisted of 32 pages with two addendum. The Navy specification for the Dalmo antenna RE-13A-633 consisted of 17 pages with three addendum. In addition, the list of referenced specifications, which today can run into many hundred, covered only five for the radar and seven for the antenna. In today's over-preoccupation with secrecy and over-classification, it is interesting that the two specifications were "Confidential."

Early in the design stage, it was felt that the advantages of the new design for the "transmitter-converter" as it was called, now known as the receiver/transmitter or R/T unit, were such that time should be allowed to fully test the new design before going to full production. With that in mind, it was decided to use a modified AN/APS-3 RF head or R/T unit for the first 150 radars produced. It was here that the Navy made one mistake. It called the interim set the AN/APS-6A. Normally, later, improved versions of equipment were designated with model number *A*, then *B*, then *C*, etc., suffixes. All during the war, pilots in the Pacific who were very happy with the -6 would, upon hearing about the -6A model, kept asking When would they get the improved model? Our field engineers were kept busy trying to explain that the -6 was better than the -6A.

At the time-of-issue of the *A* version of the specification in July 1943, the Navy had not made up its mind as to the range choices for the control unit. It was about the time of the issuance of the *B* version of the specification at the end of December 1943 before the Navy settled on the range choices. In an attempt to save time, the drafting department was asked to make about four sets of control unit panel drawings in all the possible combinations so that when the decision was finally made it could be immediately released to production.

Receiver/transmitter unit RT-17/APS-6

The heart of an airborne radar is the receiver/transmitter or R/T unit. This consists of the microwave magnetron; the magnetron filament transformer; the associated magnet; the local oscillators (Klystrons); the waveguide mixer/duplexer assembly with the T/R and R/T cavities; the voltage supply for the *keep alive electrode*; the pre-amplifier or front-end of the receiver; the automatic frequency control unit; and the pulse transformer to couple the magnetron to the pulse modulator. This small box contains high-voltage pulses, steep-wavefront signals, sensitive crystal detectors and built-in shielding to allow 40-kilowatt pulses in the same area as the sensitive receiver capable of detecting signals in the microwatt level. Not only does shielding have to be considered, but cooling as well.

Prior to the meeting at the Radiation Laboratory at MIT to discuss the AN/APS-6 radar, the

Westinghouse Research Laboratory at Pittsburgh (Dr. William. E. Good and Dr. John Coltman) had been working with the Baltimore Electronics Division (Cyril E. "Cy" McClellan) in developing various components for radar application. Work had been going on in the area of improved insulation for very-high-voltage transformers, such as pulse transformers, in conjunction with Reuben Lee in Baltimore, who was designing pulse transformers with extremely good waveform. McClellan headed the activity to pull all of the inputs together to design a most compact production R/T unit.

The development of the integral-magnet magnetron at this time also was a great help because the early 725 magnetrons with eternal magnets were heavy and bulky. The 2J55 magnetron, together with its magnet, was a compact, lightweight 9,375MHz 40-kilowatt unit. It was clear that the new-design R/T unit would be the best direction to go for the improved radar.

The design target was a cylindrical, double-walled can about 14 inches in diameter and 16 inches long. This configuration took many tries at the packaging. Components were moved around, mock-ups were made and tests were run for clearances, cooling, shielding, assembly and service considerations.

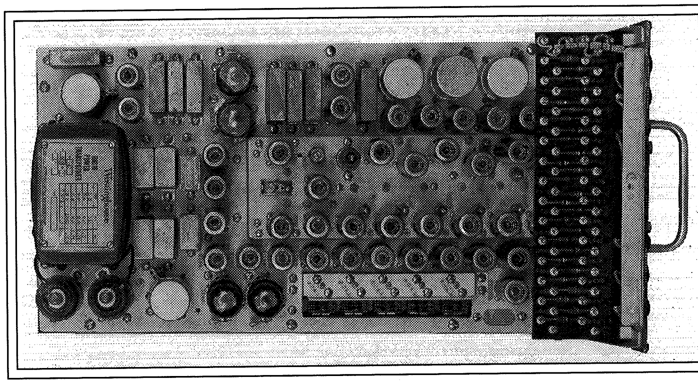
It soon became apparent that this goal would take slightly more time to achieve than originally was estimated, so, with the agreement of the Navy, it was decided to use a slightly modified ASD AN/APS-3 RF head with the IF frequency and AFC changed to match the APS-6 plan, and with cables adapted to the interface between the -3 and the -6 radars. This plan would be carried out for the first 150 sets off of the production line, and then the radar would change to the original design goal with the newer RF head.

Cy McClellan was the prime engineer for the RF head.

Receiver/amplifier R-35/APS-6

From a circuit standpoint, the receiver/amplifier R-35/APS-6 was the most complicated unit of the radar. (See Photo 2.) With a series of timing circuits, it generated the sweep voltages for the display; the information for the cathode ray tube to show the relative azimuth and relative elevation of targets; the even more complex display of the simulated aircraft for *gun-aim*; and the ±2,000 volts for the cathode ray tube, the receiver IF amplifier, the detector and video drive circuits, the beacon display and other related circuit functions.

The receiver/amplifier is frequently called the *synchronizer* because of its complex circuits. In the days of World War II, old-fashioned devices called vacuum tubes were used. In all, it took 45 tubes: 26 6C4 miniature triodes, two 6SL7 dual-triodes, two 2X2 high-voltage rectifiers, two 6V6 pentodes, 10 6AK5 miniature pentodes and three 2D21 miniature gas tetrodes. Just think what today's solid-state devices would do to reduce the size, complexityy and power consumption!



▲ *Photo 2. From a circuit standpoint, the receiver/amplifier R-35/APS-6 was the most complicated unit of the radar. Because of its complex circuits, the receiver/amplifier is frequently called the synchronizer.*

The receiver IF section was on a separate subchassis that could be removed as a unit, thus simplifying manufacturing, and testing and servicing.

For reliability, larger capacitors were oil-filled paper, smaller ones, mica. All resistors were 5% tolerance.

Six of the 6C4 miniature triodes were used as diodes, rather than using 6H6 tubes, with the intent to minimize number of tube types, thus simplifying field service and spare parts stocks.

Circuit considerations within the receiver/amplifier resulted in several decisions that proved to be very helpful to the people in the field.

The preferred number series of resistor values was being introduced by the joint Army/Navy standardization group, and this seemed to be a very good approach to simplifying the resistor value choices. Although there was a 20%, 10% and 5% series of values, it was though that by internally standardizing on all 5% values for the radar there would be several advantages. There would be a narrower spread of voltages in the production units and, in the field when parts were removed from the spare parts stock, one would not face the possibility of selecting a 20% part for a circuit that required a 5% part. This plan seemed to be such a good idea, and it was supported by reports from field engineers, so we tried to require the same set of preferred values for capacitors. A representative of one large capacitor manufacturer looked at this requirement and told us that there was no way his company would ever go to the preferred number values! Wonder where this fellow is today?

Aubrey Vose was the responsible engineer for this unit, including the receiver design, and the unit did an excellent job as proven by field reports.

The antenna or scanner AS-24/APS-6

Early work on antennas for the fighter aircraft was based upon the AIA radar for the Navy and used the frame type of scan. The reflector's stop and reverse motion was a mechanical problem, as well as a maintenance problem. Sperry was building the AIA radar, and the company was overloaded.

The Navy wrote a specification for the new antenna design, which was a spiral scan, 1,200 rpm, nod four cycles per minute from dead ahead to 60°. This specification resulted in a solid cone of 120° radar sensing ahead of the aircraft. A two-phase generator coupled to the spinning antenna gave angular position data, and a potentiometer across the generator gave azimuth data. To go to the *gun-fire* condition, the antenna continued to spin, but it was locked at approximately 3.5° continuous spin so that, with the overlap of the beamwidth, one had direction information relative to dead ahead. The plan was to mount the antenna in a small radome near the end of the aircraft's right wing, and to minimize drag and to reduce weight on the wing, extensive use of magnesium was implied. (See Photo 3.)

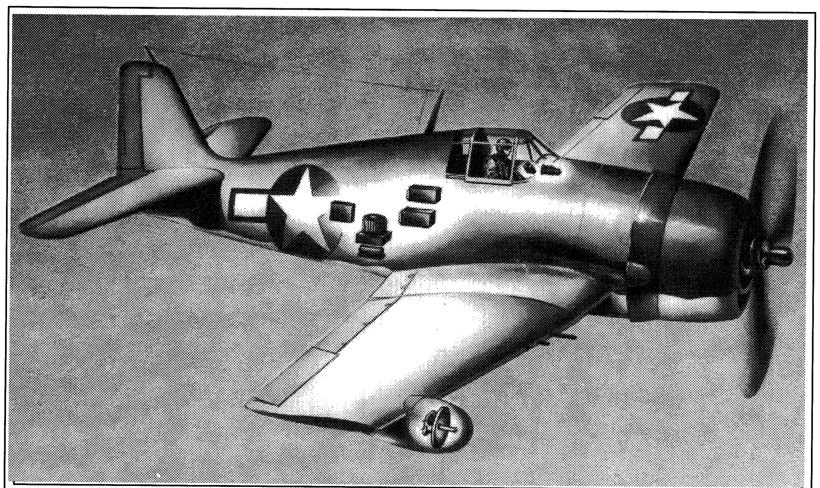


Photo 3. The radar antenna or scanner was to be mounted in a small radome near the end of the aircraft's right wing to minimize drag and to reduce weight on the wing, so magnesium was used extensively in its fabrication. This picture also shows the positioning of the indicator in front of the pilot and the auxiliary control unit to his left. Behind the cockpit are the rectifier power unit, the receiver-amplifier and the modulator. The transmitter-converter and junction box are behind the wing-mounted antenna.

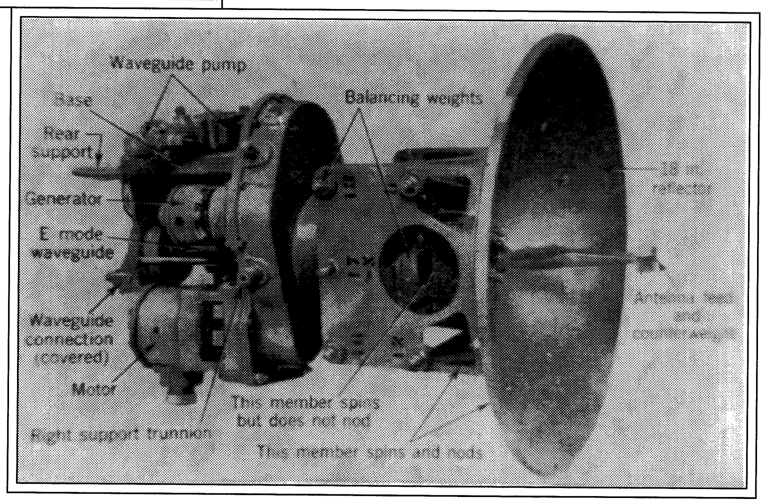


Photo 4. The AN/APS-6 spiral scanner's (antenna) size constraints required a small configuration for the drive motor and 20-cycle generator. The complex scan required careful balancing.

The antenna sources on the East Coast were heavily loaded, and fabricators there had very little experience with magnesium. Because of the large number of aircraft manufacturers ranging from San Diego to Seattle on the West Coast, there were more manufacturers there with experience in magnesium. In addition, Dalmo Victor a manufacturer just south of San Francisco and headed by T.I. Moseley, had been casting and fabricating magnesium. The Navy held a meeting with potential antenna manufacturers to discuss their requirements, and Dalmo Victor appeared to have the fabrication experience and capability necessary to build the antenna. Before the meeting was over, Moseley came up with a quote of $20,000 each for 50 antennas.

Cy McClellan was requested by Westinghouse management at the meeting to prepare a purchase request for the antennas, and there was quite a bit of excitement in the purchasing department the next morning when McClellan came in with a purchasing requisition to a company they had never heard of, for $1 million. Although Dalmo Victor had no microwave or antenna-building experience, the company learned fast, led by Moseley himself. The size constraints required a very small configuration for the drive motor and the 20-cycle generator, and because the motor companies were overloaded, Moseley and his team designed and built their own. The complex scan required careful balancing and no Dynetric balancing machines were available, so the Dalmo crew devised their own technique, which did the job. (See Photo 4, previous page.)

The modulator MD-9B/APS-6

After consideration, it was decided to retain the Stromberg Mark II model modulator that already was

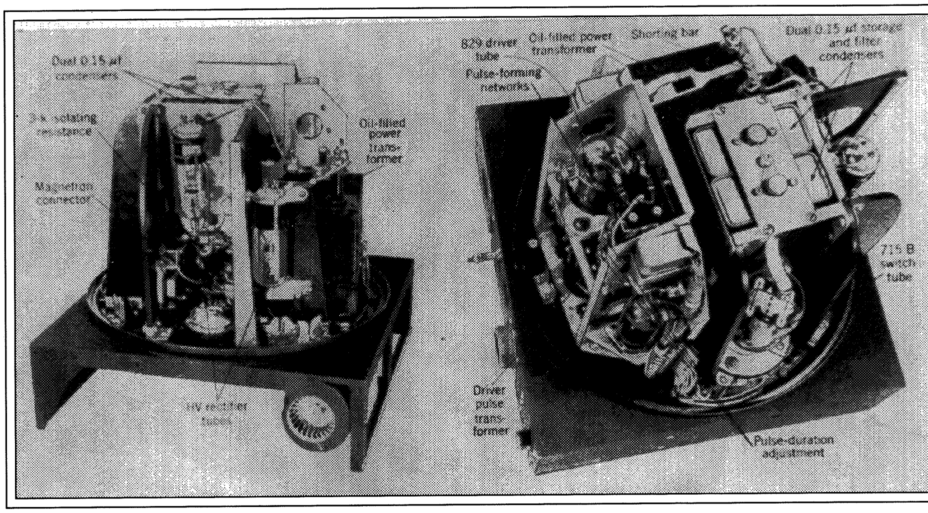
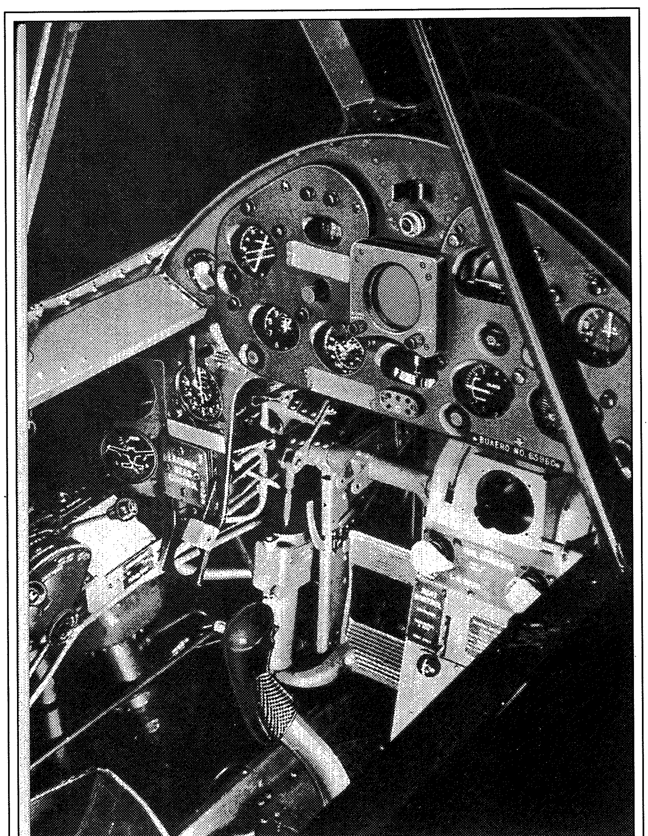


Photo 5. The radar modulator was designed by the Radiation Laboratory at MIT and already was in production as the Stromberg Mark II. It had been and was in use in several radar systems in the field. Using this unit saved considerable design time.

in production. (See Photo 5.) It had been designed by the Radiation Laboratory at MIT and was in use in several radar systems in the field. Continuous upgrades made by Stromberg and the experience of field use indicated that the modulator was a very reliable unit. Using this unit would save considerable design time. Al Palmes served as the engineering coordinator for this unit.

The modulator is well-covered in the Radiation Laboratory Series, Volume 5, "Pulse Generators," pages 140-152.



The indicator ID-32/APS-6

The indicator was to be mounted in the center of the pilot's instrument panel, and because this was a small, compact, panel in the F6F, there was little room. The top center seemed to be the logical place, but the arrangement of the instruments was considered to be sacred. Much discussion and several models resulted in the slight rearrangement necessary to get the indicator in the best location for the pilot to use it. (See Photo 6.)

The actual size of the indicator was critical, and because the cathode-ray tube size was a limiting factor, the electrostatically deflected 3-inch type 3FP7 was selected. An amber filter held back the bright initial blue flash from the phosphor and passed the longer persistence of the display. A short shield hood was available to place between the indicator face and the pilot's eyes to aid visibility.

A big consideration in the design and packaging was the requirement for the utmost in reliability. One could not be disassembling instrument panels of aircraft to service the indicator very frequently. In addition, the area was not pressurized, and it was subject to high shipboard humidity. Moreover, space behind the panel was limited.

The author designed the indicator in close liaison with Grumman employees. All of the internal resistors and capacitors were mounted on small terminals mounted, in turn, on small ceramic insulators to increase the leakage path. The few controls were located on a board set at a slope to save space at the rear of the unit, and they were operated by short, flexible shafts of bronze cable connected to the knobs at the front panel. (See Photos 7 and 8.) It required several trips with mock-ups to Grumman to complete the front

Photo 6. The indicator was mounted in the center of the pilot's instrument panel. Much discussion and several models resulted in the slight rearrangement necessary to get the indicator in the best location for the pilot to use it.

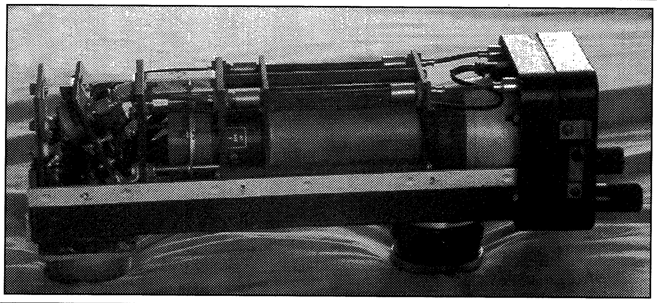


Photo 7. All of the indicator's internal resistors and capacitors were mounted on small terminals mounted, in turn, on small ceramic insulators to increase the leakage path. The few controls were located on a board set at a slope to save space at the rear of the unit, and they were operated by short, flexible shafts of bronze cable connected to the knobs at the front panel.

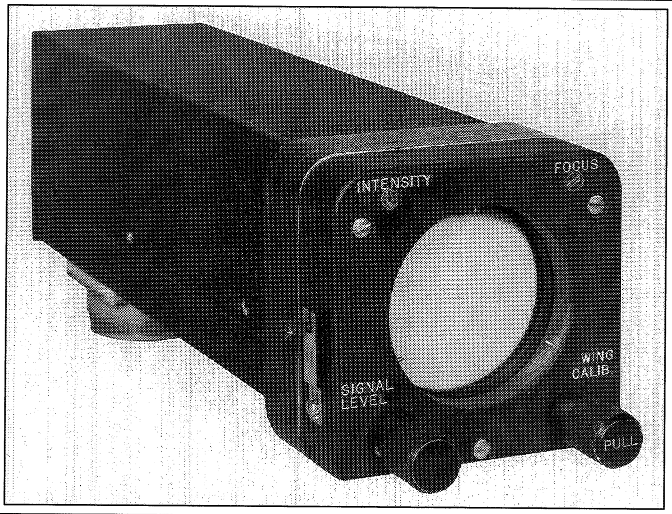


Photo 8. Another view of the indicator.

panel and connector location in conjunction with the aircraft pilots and others who worked on the control panel.

Display

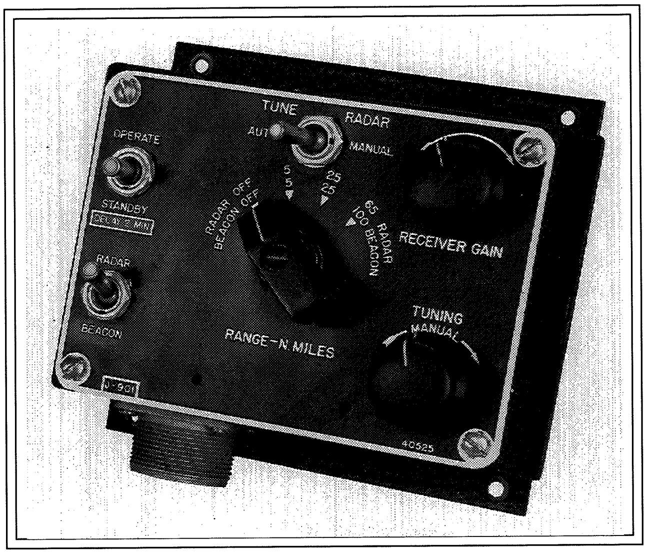
The spiral scan antenna allowed the use of a clever display. The 3-inch cathode-ray tube indicator was mounted in the top-center of the pilot's panel. For *search*, the display was a modified type B. The range to 65 nautical miles was displayed vertically from the bottom of the display up, with the azimuth to the left and right of the vertical center line. The presentation was a double-dot spaced 1/8-inch to 3/16-inch apart. Range and relative azimuth were read from the left dot; the right dot indicated target elevation relative to the flight path of the F6F aircraft. If the two dots were level, the target was on the pilot's projected flight path. The dot below or above the target dot meant that the target was below or above the flight path, respectively. Thus, on one two-dimensional face of the cathode-ray tube, the pilot had a three-dimensional data display of range, relative azimuth and relative elevation.

The pilot's job was to get behind the target at the target's altitude and close to within 3,000 yards. At this point, he switched the radar from *search* to *gun-fire* mode. This change locked the antenna into a conical scan of 3° to 4°, and the display changed to that of a larger dot with "wings." The filter in front of the 3-inch cathode-ray tube had a circle engraved in the center about 1/2-inch in diameter and two vertical bars each side of the center circle. The pilot now had a simulated optical gun sight with range indicated by the length of the horizontal "wings." By keeping the dot centered and by approaching the target until the "wings" reached the short vertical bars, pilot would bring the F6F about 250 yards behind the target. Then he would fire his six .50-caliber guns — quite a surprise for the unsuspecting target.

Power supply PP-16/APS-6, cables and connectors

The three elements of the power supply PP-16/APS-6, cables and connectors are grouped together because they compose one of the generally overlooked problem areas. An experienced engineer, John Gilhooly, handled this complex area. In the preliminary stages, the circuit designers are determining the voltage and current for the various circuits, and because everything is in a state of flux, they can only give vague sets of figures to the power supply designer, who is in an even more difficult position in trying to give the transformer designers useful data. For a radar to perform under the conditions of humidity, shock, vibration and varying line voltage in the field, the iron-core components must be very rugged. On top of this, the varying voltage from the aircraft generators means that sufficient voltage margin must be designed into components to prevent breakdown. The wide temperature range of operation means that the heat rise of each component must be designed conservatively. Thus, the power supply designer is last to go to work, and yet the power supply is the most critical component.

Cables and connectors are other generally neglected items. As circuits change, more pins are needed on the connectors. The specifications calls for a certain number of spare pins. Consideration must be given to adjacent pins' waveform, current and voltage. Connectors must be selected so that no one can inadvertently insert the incorrect connector into the sockets on any one unit. The color-coding of wires, which is a great help for field maintenance, must be carefully defined. Wire sizes must be selected carefully to allow for the installed length. The lengths of cables must be



▲ *Photo 9. The control unit had a range selection for both radar and beacon modes, receiver gain, manual tuning (as backup for the automatic frequency control), operate-standby switching and radar-beacon selection.*

coordinated with the aircraft manufacturer, and the manufacturer must be continually aware of the sizes and weights of not only the cables, but of all the equipment. Clearances and weight and balance are most importantt items to an aircraft manufacturer. John Gilhooly not only coordinated the power supply design, he worked closely with Grumman in the equipment installation and in the cable design.

Control unit C-46/APS-6

The control unit had a range selection for both *radar* and *beacon* modes, receiver gain, manual tuning (as backup for the automatic frequency control), operate-standby switching and radar-beacon selection. (See Photo 9.) For some time, the Navy had difficulty in settling on the choice of ranges to display. The Navy vacillated so much that we made four or five separate final artwork layouts for the reverse-etched panel and held them all until the final decision came along. Then we were ready.

The *range selection* would be the most used knob, and because the pilot had gloves and no time to be delicate in operating the switch as one might be in a laboratory, we selected a very rugged switch assembly and a knob that had been used on several Westinghouse Navy radio equipments in the field. The switch assembly had proven to be rugged. Rather than being pinned with set screws, the knob was pinned to the shaft by a stainless-steel pin that fit into a slot molded into the knob and extended through hole through the shaft. The knob was retained to the shaft by an axial screw. This combination made the knob almost impossible to damage or cause it to slip.

Auxiliary control unit C-47/APS-6

The very small auxiliary control unit was located so that the pilot could hit the switch with a gloved hand without looking at it. The unit changed the radar display from *radar search* to *gun-aim*. This switching was done when the target being tracked was within 1,000 yards, and there was no time was available to look at knobs and labels. This switch changed the indicator display from a search display to the type G display in which a simulated aircraft showed a central dot with short wings. Adjacent to the switch was a knob-type control for adjusting the amount of *sea return* displayed.

Weight

The weight of the units and the entire radar (including shock mounts, where applicable) were:

UNIT	WEIGHT IN POUNDS
Modulator	62.8
Scanner (antenna)	52.6
Receiver/amplifier	30.7
Rectifier/power	37.8
Trans/converter	40.7
Indicator	5.9
Control box	1.2
Wing junction box	2.1
Waveguide section	0.5
Auxiliary control unit	0.7
	235.0
All cables	68.3
Installed weight	303.3

The F7F installation

As the Grumman Aircraft Corporation started working on the F7F design, the Navy wanted to consider the AN/APS-6 radar for this new aircraft. The F7F was a two-man aircraft, so an additional indicator was called for.

The number to be considered was 250 aircraft, thus probably 300 or more sets of the radars and the dual indicator parts would be required. The order was placed with Westinghouse for the radars and the new junction box, cables and indicators, including spares.

Because time was most important, design considerations included the use of as many parts as possible from the items used in the basic radar. This duplication would mean that production could be started very rapidly without a time lag to order new component parts. Production of the additional indicator was merely a case of increasing the delivery order and schedule with the Philadelphia M & R plant.

By using of one of the standard indicators, only one new item, the junction box, would be required. By careful design calculations, internal coupling components that would introduce minimum phase-shift into the display were selected; thus, alignment and accuracy of the basic radar would be maintained.

All of these components were used in the basic radar, so no new purchases would be required with the attendant delay in procurement.

In no time at all, the design was completed, and it was released to production. Then the Navy, which was having "Wave-off" problems with the F7F, cancelled the order.

Subcontracting

To minimize the loads on manufacturing facilities, every effort was made to subcontract as many items as possible. As a result, Westinghouse's Baltimore plant subcontracted the indicator and the two control boxes to the Philadelphia M & R (manufacture and repair) facility. This small facility had a group of most flexible and creative people. They could take apart, fix and return to use almost anything built by any Westinghouse division. This group had never seen anything of radar and probably never had a cathode-ray tube item to work on, yet they swung into production, improved the test technique, came up with many small but significant changes to reduce cost and improve performancee, and were most cooperative. They exceeded their shipping goals every month.

In their test setup, they observed a shift of the CRT spot in azimuth as the intensity was increased. Simultaneously, this malfunction had been observed in the Baltimore test department. Not all cathode-ray tubes exhibited this defect, but enough did to demonstrate a potential problem. The M & R shop and the Baltimore test department, responding to a request from the engineering department, ran a series of tests, took the data and selected about 20 of the worst-case tubes. The engineering department then rechecked these tubes in the lab and then contacted the Radiation Lab. at MIT to set up a meeting to discuss this problem.

Simultaneously, RCA, the primary source of the 3FP7 cathode-ray tubes, was contacted about the problem. RCA's only comment was, that the tubes met the JAN-1A tube specs and the company could see nothing wrong.

Samples of the tubes in question were taken to the MIT Radiation Laboratory for testing. MIT concurred that it was a problem, particularly for displays such as the AN/APS-6. The Radiation Lab, as a "focal point" for radar, was able to bring pressure upon the cathode-ray tube manufacturers, and a study was initiated by the tube manufacturers. This study resulted in a change in the gun design within the cathode ray-tube. The 3FP7A tube incorporated the improved design, and another 3-inch tube with a later design improvement was the 3JP7. This improvement solved the problem for the AN/APS-6 and other radars that used the intensity-modulated, electrostatically deflected cathode-ray tubes.

Small waveguide items and some small brass parts were subcontracted to the Steif Silver Company in Baltimore, and they did an excellent job.

A small item in the indicator required a non-magnetic stainless-steel part, 1/2-inch long, 1/2-inch in diameter, with two bore dimensions and an internal hex broach — a difficult part to machine. A jewelry company in New York was looking for war work and offered to make the part. The company ended up centrifugally casting the stainless-steel part, something that many of the mechanical engineers in the Baltimore division did not think possible.

It was believed that a visor for the indicator would help the pilots to see the scope face in daylight, so a unit was designed and fabricated out of felt by a hat company in Baltimore.

Protection

As a precaution against loss or damage to the main factory, all drawings were microfilmed, and the films were stored in a secure place well away from the center of the city. Whenever a change was made, another film was made and sent to storage.

Another example of protection of components to assure that production would continue revolved around the special connector used to couple the indicator to the synchronizer. This connector was made by Winchester and was one-of-a-kind. The connector had three center pins in insulated wells for the two cathode-ray tube filaments at −2,000 volts, and the single pin for the +2,000 volts to the accelerating electrode. Surrounding the center pins were 15 smaller pins for the various control and other circuit functions. Four of these connectors were used in every radar, one on each end of the cable connecting the synchronizer and the indicator, and one each of the two units; thus, anything that might happen to the Winchester facility would shut down production, not only for Westinghouse, but for other manufacturers using the Winchester connector. With that in mind, Westinghouse elected to design and fabricate tools to mold the two connectors and to machine the pins. These tools were run to obtain quality-check parts and were assembled and tested. Once they were proven capable of running in production, the tools were put in storage for emergency use only.

Too many new equipments were being shipped to the field with maintenance manuals despite the fact that no one could expect a pilot to wade through hundreds of pages to ascertain how to operate the equipment — they wanted to use it, not fix it. We decided to originate a *Pilot's Operating Manual*. The result was a thin booklet, full of pictures, that became a hit with the pilots. At first the Navy objected, but soon came around to be in favor of it and made it a specification item. Frank Lyon was the spark plug behind this manual, as well as the maintenance manual.

Pulling this paper together from memory and from what little data remain was a long task. Cy McClellan was a great help and a major contributor. Sadly, McClellan passed away before this paper was completed, yet he deserves much credit.

It is interesting to note that *Eagles of Mitsubishi* author Jiro Horikoshi, who designed the Japanese Zero fighter aircraft, paid much credit to the F6F Grumman Hellcat as the Japanese airmen's most formidable foe. His book includes a photo of the F6F with the AN/APS-6 radar mounted on the wing.

After the war, Aubrey Vose, Albert Palmes and I moved to California where we designed and built the first commercial airlines radar. Vose and I then directed the Houston Corporation work in the design and production of the AN/APS-42 radar. This radar was installed in the C-97 aircraft, and it was the first radar installed in presidential aircraft, including the *Independence* for President Truman and the *Columbine* for President Eisenhower.

Anyone possessing AN/APS-6 radar components should consider donating them to the Historical Electronics Museum. Sadly, insofar as I can determine, no one saved even one radar for historical purposes. The data files at Westinghouse were cleaned out periodically. A representative of the Navy said that all its information was sent to a location in Philadelphia, but no one seems to know exactly where or under what name. Somewhere, in a warehouse, there probably are several complete radars in original crates, stored since 1946, just waiting to be found!

The Historical Electronics Museum's mailing address is P.O. Box 746, M.S. 4015, Baltimore, MD 21203; telephone 410-765-3803; fax 410-765-0240.

Frederick G. Suffield, P.E. (F), is a fellow in the IEEE. He has been engaged in the design of radar and systems since 1939. He lives in Sequim, Washington.

Alfred H. Grebe, 1895-1935

(continued from page 6)

provided on-site transmissions for relaying program material to the main transmitter.

Quoting William S. Paley (*As It Happened*, page 64): "We bought our home station, WABC, from a maker of radio sets who thought that the manufacturing side of the business would be much more profitable than broadcasting itself." Grebe, the "radio set maker" not named by Paley, was correct at the time, but his love of manufacturing blinded him to the future of broadcasting.

In December 1928, WABC (now WCBS) was sold to Paley for about $390,000 and formed the nucleus of the Columbia Broadcasting System.

We will never know "what might have been," but we can remember Alfred H. Grebe and his actual contributions and accomplishments in the field he dearly loved: radio.

Alan Douglas (F) writes on radio and electronics history and has published the three-volume Radio Manufacturers of the 1920s, *Vestal Press, 1988, 1989 and 1991. He lives in Pocasset, Mass.*

Alfred H. Grebe Jr. (LF) earned a B.S.E.E degree and an M.S. degree in management from Rensselaer Polytechnic Institute. He retired in 1993 after 17 years with General Medical Corp. in Richmond, Virginia, where he was director of quality assurance and regulatory affairs. He lives in Richmond.

Biographical data

In 1912, Alfred H. Grebe used the amateur radio call sign 2LH and, later, 2ZF, and still later, in 1916, 2PV. He joined the Radio Club of America in January 1915, and he presented a paper before the club on Sept. 15 that year titled "A Modern Experimental Radio Telegraph and Telephone Station." He was made a fellow in 1920 and served on the board of directors in 1929.

Grebe joined The Institute of Radio Engineers in 1917 and was elevated to fellow in 1927. He served on the board of directors of the IRE from 1921 to 1926 and was reappointed in 1928. He served on many committees of the IRE, and in 1928, he served on its board of directors.

More than a dozen U.S. patents were issued to the Grebe Company, with most of them having been issued to Grebe personally. In addition, at least seven Canadian patents were issued to the Grebe Company.

—*Jerry B. Minter*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LIGHTNING
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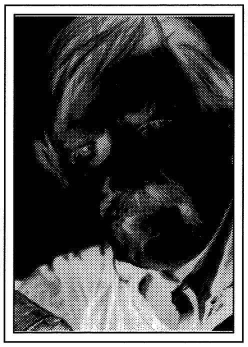


Insanity In Charge: Welcome to the New Normality

By Dr. Don Erickson
Illustrations by Bryant Robert

Prologue ...

Is there a moral or ethical component to a scientist's findings or an inventor's creations? Most readers will remember the arguments about this that were brought on by the creation of the atom bomb (and much earlier, the invention of dynamite). It is doubtful that many or any members of the Radio Club of America have given much thought to *how* their inventions and discoveries have been used by the commercial interests, the government, religion or malcontents of the world.

... [M]illions of people live in two (usually) contradictory worlds simultaneously.

Even so, most readers of *Proceedings of the Radio Club of America* always have been aware of a continuing debate over the *effects* of the content of media, especially broadcasting. This monograph attempts to describe some far deeper effects on personality caused by television and media consumption than has been attempted during the previous 40 years. I tend to side with those who believe that the scientist should not be held responsible for his or her inventions. However, when I think of such subjects as chemical warfare, I run into an intellectual dilemma of major proportions! After all, one *knows* what one is doing when one is involved in chemical warfare!

Now, enter a world in which a person uses the unconscious mind, the conscience mind and a *third* consciousness — *illusion-as-reality* — and the behavior that must follow. In other words, from the inventions, uses and marketing efforts of the electronics field we all love can come some bizarre effects in addition to the positive effects.

'Twilight Zone'

You're reading this with the conscious mind. Perhaps below the threshold of consciousness, other thoughts register subliminally. Somewhere, in between this Awareness and Non-awareness, the mind functions in a "twilight zone" of conscious illusion: A world of insane sanity or sane insanity.

The reference to a twilight zone is not accidental — it is a direct reference to television, and just as Rod Serling insisted that this *Zone* can be very real indeed, I wish to postulate that millions of people live in two (usually) contradictory worlds simultaneously. For them, the real world tends to intrude on the world in their mind, a world created by a gross intake of mass media, especially television.

Of all the mass media, television has inspired the largest amount of theoretical and practical research in the shortest period. Television is barely 40 years old as a commercial and popular medium. To pass from invention to experimentation to commercial acceptance by the general public took only two decades (1930-1949). By the end of the 1950s, most Americans had at least one TV set in their homes.

Video

Today, many call television "video," and the TV screen receives messages from traditional (through-the-air) broadcasting, cable, satellites direct to the home, video cassette recorders (VCRs) and laser disc players — and from compact-disc, read-only memory (CD-ROM) players on computer video screens.

Noticeable effects of television programming and advertising had caught researchers' attention as early as the 1950s when the U.S. Senate (under Senator Estes Kefauver) held hearings on television's "effects on children." There has been no let-up in research on effects, conscious and unconscious (subliminal) manipulation, improving visual techniques, improving TV signal quality and creating new video systems (e.g., digital TV, high-definition TV and laser-disc TV).

However, only minimum research or comment has been devoted to the deeper effects that large quantities of TV viewing can have on a child and an adult in areas beyond "violence" and "consumerism." The teaching environment of media (using "teaching" in its most broad sense) is as important in creating the individual as are the family, the school, the church, peer effects and any other major influence on an individual's thinking and behavior. Indeed, in many people the "socialization" or "humanization" or "civilizing" effect of mass media overrides and supplants all other non-physical influences.

Third Consciousness

Television and media consumption can create The Third Level of Consciousness in a person who is totally conscious, but who is operating and functioning in two worlds, one real and one "real," with both operating simultaneously.

A favorite science-fiction author of mine is Harlan Ellison. Ellison also has been a TV critic, not only of programming, but of the medium's effects. I know of two books containing his TV columns (*The Glass Teat* and *The Other Glass Teat*), and I have used them in the classroom very effectively. In an introduction to one of his books of short stories, he reports the following anecdote that exemplifies someone functioning in two worlds, one real and one "real," simultaneously.

Bonanza

Actor Dan Blocker, who played the character "Hoss" Cartwright in the early TV series *Bonanza*, often appeared at shopping malls and one kind of promotional event or another. He told Ellison that at one particular event, a small, middle-aged woman approached him to say how much she enjoyed *Bonanza*. He thanked her for her kind remarks. On parting, she added " ... and when you get back to the *Ponderosa*, tell your daddy to get rid of that Chinese cook and get a real good female cook." Because she said it with such sincerity, Blocker realized that she was serious, and he felt obliged to say, "Excuse me, ma'am, but my name is Dan Blocker. 'Hoss' is just the character I play. When I go home, I'll be going to my house in Los Angeles and my wife and children will be waiting."

She went right on, Blocker tells Ellison, "just a bit affronted because she knew all that, what was the matter with him, did he think she was simple or something, 'Yes, I know ... but when you go back to the *Ponderosa*, you just tell your daddy, Ben, that I said ...' "

Ellison observed, "For her, fantasy and reality were one and the same."[1]

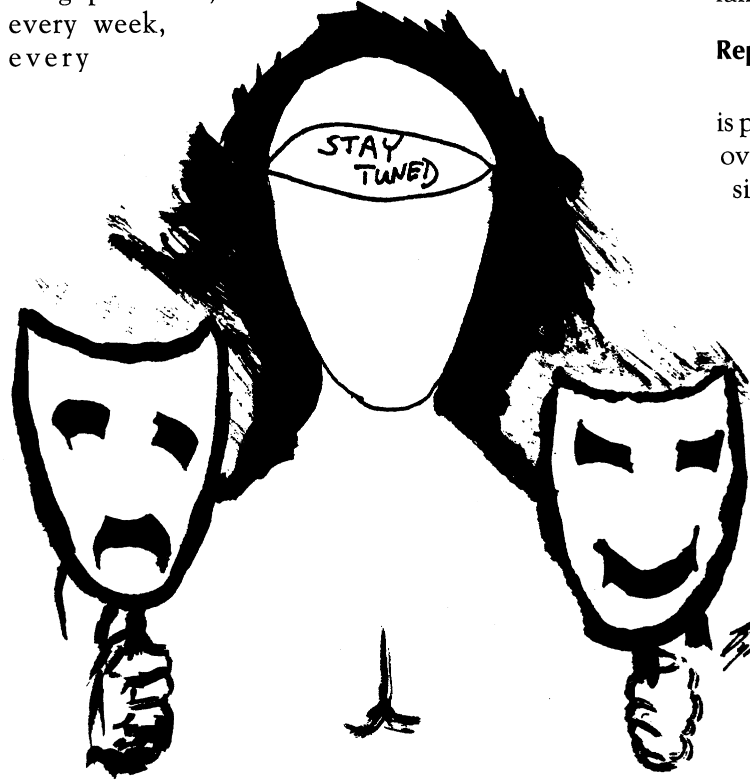
It is quite possible that

1. Ellison, Harlan, *Strange Wine*, Warner Books, New York, 1979.

you may not fully grasp what Ellison, Blocker and I are trying to convey. This woman lives in a world of media fantasy, knowing that it is fantasy, yet believing that the fantasy world exists. *Truly* exists. Blocker said that the same sort of thing happened to him *all* the time. Others who study TV soap opera program addicts have seen the same phenomenon.

A new demographic

We need to add a new "demographic" to the way we categorize people: age, race, sex, income, religion and *media freak*. The media freak may watch about 30-40 hours of television per week. In addition, some may read a daily paper, read a magazine or two, read a paperback, listen to a car radio, see a film or rent a film for the VCR. Some media freaks may watch as much as 50 hours or more of programming per week, every week, every month, every year. The average U.S. adult spends more than *half* of his or her waking life with the media!



Television tends to polarize people as a result of watching so much. " . . . [H]eavy viewers are more stereotyped in their thinking, seeing people as either good or bad, weak or strong." The world is OK or a disaster; buy or sell; you're either with me or against me. Behavior may be based on "who I am today," and that behavior will be based on a variety of television and media role models, many or most of whom are "bad," whether human or animated. The schizophrenic part is that such a person "talks" against, for example, violence, but exhibits it and approves of it by inaction.

(Davison, Boylan and Yu, Mass Media: Systems and Effects, *Praeger Publishers, New York, 1976, p. 163.)*

Obviously there *has* to be effects! Effects on cognition, perception, analytical abilities, needs and wants, desires and wishes, attitudes and beliefs. Not to mention such obvious things as the priority for the media freaks' use of time, what kinds of time they can give to family, friends, work and physical leisure. What kind of mind-set or frame of reference can they bring to a *real* personal relationship?

Serious problems are resolved in 30 to 60 minutes on TV. Never so, in actual day-to-day affairs. A TV program's advice tends to be no more than easy-to-remember platitudes: "Things have a way of working out," "You can do anything you set your mind to," "It all comes out in the end," "Say a prayer; ask God to help," "What can one person do?!," "Who said life is fair?" and "Have a nice day."

Repetition

For all the research that has been done, most of it is predicated on the fact that any act repeated over and over and over and over and over and over and over simply must have an effect. Still, almost nothing has been done to document this creation of a person whose personality is being shaped and reshaped in such a way as to form what might be called (for lack of a better name until research findings can more precisely define the state of mind I am trying to define) The Sane Schizophrenic.

The result of consuming great quantities of all this modern media technology is surely creating a person who has characteristics that can be identified. Such a person probably is more docile (even though they can be temporarily manipulated to take action, to support causes and to experience short periods of excitement). Eventually, they become convinced (without even knowing it) that *action* and *change* are effected merely by having a subject, an idea, a scandal or a problem simply *reported* in the media (in the form of news or entertainment); that is, once the media notices something and programs that "something" in the form of a news story, a documentary, a docudrama, a live event or a movie "based on fact," my Media Homo Sapien is simultaneously "informed" and "relieved." Whether anything *happens* becomes a moot point or is irrelevant.

A serious study is needed to discover whether and to what extent great amounts of unstructured, no-pattern media consumption creates an unstructured, no-pattern (illogical) mind. The more normal patterns of behavior taught directly or indirectly by family, church, formal education and even by the logic required for doing certain manual-labor and office jobs are constantly undermined by the final effects of media bombardment and the residual intellectual build-up of effects that affect behavior.

Eclectic menu

Commercial television fare, especially, mixes a radically eclectic menu of ideas, plots and commercials that, viewed in a linear, chronological order, still make no structured sense. During the first night of continuous coverage of the Persian Gulf War on the ABC-TV network, war coverage was interspersed with commercials featuring Angela Lansbury selling laxatives. Surely, even though we are used to this bizarre mixture of news and commercials by now, it still tends to "teach" *something*: that laxatives and war somehow have a connection.

Because there *is* no connection (beyond some gross humor), it may be that a person slowly has his own abilities for common-sense analysis undermined and replaced by a new and altered way of thinking. Beyond the more-or-less accepted fact that today's students cannot read, write, speak, listen or retain information well and that they have little imagination or creativity, the research I wish to see undertaken might identify a deeper cause and effect among media consumption, the technology that allows it and the characteristics that might be identified in media freaks.

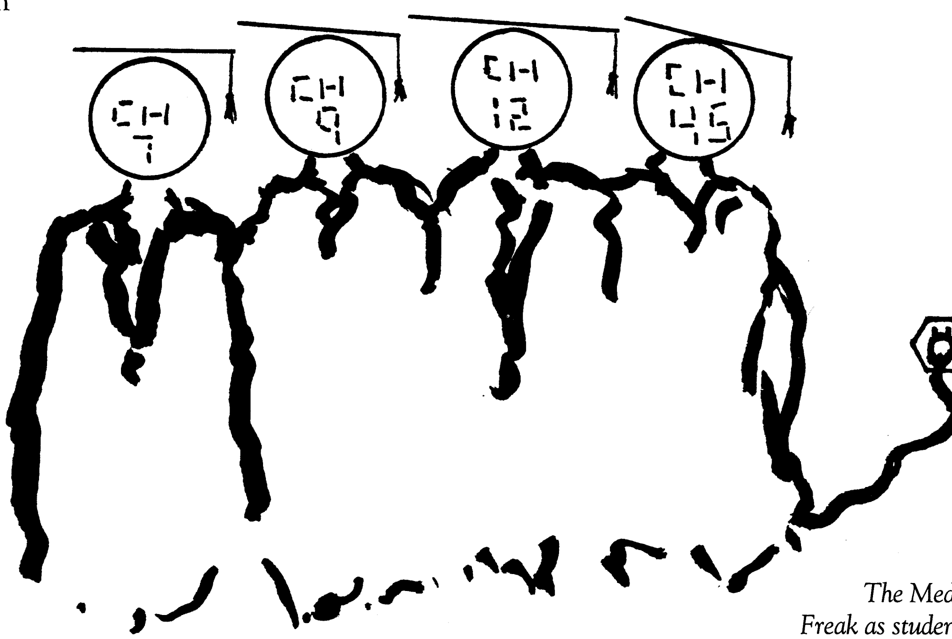
More than one commentator or critic has pointed out this non-linear presentation of material that may be seriously affecting expected normal performance and behavior. In the 1960s, Marshall McLuhan made a big splash with speeches and books on the subject. That he was controversial probably suggests he was correct in his analysis!

Unprepared students

I have been teaching college full-time since 1961 (with some part-time teaching before that). Anyone who has taught continuously during the last 30 years *must* agree that today's students are radically different. If anyone teaching today believes that the caliber of today's students matches that of students from 30 years ago, either he is in an exceptional school (or school district) or he is a liar. The pleasure that came from teaching has all but disappeared because the student now comes to class (from kindergarten through graduate school) *totally* unprepared.

Let me build my case for an altered personality (due to TV and media overkill) by using an example of the change in students. Ninety-nine percent of my teaching has been at the college undergraduate and graduate level, with a few horrible months in the New York City high school, junior high school and 7th and 8th grade classrooms. The college classroom was a pleasure during the 1960s and most of the 1970s because students consciously and unconsciously wanted to learn. It was taken for granted that they showed up in class, remained silent during those lecture moments when it was necessary to remain silent, turned in assignments (on time), took tests, read books, did hands-on laboratory work, performed when it was demanded, took notes (from lectures and texts) and typed perfectly acceptable papers of all kinds and contents.

No more. Now they come with an intellectual chip on their shoulder. Everything is a confrontation. All is argument, not discussion.



The Media Freak as student. "One other reason why Americans aren't learning anything may be our education system. At a Harvard commencement, only two of 23 students could answer the question, 'Why is it hotter in summer than in winter?' What does that portend for our next generation?" (Leon Lederman, who won the 1988 Nobel Prize, as quoted in Modern Maturity, *June 1994.) My own graduate students with bachelor's degrees in marketing could not define "marketing." Their educational channel was full of glitches.*

They ask questions that have nothing to do with the course! Their writing is truly unintelligible. (The horrors go far beyond spelling mistakes and a few grammar problems.) In one of my classes in New York City (Brooklyn), not a single student turned in a major assignment! The due date had been clearly announced in class and in the course outline handed out the first week. That never happened in one of my classes before.

Too much work

Students on a Long Island campus tried to get me fired for assigning 14 chapters to study in a 24-chapter text, plus insisting on the preparation of four case studies (in marketing) when eight cases was the norm. They felt that these assignments were too much work! I might add that this was a graduate class in advanced marketing. All 16 students had a undergraduate degree in marketing/management. Not one of them could define "marketing," but they had degrees! Eight of them had been awarded undergraduate degrees from the same school where they enrolled for graduate study. In other words, they graduated in June with a degree *in marketing* from the same school where they then took advanced marketing, but they could not define what it was! I quit. The advantage of not having a family or a mortgage allows one to do that sort of thing.

Cause and effect

Now . . . back to the point. Something changed. Certainly, the school had no standards. (Try to get a school to admit *that.*) The attitude in the classroom was positively hostile. (One creature told me he wasn't sure whether he should throw me *or* the textbook out of the second-story window.) What could make from 90%-100% of these classes so radically different from 10 or 15 years before? I believe there is a direct cause-and-effect relationship between how the current students were brought up and students brought up during the previous several hundred (if not a thousand) years. Even though you may have your own explanation of "what is wrong" with today's youth *and* adults (and surely most of your reasons will have some kind of validity), in my opinion the major culprit is both the quantity of TV viewing *and* the effects of the way it is programmed.

My case for *TV Effects* goes far beyond anything postulated in the past (but certainly includes all past findings). Today's college students are simply one, extended example. You do not have to be in college to be stupid, arrogant, hostile, illogical, irresponsible or incompetent. But you will get a degree (if you pay your tuition).

A few "facts" from my experience. A New Jersey state college has an average of 33% of its students absent on any given day. No educational penalties accrue to absent students. A New York City high school teacher reports a student for violent behavior. The teacher is warned not to be a troublemaker, and it is implied that he should quit or be fired. A college has 24 sections of remedial English. (Remediation seldom works, any more than prison makes a convicted felon change). Sixty-six percent of all incoming freshman in a *large* east-coast city must take remediation in English, math and other courses, even though they have high school diplomas to indicate that they previously passed similar courses.

Future employees

These are the students some of you will hire! If you are lucky enough to find talented graduates, your new employees still may have personalities that thwart all attempts at teamwork and cooperation. Indeed, you also may get the unwanted baggage of drug or alcohol problems and all the other personal problems that people with such altered personalities bring to work each day!

The concern over media's effects on children is on-going and surely will continue. Research should continue on these younger subjects *and* should follow their progress, lifestyles and performance into adult life and old age. Ingrained habits, good or bad, do not disappear at age 18 or 21! When a child grows out of the researcher's "youth" parameters, he carries with him all of the intellectual baggage he has collected. The ultimate statement on this may be Jerry Kosinksi's novel *Being There* and the movie version starring Peter Sellers.

Normality for the 21st century may even make the presence of a *non*-media segment of our society a serious threat to the *new* Media Freak Majority. The "normality" I speak of is a majority (51% to 99%) of humans "socialized" primarily by media and television directly by consuming as much as 50 or more hours per week for a lifetime, or, indirectly by fathers, mothers, peers, teachers, preachers and role models who have been ingesting these great quantities of unstructured, but powerful, pap.

Educated minority

If there is any truth in this, remember that the majorities, present and past, have given minorities a truly tough time, all the way from ignoring them to disfranchising them to social ostracism and genocide — a charming solution that continues to this very second. The logical, educated, compassionate and competent person already is in the minority. For those old enough to remember, Adlai Stevenson lost a bid for the presidency primarily as the result of a counter-campaign that he was an "egghead" — an educated person — and that was an anathema to the U.S. public.

What we needed was a Nixon or a Clinton, leaders in no danger of being accused of having "brains!" (I did not say that they were not clever — cleverness and intellect are not quite the same.)

A more sobering thought about the growth of Media Freaks is the fact that we will draw from *their* ranks all sorts of "leaders" from Family Head right up to President. I am not the only American who knows that several U.S. presidents of the past 30 years could easily have been inmates of a mental institution. (Dead or alive, they serve as notice as to just how far we have sunk in picking national leaders!)

I have developed some logical and direct relationships between heavy, continuous media consumption, and such trends as the growing divorce rate; use of drugs; increased sexual activity; acceptance of unacceptable behavior in religion, politics, business, academia and personal relationships. I do not see such research as having a goal to change matters . . . it is far too late for that . . . but, instead, to give more effective tools to psychologists to handle such people in school or business or wherever they are found.

People have changed

To me, it is the fact that media programming (television especially) was consumed so extensively during the 1950s that led to much of the 1960s being the decade that the public wanted "accountability" out of its leaders and institutions. Things only got worse; we called the 1970s the Decade of Lies and the "me" decade. The 1980s resulted in more scandals, including illegal and shady behavior at all levels of government and business than we thought possible! By the 1990s, nothing much shocks us anymore, and we accept worldwide antisocial behavior with a shrug and the all-time Champ of Excuses: "Times Have Changed." No way! The role of time in all this trouble is negligible. It is *people* who have changed by being brought up so differently that their actions (seldom their words) have altered the entire planet. The New Normality is simply "not nice."

Properly conducted research is likely to show a direct relationship between many of today's ills (new ones and old ones increasing at exponential rates) such as stock market scandals, the destruction of the nuclear family, the trend away from U.S. manufacturing and the growth of business mergers (mergers being, evidently, the *only* thing a big business knows how to do, until it sells off what it merged with a few years later because the company should not have merged in the first place), intensified race problems, the growth of ill-conceived cults and a 5,000% to 10,000% increase in crime since World War II. American education has slipped so badly that it passed the "danger" stage (1960s), it passed the "at risk" stage (1970s), it passed the "crisis" stage (1980s), and it is now in the "what-in-the-world-can-we try-now" stage (1990s).

Classified ad

As a side comment on education, here is the text of a classified ad in the *New York Times* in October 1986:

> Public Policy Research Institute seeks to commission serious book by current or former teacher showing why public education system has failed and how to reform it.

Notice the use of the past-tense "failed." The Manhattan Institute, New York, knew just what it was saying by using that word. Failed. Failed. Failed. By the way, I was interviewed for that book, and there *is* no way to reform the public education system! If it were possible to give a 6th-grade test (circa 1950) to all U.S. grammar school, high school, B.A. and B.S. graduates today, 50% would fail.

Behavior vs. communications systems

There is a direct relationship on people's behavior based on *how* we use our communication systems, *who* is doing the using and *what* are their motivations (economic, instructive, informative or persuasive). Motivations by a company are as powerful as in an individual. Motivations of a government (i.e., a group of politicians) are taken for granted to be 100% self-serving.

Prof. Herbert Zettl, in an excellent book on media production, aesthetics and ethics, states the users of technology's responsibility very well:

> Wherever we engage in an act of manipulation, we must assume great responsibility. This is especially essential when we manipulate someone's feelings, his emotions, and *ultimately* his behavior [emphasis added]. Most often, the recipient of our . . . messages is not even aware of being, at least partially, manipulated.
>
> There is relatively little difference between the anesthetized patient on the operating table and the . . . unaware television or film viewer. Both persons can do very little about what is happening to them. All they can do is to *trust* us, to trust our skills, our good judgment and, above all, our good intentions. Obviously the surgeon who cuts

> into human beings with a scalpel, and we, who cut into human beings with highly charged, keenly calculated aesthetic energy, have an equally grave responsibility toward them. That is why [this text] stresses the close relationship between aesthetics and ethics, between [technology] and moral purpose.[2]

Media publishers and owners of print, broadcasting and film businesses would surely give *that* thought short shrift!

With violence and crime and war a daily, normal state of affairs, you may wonder why it was stated earlier that "being docile" may be a trait of the Media Freak. Being docile means acceptance. It took nearly 70 years for the general publics of communist nations to get fed up and end those regimes, mostly bloodlessly. Because the United States does not yet have death squads, our public tends to accept the bad things when they occur over time and in great quantities.

Outrage demands action

We should be outraged that we cannot swim in our local lake or river or ocean! We should be outraged that students carry weapons to school (and use them)! We should be outraged that there *is* a hole in the atmosphere allowing lethal sun rays to strike the earth! We should be outraged that we cannot use our parks or streets at nights without fear! We should be outraged at the depths of low behavior that religious, government and business leaders have fallen to! We should be outraged that our water and air are polluted and getting worse! We should be outraged that we cannot even catch fish due to toxins and acid rain! We should be outraged that species are dying out faster than we can keep up with their demise!

Outrage does not take the form of trivial articles like this! Outrage *demands* action that changes things. Our media act like a Roman circus, keeping the public so busy consuming the content that they pay little attention to the real, outside environment. The U.S. public will not revolt . . . more's the pity. Even Thomas Jefferson believed that a good, bloody revolution that dumps a poor government was the best way to correct government ills.

Freedom of expression, as guaranteed by our Constitution, does not include freedom of expression that endangers. Freedom of the press is *not* a license for unethical behavior.

Epilogue ...

Every introductory text on mass media and communications contains at least one chapter on media effects or media controversies or both. Additionally, there are entire texts on those subjects, plus texts on communication ethics. The effects of teaching responsibility to students is probably nil, just as "justice" is not a course in legal training. Certainly the effects of "good behavior" as espoused by every major religion has had little or no effect on world behavior!

Still, I can only wish that funding might be found to research this field of the social effects of behavior as it relates to a person's absorption of something they do for half of their life — consume media. It may be that very few people, companies and government agencies *want* that kind of research done and distributed.

It is not accidental that a major textbook used in hundreds of college classrooms some years ago was written by an employee of CBS (Columbia Broadcasting System), Joseph T. Klapper. In one of his books, *The Effects of Mass Communication*, The Free Press, New York, 1960, he wrote: "The preparation of this volume was made possible by a grant from the Columbia Broadcasting System ... ." The book, generally, indicates that there are no effects from watching television, or that there is not enough research (as accepted by Klapper) to prove deleterious effects. Well, what would you expect from "the hand that feeds you"? Somebody get *me* a grant!

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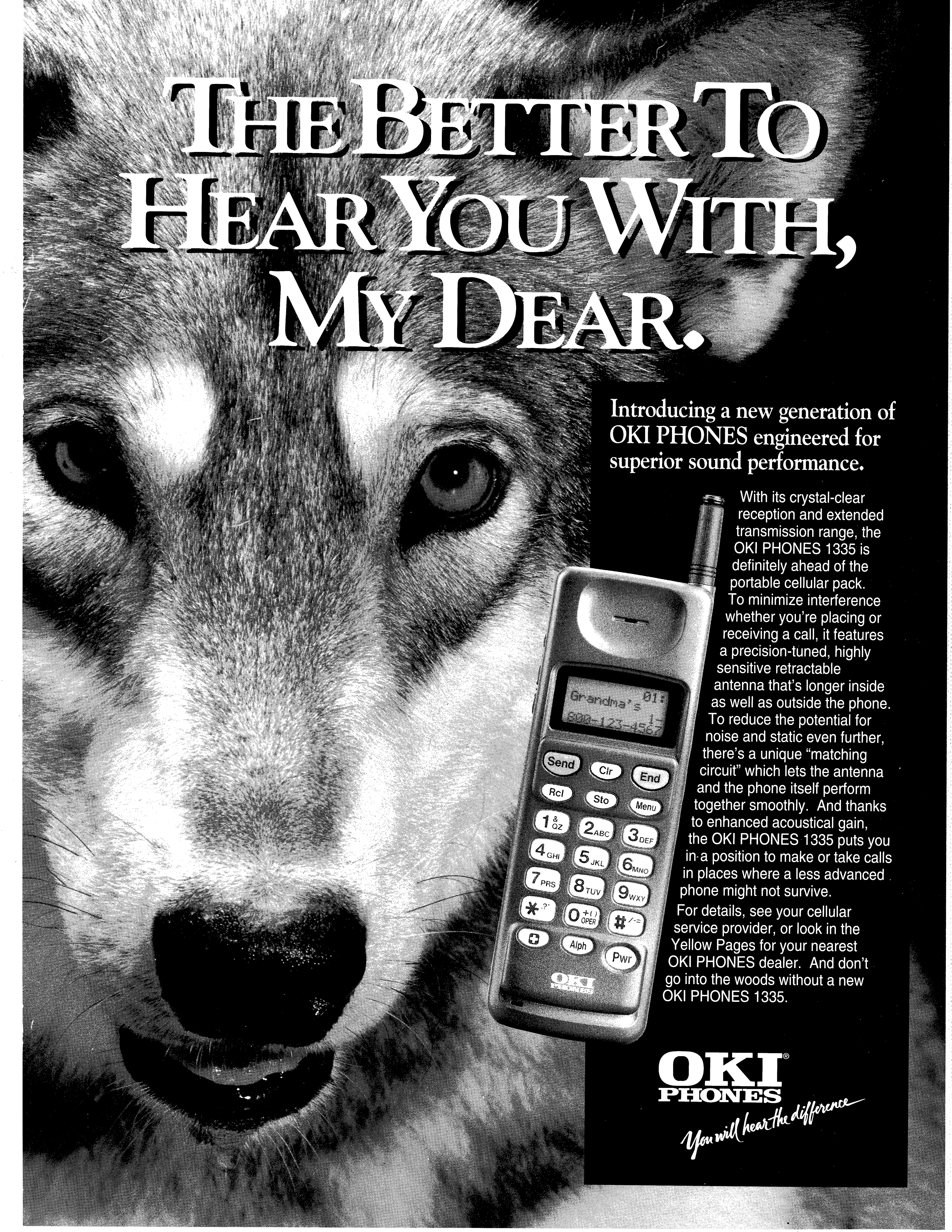
Bryant Robert has a BFA degree from the University of Nebraska, Lincoln, Nebraska, and lives in Denver.

2. *Sight, Sound, Motion: Applied Media Aesthetics*, pp. 8,9, Wadsworth Publishing, Belmont, CA.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The Binding Effect of Environmental Television

By Maurice H. Zouary

In retrospect ...

There was nothing the matter with this new TV business that 250,000 receiver sets could not cure. But the word was, in October 1946, that some 25,000 receiver sets for anticipated buyers were being promised for delivery in time for Christmas.

"Let us have vision by way of television," Edgar Kobak, president of the Mutual Broadcasting System, said that same year. He went on with his message to everyone concerned with this new fledgling art form, "Millions [of dollars] have been spent for design and engineering and for equipment, and I believe that it is time that the millions more should get started to go into the program end of this new television business." However, in a solemn note of warning, he also said, "Television is going to have a great deal more to do than the movies or radio in bringing understanding to people. It will bring people closer together, and with that responsibility we have got to be careful to not misuse this gift. You must remember that we are visiting people into their own homes. Let us stride forward with a determined resolve at all times on a high plane."

Television's great challenge today — and always — is one of moral responsibility. More than a challenge, it is a necessity.

1946 saw some 10 years of prior technological development of television making the new medium ready for a new form of show business. Now, nearly 50 years later, almost all homes in the United States are TV- and cable-equipped, with many tens of millions of dollars spent in the programming end of this seemingly ancient television business. What seems sad, ironic and significant, is that television is now on trial! Television had started out as a great new art form for entertainment with people spending millions of hard-earned dollars as their own welcome mat for TV programming to enter into their private domains.

What seems predominant so many years after television's official launching in 1946, is that it has become an independent environment of unwelcome influences of a binding effect in a cold and hard multi-billion dollar business.

"Let us always keep before us the oft-repeated adage that a picture is worth a thousand words, and hence a picture affixes upon the mind a bad impression just as readily as it does a good one. Both are difficult to erase." Stating those profound words on Oct. 10, 1946 at the Second Television Conference held in New York's Waldorf Astoria Hotel was Jack R. Poppele, president of the Television Broadcasters Association for the two terms (1945-1946).

Poppele was then chief engineer and vice president of the Bamberger Broadcasting Service, the operator of WOR Radio, New York. Addressing some 1,009 men and women from virtually every state in the union and several foreign nations, a great number of distinguished guests and speakers from all phases of show business, entertainment and technology, Poppele continued his message of "Television's Great Challenge" with almost prophetic foresight on the future of television, now that it was here, in fact, to serve the public. He said, "As broadcasters, the roads we choose to traverse must be carefully scrutinized before we proceed. There is no turning back. Here we have in television a mighty new instrument in our hands, a potent force for tremendous good or a weapon for evil if improperly handled, a utility that outstrips all others in universal appeal — one that looms not only as a great aid toward the achievement of international goodwill and lasting peace, but as an important challenge and a responsibility to those who elect to harness its potentialities. Television's great challenge today — and always — is one of moral responsibility. More than a challenge, it is a necessity. If television is to succeed as the greatest means of communication yet conceived, and as a monumental contribution to public service, it must be clean and wholesome, completely tolerant, fair in all public issues and a *welcome visitor to the American home*. There can be no compromise with decency, and while it is not my purpose to take your time with a lot of do's and don'ts for television, I am certain that more care and attention must be given to TV program quality and its standards than any other form of entertainment. The imposition of common sense upon ourselves is the greatest responsibility of all."

The names of other principal speakers at that 1946 Second Television Conference who were experts read like a *Who's Who* of every phase of TV endeavor. A wide variety of panel meetings comprised an authoritative report on the ambitious efforts of the many people participating in the creation of a great new industry. Distinguished panelists covered topics of necessary and pertinent subjects dealing with the future course of television and its essential services to its eventual mass audiences. Entertainment concepts that were to be part of a comprehensive record given on the status of television.

Here was basically an establishment of television's legacy in 1946. Topical papers delivered formed some affirmative guidelines for future decision makers. In effect, establishing what was to become a set of *First Principles* for the future thousands of executives in management and programming who would some day determine what the public will see on their home TV sets.

Television is now big business and almost 50 years old. Television is also now on trial for its visual intensifications, which have become an autonomous environmental counterproductive school for the young and a source for some of desperation rather than inspiration.

Television's ability to enlist all of the powerful human senses with greater intimacy can teach youth anything and everything there is to know about the inner workings of crime. Influences are becoming unmistakably indelible to the young mind with visual suggestions of raw violent action and open immorality depicted as part of our present social and cultural expression. Television is no doubt an autonomous environmental dimension affecting the lives of many. There is no turning back! Television has become an instrument of use creating an environment for ideological misimpressions away from traditional mainstream influences caused by consistent psychological single-viewed entertainment.

Traditional and long-accepted diversionary show business performances, spectacles and general entertainment were always considered as an effective escape from routine realities of daily happenings. Instead, in order to form a more perfect rating, "adrenaline entertainment" designed for maximum effect is projecting predominantly negative aspects of life exhibited to millions of people within their own homes. These injections expose the immature and the children to psychological influences, thus creating a natural "Child's Garden of Reverses." The public has become increasingly alarmed about this insidious destructive force of constant exposure of negative influences, and yet are helpless to protect their young.

The prime issue raised by various parent-teacher organizations throughout the country is that, "there was too much violence on television programs. That such violence on television encourages or even promotes violence in real life." Television has become the instrument of "monkey sees; monkey does," affecting the molding stages of the new being. These results undoubtedly create psychological reverses, although it must be recognized that such programming obviously is being projected to adults.

But an enormous price is being paid through the gradual preconditioning of a large segment of television audiences susceptible to a fear-psychosis to believing that social upheaval is imminent and the result must eventually be violent.

Largely one-sided preoccupational conditioning of realistic visual expressions are trusted as entertainment to the public. These expressions tend to have a decidedly reverse effect on the very meaning of purposeful entertainment. This practice requires, to say the least, no great production imagination or creative showmanship, appealing as it does to only the worst of elements of human behavior.

To some degree, prime time television can be faulted with providing the visual tools of destruction within an independent environment of warped values. Leaving educators helpless in the classroom to cope against the daily onslaught of misguided suggestions through television on the young, who someday will become parents themselves.

(continued on page 59)

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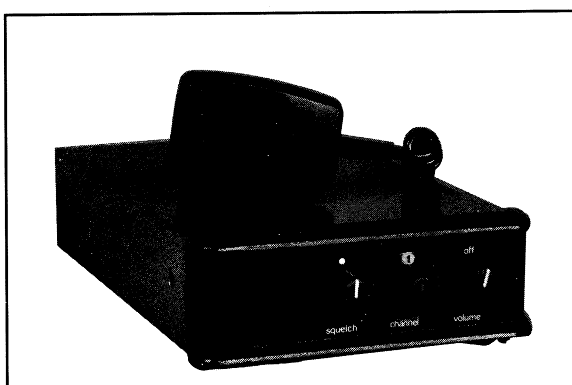

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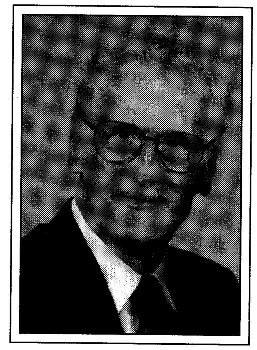


Hams: Unknown Diplomats

By Pat West

"Today we are faced with the preeminent fact that if civilization is to survive, we must cultivate the science of human relations — the ability of all peoples of all kinds to live together and work together in the same world at peace."
— Franklin Delano Roosevelt, 1945

Nobody knows why they call themselves "hams", but there are a lot of them, some 2 million radio amateurs — communications enthusiasts who are licensed by their governments to operate on frequencies authorized by the International Telecommunications Union. More than a half million of those hams live and operate in the United States.

If you have one in your community (and there is probably at least one), you may regard this individual as a garrulous nuisance whose international chats interfere with your own essential electronic gadgets. Your mind would quickly change if disaster struck. In emergencies, ham radio operators give freely and extensively of their time and talent to maintain communications links.

You may also think more kindly about the on-the-air activities of your friendly neighborhood ham operators when you know how important their efforts could be to the cause of diplomacy and international cooperation.

In the Republic of Kazan, formerly part of the U.S.S.R., the activities of these "unknown diplomats" are called the "Rainbow Bridge." A joint Soviet-American expedition from Anadyr, Siberia, to Kotzebue, Alaska, was referred to as the "Bering Bridge." In the Peoples Republic of China, amateur radio activities are called the "Golden Bridge." Not many identify amateur radio enthusiasts as diplomats. Being one myself, I feel that it is my duty to tell a small part of the story of amateur radio; it constitutes a major contribution to world friendship.

The origin of the term "ham" is unknown. Amateur radio certainly doesn't have anything to do with Citizens Band radio or short-wave listening. To legally operate, hams must pass exams to demonstrate their knowledge of communications technology and their country's governing laws.

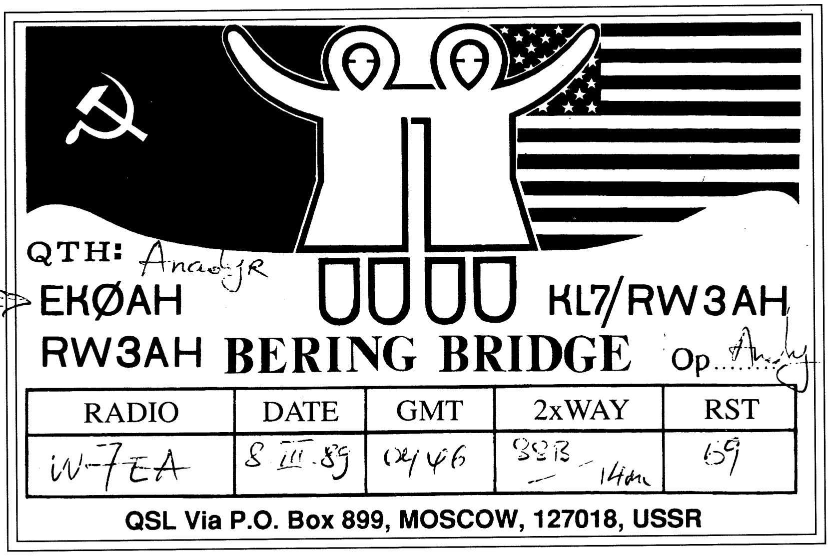
Hams, as "unknown diplomats," enhance friendship between all the peoples of the world.

Hams, as "unknown diplomats," enhance friendship between all the peoples of the world. Hams are diplomats in their own right. A world-wise ham in South Africa conducts a daily meeting of hams from many countries. A Chinese gentleman from Beijing shares much responsibility for the re-introduction of amateur radio into mainland China. Father Marshall D. Moran worked in Nepal. Amateur radio became an Olympic-type sport during the 1990 Goodwill Games held in Seattle.

During the 1991 coup attempt in Moscow, an amateur radio station was established in the Russian parliament building. American hams helped to save the life of a Russian named Oleg.

Margate Safari Net

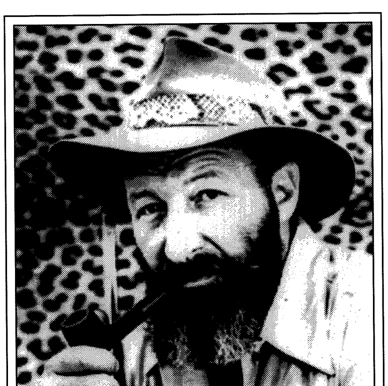
Manny Laxton, a retired safari leader and ex-desert rat, served with the South Africa contingent, an element of the British Eighth Army in the war against the



This is a radio contact verification card I received from the joint Soviet-American expedition. My station call sign is W7EA and EK0AH was the call sign of the expedition. I talked with them on March 8, 1989, at 0466 Greenwich Mean Time (GMT) via voice using single-sideband (SSB) on the 14 MHz amateur band. They gave me a signal report (RST) of 59 which means a very readable and very strong signal. Their location at the time of our contact was Anadyr which is in Russia on the Bering Sea.

German Wehrmacht. He is a veteran of many battles against that most famous of German Generals, Field Marshal Erwin Rommel. Manny is now an avowed conservationist. He has purchased and fenced a 3000-acre ranch near Durbin, South Africa, and is collecting animals native to Africa. He plans some day to open the game farm for youth to observe game in their natural habitat.

Manny's main love is running his special radio network (which he calls the Margate Safari Net) from his home on the shores of the Indian Ocean in South Africa. A net consists of a gathering of stations on one frequency, each operator talking in turn under the direction of the person running the net, who is referred to as the net control station. Stations check into these nets from many corners of the globe. World politics are seldom discussed, though just about everything else is. Long and interesting dialogues bring people together, develop relationships and create new thinking. The results are even greater than the verbal visits. The American hams who check into Manny's Margate net are retired industrialists, medical doctors, engineers, farmers and others. Manny has an assistant, Bill Rea, in Pasadena, California. Several participants have visited Manny, and he has visited the United States.



Manny Laxton, a retired African safari leader, runs a radio net each day from his home that overlooks the Indian Ocean in south Aftrica. He is a true diplomat as his meetings on the air with hams from all over the world constitute a major activity of amateur radio in generating and maintaining world friendship.

Each year, hams from all over assemble at Visalia, California, for the International DX Convention, which Manny has attended. "DX" is a ham acronym for one's ability to communicate with others at great distances all over the world. The object of DXing is to communicate with each of the more than 300 recognized countries in the world. Verification cards, called QSL cards, are exchanged. Many amateur enthusiasts have QSL cards from every country! At the conventions, the relationships and networking take on a deeper meaning, as hams who have talked to each other by radio get to meet each other face-to-face.

A Tense Moment in China

Beijing, September 1981:

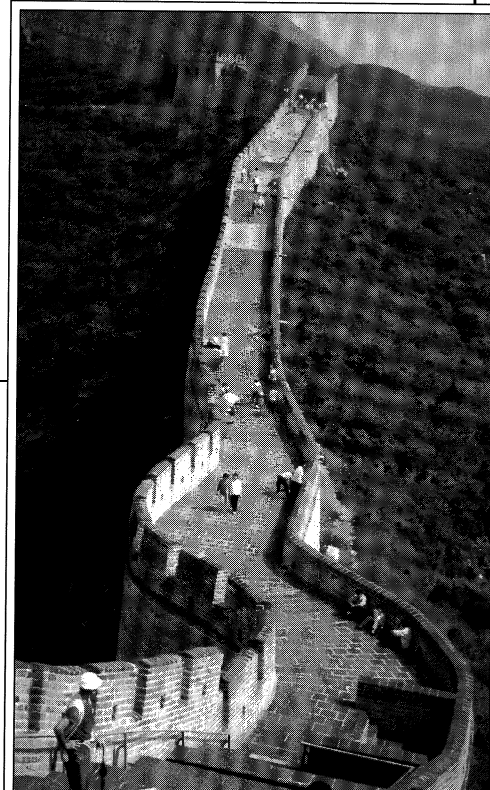
I first visited China in 1980 as a member of an engineering group. During that visit, my on-the-side activities were aimed at convincing our coordinator, Zhou Mengqi, that amateur radio would be good for China. These side discussions resulted in an invitation to visit China the following year with an official amateur radio delegation composed of Bob Hudson, Bill Showers, Henry Oman and me. Most of the credit for the invitation must go to Mr. Zhou, an official of the Chinese Institute of Electronics.

We packed enough equipment to set up two radio stations, anticipating that we would get to operate at least one. Sure enough, we were given about 15 minutes notice, permitting us to set up and operate a station in our hotel. There was a flurry of activity as we and the Chinese installed the station. We located the radio in a room on the first floor of the hotel and the antenna on a 11th floor balcony. We would have

Photo Story —

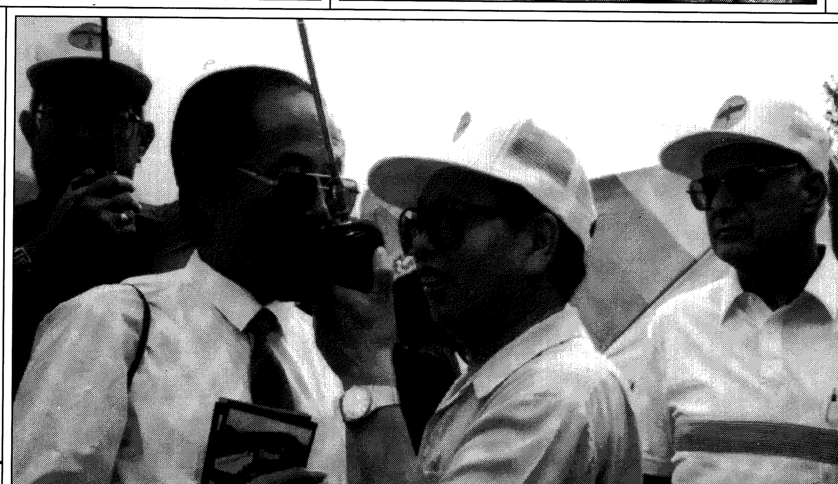
During my visit to China in 1980, I was able to convince Mr. Zhou, a superb diplomat, that amateur radio would be good for China. He took my message to his superiors, which resulted in an invitation for me to bring a group with radios to his country. In September 1991 the first amateur radio communications in more than 30 years between China and the United States was accomplished by my group. Most of the credit for our success must be given to Mr. Zhou. He was not only a diplomat, but he was also a good salesman.

In September 1988 the Chinese Government invited a Boeing Employees Amateur Radio Society (BEARS) delegation to visit Beijing to participate in an occasion, "The Week For Promoting Electronic Technology." One event of this occasion involved the first amateur radio operation from China's Great Wall. The BEARS brought the appropriate radios as gifts for the Chinese. Chinese and American operators used hand-held radios to talk directly with hams in the United States. Signals to and from hand-held radios were relayed to the United States from a radio repeater located 25 miles away in Beijing. From Beijing, a satellite radio circuit was used to tie in to a repeater near Seattle. Two-way voice conversations were held with hams in Washington, Idaho, Montana, Oregon, and even in British Columbia. One ham in Eastern Washington was talking while driving a tractor on a farm.



The Great Wall of China — The only man-made object recognizable from space.

Zhou Mengqi, Chief for International Activities, Chinese Institute of Electronics, and Pat West, Computer Society, Institute of Electrical and Electronic Engineers, Beijing, China, September 1980.



L to R: Dick Mehnert, President of BEARS; Ning Yun-He, official of China Radio Sport Association; Zhou Mengqi, Chief for International Activities, Chinese Institute of Electronics; and Bill Showers, BEARS member.

installed it higher, but we did not have enough coax cable.

Bob Hudson was responsible for installing the antenna. To do this, he had to stand on the unstable 11th floor balcony railing supported by two Chinese helpers. As Bob told it later, "I was in danger, supported by two Chinese Communists on a fragile railing, 11 stories above the ground." Talk about developing a sense of trust!

I was responsible for hooking up power to the radio in the hotel room. We had brought along numerous power adapters; none of them worked. I had an idea that we could use a couple of 5- or 6-inch wires to do the job; we had no wire. One of our Chinese friends solved the problem by using a knife to cut the room telephone cable to make two wires. After the insulation was stripped from each end of the wires, they were used to connect the room television set power plug to the power plug of our radio. When the television set power plug was inserted in the power socket, it held the Rube Goldberg assembly together to provide power to our radio. Our Chinese helper was a top-level executive in the electronic industry. It must have been an interesting sight: the Chinese entrepreneur and me, the engineer, lying on the floor together, working the power problem. We were successful.

Chinese officials and our delegation filled the room to capacity. The atmosphere was charged with anticipation of making the first amateur radio contact between China and the United States of America in more than 30 years. We had barely turned the radio on and tuned it when we heard Bill Bennett (now deceased) calling us from Seattle, coming in loud and clear. Bob Hudson responded to his call. A contact was established, and a historical event completed at precisely the time we had scheduled it with Bill Bennett before we left Seattle. We Americans were excited and pleased — then a sudden, deadly silence filled the room. The Chinese were upset because Bob had responded to Bill's call without the express permission of the Chinese government.

We each were questioned in detail concerning our understanding about whether we had permission to respond to the call from Seattle. Three of our party answered in the affirmative; however, one surprisingly stated, "I only hooked up the coaxial cable to the radio." We did not know what to expect, and were very concerned. I sincerely believe the Chinese gave us permission because they could not visualize we had the capability (on such short notice) to communicate from Beijing, China, to the United States of America with our little radio and our makeshift antenna system. Moreover, it would have been senseless to install a complete radio station just for listening. That night all of our delegation had difficulty sleeping, particularly Bob Hudson. But the next day, all was well. The Chinese told us they had checked with their leaders, who not only approved, but who wanted maximum publicity for the event.

In 1988, during our visit to operate from the Great Wall, the Chinese told us that our 1981 transmission was the catalyst that turned China on to amateur radio. The event had shocked not only the Chinese government, but also the Japanese government. The Japanese had wanted to be first to operate from mainland China. I kept as souvenirs those two connecting wires that provided the power for our station. The wires are now in my scrap book and symbolize the potential for the cooperation and communication we personally experienced between our two great nations.

Father Moran

When King Tribhuvan returned to Nepal in February 1951 after the overthrow of the Rana dictators, one of the King's first acts was to send for Jesuit Father Moran to help in opening a new school. In 1960, Father Moran requested an amateur radio license, the first ever issued in Nepal. Thirty years later he had communicated with 100,000 people in more than 200 countries. Here is what he said about amateur radio:

"All this is more than a personal hobby, but a means of international friendship and valuable service to Hindu, Buddhist, Marxist, atheist, agnostic, Jew, Muslim and even royalty. I have had talks with King

You Too Can Become A Ham Diplomat

Amateur radio is one of the world's most enjoyable hobbies. Anyone can become a ham and a diplomat — all it takes is the desire, a little studying and exercise of memory.

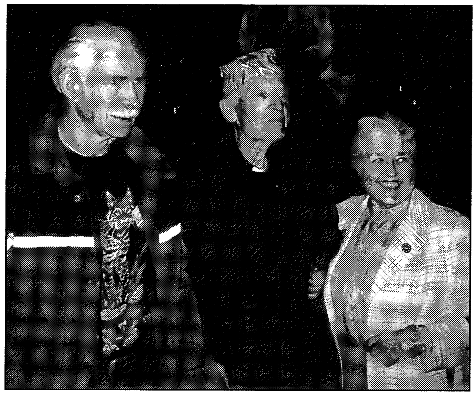
For more information, contact the non-profit

American Radio Relay League

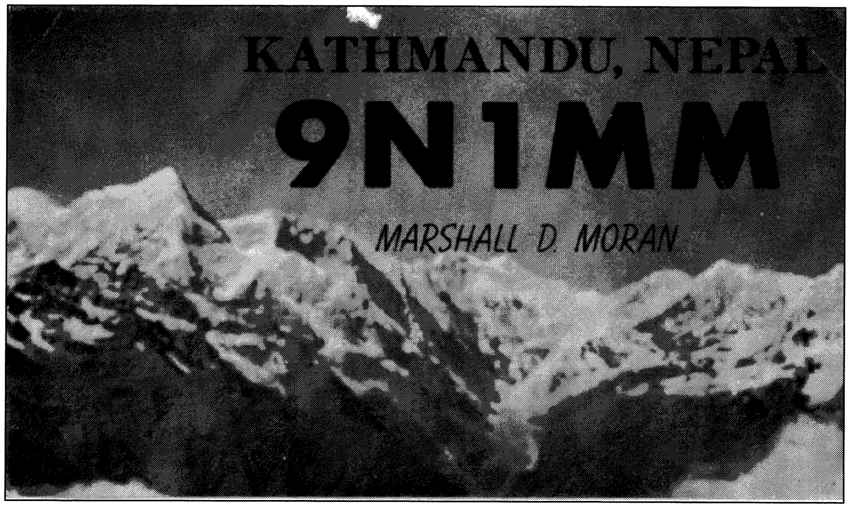
225 Main St., Newington, CT 06111-1494

Telephone: 203-666-1541

Fax: 203-665-7531 (24-hour direct line).



Host Morris Shepherd, Father Marshall D. Moran, and hostess Florence Shepherd, Seattle, Oct. 30, 1991.



Shortly before his death, Father Moran, from Nepal, visited the Western Washington DX Club in Seattle. He showed slides of his amateur radio station 9N1MM and spectacular Himalayan mountain scenery. He spoke of his adventures of over 60 years of living with and teaching the children of Nepal. He was a distinguished ham diplomat and will be missed.

Hussein of Jordan. All republics of the Soviet Union speak to us as friends and wish us their Merry Christmas and Easter greetings and talk of their families... Is this not daily ecumenism?"

Father Moran died April 14, 1992, in New Delhi after a brief illness. He was 85 years old and a legendary figure to amateur radio enthusiasts around the world. He was virtually the sole amateur radio contact with the Kingdom of Nepal for several generations. His ashes were returned to Nepal.

Russia's coup attempt

Moscow, August 1991:

Martial law had been declared, and Russian army tanks massed outside the Russian Parliament Building. All communications had been shut down. Tens of thousands of defending faithful massed outside the parliament building were badly shaken; they believed it meant the end of life and liberty. Only one communications link remained: A ham radio station had been set up in the parliament building. Through this station and ham radio operators, Yeltsin was first able to relay information to areas outside of Moscow. Through this station, people first began to hear Yeltsin's message that the coup attempt was illegal. Ham radio was the only way to put the information out. Yeltsin later acknowledged the important role amateur radio operators played in fighting the coup. Perhaps it was a key in keeping spirits alive.

Radiosport

In China and in the former Soviet Union, amateur radio is treated as a sport. The same awards for excellence are given to these enthusiasts as to top athletes. One main competitive event is referred to as fox hunting. Beacon transmitters are positioned along a difficult terrain, and contestants use direction-finding radios to spot and find each beacon. The event is both technical and athletic, with some similarity to the current Olympic rifle event in which cross-country skiing is combined with marksmanship.

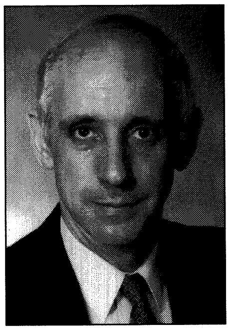
In 1990, during the Goodwill Games held in Seattle, local hams led by Danny Eskenazi sponsored the first-ever amateur radio activity in an Olympic-type event. Local hams hosted teams of amateurs from throughout the world and permitted use of their stations. The objective of the event was for each team to talk with other amateurs throughout the world during a specified period. The team with the most points accumulated during the contest period would be the winner. The event was won by a team from the United States. The real payoff, however, was the comradeship of working together to achieve a goal.

I believe that at some future Olympics, there will be an amateur radio event; however, it will be an event like fox hunting, which involves athletic ability, because that is what the Olympics is all about. The mix of radio skills and athletic ability would be similar to the mix of rifle skills and cross-country skiing.

The saving of Oleg

A person's diplomatic capability often expresses itself when another member of our human family is in need, in danger. Such an expression was the devoted collaboration between amateur radio operators in the U.S.S.R. and the United States to rescue Oleg Murugov from the brink of death. In late May 1990, six Russian

(continued on page 37)



From Seat-of-the-Pants to Instruments

By Albert Helfrick, Ph.D., P.E.

It is my pleasure to be invited to this luncheon and to address all of you. You have been honored for your leadership, scholarship and accomplishments at this luncheon.

This is the first time a member of the avionics technology faculty has addressed this event, and I would like to relate to you a story of foresight, ambition and leadership by five pioneers of aviation instrumentation and electronics. This is the story of the first category III C instrument landing.

... [M]ost of the [world's] medium and large airports have the capability of instrument landings.

For those of you who may not be familiar with instrument flying, there are two types of instrument landings; precision and non-precision. The precision approaches are divided into three categories, I, II and III, with category III, called "CAT THREE", being the most difficult. The CAT III landings are further divided into three subcategories, CAT III A, CAT III B and, the most difficult of all, CAT III C. Of course, CAT III C is used for the worst possible weather with zero ceiling and zero visibility.

Of all the airports in the world, most of the medium and large airports have the capability of instrument landings. The larger airports have the ability to perform precision approaches, usually CAT I and CAT II. A few airports and airplanes, together, can perform CAT III approaches. Of all the airports and airplanes in the world, not one of either can perform CAT III C landings on a regular basis.

First CAT III C approach

There have been experimental CAT III C approaches made, and I would like to relate to you this story of the first CAT III C approach and the aviation pioneers that achieved this goal.

You are all probably thinking that the first CAT III C approach was made with state-of-the art equipment, not yet available, and within the last few years. Well, that is not the case! The first CAT III C approach was made Sept. 24, 1929!

In the mid-1920s, the United States Army and the scheduled airlines had a great interest in the airplane, but recognized that the airplane must be capable of reliable operation in poor weather conditions to be useful in military operations or to maintain any serious schedule.

Most commercial aviation in the 1920s was carrying the mail. Back then, air mail pilots would receive weather information at the beginning of a flight, usually a night flight, and, navigating by light beacons and dead reckoning, make the already treacherous journey, such as from Newark Metropolitan Airport west to Cleveland and Chicago, only to find that the weather had deteriorated or the weather forecast was inaccurate and the destination airport was socked in. This would require that the pilots attempt a landing at an alternate airport. This search for an alternate airport was a very dangerous undertaking. The aircraft had indicators of altitude did not have the necessary precision for instrument flying.

Paul Kollsman, instrument-maker

The Guggenheim Fund employed Paul Kollsman, an instrument-maker, to

This paper is the text of a speech delivered to the senior achievement luncheon at Embry-Riddle Aeronautical University on May 6, 1994.

provide an aneroid altimeter with the necessary 100-foot precision, which would be better than any altimeter ever made. Like the gyroscope, the instrument would have to survive the vibrations, temperature and other environmental onslaughts encountered in the aircraft of the day.

Kollsman was manufacturing altimeters in a small shop in the attic of his home. He had borrowed $500 from his brother to buy a lathe, drill press and some small tools and was hand-making altimeters with hand-made paper dials. What the Guggenheim Fund was seeking was an altimeter of a greater precision than had been made to date.

Kollsman accepted the challenge and produced the finest parts of the highest quality and assembled the "sensitive altimeter" used for the first blind flight.

The third ingredient for the first blind flight was some sort of navigation system that would provide the necessary guidance to find airfields when there was no visibility.

Radio had been considered for bad-weather navigation guidance and was the obvious choice. It must be remembered that in the mid-1920s, radio was a new art; the term "electronics" hadn't even been coined. But, the engineers and scientists of the time knew that the straight-line propagation of radio waves and the ability of these waves to penetrate clouds was the vehicle for an all-weather navigation system.

Unlike the sensitive altimeter and the gyroscope, which were improved versions of existing products, there were no radio navigation systems in operation. An entire concept would have to be developed, and practical equipment would have to be invented.

Dr. Lewis Hull

The Guggenheim organization called upon a young physicist with a great understanding of radio, Dr. Lewis Hull.* The 28-year-old Hull earned a Ph.D. from Harvard and had already, in 1928, been working on aviation radio for four years. Hull was the chief operating officer of the Aircraft Division of Radio Frequency Laboratories, a small company in New Jersey that was formed for the sole purpose of developing applications for radio. About a year before the first demonstration of blind flight, the division became a separate company, the Aircraft Radio Corporation, with Dr. Hull as Director of Research.

Aircraft Radio had a laboratory and an airfield in Boonton Township, New Jersey, which was close to a number of other radio pioneers and their fledgling companies.

Like Sperry and Kollsman, Hull accepted the challenge. Of the three, Hull's challenge was the greatest. Radio broadcasting had existed for less than a decade, and the radio receiving equipment in use was simply too large and too fragile to survive a ride in an airplane. There were other problems, too. The 1920s radios required a large number of very heavy batteries and used long antennas. The ignition systems of the aircraft engines created a constant static.

Practically none of the normal radio components of that period would suit an aircraft, so Hull made his own components. Hull purchased glass-blowing equipment and a vacuum pump and made his own vacuum tubes that would perform the necessary functions with the ruggedness required for an aircraft. He manufactured many of his own parts that were lighter and smaller than those used in home-style radio receiving sets. He designed special circuits that required fewer batteries than the normal radio equipment.

Hull and the engineers at the Aircraft Radio Corporation shielded the entire ignition system of the aircraft engines to eliminate the debilitating static created by the engines. They developed short and robust antennas that could be mounted on an aircraft.

Radio navigation

Making an airborne radio receiver was only half the problem. A radio navigation scheme had to be formulated. The method of encoding the radio signal to provide an invisible line in space to guide a landing had to be invented. And then, an indicator had to be provided to make the invisible radio path visible to the pilot.

With a dedicated and eager staff and the assistance of many of the other radio pioneers in the Northern New Jersey area, Hull solved every problem, and a radio navigation system was perfected.

With the hardware ready, a demonstration flight was planned. The best test pilot the Army had was on loan to the Guggenheim Fund and was employed for the demonstration. The army's top test pilot was not only highly skilled as a flyer, but he had a keen understanding of engineering and science and would be able to provide very helpful suggestions to perfect the system. That pilot was 33-year-old Lt. James Doolittle. To ensure the test flight was carried out safely, a safety pilot, 23-year-old Lt. Benjamin Kelsey was employed.

Kollsman's altimeter, Sperry's gyroscope and Hull's radio equipment were installed in a Consolidated NY-2 aircraft. The equipment was installed in the best engineering fashion, with aluminum straps, blocks of wood, steel wire and duct tape.

The Consolidated biplane was selected because of its strength. The radio navigation system only supplied lateral guidance, so the glide path would be set to a constant sink rate, and the aircraft would simply be

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*Lewis Hull joined the Radio Club of America in 1951 and was a Fellow.

flown into the ground, the first indication of a landing being the wheels touching the runway.

Public demonstration

A number of test flights were made to prove the equipment, but finally the big day came for the public demonstration for the press and dignitaries. On Sept. 24, 1929, at Mitchel Field in Long Island New York, Doolittle and Kelsey were ready to make their historic flight.

The aircraft had a front and rear cockpit, and the rear cockpit was fitted with a canvas hood that completely covered Doolittle. This provided the young lieutenant with what we call CAT III C conditions today, zero visibility and ceiling.

The demonstration flight called for Doolittle to take off and fly outbound for about five miles, perform a 180-degree turn, overfly the airfield fly outbound again, make a second 180-degree turn, return to the airfield and land, all while under the hood. Doolittle had sketched the flight path in his notebook along with drawings of how the instruments should look as he intercepted the radio beam, and he carried a copy in the aircraft for the flight. This, of course, was the first approach plate, as invented by Doolittle.

About 10 a.m., Doolittle and Kelsey taxied to the end of the runway. Doolittle pulled the hood over his head, and the plane sped down the runway, became airborne and soon disappeared from view. Shortly, the aircraft flew directly over the airport. But this was the easy part. After another 10 minutes or so, a small spot appeared off the end of the runway. As the spot grew larger, the shape of the biplane became apparent. It seemed that the plane was heading right for the runway. The observers were tense, but the plane continued to approach the runway, losing altitude at a constant rate, just as planned. As the plane came closer, Lt. Kelsey could be seen in the front cockpit with his hands raised above his head as a sign of impending victory and proof that the hooded Doolittle was flying the aircraft. With a solid touching of the wheels the sturdy biplane was down, and the epic flight was over.

The flight was over, but several industries were born. This demonstration of all-weather flying was crucial for the airline industry. It also started the aviation electronics industry. For the good and the bad of it, it was the beginning of tactical air power.

Pioneer characteristics

Those who gave birth to these industries demonstrated a number of characteristics. First, they all had a vision. No problem was too big. All-weather flying could be achieved. Second, they all had determination. Even when things looked bleak and there seemed to be no answer to the problem at hand, they doggedly worked on. Third, they had courage. It is hard to believe today that, in the 1920s, there were many people, including influential and educated people, who believed that there was no future in the airplane. There was opposition to such foolish research as blind flying. Finally, they had ability. Those involved were educated and skilled. Doolittle, as an example, not only was a flying ace, but obtained a Ph.D. and became a lieutenant general before his retirement.

I joined the Aircraft Radio Corporation in 1977, and it was my great fortune to have an office in the oldest part of the plant. From old advertising brochures, I determined that my office had at one time been Dr. Hull's. I shared the office with another young engineer, and next to the office was our lab. Originally, our lab was the engineering library. The old pictures showed the library with a hardwood floor, a large overstuffed leather couch and a fireplace, above which was a mounted deer head.

I knew that Doolittle had been in this room and, with Hull and others, he discussed their mutual problems, sitting on the leather couch in front of the fire and under the watchful glass eyes of the hapless whitetail. My office mate and I had spent our share of late hours in this room doing our own aviation electronic pioneering. We were designing an area navigation computer using a new device made by the Intel Company called the microprocessor. It is interesting to look back on that time and some of the crude equipment we had. It often took our development computer hours to assemble what would be, today, the simplest of programs, and what would take a few minutes, at most.

Often while we waited for the computer to determine how many programming errors we made this time, we thought about what Hull and Doolittle would say to encourage us when the hour was late and we were discouraged. We also knew which wall hid the fireplace. We often thought about exposing the fireplace for the first time in about 40 years and starting a nice roaring fire. Knowing Aircraft Radio's penchant for saving things, we were sure we could find the leather couch and the deer head some place in the now-sprawling plant, carefully preserved for whatever future may be in store for it. We were afraid, however, that our forward-looking engineering management would not approve of our returning to those old, obsolete techniques of engineering.

Keys to success

These pioneers were successful in achieving what no one else had ever done and some thought impossible. But what does it take to be successful? Some of you in this audience, today, are students of mine and have heard this before. Those who are successful are not always the smartest, those with the most money, or even those with the best idea. Those who are successful are those who survive. The characteristics of the pioneers of the first blind flight are the keys to success: *vision*, *determination*, *courage* and *ability*.

Those of you here today are being honored for your achievements, and I urge all of you to employ these keys to success in all that you do.

Epilog

Aircraft Radio Corporation grew in size, and during the Second World War, designed and produced the famous "Command Set" line of airborne communications equipment of which more than 1 million pieces were made by a number of manufacturers. Dr. Hull resigned as president in 1952, was elected chairman of the board and served in that capacity until his retirement. Dr. Hull died in 1984 at the age of 85.

The Sperry Corporation continued to make gyroscopic products and branched into a broad base of flight control products. The Aircraft Radio Corporation was purchased by the Cessna Aircraft Corporation in 1954 and was subsequently sold to Sperry in 1983. The year 1983 was a bad time for general aviation, and the aircraft radio line of equipment was not continued. Finally, Sperry was purchased by Honeywell a few years later.

The Kollsman Instrument Company prospered and was sold by Kollsman to the Square-D Company in 1940. Kollsman attempted to repurchase his company in 1945, but lost to the Standard Coil Company, a radio parts manufacturer. The reorganized company, Standard-Kollsman Industries, was acquired by the Sun Chemical Corporation in 1972. Kollsman is now a division of the Sequa Corporation and manufactures a broad line of air data equipment, including altimeters.

Benjamin Kelsey retired as a brigadier general and died in 1988. James Doolittle became a lieutenant general and died in 1993 at the age of 96.

My office mate continued to pioneer the applications of microcomputers and established his own company to design and manufacturer electronic voice mail systems. Today, the company, Dialogic Corporation, is a multi-million-dollar, publicly traded corporation.

The old buildings from the original Aircraft Radio plant now house the Breed Corporation, which has exploded in size because of its involvement with automotive airbags.

The fate of the deer head and leather couch is unknown.

Albert Helfrick, Ph.D., P.E. (LF), is an associate professor at Embry-Riddle Aeronautical University.

Hams: Unknown Diplomats ...

(continued from page 33)

hams traveling to Moscow for radiosport games were involved in an accident. One was killed, and Oleg Murugov, age 25, barely alive, ended up in a deep coma, sustained by artificial respiration.

The Russians asked American hams for help via the various operating modes of ham radio. Within hours, a daily intensive U.S.-U.S.S.R. medical dialogue was established as Soviet and American physicians collaborated to restore Oleg to health. Doctors Lionel (Len) Traubman (an active ham) Lawrence Probes (an active ham) and neurosurgeon Dr. Joseph Izzo relayed vital statistics, lifesaving medical advice, trauma treatment methods and status reports via telex and various short-wave radio modes, including a car phone. After 17 days in a coma, Oleg opened his eyes and moved his hands. Oleg lived, thanks to ham radio and the cooperation of many in the United States and U.S.S.R.

As Dr. Traubman states, "Around the world, individual initiative continues to play a unique role in building bridges of understanding and cooperation, based on open dialogue and direct personal communication. Millions of citizens in all nations are manifesting the human spirit to save life on Earth and build a sustainable way of life — a global community. In 1990, the Cold War between the United States and the Soviet Union finally ended. Walls fell. Democracies sprang up. New partnerships began. The evolution of human spirit continued. Oleg went home."

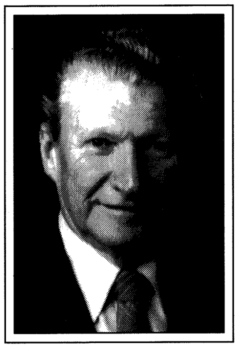
When a ham diplomat ends a conversation with another ham diplomat in Moscow, Beijing, Rome or wherever, both parties say in turn to each other as I say to you, "Best regards to you and to your family."

C.P. "Pat" West, P.E., *a graduate of Purdue University, West Lafayette, Indiana, is a retired Boeing engineer of nearly 35 years. Much of his activity at Boeing was spent in the command, control and communications area. He was in the Signal Corps during World War II, and he spent three years in Africa and Europe.*

The majority of his writing during Boeing years was technical. As an amateur radio enthusiast of 57 years, he has published several articles in amateur radio publications.

He is a registered professional engineer and a life senior member of the IEEE, and he has held many of the IEEE management positions in the Seattle area. He is also an associate fellow of AIAA. He holds the Amateur Extra class license and remains active with the station call W7EA. He is also an avid trout fisherman and golfer.

He has been married for 47 years and has two sons. Currently, he is writing his memoirs.



Radio Broadcasting at Purdue

By L.A. Geddes, M.E., Ph.D., F.A.C.C.

Wireless communication was initiated at Purdue around 1910 when senior electrical engineering (E.E.) students set themselves the task of building a telegraphic station. R.V. Achatz, a member of the E.E. faculty from 1916 to 1923 and an originator of radiotelegraphy at Purdue, provides the background of this project (*Indiana News*, 1920):

"The first attempt to install a radio station at Purdue University was made in connection with the senior thesis of R.A. Garrett and O.W. Melndoo of the 1910 class. These two erected an aerial from the top of the (power-house smoke) stack to the north wing of the Electrical Engineering Building on the campus and installed an apparatus. No communication at that time was established with other stations, and the experimenters turned their attention to tests of various types of crystal detectors then used exclusively for receiving signals. A small indoor antenna was used to send the signals.

Purdue recognized the 25th anniversary of WBAA in March 1947. The station was then operated by a committee of E.E. professors and representatives from other schools ...

"The next installation was commenced in 1912 by A.E. Hague and J.R. Pigman. The work was continued in 1918 by R.E. Cleveland. In 1915, G.M. Wilson and E.H. Bulls undertook the improvement of the station. A new oscillation transformer and a new high-tension condenser were constructed for the transmitting outfit. The design of the condenser was unique, as it consisted of a group of milk bottles, which were placed in a metal tank filled with salt water to about two-thirds the height of the bottles. The bottles were filled to about the same height with salt water. The tank and the salt water outside the bottles formed one plate, and rods reaching down to the salt water inside the bottles formed the other plate. A new receiving set also was constructed.

"In 1918, the university entered actively into the work of instruction along radio lines in conjunction with the Signal Corps of the United States Army. The university undertook the instruction of 150 radio operators for the Army. This number was later increased to 400. In 1919, a temporary permit was granted the university for the operation of a radio station, and immediate steps were taken to install a permanent station. During 1919-20, much construction work was done, and the sending set was installed in the present radio room of the university. The call letters 9YB were assigned, and the transmitting wavelengths of 200 and 375 meters were permitted."

Further information about the teaching of wireless is presented in the Purdue Trustees Report of 1917-18:

"This line of work is administered under the direction of the Signal Corps of the U.S. Army. It is open to students in engineering schools who have had adequate preparation in electric theory. All students electing this course are required to pass physical examination for entrance into the U.S. Army and to take an oath

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This article is an excerpt from *A Century of Progress: The History of Electrical Engineering at Purdue (1888-1988)* by L.A. Geddes.

before a Notary Public to regard the material as strictly confidential. Enlistment in the U.S. service is not a prerequisite, but those taking the course are expected to be available for the Signal Corps later. Seniors in E.E. may take this course as a substitute for other second semester electives as well as for E.E. Lab or Thesis. (It seems that this was the only year this course was offered. It was not until 1920-21 that another radio course, Radio Communication, was offered, carrying the description: `This course covers the fundamental principles of radiotelegraphy and radiotelephony, together with a study of the construction and operation of radio apparatus.')

"The Purdue station has talked with all states along the Atlantic seaboard and as far west as Texas and the Black Hills in South Dakota. It has been heard in almost every state from Colorado east to the Atlantic. Radio work is given, besides that in the electric school, to certain sections of the ROTC and is used in the military maneuvers by the motorized unit of ROTC. A number of men in the Signal Corp sections take this work and get actual field experience in handling wireless outfits for the artillery units.

"Purdue was instrumental in starting the Western Conference radio service. This radio service between Big Ten schools is every Monday night. Student operators take turnabout each night at the Purdue station, two being on duty Monday to Friday nights.

"Purdue co-operated with the bureau of standards in making fading of wave tests last year.

"Last year, results of the regional basketball tourney were broadcasted after each game, practically all schools in northern Indiana which had receiving outfits reporting receipt of the score a few minutes after each game was over. This same plan is followed this week-end."

In 1912, a receiver built by a senior student obtained the returns of the presidential election in which Woodrow Wilson defeated Theodore Roosevelt and William Howard Taft. Even at that early date, the local hams (radio amateurs) were flourishing; by 1913 there were six ham radio transmitters in Lafayette, with a federal inspector arriving to check them.

One of the amateur radio stations was owned by a very young man, John Fetzer, who later became famous as a midwestern broadcaster and the reorganizer of telecommunications in Germany after World War II. Between 1914 and 1917, Fetzer built a spark-gap transmitter. He placed a carbon-button microphone in series with the battery energizing it and transmitted the human voice a distance of three miles. This was the first voice broadcast in Indiana.

In 1916, with entry of the United States in World War I, all radio broadcasting was halted. Local amateurs, however, including those at Purdue, went on broadcasting to each other. According to Fetzer, they used bedsprings as antennas, rather than outdoor antennas which could easily be spotted by inspectors.

While he was living on Lutz Street in West Lafayette, Fetzer built a 500-watt amateur radiotelephone station, which was licensed as W9FD — all the while maintaining contact with the faculty of the E.E. School.

Fetzer later became manager of the radio receiver manufacturing department of the Wolever Electric Company of Lafayette and attended Purdue as a part-time E.E. student in courses taught by Achatz. Although he did not complete his degree, an event that was not uncommon in those days, Fetzer made genuine contributions to the faculty who were developing WBAA at the time and was one of the pioneer designers and producers of vacuum-tube radio receivers.

Fetzer acknowledged his indebtedness to Purdue in his memoirs: "In collaboration with the Electrical Engineering Department at Purdue University, I continued my interest in furthering my knowledge of the communication field. I well remember the communication courses given by Dr. R. V. Achatz, professor of Telephone Engineering at Purdue. To him I owe a debt of great gratitude." And, on May 18, 1986, Purdue recognized Fetzer's contributions to broadcasting by awarding him a Doctorate of Humane Letters "for outstanding accomplishments in electronic communications, both as a wireless pioneer at Purdue and as a broadcast industry leader." The School of Electrical Engineering can be justly proud of its former student who was to make such a name for himself in international broadcasting and in sports.

World War I clearly demonstrated the importance and value of wireless communication. Although Marconi broadcast the first wireless signal across the Atlantic in 1901, with a message in Morse code consisting of the letter S (three dots), it was Reginald Aubrey Fessenden, former Purdue professor and head of E.E. (1892-93), who first broadcast the human voice and music on Dec. 24, 1906.

Commercial radio broadcasting was launched in the United States on Nov. 2, 1920, by the experimental station 8XK, later licensed as KDKA (Westinghouse), Pittsburgh. This station is still in operation with the same call letters. At Purdue, meanwhile, Achatz and D.L. Curtner, who taught courses in wireless telegraphy and telephony, were constructing Indiana's first broadcast radio station. Without funds, but with incredible scrounging and the help of E.E. student volunteers, they built their station in a 12 x 14 basement room of the first Electrical Engineering Building (erected in 1889 on the site of the present Chemistry Building).

On April 4, 1927, the Achatz and Curtner station was licensed by the Federal Radio Commission (FRC) to broadcast on 360 meters (833 kHz) with the call letters WBAA and a power of 200 watts. The first program was presented two weeks later at 9 p.m. on April 21, 1922. The schedule called for programming on Mondays and Fridays from 3 to 5 p.m. and 7 to 9 p.m.

A student, Glenn Williams Earnhart, helped to build WBAA. Earnhart received his B.S. in physics in 1925, writing his thesis on "Design and Improvement of the Radio Station of Purdue University." He also received an E.E. degree in 1936. The work Fessenden started in E.E. three decades earlier had finally blossomed at Purdue. In 1922, the *Indiana News* reported the current interest in radio at Purdue as follows:

"When the members of the 1922 graduating class of Purdue University receive their degrees in June, among the number will be several who have specialized in radio engineering, having completed the regular course in that subject conducted by Professor R.V. Achatz, who has charge of all radio work at the university and is operator of 9YB, Purdue University's wireless transmitting station. Seven seniors are taking the radio course, and eight students are enrolled in an advanced course, which amounts to post-graduate work. Lectures are given each Wednesday evening which are attended by more than fifty students. The men who are studying radio as a specialty are planning to take up work as radio engineers or to use the information gained in connection with electrical work in connection with phone or telegraph."

About three weeks after broadcasting began, deliberations from the Lafayette meeting of the League of Women Voters were broadcast by WBAA. Most of the first programs, however, consisted of agricultural information and recordings. The station was operated mainly by E.E. students. Faculty wives sang, and everyone within reach (including professors) was commandeered to fill the air time. Programming was described as "spontaneous planning." The official 1929 *Purdue Report* stated that "lectures and other educational matters are broadcast in radiotelephone under the call letters WBAA."

Not long after WBAA started broadcasting, the wavelength was changed to 373 meters (804 kHz), and plans were made for rebuilding the equipment to increase its power to 500 watts. This new transmitter was also located in the first Electrical Engineering Building until 1927. In 1923, construction of the present E.E. Building on Northwestern Avenue was already under way, and WBAA was to be located in it. A rare glimpse of its birth comes from George F. Metcalf, who, after four months as a wireless operator on ships, came to Purdue for his E.E. degree. Metcalf wrote:

"By the summer of 1926, space was made available on the third floor, and the towers were erected on the roof. Walter Lanterman (B.S.E.E. 1928) and I were given the job to work full-time that summer to build and get a 500-watt radio broadcast station into operation.

"When I say build, I mean build and make all the parts (except tubes, etc.), and we finally worked for one to two weeks hand chiseling a hole through the six-inch concrete roof for the antenna lead. This work was finished in time to broadcast that fall.

"I also remember that the new equipment was in operation in September of that year and that we broadcast the first football game of the season. We used an open telephone circuit in the stadium and the telephone in an adjoining lab to relay the broadcast.

"As to the programs, I broadcast agricultural market reports every weekday at 10 a.m., which sometimes interfered a little with my classes as I had to warm up the transmitter and check the frequency, etc., then announce market reports and hope that the transmitter was operating — as I was there all alone. I kept this job until graduation in 1928. The State of Indiana paid 75 cents per broadcast, which was a lot of money for me.

"On Friday and Saturday nights we broadcast popular records until the telephone calls with requests stopped coming in, usually about 2 to 3 a.m. Calls came regularly from Fort Wayne, Chicago and Indianapolis, and occasionally from remote points when conditions were just right. A hundred or more calls were usually received during an evening."

Such was the beginning of WBAA in the E.E. Building. After graduation in 1928, Metcalf joined the General Electric Company and became regional vice-president of Defense Activities. He later joined the Martin-Marietta Company as vice president of engineering and, in 1966, he was awarded an honorary doctorate by Purdue.

In the new E.E. Building the WBAA transmitter and studio were on the third floor, in the area now occupied by Rooms 330 and 332, at the top and to the west of the Northwestern Avenue stairway .

Two towers to support the vertical antenna were erected on the roof, which had been designed to accept this load. The attic was also designed to contain and support the weight of the motor-generator sets needed to provide dc plate and filament voltage for the transmitting tubes — for mercury-vapor and copper-oxide (solid-state) rectifiers had not yet made their appearance.

Comfortably installed in the new E.E. Building, the station was headed for a bright future. In 1929, however, it was almost completely destroyed by fire. C. Francis Harding, then head of E.E., attributed the fire to "a short circuit between a cigarette and the waste-paper basket!" Despite this disaster, faculty, staff, and students again set themselves the task of rebuilding the station, which they did in record time. The scars of the fire are still to be seen in the attic of the E.E. Building.

Volunteer faculty and students, notably Prof. Glenn E. West and John Hammond (B.S.E.E., 1932), continued to keep the station on the air, which was no small task since on-the-spot maintenance and improvisation was continually required. It is reported, for example, that there were numerous bugs (entomological) in the equipment. On warm summer evenings, when the transmitter-room windows were open, insects found their way between the plates of tuning capacitors and caused some rather spectacular arcing. Evidently no one recognized that this was an excellent way of killing bugs, for electrostatic bug killers did not appear until decades later.

In spite of these difficulties, WBAA was achieving maturity. Programming became more sophisticated, and radio plays were popular. The players read their lines from scripts, a practice that has been largely put to an end by television. Soon a full-time engineer, James Ebel, was appointed, and he was succeeded by Ralph Townsley (M.S.E.E. 1934), one of the early student volunteers, who remained with the station until his retirement in 1982. Ebel went on to the University of Illinois, after which he joined John Fetzer's organization where he later became president of the Cornhusker Television Corporation, a Fetzer company.

G.D. Williams of the Speech Department became the first program director, and the hours of programming were increased. In 1935, C.B. Aiken of the Speech and Communication Department became program director. WBAA was clearly coming of age, with programming being the province of a new type of specialist. Nonetheless, assistance from Electrical Engineering was still required to keep the station on the air.

An interesting sidelight on these early days of radio was the sharing of the same frequency by two stations. Both WBAA and WKBF (now WIRE) at Indianapolis shared broadcast hours. Early in the spring of 1933, the FRC changed WBAA's frequency to 890 kHz and authorized a power of 1,000 watts, but WBAA was to share time with WILL (University of Illinois, Urbana) and operate during the daytime only. With this change, WBAA was able to extend its broadcast schedule from 10 a.m. to 2 p.m. and from 6 p.m. until local sunset. With the increase time, the programming included sports, homemaking, musical performances, agricultural information and a half-hour Saturday morning children's program entitled *Just Kids* and hosted by Al Stewart. Later television stations were to copy this concept.

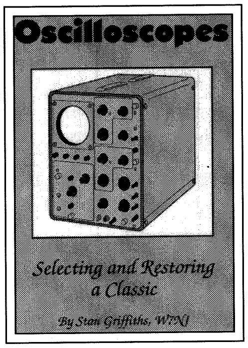
In 1941, the WBAA studio was moved to the Elliott Hall of Music, but the transmitter remained in Electrical Engineering for another year. A new 5,000-watt transmitter was ordered and, when delivered, was located in Wea Plains, South 9th Street, in Lafayttte. Radio had matured and no longer needed the EE staff, faculty and students to keep the transmitter on the air. The official *Purdue Report* for 1939-40 lists WBAA as broadcasting on 890 kHz. In 1941, while the transmitter was still in E.E., the operating frequency was moved to 920 kHz, its present frequency.

Purdue recognized the 25th anniversary of WBAA in March 1947. The station was then operated by a committee of E.E. professors and representatives from other schools; the chairman was T.B. Johnson, and the late Jim Miles was the station manager. There were 34 student announcers working at the station at this time.

From 1927 to 1982, the E.E. Building had a distinctive appearance with its two huge Marconi towers that made it easy to tell a stranger how to find the building. The fate of the towers was uncertain, however. Despite their not having been used since 1942, the towers had to be painted regularly. At E.E. faculty meetings, there were frequent heated discussions between the pro-tower and anti-tower advocates. The cost of painting every few years was about $1,800. Removal of the tower was estimated to cost about $7,000. It was difficult, therefore, to make the decision which soon forced itself on E.E.. The towers were 88 feet high and, with the antenna, constituted an excellent collector of static electricity. During thunderstorms, the discharges brought short-duration, high-voltage pulses into the building where digital computers were trying to keep track of useful zeroes and ones. After two lightning strikes damaged a dozen terminals and the main computer, it was finally decided that, even if they were attractive and part of a tradition, the towers had to go. On May 24 and 25, 1982, the Marconi towers were removed, leaving the E.E. Building bereft except for a radar antenna. In 1988 the upper halves of both towers were cut up and made into Centennial trophies.

One might well ask, "What good did wireless and WBAA do for E.E.?" But the answer is clear: It was the force that brought electronics into the E.E. curriculum.

L.A. Geddes, M.E., Ph.D., F.A.C.C., is Showalter Distinguished Professor Emeritus of Bioengineering at Purdue University.



372 pages, self-published. Available from the author for $19.95 postpaid, personal or business check.

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Book Review

Oscilloscopes: Selecting and Restoring a Classic

Reviewed by K.T. "Tom" Green

Buying and restoring old Tektronix oscilloscopes might be an interesting hobby for someone involved in the electronics industry. Until now, information about selecting and restoring scopes was not abundant. A new book, *Oscilloscopes: Selecting and Restoring a Classic*, provides helpful information to a novice collector and could serve as a reference for experienced collectors.

Stan Griffiths' book is in the style of a collector's guide. The bulk of the book is pictures of all types of Tektronix oscilloscopes, descriptions of each, their original prices and what one could expect to pay for the scope now.

Chapter one provides a brief overview of the operation of an oscilloscope and refers to chapter seven, a glossary of oscilloscope terms, for explanations of terms used with oscilloscopes. Chapter three discusses how to find and determine the overall condition of classic scopes. Chapter four contains information regarding the repair and restoration of the electrical circuits, and chapter five contains useful information about part numbers and the meanings of serial numbers.

The book is intended to help the buyer of a classic Tektronix oscilloscope to get the best buy for his money; however, it is never clear who that person might be. It is implied that the buyer might be a collector of vintage electronic equipment, but the book also would have meaning to an electronics technician looking for a high-quality, low-priced oscilloscope. Many electronics technicians and electronics enthusiasts might be hard-pressed to afford a new oscilloscope, whereas the vintage scope could be within the range of their finances.

The descriptions section of the book takes up about seven-eighths of the text volume. This section is an excellent reference that allows the reader to find and to identify the various scopes quickly. This section should prove helpful in finding units to restore. Even so, the text covering the other sections is written in a somewhat simplistic manner. The novice restorer will find the information incomplete and will need to seek more advanced information from other sources. The advanced restorer or an experienced technician probably will not find the information highly useful; however, several interesting suggestions are given.

After reading Griffiths' book, I felt somewhat nostalgic. In my experiences as an electronics technician and electronics instructor, many of these classics have crossed my path. Over the years, I have disposed of many usable units, and I feel a little sad knowing that those units are gone forever. I did, however, find in my storage area a model 310A single-trace scope. I have taken measures to preserve this little gem, as its physical size is smaller than most of the units discussed in the text, and storing it doesn't create a problem. This text helped me to see the value of this classic oscilloscope.

I recommend this book to anyone interested in restoring high-quality "vintage" Tektronix oscilloscopes.

K.T. "Tom" Green (M) is an instructor and communications manager of communications electronics at Ranken Technical College, St. Louis. He is chairman of the volunteer leadership council of the Association of Communications Technicians, a membership section of the National Association of Business and Educational Radio (NABER), and a member of NABER's board of directors. He lives in Granite City, Illinois.

Francis H. Shepard Jr., P.E. 1906-1994

By A.L. Arledge

After graduation from Yale University's Sheffield Scientific School, Frank Shepard began his career working for Dr. Sperry. His early work developing chopper-stabilized dc amplifiers led to an infrared detector sensitive enough to detect a ship beyond the horizon.

While with Dr. Sperry, Shepard developed and perfected relaxation-type oscillators that were used in fathometers, burglar alarms and weather balloons, to name a few applications.

After Sperry, Shepard worked for RCA where he was instrumental in the design and development of a vacuum-tube voltmeter known in the industry as the RCA Voltohmist. During the years with RCA, he developed a keen understanding of the principles of feedback, which he applied time after time throughout his career.

He often remarked about how his use of feedback was not invention, just the application of the teachings of the old-timers. "For example," he said, "where an old printing press may employ an air dashpot to eliminate a mechanical overshoot problem, I may use a R-C integrator in the feedback loop of a motor servo for stability." Frank would explain that all the components used to accomplish a task has some degree of limiting. For example, a power supply will limit the current, an amplifier has limited drive, and a clutch will limit the torque. All these limits, including nonlinearity in an amplifier, may be precisely compensated for by a thorough understanding of how to employ the proper feedback. An excellent example was the development of a clutch-operated antenna servo on the Navy's Kingfisher missile that would lock on and track a target regardless of the pitch and yaw motion of the missile. Another important contribution to the Kingfisher missile program, was the development of a simple, single-tube, super-regenerative radar used as a proximity fuse.

The list of companies that retained Shepard's engineering expertise is endless.

Subsequent to RCA, Shepard was retained by several companies including the Telautograph Company, Brown Instrument Company, Bristol Instrument Company, U.S. Bureau of Standards, Dupont, U.S. Army Signal Corps and Raymond Engineering Company just to name a few.

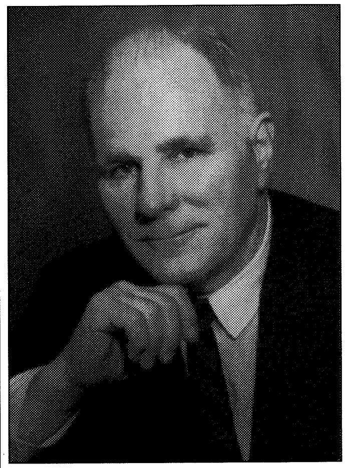
...to converse with many individuals at their own level of understanding. Shepard exclaimed that <u>that</u> was the sign of a really great man. Little did Frank know that he was describing himself as well.

On many occasions, Frank would tell a story about a visit to Raymond Engineering. It seems that Albert Einstein had come to visit his nephew, a tool maker, and was able to converse with many individuals at their own level of understanding. Shepard exclaimed that that was the sign of a really great man. Little did Frank know that he was describing himself as well. Frank had such a profound understanding of engineering basics that he could describe an electronic concept in the language of a mechanical engineer and visa versa. He could draw on a simple concept or use a common object to describe a more complicated scientific phenomenon.

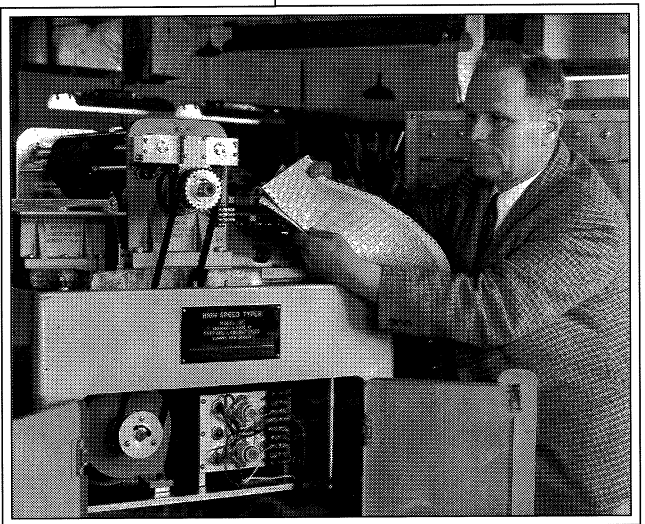
For example, he would spin a quarter on the table to demonstrate principles of gyroscopic motion that caused his early clutch-brake designs to fail or, to show

how the length of a printer hammer in his high-speed line printers controlled impact force, he used the long spring from a common window roller shade.

Frank Shepard's first wife was a coloratura soprano, and wanted recordings of her voice. Frank was disappointed in the best RCA recorder that money could buy. He decided to study the characteristics of the human ear to determine just what it is that we like to hear, and how to improve audio amplifiers and recorders. As a result of this research, he developed a hearing aid that was licensed to Maico and Zenith. By World War II, Zenith had manufactured and sold more Shepard hearing aids than the rest of the industry combined.



As a result of the hearing aid research, Shepard designed the non-linear characteristics of the human ear into small ac-dc table radios. As a result of the odd harmonics generated, the brain was fooled into thinking it was hearing the low frequencies. Synthetic bass, as it was known, made a table radio sound as though it were driving a 12-inch woofer. His technology was licensed to Zenith, Motorola, RCA, Admiral, Majestic, Belmont, Emerson, Stromberg-Carlson and others.



◀ *Francis H. "Frank" Shepard Jr., P.E.*

▼ *Shepard at work with one of his high-speed printers.*

One day in the early 1950s, Frank had lunch with a friend involved in generating ballistic tables for the U.S. army. He was amazed to hear that it took a room full of IBM's fastest, state-of-the-art number-crunching machines to keep up with a new computer. Shepard left the lunch table with an idea that would revolutionize the printer industry. He went home and attached a simple spur gear to a 600 rpm motor, and then dropped a hardened dowel pin on a sandwich of paper and carbon paper held just above the rotating gear. Upon examining the results, he exclaimed "Eureka!" For there, upon the paper, were sharp clear images of the ends of the gear teeth. It was just a simple matter of replacing the teeth with embossed characters and stacking these little elements together to create the rotating drum of a high-speed line printer. Shepard Laboratories was born about 1952 when Shepard delivered to Aberdeen Proving Ground the first 48-column line printer running at a staggering 600 lines per minute. Shepard, known as the father of the high-speed line printer, developed and manufactured printers until the mid-1970s when he sold his business to Vogue Instrument Co.

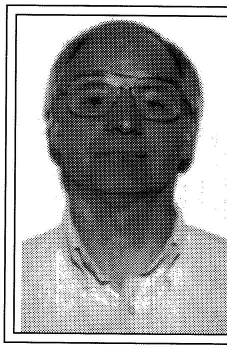
About this same time Shepard was approached by Jim Gubelmann. After inventing the mechanical calculator, Gubelmann's grandfather developed a mechanical, right margin-justifying, proportional-spacing typewriter. A model shop quoted $1 million to build one typewriter. Frank suggested that a model using electronic means could be built using the teachings of the 1,500-page and 250-figure Gubelmann patent. As a result, Shepard developed one of the first word processors using a Remington Selectric typewriter. He replaced the mechanical keyboard with an electronic keyboard, replaced the mechanical 10/12-character per-inch escapement with a closed-loop servo, and exchanged the fixed-pitch character ball with a ball having proportional characters along with a microprocessor controller to drive the Selectric. He developed a cathode-ray tube (CRT) display that not only would show a page exactly as it would be printed, but that would show proportional-width characters. The unit had many of the basic word processing features seen in today's models. Because of the expense of early solid-state memory chips, Frank elected to convert memory data to audio signals and record them on a standard cassette tape recorder. Another benefit of the audio format was that data could be sent to a remote unit over standard voice-grade telephone lines.

Along with his interest in electronics, Shepard loved Scottish music. He and his second wife, Maggie, became interested in the Berkeley Heights Highlander Bagpipe band. Together they set up a scholarship fund to award the most outstanding band member. Frank would grin from ear to ear when telling a story about

(continued on page 74)

The Discovery of the Ionosphere: 1900-1930

By Robert H. Welsh



The ionosphere has been the primary mode of long-distance communications by short-wave radio for the past 90 years. Short-wave radio (radio signals at frequencies ranging from 3 MHz to 30 MHz) has, in the past, provided the bulk of long-distance communications for such varied users as ocean-going ships, international broadcasting, international news, photofacsimile, weather data, military communications and thousands of amateur radio operators around the world.

Only within the past 20 years has there arisen any serious rivals to short-wave radio. Weather and communications satellites orbiting the earth, along with an increase of fiber-optic telecommunications cable, are beginning to replace the radio circuits that, in the past, handled the bulk of long-distance communications.

The purpose of this article is to analyze the discovery and the earliest use of the ionosphere and, additionally, to show how the scientific method was put to use by professional scientists and amateur radio operators.

Physical facts

I shall begin by reviewing a few simple physical facts that allow long-distance radio to be so successful. Our planet is surrounded by a gaseous atmosphere that is normally invisible to the eye — except for haze and pollution. The earth receives all manner of electromagnetic radiation from the sun. Some of the invisible solar radiation carries enough energy to strip electrons from the gases that make up the atmosphere. This interaction between solar radiation (primarily ultraviolet waves whose wavelengths are nominally shorter than 400 nanometers) and the atmosphere is what gives rise to the "bending" of short-wave radio signals.[1]

None of these facts were obvious to the earliest users of the ionosphere. In 1901, when Marconi transmitted the first transatlantic radio signal between Cornwall, England, and Saint John's, Newfoundland, the mechanism of radio propagation by the ionosphere was unknown. The scientific community of that time immediately set forth several hypotheses to explain this phenomenon.

Interaction between solar radiation and the atmosphere is what gives rise to the "bending" of short-wave radio signals.

The first hypothesis that was later accepted by experiment was offered independently and almost simultaneously by Oliver Heaviside (1850-1925) and Arthur Edwin Kennelly (1851-1939). Both of these scientists began their careers in wire telegraphy.

Self-teaching

Heaviside left school at age 16 and taught himself both Morse code and the basics of electricity. Two years later, his uncle, Sir Charles Wheatstone, got him a job as a telegrapher in Denmark. He worked there until he was 21, when he returned to England to become chief telegraph operator for the Great Northern Telegraph Company at Newcastle-on-Tyne. He continued his self-teaching by embarking on an ambitious program of study in science and mathematics.

This hard work paid off when he published two papers on electricity during the following two years. It is worthwhile to note that the first paper used only algebra, while the second paper used calculus to explain the operation of the Wheatstone Bridge. The second paper was significant enough to earn a mention in Scottish mathematical physicist James Clerk Maxwell's (1831-1879) *Treatise On Electricity and Magnetism*.[2] It was Maxwell who wrote four equations stating most elegantly that fields generated by moving charges can leave their sources and travel alone through space. This *is* radio!

Kennelly

Kennelly was born in India. He was the son of an Irish-born employee of the East India Company. Kennelly left school at age 14 to work as an office boy for the London Society of Telegraph Engineers. As did Heaviside, he obtained his scientific education through "on-the-job" training and self-teaching while employed by the Eastern Telegraph Company from ages 15 to 25. When he was 26 years old, Kennelly emigrated to the United States, where he became an assistant to Thomas Edison.

What led Kennelly and Heaviside to this hypothesis? To answer this question, we shall briefly look at the cast of characters whose hypotheses and experiments preceded the development of radio. Hans Christian Oersted (1777-1851) of Denmark discovered, by chance, in 1820 that there is a definite connection between electricity and magnetism — a hitherto unknown connection.

In the next decade, experiments by Michael Faraday (1791-1867) led him to discover the principles of electromagnetic induction; that is, an alternating current flowing in one coil of wire causes a voltage to be generated in a second coil of wire not connected by wires to the first coil. This led to the concept of electric and magnetic fields which carry energy from the first coil to the second coil by traveling through the intervening space between the coils.

Speculations

There were speculations on the concept of electric and magnetic fields traveling through space at least a century before Faraday. Natural philosophers such as Descartes considered the possibility, but it was not until the time of Karl Friedrich Gauss (1777-1855) that these discussions took on a more definite form. Gauss' investigations of the geomagnetic field led him to hypothesize a system containing two parts. One part of the geomagnetic field resided within the earth itself, while the other part was apparently above the earth. Gauss suggested that this "external" part might be the result of electric currents flowing in the earth's upper atmosphere.[3]

In a letter to Weber dated 19 March 1845, Gauss wrote that "he had long ago proposed to himself to supplement the known forces which act between electric charges by other forces, such as would cause electric actions to be propagated between the charges with finite velocity."[4] Gauss chose not to publish these hypotheses until experiments could be performed, which he never succeeded in doing.

It was Gauss' pupil, Riemann, who proposed an aether that was endowed with the power of resisting compression and the power of resisting changes in orientation — the former property being the cause of electrostatic effects and the latter being the cause of optical and magnetic effects.[5]

Laws of electrodynamics

It was to the previously mentioned Maxwell that we credit the mathematical foundation of these early discoveries. It has been said that "From the long view of the history of mankind — seen from, say, 10,000 years from now — there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics. The American Civil War will pale into provincial insignificance in comparison with this important scientific event of the same decade."[6] Maxwell provided not only a set of equations but also a model of how these fields were propagated. He assumed space to be an elastic medium through which these fields traveled.

Science does not accept a hypothesis, whether theoretical or mathematical, without experimental evidence to support that hypothesis. The experimental proof was given by Heinrich Hertz (1857-1894), professor of physics at the University of Bonn. In a series of brilliant experiments performed from the spring of 1886 to the spring of 1888, Hertz established forever that these "fields" were electromagnetic waves that propagated from point to point at the velocity of light, just as Maxwell predicted.

From this set of experiments, radio was born as a scientific curiosity, not as a practical method of communications which could rival the wire telegraph or telephone.

Marconi

It was to another experimenter that we now turn to observe the transition of "Hertzian waves" from the domain of laboratory physics to a practical system of communications. Guglielmo Marconi (1874-1937), 20 years of age and a student of Professor Augusto Righi of Bologna, began experimenting with a Hertzian oscillator.

Although Hertz's original experiments were at wavelengths on the order of 66 cm (450 MHz), the conversion of the scientific curiosity of radio into a system of practical communications took place at much longer wavelengths. Marconi's early experiments took place at wavelengths of about 365 meters, corresponding to an operating frequency of 820 kHz. At these very long wavelengths, Marconi recognized that very large antennas and very high power were necessary as he continued to increase the distance between his transmitting and his receiving stations.

His first transmission took place from Poldhu in Cornwall with his transmitting antenna supported by masts 55 meters (180 feet) tall and with a receiving antenna 152 meters (500 feet) long supported by a kite.[7] At the frequencies used by Marconi, and for 20 years thereafter, transmitted signals were what we now refer to as "ground waves," due to their low frequency. For example, a German radio station was established at Tuckerton, NJ, with towers 240 meters (800 feet) high. It operated at a wavelength of 5,000 meters (60 kHz), and the transmitter power was 200 kW. A Dutch station in Java (Indonesia) operated from 15 kHz-50 kHz using a flattop antenna 1,970 meters (6,500 feet) long suspended between two peaks. The feedline was suspended 900 meters to the valley below where the actual radio station was located.

Scientific dilemma

We now arrive at a true scientific dilemma. It was supposed that radio waves remained close to the surface of the curved earth (the ground wave). It had also been proven that radio waves decreased their field strength (signal strength) as the inverse square of the distance that the wave traveled; thus the signal would be attenuated rapidly. Early mathematical analysis[8] by Lord Raleigh (1903) and Henri Poincare (1910) showed that the amplitude of the field intensity should decrease with a corresponding increase in distance between the transmitter and the receiver according to the equation

$$E = E_o \exp(-a\lambda^{-1/3} d)$$

where

E = the received field intensity

E_o = a constant

a = earth conductivity constant

λ = the transmitted wavelength

d = the radio range

Based on this expression, the attenuation of the signal should decrease for longer wavelengths. Thus, the longer waves should be the subject of further inquiry, whereas the shorter waves were deemed useless for long-distance radio. This analysis supported the idea of giving the shorter wavelengths to the amateur radio operators while keeping the longer wavelengths for government and commercial use.

Austin's measurements

Louis Winslow Austin (1867-1932), physicist, was head of the Naval Research Laboratories from 1908 to 1923, after which he became chief of the Bureau of Standard's Radio Physics Laboratory until his death. He performed quantitative measurements of long-wave radio signals at wavelengths from 3,750 meters to 1,000 meters (80 kHz to 300 kHz) from the Fessenden station in Massachusetts to the U.S. Navy cruisers *Birmingham* and *Salem*. As these two ships sailed to Liberia and back, Austin and his assistant, Dr. Louis Cohen, an engineer with the National Electric Signaling Company, made careful measurements of the received signals to determine the law which governed the long-distance transmission of these signals.

Austin and Cohen plotted signals each day, looking for the relationships that equate distance, wavelength and antenna height with transmitted and received signal currents. The result of these experiments was the Austin-Cohen formula, an expression that yielded the received current for a given wavelength at a given distance to the transmitter.[9] This equation, in a form similar to that developed by Rayleigh and Poincare is:

$$E = E_o \exp(a\lambda^{-1/2} d)$$

with the variables having the same meaning as in the Rayleigh-Poincare equation.

Transatlantic experiment

A transatlantic experiment would surely test these ideas. The success of this test led scientists to consider that there must be another, unknown factor that allowed the signals to travel from England to Canada and from Massachusetts to Liberia. It was the hypotheses of Heaviside and Kennelly which suggested what the unknown factor was.

Could it be that high above the earth, there was a natural reflector of radio waves? If this reflector were a conducting layer of ionized air, then the restriction placed on the signal by the earth's curvature would be overcome. Moreover, the energy spread would be restricted to only two dimensions. If this were true, the attenuation of the signals would vary with the first power of distance instead of with the square of distance.

Kennelly did not just assume the existence of a conducting, reflective layer; he showed mathematically that an electrically conducting medium must exist because of rarefaction of the atmosphere at heights above 80 km (50 miles). His reasoning was based on the principles of air mass and air pressure. (See Figure 1.)

Heaviside took a slightly different view of the same

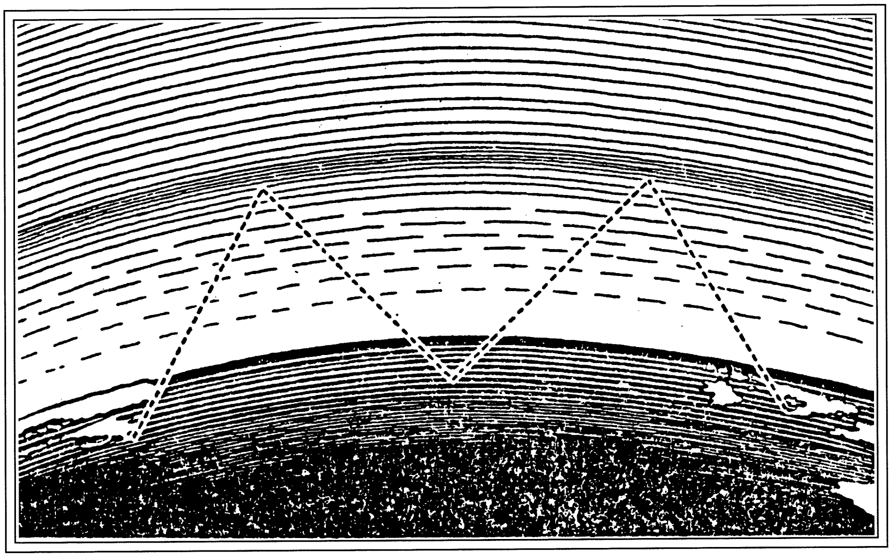


Figure 1. Heaviside's explanation of how wireless waves cross the Atlantic.

problem. He began with the same physical view of the atmosphere; that is, as we rise above the earth, the air becomes increasingly rarefied.

He further considered that atmospheric atoms high above the earth are thinly dispersed and are subject to solar ultraviolet radiation. These two conditions cause the atoms to lose some of their electrons. When electrons are forcibly removed from an atom, the remaining atom becomes positively charged and is called an *ion*. That region of the atmosphere where there are positive ions and free electrons was later given the name *ionosphere* by Sir Robert Watson-Watt, the British pioneer in radar.[10] Heaviside believed that this region would act as a mirror to radio waves; he also believed that both land and oceans would act as a mirror. Combining the hypotheses of Kennelly and Heaviside, there now was a satisfactory scientific explanation for Marconi's transatlantic communication.

This hypothesis remained untested by the scientific community for the next 20 years, during which time radio improved as a commercial, military and amateur enterprise. Even though commercial and military use remained on the longer wavelengths for the most part, amateurs began using the "shorter" wavelengths after the First World War. Consider, for example, the tests that the American Radio Relay League (ARRL) sponsored in the early 1920s.

Receiving tests

The initial scientific receiving tests, a joint venture of the U.S. Bureau of Standards and the ARRL, were announced in the League's journal *QST* in June 1920. Under the direction of R.S. Kruse of the Bureau of Standards, a series of scheduled transmissions were set up with the amateur community receiving the transmissions and recording the signal strengths.

The experiment worked well enough for the Bureau to develop a comprehensive theory on propagation and fading effects at the operating wavelength of 250 meters (1.2 MHz). Kruse presented the results of these experiments at a meeting of the Radio Club of America held at Columbia University on 24 September 1920.[11]

The tests were remarkable in their cooperation. There were six transmitting stations. Five were amateur stations, including the League's headquarters station, 1AW, and the sixth station was NSF, the U.S. Navy's Radio Laboratory station at the Naval Air Station, Anacostia, DC. (See Figure 2.) There were 48 additional stations that acted as "recorders" using a common report form to record signal intensity, identical receivers (the three-tube Paragon manufactured by the Adams-Morgan Co.) and similar antennas (four-wire or six-wire inverted L antennas about 60 feet high and 60 feet long) all operating at a wavelength of 250 meters (1.2 MHz). (See Figure 3.)

In light of current knowledge of ionospheric radio propagation, Kruse's conclusions were most interesting.

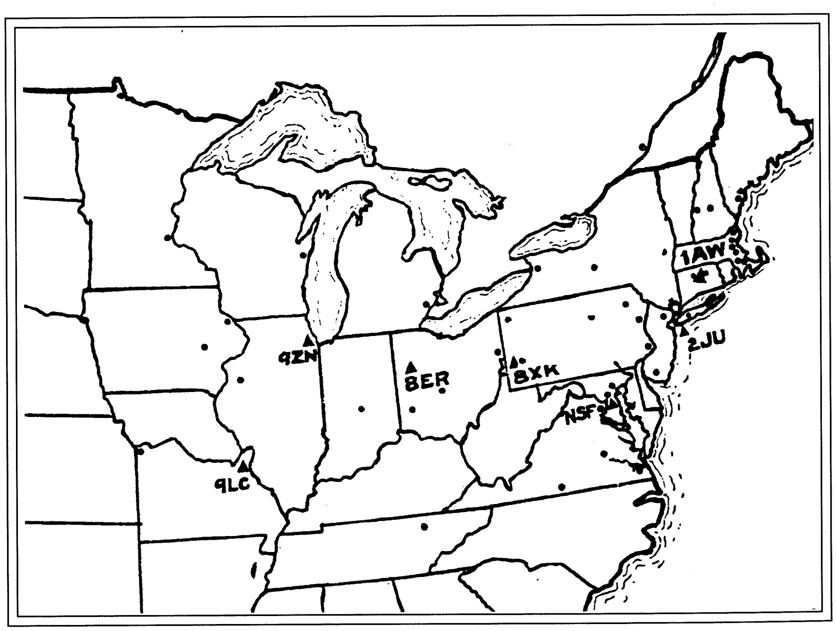


Figure 2. A map of the station network in the Bureau of Standards-ARRL test of short-wave radio signal fading.

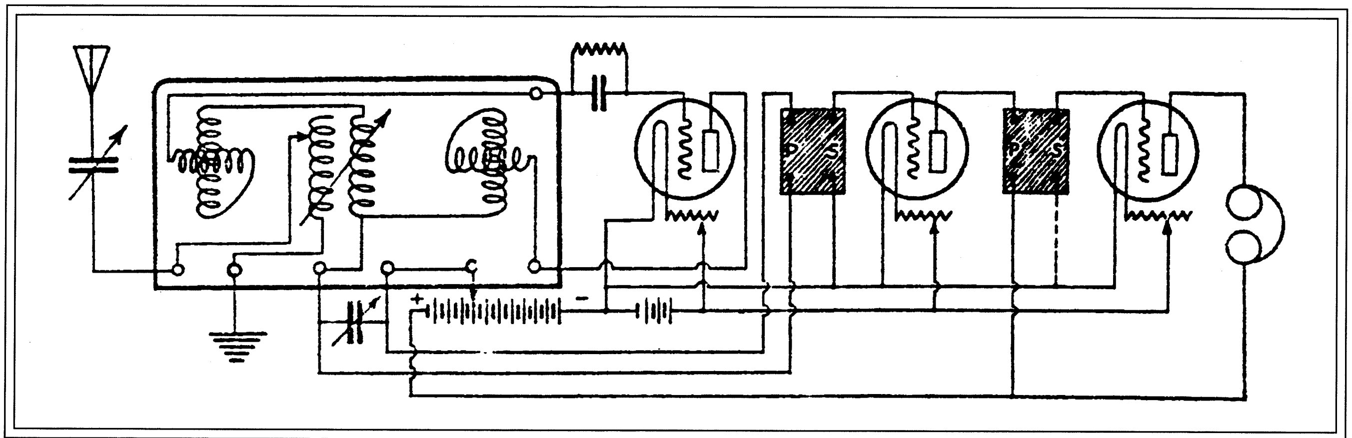


Figure 3. A circuit diagram of the Paragon receiving set.

He first considered fading as a physical phenomenon quite similar to Thomas Young's explanation of the interference of light waves, consisting of a source, multipath signals via reflector and a receiving screen. If the reflector tilted or moved in any direction except its own plane, then regions of interference bands (increased signals and decreased signals) would move along the receiving screen.

Kruse then analyzed the causes of the reflecting screen. His list of causes included large clouds, fog banks, fumes from industrial plants and possibly the Heaviside layer. He commented that at least one of the transmitting stations, 8XK, Pittsburgh, was located near smelters and steel mills whose fumes could collect in sufficient mass to act as radio reflectors.

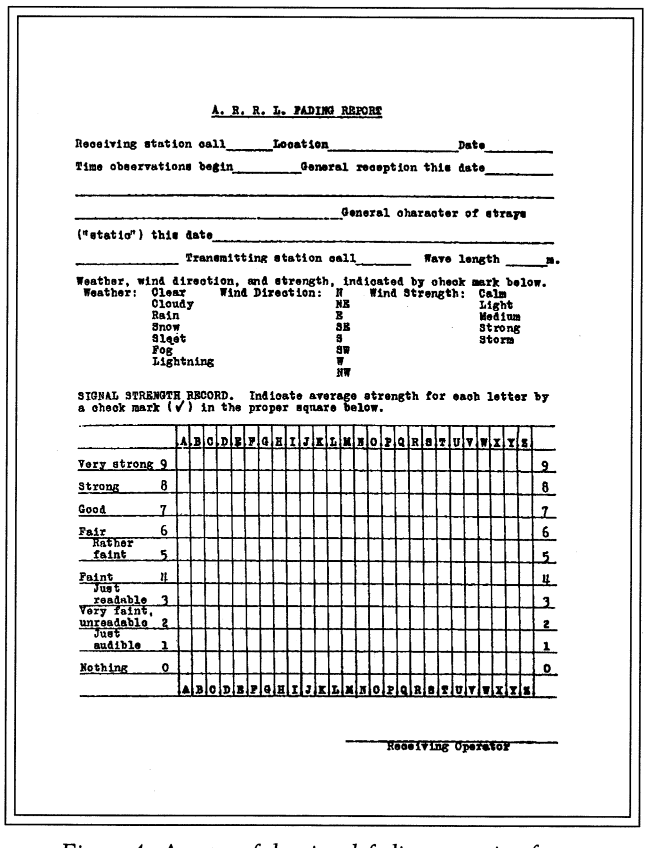
In addition, weather conditions were considered, but no correlation could be found between the weather at any station and the effect of fading. The same conclusion was arrived at with respect to the difference in transmitters among the six transmitting stations. Kruse stated in his last paragraph, "The tests furnish good evidence in support of the belief that radio signal variations such as fading and swinging are caused by varying reflection and refraction of waves."[12] (See Figure 4.)

Amateur experiment

The success of these receiving tests led the amateur community to consider a similar experiment, but this time with the Atlantic Ocean between the transmitting and receiving stations. The experiment was led by Paul Godley, 2XE, a member of the Institute of Radio Engineers, the Radio Club of America and the ARRL's Advisory Technical Committee.

Godley traveled to London and then to Scotland where he set up a receiving station at Androssan Moor. On the night of 7 December 1920, Godley's receiving station began picking up signals from U.S. amateurs. Godley recorded the following comments in his log, "At 1:35 am picked up 60-cycle synchronous spark at about 270 meters, chewing rag. Adjusted for him, and was able to hear him say 'C U L' and sign off what we took to be '1AEP'; but atmospherics made sign doubtful.... That this was an American ham there was no doubt!... His signal had doubled in strength, and he was booming through the heavy static and signed off clearly 1AAW, at 1:42 am!"[13]

At least 30 U.S. amateur stations were heard by Godley and a group of British experimenters during the second transatlantic receiving test. In addition to the British listeners, signals were heard in The Hague, Netherlands, and by Leon Deloy in Nice, France.



A. R. R. L. FADING REPORT

Receiving station call______Location____________________Date__________

Time observations begin__________General reception this date__________

____________________________________General character of strays

("static") this date____________________________________

______________ Transmitting station call________ Wave length ______m.

Weather, wind direction, and strength, indicated by check mark below.

Weather: Clear, Cloudy, Rain, Snow, Sleet, Fog, Lightning

Wind Direction: N, NE, E, SE, S, SW, W, NW

Wind Strength: Calm, Light, Medium, Strong, Storm

SIGNAL STRENGTH RECORD. Indicate average strength for each letter by a check mark (✓) in the proper square below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
Very strong 9																											9
Strong 8																											8
Good 7																											7
Fair 6																											6
Rather faint 5																											5
Faint 4																											4
Just readable 3																											3
Very faint, unreadable 2																											2
Just audible 1																											1
Nothing 0																											0
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	

______________ Receiving Operator

Figure 4. A copy of the signal-fading reporting form published by the ARRL.

130-meter test

In 1922, a successful test was performed on a wavelength of 130 meters (2.3 MHz) by Boyd Phelps, 1HX, of the ARRL headquarters staff, followed by a 90-meter (3.3 MHz) test that seemed to indicate that, as wavelength decreased, signals become better. Following Marconi's example, ARRL set up a transatlantic experiment between the United States and France. On the night of 27 November 1923, Schnell, 1MO, and Reinartz, 1XAM, had two-way communications with the French amateur Leon Deloy, 8AB, on a wavelength of 110 meters (2.7 MHz) for several hours.

The significance of the Deloy-Reinartz-Schnell experiment is not limited to the fact that this was the first two-way communication across the Atlantic, but that it was done at a wavelength previously thought to be useless. An exodus from the longer wavelengths began with operations at wavelengths shorter than 100 meters (3 MHz), primarily by amateur radio stations.[14]

The powerful stations of the U.S. Navy and the various commercial broadcasting stations remained at the longer wavelengths during and after the time that the radio amateurs proved the long-range potential of the shorter wavelengths. The amateurs wished not only to escape the interference of the Navy's stations, but also to escape the chaotic frequency changes of the commercial broadcasting industry. Throughout 1924, the experiments of the radio amateurs showed that short waves could not only span the Atlantic but also the Pacific. By September of that year, a station operated by W.D. Magner, 6BCP, at San Pedro, CA, heard the signals of Frank Bell's station, Z4AA, at Waihemo, New Zealand. Short-wave communications had now spanned a distance of 6,900 miles.

Experimental evidence

There now existed a body of experimental evidence, generated almost exclusively by amateur radio stations, that supported the earlier Kennelly-Heaviside hypothesis. Short-wave radio signals were apparently not propagating along the curvature of the earth, but were traveling up into the atmosphere where they were being reflected forward toward earth.

In May 1924, Dr. A. Hoyt Taylor, a physicist and superintendent of the Naval Research Laboratory's Radio Division and a pioneer in the study and development of short-wave radio, wrote an article in the amateur journal *QST*. In Taylor's words, "The intensity of signals received on these (high) frequencies is so great that I am forced to conclude that these waves do not follow at all the ordinary laws of transmission.... To me, this would indicate that there is so complete a reflection of these waves at some upper and probably ionized layer of atmosphere that they travel not as an ordinary wave, but more as a wave confined between two parallel planes."[15]

Taylor's article described the Navy's short-wave stations and closed with a request to the amateurs to assist in the Navy's upcoming North Pole flight by the *Shenandoah*, which would be operating one of its two stations on 100 meters (3 MHz).

Antipodes link

Toward the close of 1924, a two-way communication occurred between the amateurs of New Zealand and Great Britain. For the first time, the antipodes were linked by radio. Again, it was the station of Frank Bell, Z4AA, who was at the forefront of experimentation when he contacted the station of the Mill Hill School in London, G2SZ, for a period of 90 minutes. Lest one think that this was a freak occurrence, five days later, on the 25th of October, Ralph Slade, Z4AG, communicated with G2NM. Radio signals were now seen to propagate over distances that were halfway around the planet, almost 12,000 miles, at wavelengths previously thought of as useless. What is more astounding was that the London station had an input power of 230 watts![16]

The experiments of the world's amateurs dealt a severe blow to the previously mentioned Austin-Cohen hypothesis. It was none other than Arthur Edwin Kennelly, now a professor of electrical engineering at Harvard University, who wrote an article in the December 1924 issue of *QST*, questioning the concept that the Austin-Cohen formula was the sole determinant of how radio signals propagated.

In his article, he summarized how the Austin-Cohen formula predicted that shorter radio waves would be highly attenuated, but, he reminded the reader, radio waves of 100-meter wavelengths were now routinely carrying messages at night across the oceans, with relatively low antenna power. At this point, Kennelly restated his 1902 hypothesis about the ionosphere: "There is now good reason to believe that a conducting layer exists in the upper air, say at an elevation of 80 km. Its possible existence seems to have been first published in 1902. If that conducting layer is sharply defined; so that there is a sudden transition from a lower insulating to an upper conducting region, then that layer should transmit radio waves like an inverted ocean surface, without much absorption at the boundary."[17] After 20 of theories and experiments, the stage is set for the final confirmation.

Reinartz article

In the April 1925 issue of *QST*, the amateur John Reinartz, 1XAM, the same person who had that first, momentous two-way communication across the Atlantic, wrote a classic article which presented his ionized reflecting layer hypothesis. He began his discussion by reviewing Oliver Heaviside's theory of radio reflection from the low-pressure, ionized gases of the upper atmosphere. He continued by reviewing the 1924 tests and the effects observed from almost 5,000 reports on the transmissions from his station. His discussion included drawings of ray paths between his station and others, including the position of the sun during these tests.

Reinartz suggested a region on earth that is below the radio path which he calls the "dead belt." Today, that region is referred to as the "skip zone" or "skip distance." He further suggested that different frequencies are from different heights above the earth, thereby forecasting the refraction from the D-, E- and F-layers of the ionosphere.

He made note of seasonal changes in propagation between his station in New Hampshire and Paul Willis' station, 6TS, in Santa Monica, CA, on the 40-meter band. Reinartz closed his article with an interesting comment: "The advantage of the short wave is not that it is radiated more effectively, but that it is reflected to points further away with the result just the same as if it had been bundled up and delivered intact at the receiving station."[18]

The editor of the journal commented on Reinartz's theory, writing that high-frequency wave penetration of the Heaviside layer to greater elevations than low-frequency waves is in opposition to generally accepted beliefs and deserves further investigation. Healthy skepticism certainly is good science!

Scientific propagation analysis

During the same period of time that the amateur fraternity was showing the ability of short-wave signals to propagate around the planet, serious scientific analysis of radio propagation was being conducted in England. Prominent physicists were developing theories concerning radio signals and ionized media. In 1921, T.L. Eckersley published an article in *Radio Review* entitled "The Effect Of The Heaviside Layer On The Apparent Direction Of Electromagnetic Waves." Eckersley argued for the existence of an ionized layer at the upper reaches of the atmosphere.

One of the most prominent physicists of that time, Sir Joseph Larmor, Fellow of St. John's College, Cambridge, England, and an expert in the theories of electromagnetism, added his hypothesis to the growing list of radio propagation theories. Larmor envisioned a wave passing through the lower regions of the atmosphere with little attenuation but traveling in the ionized field region at a speed greater than in a vacuum, allowing the wave to be bent to conform to the curvature of the earth. Mathematically, Larmor treated the ionized region as having the properties of a dielectric with the particles of the region being electrons, not ions.

Larmor's hypothesis was an extension of the 1912 hypothesis of W.H. Eccles, who treated the charged particles as ions and the medium as a conductor. It was Eccles who named the medium the "Heaviside layer" in his writings.[19] Although the theories of Eccles and Larmor differed, the theories were generally referred to as the Eccles-Larmor Theory by those investigating the phenomenon of radio propagation. This theory is similar but not identical to Larmor's theory describing the precession of an atom in a weak magnetic field where the precession is called the Larmor frequency.

Appleton

One of those investigators mentioned above was Edward V. Appleton, a student of Larmor's and an expert on thermionic vacuum tubes during the period 1919-1923. An outstanding theoretician and a tireless experimenter, it is to Appleton that one must look to bring this discussion full circle. As a result of the publication of Larmor's work, Appleton took up the question of radio atmospherics (static). Under Larmor's influence, Appleton began considering the physics of the atmosphere in terms of radio waves.

In 1923, Appleton discussed with Hendrik Lorenez, the great Dutch physicist, the possibility that the particles of the atmosphere responsible for the propagation effects might be electrons, and what influence the earth's magnetic field might have on the plane of polarization of those radio signals passing through the atmosphere. During the following year, Appleton attended a lecture given by Larmor in which he (Larmor) did not address the effects of the earth's magnetic field on radio signals passing through. When Appleton remarked to Larmor that the magnetic field had not been considered, Larmor suggested that Appleton may want to deal with this issue himself.

Deal with it, he did. In a few short years, Appleton established himself as the preeminent expert in the field of radio propagation studies — expert enough to be awarded the Nobel Prize in Physics for 1947 "for his investigations of the physics of the upper atmosphere, especially for the discovery of the so-called Appleton layer." This was only the second Nobel prize awarded that related directly to the field of radio science. Marconi and Braun were awarded the 1909 Nobel Prize in Physics for their contribution to the development of wireless telegraphy.

Letter to Nature

It was during the five-year period (1923-1928) that Appleton's tireless research confirmed the existence of the ionosphere. His publications show a methodical, step-by-step process of hypothesis formation and experimental confirmation. In a letter to the editor of the British scientific journal *Nature* titled "Local Reflections of Wireless Waves from the Upper Atmosphere"

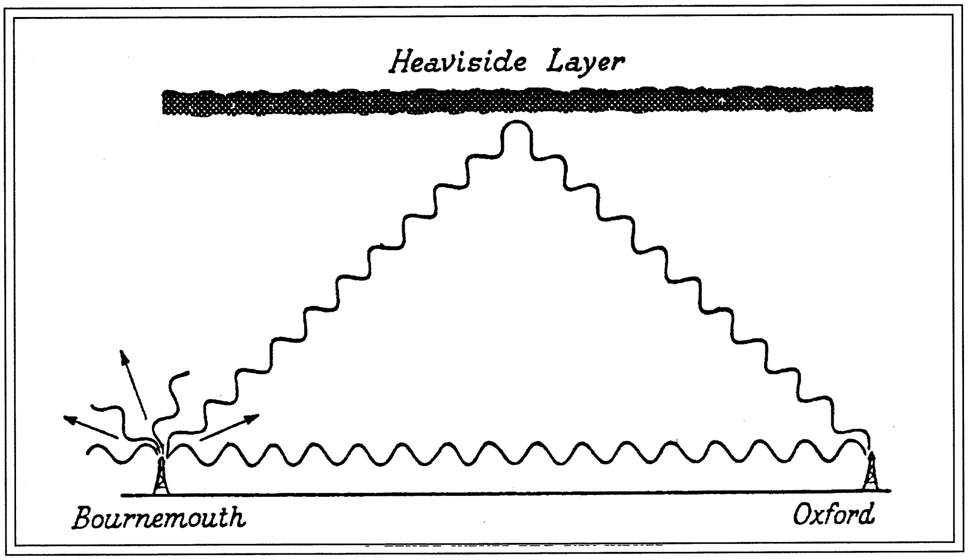


Figure 5. A diagram of ground-wave and sky-wave propagation between Bournemouth, England, and Oxford, England. Reprinted with permission from Nature, March 1925. Copyright 1925 by Macmillan Magazines Limited.

and published 7 March 1925, Appleton and M.A.F. Barnett describe their recent research. To anyone familiar with the scientific method, this letter is a classic model of its use.[20]

They began their letter by describing the diurnal variations of radio signals received at Cambridge from station 2LO of the British Broadcasting Company (BBC). The first observation is a day-night comparison of signals received over a short range of 80 km (50 miles) between London and Cambridge. They wrote that daytime signals are fairly constant in received intensity, whereas nighttime signals vary with an almost periodic nature. Next, they compared the day vs. night received intensity over a longer range — this time, between Cambridge and Bournemouth on the south coast, a distance of about 200 km (130 miles).

Daytime vs. nighttime signals

At this longer distance, the phenomena appear different than at the shorter distance. According to Appleton, the daytime signals are weak but constant, whereas the nighttime signals tend to be variable in intensity but much stronger. He concluded from these measurements that atmospheric reflections are "ineffective" during the day but "bends them down very markedly at night." Further, he suggested a mechanism for the variation of the signal intensity at night. Two rays are transmitted and received; one ray, which he calls the direct ray, is near to the ground, whereas another ray, which he calls the indirect ray, propagates up into the atmosphere. The nighttime variation is the result of the interference of these two rays at the received end of the signal path.

This type of interference, discovered by Thomas Young in 1801, is a result of any two or more rays emitted by the same source and propagated along different ray paths according to the equation $n(\lambda) = D \sin \theta$. Using the London-to-Cambridge distance, Appleton estimated the height of the reflecting stratum to be 100 km (60 miles) and the incident angle of the indirect ray to be about 22°. Up to that time, this angle was considered too high to be reflected from the Heaviside layer, so Appleton again approached the BBC to conduct a new set of experiments in which he would vary the transmitting frequency and attempt to observe the interference effects.

BBC cooperation

A better understanding of radio propagation was in the interests of the BBC, so the company kindly consented to work with Appleton in a series of experiments using its Bournemouth station as the transmitter. A receiver was set up at Oxford University, about 140 km (84 miles) to the north. (See Figure 5.) The Oxford group headed by Professor J.S. Townsend of the Oxford Electrical Laboratory designed a special receiver for the experiments. Much care was taken at both the BBC end and at the Oxford end to ensure the efficacy of the results. The transmitter frequency was varied at a constant rate during a fixed period of time while the antenna current was kept constant. The signal intensity was recorded using the specially designed receiver which had a constant output over the frequencies of interest. In addition, a land-line communication link was established as a control during the experiment.

Appleton wrote in his letter to *Nature* that definite examples of interference bands were observed as the transmitter frequency was varied. He continued by stating that the amplitude varied from a maximum value to almost zero as predicted by their choice of distance between stations. Using a variant of Young's system (the Lloyd's mirror fringe system), Appleton calculated the height of the reflecting layer at about 80 km (50 miles).

He hypothesized that the reflection did not occur as a result of the sharp boundary between a dielectric and a conductive region, as suggested earlier, but as a result of heavy ionization causing "ionic refraction" — possibly the first time that refraction is considered as a mechanism for ionospheric radio propagation. The differences in received signal between day and night reception were attributed to a change in the height and density of the effective layer.

Appleton closed his letter with the suggestion that, for radio signals traveling over distances greater than 160 km (100 miles), "night-time reception is dependent entirely on the upper indirect ray...the signal strength maximum may increase with increase of distance from the transmitter."

Earth's magnetic field

In the same issue of Nature immediately following Appleton and Barnett's letter, there is a letter written by H.W. Nichols and J.C. Schelleng of the Bell Telephone Laboratories entitled "The Propagation of Radio Waves over the Earth."[21] In this note, the authors suggest that Larmor's hypothesis relating to the bending of long waves around the earth is incomplete when applied to shorter wavelengths. Nichols and Schelleng's theory takes into account not only the distribution of ionized particles in the atmosphere but also the contribution of the earth's magnetic field. They suggested that for wavelengths of 100 meters-200 meters (half of the wavelength used by Appleton and Barnett), there are "marked selective effects." These effects manifest themselves as measurable differences in signal strengths dependent upon the direction of propagation (with respect to the alignment of the geomagnetic field) and the polarization of the transmitted signal.

An additional suggestion was that the plane of polarization is rotated if the wave propagates parallel to the geomagnetic field, whereas "ordinary waves" moving at right angles to the field are unaffected. Further, they wrote that either the magnetic field or the ion density may cause the wave to travel over widely different paths from transmitter to receiver. These phenomena are currently referred to as field-aligned irregularities.[22]

A more detailed account of these experiments was published in the Proceedings of the Royal Society of London.[23] In this 20-page article, Appleton and Barnett described in detail each step of their experiments, including a schematic drawing of the receiver, a graph showing the variation in received signal strength as a function of time and drawings of the theoretical ray paths. They provided quantitative explanations by deriving the algebraic equations necessary to support each theoretical statement.

Simulated interferometer

An example of this procedure can be found on the seventh page of their article under the heading "Experimental Proof of Existence of Atmospheric Deflecting Layer." It is in this section that they carefully describe the technique of varying the transmitter frequency to simulate a Lloyd's Mirror interferometer. The use of interferometry is the basis for their proof that the radio signals rise obliquely from the transmitter to an ionized layer and are "deflected" forward toward the receiver. The equation derived to support their hypothesis is as follows"

$$N = (a' - a)/\lambda$$

where

a = the ground-path ray

a' = the atmospheric ray

λ = the transmitter wavelength

N = the number of wavelengths that one ray is behind the other.

A modification of this equation yields a solution that conforms to the experimental procedure of changing wavelength while recording received signal intensity; that is:

$$\Delta\lambda/\lambda 2\ (a' - a)$$

Because both $\Delta\lambda$ and λ are known, the value of $(a' - a)$ can easily be computed. The numerical value of the expression $(a' - a)$ is the height of the reflecting layer. At an operating wavelength of 385 meters (780 kHz) with a 10-meter shift in transmitter wavelength and an average of 4.5 fringes recorded, they calculated a layer height of 80 km. This calculation is in close agreement with the value cited by Kennelly in his December 1924 *QST* article. Modern methods yield the height of the E-layer to be about 100 km above the earth.

Investigating reflections

With the evidence mounting that short-wave signals arriving over long distances do so by ionospheric reflection, Appleton began investigating the characteristics of these reflections. This investigation began with a measurement of the angle at which the incoming waves reached the ground. He set up two identical receiving systems but with different antennas feeding each receiver. One antenna was T-shaped, while the second was a large, one-turn loop. The horizontal portion of the "T" was at right angles to the direction of propagation (assumed to be vertical), whereas the loop

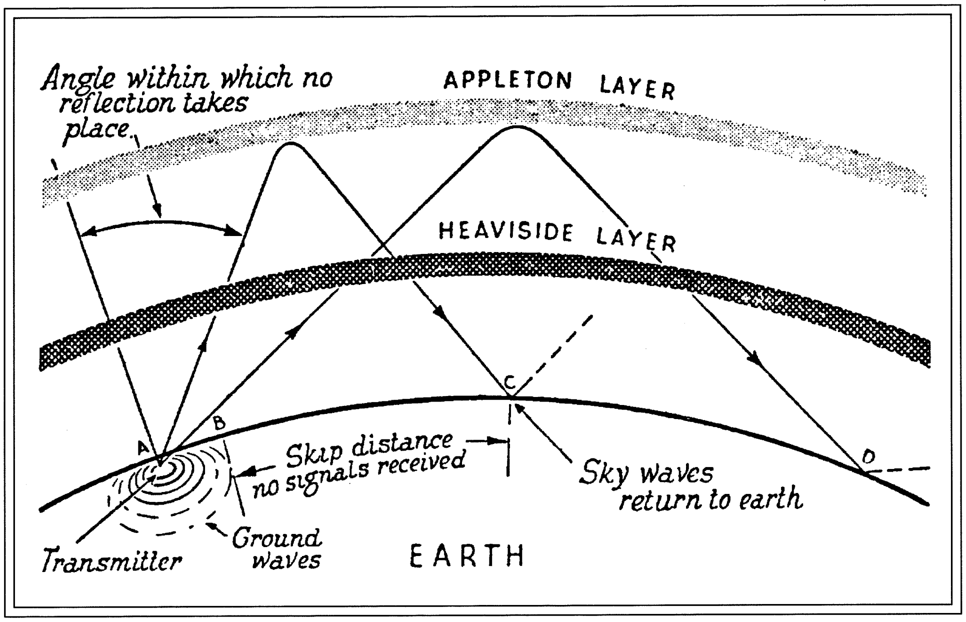


Figure 6. The reflection of wireless waves by the Appleton layer. Reprinted with permission from Nature*, September 1927. Copyright 1927 by Macmillan Magazines Limited.*

was considered to be in the plane of propagation.

The measurements were taken as the ratio of the mean daytime received signal currents. These initial tests were made at wavelengths of 475 meters and 385 meters, respectively, on signals received at Cambridge from the same London transmitter (2LO) as before. From his calculations, Appleton calculated an incoming angle of 69°. He increased the spacing between the two antennas and repeated the measurements, this time with a calculated incoming wave angle of 63°.

Appleton took the next logical step by increasing the distance between the transmitter and the receiver. A transmitter at Birmingham (5IT) was used, which was 140 km (84 miles) away from Cambridge, almost twice the distance of the London-Cambridge test. This time, the wave angle decreased to 48°, which Appleton rightly assumed to be due to the longer distance between stations. Finally, Appleton decided to decrease the distance between the transmitter and the receiver to observe the effect of the ground-wave signal. He set up his receivers at Potters Bar, about 19 km (12 miles) from London. There were almost no discernible differences between the T-antenna and the loop antenna. Appleton wrote that this must be due to the ground ray overwhelming the incoming sky wave.

To confirm his suspicions, Appleton had his student, J.A. Ratcliffe, set up a similar receiving system at Rawtenstall at a distance of 30 km (18 miles) from Manchester. Ratcliffe found that the intervening hills between Rawtenstall and the Manchester transmitter (2ZY) produced excessive attenuation of the ground ray. These measurements, coupled with the previous ones, appeared to be adequate confirmation that over short distances, propagation was by ground-wave signal, whereas over increasingly longer distances, sky-wave propagation was the dominant mode.

American experiments

One more set of experiments by two American physicists yielded proof of ionospheric reflection of short-wave radio signals. Gregory Breit of the Department of Terrestrial Magnetism (D.T.M.), Carnegie Institution of Washington, and Merle A. Tuve, a physics instructor at Johns Hopkins University who was a radio amateur during his high school days, collaborated on measuring the height of the ionosphere by echo-sounding. Breit first proposed construction of a large parabolic antenna 25 meters tall and 23 meters across. He had no luck in selling the idea to the D.T.M., which was a serendipitous result, anyway. Breit had planned on operating his antenna at a wavelength of 3.3 meters (90 MHz), which, it turns out, is much too short to be reflected back from the ionosphere under normal conditions.[24]

Breit then enlisted the aid of his friend Tuve to work with him during the summer of 1925. They were successful in obtaining the use of the U.S. Naval Research Laboratories transmitter at Anacostia, the same location as Kruse's earlier 1920 experiments. The transmitter was operated at a wavelength of 71 meters (4.2 MHz) with a power of 10 kW. The transmitted signal consisted of 500 Hz pulses emitted during the positive half-cycle of the operating frequency. A receiver was set up 11 km (7 miles) away from the transmitter site. Both the transmitted and the received signals were recorded on an oscillogram which plotted signal amplitude as a function of time. This plotting method allowed a calculation of the delay time between transmitted and received pulses.

Confirming the layer

The experiment yielded a "retardation of the secondary humps with respect to the primary..." to be on the order of 1/1,700 seconds. Using the distance-velocity-time relationship of d = ct where d is the round-trip range, c is the velocity of light and t is the round-trip time, Breit and Tuve obtained a path length of 176 km (110 miles), which is a one-way distance (layer height) of 88 km (55 miles).[25] This height correlates well with Appleton's calculations using the Lloyd's interferometer during the December 1924-February 1925 tests; thus, the pulse-echo method provided another independent confirmation of the existence of a radio-reflecting layer in the atmosphere.

The experimental procedures developed by Breit and Tuve have become the most widely used technique for investigating the state of the ionosphere. Ionosondes or pulsed radar devices have been set up around the world for daily investigation of the ability of the ionosphere to support propagation at specific radio frequencies.[26]

In his letter to *Nature* published on 3 September 1927, Appleton summarized his past observations. He made note of the fact that, through his experiments and data analysis, there appeared to be several layers of ionization that are responsible for radio propagation. He commented on the differences in calculated layer height between his summer 1926 nighttime values (90 km-130 km) and his fall-winter-spring 1926-1927 values (250 km-350 km). He specifically noted that the difference in layer height occurred several hours before dawn, with the higher values occurring 30 minutes to 40 minutes before sunrise. He proposed that the ionization of the Kennelly-Heaviside layer is sufficiently reduced by recombination during the night and that the layer is reformed under the influence of sunlight as the day progresses.

In addition, Appleton suggested that this phenomenon should be investigated with respect to the operating wavelength "[s]ince ultra-short waves require more concentration to deflect them back than do the longer waves ... ."[27] In yet another instance, Appleton had observed a new phenomenon; that is, several layers are responsible for ionospheric propagation. Today, we understand that there are several layers which vary in height for different times of the day and night and which vary in ionization density depending on solar activity. They are named the D region at heights of 60 km-92 km, the E region at heights of 100 km-115 km and the F region, divided into two heights, F_1 at 160 km and F_2 at 210 km-420 km. He ended this letter to Nature by briefly commenting on how Breit and Tuve's results fitted in with his experimental data.

URSI paper

Appleton summarized his investigations along with providing a firm mathematical foundation in his paper read at the 13 September 1928 meeting of the International Scientific Radio Union (URSI) held at Brussels. He provided a mathematical analysis for his Lloyd's mirror experiment with Barnett, showing ray paths graphically along with the supporting equations for "effective height." (See Figure 6.) He compared his method with that used by Breit and Tuve, suggesting that the two different experimental procedures essentially measure the same natural phenomenon — philosophically, an important concept in hypothesis confirmation. Finally, he considered the refractive index of the atmosphere and the ionization gradient based on radio-ray tracing.[28]

Kennelly-Heaviside hypothesis

After almost 30 years of intense scientific investigation, Appleton and his contemporaries succeeded in confirming the hypothesis of Kennelly and Heaviside. The theories that Kennelly and Heaviside first developed were placed on a firm scientific footing through repeated, careful experimentation supported by mathematical statements based on the known theories of

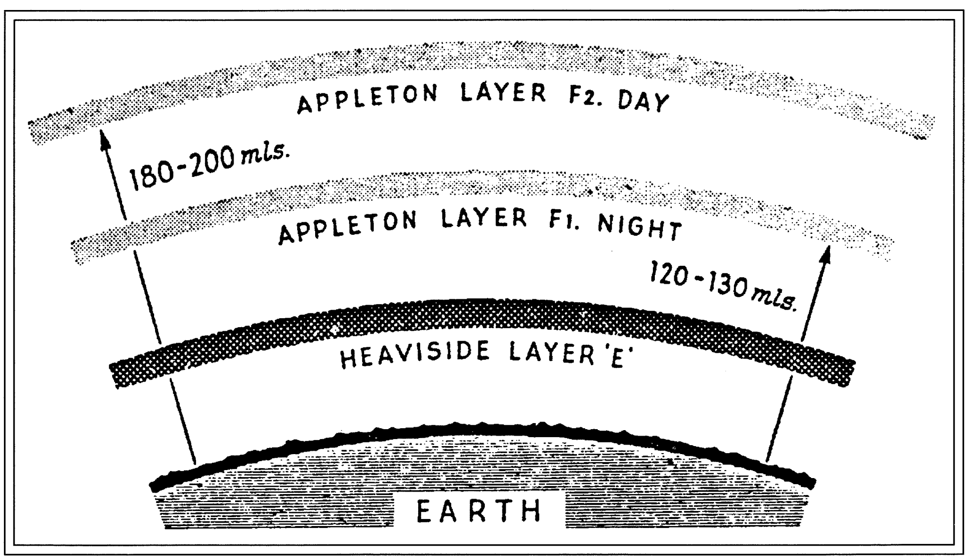


Figure 7. The E, F_1 and F_2 layers. Reprinted with permission from Nature, *September 1927. Copyright 1927 by Macmillan Magazines Limited.*

physics. Experimental procedures were developed that allowed further investigation into ionospheric phenomena so necessary to the understanding of this medium of radio propagation. (See Figure 7.) From the 1920s to the present, ionospheric propagation of radio signals with wavelengths in the range of 100 meters to 10 meters are used daily to communicate voice, data and pictures from one location to another on this planet. Radio amateurs, commercial broadcasters, governments and their military still regularly use the short-wave spectrum to link distant parts of earth. Solid scientific investigation has made these communications not only possible but commonplace.

References

1. *The ARRL Antenna Book*, American Radio Relay League, Newington, CT, 1974, p. 14.

2. Nahin, P.J., "Oliver Heaviside," *Scientific American*, June 1990.

3. Kelso, J.M., *Radio Ray Propagation in the Ionosphere*, McGraw-Hill, New York, 1964, p. 2.

4. Whittaker, Sir Edmund, *A History of the Theories of Aether and Electricity*, American Institute of Physics, 1987, p. 240.

5. Whittaker, *History*, p. 241.

6. Feynman, R.P., The Feynman Lectures on Physics, Addison-Wesley, Reading, MA, 1977, pp. 1-11.

7. Belrose, J.S., "ELF/VLF/LF Radio Propagation and Systems Aspects," Advisory Group for Aerospace Research and Development, NATO, May 1993.

8. Kelso, *Radio Ray Propagation*, p. 3.

9. Dunlap, O.E. Jr., *Radio's 100 Men of Science*, Harper and Row, New York, 1970, p. 144.

10. Gillmor, C.S., "The History of the Term 'Ionosphere'," *Nature*, July 29, 1976, 262, p. 347.

11. Kruse, S., "The Bureau of Standards-ARRL Tests of Short Wave Radio Signal Fading," *The Proceedings of the Radio Club of America*, November 1920.

12. Kruse, "Radio Signal Fading," December 1920.

13. DeSoto, C.B., *Two Hundred Meters and Down*, American Radio Relay League, West Hartford, CT, 1936, p. 73.

14. DeSoto, *Two Hundred Meters*, pp. 86-87.

15. Taylor, A. Hoyt, "The Navy's Work on Short Waves," *QST*, May 1924, pp. 9-14.

16. Warner, K.B., "Antipodes Linked by Amateur Radio", *QST*, December 1924, p. 14.

17. Kennelly, A.E., "The Conference, in Relation to Amateur Activities," *QST*, December 1924, p. 19.

18. Reinartz, J.L., "The Reflection of Short Waves," *QST*, April 1925, p. 12.

19. Eccles, W.H., "Wireless Communication and Terrestrial Magnetism," *Nature*, Volume 119, January 1927, p. 157.

20. Appleton, E.V., and M.A.F. Barnett, "Local Reflection of Wireless Waves from the Upper Atmosphere," *Nature*, Volume 115, March 1925, p. 333.

21. Nichols, H.W., and J.C. Schelleng, "The Propagation of Radio Waves over the Earth," *Nature*, Volume 115, March 1925, p. 334.

22. Davies, K., *Ionospheric Radio Propagation*, National Bureau of Standards Monograph 80, Washington, 1965, p. 184.

23. Appleton, E.V., and M.A.F. Barnett, "On some Direct Evidence for Downward Atmospheric Reflection of Electric Rays," *Proceedings of the Royal Society of London*, Series A, Volume 109, December 1925.

24. Gillmor, C. Stewart, "Wilhelm Altar, Edward Appleton, and the Magneto-Ionic Theory," *Proceedings of the American Philosophical Society*, Vol. 126, No. 5, 1982, p. 401.

25. Breit, G., and M.A. Tuve, "A Radio Method of Estimating the Height of the Conducting Layer," *Nature*, Volume 116, September 1925, p. 357.

26. Davies, "Ionospheric Radio Propagation", pp. 101-158.

27. Appleton, E.V., "The Existence of More Than One Ionised Layer in the Upper Atmosphere," *Nature*, Volume 120, September 1927, p. 330.

28. Appleton, E.V., "Some Notes on Wireless Methods of Investigating the Electrical Structure of the Upper Atmosphere," *Proceedings of the Physical Society* (London), Volume 41, Part 1, 15 December 1928, pp. 43-55.

Robert H. Welsh (M) has a diploma in radio engineering from Phila-delphia Wireless Technical Institute (1961). He is a graduate of the U.S. Army Signal School (Radar and Electronic Warfare). He received a B.A. in history and electronic physics from LaSalle College (1972) and an M.S. in science education from Temple University (1977), both in Philadelphia. He completed additional graduate work in radio astronomy at the National Radio Astronomy Observatory in West Virginia.

Welsh formerly worked as an electronics technician and laboratory engineer for such employers as the Radio Corporation of America, American Electronics Laboratories and the University of Pennsylvania for 12 years. He has taught electronics technology, and he currently teaches physics for the School District of Pennsylvania. He is a lecturer in the Department of Physics at LaSalle University.

Welsh has been a licensed radio amateur since 1959. His original station call sign was K3JHE. Since 1977, his station call sign has been N3RW. Using vacuum tube equipment, he operates CW more than any other mode. Besides teaching, playing with radio and conducting antenna experiments, he enjoys spending time with his wife, his children, and the family's four-year-old Chesapeake Bay retriever.

Amateur Radio Bridges Geographic and Cultural Gaps for Students

By Carole Perry, WB2MGP

This term marks my 14th year of teaching "Introduction to Amateur Radio" to 6th-, 7th- and 8th-graders at Intermediate School 72 in Staten Island, New York. There is such a myriad of materials and experiences to encounter when you teach a course like this that I can honestly say I have never had to teach the program the same way twice in all these years. As a teacher, I appreciate the flexibility, relevance of current happenings in the world and newly discovered excitement this can bring to a classroom.

Throughout the years, the one thing that all the children, regardless of their backgrounds or abilities, love the most, is speaking with other kids on the air. Because of the nature of amateur radio, an added depth of interest and excitement occurs when the other children are from another country or from a different region of the United States. Even my more "reluctant learners" spring to life when they have an opportunity to speak on the radio to their counterparts in another location. Watching their faces light up is part of the self-perpetuating cycle of enthusiasm that I enjoy and partake of with the youngsters.

Children lead the way

I have received many letters from hams this past year telling me how much they enjoyed just listening to the weekly exchanges that took place between the students at our school and the children at the Navajo Indian Reservation in Sun Valley, Arizona. In some small yet significant way, I believe these children are leading the way for the rest of the world to follow: learning to reach out and communicate, and learning how to enjoy listening to what others have to say.

Early in the fall of 1993, the kids in my ham radio classes were really excited about a contact we made with children from the Navajo Indian Reservation on the CQ All Schools Net. Our initial contact was with a teacher, Gary Ragsdale (KB7PXI). Gary's enthusiasm and wonderful way of describing things on the reservation made the children at my end eager to make contacts each week.

It was fun to watch the incredulous looks on my students' faces as they listened to Gary describe their school in Sun Valley, Arizona, as having fewer than 100 children in grades one through eight. You can appreciate the culture shock when you realize that we have more than 1,800 students in our intermediate school in grades six, seven and eight.

In my classes, I never assign homework. I do encourage the youngsters, however, to do extra-credit projects when something is especially interesting to them. I am always amazed at how well this approach works. I have no doubt that the fact that a ham radio program is involved makes a big difference.

Culture-sharing potential

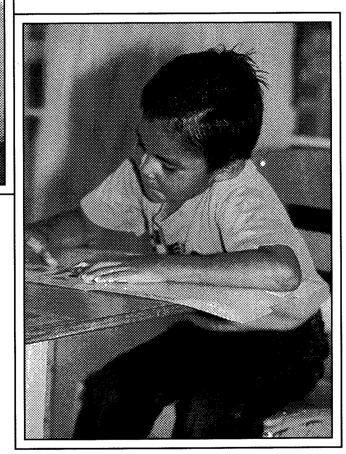
After several phone conversations, Gary and I quickly realized the enormous potential for culture-sharing. He is busy convincing the administration to allow him to set up a regularly scheduled ham radio class at Sun Valley. As of this writing, he must walk the children to his ham shack from whatever class they are in. So far, according to Gary, the administration likes what it sees.

After the first radio contact in October 1993, I was delighted to see that some of my 6th-graders really got into it by suggesting to me that they be allowed to do an extra-credit report about the Navajos. In my classes, I never assign homework. I do encourage the youngsters, however, to do extra-credit projects when something is especially interesting to them. I am always amazed at how well this approach works. I have not doubt that the fact that a ham radio program is involved makes a big difference. What other subject comes close to offering the myriad of adventures and opportunities for exploration that ham radio in a classroom does?

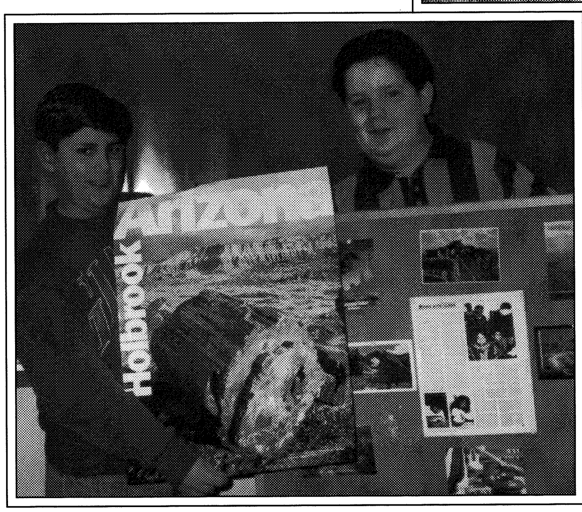
Sharing experiences

This first group of eager beavers educated the rest of the class with some background about the Navajos, such as the fact that the Navajos call themselves "Dine" (pronounced "di-nay," which derives from the group's traditional Athabaskan language, which can mean both "people of the earth" and "man." The term "Navajo," we learned, has no clear meaning and was bestowed by the Spanish during the period when they claimed control over the 17 million acres that now is Navajo land. One of my 7th-graders brought in an article from a Staten Island newspaper titled "Navajos Want to Change Their 'Foreign' Name." It seems as though the 200,000-member Navajo Nation has begun holding public hearings on a proposal to abandon the term "Navajo" in favor of "Dine." Many older Navajos cannot even pronounce the word Navajo because the "v" sound does not exist in their language.

Sun Valley Indian School 1st-graders (from left to right) La Tonya Bedonie, Daren Nez and Sterling Yazzie.



Sun Valley Indian School 1st-grader Woody Terrell.



Intermediate School 72 7th-graders Robert and Brian are students in Carole Perry's ham radio class. They display an exhibit they created featuring postcards, reports and photographs about Arizona, the Navajo Indian Reservation and the Petrified Forest.

While my students were busy assimilating all of the information that they could about their counterparts in Sun Valley, Gary's students were expressing an interest in learning more about the Verrazano Bridge and the Staten Island Ferry. Living on the country's largest Indian reservation, which stretches into Arizona, New Mexico and Utah on more than 16 million acres of forests, sand dunes, mountains, mesas and buttes, Gary's kids were, of course, curious about Manhattan skyscrapers and bridges and about big-city life in general. Altitudes range from 4,000 feet to more than 10,000 feet above sea level on the reservation.

Videotape exchange

Gary put several of his youngsters on the air with some of mine, and the kids took it from there. The Sun Valley Indian School has provided a Christian education to Native American children for more than 31 years. I suggested to the children that we each videotape our respective schools, along with our "ham pal" letters. Students at both ends loved the idea. My kids made a major production out of the video so that their new friends could see what a day in a big New York City school was really like. Everything and everybody got taped. Our entire school soon knew. We videotaped all the shop classes, school assembly programs, concerts, and of course the cafeteria.

At the children's suggestion, we collected items that highlighted New York and put together a package before Christmas vacation began. The kids brought in loads of photos of New York attractions, such as Radio City Music Hall, the Empire State Building and the Statue of Liberty. Many children wrote letters and enclosed photos of themselves. We also sent a school sweat shirt along with copies of the school newspaper. The whole project took on such an air of fun that even other teachers got caught up in it. Several teachers would stop by each morning to see what we were doing with the "Navajo Project." They would encourage students in their classes to stop by my room to get an update. Sample items that children make in our shop classes came pouring in. Children contributed stationery items from our fine graphic arts shop and beautiful ceramic and stained-glass pieces from those shops.

We have not received Gary's tape yet, but we did get a package of beautiful samples of petrified wood along with a wonderful sample of handcrafted work. He sent us a handcrafted Navajo woman making bread. The details on it are incredible. I keep it on my desk. The kids are fascinated with it.

Gary and I are looking forward to a fun, educational year through radio contacts on the CQ All Schools net. Join us on Tuesdays and Thursdays at 1730 UTC on 28.303MHz. Also look for the Educator's Workshop and the Youth Forum at the Dayton Hamvention in April 1995. Stop by and say "hello."

Carole J. Perry (M) is president of Media Mentors Inc., Staten Island, New York.

Environmental Television ...

(continued from page 27)

We must consider the fact that there is no really effective way to impose of a regulatory system within the home similar to motion picture industry's rating control system, except perhaps if parents were to attempt the impossible by securing advance knowledge about programs for the purpose of limiting their children's viewing to non-violent, non-sadistic to programs.

Realistically, home audiences cannot be separated by age groups for TV viewing. One thing is certain: If we heed the growing outcries of adult TV audiences and heed the increasing protests of what is being offered at all times for home entertainment when the family sits together, the result could be a mid-course correction by those desiring to sell their products via the TV screen. A welcome correction would use the original established programming concepts that fulfill the meaning of decency and sensibility; give care and attention to program quality and standards now and for TV's future; and serve the variety of tastes and needs for young and old alike — comparable to other forms of the entertainment arts.

Managers and programmers in control of what is being transmitted over the home TV screens either have lost sight of, forgotten or never knew of TV's legacy established by the Founding Fathers of Television in 1946.

Those pioneers of television attending that historic conclave of the Television Broadcasters Association on Oct. 10 and 11, 1946, included Dr. Alfred N. Goldsmith; Merlin H. Aylesworth; Jack R. Poppele; Dr. Frank Kingdon; Terry Ramsaye; Paul Raiborn; Dr. Allen B. Dumont; Barney Balaban; Niles Trammel; and George T. Shupert; a few among the many who were prominent in the fields of communication and entertainment at the time.

It would be most significant to relate the basic purpose and message of this article with excerpts from the address by Dr. Frank Kingdon. He said in part, "When you begin to deal with human experience in terms of intensifying sensations and touching human experiences more intimately, obviously you are dealing with greater responsibility. The responsibility of the television programmer therefore becomes even greater than that of the motion picture man or that of the radio man. So I think the television programmer is going to find himself caught between a natural sensitivity to his social responsibility, and yet a desire to make his programs interesting and even sensational. He will have, of necessity, to find new ways of appealing to the imagination and to the sense of people. But when it comes to good taste, that pretty largely has to be governed by public pressures."

Those were was only some of the *First Principles* of television enunciated at television's commercial launching in 1946.

What was said was valid then ... and will be valid to eternity.

Maurice H. Zouary (LF) is an active supplier and producer of entertainment programs syndicated for all media worldwide since the 1950s. He is a life member of the Motion Picture Pioneers (class of 1965) and a past member of the National Association of Television Program Executives (NATPE). He is the author of DeForest: Father of the Electronic Revolution *(unpublished). He has received the Award of Merit from the DeForest Pioneers (which since has been merged with the Radio Club of America) and the Lee de Forest Award and Special Services Award from the Radio Club of America. The Library of Congress has proclaimed his major contribution of a unique treasure of the earliest DeForest-produced synchronous sound-on-films (1919-1924) as "one of the major gifts to the National Collection in 30 years." He lives in New York.*

Editorial Comment ...

(continued from page 2)

Barry M. Goldwater Award

Stu Meyer will receive the Club's first Barry M. Goldwater Award in a posthumous presentation on Nov. 18. The award recognizes technical achievement or public service through amateur radio.

Prior to the Goldwater Award, the Club had no amateur radio award, despite the fact that the Club was founded by young radio amateurs in 1909.

Barry, K7UGA, personifies achievement in amateur radio. He was a proponent of the hobby as a U.S. senator, and his amateur station has carried a high volume of third-party traffic (telephone calls and messages) on behalf of armed service members overseas.

Alfred H. Grebe Award

Another first-time award is the Alfred H. Grebe Award, given for excellence in manufacturing quality. Frank A. Gunther, a member since 1940 and a president emeritus, is the first to receive the award.

An article about Grebe appears on page 3. He was active in the Club and in IEEE. Despite his having died young and his company having failed in the Depression, Grebe left his mark in the manufacture of high-quality products and in quality testing that was unusual at the time. Grebe's engineers used one of the first signal generators made by General Radio to test his products. (See photo on page 4.) His company manufactured its own transformers, punched its own laminations and made its own tuning condensers – all in a plant that Grebe built from the ground up. He tore down his father's workshop and built a factory that still stands. (See cover photos.)

Frank was chosen to receive the award as the moving force behind Radio Engineering Laboratories (REL), a manufacturer of broadcast radio transmitters, two-way radio and military radio communications equipment, and FM transmitters and receivers.

REL pioneered and built the first long-range navigation (LORAN) system with more than 100 transmitters for use during World War II. Later, REL developed forward-scatter, over-the-horizon radio communications systems for use during the height of the Cold War. Frank helped to install the systems.

Presidents emeriti

I mentioned that Frank is a president emeritus. The Club now has several presidents emeriti.

Last year, the board of directors voted to name Fred M. Link (LF) president emeritus. Fred was president from 1969 to 1992.

This year, the board named all past presidents as presidents emeriti. Along with Fred, the list includes William H. Offenhauser Jr. (HLF), 1968; Renville H. McMann Jr. (LF), 1960- 1962; Frank A. Gunther (LF), 1956-1957; and Jerry B. Minter (LF), 1948-1949. The list appears on page one.

Also named were Stuart F. Meyer (LF), 1993; and Francis H. Shepard Jr. (LF), 1954-1955. Stu and Frank passed away before their names would have been added to the masthead.

Volunteering

Club members sometimes ask how they can participate in Club activities on a national level. Most of the opportunities involve committee participation or becoming a director or officer.

Members of the Club's 13 committees are appointed by the president. The president for 1995 is John W. Morrisey, P.E., 45 S. 5th St., Park Ridge, NJ 07656.

For information about committee work, individual committee chairmen can be reached as follows:

Advertising: position vacant.

Awards: Jerry B. Minter, 48 Normandy Heights Road, Covent Station, NJ 07961.

Banquet: Mal Gurian, 14 Old Farmstead Road, Chester, NJ 07930.

Constitution & By-laws: Joseph S. Rosenbloom, Rose Hill Plantation, 2 Hackmore Drive, Bluffton, SC 29910.

Editorial: Jerry B. Minter, 48 Normandy Heights Road, Covent Station, NJ 07961.

Finance: Gaetano J. Amoscato, 87-30 Dunton St., Holliswood, NY 11423.

Good & Welfare: June Poppele, 5 Jenni Lane, Morristown, NJ 07960.

Grants-In-Aid: Kenneth M. Miller, 16904 George Washington Drive, Rockville, MD 20853-1128.

Legacy Fund: Archibald C. Doty Jr., 347 Jackson Road, Fletcher, NC 28732.

Meeting, Papers & Seminars: Mr. Raymond C. Trott, 4027 Courtshire Drive, Dallas, TX 75229.

Membership: Vivian A. Carr, 645 Hoey Ave., Long Branch, NJ 07740-5040.

Nominations: Frank A. Gunther, 10 Highpoint Road, Staten Island, NY 10304.

Publications & Publicity: John W. Morrisey, P.E., 45 S. 5th St., Park Ridge, NJ 07656.

To become an officer or director, a member has to be nominated and then elected. To volunteer for nomination by committee, contact the nominations committee chairman. Members also may be nominated by petition as described in the by-laws.

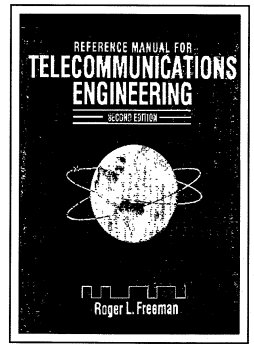
Members are welcome to suggest potential award recipients – contact the awards committee chairman. The Club has 14 awards, and policy limits the number given in any particular year to six or seven, depending on the merit of the award candidates.

— Don Bishop

Book Review

Reference Manual for Telecommunications Engineering

Reviewed by William D. Cheek Sr.



William D. Cheek Sr. is the author of The Scanner Modification Handbooks, Vols. 1 & 2, *the publisher and editor of* The World Scanner Report, *and the system operator of The Hertzian Intercept BBS, 619-578-9247, 6 p.m. to 1 p.m.*

He is the owner of COMMtronics Engineering, San Diego.

If it takes a page to do a decent review of a 300-page book, I'll need all the space in this journal to properly treat the new *Reference Manual for Telecommunications Engineering, 2nd Ed.* by Roger L. Freeman. First published in 1985, the *Reference Manual* is well on its way to becoming the definitive, unabridged compendium for engineers and technicians involved in radio and telecommunications systems subsystems design.

The second edition has been revised and expanded to more than 2,300 pages of tables, graphs, nomograms, figures, conversions, formulas, statistics and other data, from the routine to the obscure and from elementary to "Einsteinian" in scope. The wealth of reference material is organized into 31 logical subject areas designed for quick access and application. The table of contents runs eight pages, and an exhaustive, 43-page index in 8-point type leaves no pertinent subject not readily accessible.

The following are some of the major sections:

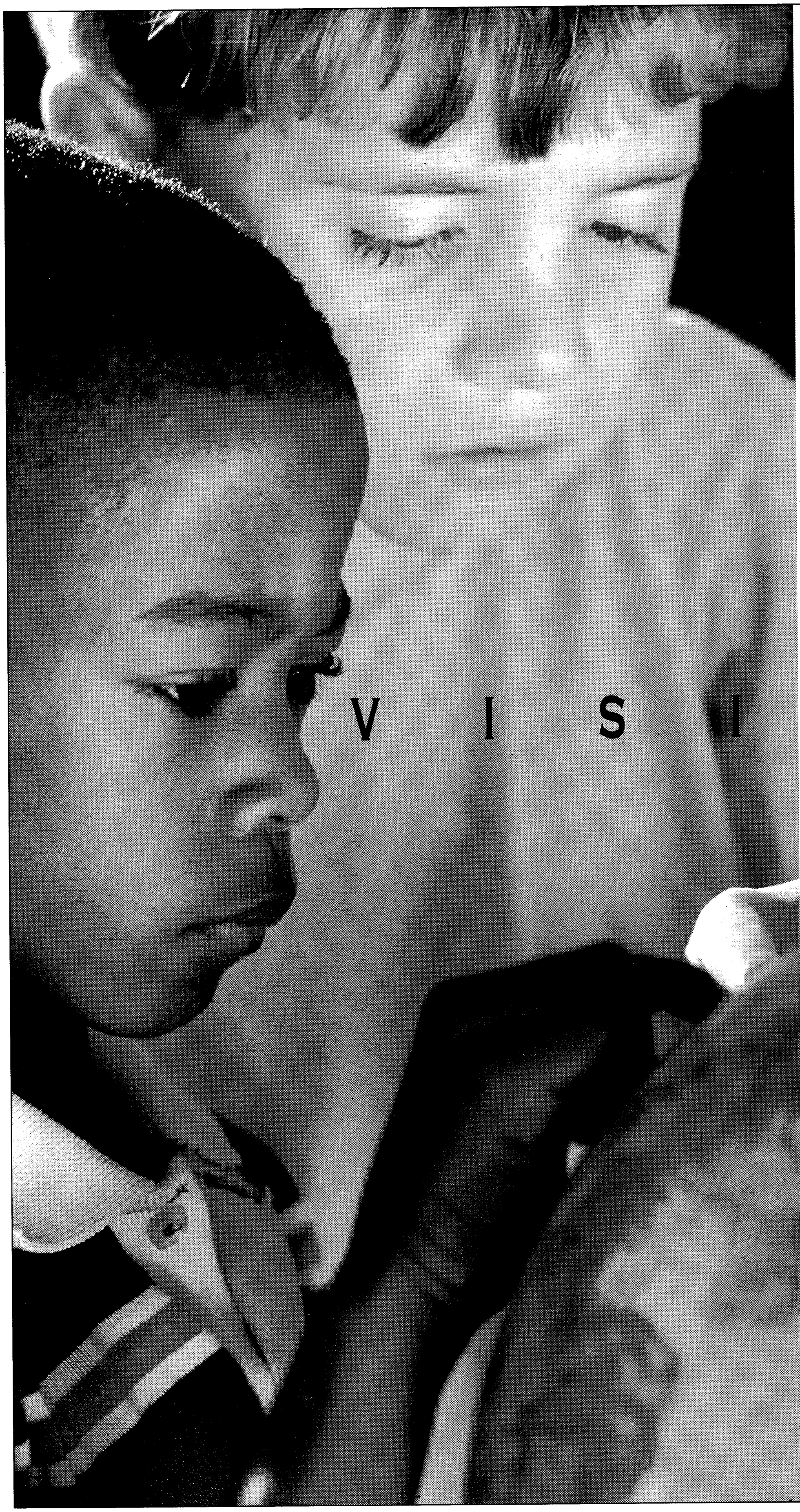
- telephone traffic, signaling, switching, numbering, routing and networks.
- noise, modulation and other radio system parameters.
- transmission factors in telephony.
- multiplexing techniques
- radio frequency data and regulatory information.
- electromagnetic wave propagation.
- antennas, passive repeaters, towers, transmission lines.
- data/telegraph transmission, data networks, ISDN.
- Facsimile and TV transmission, office and industrial communications.
- emergency and standby power systems.
- standard time and frequency.
- grounding, bonding and shielding.
- engineering economics.

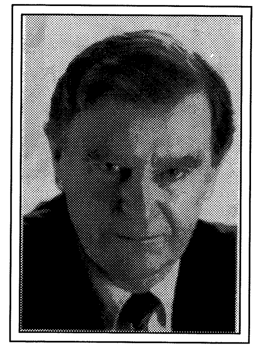
Freeman's book is a stand-alone reference for radio propagation modeling and prediction. The 100 pages on this subject alone are filled with charts, tables and nomograms covering atmospheric attenuation, fading, reflectivity, free-space attenuation, fresnel zone analysis, line of sight, rainfall attenuation, and groundwave and skywave propagation.

Major changes in the telecommunications industry over the past decade are thoroughly documented in Freeman's work. Outlined in detail are the latest practices and standards recognized by important telecommunications entities, corporations and military agencies. Emphasis is placed on international and domestic standards and practices, including those from the ITU, IEEE, Bellcore, ANSI, EIA and the ISO.

Reference Manual for Telecommunications Engineering, 2nd Ed. will complement and enhance ready reference libraries across a wide spectrum of professional disciplines, from the smallest practicing consultant to the largest corporate engineering staff to communications law offices. The *Reference Manual* will be kept current and relevant with subscription-based annual updates that feature the latest statistics, standards and reference data.

Reference Manual for Telecommunications Engineering, 2nd Ed. by Roger L. Freeman, founder and principal of Roger Freeman Associates. 8¾ inches by 11¾ inches, illustrated, 2,308 pages, cloth bound, $195. Published by John Wiley & Sons Inc., 605 Third Ave., New York, NY 10158-0012. ISBN 0-471-57960-2.





John Stone Stone: A Memoir

By Hugh G.J. Aitken, W1PN

What is a grip dip meter? Some younger members of the Radio Club of America may have trouble answering that question. Old-timers, on the other hand, will remember a once-familiar friend.

My first grip dip meter was built from a Heathkit. I never got much profit out of it. I thought I knew something about tuned circuits, so I coupled the coil on the grid dip meter as closely as I could to the tuned circuit I wanted to measure, and hoped to spot a clear dip in the meter as I tuned across that range of the spectrum. More often than not, I didn't. In fact, I used to get a strange "double dip" on the meter. The more tight the coupling, the more obvious was that strange double dip.

Obviously I should have read the manual! But it would also have helped if I had known more about radio history. In particular, it would have helped if I had known something about John Stone Stone. I know a little more now — enough to know that "close coupling" to a tuned circuit is no way to get a sharp resonance peak. Stone found that out in 1899.

Recently the editor of *American National Biography*, soon to be published by Oxford University Press, asked me to contribute a short biographical essay on Stone. It turned out to be a harder job than I anticipated. It isn't easy to sum up a man's life in a few words. Try the experiment on yourself: If you were allowed only a thousand words to write down what you wanted posterity to know about you, what would you write?

What made it even more complicated was that, the more I learned about Stone, the more intriguing he became. I wanted to learn more, but I was pretty sure I had checked all the usual sources. It occurred to me that other members of the Radio Club of America might know more about Stone than I did. And those who didn't might be interested in learning something new. So here is the story — part of it, anyway — and an open invitation to anyone with additional information to pass it along. I would be grateful.

The family background

Stone is one of the pioneers of modern radio. But he is not one of the well-known pioneers, like Marconi or de Forest or Fessenden or Armstrong. Why not? Partly because no single great achievement is associated with his name. He was widely admired by his contemporaries and took out scores of radio patents. He had a fine instinct for what in radio technology was fundamental and what was not. But none of his work "made the headlines," so to speak. He was not a publicity-seeker, like de Forest; he was not confrontational or litigious, like Armstrong. Everybody seems to have liked John Stone Stone. And many people found him very useful. But famous? The word doesn't quite fit.

He was not a publicity-seeker, like de Forest; he was not confrontational or litigious, like Armstrong. Everybody seems to have liked John Stone Stone.

You can write about some people and ignore their family background. That is not possible for Stone. He started out in life with many advantages, which he owed to his father. He had an easy-going, non-compulsive attitude to daily life, which probably reflects the unusual circumstances of his boyhood. And, throughout his life, he was never short of money. So, at least, his biographer, George H. Clark, tells us. Clark does not tell us where the money came from, but we can make a shrewd guess.

Let's tackle the obvious question first. How did it happen that his middle name was the same as his last name? (Copy-editors find this hard to believe: they usually delete one or the other.) The answer is that both his parents were named Stone and, when the child was born, they decided he should have both names and not just one. Which I suppose was logical enough; it certainly suggests a strong-minded mother.

Although their last names were the same, his father and mother came from quite different backgrounds. His father, Charles Pomeroy Stone, was a Yankee from Greenfield, Massachusetts, trained at West Point, who after a somewhat checkered combat career during the early years of the Civil War found himself appointed chief of staff of the Department of the Gulf in 1863. There, in New Orleans, he met and married Annie Stone, who was no blood relation at all. And, from that unusual (for the times) marriage of a senior staff officer in the Union Army to a Southern girl, there was born in 1869 the John Stone Stone in whom we are interested.

By that time his father was working as engineer and superintendent for a mining company in the Virginia piedmont. The job didn't last long. I don't know what would have become of John Stone Stone if his father had stayed there; I don't even know what the Goochland Mining Company was mining. Probably soft coal, which was no way to get rich quick in those days. But, as the novelists say, "fate intervened."

What intervened was a request from the Khedive of Egypt that the United States should supply him with a chief of staff. The Khedive was at that time trying to modernize his nation. High on his list of priorities was modernizing his armed forces, as is often the case in developing countries. The man he really wanted was General Sherman. Sherman, however, had other things on his mind. He recommended Charles Pomeroy Stone. And so, in 1871, Stone *père* found himself appointed aide-de-camp to the Khedive and some time thereafter "ferik pasha" (lieutenant general) and recipient of the "Star of Egypt," one of the highest awards that could be given to a foreigner.

What does all this have to do with radio? Nothing much except that it was in the household of one of the highest officials of the governor of Egypt that John Stone Stone spent his boyhood and received his elementary education. And perhaps more than an education. In any nation intent on accelerated modernization there are plenty of opportunities to get rich, particularly for someone who is "on the inside" of government negotiations and contracts. I don't mean to imply anything improper. Charles Pomeroy Stone was a trained engineer, a combat veteran, and a man who could get things done; in the Egypt of the 1870s such men were badly needed. The same is true in the "third world" today. These nations are desperately poor, and yet there are many opportunities in them for people who have access to power and know their job to get rich.

In that environment John Stone Stone spent his boyhood. He had a private tutor. The family always had servants. They were not short of money. He traveled widely around the Mediterranean. He lived, in short, a life of privilege. Basically, however, the fortunes of his family depended on the fortunes of Ismail Pasha. Accelerated modernization forced Egypt into heavy debt to Great Britain and France. It was called "extravagance" in those days, but we might have a kinder word for it today. However that may be, in 1875 Ismail Pasha sold his shares in the Suez Canal to Great Britain; and in 1881-82 his successor, Tewfik Pasha, faced with national bankruptcy, submitted to British rule over Egypt.

In those circumstances it was hardly surprising that, in 1883, General Stone thought it best to submit his resignation and return to the United States. Our John Stone returned with his parents. When next we hear of him he is living in New York and attending first Columbia Grammar School and then the Columbia University School of Mines. What he thought about that change in his environment we do not know, but clearly his interest in communications had not yet been kindled.

Return to America

His next move was to Johns Hopkins University in Baltimore. We accept it as not unusual today when a smart undergraduate decides to go on to graduate school. It was not so common in 1888. Johns Hopkins was the first American university to specialize in graduate study. It was particularly strong in mathematics and physics. Those were the fields in which Stone specialized, working under the distinguished scientist, Henry A. Rowland. Equally important, he became interested in the work of the English mathematician and physicist, Oliver Heaviside — a self-taught genius if ever there was one.

Heaviside played a critical role in Stone's intellectual career for two reasons. First, because he developed the operational calculus. Cambridge-educated mathematicians didn't think much of this new kind of analysis, but engineers liked it. And second, because he was deeply interested in the practical problems of long-distance telegraphy and telephony. Heaviside had started out as a telegrapher, but he had taught himself physics. He knew something that the engineers of the British Post Office refused to recognize: that a long-distance telephone or telegraph wire contains not just resistance but also reactance — in other words, it exhibits both capacitance and inductance. On a long-distance telephone line this meant distortion. On a long-distance telegraph cable it meant slow sending speeds, because the dots and dashes of Morse code became blurred and smoothed out with distance. More was involved, in other words, than just attenuation.

Stone got two gifts from Heaviside. First, he learned Heaviside's mathematics: on top of what he had been taught at Johns Hopkins, this gave him a confidence and expertise in mathematical analysis that his fellow workers came to respect and even envy. Second, he became fascinated with telephone technology — so much so, in fact, that during his summer vacation in 1899 he worked as an assistant for the Bell Telephone Company at the Paris Exposition.

This experience must have counted for a lot when, after leaving Johns Hopkins, he was interviewed for a job with the Bell Company's Experimental Department in Boston. By this time he was clear about what interested him most: It was electrical resonance. By this time, too, he had learned about Heinrich Hertz's experiments at Karlsruhe — the first deliberate production of electromagnetic waves in a laboratory.

The Boston Experimental Department was in those days the research and development arm of the Bell Telephone Company — a distant ancestor of Bell Labs. It was run by Hammond V. Hayes. Hayes' managerial style was to assign problems but not to tell his subordinates exactly what to do. Stone's first task was a Heaviside-type problem: how to increase the efficiency of a long-distance telephone line by adding inductance. His next was to devise an automatic switching system, based on musical tones, something like our Touch-Tone system today. But his third pointed directly away from conventional wired telephony: It was to find a method for "the transmission of speech to vessels at sea without the use of connecting wires, by using currents of high periodicity and changing their amplitude." In other words: AM radio. The date of the assignment was April 1892. Marconi's first experiments in wireless transmission took place in 1894.

Stone did not complete the assignment. He did design a laboratory transmitter, using a Tesla coil and a small arc to generate high-frequency oscillations. Presumably some kind of receiving station went along with this, but the details have not survived. Even if Stone did not solve the problem at that time, he made significant progress. He understood even then that, if one wanted to create a wireless communications system, the central problem was resonance — what Oliver Lodge called syntony and what we now refer to as tuning. And he had the mathematics to deal with that. Instead of a wireless system, he came up with a system of multiplex wired telephony: feeding a large number of high-frequency currents into a telephone line and modulating them with speech. This is what came to be called "wired wireless."

In the United States we usually associate that invention with the name of General George O. Squier of the Army Signal Corps, and in fact Stone was later involved in patent litigation with Squier, Michael Pupin and others over priority.

This work taught Stone a lot about the drafting of patents and about patent litigation. He was to make good use of that knowledge in later life. In the short run, however, he found it frustrating — or perhaps the Experimental Department was too confining an environment. Whatever the reason, he resigned in 1899 and set up in business as an independent consultant, based in Boston.

Radio and resonance

He found only one client — a certain Herman Ladd — but that was enough to make a big difference. Ladd had invented a radio system by which transmitters could be distinguished from each other, at the receiver, by the use of directional antennas. Stone worked on trying to improve the antennas, but he quickly came to a conclusion that seems obvious to us today but was far from obvious in 1900.

The conclusion was simply this: There was little point in trying to separate one transmitter from another merely by the direction from which the signals reached the receiver. The separation had also to be by frequency. This meant that transmitters and receivers had to be precisely and narrowly tuned. Ladd had got the problem right: Receivers had to have some way to discriminate among transmitters. But he had got, at best, only a partial answer.

Two important consequences followed from this experience. First, Stone became intensely interested in radio. And second, he became convinced that the key to a successful system of radio communication lay in tuning — in other words, the same phenomenon of resonance that he had been working with in multiplex telephony. The mathematics were the same: Only the wavelengths and the mode of transmission differed.

The problem was: How to do it? Spark transmitters were inherently "dirty." Their signals blanketed a wide band of the spectrum. Stone got the answer quickly, and he got it right. Between the device that generated electromagnetic waves and the device that radiated them there had to be placed tuned circuits, containing inductance and capacitance in precisely selected values, that were resonant at the chosen frequency. And, preferably, not just one tuned circuit but several, coupled loosely together, so that the mess of frequencies generated by the spark gap could be converted into a single sine wave — what Stone called a simple harmonic electromagnetic wave of a definite frequency.

Today, as we approach the end of the twentieth century, it is hard to appreciate innovations made when the century was new, but which we now take for granted. Tuning was one of those. Stone, of course, was not alone. The physicists knew about resonance. Oliver Lodge in England and Nikola Tesla in the United States had both demonstrated syntonic or resonant circuits. Marconi was granted the famous "four sevens" tuning patent in April 1900. But Stone was certainly one of the pioneers. And he was the only one, at that time, to emphasize the importance of "loose coupling." If two tuned circuits were tightly coupled together, you got two resonant peaks, not one, and neither of those was the free resonant frequency of either circuit. The two circuits tended to "pull" each other. Selective tuned circuits and loose coupling were to be the hallmarks of the Stone radio system.

Patent law is complicated, and those of us who are not patent attorneys must write cautiously on the subject. Some things are clear, however. Who patented something first doesn't always tell you who invented it first: Much depends on filing dates. And who was the first to invent something may not be all that important a question anyway (except, of course, to the inventor).

About tuning patents, the bare facts seem to be as follows. The basic patents in Britain were probably held by Oliver Lodge. But Lodge was not interested in exploiting them aggressively, so for several years the Marconi Company could safely ignore them. Marconi's first British tuning patent (No. 12039) was applied for on 2 June 1896, with complete specifications accepted on 2 July 1897. Under British law, the date of initial application was the date that counted. Marconi's American tuning patent (No. 763,772) was granted on 28 June 1904, on an application filed on 10 November 1900. Under American law, the date on which the patent was granted was the date that counted.

Where did Stone fit in? His tuned circuit patent (No. 714,756) was applied for on Feb. 8, 1900, nine months before the date of Marconi's American application. And it was "allowed" on 2 February 1902, eighteen months before Marconi's American patent was granted. On that basis, and as far as the United States was concerned, Stone had priority. And this is what the U.S. Supreme Court finally decided on 21 June 1943, in a case brought by the Marconi Company against the U.S. Government. Stone, unfortunately, died shortly before the Court rendered its verdict; but perhaps, by 1943, he did not much care.

Stone's patent makes interesting reading. Essentially it describes a "four-circuit" radio system — two tuned circuits loosely coupled together at the transmitter and two at the receiver. A number of variations on the basic circuit are described, each designed to achieve sharp selectivity. This would be pretty dull stuff, were it not for the way Stone presents the material. It is almost as if he were writing a textbook on wireless telegraphy; he has to explain all the "fundamental principles" before he gets to the details that were really important to what he was trying to patent. One begins to understand what Lee de Forest was getting at when, in his obituary for Stone, he wrote: "John Stone invariably prepared his own patent papers and I know of none in any art whose language is so precise, yet so elegant in expression. To read them is a delight, for they may well be classed as literature ... " That can't be said of most patents.

The search for contracts

Stone was not content just to experiment and take out patents. He wanted to build a radio system, prove that sharp tuning and loose coupling worked, and win some contracts. Boston venture capital came to his aid — he was lecturing part-time at MIT and that may have helped — and in December 1900, the Stone Wireless Telegraph Syndicate was formed.

Early experiments on a laboratory scale were promising. Stone wanted what he called "ten per cent selectivity," that is, he wanted transmitter and receiver to be so sharply tuned that, if the receiver were tuned ten per cent away from the transmitter's frequency, the signal was completely lost. (We would call that pretty broad tuning today, but standards have changed.) And he contrasted this approach with what he thought Marconi was up to. Marconi by 1900 had learned not to connect his spark gap directly to the antenna. Now the spark gap was in a tuned circuit of its own, and that circuit was inductively coupled to the antenna. But Marconi — as Stone understood the matter — was still trying to pump maximum power into the antenna, and to do that he was coupling the two circuits tightly together. The result was a "two-humped" curve of resonance, a needlessly broad signal, and indeed a waste of power as well as of spectrum. Stone's system was to be different: loose coupling and sharply tuned circuits were the key.

Stone had his laboratory system checked out by academic authorities — a professor of physics at MIT and one of his former professors at Johns Hopkins — and when they endorsed his claims, he felt ready to look for contracts. The Syndicate was dissolved and the Stone Telegraph and Telephone Company formed in its place, with an infusion of new capital. Two model stations were set up, one in Cambridge near MIT, the other in Lynn near the General Electric plant. There were nibbles of interest from the U.S. Army Signal Corps. And the Navy allowed Stone to set up (at his own expense) stations at the Boston and Portsmouth (NH) Navy Yards, which for the first time made possible direct wireless communication between the two bases. But there were no contracts.

Why not? Stone had a system that worked. It was singularly immune to interference — the Navy's tests had proved that. It was free from any suspicion of foreign ownership or control, which could not be said of the Marconi or Slaby-Arco systems. And Stone was not the kind of man to be financially grasping. No clear answer to the puzzle comes to mind. If you read Howeth's *History of Communications-Electronics in the U.S. Navy*, however, you are likely to get the distinct impression that (in this period at least) the U.S. Navy didn't know quite what it wanted from a radio communications system. Many line officers were profoundly suspicious of the new gadgets. Funds were limited. And there were many contestants for Navy contracts, since civilian markets were virtually non-existent.

For what it may be worth, my hunch is that Stone's apparatus was too tricky to tune. Those highly circuits were great for spectrum conservation and for limiting interference, but they called for skilled operators with a sensitive touch on the tuning controls, and the Navy was not well supplied with that kind of personnel. What the Navy wanted was equipment that was powerful, easy to operate and maintain, and rugged enough to stand shipboard conditions, even in combat. Perhaps Stone's equipment flunked those tests.

Stone's biographer, George Clark, who was an employee of the Company at that time, provides unwitting support for this hunch. In one chapter he describes in great detail and with obvious pride a 15 kilowatt spark transmitter, with no less than eight tuned circuits, that Stone designed and installed in the Brooklyn Navy Yard. This was intended to be the clincher as far as Navy contracts were concerned. Unfortunately, it turned out that there was only one man in Stone's organization (and none in the Navy) who could tune the transmitter properly. Not surprisingly, the official report on the episode was not complimentary.

Whatever the explanation, Stone did not get the contracts he had hoped for. Instead, the Navy adopted as standard equipment the German-designed Seibt "quenched gap" system. The idea of loose coupling, on the other hand, spread rapidly. This was, after all, only partly a matter of design. Mostly it was a matter of operating adjustments and, once the advantages were appreciated, loose coupling could be adopted without any hassles over patents and without acknowledging any debt to Stone.

Stone dissolved his company in May 1913. Its assets, which included all Stone's radio patents up to that date, were sold to Lee de Forest's Radio Telephone Company. This cemented a relationship between Stone and de Forest which, as we will see in a moment, was later to prove vitally important. Meanwhile, Stone returned to independent consulting in New York City. AT&T, however, retained his services as consultant and expert witness in patent litigation, and Stone was careful to keep up his connections with telephone engineers and executives. This too was to prove important.

The fundamental problems

Stone must have realized what his basic radio problems were. First, he didn't have a device that would generate true continuous sine waves. Others were working along those lines and having some success. On the west coast, Federal Telegraph had a refined version of the Poulsen arc. From 1901 on, Fessenden and General Electric were building radiofrequency alternators. Arcs and alternators were at least moves in the right direction. Stone had only the usual spark gap, or sometimes a small arc. Filtering a single simple harmonic oscillation out of that kind of discharge was no easy task, no matter how many tuned circuits you used.

Second, Stone had no good detector. Neither did anyone else. The best were probably Fessenden's liquid barreter, the Marconi magnetic detector, and the crystal and carborundum detectors. Stone and his team used a peculiar device made of three sewing needles, arranged as a tripod, which sat on a metal plate and "buzzed" with the dots and dashes when a signal was detected. Temperamental at best, one would say.

The paradox is that the device which would solve both these problems already existed, but its potentials were not realized even by its inventors. This is where Stone came in. We are referring, of course, to the vacuum tube. J.A. Fleming, working for the Marconi Company, had invented a diode vacuum tube in 1904. For him it was a detector and a rectifier. But the Marconi Company already had a reasonably good detector and was not much interested. Lee de Forest, in the winter of 1906, did what Fleming never thought to do: He placed a grid between the cathode and the plate, controlling the transfer of power from the input to the output circuits. He didn't know exactly how it worked — at one time he thought dust particles carried the current — but it made a pretty sensitive detector when the voltages were adjusted just right. Nevertheless, as with Fleming's diode, de Forest's triode at first caused little excitement.

Let's move ahead to 1912. Stone has just moved to New York as an independent consultant. De Forest, having quit New York one step ahead of the sheriff, is in California, working as a researcher for Federal Telegraph. What he is actually doing is trying to convert the audion (as he called his triode) into a reliable amplifier. And the market he has in mind is not really Federal Telegraph but rather AT&T. The Telephone Company is, at that time, facing a serious problem. It has made a promise, widely publicized, to provide coast-to-coast telephone service by the end of 1914. Loading coils and high-quality lines alone won't do that. AT&T needs what it calls a repeater: a line amplifier.

By August 1912, de Forest had figured out an amplifier circuit that was stable and provided gain. Some of his audions — modified Christmas-tree bulbs — had been re-evacuated, and that probably helped; but the rest of the story seems to have been a matter of tinkering with circuits until he found one that worked. What to do now? He could hardly approach the Telephone Company directly; his reputation for financial and scientific integrity was hardly good enough for that. He needed an intermediary, a friend he could trust and someone the engineers and executives of the Telephone Company also trusted. In fact, he needed John Stone Stone.

Stone, de Forest, and the audion

They met at the Fine Arts Club in New York City, where Stone was living. De Forest set up his circuit there and demonstrated what it could do. Stone was impressed: he promised to contact his friends at AT&T and also to mention the new device in a lecture he was scheduled to give at the Franklin Institute. Both he and de Forest referred to it at that time as a telephone relay amplifier.

But Stone did de Forest a bigger favor than that. He asked him whether his circuit had any problems with stability. De Forest answered that indeed it did. The amplifier tended to "howl." But there was no reason to worry: he had managed to control the tendency, and it should cause the Telephone Company's engineers no anxiety.

This is a subtle point but an important one; it was later to be argued over intensively in patent litigation. My reading of the evidence leads me to believe that, when the two men met in New York in August 1912, de Forest knew that he had a vacuum tube detector and a vacuum tube amplifier. He also knew that the amplifier tended to break into self-oscillation, but he thought of that as a problem to be overcome, not an advantage to be exploited. In other words, he did not tell Stone something like: "See, it not only detects and amplifies: I can also get it to oscillate." Nevertheless, what de Forest had invented was exactly the generator of pure sine wave oscillations that Stone and others had been looking for. And not just at audio frequencies — the "howl" that de Forest had mentioned. At radio frequencies too.

The rest of the story is well known. Stone carried out his assignment well. The Telephone Company's engineers, at first skeptical, were soon convinced. Of course, modifications would have to be made. To be a useful line amplifier, the device would have to be able to handle more power. And the audions, as de Forest used them, had too much residual gas. Harold D. Arnold, the young physicist who had joined AT&T's research branch the previous year, made the key contribution there. He knew that the current between cathode and anode was carried by electrons, not by gas ions or the dust particles that de Forest had earlier suspected. Higher vacuums and sturdier filaments with greater electron emission would give the Telephone Company the line amplifier it was looking for. Nevertheless, the device and the circuit, even in crude form, were impressive enough for AT&T to purchase rights to de Forest's vacuum tube amplifier in 1913 and the remaining rights by 1917. (De Forest kept some personal rights to sell to amateurs and experimenters.)

What did Stone contribute?

What are we to make of this story? If my interpretation is correct, Stone performed two important functions. First, he induced de Forest to rethink his own invention. Probably he did no more than ask the right questions. "Does the circuit oscillate? Only at audio frequencies? At radio frequencies too, you say? Ah, well, then ... " One can easily imagine the conversation. Asking the right questions is often enough, as any experienced teacher knows. Second, Stone served as the indispensable link between the man who had the invention and the people who needed it. He was the "honest broker," the person both sides trusted. This was a role not to be underestimated. Fritz Lowenstein had demonstrated a vacuum tube amplifier to the same group of engineers the previous January, but had got nowhere. Not the right sponsorship? Not the right introductions? It is regrettable, perhaps, but these things count.

What did Stone get for his services? Friendship is a fine thing, but the services Stone had performed deserved their reward. We will never know the details. De Forest always insisted, however, that the basic audion patents were the property of his Radio Telephone Company. (This is how he got away with giving Federal Telegraph only "shop rights" to his audion amplifier, despite the fact that the circuit had been invented while he was in the employ of that company.) Stone turned over all his radio patents to the Radio Telephone Company in 1913, when he dissolved his own Telegraph and Telephone Company. He received in exchange a substantial holding of stock in de Forest's company.

Any profit accruing from the sale of audion patent rights to AT&T went to the stockholders of the Radio

Telephone Company and therefore, in part, to Stone. De Forest always thought that AT&T had not paid enough for the audion patents — he implied, in fact, that he had been cheated. But the amplifier rights alone yielded $50,000 — no small sum in those days — and the remaining rights (including the rights to use the audion in radio circuits) still more. Stone had never acted as if he were short of money before the audion deal; after it, he was probably very well off. He retired to San Diego, where his mother was living, but was still kept "on retainer" by AT&T and continued to experiment, invent, and patent. He died in 1943.

John Stone Stone in retrospect

Shortly after Stone died, the *Proceedings of the Institute of Radio Engineers* published in a single issue no less than three obituary essays on his life and works: one by the editor, one by de Forest, and one by Clark. Needless to say, all three were highly laudatory. The fact that three obituaries were published in the same journal, however, bears witness to the great respect in which Stone was held by professional radio engineers.

The respect was warranted. Stone had, in fact, done a great deal to help create that profession and to give radio engineers a sense of professional identity. Perhaps this was not the smallest of his contributions. He founded the Society of Wireless Telegraph Engineers in 1907 — an association composed of employees of the Stone Telegraph and Telephone Company.

There was a somewhat similar group called the Wireless Institute, made up mostly of employees of United Wireless. The Institute of Radio Engineers was created by the merger of these two associations in 1912. And in 1963 the I.R.E. merged with the American Institute of Electrical Engineers to form the Institute of Electrical and Electronic Engineers (IEEE) that we know today. Stone played a prominent role in this process of institution-building, and his fellow engineers honored him for it. He was president of the I.R.E. in 1915 and received its Medal of Honor in 1923.

Why, among radio pioneers, is John Stone Stone not better known? Why is his work not more widely recognized today? Partly, I think, because of his somewhat retiring personality. Stone never pushed himself forward. He never made extravagant claims. Nobody ever accused him of stealing someone else's invention — or, by "stock-jobbing" deals, someone else's money. His colleagues respected him because he always knew what he was talking about, and because he had skills in mathematical analysis and clear exposition that, in the early days of radio, most of them lacked. These are the characteristics that made him so useful as an expert witness in patent cases. But Stone was never at the center of controversy. Sometimes, I suspect, it takes controversies and confrontations to get an inventor into the history books.

And then there is the fact that none of Stone's patents and inventions were "high-profile" things. It took until 1943 for his tuning patents to be finally vindicated. Loose coupling was an idea that spread until, after a while, engineers took it for granted. The radio systems Stone designed and operated were probably the best that spark technology could achieve. But, once continuous-wave devices came on the scene, spark systems were doomed to obsolescence.

Stone's reputation, in short, was a reputation among his fellow professionals, and it was won by the kind of work that professionals recognize. It was not a public reputation, won by the kind of notoriety that the mass media encourage and exploit. That, I like to think, is precisely the way Stone would have wanted it to be.

Hugh G.J. Aitken, Ph.D. (F), died April 14, 1994. He had retired as a professor of economic history at Amherst College, Amherst, Massachusetts. His amateur radio station call sign was W1PN. Aitken received the Dexter prize and the Leonardo da Vinci medal from the Society for the History of Technology. His books include Syntony and Spark *and* The Continuous Wave, *published by Princeton University Press.*

Sources

1. George H. Clark, *The Life of John Stone Stone: Mathematician, Physicist, Electrical Engineer, and Great Inventor* (San Diego CA, 1946).

2. Hugh G. J. Aitken, *Syntony and Spark: The Origins of Radio* (Princeton NJ, 1985).

3. Hugh G. J. Aitken, *The Continuous Wave: Technology and American Radio.* 1900-1932 (Princeton NJ, 1985).

4. Lee de Forest, "May 20, 1943" (Obituary), *Proceedings of the Institute of Radio Engineers*, Vol. 31, No. 9 (September 1943), pp. 521-22.

5. George H. Clark, "The Career of John Stone Stone" (Obituary), *Proceedings of the Institute of Radio Engineers*, Vol. 31, Vol. 9 (September 1943), pp. 522-23.

6. Orrin E. Dunlap, Jr., *Radio's 100 Men of Science* (1944), pp. 19-53.

7. U.S. Supreme Court, Cases Adjudged at October Term, 1942, *Marconi Wireless Telegraph Company of America v. the United States* (decided June 21, 1943).

8. Louis Duncan, "The Stone Wireless Telegraph System," *Electrical World and Engineer*, Oct. 24, 1905, pp. 675-76.

9. L.S. Howeth, *History of Communications-Electronics in the U.S. Navy* (Washington, DC, 1963).

10. U.S. Patent Office, "Method of Selective Signaling" (specifications forming part of Letters Patent, No. 714,756, dated Dec. 2, 1902).

11. "John Stone Stone," *Dictionary of American Biography*, Supp. 3, 1941-45, pp. 747-48 (by Charles Susskind).

12. "John Stone Stone," *Cyclopedia of American Biography*, Vol. XIV, pp. 336-37.

13. "Charles Pomeroy Stone," *Cyclopedia of American Biography*, Vol. XI, pp. 215-16.

The Radio Club of America, Inc.

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

WORLD'S OLDEST RADIO COMMUNICATION SOCIETY

APPLICATION FOR MEMBERSHIP

Date:____________________

TO: THE EXECUTIVE COMMITTEE

I hereby apply for membership in THE RADIO CLUB OF AMERICA, INC. and agree, if elected, that I will be governed by the Club's Constitution and By-Laws as long as I continue to be a Member.

____
Signature

Full Name:____
(FAMILY NAME) (GIVEN NAME) (INITIAL) (CURRENT AMATEUR CALL)

Home Address: ____
(STREET) (CITY) (STATE) (ZIP CODE)

Business Address:____
(ORGANIZATION) (DIVISION)

____
(STREET) (CITY) (STATE) (ZIP CODE)

Telephones: Home (____)____________, Business (____)____________ Ext. ________

Birthplace ____________________ Date of Birth: ____________________

Education and memberships in other clubs and societies: ____________________

____

____

In what particular branch of the Communications Art are you most interested? ____________________

Present occupation: ____

In what year did you become interested in electronic communications?____________________

Previous experience (indicate approximate dates): ____________________

____

____

____

Please list the names of two or more members to whom you are personally known and who will sponsor you. A letter of recommendation must be submitted by one of the sponsors, and entered on the reverse side, before submission to the membership chairman.

Sponsors

____

Mail this application to the Membership Chairman, Mrs. Vivian Carr, at 645 Hoey Avenue, Long Branch, NJ 07740, with $25.00 entrance fee, plus $40 for three year's dues, in U.S. funds. made payable to The Radio Club of America, Inc.

(OVER)

The Radio Club of America was founded in 1909 by a group of the industry's pioneers, and is the oldest active electronics organization in the world. Its roster of members is a world-wide Who's Who that include many who founded and built the radio industry.

The Club's objectives include promoting cooperation amongst individuals interested in electronic communications and in preserving its history. The Club administers its own Grants-in-Aid Fund to provide educational scholarships from tax free contributions of the Club's members and business organizations.

The Club publishes and distributes its PROCEEDINGS twice a year.

EXTRACTS FROM BY-LAWS

ARTICLE II — ENTRANCE FEE AND DUES

SEC. 1. The entrance fee for new members shall be Sixty-five dollars ($65.00) which includes the cost of the Club pin, membership certificate and dues for three years.

SEC. 2. The dues payable by Members, Senior Members, and Fellows shall be Fifteen dollars ($15.00) per year or, in the alternate, Forty dollars ($40.00) for a three-year period. Honorary members and Life members shall be exempt from the payment of dues or fees.

Recommendation of sponsor :

FOR OFFICIAL USE

Date Application received: ____________________

Admitted to Membership: ____________________

Date and Amount
of Dues Received: ____________________

Membership Certificate
and Card issued on: ____________________

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PROFESSIONAL DIRECTORY

Shepard ...

(continued from page 44)

presenting an award one evening. All dressed in Scottish garb, Frank had just made a presentation when an attractive young lady in the front row asked if anything was worn under the kilt. Frank exclaimed, "Young lady, I'll have you know that nothing is worn under my kilt! Everything is in perfect working order!"

In the early 1980s, Shepard was retained by the Breeze Corporation to develop a 3-phase motor controller for use on Sikorsky helicopters. Not only did the lessons learned he learned from this project enable Shepard to develop the basic drive electronics for induction and dc motors, he developed an electronic drive for mercury-vapor arc lamps and fluorescent lamps. One application of his ac motor controller was a battery backup unit used in the elevator industry to lower an elevator in the event of a power failure.

In the middle 1980s, Shepard purchased a used electric car. It was a mass of six-volt batteries and a bank of mechanical relays. His dream was to build a solid-state motor controller to eliminate the relays. Even at 88 years young, and even while courting his fifth wife, he came to the lab daily, developing and improving his dc motor controller.

Shepard background

Francis H. "Frank" Shepard, Jr., P.E. became a member of the Radio Club of America in 1936, was elected to the grade of fellow in 1942 and was elected to life membership in 1970. He served many years in Radio Club offices as director (1944-1951); recording secretary (1951); corresponding secretary (1952-1953); president (1954-1955); and secretary (1971-1985). In 1985, he was elevated to the status of secretary emeritus.

Shepard was awarded the Armstrong Medal in 1969 and the E.F. Johnson Pioneer Citation in 1988. He was elected to the grade of fellow in the IEEE in 1969 "for contributions in the field of high-speed printers and electronic instrumentation."

He was a founding member of the Armstrong Memorial Foundation, and he was a member of the Institute of Radio Engineers (IRE) and the American Society of Mechanical Engineers. He was awarded patents on more than 100 inventions, and he was a licensed professional engineer.

Shepard died July 12, 1994.

Arledge was a long-time employee of Frank Shepard's.

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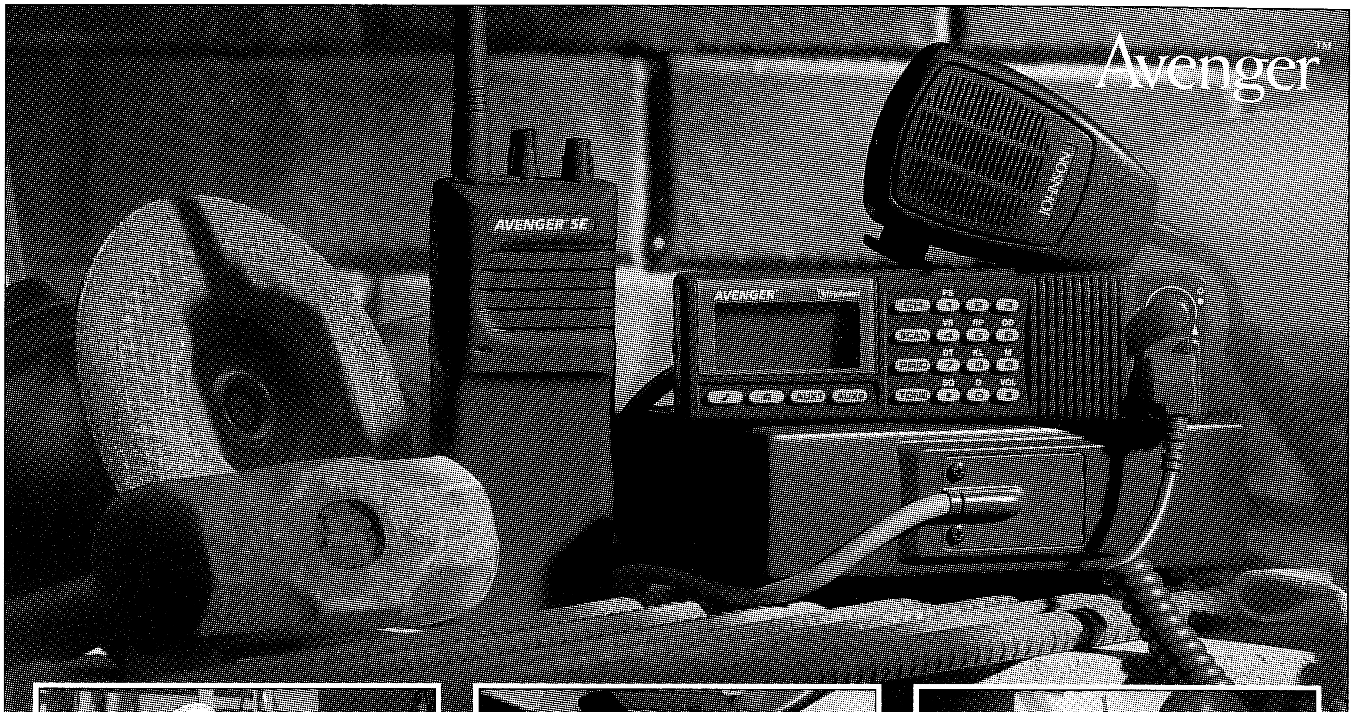

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