

**HISTORY
BETWEEN
THEIR
EARS**

THE RICHARD SCHNEIDER MEMORIAL PROJECT
TO THE MEMORY OF RICHARD C. SCHNEIDER



1925-1991

***Courtesy National Cable Television Center and
Museum***

Richard Schneider was born in Garber, Oklahoma, on March 25, 1925. He received a bachelor of science degree in aeronautical engineering from the University of Texas in 1948. Richard and his younger brother Gene were Bill Daniels' original partners in the company that built the first cable television system in Casper, Wyoming, in 1953.

About 1951, Richard and Gene Schneider were invited by Bill Daniels and a group of local oil men to come up from Texas to participate in the community television antenna venture in Casper, Wyoming, as Chief Engineer and Operations Manager, respectively. Both were graduate engineers with extensive electronic training in the U.S. Navy Radar Program during World War II, and were indispensable to the development of the television distribution network in Casper.

At that time, no television reception existed anywhere in Wyoming. The nearest TV station was in Denver, nearly 100 miles from the Wyoming border and 225 miles from Casper. Richard and his brother probed exhaustingly for Denver TV signals until, finally, they

found a suitable receiving site on the 12,000-foot mountain called The Summit, between Cheyenne and Laramie, just north of the Wyoming border. Casper was the first cable system in the country to use microwave to import distant signals, provided by AT&T for \$7,800 a month. The oil men secured the prerequisite \$125,000 bond and put up the bulk of the money to build the distribution system. So, late in 1953, Community Television Systems of Wyoming began operation by delivering a single channel of television from a Denver TV station operating no more than eight hours a day.

After buying Bill Daniels out of the Casper system, Gene and Richard joined with Ben Conroy, Jack Crosby, Glenn Flinn and others in 1966 to form the GenCoE multiple system organization (MSO), which was soon merged with Livingston Oil Company (LVO) to form LVO Cable. In 1974, the Schneiders formed a group of investors who became the principal owners and directors of the United Cable Television Corporation (UCTC), comprising LVO Cable systems and franchises spun off by LVO as a dividend to shareholders. Richard Schneider held the position of Chief Engineer and Director of UCTC for fifteen years, until 1989 when it was merged into United Artists Entertainment, Inc. (UAE).

As part of that merger, several former UCTC executives and Board members formed United International Holdings, Inc. (UIH), for the purpose of acquiring many of UCTC's overseas holdings. Richard Schneider was a founding investor and member of the Board of Directors of UIH until his death on March 29, 1991.

Richard Schneider was one of the early inductees into the Cable Television Pioneers. He was a member of the NCTA Standards and Engineering Committee and the Society of Cable Telecommunications Engineers (SCTE). Besides the use of microwave for CATV, Richard served as an adviser to Jerrold, and others, with guidance and assistance at the cutting edge in the development and utilization of new technology for cable television.

Richard and his wife Janet maintained their home in Casper, with their three children, now grown and with families of their own. He was an active participant in community services in Casper.

HISTORY BETWEEN THEIR EARS

Recollections of Pioneer CATV Engineers

The Richard Schneider Memorial Project

Archer S. Taylor



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Denver, Colorado**

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Foreword

THIS VOLUME IS PUBLISHED UNDER THE AUSPICES OF THE NATIONAL CABLE TELEVISION CENTER AND MUSEUM. One of the principal objectives of the establishment of the Center and Museum was, and is, to develop a continuing historical record of the birth and evolution of the cable television industry by means, among others, of a comprehensive Oral Histories Program. Such a program was designed initially to focus on the founding pioneers followed by others who entered the industry during the period of its early growth. It was also planned that the program would move ahead to encompass current leaders in the rapidly evolving industry. In large part, these goals are being achieved.

After the program had been under way for several years, it became apparent that it was failing to record a critically important aspect of the industry's history—namely, the inventive contributions of the engineers, technicians and other contributors to the development of industry technology. In an industry that for all practical purposes developed its technology, manufacturing and supply arms almost from scratch, this was not acceptable.

The program initially focused on management, which had to deal with the legal and management problems of establishing an entirely new industry fraught with controversy and opposition from the broadcasting and telephone industries, programmers claiming infringement of enforceable rights in the televised programs, and an ambivalent government. These problems were integral and vital to the existence of the industry and had to be dealt with immediately and continuously. On the other hand, the industry would have perished if its technology could not meet the insatiable demand of the public nationwide for more channels and superior pictures.

To address this problem a separate program of Oral Histories of those engineers and technicians was established and has been completed. It being recognized that many persons who might otherwise be interested in reading about this segment of the evolution of cable television would be unable conveniently to avail themselves of, or devote the necessary time to read, the actual interview transcripts, the program also called for the preparation of this volume to provide a single, cohesive narrative account based on the content of the interviews together with the observations of the interviewers and the author.

The generous financial support of the family of the late Richard Schneider, one of those pioneer technical geniuses in whose name this program has been conducted and is dedicated, is gratefully acknowledged. That support, together with generous contributions from others who wished to see the technological heritage of the industry preserved, made this program and book possible. Thanks to all.

The status of the industry today as a major player in the development of the telecommunications infrastructure of the information age is testimony to the technological genius of the pioneers as well as those whose task today is to keep the industry in the forefront of broadband telecommunications technologies.

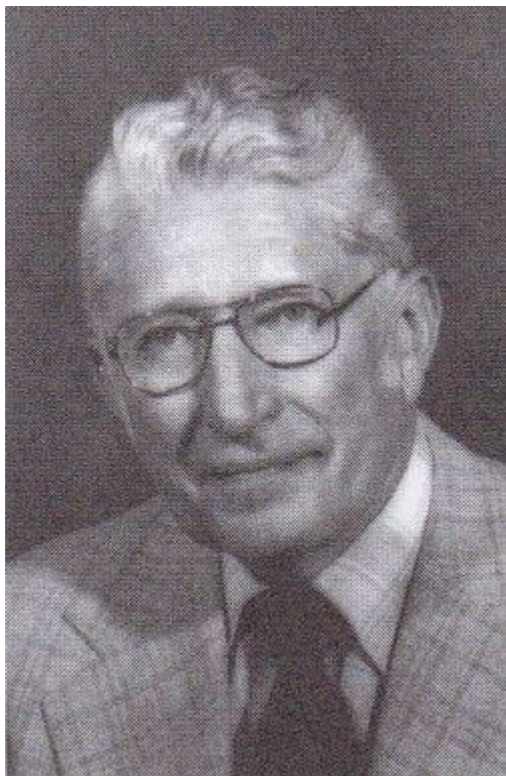
And now to those technological pioneers listed in [Appendix A](#), who so graciously and enthusiastically gave of their time and energies for the Oral History interviews, as Bob Hope would put it: THANKS FOR THE MEMORIES.

E. Stratford Smith, Esq.

Director, Oral Histories Project

National Cable Television Center and Museum

About the Author



IN 1953, ARCHER TAYLOR and three colleagues, all engineers by training, organized, built, and operated until 1968 the first community antenna television (CATV) system in Montana, at Kalispell. After receiving a bachelor of science degree in physics in 1938 from Antioch College in Yellow Springs, Ohio, he joined the radio section of the National Bureau of Standards (NBS), where he was one of two bureau scientists participating in the NBS-Louise A. Boyd Arctic Expedition. For five months in 1941, he operated automated ionospheric sounding equipment on board the schooner *Effie M. Morrissey*, west of Greenland at latitudes up to 78°N. His career as a consulting engineer in radio and television broadcasting extended from 1944 until semiretirement about 50 years later. In 1948, he opened his own one-man consulting office in Missoula, Montana, where his clients increasingly were seeking assistance with CATV-related problems. In 1965, he joined cable pioneer Martin Malarkey as cofounder of the widely recognized, multidisciplinary cable TV consulting firm Malarkey-Taylor Associates (MTA). The firm was sold to senior associates in 1992. After Malarkey's death in 1997, the firm expanded and broadened its scope under a new name, The Strategis Group.

Taylor has been honored as Lifetime Fellow by the Institute of Electrical and Electronic Engineers (IEEE), as Fellow in the Society of Cable Telecommunications Engineers (SCTE) in the United States, as well as Fellow in the separate organization of the same name in the United Kingdom. He has published widely in professional journals and the cable TV trade press, including a decade of monthly columns in *CED* as well as a few in *Communications Technology*. He is a registered professional engineer (retired) in Montana, the District of Columbia, and Colorado.

Prologue

FEW CABLE TV ENGINEERS AND TECHNICIANS LIVE IN THE RAREFIED ATMOSPHERE OF A BELL TELEPHONE LABORATORY OR A UNIVERSITY CAMPUS. Almost without exception, they are in constant touch with the harsh discipline of the bottom line. This book tells the story of how these imaginative and creative engineers, with credentials ranging from amateur radio and military electronics to prestigious doctorate degrees, set in motion the sophisticated technology by which more than 60 million households receive modern television.

While some of their history is documented, much of it resides “between the ears” of the pioneers who created it. This volume is based primarily on the Technological Oral Histories of many individuals who played key roles in the history of cable TV, recorded and transcribed with the support and encouragement of the Richard Schneider Memorial project of the National Cable Television Center and Museum. Informal telephone interviews and the author’s own experience helped to fill in the gaps. Many documents collected with the interviews and all of the transcripts are retained by the Cable Center for scholarly

research or just plain fun. Oral history transcripts are also accessible on the Internet at www.cablecenter.org.

Pioneering technicians and engineers probed the mountains and hilltops, on foot or horseback, in Jeeps and airplanes and helicopters, for suitable receiving sites, adapting every conceivable type of antenna array in the endless search for high signal gain and directivity. During the 1950s and 1960s, research and development for CATV was provided primarily, although not quite exclusively, by the manufacturers. Equipment suppliers necessarily looked to operators for guidance regarding their problems and needs, as well as for important feedback on operations under actual field conditions. For practical reasons, the present volume relies primarily on interviews with the manufacturer's technical personnel. It is left to another volume to recount the indispensable contributions of the technicians and engineers who spearheaded the building and successful operation of cable television facilities in their own and nearby communities.

For many years Milton Jerrold Shapp and the Jerrold Electronics Corp. dominated the history of the manufacture and supply of equipment designed specifically for cable television. Even today, General

Instrument (GI), successor to Jerrold Electronics Corp., is still predominant in the field. [Just prior to publication, General Instrument announced agreement to merge with Motorola.] It was inevitable, then, that the recollections of Milt Shapp and his pioneering engineers would necessarily constitute a major part of the early technological history of the industry.

The interviews are focused on preserving the recollections of the first generation of engineers, covering roughly the 25 years between 1948 and 1973. The launch of the cable TV satellite network in 1975 marked a profound change in cable TV. By then, many of the pioneers were moving into operational or management positions, or stepping aside for younger people eager to take the industry beyond the limits of over-the-air broadcast reception. Firms were changing ownership and direction, or even going out of business. A new era was arriving. Its history and recollections are for another project.

Unfortunately, it has not been possible to interview all of the pioneers who could have provided valuable insights. The oral history interview with Milton Shapp in 1986 left unanswered many intriguing questions, but advancing Alzheimer's disease precluded effective follow-

up. And some, like Don Spencer and Fitzroy Kennedy, died before the project got under way. We were especially fortunate to be able to interview Don Kirk, who in spite of his difficult battle with Parkinson's, graciously not only spent many hours recollecting his early participation, but volunteered his daughter, who is a librarian, to collect and organize his papers for the Center. Don Kirk died November 24, 1999.

The reader should make allowances for the limitations inherent in retrospection regarding events that took place many years ago. In most cases, the subjects of the interviews on which the book is based have been given the opportunity to edit the transcript. No attempt has been made to summarize everything in the interview transcripts, which are often tantalizingly disorganized and inconsistent. To some extent, the interviews have been enhanced by information from other interviews or independent sources, but no attempt has been made to resolve inconsistent or conflicting recollections. Accurate dating has been particularly elusive. While we have attempted to confirm at least the relative chronology, the accuracy of specific dating remains softer than we would have preferred.

This book shows not only how the technology

evolved, it also explores motivations and impacts and reveals something of the character and thought processes of the engineers who designed and built the equipment for CATV. It is to be expected, in a work of this sort, that some readers may have knowledge and experience at variance with the contents of this book. We would be pleased to receive such comments. (Please send comments to the author, care of the National Cable Television Center and Museum.)

While the text was not designed as a tutorial, the reader is likely to learn a good bit about the technology. A Glossary is provided to help readers follow the essence of the story without fully understanding the technology. In order to avoid burdening readers with excessive technical detail, the definitions in the Glossary are meant to be conceptually descriptive, although not necessarily complete and unqualified.

Acknowledgments

THE PIONEER ENGINEERS WHOSE ORAL HISTORIES WERE RECORDED AND TRANSCRIBED ARE LISTED IN [APPENDIX A](#). We acknowledge with special appreciation the time and effort given so graciously by each of these pioneers for reminiscing about their experiences as midwives in the delivery room at the birth of the new industry.

The Oral History Project of the National Cable Television Center and Museum was initiated by Professor E. Stratford Smith, of the School of Communications at Pennsylvania State University at State College, Pennsylvania. From about 1950, and for the better part of two decades, Strat Smith was the principal legal and regulatory counsel for the National Cable Television Association and much of the industry. He is particularly respected for his handling of such critical litigation as the Fortnightly copyright and Carter Mountain microwave cases. I am especially grateful to Strat for his support and encouragement throughout the preparation of this volume. Dr. Pamela Czapela, his assistant and curator of the Museum Library while it was at Penn State, arranged

for the transcribing of many of the interview tapes and provided enormously appreciated guidance and assistance.

Although the Center and Museum have been relocated to Denver, Professor Smith continues to administer the Technological Oral History Project from his university office. Thus, the publication of this volume is a cooperative effort in which Kim Dority played a crucial role, as a former Librarian for the Center in Denver. Her professional knowledge and expertise in publications were invaluable. It was Kim Dority who arranged for Constance Hardesty, whose expert editorial assistance with respect to the critical review of content, organization and preparation for printing was indispensable and greatly appreciated. I am especially grateful to Barbara Newell-Berghage for library research, Jancey Shetterly and Brenda Nolan for transcribing many of the interview tapes, and David Willis, Museum Curator, for photographing pieces of equipment in the Museum's collection. Finally, Jim Wilson deserves special recognition for creating the charts and drawings, and for his expertise in preparing the photographs for reproduction, several of which were cropped from halftones and required considerable restoration.

CHAPTER 1

Historical Roots

NEW IDEAS SELDOM, IF EVER, COME OUT OF NOWHERE. Invention is inevitably rooted in the vision of our predecessors. Cable TV could not have happened without the development of television itself. How it became possible to convert an optical image into a varying electrical current is the story of the achievements and frustrations of lonely, dedicated zealots who often had unreliable financial support, yet refused to abandon their faith in the future of the electrical transmission of pictures.

The “inventor” of television is either Boris Rosing, John Logie Baird, or Philo T. Farnsworth, depending on whether you are Russian, British, or American. The mechanical scanning disc arrangement ([Figure 1.1](#)), patented in Germany in 1884 by Paul Nipkow, is generally considered to be the progenitor of television <Abramson 1987, 13–15>. Nipkow worked in Berlin, but came from L  bork (Lauenburg), a part of present-day Poland, which was annexed to Germany at that time. In 1908, Alan Campbell-Swinton, a British consulting engineer, proposed an all-electric television system, conceptually

anticipating modern technology. Ironically, he commented in a discussion following a presentation before the Radio Society of Great Britain that "...the real difficulty in regard to this subject is that it is probably scarcely worth anyone's while to pursue it. ... I think you would have to spend some years in hard work, and then would the result be worth anything financially?" <Jensen 1954, 358-359>.

TELEVISION BEFORE WORLD WAR II

The British Broadcasting Company (BBC) inaugurated an experimental 30-line television broadcast service on August 22, 1932, using John Logie Baird's mechanical television system. The service was offered for half an hour a day, four days a week, from 11:00 p.m. to 11:30 p.m. A face-off competition was inaugurated on November 2, 1936, to determine whether the BBC should adopt Baird's hybrid mechanical system using Farnsworth's image dissector camera or the all-electric "emitron" developed by EMI (Electric and Musical Industries). EMI was affiliated with Marconi Wireless Telegraph and RCA. The superiority of the all-electric system was easily demonstrated. EMI was selected in spite of considerable sympathy for Baird, whose research

laboratory in the South Tower of the Crystal Palace was consumed in a disastrous fire after the competition began <Abramson 1987, 234; Abramson 1992, 781; Norman 1984, 82, 138–141>.

In the United States, the contest was between Farnsworth ([Figure 1.2](#)), a determined inventor with limited facilities and resources, and the well-financed RCA, led by its dynamic and powerful president, David Sarnoff ([Figure 1.3](#)). Farnsworth was a farm boy from Utah who enhanced his high school education by reading technical magazines and journals. Although Sarnoff had no formal education beyond the eighth grade, he completed a special night course at Pratt Institute that telescoped three years of electrical engineering into one, and did very well <Lewis 1991, 105, 109; Lyons 1966, 56>.

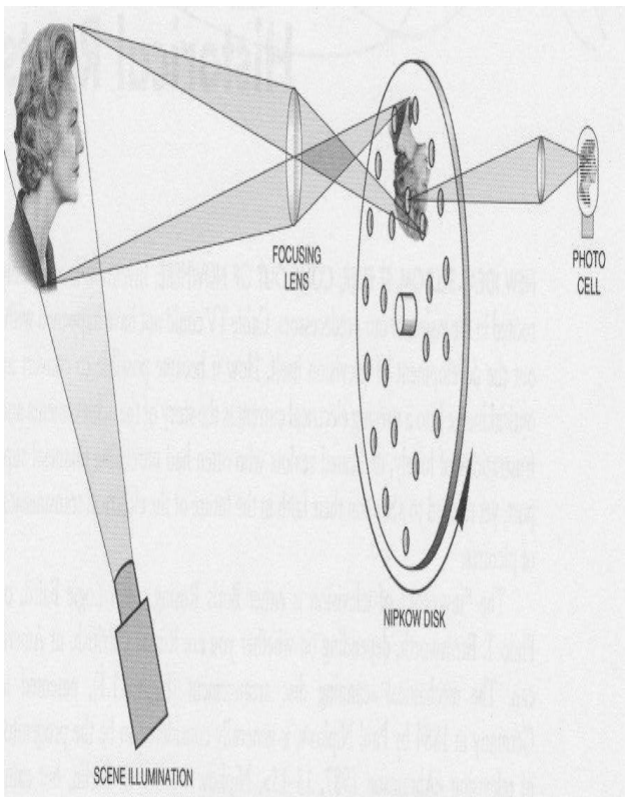


Fig. 1.1 The Nipkow disc mechanical scanning arrangement (1884)

Courtesy Commonwealth Design Group

Sarnoff brought with him to RCA the talented Vladimir Zworykin ([Figure 1.4](#)), who had been a student under Boris Rosing in pre-revolutionary Russia. In 1936, the U.S. Patent Office Examiner of Interference closed a bitter and protracted litigation by awarding priority of Farnsworth's patent on the image dissector camera tube over Zworykin's patent on the iconoscope. It was an enormous victory for Farnsworth, giving him complete control of camera technology. He would not sell the rights he had won, and RCA had no choice but to sign a cross-licensing agreement in 1939, for the first time ever.

On April 30, 1939, RCA inaugurated a prestigious demonstration of television at the New York World's Fair with a televised broadcast of President Franklin Roosevelt's opening-day dedication speech. It was planned as the opening for an aggressive campaign to promote commercial television. The dramatic opening was followed, before the wartime freeze, by a steady stream of entertaining television programs <Fisher and Fisher 1996, 281; Inglis 1990, 182–183>.

CBS had inaugurated its first television program in 1931 with Mayor Jimmy Walker bidding welcome to Kate Smith, who sang “When the Moon Comes Over the Mountain.” RCA/NBC initiated regular broadcasting schedules providing up to 12 hours a week of special events, including Billy Rose’s Aquacade, Mike Todd’s “Hot Mikado,” Abbott and Costello, Gypsy Rose Lee, the 1940 Republican Convention, and the Rose Bowl Parade <Gross 1970, 281; Fisher and Fisher 1996, 292>. Sporting events such as baseball, the Six-Day Bike Race, and the Baer-Nova heavyweight prize fight were also televised.

Pictures were broadcast from an airplane and, in one spectacular demonstration, pictures from a camera at the airport were broadcast to a receiver in the plane so passengers could even witness their own landing <Abramson 1987, 254>. In September 1940, Dr. Peter Goldmark, a CBS engineer and inventor, even demonstrated color TV to technical observers <Abramson 1987, 262-63; Fisher and Fisher 1996, 302>. Sarnoff projected that 20,000 to 40,000 television receivers would be sold in the first year. However, with monochrome receivers priced at \$395 to \$675 (roughly equivalent to \$3,000 to \$5,000 in 1998 dollars), it is hardly surprising that only 800 were sold <Fisher and Fisher 1996, 281; Inglis

1990, 182–183>.



Fig. 1.2 Philo T. Farnsworth (1906-1971)
*Courtesy National Cable Television Center and
Museum*



Fig. 1.3 David Sarnoff (1891-1971)
RCA, courtesy David Sarnoff Collection, Inc.

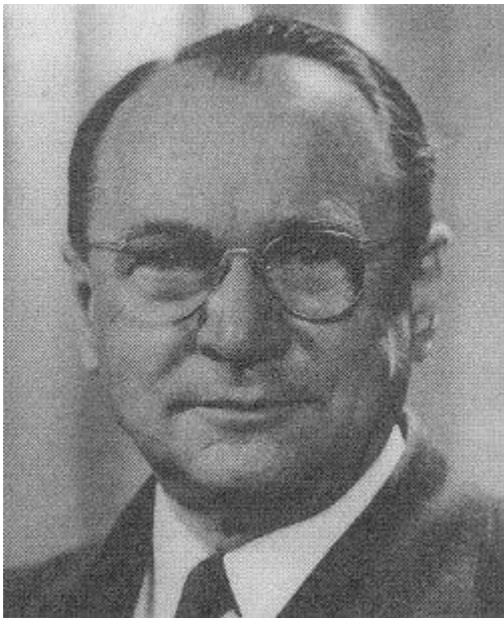


Fig. 1.4 Vladimir Zworykin (1889-1986)

RCA, courtesy David Sarnoff Collection, Inc.

The public mood following the introduction of television at the New York World's Fair in 1939 bounced

between euphoric anticipation of the new “picture radio” and frustration as delay after delay postponed its realization. RCA president Sarnoff had declared at the opening of the RCA exhibit at the Fair, “Today we are on the eve of launching a new industry, based on imagination, on scientific research and accomplishment. ... Now we add radio sight to sound” <Lyons 1966, 216>.

But the dawn of the new industry was still many years away. The Federal Communications Commission (FCC) had insisted that before the “experimental” broadcasts could be converted to commercial operations, all parties would have to agree to a set of interoperability standards. To this end, the National Television Standards Committee (NTSC) was formed in July 1940. Early in 1941, the NTSC recommended to the FCC the standards for television that have remained essentially unchanged for more than 50 years, except for the addition of compatible color <Fink 1976, 1322>.

In 1939, the FCC decided that a minimum of 19 channels should be reserved in the VHF (very-high frequency) spectrum for a nationwide television system. This was reduced to 18 channels in 1940 when channel 1 (44-50 MHz) was reassigned to the new frequency

modulation (FM) radio service. In 1945, six more VHF channels were reallocated from television to the present 88-108 MHz FM radio band and other services. Channel 1 was initially restored for television but soon reallocated to other services. By May 1948, the VHF TV allocation had been reduced from 18 to the 12 channels presently available for television broadcasting <Inglis 1990, 181, 195>.

The FCC promptly adopted the recommended NTSC standards for commercial operation in April 1941, which became effective July 1, 1941. Perhaps the FCC acted so quickly with foreknowledge of President Roosevelt's May 27, 1941, declaration of a state of unlimited national emergency, prohibiting diversion to television of raw materials and production capacity <Abramson 1987, 272>. The staggering blow at Pearl Harbor on December 7, 1941, "a date which will live in infamy," extinguished all but the dream of television.

FOLLOWING THE WAR

The freeze on production was to last until the war began to wind down in 1945. Six television stations were able to operate during at least part of the wartime freeze,

three in New York City and one each in Philadelphia, Chicago, and Schenectady, N.Y. An RCA/NBC station in New York, a Zenith station in Chicago, and the Don Lee station in Los Angeles had been assigned to channel 1, at 44-50 MHz. However, they were forced to shut down in May 1940, when the 42-50 MHz band was reassigned to FM radio <Inglis 1990, 181>.

As early as 1944, with the demands of war slowly receding, Colonel Sarnoff (promoted to Brigadier General on December 7, 1945) repeatedly pressed the American Telephone and Telegraph Company (AT&T) to make preparations for interconnecting television stations across the nation for network operation. By 1945, coaxial cable was in place, linking New York and Washington and moving toward Dallas en route to the West Coast <Lyons 1966, 278>.

But broadcasters were not eager to get started in television. CBS had petitioned the FCC in 1946 to adopt standards for color, throwing the future of television in doubt. Broadcasters were skeptical regarding the economic viability of the new medium, and tormented with the age-old chicken-and-egg dilemma that would require enormous investment, strictly on faith that the revenues would materialize in time. Equipment for TV was much

more expensive than for radio, and operating costs were at least five or six times greater. Network facilities were limited and expensive, and programming for TV was an unfamiliar and costly enterprise with which they had no experience. Receivers were expensive and there were so few of them out there. How long would it take to build the viewing audience? Would advertisers support what seemed to be the enormous costs of television? Would Zenith's subscriber-supported Phonevision™—pay-TV—be the way to go? <Hilliard and Keith 1992, 114, 134>.

Although the CBS color demonstration in support of its 1946 petition to the FCC went “exceedingly well” <Inglis 1990, 241-242>, the Commission decided there were still too many uncertainties and denied the petition, clearing the way for monochrome television. Following a stirring speech by General Sarnoff to NBC radio affiliates in September 1947 <Inglis 1990, 156-157>, applications for TV licenses began to snowball. By the end of 1947, there were only 16 operating TV stations. But by the end of 1948, the FCC had authorized 124 stations, of which only 51 were actually on the air, although another 63 were later activated.

Television set production exploded from 180,000 sets in 1947 <Inglis 1990, 190> to 7 million in 1950. From 1950

on, roughly 6 to 7 million black-and-white TV sets were being produced every year <*Television and Cable Factbook* 1998, I-10>. Set manufacturers were eagerly preparing to supply a huge public demand for television reception.

Applications for new television facilities poured into the FCC, virtually all of which would be entangled in one or more mutually exclusive conflicts. The FCC staff found itself overwhelmed by the task of examining hundreds of applications. In addition, the staff spent time preparing for the exceedingly complex and time-consuming hearings to be held before quasi-judicial examiners assigned to compare and evaluate the legal, financial, and technical qualifications of applicants competing for the same spectrum space.

THE ALLOCATION FREEZE

Ironically, with a kind of perverse logic, it may have been Sarnoff's 1947 confidence-inspiring panegyric on the potential of commercial television that so inundated the FCC with TV license applications as to force another freeze. It quickly became apparent that the 12 channels then allocated for television would not even come close to

satisfying the public demand for television service. Moreover, the FCC had begun to receive alarming reports from the field of complaints about unacceptable cochannel interference. Frustrated and overwhelmed by the deluge, the FCC declared, on September 30, 1948, that it would take no action on pending applications until it could complete a comprehensive review of assignment policies and obtain additional propagation data in order to establish effective procedures for controlling interference <Inglis 1990, 193–194>.

Little did anyone realize that television in the United States would remain at a near standstill for the 15 years following David Sarnoff's dramatic introduction at the New York World's Fair in April 1939. The allocation freeze was lifted in April 1952, and television began to spread across the nation gradually until the enormous backlog of pending applications was finally cleared by the end of 1954 <Inglis 1990, 202>. Public access to television was successively stymied by the "Great Standards Battle" (culminating in the National Television Standards Committee standards), the World War II freeze, processing delays at the FCC, and a freeze to sort out spectrum congestion and interference issues.

Compounding the delay still further was the recurrent

CBS campaign for color television. In 1949, CBS again petitioned the FCC, this time for authority to broadcast field-sequential color television commercially on all channels. The FCC decided to reopen the color question and set a date for the hearings. CBS apparently hoped that simultaneous introduction would enable noncompatible color to win out over monochrome, in spite of higher cost and technical limitations. Some say CBS really wanted to delay television as long as possible, while radio continued to be so profitable. At the hearing on September 26, 1949, RCA described its as-yet unfinished compatible color system. A year later, the CBS petition was granted, to the utter dismay of informed television engineers. After a delay for a Supreme Court ruling, CBS commenced color broadcasts on June 25, 1951, but discontinued five months later, with scarcely 100 color TV sets in existence <Fink 1976, 1327-39; Inglis 1990, 264-67>.

The industry reacted to the reopening of the FCC color hearings by convening a second NTSC in January 1950, to develop proposed standards for compatible color television. On July 21, 1953, NTSC recommended to the FCC the color TV standards in use today <Fink 1976, 1329>. Even the European PAL (phase alternating lines)

and the French and Russian SECAM (sequential colour avec mémoire) standards are based on the same underlying concepts as NTSC but with important differences in implementation. NTSC color TV standards were adopted by the FCC on December 17, 1953, effective for commercial color broadcasts on January 22, 1954 <Pritchard and Gibson 1980, 111>.

TELEVISION AFTER THE FREEZE

The issuance of the Sixth Report and Order on April 14, 1952, marked the end of the freeze, and the processing of television applications was resumed. A new 70-channel UHF (ultrahigh frequency) band was established, along with a comprehensive Table of Assignments and a set of inflexible limits for radiated power, tower height, and mileage separations.

Public interest in television had been evident, even as early as September 15, 1938, when the *New York Evening World* devoted a full page to an article by Robert Herzberg on “Television Construction Data for the Amateur.” The radio *World’s Fair* Supplement of the *Sunday New York News* had a story by Ben Gross stating that “the most absorbing topic in the radio industry today

is television. ... Hardly more than a year ago there were thousands who did not even know the meaning of the word. Now, it is on every tongue" <Gross 1970, 278>.

After the war, NBC and CBS worked valiantly to create a growing complement of television programming suitable for a broad range of tastes and interests. In this way, they hoped to stimulate the purchase of television receivers (manufactured by RCA, of course) in order to create the audience sought by advertising sponsors. The first World Series of baseball ever to be televised was between the Brooklyn Dodgers and the New York Yankees in 1947. "Howdy Doody" and "Kookla, Fran, and Ollie" made their debut in 1947. Milton Berle—"Uncle Miltie"—moved over from radio. The "Kraft Television Theatre" began its long television run, and the "Texaco Star Theatre" was number one on television. The "NBC Symphony" was tenth on the 1948 TV rating charts. CBS engineered a striking coup by luring Jack Benny and Amos 'n' Andy away from NBC. Programs like the Six-Day Bike Race and the Roller Derby were easy on the talent budget. Professional "rassling" (as distinguished from the more decorous "wrestling") and boxing, both amateur and professional in all weights, became staples of the television schedule in the postwar years.

Although television cameras were present during the 1940 and 1944 political conventions, it was during the 1948 presidential election campaign that television truly established itself. Both parties held their nominating conventions in Philadelphia to take advantage of the largest network audience then available through the coaxial cable connection to New York and Washington and a microwave link to Baltimore. President Harry Truman combined his whistle-stop campaign tour with television appearances. As the incredible election returns rolled in, commentator H.V. Kaltenborn reflected the disbelief of most observers that Truman was actually defeating Republican Tom Dewey. The recorded scene of President-elect Truman mimicking Kaltenborn's assurance that Dewey would win in the end is a television classic <Gross 1970, 161, 244-245>. Hundreds of thousands of television receivers were sold, many of which were even installed in schools. The January 1949 inauguration was covered on television for the first time by the pooled resources of ABC, CBS, NBC, and the then-existing Dumont Network.

Booming Demand—Limited Supply

Television programming accelerated rapidly on a steady diet of publicity provided by news stories and radio columnists. For better or for worse, people wanted to watch television. The 6 or 7 million TV sets manufactured each year were expensive, but people were buying them. If they lived in a city with one or more TV stations, they were in luck. But if they lived outside one of the fortunate cities or in a valley with hills obstructing the signal, their TV screens were likely to display only tantalizing “snow” that might occasionally form into some kind of a picture, however briefly.

People began to travel hundreds of miles or more just to watch TV in the hotels and taverns that did a gold-rush business on weekends merely by advertising “Free TV Tonite.” Friends who could not get TV at home were invited to dinner or a party by those who were more favorably located. Program schedules and critiques were published in newspapers available to those who could not receive television at home. Approximately 20 million monochrome television receivers were manufactured during the freeze, many of which went into homes beyond the reach of the few operating TV stations in major cities. A substantial portion languished on dealers’ shelves, “gathering cobwebs,” as Martin Malar-key reports, or in

manufacturers' warehouses.

By 1949, there was enormous market demand for television. Sarnoff declared that this was the year "when television shook off its adolescence and came into man's estate" <Lyons 1966, 280>. Yet, until about 1954, when the backlog of pending applications was finally cleared, television broadcasting in the United States was effectively stymied beyond the fortunate few big cities. For 15 years after the optimistic introduction of television at the 1939 World's Fair, the public appetite for television, stimulated by a crescendo of propaganda, was endlessly frustrated by a succession of disconcerting delays. That it was precisely during this period that the CATV industry got its start could hardly be called coincidental.

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NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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CHAPTER 2

Wired Television

THE RUDIMENTS OF WIRED TELEVISION WERE CONCEIVED EVEN BEFORE THE DRAMATIC RCA DEMONSTRATION AT THE 1939 NEW YORK WORLD'S FAIR. An intriguing patent, applied for in 1937, describes a method for sending television signals to individual homes on telephone wires enclosed in metal tubing. Because of wartime and regulatory freezes, however, the idea remained dormant. For several years, the Bell Telephone Laboratories had also been studying the characteristics of coaxial cable. However, it was the public's long, yet frustrated, interest in television that created the market for community antenna television (CATV), by wire.

THE CROOK PATENT

As early as 1937, more than 10 years before Ed Parsons and Jim Davidson connected their first CATV customers, the idea of distributing television on coaxial cables was set forth in a patent application. On November 26, 1940, even before the FCC adopted the standards for

broadcasting television on radio waves, a remarkable patent was issued to Louis H. Crook, a professor of aeronautical engineering at Catholic University in Washington, D.C. Crook applied for the patent in November 1937; it was titled “System and Method for Sending Pictures Over Telephone Wires.” Patent No. 2,222,606 ([Figure 2.1](#)) is described in the preamble as follows, in part:

I provide a complete shielding, not only of the wires and the instrumentalities employed for sending and receiving messages and pictures, but also of the ends of the wires where they are joined to said instrumentalities. In other words, I make use of insulated electric transmission lines...as one conductor for picture transmission, while the complete metallic shielding or covering constitutes the second conductor for picture transmission <Crook 1937>.

The patent description notes:

Supposing now that one of the houses desires to have television transmission installed, all that is

then necessary is to provide the arrangement... where the telephone conductors... are enclosed in a metal tube... one end of which is soldered or tightly secured to the metal lining of the distributor box. ... The other end of the metal tube... is similarly tightly secured to the metallic casing... containing a conventional television receiving instrument... <Crook 1937>.

This is a clear, although primitive, description of picture and sound transmission on coaxial cable. Crook had earlier obtained a patent (later cancelled) for protecting aircraft radios from ignition noise using topological shielding (shielding without surface discontinuities).

Nov. 26, 1940.

L. H. CROOK

2,222,606

SYSTEM AND METHOD FOR SENDING PICTURES OVER TELEPHONE LINES
Filed Nov. 18, 1937

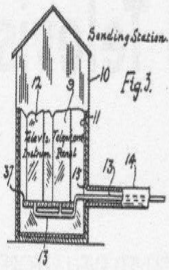


Fig. 3.

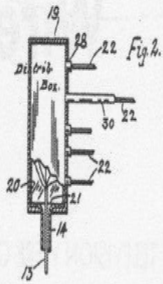


Fig. 4.

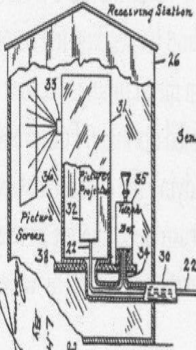
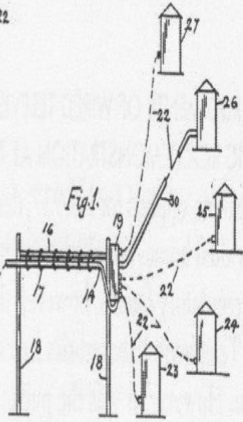


Fig. 5.

Sending Station

Receiving Stations

Fig. 1.



Inventor
L. H. Crook
BY
[Signature]
Attorney.

Fig. 2.1 The Crook patent drawing (1940)

Source: U.S. Patent Office

THE FCC REPORT

Equally interesting is a lengthy staff report issued in 1938 by the FCC detailing the findings of 125 investigators over the three-year period from 1935 to 1937. By remarkable coincidence with the 1937 Crook patent application, the FCC staff report, in a single paragraph buried on page 239, clearly anticipates the possibility of transmitting television to homes by means of broadband coaxial cable as well as over-the-air. An excerpt from that paragraph follows:

Transmission (of television) may be by air... or conceivably it may develop into some sort of wire plant transmission utilizing the present basic distribution network of the Bell System, with the addition of coaxial cable or carrier techniques now available or likely to be developed out of the Bell System's present research on new methods of broadband wire transmission. The prior development... by

the Bell System, and their patent control of these new devices while they are being adapted to their own existing investment in permanent wire plant, constitute an advantage of intangible nature, but one having far-reaching effect upon the probable commercial success attending independent research upon methods which might become operative independently of the Bell System plant <FCC 1938>.

The FCC evidently recognized as early as 1937 that the Bell System might use its patent position on broadband coaxial cable to delay or thwart the development of independently wired TV systems. It did not happen, of course, although they are still trying.

CATV BEGINNINGS

Claiming “first” for any invention or idea is a mercurial endeavor at best. There is no indication that any of the cable TV pioneers were even aware of the Crook patent or the FCC suggestion. All things considered, it was Milton Shapp’s vision of a nationwide entrepreneurial community television distribution system, inspired by Robert Tarlton’s activity in Lansford and

sustained by Martin Malarkey's leadership in the trade association, that resulted in the germination and flowering of the seeds planted in 1948 in Oregon, Arkansas, and Pennsylvania.

Ed Parsons in Astoria, Oregon¹

Ed Parsons' CATV system in Astoria, Oregon, was officially recognized by the National Cable Television Association (NCTA) as the first cable TV system, although not without challenge. A commemorative monument was erected on Coxcomb Hill, where Parsons later installed his permanent antenna and head end.



Fig. 2.2 Ed Parsons (1906-1989) at his workbench
*Courtesy National Cable Television Center and
Museum*

L.E. “Ed” Parsons ([Figure 2.2](#)), born in 1906, began

experimenting with radio and electricity in his father's garage when he was only 10 or 12 years old. A teacher tried to subdue his mischievous pranks with a book on Marconi's experiments with wireless; he later went to an engineering trade school. Parsons earned his amateur radio license (W7FKZ) as well as commercial radio operator's license. Before World War II, he owned and operated the Radio and Electronics Company, where he serviced radios, marine and aircraft electronic gear, and refrigeration and provided various electronic engineering services. During the war, he was a superintendent at the Navy control plant in Portland. While working relief shifts as an engineer at Portland radio station KGW, Parsons arranged to purchase the money-losing, Astoria newspaper-owned radio station, KAST (1370 kHz, 1 kW), which he promptly turned into a profitable enterprise.

In 1947, at a convention of the National Association of Broadcasters (NAB) in Chicago, Parsons' wife, Grace, a former Canadian journalist, saw television for the first time and remarked that she would like to have television at home in Astoria. At the broadcasting convention the following spring, Seattle radio station KRSC announced that it would build a TV station. Throughout the summer of 1948, coordinating with KRSC General Manager Bob

Priebe, Parsons meticulously probed the area for channel 5 signals from 125 airline miles away. When KRSC-TV (later changed to KING-TV) began operation on November 25, 1948, Parsons was ready. His antenna and booster were installed on the roof of the eight-story John Jacob Astor Hotel, connected with twinlead to his penthouse apartment a short distance down Commercial Street. Friends crowded into his living room to see television for the first time. Years later, Parsons himself said, “Reception [on Thanksgiving Day 1948] was not of a quality that would be saleable today, but we received a picture and started attracting guests” <Phillips 1972, 13>.

By New Year’s Day 1949, he had connected Cliff Poole’s music store across the street from the hotel, this time using coaxial cable. Poole was reported in the local newspaper as being “the first documented cable customer in the nation” <Phillips 1972, 14>. Parsons’ project in Astoria was featured in an article in the April 1950 *Popular Mechanics* <Gibbs 1950>. Parsons focused primarily on experimenting with TV reception. His entrepreneurial instincts were apparently directed more to establishing a UHF TV station than making money by wiring Astoria for television. At first, it was just a hobby, but the clamor from the community for television service

was irresistible.

Parsons says, “We started out stringing wires across the streets.” But the city council disapproved. “As the cable system expanded, we installed one amplifier on one side of the street where we had the cable, put another amplifier across the street, put an antenna on each side of the street, and transmitted the signal across the street. We then ran house-to-house and covered a whole block” <Parsons 1986, 5-6>. Perhaps this unorthodox and probably illegal procedure was responsible for an official FCC inquiry about his operation in Astoria, to which Parsons responded, on August 13, 1949, in this way: “... This was developed and installed experimentally...as a means of testing the dependability of our reception of TV signals in preparation for the requesting of a construction permit for an experimental station locally in the UHF... <Phillips 1972, 17>.

The cables and other equipment Parsons installed were considered the cooperative property of the customers, who paid approximately \$125 per installation. It seems that there was not even a service charge until sometime in 1951 <Parsons 1986, 8; Phillips 1972, 14, 23>.

Parsons soon became the regional CATV expert,

flying his own aircraft around the Northwest. The names of people with whom he was involved read like a directory of pioneers: Fred Goddard, Harry Spence, Elroy McCaw, and Lew Davenport; he met them at places like Aberdeen, Hoquiam, Kelso, Longview, Pasco, Kennewick, Medford, and Roseburg. He built amplifiers and other hardware for some of the systems with which he was working, but he also found a mix of Jerrold and other types in use. He worked long hours, probing for signal on the ground and in his airplane, designing and installing antennas, solving problems, and generally helping to get systems in operation. To get power to the head end at Aberdeen, he fed 220 Vac on seven miles of cable where there were no existing power lines. This would have been 1951 or 1952 <Parsons 1986, 9>.

Parsons suffered a complete physical and emotional collapse about 1953 and retreated to recuperate in Alaska, where he had lived earlier in his life. He became a bush pilot and was soon deeply involved in establishing communications networks across that barren land. Incidentally, he also developed some video tape distribution networks <Parsons 1986, 18-21>.

Jim Y. Davidson in Tuckerman, Arkansas²

Jim Y. Davidson ([Figure 2.3](#)) was born in Little Rock, Arkansas, in 1922. His mother died when he was eight years old and his father was killed 11 months later. He and his two younger sisters lived with their grandmother until she died, when Davidson was about 12. His father had been an optometrist, with wide-ranging skills—he had 19 patents involving radio and electronics and was an accomplished violinist. Although the family had been reasonably affluent, they discovered at the father's death that he had given away or squandered everything, leaving nothing for the support of his three children. Jim Davidson fought and struggled against unspeakable odds to survive through the Great Depression in deep poverty. Somehow, he managed to finish high school while working on the farm, pumping gasoline, repairing radios and appliances, operating the projector in a movie theatre, driving as a chauffeur, and performing other odd jobs. He once looked up at an airplane and said, “That pilot is a human being. If he can fly that, I know I can do it, too.” With that kind of determination and persistence, he succeeded in establishing his own radio and television repair shops and dealerships and the electronics and

appliance wholesale business known as Davco.



Fig. 2.3 Jim Y. Davidson

Courtesy Jim Y. Davidson

In the summer of 1948, he learned that WMC-TV, in

Memphis, Tennessee, was preparing to begin broadcasting. He erected a 100-foot tower and antenna on top of his two-story radio shop in Tuckerman, Arkansas, to receive the television signals from channel 5, about 90 miles to the east, whenever they were transmitted. By October 1948, Davidson had wired 17 TV outlets in his store to the antenna on the roof, using war-surplus coaxial cable. Carl Toler, the local telegraph operator who lived across the street from Davidson's shop, was extremely interested in television. He often came over to the shop to see the test signals from Memphis. So Davidson ran a coaxial line the 350 feet to Toler's house. Davidson says Toler paid a \$150 installation fee and \$3.00 a month for the service until he moved away in 1953. He also connected the nearby American Legion hall as a public service. *The Tuckerman Record* reports that on Saturday, November 13, 1948, WMC-TV broadcast the football game between the Tennessee Volunteers and Ole Miss on an experimental basis,³ although regular operation did not commence until December 11. It was an exciting event in Tuckerman. There was standing room only at Toler's house, the Legion hall, and Davidson's shop <Southwick 1998, 62>. *The Tuckerman Record* noted that "...[while] reception was not clear at all times, those witnessing the

broadcast could get the idea of what the real thing will be like once all the ‘bugs’ are worked out” <Davidson 1998a, 55>.

Davidson did not extend the system in Tuckerman until later. Instead, he moved to Batesville. With a population of 8,000 or so, Batesville was four times as large as Tuckerman. There, he built an elaborate rhombic antenna to receive WMC-TV ([Figure 2.4](#)), which was about 115 miles away. In mid-1951, he wired the city for community antenna television service <Davidson 1998a, 1998b>.

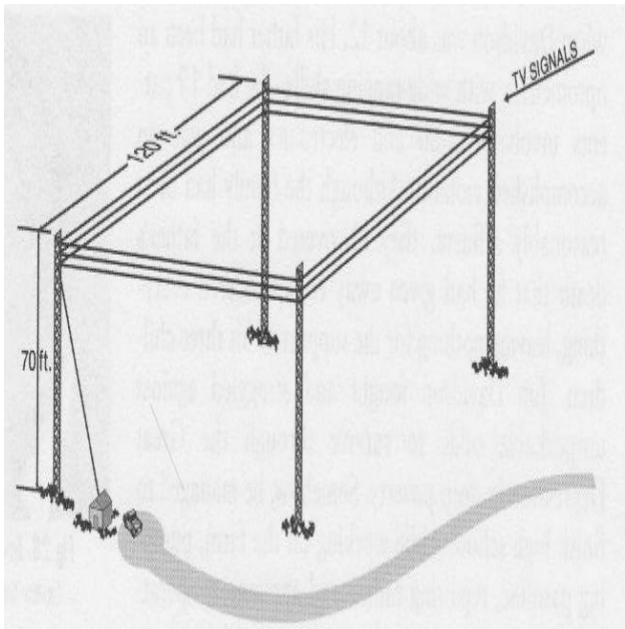


Fig. 2.4 A rhombic antenna

Courtesy Commonwealth Design Group

Robert Tarlton in Lansford, Pennsylvania⁴

After graduating from high school in 1932, Robert J. Tarlton ([Figure 2.5](#)) had his own business repairing radios in Lansford, Pennsylvania. “It was going great.” In 1938, his father joined him, and they opened a store to sell radios as well as repair them. After the war, about 1946, they added a full line of appliances, including television sets. Channel 3 was the only television station operating in Philadelphia at that time. The only place it could be received was in the hilltop community of Summit Hill, just south of Lansford. While they sold “dozens and dozens” of TV sets in Summit Hill, television reception was simply nonexistent in Lansford, half a mile away in the Lehigh valley. Even in Summit Hill, they usually had to provide one of Jerrold’s single-tube, set-top boosters to amplify the fringe-area signal to improve the picture.



Fig. 2.5 Robert J. Tarlton

*Courtesy National Cable Television Center and
Museum*

Channel 6 began operation in Philadelphia in 1947; channel 10, in 1948. Tarlton then began using Jerrold's

new three-channel booster, designed for dealer displays, hotels, and apartments, using coaxial cable. Late in 1949, he began experimenting with a second Jerrold apartment booster to reamplify the output of a single booster in order to extend the distance the signal could be carried. He found that pictures came through two or three boosters reasonably well, but the sound was completely lost at the second booster. By carefully retuning the Jerrold boosters, Tarlton succeeded in getting usable sound through several such reamplifications <Tarlton 1993, 8-9>. He also used the antenna distribution outlet (ADO) boxes that Don Kirk developed for apartment and dealer display installations <Phillips 1972, 36>.

In the spring of 1950, he began to plan the installation of a distribution system to deliver television signals to 200 homes. He persuaded George Bright, grandson of the founder of the Bright department stores, and several other retail businessmen to join him in this community television endeavor for Lansford. The group was incorporated as the Panther Valley Television Company. The first phase of the system was completed and they began connecting subscribers the week before Christmas 1950 <Phillips 1972, 36-37>, with an installation charge of \$100 plus \$3.00 a month service charge <Tarlton

1993, 11>.

Even before the Jerrold Electronics Corp. existed, Milton Shapp made sales visits as a manufacturer's representative to the Tarlton radio-television repair shop. When Tarlton realized, early in 1950, that he would be purchasing Jerrold boosters in quantity, he went to Philadelphia to arrange for a more favorable price. "Bud" Green, who was then sales manager for Jerrold, advised Tarlton that the boosters he was using were not designed for cascaded operation and demanded a release from liability in case they did not work.

Curious as to what Tarlton was up to with all those boosters, Shapp and his family came to Lansford the day before Thanksgiving 1950. Shapp was excited about what he saw and perceived the Lansford operation as the first of what would become the entrepreneurial business of community-wide wired television distribution. He was so impressed that he asked Tarlton to come to work with him <Tarlton 1993, 16>. Tarlton declined but agreed to work with Jerrold's engineers to design equipment especially for applications of this type. In February 1952, Tarlton began working as field engineer for Jerrold. One of his first assignments was in Williamsport, Pennsylvania. This was about the time that Entron's Hank Diambra and Len

Ecker were installing experimental distributed gain amplifiers and German-built, low-loss Styroflex coaxial cables in South Williamsport, across the river. The competition was spirited.

Martin Malarkey in Pottsville, Pennsylvania⁵

In Pottsville, Pennsylvania, not far from Lansford, Martin Malarkey ([Figure 2.6](#)) managed the Malarkey Music Company, a family business that his father had started many years earlier. They sold radios in addition to musical instruments and sheet music and had a \$75,000 inventory of TV sets “gathering cobwebs,” as Malarkey once said. Malarkey knew that the three Philadelphia television stations could be received on Sharp Mountain, outside of town, but not in town where the people lived. With television so tantalizingly close yet out of reach, many folks drove to Philadelphia just to watch television in one of the taverns or motels.



Fig. 2.6 Martin F. Malarkey, Jr.
(1918-1997)

Courtesy Malarkey-Taylor Associates, Inc.

On a buying trip to New York in 1949, Malarkey

stayed at the Waldorf Astoria. Discovering that TV was available in the guest rooms, he quickly sought out the manager and engineer to find out how they did it. They showed him the antenna on the roof, the coaxial cables pulled through the walls to the rooms, and the RCA Antennaplex amplifiers needed to overcome signal power losses in the cables and deliver good signals to the TV sets in the guest rooms. Antennaplex equipment was built in the 1930s to distribute radio signals to hotel rooms and apartments. In the mid-1940s, it was expanded to include television <Fink 1947; Kallmann 1948>. Antennaplex was used in 1946 to distribute television programs between the NBC studios, offices, and client rooms in the RCA building. RCA appointed Malarkey sales representative for the Antennaplex wired television system.

In Pottsville, the sideband response of the Antennaplex amplifiers was broadened for cascade operation. Permission to attach TV cables to the utility poles and to install wires across city streets was obtained. George Bright became a shareholder in Malarkey's venture as well as Tarlton's. Shortly after the Lansford system start-up, the new Pottsville CATV Company connected its first commercial subscriber, early in January 1951.

Like Parsons, Davidson, and Tarlton, Malarkey was soon surrounded by people from across the country, inspired by the idea of community television reception as an entrepreneurial venture. Many of them coalesced behind Malarkey's leadership to deal with a host of unexpected regulatory and taxation hazards.

John Walson at Mahanoy City, Pennsylvania



Fig. 2.7 John Walson (1915-1993)

*Courtesy National Cable Television Center and
Museum*

John Walson ([Figure 2.7](#))⁶ lived in Mahanoy City,

within about 10 or 15 miles of Lansford and Pottsville. At one time, he had been a hard rock coal miner, but later became a maintenance man for the Pennsylvania Power and Light Company (PP&L). Legend has it that when PP&L was ordered by the utility commission to divest its appliance business, Walson negotiated an arrangement that would allow him to sell the inventory on consignment. This became the original core of Walson's Service Electric Company, a retail appliance dealer and service organization. In order to advance the sale of TV sets, Walson devised a way to transport the Philadelphia signals from a hilltop into town. Like Ed Parsons in Astoria, he used twinlead at first but had to change to coaxial cable when rain caused the signals to disappear. Milt Shapp supplied equipment to Walson as well as Tarlton <Shapp 1986, 10>. Walson's service technicians apparently modified Jerrold amplifiers and built some of their own. Eventually, the Holt Electronics Company was formed in Mahanoy City to manufacture equipment for Service Electric and other CATV operators.

By June 1948, Walson claimed that he had 727 subscribers to his wired television system, although he says he refused payment until the end of the year. In 1950, the chief of police in Mahanoy City was so impressed

with Walson's system that he started another one at the other end of town. Walson purchased the second system in 1970 and merged it with his own <Phillips 1972, 7-10>. This could explain how the sign "Established 1950" painted on company service vehicles came to be changed to "Established 1948."

Unfortunately, a fire in 1952 destroyed documentation that might have supported Walson's claim that he developed the first commercial CATV system <Walson 1987, 3>. Surprisingly, such a newsworthy event as the start-up of a CATV system in 1948 does not appear to have been noted in the local papers <Southwick 1998, 62>. Even more damaging to Walson's claim are the listings in TV Digest's *Television and Cable Factbook*. Widely recognized as the most reliable data source for cable TV systems, the *Factbooks* are based on information supplied by each system operator. From 1953 through 1966, Walson reported 1950 as the starting date for his Mahanoy City system. But, in the 1967 and later editions of the *Factbook*, the starting date is listed as 1948.

The story of the pioneer community television systems spread rapidly. People came from all over the country to talk with the pioneers to find out how the system worked, how to build it, and how to operate it successfully. Martin Malarkey, in Pottsville, quickly became a sort of CATV “guru.” Several CATV operators in Pennsylvania were particularly distressed concerning the 8 percent excise tax that the Internal Revenue Service was trying to enforce. Malarkey consulted with E. Stratford Smith, a former FCC attorney, now in private practice, for advice and suggestions on dealing with this matter. At Smith’s suggestion, a group of community antenna operators in Pennsylvania convened on September 18, 1951, in Pottsville, for the specific purpose of discussing the seriousness of the excise tax. The group organized formally as the National Community Television Council, and several meetings were held. On January 28, 1952, the group was reorganized as the National Community Television Association Incorporated (NCTA) <Phillips 1972, 29-33>. The first annual convention of the NCTA was held on June 9, 1952, at the Necho-Allen Hotel in Pottsville. Sixty or so operators were present and several manufacturers were represented <Television Digest with Electronics Reports 1952>. Martin Malarkey

was elected president, serving five consecutive one-year terms as leader of the organization. At the annual convention in Chicago in June 1967, the name was changed to National Cable Television Association (NCTA), acknowledging the expanded scope of the industry to include all types of broadband communications <Milestones 1997>.

It is perhaps speculative to suggest that cable TV as we know it would not have happened but for the wartime and regulatory delays spanning the 15 years from the 1939 inauguration of television at the New York World's Fair to the final clearing of the backlog of television broadcasting applications. For nearly two decades, the emergence of "picture radio" seemed always to be so close at hand, yet denied for so many people for so long. The situation from 1948 to 1954 and beyond was ripe for imaginative entrepreneurs and hobbyists with some technical skill, or access to it, to create a wired television distribution system. It was not by chance that the early development of CATV systems was often in mountain valleys between 50 and 150 miles from at least one operating TV station.

If Jim Davidson, Ed Parsons, Bob Tarlton, Martin Malarkey, and John Walson had not started CATV in 1948-1950, someone else would have had to do it. Some

radio station operators, including Fred Stevenson and Senator William Fulbright (D-Ark.) at a radio station in Fayetteville, Arkansas; Ken Gunter in San Angelo, Texas; and Ed Parsons in Astoria; saw CATV as an opportunity to get into television without waiting for an end to the freeze. But it is truly amazing that so few radio broadcasting professionals responded to the burgeoning public demand to see pioneer performers like Milton Berle and Red Buttons live on television, or opera, or Shakespeare, or even movies at home. Instead, many feared the competition of television itself, and CATV, pejoratively pronounced “cat-vee,” symbolized the enemy.

FRANCHISES

In the early years of CATV, municipal franchising was more or less perfunctory. Franchise periods were long, generally 10 to 20 years, and renewable. Terms and conditions were designed to protect city property, indemnify the city against loss, and provide for the public safety. Franchise fees were quite nominal, usually 1 or 2 percent of gross revenues. Although franchises were not explicitly exclusive, competing applicants were seldom

awarded overlapping geographical territories. In 1972, the FCC left to municipalities and counties the onerous task of refereeing the contest between mutually exclusive applicants competing for authorization to operate CATV facilities and the primary responsibility for administering the franchisee's activity and performance.

The 4,000 systems in 1979, now identified as cable TV, serving about 14 million subscribers, were located mostly in small towns in rural America <*Television and Cable Factbook*>. Subscribers were hard to come by in the urban metropolitan areas where all four networks (ABC, CBS, NBC, and PBS) plus a few other unaffiliated stations were easily received on rabbit-ear or rooftop antennas. By 1980, however, the city dwellers were not only willing to pay but even demanded access to the new satellite programming, stimulated by HBO's satellite relay of the Ali-Frazier prize fight from Manila. The fair market value of franchised cable TV systems ballooned rapidly, greatly exceeding the cost of building from scratch. Suddenly, every major urban metropolis was ripe for cable TV.

Bitter franchise wars erupted in 1980, lasting throughout most of the decade. Local city councils generally had no experienced technical staff, often were

not expert in economics or management, and not infrequently depended on legal advice from lawyers with little or no experience in communications law. Competing applicants promised to implement every conceivable blue sky “service,” each seeking to out-promise the other. Outrageously irresponsible franchise fees were proposed. Fully equipped video studios were committed, at no cost, along with annual financial support for the staff to produce public access programs. Those applicants who promised the most attractive monetary and political plums, however unrealistic they might be, were frequently favored, and unethical practices were not entirely unknown.

While the awards tended to be rather chaotic and often less than rational, the fact is that 97 percent of all television households in the United States now have access to cable TV service. When the freeze was lifted near the end of 1952, there were some 150 CATV systems with 30,000 subscribers, growing at the rate of 85 new systems a year over the next 10 years. By 1998, however, more than 65 million subscribers were connected to nearly 12,000 cable TV head ends, representing two thirds of the total number of television homes in the United States <Television and Cable Factbook 1998>. There are

presently close to 150 national cable TV program networks and nearly 50 regional networks carrying mostly sports and news <Cable Television Developments 1998>. Moreover, the law requires that cable TV systems also carry the local TV stations, including PBS, that broadcast major national network programs, as well as unaffiliated stations.

HISTORICAL BENCHMARKS

Four major events since the birth of cable television stand out sharply, not only as keystones in the growth and significance of the industry itself but also as benchmarks in the broader arena of television and telecommunications. These events are:

- The development of the set-top converter in 1967, which cleared the roadblock at the thirteenth channel and opened the way to almost unlimited channel capacity.
- The use of the geosynchronous satellite in 1975 to relay the Ali-Frazier prize fight from Manila to cable TV systems in Mississippi and Florida. This dramatically demonstrated the feasibility of

distributing movies and other video programming by satellite. This was the spark that touched off the franchise gold rush, putting cable TV within reach of 97 percent of the households in the United States.

- In 1988, the successful demonstration of the hybrid fiber/coaxial (HFC) architecture in a cable TV system, using amplitude-modulated lasers with multiple analog NTSC (National Television Standards Committee) TV carriers (AM/FDM; see Glossary). The feasibility of using AM instead of FM or baseband digital codes made fiber optics technology compatible for the first time, with more than a billion analog TV sets in use worldwide, and opened the door to a broader future in telecommunications.
- The injection, in 1990, of the GI (Jerrold) DigiCipher compressed digital technology into the high-definition television (HDTV) proceedings at the FCC. This astonishing and unheralded event had the most profound impact on telecommunications, including broadcasting and telephony. Suddenly, after 20 years of intense development, the Japanese analog MUSE systems

were obsolete, along with untold man-hours of research by the giants of the broadcasting industry, including RCA Laboratories, CBS, NBC, Zenith, Philips, and newcomers Scientific Atlanta and Tektronix. Moreover, the HDTV digital compression technology could be adapted to pack four or more conventional video programs into each 6-MHz TV channel. Suddenly, digital television became a reality, not a prospect.

REFERENCES AND ADDITIONAL READINGS

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CHAPTER 3

The Technological Challenge

CABLE TELEVISION HAS BECOME A HOUSEHOLD WORD. Today it provides a menu of television entertainment, news, and information programming beyond the wildest imagination of those living just half a century ago. You turn on the TV when you come home or settle into a hotel room, to get the latest news from 24-hour CNN or your favorite sitcom from a national network. Or perhaps you choose a fine movie from Home Box Office (HBO), American Movie Classics (AMC), or Turner Classic Movies, or a quality drama on PBS, or sports on ESPN or a regional sports channel.

Next time you are driving in the country, take a look at the utility poles alongside the road. You will probably see a shiny aluminum cable (sometimes covered with black plastic) attached to the poles with offsets at each pole to allow for expansion. This is ubiquitous cable TV, way out there in the countryside. More than 97 percent of the households in America can get cable TV, if they want it. And two thirds of them do.

But, in 1948, things were different. You could get television signals only if you lived within 50 to 60 miles of one of the two dozen or so cities with an operating TV station, and then only if there were no mountains in the way. Television sets were still new and not very sensitive. So, ingenious engineers and radio hobbyists got the idea of building antenna boosters to intensify the signal picked up off the air. These boosters were tuned to the particular channel that could be received in the area. In the Washington-New York-Boston corridor, two or even three stations could be received, making it necessary to retune the booster each time you changed channels or to use a separate booster for each channel.

CHANNEL CAPACITY AND BANDWIDTH

It is strange to recall a time when there was no public interest in channels other than the three national network channels. Yet, this same tunnel vision progressively perceived the ceiling at 5 channels, then 12, 30, 50, 60. Today, even 120-channel capacity seems inadequate, and there is talk of even 500 channels. Actually, with compressed digital technology, 6 to 12 or more standard definition programs can be multiplexed in each

conventional television channel. “More is better,” they say. But, is it? Just how far can either customer fees or advertising revenue, or both, provide economic support for programs with a minuscule audience? Surely, there is a limit; but we do not know where it is. The bandwidth is there; it will be used, like the advertising space on the side of an old barn, waiting to proclaim some wondrous product or noble cause.

Bandwidth is merely the slice of the electromagnetic spectrum needed for a particular purpose. Television requires a fairly large slice, 6 MHz per channel. As many as 1,500 old-fashioned analog telephone channels (0.004 MHz each) would fit in a single TV channel. The slice of the spectrum, or bandwidth, available for modern multichannel cable TV networks is 750 MHz to 1,000 MHz, for 110 to 150 standard 6-MHz TV channels.

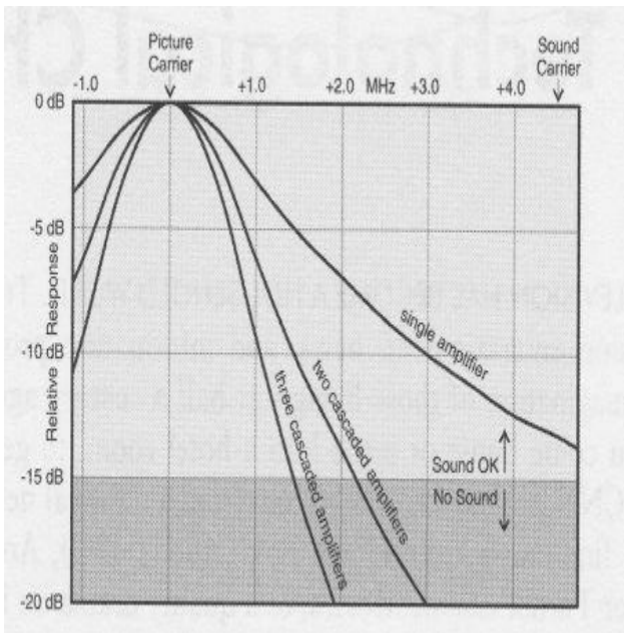


Fig. 3.1 Response curves showing bandwidth shrinkage and loss of sound in amplifier cascades

In the beginning, each 6-MHz TV channel was considered wideband. To demonstrate television receivers

to customers who had never seen television, dealers installed miniature networks connecting rooftop antennas to many TV sets displayed in their showrooms. Two or three single-channel antenna booster amplifiers, tuned to different stations and called strip amplifiers, were coupled to a single output port and mounted on a chassis with a common power supply. Strip amplifiers were also used in master antenna television (MATV) systems to connect rooftop antennas to TV sets in individual hotel rooms and apartments. Hoping to cash in on the enormous unsatisfied demand for television, several Pennsylvania entrepreneurs got the idea of using these strip amplifiers to bring the Philadelphia TV signals received on a nearby hilltop to homes in the valleys at Lansford, Pottsville, and Mahanoy City.

But the strip amplifiers were not powerful enough to drive the signals all the way from the antenna to the homes in town. After the first 1,000 feet or so, another amplifier was needed to boost the signal back up for another 1,000 feet, and yet another, and another. This is called *cascading*. But it did not work. The problem was bandwidth. Television requires 6-MHz bandwidth for each channel, far more than any prior communication media, except radar. The trouble was that in a cascade of several

single-tuned booster amplifiers, sound was lost completely and the picture lost its sharpness because of bandwidth shrinkage ([Figure 3.1](#)).

From the very beginning, the dominant task of cable TV equipment engineering has been to find out how to increase bandwidth and channel capacity. Typically, the early boosters were barely capable of sufficient bandwidth for a single TV channel, let alone multiple channels in cascades of dozens of amplifiers.

To appreciate the bandwidth problem with which the pioneers had to struggle, think about tuning an old-fashioned radio. As you turn the tuning dial, a weak signal becomes louder until it reaches a peak and falls off as you continue to turn the dial. This is the phenomenon of resonance and is key to understanding how engineers tried to increase the bandwidth. In a sense, the television signal includes a multitude of individual frequencies spread out over the 6-MHz channel. These are the sidebands, each one of which carries part of the information that, taken together, make up the picture and its associated sound. If the tuning mechanism is too sharp, some of these important components will be lost. The challenge is to make the tuning broad enough to include the entire band of frequencies but sharp enough

to reject an adjacent channel. This gets even more complicated in cable TV, because the tuning must be broad enough to include not just one station with all of its components in its 6-MHz channel but many such channels combined, or multiplexed, in the coaxial cable.

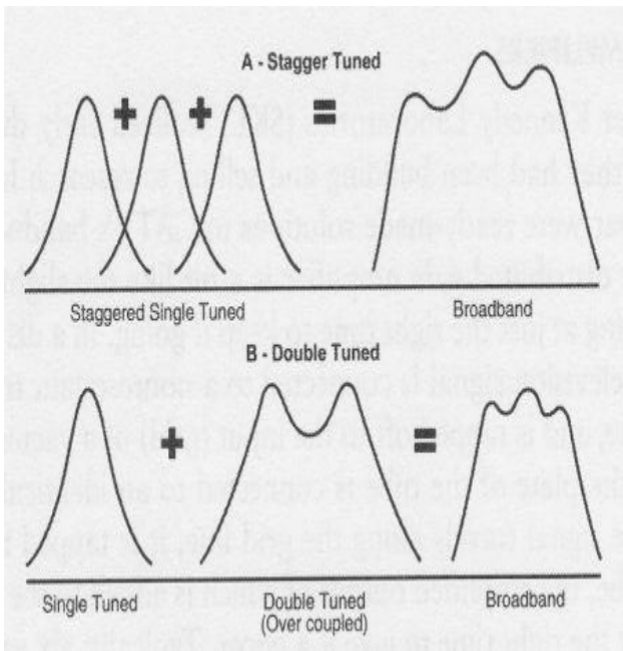


Fig. 3.2 Broadband techniques

Most of the ideas for increasing bandwidth originated in techniques developed during World War II

to accommodate the wide bandwidths occupied by the very short pulses required for radar. The simplest way to increase bandwidth is to broaden the response of single-tuned circuits by cutting down (damping) the resonant peak. A more effective technique amounts to spreading a number of peak responses at discrete frequencies across the desired bandwidth in such a way as to approximate a uniform response, called stagger tuning ([Figure 3.2A](#)). Over-coupling, sometimes called double tuning, is another way to do this. When single-tuned circuits are tightly coupled together, beyond a critical coupling threshold, tuning across the band causes the signal to rise to a peak, then fall off slightly, and rise again before falling off completely ([Figure 3.2B](#)). When combined, the result is reasonably flat response, with slight variations called ripples, over a much wider frequency band than would otherwise be possible. Radar engineers developed a stagger-damped single-tuned arrangement that was particularly effective, combining all of these effects. Sophisticated bandpass filters that no longer act like simple tuning circuits, with such esoteric names as m-derived, multi-pole, elliptical, Butterworth, and Chebyshev, designed according to complex mathematical formulas identified by engineers, are also used for

broadband amplifiers.

Modern fiber optic technology has stepped in to ease the bandwidth problem. Optical fibers with almost unlimited bandwidth capability are used for long runs, from a few miles up to 20 miles or more, generally without amplification along the way. Optical fiber trunks are connected to short coaxial cable networks that carry the signals another mile or two to a group of 500 or 1,000 households. This arrangement is known as the hybrid fiber/coaxial (HFC) architecture.

DISTRIBUTED GAIN AMPLIFIERS

Spencer Kennedy Laboratories (SKL) realized early that the distributed gain amplifiers they had been building and selling to research laboratories during and after the war were ready-made solutions to CATV's bandwidth problems. Operation of the distributed gain amplifier is a bit like the slight push given to a playground swing at just the right time to keep it going. In a distributed gain amplifier, the input television signal is connected to a nonresonant transmission line, called the grid line, and is tapped off to the input (grid) of a vacuum tube. The amplified output at the plate of the tube is connected to

an identical plate line. A moment later, as the signal travels along the grid line, it is tapped to the grid of a second vacuum tube, the amplified output of which is added to the signal on the plate line at precisely the right time to give it a boost. Typically, six vacuum tubes take turns boosting the signal on the plate line, at just the right moment. The bandwidth of the distributed gain amplifier is theoretically almost unlimited.

In conventional multistage amplifiers, the gains of the individual stages are effectively in series, like Christmas tree lights. When one tube fails, the entire amplifier is dead. On the other hand, the stages in the distributed gain amplifier are effectively in parallel. The failure of one tube in the chain simply subtracts a little from the overall gain rather than completely killing it. Moreover, the non-resonant transmission line is capable of providing uniform frequency characteristics over very wide bandwidth.

PUSH-PULL AMPLIFICATION

The “push-pull” circuit arrangement now used universally in transistorized cable TV amplifiers was developed many years ago to minimize the generation of distortion products in high-fidelity and stereo audio

amplifiers. If the positive and negative portions of the signal are not amplified by the same amount, undesired frequency components equal to twice the frequency of the input signal are generated. This is known as second-order, or second-harmonic, distortion. To minimize this effect, a pair of identical amplifiers is arranged so that during the portion of the cycle when the input signal voltage is positive, one gives a “push” in the positive direction while the other is idle. Then, during the time when the input signal voltage is negative, the previously idle amplifier “pulls” the signal in the negative direction while the “push” amplifier becomes idle. If the push and pull effects are precisely the same, second-order distortion is largely avoided. Because vacuum tubes deteriorate with time, vacuum tube push-pull circuits generally require balancing adjustments to minimize second-order products. Balancing adjustments are not needed for transistor-based push-pull circuits, because they have proven to be so much more stable than vacuum tubes over time. Virtually all transistorized cable television amplifiers are now designed for such push-pull operation.

FEED-FORWARD AMPLIFICATION

Another interesting and useful circuit arrangement developed in the 1970s for cable television amplifiers is called feed-forward. By electronically subtracting the desired input signal from the distorted output signal, adjusted to the same power level as the input and properly synchronized, an error signal is generated. This error signal is amplified to the proper power level and subtracted from the distorted output signal. Like magic, the distortion has been removed from the amplified signal! It sounds like a bootstrap operation and, in a sense, it probably is. However, it is not as simple as it sounds, and its effectiveness is limited by various practical realities. Nevertheless, it has proved to be feasible and effective in extending the useful length of cascaded coaxial trunk lines, i.e., the number of amplifiers that can be used in a chain without exceeding acceptable limits of distortion.

CABLE, CONNECTORS, AND TAPS

In addition to dealing with the bandwidth and distortion requirements of television, the early CATV engineers had to be concerned with a number of coaxial cable problems. In the beginning, the surplus military cables with braided shielding, designated RG-59/U and

RG-11/U, were used exclusively because of their ready availability and low cost. But these cables had never before been used in lengths of several thousand feet or even many miles. In short lengths, any old connector or even simple binding posts could be used. But for CATV, special connectors had to be designed that would provide a proper impedance match to avoid reflections (ghosts), be convenient to install, protect the cable against corrosion due to moisture, and prevent signal leakage that could degrade the pictures or cause interference to others.

In military service, coaxial cables were used to connect one nearby location to another without intermediate connections. For CATV, however, methods had to be developed to tap into the cable to serve many subscribers along the way. At first, the tap consisted simply of a resistor soldered to the center conductor of the main coaxial cable to drain off a minute portion of the signal to feed the subscriber TV set. They soon realized that a better arrangement than soldering was needed. A special device was needed with connectors for the main line input and output and to the subscriber line. This was awkward, so a pressure tap was devised that could be clamped to the main line cable with a means to press a sharp pointed "stinger" through the jacket and shield

braided to make contact with the center conductor without having to cut the cable. Finally, they devised the directional multi-tap that provided multiple tap-ports (outlets, or “spigots”) to which individual customers’ TV sets could be connected. The directional feature prevented reflections and interference from entering the customer’s TV from further down the line.

DECIBELS

It is virtually impossible to write about cable television technology without using the word *decibel* (dB). Actually, references to the decibel in the following chapters are few and far between.

Literally, the term *decibel* means one-tenth of a bel, named for Alexander Graham Bell since the idea was devised by the telephone industry. dB represents a power ratio, according to the formula:

$$\text{dB} = 10 \log_{10} (P_1/P_2).$$

For example, decibels may be used to indicate the ratio between the output signal power of an amplifier and its input, or the fraction of the signal power remaining at the end of a coaxial or optical fiber transmission line. In

other cases, the decibel simply indicates the ratio between the signal power at some point and a specified reference power. Thus, the expression “dBmV” indicates signal power relative to the power of a 1-millivolt (mV) signal, measured across a 75-ohm load, which happens to be equivalent to 13.33 nanowatts (billionths of a watt), and is defined as zero dBmV.

ENGINEERING BACKGROUND OF THE PIONEERS

Except for Fitzroy Kennedy, the technological pioneers who conceived, designed, and produced the electronics hardware for CATV were generally on their first job after graduating from college with degrees in engineering or physics. A surprising number started as cooperative, work-study students still in college. Many were licensed ham operators or had experimented with amateur radio. Several had military experience but often not in engineering. Only a few had even limited experience in radio or television broadcasting.

CATV has generally been considered ancillary to terrestrial television broadcasting. Yet the basic technology was derived more from the radio frequency (RF) experience in amateur radio and military radar than

from broadcast television technology. It is amazing that, with few exceptions, the pioneer CATV engineers had only primitive and superficial knowledge of the characteristics of the basic television signal. For most of them (and for many of our readers), important but rather esoteric characteristics of the basic video signal (e.g., differential gain, delay inequality, etc.) were shrouded in mystery. They were still struggling to master the fundamentals of bandwidth, RF signal levels, noise, and distortion. The vendor's engineers looked for guidance in reports on wideband amplification and studies such as those by the Bell Telephone Laboratories regarding multichannel transmission in cascaded repeater networks.

However, until about the late 1960s, they paid little attention to the extensive professional literature by broadcast engineers regarding the subjective impact on viewers of various kinds of distortion of the basic video signal. In fact, picture quality judgments were crude. Don Kirk tells about a Jerrold engineer who complained that open-wire transmission makes what he called, "Consensus pictures—the consensus is that the nose in that picture is probably right about there [pointing]!" <Kirk 1992, 30>.

LOW COST—HIGH PERFORMANCE

The pioneer engineers for the CATV manufacturers were keenly aware that their potential customers were likely to be grossly undercapitalized entrepreneurs, desperately trying to get started without enough money. Moreover, most of the CATV equipment manufacturers were start-up enterprises, inadequately financed (except for Spencer Kennedy Laboratories and Scientific Atlanta, which had been independently established for several years before engaging in CATV). Pioneer engineers, especially those with ham radio experience, had long known how to improvise, jury-rig, and make-do with the tools, materials, and techniques that might be available without spending a lot of money. They had little experience, and less patience, with the culture of utilities whose products and services were sold at cost, plus an assured profit. Nor were they expecting to deal with customers, such as the military and other government agencies, whose budgets were not tied to the bottom line of profit and loss statements.

From its inception in 1950, the CATV equipment suppliers have displayed a veritable genius for producing electronic hardware with performance characteristics at

least equal to if not better than those of their high-priced equivalents. This is probably somewhat less true since the great expansion in the 1980s than it was in the pioneer period. This ability to design and manufacture sophisticated equipment at uncommonly low cost may have led some opponents to claim that CATV was “cheap and dirty.” Indeed it was often low cost. While the packaging designs might not win beauty prizes, the circuit arrangements were often ingeniously simplified and innovative, performing their intended functions well.

The ability to produce the required performance at low cost represented an extraordinary talent that those early pioneers brought to the cable TV industry. The use of optical fiber is a classic example. Conventional wisdom held that transmission on optical fiber would have to be digital. However, CATV was designed to deliver television to conventional, consumer-type analog TV receivers, and the business could not justify the price of converting digital signals to analog at each customer tap. Then, in the late 1980s, cable TV engineers demonstrated that analog signals compatible with conventional TV sets could, in fact, be transmitted on optical fibers. The telephone companies eventually adopted the technique.

The exceptional transfer characteristic linearity (see

Glossary) of the amplifiers developed by these manufacturing engineers has not been as widely recognized as their achievement deserves. Unusually exacting transfer linearity, as measured by harmonic or intermodulation distortion, may be as much as 10,000 times more stringent for CATV than is required for the best high-fidelity audio amplifiers, or probably any other amplifier in commercial service. As amplifier loading increased from the early five low-band channels, amplifier linearity had to be improved still further just to maintain distortion at levels suitable for cascaded operation.

The growing use of microwave in the late 1960s and satellite relay thereafter resulted in greatly increased use of modulators and demodulators (closed-circuit transmitters and receivers) to convert the baseband video and audio signals to radio frequency and back. As a result, video degradation studies and analyses published by broadcast engineers began to be important references for cable engineers. They began to look more critically at the fundamental characteristics of the television signal itself, as it might be affected by the RF transportation system. As a result, they were able to design and manufacture modulators and ancillary equipment generally equivalent to, or in some cases even better than,

comparable equipment used for broadcasting, and at a fraction of the cost.

The design, construction, siting, and installation of antennas generally required custom engineering uniquely adapted to each individual situation. Thus, the innovative and skillful achievements of operating engineers in the field regarding antennas and propagation of television signals played an important role in the technological history of cable TV before the advent of satellite relay. Although many system operators did not have the facilities or, in some cases, the skills needed for designing and building equipment, vendors depended heavily on them for guidance regarding field experience and expanding needs. The development of equipment and network architecture was the indispensable role of the pioneer engineers who created the cable television manufacturing industry.

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CHAPTER 4

Jerrold Electronics Corporation: The Engineers

MILTON JERROLD SHAPP^{[1](#)}



Fig. 4.1 Milton J. Shapp (1912-1994)

*Courtesy National Cable Television Center and
Museum*

NO ONE IS MORE WIDELY IDENTIFIED WITH THE

DAWN OF CABLE TELEVISION THAN MILTON JERROLD SHAPP ([Figure 4.1](#)). From 1948 when he organized Jerrold Electronics Corp., on little more than a shoestring, until 1971 when he was inaugurated for the first of two four-year terms as governor of Pennsylvania, media reports about CATV routinely featured Jerrold Electronics or its founder, Milt Shapp.

In 1960, he participated in John F. Kennedy's campaign for president of the United States. He conceived the idea that was later developed as the Peace Corps. During the campaign and even after the inauguration, Shapp spent considerable time and effort persuading JFK, through his brother Robert Kennedy, of the feasibility of the Peace Corps and its appeal to voters <Wiley 1961>. In order to pursue his intense political interests, including a possible run for the U.S. Senate, he merged the Harmon Kardon Company into Jerrold as a subsidiary and relinquished active management to Sidney Harmon. About 1964, under the terms of a buy-sell agreement with Harmon Kardon, Shapp bought Jerrold back and resumed management responsibility. However, he continued to pursue his political interests and actively campaigned as the Democratic candidate for governor of Pennsylvania. In June of 1966, Jerrold's board of directors removed his

authority, concerned that Shapp's attention had become completely distracted from company operations. He lost the gubernatorial election in 1966 but came back to win in 1970 and again in 1974. Meanwhile, the publicly held company was acquired in 1968 by General Instrument (GI) and continues to dominate the market, even after dropping the name Jerrold in the early 1990s.

Milt Shapp was born in Cleveland, Ohio, June 25, 1912, son of Aaron and Eva (née Smelsey) Shapiro. At the age of 8 or 9, he spent many days with a family friend who had a ham radio setup. Although he never had an amateur radio license, Shapp became deeply involved in radio and determined to study electrical engineering. He graduated from Case Institute of Technology (now Case Western University) in 1933 with a bachelor of science in electrical engineering.

Shapp was an instinctive entrepreneur, constantly on the alert for opportunities requiring engineering and marketing skills rather than deep pockets (which he did not have). His first job after graduation, during the Great Depression, was driving a coal truck seven days a week for \$1.50 a day. He quickly found an opening as a field service engineer with the Radiart Corporation, in Cleveland, which manufactured the vibrators used to

provide ac power for automobile radios. In a short time, he became eastern sales manager, conducting seminars on auto radio servicing and becoming widely known in the radio parts industry.

It was not long before he and a friend, Neal Bear, joined forces to become one of the largest manufacturer's representative organizations in the Midwest. When Radiart opened a Philadelphia office, about 1936, Shapp moved to Philadelphia and became their eastern sales manager, while Bear continued to cover the Midwest. Shapp regularly traveled between Richmond and Boston and had four or five men working with him. He began taking on other lines, building his own sales organization. In his oral history interview, Shapp says, "I was making more money than I ever thought I would make in my lifetime" <Shapp 1986, 5>. And that was in the middle of the Depression.

At the outbreak of World War II, Shapp enlisted and turned his manufacturer's rep business over to his associates. After three and a half years in the U.S. Army Signal Corps, he left with the rank of captain and came back to Philadelphia to restart his business, focusing on the intensifying activity of television receiver manufacturers and broadcasters.

The Antenna Booster Inaugurates Jerrold Electronics Corp.²

Every fortnight or so, sales trips for clients took Shapp to the Baltimore electronics parts shop run by Ben Freeland. On one of those trips in 1947, Shapp heard about Donald Kirk, a graduate student at the Naval Academy in Annapolis studying under Professor Gene Cooper, a friend of Freeland's, who later became a Jerrold employee. As a project for his master's thesis, Kirk had built what he called a "gutless wonder" television receiver, in which any parts not deemed vital were eliminated. Several "build-it-yourself" kits were already available from various sources, but Kirk thought he had found a lot of things he could change in order to make a better and simpler receiver.

Shapp liked what Freeland told him about Kirk and decided to meet him and find out what he was doing. With his active imagination at full tilt, Shapp was thinking there might be a market for a TV kit like the one Kirk had built. In fact, he knew that Meissner, one of his clients, was looking for just such a kit. Meissner's firm built coils, capacitors, transformers, and other electronic components.

Freeland arranged for Shapp to visit Kirk at his home in Annapolis, probably in the latter part of 1947. When Shapp arrived, they talked in general terms about television, radar, and the new technology that was coming out of wartime research. But Shapp was anxious to see Kirk's TV receiver.

In 1947, television stations WRC-TV, WTTG, and WMAL-TV (now WJLA-TV) were in operation in Washington, D.C., on channels 4, 5, and 7, respectively. Baltimore station WMAR-TV was also in operation on channel 2. Annapolis is just 30 miles from all four transmitters. Kirk was trying to make a 7-inch electrostatically scanned TV set with nine tubes—far fewer than was common practice at the time. He acknowledged that, “We came up a little shy at every turn. The little TV set did not cut the mustard on gain” <Kirk 1992, 2-3>.

Sensing Shapp's disappointment, Kirk slipped out to his car to get a little homemade gain-box with which he had been experimenting. He was determining whether he could improve reception by increasing the signal voltage at the tuner input. The improvement with the little gadget inserted into the antenna down lead was dramatic. Pictures were extraordinary. Shapp immediately dropped

all interest in the TV kit and focused instead on the fantastic results obtained with the booster. This was something he could build and sell, because everyone was buying TV sets. He believed it might be the seed that could grow in ways he could not imagine.

On March 17, 1948, Kirk sent Shapp not only a model of the one-tube booster but complete instructions for fabrication, including circuit diagram, coil winding details, and lab test data <Kirk papers, File #1>. Shapp got together immediately with Henry (“Hank”) Arbeiter, an instructor at the Technical Training Institute in Philadelphia. Working in a basement below the street level at North Fifth Street, Philadelphia, Arbeiter produced the booster that Kirk had demonstrated in his basement lab in Annapolis. Kirk reports that they sold a quarter to a half million of those TV boosters. Kenneth Simons, Shapp’s principal engineering associate, donated one of the 25 prototypes of this historic piece of equipment to the National Cable Television Center and Museum. (See [Figure 5.1.](#))

In March 1948, with a cash investment of only \$500, Shapp organized the company he called Jerrold Electronics Corp. Shapp and Arbeiter were the only employees. Kirk’s booster was to be its first product.

When Jerrold Electronics shares were offered to the public in 1955, the prospectus claimed about 250 employees, of whom 100 were employed at a factory in Philadelphia, located at 26th and Dickinson. Executive offices by that time were at 23rd and Chestnut Streets. Gross revenues in 1951 were \$855,000; in 1955, \$3.4 million <Jerrold Electronics Corp. 1955a>.

Lansford CATV and the Service Agreement³

Until 1950, Shapp was in the business of selling antenna boosters and master antenna (MATV) systems for apartments. Bob Tarlton's idea of using Jerrold's apartment boosters to bring television from antennas on Summit Hill down to viewers in Lansford, Pennsylvania, resonated in Shapp's fertile imagination with a vision of wiring entire communities for television. Tarlton soon discovered that the Jerrold apartment booster amplifiers could not be used without modification to reamplify TV picture and sound in a series chain, or cascade. Jerrold's engineers were assigned the task of designing amplifiers specifically for this application. They also had to solve a host of other problems unique to community television distribution that had not been encountered in the much

smaller, indoor apartment MATV systems.

The problems and adjustments encountered at Lansford may well have been the experience that led Shapp to initiate the service agreement in 1951. He was concerned that, unless Jerrold equipment were properly installed by people who knew what they were doing, and could even modify equipment in the field, Jerrold might be held responsible for any failures. He established the policy that Jerrold would sell equipment only on condition that the system be designed by Jerrold engineers and installed under Jerrold's guidance. As enticement to sign the agreement, Jerrold promised to provide training courses and engineering assistance in case of trouble and to upgrade within five years after purchase if it ever became possible to have five channels instead of three. Moreover, it was Jerrold's policy not to sell to competing customers in the same market.

To cover the cost of these services, the purchaser agreed to pay \$5.00 for each customer connected, plus 25 cents a month (out of the typical \$3.75 monthly service fee) for each subscriber. The basic rationale for the service agreement appears to be both defensible and appropriate, but basing the charges on gross operating revenue rather than on services actually performed was

widely, and properly, criticized. And the promise to upgrade to more than three channels at no cost was soon recognized as dangerously irresponsible.

In order to facilitate sales to community entrepreneurs, Shapp made an arrangement with J.H. "Jock" Whitney and Fox-Wells, New York investment bankers with substantial ownership shares in Jerrold, to provide at least part of the capital required for installing systems in larger communities. In some cases, Jerrold assumed certain management and installation responsibilities and actually became principal owner of a number of systems. Jerrold also entered into an agreement with Times Wire and Cable (now Times Fiber Communications, Inc.), formerly a division of the International Silver Company, whereby Jerrold became the exclusive sales agent for the coaxial cables manufactured by Times for use in apartments and with CATV. Larry DeGeorge, president of Times, agreed not to compete in the electronics field. The agreements were terminable by either party on 90-days notice <Jerrold Electronics Corp. 1955a>.

The service agreement was abandoned after a few years and eventually led to anti-trust sanctions in 1960. Under a consent agreement with the Justice Department

requiring divestiture, Jerrold transferred its operating systems to Leon Papernow, a former television broadcaster (San Diego, California) who had been working with Shapp to acquire and develop new franchises. Papernow arranged the necessary financing through H&B American, a company that had just liquidated a large automobile parts and accessories business. H&B American was later sold to Jack Kent Cooke, the late renowned sports mogul and former radio broadcaster. Cooke later merged his properties with Irving Kahn's TelePrompTer.

Without violating the noncompete provisions of the consent decree, Jerrold was still able to put together another group of profitable operating systems before selling out to General Instrument in 1968. However, in order to improve GI's cash position, the second group of Jerrold operating systems was sold in October 1971 to Charles Sammons, a Dallas investor, to become the nucleus of the National Transvideo cable TV multiple system organization (MSO).

RCA Antennaplex Competition

In 1948, CATV pioneers either had to adapt

equipment intended for MATV distribution in apartments and hotels or build their own. The RCA Antennaplex system was introduced in the 1930s to distribute broadcast radio and shortwave RF signals to hotel rooms and apartments. After the war, the system was expanded with the addition of separate boosters for each television channel. By 1947 many expanded Antennaplex TV systems, as well as similar systems by other firms, had already been installed in major hotels and apartment buildings in New York <Electronics 1947; Kallmann 1948>. According to interviews with Harry Wall and Karl Solomon, both RCA engineers involved at the time, the television version of Antennaplex was a channelized amplifier, using strip amplifiers specifically designed to accommodate color TV. It was installed circa 1946 in the RCA Building in New York to distribute television signals to NBC offices and client rooms. By 1952, however, Antennaplex had been redesigned with broadband instead of strip amplifiers.

It is hard to sort out the conflicting remarks of obviously biased competitors. As a manufacturer's representative, Shapp had sold various products to RCA and certainly was aware of Antennaplex. In fact, it was believed at RCA that Shapp was inspired by RCA's

success with Antennaplex to get into the hotel and apartment television distribution business. But, in his oral history interview, Shapp disparaged RCA and Antennaplex as “junk” and “obsolete before it was made” <Shapp 1986, 11, 35>. On the other hand, Solomon said RCA regularly bought Jerrold equipment for evaluation and “found them wanting.” Then again, Henry Diambra, a former Jerrold sales representative who later founded Entron, repeatedly criticized almost everything Jerrold did (see [chapter 6](#)). Yet, while acknowledging that the former Jerrold engineers who later formed Entron “were very capable guys,” Shapp claimed “they were selling systems based on price. Their amplifiers were not the quality that either RCA or Jerrold was manufacturing” <Shapp 1986, 34, 36>.

Nevertheless, Shapp appeared to consider RCA a formidable rival, in part because of its enormous prestige and dominance in radio and television. But, while Jerrold was helping Tarlton build his pioneering system in Lansford, Martin Malarkey was building his system in Pottsville using RCA Antennaplex without any help from Jerrold. Most troubling to Shapp was the fact that Malarkey had been designated the national sales representative for RCA Antennaplex products, in direct

competition with Jerrold. Moreover, Shapp believed that Malarkey was discrediting the Jerrold service agreement as being of little value and quite unnecessary for purchasers of RCA systems <Shapp 1986, 34>.

In fact, Shapp perceived Malarkey's leadership of the NCTA as the establishment of an anti-Jerrold faction in the industry <Shapp 1986, 35>. Ironically, many members of NCTA were equally concerned lest the trade organization become merely a front for Jerrold. Their concern was not entirely unfounded, in view of Jerrold's dominant position with its products in three fourths of the systems <Shapp 1986, 21>. Shapp was never asked to serve on the NCTA Board of Directors. In fact, he has stated that, if asked, he would have declined because he believed that the NCTA was an anti-Jerrold organization <Shapp 1986, 36>.

Shapp's competitive advantage was flexibility. In his oral history interview, he says,

At Jerrold, we had, I'd say, five of the best on the engineering staff. That's one thing I've said many, many times. A small company in a fast moving industry can run rings around the big companies

because, while their engineers and their sales department are sitting around the board tables, or at the engineering room meeting, talking about the problems, we are out in the field solving them. ... That was probably the key advantage that we had at Jerrold <Shapp 1986, 13-14>.

The Bartlesville Project

In 1955, the FCC issued a Notice of Proposed Rule Making (Docket No. 11279) proposing to establish a subscription television service based on the existing channels assigned to television broadcasting. The proposal was met with enormous opposition, spearheaded by motion picture theater owners, television broadcast networks, the broadcasters' association, and the large, profitable TV stations. The debate was intense and very public.

Shapp seized the opportunity presented by the FCC proposal to proclaim to the FCC, Congress, and the public that authorizing broadcast subscription television over-the-air would be a huge mistake. With his usual vigor, Shapp contended that, "... the wired system for delivering a subscription television service to the public is not only

the best and most economical, but the only practical method for effecting such a service” <Jerrold Electronics Corp. 1955b, 29>.

In an aggressive and creative campaign, Shapp challenged the over-the-air proponents to join with Jerrold in “conducting public tests and demonstrations designed to prove or disprove the security of their codes” <Jerrold Electronics Corp. 1955b, 8>. Jerrold had analyzed the scrambling and billing methods proposed by Zenith, Telemeter, and Skiatron for over-the-air subscription TV and concluded that, “... technical problems, as well as operational business problems render the scrambled broadcast system thoroughly impractical” <Jerrold Electronics Corp. 1955b, 3>. Shapp’s dramatic and well-publicized challenge was never answered.

Meanwhile, Shapp and his staff were preparing to demonstrate home theater in a CATV system. Henry Griffing, president and principal owner of Video Independent Theatres (VIT) of Tulsa, Oklahoma, was apprehensive about the growing impact of broadcast movies on his theaters and agreed to put up the money to test the feasibility of delivering first-run movies by cable directly to the homes of subscribers. VIT also operated CATV systems in five Oklahoma cities through a

subsidiary, Vumore, Inc., with Larry Boggs as president. The project, as planned, would use the existing Vumore CATV lines passing 8,000 homes in Bartlesville, some 70 miles north of Tulsa.

However, the Bartlesville cables were attached to poles owned by Southwestern Bell Telephone Company under agreements that prohibited transmitting anything but off-air broadcast television signals. Southwestern Bell refused to waive the terms of the agreement. After extensive negotiation, Southwestern Bell and its parent at that time, AT&T, agreed to build a separate five-channel system that Southwestern Bell (or AT&T) would own and lease back to Vumore, solely for the home theater experiment. Since neither Southwestern Bell nor AT&T had any experience building a coaxial video network, Shapp and Jerrold agreed to build the 38-mile plant for them. A film projection room and studio were built in the VIT Arrow Theater so that the equipment could be seen from the sidewalk. The professional film projectors were arranged to accommodate any of the so-called anamorphic aspect ratios (4:3, 2:1, 1.8:1, etc.) for CinemaScope, Vista-Vision, and others.

There was considerable opposition from the Hollywood film moguls as Shapp and his alter ego, Zal

Garfield, sought their support for the Bartlesville trial. Columbia Pictures was the first major film company willing to provide first-run movies for a limited time and under specified conditions. However, virtually all the major studios soon climbed aboard and committed to provide comparable programming for the project.

In September 1957, the first home theater service, distributed by closed-circuit CATV, opened in Bartlesville, Oklahoma, with the showing of the Columbia Pictures feature film *Pajama Game*. The home theater service, called Telemovie, offered 13 first-run films per month on one TV channel and 13 reruns on a second channel. Subscribers paid \$9.50 per month on a package basis. The fee was later reduced to \$4.95 per month to test price sensitivity. The service opened with 300 subscribers but never reached the projected 1,500 to 2,000 break-even point. The experiment was discontinued in May 1958 with fewer than 1,000 subscribers.⁴

Griffing believed that lack of a practical metering system for pay-per-view billing was a major factor in the failure to attract sufficient subscribers to the TeleMovies service. However, motivation to pay for telemovies in Bartlesville must have been severely impaired when the

Tulsa TV stations increased the number of free movies broadcast during the experiment by several-fold. Shortly before the Bartlesville project shut down, Kirk was developing a system for program-by-program billing (PBPB), but it was too late <Kirk 1958>. Some said that Griffing was “just ahead of his time.” Tragically, Griffing and his entire family died in the crash of a plane he was piloting less than two years after inaugurating the Bartlesville home theater project.

In June 1959, a more expansive test of pay-TV on cable was inaugurated in Etobicoke, Ontario, a suburb of Toronto. A Canadian subsidiary of Paramount Pictures sponsored the project in a portion of its existing CATV system in Etobicoke. The coin box metering system developed by International Telemeter, also a Paramount subsidiary, was used for metering and collections. Jerrold supplied some engineering and equipment for the coaxial network but was not a major participant. The experiment ran for about two years and was terminated with indeterminate results. The time was not yet ripe.

Senate Bill S-2653

In 1960, Shapp sent an urgent call to NCTA members

to attend a special meeting in Washington, D.C., to reverse association strategy and oppose passage of Senate Bill S-2653. The bill had been drafted and introduced in Congress, with the help of NCTA staff, to provide the industry with the status and recognition of being fully licensed by the FCC. Out of respect for Shapp's enormous energy and outstanding promotional skills, members accepted his sudden shift of position, that is, to an industry that did not really need or want to be regulated in any way. Members swarmed through the halls of Congress, trying to switch friendly senators from support of S-2653 to opposition. The bill failed by one vote, but the industry lost considerable credibility in what some senators called a double cross. Whether the industry might have been better off with FCC licenses than municipal franchises is a matter of opinion. [Author's Note: I attended the special meeting called by the NCTA and sat in the Senate Gallery during the debate and vote on S-2653. My personal view was that FCC jurisdiction probably would have given the industry greater regulatory consistency and status.]

Retirement and Death

Upon completion of his second term as governor of Pennsylvania, Shapp joined several former Jerrold colleagues to acquire a number of cable TV franchises. He never returned to manufacturing and gradually retired. On Thanksgiving Day, 1994, at age 82, Milton Jerrold Shapp died at home after a long battle with Alzheimer's disease. The Jerrold Electronics Corp. of the 1950s and 1960s has been completely transformed. Shapp's dynamic leadership in the cable TV industry has been absent since he first ran for governor of Pennsylvania. Even the Jerrold name is no longer used by General Instrument. The engineering team of Kirk, Arbeiter, Simons, Jeffers, Ragone, Cooley, and others brought together by Shapp's inspiration and entrepreneurial vision has dispersed and been replaced with a new generation. Building on the creative engineering skills generated by Milton J. Shapp, General Instrument Corporation has never relinquished its leadership position in the development and marketing of cable television products.

DONALD KIRK, JR, 1920-1999⁵

Donald Kirk, Jr., was born in 1920 and grew up in Mobile, Alabama. In 1937, he graduated from Murphy

High School in Mobile. The school had an amateur radio club and Kirk earned his first ham radio license, W4EWV. Upon graduation, he entered Alabama Polytechnic Institute's electrical engineering program. His work assignment in the cooperative work-study program was with a power company in Mobile. There he cut limbs, dug holes, and learned to climb poles for three months; he then went to school for three months in Auburn. In 1941, he was licensed as a commercial flight instructor and went to work for the Alabama Air Service in Auburn.

In January 1942, he joined the U.S. Navy, graduating from flight training as ensign, U.S. Naval Reserve, in September. He transferred to patrol bombing squadron VPB-205, serving as patrol plane commander and leaving with the rank of lieutenant J.G. In 1945, he entered the post graduate school at the Naval Academy in Annapolis, where he was promoted to lieutenant U.S. Naval Reserve.

Kirk had an arrangement with the Naval Academy that enabled him to work on his master's project, the "gutless wonder" TV set (stripped of nonessentials), at his home in Annapolis, just outside the campus gate on King George Street. He had built amateur radio equipment and had a ham license but seldom operated his equipment, except to find out if it worked. He did have access to all

the tools and test equipment at the Academy and was able to develop a presentable shop and laboratory in his basement.

Upon completing his graduate studies in 1949, at government expense, he was obligated to give four more years of service to the Navy. He was transferred to the Naval Research Laboratories (NRL) in Alexandria, just outside the District of Columbia, where he developed a special distributed gain amplifier and other technology used to remotely telemeter the effects of the atom bomb tests in the South Pacific.

The Jerrold Connection

Kirk first met Milton Shapp in 1947 at his home in Annapolis. Kirk's single-tube booster, demonstrated to Shapp at that meeting, quickly emerged as the seed that became the Jerrold Electronics Corp. From 1947, when he first talked to Shapp about the TV kit and the booster amplifier, until the day in 1953 when he was released from his Navy obligation, Kirk moonlighted on nights and weekends helping Shapp and Arbeiter, sometimes in Philadelphia or with Arbeiter at Kirk's house in Annapolis. Shapp conducted his sales activity from an

office at 401 Broad Street and spent his weekends overseeing work at the shop on North Fifth Street. By 1951, the “factory” had moved to “a real honest to goodness building above street level” on North Sixth Street and had begun to add workers to assemble equipment. After resigning from the Navy, Kirk moved to the Philadelphia area and became vice president of Jerrold Electronics.

Kirk was named chief engineer about 1955, when Jerrold moved out of Southampton into the new laboratory at Hatboro. Arbeiter had been chief engineer but wanted out of the responsibility for the growing staff of engineers. Simons said he certainly did not want the job, so Kirk got it by default. About two years later, Kirk resigned from Jerrold, apparently over a rather obscure issue involving security clearances for a project Kirk was negotiating with the National Security Agency (NSA) <Kirk 1992, 44-47>. This was at the height of the unproved allegations raised by Senator Joseph McCarthy of Wisconsin. Kirk had received top security clearance for his work with the NRL. However, he feared that McCarthy-type issues might be raised against other Jerrold personnel during the security clearance investigation required for the NSA contract.

To Philco, K&F, and Back to Jerrold

In 1958, Kirk left Jerrold to work for Philco as chief engineer for industrial communications. However, he soon became uncomfortable with internal bureaucratic obstacles that greatly hampered the expeditious development of commercial microwave products.

Within a few months, he told Philco, “Look, you guys tried, and you are going to make some further trials. But I don’t believe you are going to succeed the way you are going. If I need something, I should just go buy it. But you don’t do it that way at Philco. You have to give a contract to someone to engineer it before you can buy it. If you don’t have what you need on the shelf, you have no plans for putting anything on the shelf. You’re not going to make money that way.” So he told them he was going to make microwave equipment and sell it to them. He left Philco on good terms and joined Dalck Feith, Jerrold’s sheet metal fabricator and one of Shapp’s reliable financial supporters. Together, they organized K&F Electronics to build and sell microwave equipment. Philco and Jerrold were their major customers. K&F products were sold primarily to the CATV industry, although some went to broadcasters and dozens of links

were shipped to Vietnam. The enterprise was apparently quite profitable.

Kirk took William Lambert, his field engineering assistant at Philco, with him to K&F. Lambert was a young co-op student engineer who later moved up rapidly in the Jerrold organization, becoming vice president for the CATV division and eventually president of the Jerrold Canada company. Many years later, he was named president of the reorganized Texscan after its release from Chapter 11 bankruptcy. When Antec Corporation acquired Texscan, Lambert joined AM Communications, Inc., in Quakertown, Pennsylvania.

About 1962, Jerrold Electronics bought K&F on condition that Kirk accept an employment contract. Lambert, John Nardontonia, and Frank Stiano moved with Kirk from K&F. Jerrold had just brought in an outside engineer to manage the laboratory and instrumentation department. Kirk noted that Bob Beiswanger, then president of Jerrold, instructed the head of the laboratory to keep Kirk away from Jerrold employees. So, Kirk worked out an arrangement by which he would rent a lab in Southampton in which to do his work. "It was lonesome in the lab with no one but me," he said. He went to digital seminars and had a chance to do some studying <Kirk

1992, 69>.

St. Petersburg and Retirement

In 1968, Kirk left Jerrold again and moved to Florida with Mike Paolini, who had come to Jerrold as a co-op student to work with Mike Jeffers. Together, they organized the St. Petersburg Communications Corporation (reorganized as Digital Communications, Inc., in 1970) for the purpose of designing, building, and marketing low-cost instrumentation for the CATV industry and developing digital technology for potential applications in cable TV. The St. Petersburg venture was financed, in effect, by the proceeds of the sale of K&F Electronics to Jerrold. They generated worthwhile products but lacked the financial resources to maintain an inventory and had to build everything to order. The business was laid down in 1979.

Kirk then began working as a consultant, designing video scrambling devices and related equipment for Hamlin International. Phil Hamlin was president of Jerrold Northwest, and sales representative and distributor for Jerrold Electronics from about 1953 until he left to form his own company to build set-top converters and other

products. Kirk soon became vice president for engineering and started working full-time for Hamlin International until his retirement in 1981.

For several years prior to his oral history interview in 1992, Kirk had been living with Parkinson's disease. In December 1999, Sarah Kirk wrote, "My father, Don Kirk, died suddenly, somewhat unexpectedly, but quite peacefully, the morning of November 24, 1999. He was 79 years old."

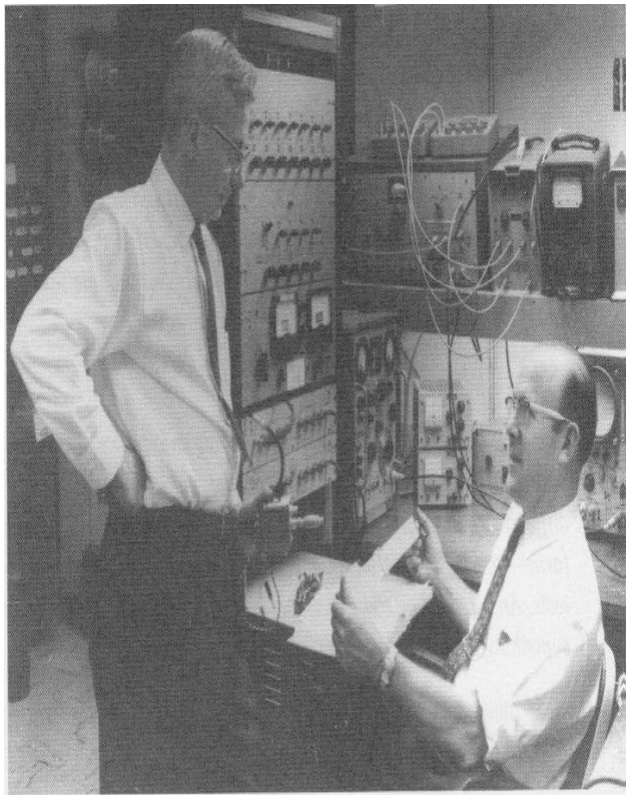


Fig. 4.2 Keneth A. Simons (seated) and Henry J. Arbeiter (1921-1986)

Courtesy National Cable Television Center and Museum

HENRY JOSEPH “HANK” ARBEITER⁶

Henry Arbeiter ([Figure 4.2](#)) was born in Philadelphia in 1921, the youngest of four children. His parents were “simple people,” hard-working, church-going citizens of German descent. His father died when he was 10 years old. He was not able to finish the twelfth grade at Northeast High School and went to work for Sears until being inducted into the U.S. Army in 1942.

He completed a radio communication course in 1943 at Camp Crowder, Missouri; with an excellent academic rating, he qualified as a radio repairman. He spent time in Scotland and Paris, France, in the radio division of the Tactical Air Command as technician third grade, Company A, 932nd Battalion. His tasks were related to communication with planes coming into France. He landed with the Signal Corps on D-Day plus 2 and was honorably discharged at Indiantown Gap in 1945 with six bronze

stars and ribbons for the European and African campaigns and Middle East service.

In 1946, he enrolled in the radio television course at the Television Training Institute, where he soon became an instructor. Later in his career, he took chemistry courses at Bristol Township High School. It was at the Institute that he met Milton J. Shapp. Shapp used to go to Arbeiter's brother-in-law's home where Arbeiter worked on television sets in the basement. His wife said that his only disappointment in life was that he never had a college degree. He was killed in an automobile accident in February 1986, at age 64.

Keneth Simons once said:

It actually was a beautiful team. We had four people on that team—Milt Shapp, Don Kirk, Henry Arbeiter, and myself. Milt Shapp, the founder of Jerrold, was behind the three of us. Shapp was very forceful; he wanted to succeed. Kirk was the idea man; he dreamed up about ninety percent of what was done. I turned a good bit of it into things that would work, and Arbeiter made it happen. He put the fine touches on what the rest of us did <Simons

1986>.

Arbeiter's real gift was production. Shapp said of him:

There's a big difference between production and design. Anybody can make one product easily. To make a thousand of the same product is the difficult job. Arbeiter's job was to make the product into a reproducible form—something that was stable and in a form that could pass field tests. And it also had to be maintained easily by the customer. That was something Arbeiter insisted on <Berlin 1986>.

Arbeiter's fingerprints were on just about everything Jerrold produced before his untimely death.

KENETH A. SIMONS⁷

While Don Kirk was still moonlighting for Jerrold, before completing his tour of duty with the Naval Research Laboratory, a young man named Keneth Simons ([Figure 4.2](#)) (“one N and one M” he insists) became associated with Jerrold. At the age of 14, Simons discovered and was thoroughly enthralled by amateur radio, popularly known as ham radio. Since 1930, he has

been known on the airwaves as W3UB. The experience and knowledge that he gained as he tinkered and experimented changed his life. His down-to-earth attitudes toward engineering development and training and his tenaciously inquiring mind were firmly established during those days of fervid ham activity.

Simons lived with his family in the suburban religious community of Bryn Athyn, north of Philadelphia. After graduating from high school, he worked at RCA Camden as a stock boy. Later, he worked his way through school at the Moore School of Engineering, University of Pennsylvania, by designing and maintaining test equipment for RCA. He earned a bachelor of science in electrical engineering.

Following graduation in 1938, he was sent by RCA to New York as one of 10 young men trained to become intern trainers of television servicemen. His instructor, Ernie Johnson, was an exceptional teacher. Johnson would create faults in a TV receiver. It was the trainee's job to learn the process of troubleshooting, which, Simons says, "... is the basis of all engineering; all engineering really involves building it wrong 12 times so the thirteenth time it comes up right" <Simons 1992, 5>. This experience established Simons' career as an

exceptional teacher and engineer.

In 1938, 100 of the 200 pre-commercial TRK-12 television receivers built by RCA for field testing the television system were located in Manhattan Borough, New York City, primarily with newspaper editors and other VIPs. Simons spent three months adjusting those TV receivers with test patterns before he ever saw a television picture. On one occasion, he fixed the receiver for David Sarnoff, president of RCA, under the watchful eye of the Chinese butler but never met Sarnoff personally.

Simons was married in January 1940. In June of that year, he was assigned by RCA to the Wendell Willkie presidential campaign train. During the three months he was on the train, he became well acquainted with Mrs. Willkie. One day he told her that he objected to the fact that, although Mr. Willkie was a college professor, he talked like a hick, referring to Roosevelt as “Presnt Unide States.” She said, “Don’t tell me; tell Wendell,” and shoved him into the living room at the end of the train. “Mr. Willkie, this young man wants to tell you something.” Willkie explained that “... he wanted to come across as a ‘down home’ type person and did not think the college professor act would go over so good”

<Simons 1992, 7-8>. He lost the election anyway.

After his son was born, Simons accepted a job with WCAU where he had worked as summer relief after graduating from college. He was given the responsibility for installing the first FM station to come on the air in Philadelphia, W69BH. In order to beat WFIL on the air, Simons and the assistant chief engineer jury-rigged a temporary antenna with copper tubing. He also supervised the console installation for the 50-kW transmitter at Morristown. After the “Day of Infamy” in December 1941, and preferring not to be drafted, Simons found out that an old friend at RCA needed radar field engineers and got the job without even asking. He recalls that it was a challenging job. He restructured a large, confusing instruction manual into a handy compact edition that was convenient to use in the field. He wrote a book for the Navy on the electrical systems known as synchro systems. Synchros are systems arranged so that the instantaneous angular positions of two or more rotating machines are precisely the same, whether stationary or rotating. At the time, synchros were a great mystery to the RCA service engineers.

Early in the war, the Signal Corps asked RCA to set up a school to train technicians on sophisticated military

equipment, specifically the APN-1 altimeter and the SA-1 aircraft radar. For a year and a half, Simons taught a new class every six weeks. It was an exhilarating experience, which taught him as much about RF as it did the students. It also gave him an opportunity to develop his method of teaching by first showing the student what is happening and then making it happen in the laboratory.

After the war, he continued with RCA Service Company. He spent about a year designing and building a simulator, called a “hot box” by his colleagues. The simulator was packaged in a standard RCA test equipment box, which included a complete synch generator with all the signals required to adjust a television receiver. Simons said, “With fifteen 6J6 vacuum tubes inside, you could make toast on the side of the box!” <Simons 1992, 13>.

In 1947, Simons taught briefly at a trade school in Kansas City. Then, as chief engineer for KMBC-TV, he was assigned to build an entire television studio full of equipment, *from scratch!* He had a crew of 10 men working for a year and spent about \$120,000. This is roughly what it would have cost to buy the equipment from RCA, had the owners not believed that building would be cheaper than buying. He also worked in advanced development at Sylvania in Buffalo, evaluating

tuners, including the Dumont Inductuner that later became the tuner for the once widely used 704-B field-strength meter.

In 1949, he formed a partnership with his cousin to design and build a superior 9-inch oscilloscope. After producing the prototype, they got cold feet at the prospect of borrowing enough capital to manufacture and take it to market. The project died.

Starting with Jerrold

Desperate for income to support his wife and small children, Simons first looked for a job at WCAU-TV, Philadelphia. Jack Leach, chief engineer, said, “We don’t need you, but someone was in here yesterday who obviously needs help. ... A little outfit called Jerrold was in here yesterday putting in some television repeater equipment for us and they didn’t seem to know what they were doing.”

So Simons waltzed up to the Jerrold office at 401 North Broad Street and asked to speak with Mr. Shapp. He said he was a consulting engineer with extensive RF experience and wondered if they could use his services.

Shapp replied, “No! We never use consultants.” (That wasn’t quite true, since he was using Don Kirk on a consulting basis.) So Simons made a proposition, “I am out of work. Give me any old project you’ve got and I’ll take it home and if you like what I do, we can talk about it. Otherwise, we shake hands as friends.” Shapp said, “That sounds like a good deal,” and asked Simons to build a “high-to-low” frequency converter. He came back in two weeks and, as they say, “The rest is history.” This was 1950 <Simons 1992, 16>.

Simons found a stained-glass factory near his home in Bryn Athyn and rented the unoccupied second floor for \$25 a month out of his own pocket. Bryn Athyn was home to numerous artists who had produced beautiful stained-glass windows for a cathedral there, as well as for the National Cathedral in Washington <Simons 1992, 23, 38>. This was Simons’ personal laboratory. Jerrold paid him \$125 a week for half time. Kirk was still part-time, and within a few months, Mike Jeffers and Frank Ragone came on board. Caywood Cooley, Vic Nicholson, and Bill Felsher probably also worked at the glass factory before the lab was moved to the space over a four-car garage in Southampton in 1953.

They soon had a long list of things that needed to be

done. They needed a good trap to take out interfering signals, field-strength meter, sweep generator, variable attenuator, and many other devices. Near the end of 1953, Shapp asked Simons to come to his office on North Sixth Street and said, "How much did I pay you this year?" Ken replied, "About \$2,500." Then Shapp said, "Please send me another bill for the same amount. I would like to double your pay." Simons commented later, "I think this is some indication of what kind of guy Milt was" <Simons 1992, 28>.

Within a year, the engineers had outgrown the Southampton laboratory. In order to convince Shapp they needed more space, they planned a quiet demonstration. When Shapp came out on his routine inspection, Simons says, "Everybody pulled out his chair and stuck his butt out in the aisle so that the place would seem to be as crowded as possible" <Simons 1992, 41>. Frank Ragone describes another strategy this way: "They would hold a meeting by clearing a little space in the front, and Milt would come up with his assistants, of which there were quite a few." All the engineers were crowded in the space where they had their drafting facilities. During the meeting, Ragone would go up and say, "Excuse me, I have to get this drawing out." Then someone else would come

up and say, “I need this...,” or “I need that...,” or “I have to make a phone call.” And Ragone added, “We have only one telephone, so we’re crawling all over each other.” This “Hollywood production,” as Ragone called it, went on until the meeting was over, and Shapp said, “Oh my gosh, how do you get anything done here?” <Ragone 1999, 38-39>.

It worked. An open field for sale on Byberry Road in Hatboro, near Southampton, was called to Shapp’s attention. He mentioned it to Dalck Feith, who promptly bought it, out of hand; Kirk talked him into building a laboratory facility. The 10 acres Feith purchased at Hatboro on Jerrold’s behalf are now the site of the main office of General Instrument, successor to Jerrold Electronics. Harry Epps, a contractor from Southampton, built the original Hatboro laboratory building for Dalck Feith in about 1955. It has been enlarged and remodeled several times to its present state.

A few years later, while the front addition to the Hatboro laboratory was under construction, Simons dropped in one Sunday afternoon, after he had been named chief engineer, to see how things were progressing. When he opened the door, he was greeted with a tremendous odor of burning asphalt. It seems that

the electrician had hooked up the air-conditioning thermostat to the furnace and the furnace thermostat to the air conditioning. The more the thermostat called for cold, the hotter it got <Simons 1992, 47>.

It is remarkable that five years after incorporating Jerrold Electronics, Shapp was still relying on consultants for engineering—Kirk, part-time, and Simons, full-time. It is quite true that he was also building a competent team. Don Kirk, Hank Arbeiter and Ken Simons represented the original solid engineering foundation upon which Shapp, with the creative support of Zal Garfield, Simon Pomerantz, Dan Aaron, and other non-engineers, was able to establish the dominant leadership position still enjoyed by the Jerrold organization and its successors.

Instrumentation and Measurements

Instrumentation and measurement technologies were (and still are) among Simons' foremost interests and special contributions in the CATV industry. In the beginning, almost nothing in the way of test equipment was available. In 1948, Kirk had to resort to a ham radio receiver with an S-meter to measure relative RF voltage. (See [chapter 5](#), p. 1.) Technicians trying to make systems

work used modified RCA 630-TS television receivers as signal-level meters.

Ken Simons had an unusually creative talent in this field and enjoyed pursuing the challenge it presented. In 1965, he wrote the first of a series of booklets titled *Technical Handbook for CATV Systems* <Simons 1968>. Later editions are known as the blue (1966), red (1968), or green (1985) versions. For many years, these books constituted the best tutorial source available regarding technical performance and measurement in CATV and still serve as a useful reference. He also published a series of technical newsletters on a variety of subjects, including:

- Measurement Techniques Using a Coaxial Switch
- Wideband Impedance Measurement
- Additional Sweep Frequency Impedance Measuring Technique
- A Bridge Method of Sweep Frequency Impedance Measurement
- Comparison Technique
- Extend Frequency Range of Comparison Technique to 1,200 MHz

He had been very successful in running training

courses for RCA and for the U.S. Signal Corps. He understood the physics very well and was especially skillful in presenting the information to technicians with limited background or training. Under Simons' guidance and counsel, Vic Nicholson and Len Ecker were primarily responsible for running Jerrold's field training sessions.

Disappointment and the IEC

As chief engineer for test equipment development, Simons was dismayed when the Jerrold accounting department claimed, in 1962, that his department was not making enough money to carry the administrative loading arbitrarily assigned to test equipment. They brought in an outsider to run the test equipment department and eventually sold it to Texscan. At that time, Texscan was a small, little-known instrument company in Indianapolis owned by Carl Pehlke and Jim Luksch. Pehlke died several years ago, and Jim Luksch has acquired the Blonder-Tongue organization. Simons stayed with Jerrold for about 10 more years, but, as he said, "My heart wasn't in it" <Simons 1992, 83>.

For at least two decades, Simons was perceived as the leading technical expert at the Jerrold Electronics

Corp. He would be the first, however, to defer to the other engineers who comprised the Jerrold Electronics Corp. during the stained-glass factory period: Don Kirk, Hank Arbeiter, Eric Winston, Mike Jeffers, Frank Ragone, Caywood Cooley, Vic Nicholson, Len Ecker, Bill Felsher, and others. Shapp was the marketing and strategic planning genius. “During the 10 years we worked for Milt, from 1951 to 1961,” Simons says in his interview, “he was a constant stimulation—he was a constant inspiration, in that when we did something good, he understood what we had done and patted us on the back. ... He was there. He was a symbol. We knew who we were working for, and I am afraid that, after he was bought out, that feeling disappeared completely” <Simons 1992, 81>.

In 1969, Simons’ wife, Rita, developed cancer. In 1973, after four years of dependence on around-the-clock nurses, she died. Simons had been named vice president for research and development for Jerrold, but there was neither research nor development work that went beyond next year’s products. In 1969, he accepted an invitation from NCTA and a consortium of cable manufacturers to represent the U.S. cable TV industry on two technical committees of the International Electrotechnical Commission (IEC), a member of the International

Standards Organization (ISO). He participated in both technical committee No. 12 on radio-distribution systems, and technical committee No. 46 on cables, wires, and waveguides for telecommunication equipment.

His handiwork in subcommittee 12G on wired distribution systems, as a member of working group 5 (WG-5) on system performance requirements, is clearly visible throughout IEC Publication 728-1. This is the governing document that sets forth standards for cabled distribution systems primarily intended for sound and television signals operating between 30 MHz and 1 GHz. Members on WG-5 included 14 representatives from the United Kingdom, Japan, Norway, Denmark, Finland, Belgium, Germany, France, Canada, Italy, and the United States. Simons was secretary, functionally equivalent to chairman.

In technical committee No. 46, Simons contributed significantly to subcommittee 46A on radio-frequency cables, with membership in WG-1 on screening efficiency and WG-2 on CATV cables. In the late 1960s and early 1970s, he undertook extensive investigation seeking to identify the causes of signal leakage and ingress and to determine effective methods for measuring and quantifying the attributes of the cable and connectors

responsible.

The IEC had previously specified a “triaxial” fixture to measure shielding efficiency. However, in order to interpret the data obtained with the triaxial fixture in meaningful terms of transfer impedance, Simons found, “you had to use some equations that filled about two pages; and nobody ever did. It was one of those standards that is obeyed more in the neglect than in the use” <Simons 1992, 97>. So, he devoted a couple of years designing and building a new shielding fixture called the terminated triaxial fixture, described in a paper found among the documents Simons donated to the National Cable Television Center and Museum <Simons 1974>. Simons’ device has been under consideration by IEC as a potential international standard for measuring and specifying shielding efficiency in terms of transfer impedance <Simons 1992, 97>. Times Fiber Communications (formerly Times Wire and Cable) uses the fixture Simons developed, although he seems to have been given little credit for it.

Resignation and Retirement

By the mid-1970s, the organizations that had

sponsored Simons' participation in the IEC found it necessary to withdraw their support as part of their retrenchment in the face of the severe economic downturn affecting the cable TV industry. Although Jerrold had kept him busy putting out fires, Simons felt that he had an empty title as vice president for research and development. So, in 1976, Simons resigned from Jerrold Electronics Corp., a division of General Instrument. The 12G secretariat of the IEC continued to list Simons as a member and secretary of WG-5 as of October 1977.

In addition to being a gifted teacher of technical subjects, or perhaps because of that gift, Simons has been a prolific writer, sometimes writing with a wry sardonic twist. His serious articles in professional engineering journals have become classics with regard not only to the measurement of shielding efficiency but also to the power series analysis of nonlinear distortion <Simons 1970> and the theoretical analysis of attenuation in coaxial cables <Simons 1966>. The widespread misunderstanding, confusion, and pervasive misuse of logarithms and decibels inspired him to write numerous pieces in the trade press, frequently in a humorous or even satirical vein. His article "The Gravelization of Spinach" <Simons 1982> is one of several attempts (not noticeably

successful) to lure engineers (and others) into a better appreciation of the true meaning and proper use of logarithms and their derivative—decibels.

After 1965, following an illustrious professional career of major contributions to the cable TV industry, Simons lost faith “... that cable was going to do anything worthwhile for the American people.” He complains bitterly that cable TV has not used the “light pipe” in a switched star configuration to provide virtually unlimited programming without advertising. He observes that “... even the Pay channels are saturated with ads,” filling the gaps between programs with promotions, while “... PBS begs, on and on ad nauseum, for MONEY.” While his views may reflect unrealistic expectations and overestimate the aspirations and inclinations of the public, many will empathize with the limericks he wrote and sent to *CATJ (Community Antenna Technical Journal)* in 1986 <Simons 1986a>.

This nation's prime mover is GREED!

*To make lots of dough with great
speed.*

We've forgotten our past.

The values that last.

*With a conscience you'll never
succeed!*

Then he complains about the sexual innuendo in so many television programs:

The networks don't show naked sex,

But they're into it up to their necks.

They tape it complete,

Covered just with a sheet,

And hope that nobody suspects!

Keneth Simons was never one to accept conventional wisdom without challenge. His outlook on the society in which we live and work is as free-spirited and plain-spoken as his endeavors in the realm of technology.

MIKE JEFFERS8



Fig. 4.3 Mike Jeffers

Courtesy Jerrold Electronics Corp.

Mike Jeffers ([Figure 4.3](#)) was born, raised, and lived most of his life within 15 minutes of Flourtown, a suburb

of Philadelphia. His father died before he was born; his mother, from strong stock, raised her four children on her own. She lived to be 85 or so. Jeffers says, "She had a tough life; but, as we grew older, she had a very nice life."

Just before World War II, Jeffers took chemistry at night school at Drexel University. He knew he wanted to be in engineering but was not yet really settled on the direction. His active duty in the military entailed flying off an aircraft carrier in fighter-type aircraft. He was made radio/radar officer for his squadron, although he knew absolutely nothing about it. However, he became interested and, after his tour of active duty, decided to switch to electrical and electronic engineering at the University of Pennsylvania. One of his classmates was Frank Ragone, who became a long-time close friend. He received a bachelor of science degree in electrical engineering in 1949 and enrolled in graduate school to work for the master of science degree in electrical engineering. However, with several children and a commitment to fly in the naval reserve, he dropped out of graduate school about two thirds of the way toward his master's degree. Jeffers now has 3 sons, 2 daughters, and 14 grandchildren.

Jobs were hard to find in 1949. After receiving their

undergraduate degrees, Jeffers and Ragone went to work for the Naval Air Development Center at Johnsville, Pennsylvania, about 20 miles north of Philadelphia. Bud Green, another classmate at the University of Pennsylvania, who could not find a job, was driving a taxicab when he met Milt Shapp. Green was hired at Jerrold to take care of production of the boosters Shapp and Arbeiter were building. In June 1950, Green helped Ragone land a job at Jerrold. When Shapp indicated he needed another engineer, Ragone steered him to Jeffers. So, in September 1951, Jeffers joined Green and Ragone at Jerrold. But, no sooner had Jeffers come into Jerrold, than Ragone left, in January 1952, for a job with Robert G. Genzlinger who was developing CATV products to be manufactured by Philco. Nine months later, Ragone rejoined Jerrold, and both Jeffers and Ragone enjoyed long careers at Jerrold.

When Jeffers joined the Jerrold organization, Ken Simons had been working as a consultant on a variety of projects for only a few months. The laboratory was above the stained-glass factory, rented in Simons' name, not Jerrold's. Don Kirk was still working out of his home in Clinton, Maryland. Arbeiter was producing boosters and MATV apartment amplifiers at the shop on North Sixth

Street in Philadelphia. Jeffers became vice president for engineering in 1968 and vice president for research and development in 1981. While Jeffers was in the research and development group of 25 people, mostly engineers, Jerrold began to move aggressively ahead with modern developments. Mike Jeffers retired about 1992 after devoting his entire professional career to Jerrold Electronics.

FRANK RAGONE²

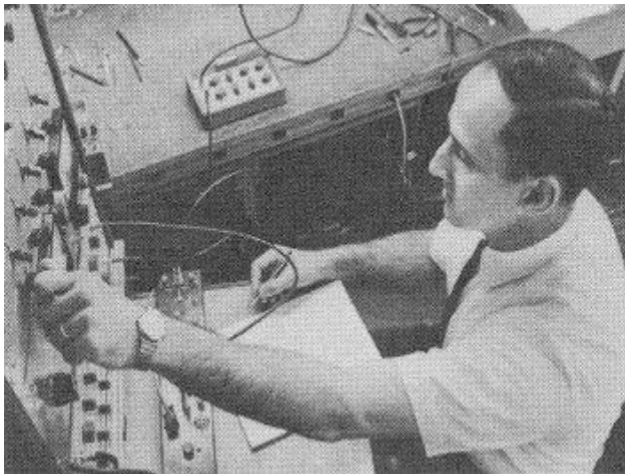


Fig. 4.4 Frank Ragone

Courtesy Jerrold Electronics Corp.

Frank Ragone ([Figure 4.4](#)), born in 1925, lived his early years in Camden, New Jersey, across the Delaware River from Philadelphia. His mother was born in Philadelphia; his father was an immigrant from Italy who settled in the Camden area. Unfortunately, Ragone's father died when Frank was only 4 years old. Ragone has

two brothers and a sister. After graduation from Camden High School during World War II, he enlisted as a volunteer and became a B-24 navigator. After completing his tour of duty, Ragone entered the University of Pennsylvania, with the support of the GI Bill. His old friends Bud Green and Mike Jeffers were classmates in the engineering studies, and they all received bachelor of science degrees in electrical engineering in 1949.

By the time they graduated, engineers could only get jobs driving taxicabs, washing dishes, and the like. But the Navy was actively recruiting engineers, and Ragone and Jeffers enlisted as summer co-op students, working at the Naval Air Development Center at Johnsville, about 20 miles north of Philadelphia. After graduation, the Navy gave them employment. Green, however, was driving a taxicab when he met Milt Shapp and was recruited as production manager for Jerrold. Ragone began work with Jerrold in June 1950, followed by Jeffers in September 1951.

Although he was happy at Jerrold, Ragone thought the “grass was greener” outside Jerrold. So, with the enticement of “a nice little pay raise,” he went to work for Robert G. Genzlinger in January 1952. Genzlinger was an aggressive entrepreneur who saw the possibilities in

delivering television signals to remote areas with CATV. He had friends at Philco who told him, “Bob, if you develop these products, Philco will go into the business of wiring communities.” So he began to develop head end and distribution amplifiers, which were actually very similar in form and function to Jerrold’s. Genzlinger provided Philco with a research and development facility; Philco manufactured the product.

After a short time, however, Ragone began to realize that it was not working out. The informal arrangement with Philco was beginning to erode, and the funding was simply not adequate to hire additional personnel and continue the development work. When he left Jerrold, Hank Arbeiter had told him, “We don’t want you to leave, and if you’re not happy with what’s going on up there, you come back.” After about nine months with Genzlinger, Ragone called Arbeiter who said, “The door is open. Come back.” By this time, the facilities had been moved to 26th and Dickinson Streets, combining the laboratory, production, and general offices under one roof.

Frank Ragone stayed with Jerrold from September 1952 until March of 1982, when he joined Comcast Cable Communications, Inc., as vice president for engineering.

In June 1993, he retired from active duty at Comcast but continued as a consultant, gradually easing off from three days a week until total retirement in 1997.

LEONARD ECKER¹⁰

Leonard Ecker ([Figure 4.5](#)) was born in September 1917. Before going to college, he lived in a small town about 25 miles northwest of Pittsburgh. For most of his adult life, he resided in the greater Philadelphia area, although he was often “on the road” or “on assignment” at various places around the world. Ecker has a son and a daughter, both in professional occupations, and four grandchildren.

His parents, who came to the United States from Hungary, were previously divorced. His mother had no children from her first marriage. His father, who came from a once wealthy family, had a son and two daughters, all born in Hungary, from his first marriage. One of the daughters was caught in the Holocaust and spent four years in a concentration camp, where she lost her husband and a son.



Fig. 4.5 Leonard Ecker

*Courtesy National Cable Television Center and
Museum*

Len Ecker's mother was almost 42 years old when he

was born. The four siblings have the same father, but Len is his mother's only child. Nevertheless, Len is very close to his sisters and often visits them in San Diego. His brother's wife, however, was not at all comfortable with her husband's Jewish background. She was bitter and did not want to know anything about Jewish people. Because of her feelings, Len's brother had hyphenated his name to Ecker-Racz as was common in Europe, joining his mother's maiden name with his father's. Len had a number of warm and genial visits with his brother but never met his wife or two children.

Ecker tells about a remarkably poignant experience when, as a Jerrold field engineer, he was given the task of presenting a proposal to the Arlington, Virginia, school board. Imagine his surprise when he walked into the boardroom to discover that the chairman of the board was none other than his brother. Neither of them acknowledged the relationship, and the other members of the board apparently did not associate the two names.

After graduating from high school, Ecker applied to three or four different colleges and was accepted by all of them. He says he was a "pretty good student" in high school and a member of the National Honor Society. He can't explain why he picked engineering, nor why he

picked Georgia Tech. He was always good at mathematics and enjoyed physics. He remembers, "... I had a mother who was old when I was born. She was very doting and I used to feel smothered. I just wanted to get away from home."

Ecker notes, "Engineering was no place for a Jewish boy to be." He told a story about how his mother belonged to a little coffee klatsch—a group of women that would get together from time to time. "And what would a group of Jewish women talk about?" he asks. "They talk about their children." One woman's son was a doctor, another a lawyer, another a dentist. Finally, one of the women said to Ecker's mother, "You have a son don't you?" And his mother said, "Yes." "So, what does he do?" "He is an engineer." "What! You mean he drives a train?"

Ecker graduated from Georgia Tech in 1939, in the Signal Corps ROTC. He worked briefly for Westinghouse at the Hoover Dam in Nevada until he was called for active duty in the Army. There he learned radar with the Royal Air Force, commanded a radar company that took him through the invasion of North Africa, and served as a radar instructor in Florida. After his discharge in 1949 as a Major, AT&T invited him to come and talk with them. He

had the interview and they told him he was “exactly what they were looking for.” But, the minute the interviewer saw Ecker’s religious preference on the application form, Len says, “It was all over. They didn’t want any part of me.”

Then, by pure chance, he found himself talking with a group that was planning to build CATV in South Williamsport and needed an engineer. Ecker says, “I didn’t know a damn thing about cable. I really didn’t.” He was hired, and they sent him to meet with Hank Diambra. Ecker says, “I must admit Diambra didn’t know a helluva lot about a cable system either. But at least he was accustomed to handling cable in apartment jobs.” Hank Diambra tells the rest of the South Williamsport story in [chapter 6](#).

Ecker’s oral history includes amusing tales about building the system in Reno for the “West Coast Mafia,” being bitten by a rattlesnake, and other misadventures with Shorty Coryell in South Williamsport. Ecker worked as a field engineer for Jerrold with Caywood Cooley and later worked in the laboratory with Eric Winston designing the “J-Jacks” system (Fig. 5.3) for the educational round robin network in Chelmsford, Massachusetts. His oral history makes interesting

reading.

DALCK FEITH¹¹

Dalck Feith was not an engineer. He provided the sheet metal housings, chassis, and silk-screen or decal markings for Jerrold equipment. Legend has it that he came from a central European country as a sailor; he jumped ship off the coast of Florida and swam ashore. Starting with nothing but determination and creative imagination, he built a successful sheet metal business in the Philadelphia area.

Originally, he was a contractor to whom Milt Shapp turned when he needed sheet metal chassis or cabinets. According to Mike Jeffers, Shapp did not even look for another source. Jeffers spoke of Feith as “a crafty guy... one smart cookie.” For example, Shapp would order, say, 500 sets of parts, and Feith would then build an inventory of 1,500, making it difficult to change the pattern.

Shapp always had a money problem. Feith, on the other hand, had money and frequently saw fit to lend some on Thursdays so Shapp could meet the payroll on Fridays. Moreover, Feith provided the financial support

that enabled Shapp to buy the Jerrold company back from Harmon Kardon in 1964.

Over time, Feith became a major shareholder in the Jerrold Electronics Corp. and became quite wealthy when General Instrument absorbed it. He was on the board of directors and had considerable influence with management. The relationship was mutually beneficial, although rather unusual. Shapp might not have succeeded as he did without Feith. The key, of course, was Feith's faith in Shapp personally and his confidence that Shapp was on to something worthwhile and had the skill and temperament to achieve big things.

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NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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CHAPTER 5

Jerrold Electronics Corporation: Engineering

BOOSTERS AND MATV

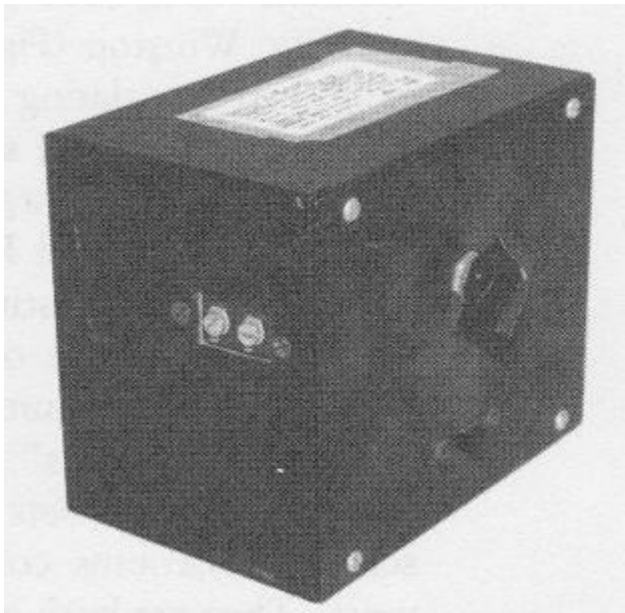


Fig. 5.1 Jerrold prototype TV-FM booster (1948)
*Courtesy National Cable Television Center and
Museum*

THE FIRST BOOSTER DON KIRK DESIGNED FOR

MILTON J. SHAPP, IN MARCH 1948, WAS A SINGLE-STAGE 6AK5 WITH TAPPED GRID AND PLATE COILS AND ROTARY SWITCH CHANNEL SELECTOR. Kirk's model used a resistance line cord, but the production models had a transformer ([Figure 5.1](#)). The models had a tendency to oscillate when the input and output 300-ohm ribbon cables got too close together. On one occasion, as Hank Arbeiter tells it, half of a shipment of 20,000 units was returned because of the oscillation. Nevertheless, the booster did get Jerrold launched, and Kirk says that Jerrold sold half a million or so of the little one-tube boosters. A letter from Kirk to Shapp, dated March 17, 1948, reveals the inadequacy of even the Navy laboratory instrumentation with which he had to work in those early days:

Enclosed you will find a sheet of lab data taken on the completed booster during the last stages of its development. All of the readings in this particular sheet apply to the high band. ... Unfortunately, the tuned vacuum-tube voltmeter, which is a Navy test set, does not cover the spectrum below 100 megacycles with the tuning head which we have. A Hallicrafter SX-36 with a built in S-Meter [see

Glossary] was used as a voltage indicating device in the low frequency channels <Kirk 1948>.

It was not long before they needed a different kind of booster that had considerably more output to serve multiple apartments with MATV. Arbeiter developed a five-tube booster amplifier with each stage tuned to the visual carrier frequency. The bandwidth of the single-tuned amplifiers was reasonably acceptable for moderate-size buildings. Except for a low-noise preamplifier, they apparently never expected that the boosters might be connected in series (cascade). Up to four of these amplifiers, each on its own modular chassis approximately $1\frac{3}{4}$ inches wide by $3\frac{1}{2}$ inches high (including the tubes) and 10 inches long, were plugged into a common chassis with a signal combiner and a common power supply. This was designated the constant level (CL) series MATV strip amplifier, which was designed to provide the same output signal level on all channels, regardless of the signal strength received on the antennas. Shapp called this the "Mul-TV" system. Channel amplifiers were designated CL-CA and the preamplifiers were CL-PR. Mul-TV found a significant market in apartment buildings, hotels, and TV dealers'

showrooms.

Mul-TV equipment was designed with 75-ohm input and output ports. The only 75-ohm coaxial cables readily available to experimenters at that time were war surplus MIL Spec. RG-59/U and RG-11/U. These cables were constructed with braided copper wire outer conductor, copper or copper-clad steel wire center conductor, and solid polyethylene dielectric. The C-52 connectors used initially with the RG-59/U cable probably did not originate at Jerrold. Kirk says, “The C-connectors were no good; they were too fragile. So Eric Winston designed a little skirt that screwed on the C-connector and made an F-connector” <Kirk 1992, 32>. Simons says, “The C-fitting happened before I came on board” <Simons 1992, 66>.



Fig. 5.2 Eric Winston

*Courtesy National Cable Television Center and
Museum*

Eric Winston ([Figure 5.2](#)) was a mechanical

engineering genius, especially skillful in translating the electrical ideas generated by Simons and others into effective mechanical structures. It is believed that he joined the Jerrold organization somewhat later than Simons, Jeffers, and Ragone. Winston was primarily responsible for creating the ubiquitous F-fitting and the subsequent line of connectors for the semi-rigid solid sheath aluminum cables. Winston and Len Ecker devised the “J-Jacks” system ([Figure 5.3](#)) that permits cameras and TV sets to be used interchangeably in school classrooms connected to a round robin network. They are both now retired.

About 1948 or 1949, Jerrold was beginning to get calls from TV dealers who wanted to display 20 or more TV sets in their showrooms but found that connecting them all to a booster amplifier resulted in disastrous interference. Kirk understood that it would be necessary to couple the TV set to a distribution cable with sufficient isolation to minimize reflections and interaction between the TV sets. Drawing on his radar experience, Kirk built a little cathode follower, a type of vacuum-tube amplifier circuit with low output impedance, whose characteristics effectively isolate each TV set on the dealer’s floor from the distribution line and each other <Kirk 1992, 50>. This

was called an antenna distribution outlet (ADO); it had C-52 fittings for the distribution feed-through and the outlet to the TV set. An isolating resistor coupled the cathode follower to the through-line. The ADO was used in a four-channel system installed in the Baltimore Montgomery Ward store. Shapp was particularly interested in this, because acceptance by Montgomery Ward or Sears could lead to many other dealer installations.

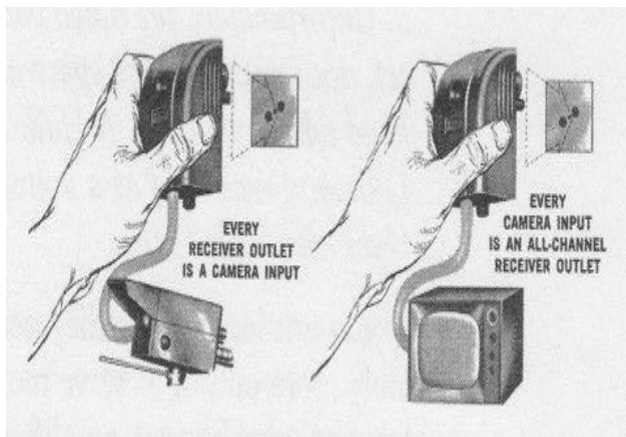


Fig. 5.3 The J-Jacks system

Courtesy Jerrold Electronics Corp.

The model 1401 taps that Shapp called “Multel” were a serendipitous by-product of the ADO developed for Montgomery Ward. At his home in Maryland, Kirk and George Edlen were studying the disturbing tendency of the ADO to oscillate. Edlen was a graduate physicist working for Jerrold in sales, although he later became a cofounder and principal of Entron. At one point, they turned the power off in order to stop the oscillation. They were surprised to find that the TV sets worked just as well with the cathode follower turned off, due to the capacitive coupling of the ADO circuit. So they built a passive tap in a small sheet metal box; it included a jumper between female C-52 fittings on the ends for the through-line and a capacitor connected to another C-fitting on the side for the TV set. They made several dealer installations with this kind of passive tap box.

But for one of Edlen’s contracts (possibly the Campbell Music store in Washington, D.C.), the taps had to be installed in standard electric outlet boxes. The sheet metal tap box was too large. So they designed a little solid metal block (originally brass but later aluminum), perhaps about $1 \times 1 \times 1\frac{1}{2}$ inches. It was hollowed out and had a cover plate and female chassis fittings to accommodate

the C-52 fittings and the capacitor or a resistor. They believed the block could be weatherproofed by wrapping it with tape and that signals would not leak out, since it had no cracks like the sheet metal box. And so, the model 1401 tap, known as the Multel was born <Kirk 1992, 52>.

LANSFORD AND THE W-SERIES FOR CATV¹

In 1949, Robert Tarlton, a TV dealer and repair shop operator in Lansford, Pennsylvania, began experimenting with Jerrold's apartment booster amplifiers. He wanted to carry the Philadelphia television signals that could be received in the Summit Hill community down to Lansford in the Lehigh Valley, a mile or two away. Because of the distance, he would have to put in additional boosters along the route to reamplify the signals when they got too weak. He found that pictures came through two or three boosters reasonably well, but that the sound was completely lost at the second booster (see [Figure 3.1](#)). By retuning the Jerrold boosters, Tarlton succeeded in getting usable sound through several reamplifications.

Shapp had often visited Tarlton's radio-television repair shop in Lansford as a manufacturer's rep. He was

intrigued by Tarlton's request about a quantity purchase discount arrangement. Why would Tarlton need so many MATV boosters? Shapp drove to Lansford with his family, the day before Thanksgiving 1950, to see what Tarlton was up to. What he saw set his imagination on fire. Shapp began to envision the exciting prospect of wiring other communities throughout the country, and even the world, for television. He was so impressed with what Tarlton had done in Lansford that he invited him to come to work for Jerrold. Tarlton declined but agreed to work with the engineers to design equipment especially for applications of this type.

Stimulated by the exciting prospects, Kirk and Simons began to investigate the requirements for extended series strings, or cascades, of identical amplifiers. Simons says that Kirk found a paper describing a system for apartment houses, probably the article by Heinz E. Kallmann, a consulting engineer in New York <Kallmann 1948>. The amplifier had three stagger-tuned stages, plus preamplifier and output stages, using 6AK5 tubes with overall gain of 60 dB. Kallmann did not discuss the feasibility of cascading the amplifiers. However, the published response curves appeared flat enough to work reasonably well in situations like that in Lansford. So,

according to Simons, Kirk built the amplifier as described by Kallmann. However, the gain had to be reduced substantially to avoid overloading with noise at the next amplifier input.

For Kirk, the authoritative source of information about amplifier design was in volume 18 of the MIT series, edited by George E. Valley and Henry Wallman <Valley and Wallman 1948>. The information was based on the extraordinary research efforts that were made during World War II. Section 5.6 of volume 18 describes “stagger-damped, double-tuned” circuits in which one or more single-tuned stages with specified Q (a measure of the narrowness of the response of the tuned circuits) are combined with an overcoupled, double-tuned stage. The result is a very flat response in the pass band, with steep skirts that can be cascaded with minimum bandwidth shrinkage. It seems more likely that Kirk followed the Wallman concept, rather than the staggered, single-tuned Kallmann arrangement. In an ironic twist, it appears that the Kallmann paper actually described the RCA Antennaplex MATV system for apartments, which did in fact have staggered, single-tuned stages with 60-dB overall gain.

Since adjacent channels were not normally assigned

in the same community, the response roll-off could be allowed to extend beyond the desired channel boundaries. Experiments with various ways to achieve bandwidths suitable for repeatedly re-amplifying signals in a long coaxial cable marked the beginning of CATV at Jerrold. The CL-series strip amplifiers were replaced with broader, single-channel modules and renamed W-series (presumably for wideband), designated specifically for CATV use.

However, the W-series still had problems. Bandwidth response was critically dependent on tuning and gain. Changes in gain caused the response to wobble. Simons developed a relatively simple interstage bandpass filter circuit (described by engineers as a “2-pole” filter) that enabled the in-band response to be flat within 1/10 dB over a single TV channel and stable. This made it possible to cascade stages and amplifiers without serious loss of picture or sound quality.

One project at Simons’ laboratory in the stained-glass factory at Bryn Athyn was to overcome the problems that turned up in Tarlton’s system at Lansford. Simons and Bill Felsher, an engineer employed by Shapp to work with Kirk and Simons, developed an amplifier based on more elaborate m-derived interstage filters, with

unusually high gain, considering the 34-88 MHz bandwidth they proposed to use. After it was built, Simons says, they had the good sense to put pictures through it, and learned the hard lesson of second-order intermodulation. It had not occurred to them that the second harmonics of frequencies between 34 and 44 MHz would fall within the 34-88 MHz passband, causing serious interference.

Another attempt was the model JR amplifier, copied directly from Blonder-Tongue's main line amplifier (MLA), with separate resonant circuits for low-band and high-band, both on the same vacuum tube. Like Blonder-Tongue's amplifier, interstage coupling was adjusted by pushing the coils closer together and tuning them by squeezing the turns together <Simons 1992, 32>. Apparently it worked, but the workers on the production line found the alignment procedure arduous. To make this easier, Simons designed a more convenient and reliable wideband sweep generator, which wasn't available at that time.

ENGINEERING PRODUCTS

Until Simons came to Jerrold in 1950 as a part-time

consultant, Kirk and Arbeiter were solely responsible for designing and developing Jerrold products. However, at about the same time, Shapp was building his engineering team with such additions as Mike Jeffers, Frank Ragone, and Eric Winston. Caywood Cooley, Victor Nicholson, Bob Tarlton, and Len Ecker were brought in as field engineers. Cooley left Jerrold in the 1960s to join the TelePrompTer organization. In 1971, he became vice president for engineering of the Magnavox CATV Division, formed when Magnavox purchased Craftsman Electronics and Professional Products Company (PPC) from Dan Mezzalingua and his father (see [chapter 12](#)). Nicholson left in the 1970s to join the Cable Television Information Center (CTIC), a nonprofit corporation sponsored by the Urban Institute and the Ford Foundation to provide CATV consulting services to municipalities. It was a remarkable team that functioned smoothly and effectively throughout Shapp's tenure and beyond in many cases.

It was at the stained-glass factory that Simons made the first A-72 switched attenuator. It was in a sheet metal housing with ordinary slide switches. The remarkable part is that the resistors were all within 1 percent of the calculated values. Staffers at Allen-Bradley, from whom

the resistors were purchased, were horrified to learn that Jerrold people were grinding notches in the factory-supplied resistors, using a Dremel grinder to bring them to within proper tolerance. John Austin ground resistors until there was a pile of dust several inches deep under his bench. The sheet metal housing and Austin's labor cost Simons an average of \$7 per attenuator. He sold them to Shapp for \$15 and they were sold to the trade at \$63.50 <Simons 1992, 33-34>. Attenuators with comparable range and precision were selling for \$100 to \$400 each.

Simons tells about designing the TLB and THB (low-band and high-band traps) at the glass factory. These were known as Hi-Q Traps that, according to Simons, could only momentarily achieve their specified 70-dB attenuation. They were necessarily big and clumsy, and Simons acknowledges that this was a case in which Kirk effectively redesigned and improved his "stuff."

Although RG-59/U cable was adequate for the apartment systems, the larger RG-11/U was needed for distribution in communities such as Lansford. However, the C-52 fittings for the W-series and the Multel taps would not fit the larger cable. Therefore, a short RG-59/U jumper had to be spliced into the RG-11/U at each connection. Center conductors were soldered, but the

outer braids were merely overlapped by several inches and taped; a dreadful arrangement! But it was the only way Tarlton's system at Lansford and a good many other early systems could get started.

Simons soon discovered that the C-52 fittings also presented a very poor impedance match for either 75-ohm or 50-ohm cable. He said the characteristic impedance was more like 30 ohms. This may have been relatively inconsequential for MATV, but in long cable runs it would constitute "bumps" in the path causing reflections and standing waves. Recognizing this problem, Winston developed the F-connector for RG-59/U cables to replace the unsatisfactory C-52 fitting. Although much maligned, the F-connector is electrically a better-performing connector than its detractors admit, considering it costs only a few pennies to half a dollar. In their simplest form, F-fittings are now used throughout much of the world almost exclusively for coaxial RF connections to consumer equipment, although a somewhat different version is standard in Europe.

The PL-259 so-called UHF connector was used for RG-11/U cable, although it is a poor match, inconvenient, unreliable, and has nothing to do with UHF. By 1960, solid-sheath aluminum cable was being used instead of

RG-11/U with Winston-designed VCC connectors. In 1973, Winston designed the VSF connector with integral sleeve and published the results of a comprehensive study of the effects of connectors on signal leakage <Winston 1973>. The aluminum sheath could be tightly clamped against the integral sleeve to provide good electrical contact and seal the connection against signal leakage and moisture contamination.

THE PRESSURE TAP

The shortcomings of the 1401 Multel tap were recognized early in the Lansford project. Don Kirk and George Edlen, a Jerrold sales engineer at the time, conceived the pressure tap as a way to install taps without having to cut the feeder cable. To install the pressure tap that Kirk and Edlen devised, a special rig was used to cut a hole in the jacket, shield braid, and dielectric of the feeder cable to expose the center conductor without cutting it. A special fitting with pointed teeth that penetrated the jacket to make contact with the shield braid or aluminum sheath was then clamped around the cable. A threaded socket was spaced directly over the open hole to accept a pointed “stinger” to make contact with the center

conductor. The stinger was connected to a resistor, capacitor, or back matching transformer in order to tap-off a small amount of signal from the distribution cable. (See [Figure 6.3.](#))

At this time, probably about 1951, Edlen was still working for Jerrold and was responsible for installing the equipment he sold. He had an informal arrangement that Hank Diambra (see [chapter 6](#)) would provide sales contacts and help with the installation of Jerrold equipment, primarily in Washington apartment houses. Edlen and Diambra gradually separated from Jerrold and Leese Electric. In 1954 they incorporated as Entron, Inc., to design and install CATV systems and to build equipment in direct competition with Jerrold.

Kirk and Edlen did not apply for patent protection on the pressure tap they had developed while Edlen was still a Jerrold employee. However, in 1954, much to the dismay of Kirk and Shapp, a patent filed in February 1953 was issued to George Edlen, assigned to Entron, for a similar pressure tap with the proprietary name FasTee (see [chapter 6](#)). The Entron FasTee differed from the Jerrold pressure tap in that the FasTee stinger was coated with insulation and pressed through the jacket, shield, and dielectric to the center conductor without first cutting a

hole. This difference was sufficient for the court to reject Entron's claim that Jerrold had infringed its FasTee patent. Kirk still complains bitterly that Edlen and Entron actually stole the pressure tap idea that had been invented in Kirk's basement laboratory <Kirk 1992, 52-54>. However, Entron may have had the last word. When Jerrold signed a consent decree in an anti-trust case several years later, misuse by Jerrold of the FasTee patent was a factor in the settlement.

When Mike Jeffers joined Jerrold in 1951, both the CL-series and W-series strip amplifiers were designed for three nonadjacent, low-VHF band channels 2, 4, and 5 or 2, 4, and 6 to take advantage of the substantially lower coaxial cable loss at frequencies below 88 MHz. The Philadelphia TV stations, however, were assigned to channels 3, 6, and 10. So, the broadcast signals on channels 3 and 10 had to be converted to channels 2 and 4, respectively. Jeffers, Bill Felsner, and others spent most of their time for the better part of a year building those converters.

THE 5-CHANNEL SYSTEM AT SOUTH WILLIAMSPORT²

As early as 1951, Ken Simons recognized that the CATV industry would not be satisfied with just 12 channels. It seemed inevitable that the midband between channels 6 and 7 (108-174 MHz) would eventually be used. Yet Jerrold's customers steadfastly maintained that three channels would be plenty. After all, they already had ABC, CBS, and NBC. What else could they possibly need to carry? In fact, many considered the prospect of 12 channels to be excessive; reception of one or more distant unaffiliated stations plus the three networks and an educational station (ETV, later to be affiliated with PBS) were already receivable without cable.

But tunnel vision was not confined to customers. The Bell System's principal supplier, Western Electric, persuaded Spencer Kennedy Laboratories to reduce the bandwidth of its 220-MHz amplifier to carry only the five low-band channels. Diambra had copied the SKL distributed gain amplifier but limited his design to the low-band VHF channels 2 through 6 in order to avoid unneeded "wasted" bandwidth. Earl Hickman's first designs for Ameco were also limited to the five low-band channels.

From his earliest introduction to CATV in 1951, Simons consistently challenged that shortsighted

attitude. Years later, in 1968, he told the audience at an NCTA convention that the number of channels they needed would be several times what they thought they needed. He said, “We now have 20 channels. There’s no reason at all why we can’t have 40. We have the amplifiers that will do it. There is no reason why they couldn’t go to 80, using parallel trunks if necessary.” Simons believed the demand was there. In his interview he says, “The people wanted all the channels they could get, not because they needed all that entertainment, but because 90 percent of their 80 channels was going to be unusable anyway because of lousy programming” <Simons 1992, 26, 95>.

By 1953, a major change in CATV system architecture was about to be initiated. Jerrold was building a CATV system in Williamsport, Pennsylvania, using its three-channel W-series. Bob Tarlton of Lansford was Jerrold’s field engineer on the job. At the same time, Lycoming Television was beginning to build a system across the river in South Williamsport, using experimental broadband distributed gain amplifiers handmade in Diambra’s shop in Washington, D.C. Leonard Ecker was Lycoming’s chief engineer at that time (he later became a Jerrold employee). This was a year or so before Diambra’s operation was

incorporated as Entron. Lycoming could not buy Jerrold equipment because of Shapp's agreement with the J.H. Whitney investment bankers that he would not sell to competitors.

Diambra's amplifiers for three channels in South Williamsport were broadband, 54-108 MHz bandwidth. In Williamsport, Jerrold was using three-channel strip amplifiers, probably W-series. With very good pictures on channels 2, 4, and 6 in South Williamsport, Ecker persuaded Diambra to install preamplifiers for channels 3 and 5 for distribution in South Williamsport just to see if it would work. The experiment was enormously successful. Diambra claims this was the first time the feasibility of carrying adjacent channels was demonstrated.

In his interview, Simons claims, without specifying the date, that Vic Nicholson was "single-handedly" responsible for the discovery that "... you could put channels 3 and 5 in there, in addition to 2, 4, and 6 to get a five-channel system" <Simons 1992, 26>. Simons also thought that SKL had installed, apparently in 1951, the first 12-channel system using the 220-MHz chain amplifier at Buckhill Falls, Pennsylvania, although it may not have actually carried adjacent channels <Simons 1992, 70>.

John Walson has also claimed to be first to distribute adjacent channels. Perhaps some light is shed on this claim by a report in the November 1953 *NCTA News Bulletin*; “Jerrold Electronics Company... displayed five-channel community antenna equipment, on October 15, to 37 operators at a meeting in Mahanoy City, Pa. It featured flexibility, expandability, efficiency and complete control of signals through use of individual channel amplifiers [i.e., strip amplifiers].” The *Bulletin* goes on to say that the second system in Mahanoy City had been “successfully converted to carry five channels,” and that “the Service Electric Company, John Walsonavitch, Manager, also distributes 5-channels and lays claim to a ‘first’” <Phillips 1972, 9, 10>. This was about the same time that Diambra and Ecker were demonstrating five channels in South Williamsport, using broadband distributed gain amplifiers, rather than single channel strip amplifiers.

Mike Jeffers and the folks at Jerrold acknowledged that Diambra’s demonstration was an eye-opener. An interim scheme was quickly devised whereby channels 3 and 5 were down-converted to channels designated 03 and 05, at frequencies below 30 MHz, for transmission with strip amplifiers. Channels 03 and 05 were then

converted back to the proper frequencies at the ADO for the customer feeder lines. It was a clumsy arrangement and was soon abandoned in favor of broadband amplification. The competitive gauntlet was down, and Jerrold embarked immediately on the development of its own broadband amplifier. Ironically, the concept of distributing adjacent channels was still greeted with skepticism: “Who wants 12 channels? Who needs it?”

HLD AT DUBUQUE, IOWA

Both Simons and Kirk became full-time Jerrold employees in 1953. The laboratory was moved from the cramped stained-glass factory that Simons had rented in Bryn Athyn to larger quarters over a four-car garage in Southampton, this time rented by Jerrold.

About 1954, Jerrold applied for the franchise in Dubuque, Iowa, but was challenged by a local group of bankers and retailers who had no expertise in this field. After losing a referendum, the local group brought suit, resulting in a second referendum, which Jerrold also won, according to Shapp, by a $4\frac{1}{2}$ to 1 margin <Shapp 1986, 51-52>. Jerrold was severely criticized for conflict of

interest arising from contesting for franchises against potential customers.

The Dubuque system would have to carry four channels (some said five) from the receiving site to a distribution hub 12 miles away. Neither the cables nor the amplifiers were good enough. So Kirk came up with the idea of down-converting all channels to the band 1.0-7.0 MHz in order to take advantage of lower cable loss. According to Kirk, the visual carrier was at 2.25 MHz, with the aural carrier presumably 4.5 MHz higher at 6.75 MHz <Kirk 1992, 39, 40). Although several interviews confirm the frequency band, no mention was made of interference due to the second harmonic at 2.25 MHz above the visual carrier in the middle of the visual sidebands, nor the third harmonic of the visual carrier falling precisely at the aural carrier frequency. Maybe they were just lucky or maybe the crosstalk simply masked the harmonic interference. Earl Hickman used the band 7-13 MHz for *Discade*TM specifically because it was less than 1 octave (see [chapter 7](#)).

Kirk is credited with calling the scheme “not quite video” (NQV). He was also credited with determining that “... it is no more expensive to use one small cable for each channel than it is to use one large cable whose cross-

sectional area is equal to the sum of all the small cables, with frequency division multiplexing” <Kirk and Paolini 1970, 1034>. According to Kirk, the plan was to use four (or five) RG-59/U cables bundled together with one channel on each, instead of trying to use a single large K-14 cable. Low-loss, foamed dielectric, aluminum-sheathed cables were not yet available at affordable cost.

Since the carrier frequencies on each cable would be the same, within tolerance, crosstalk interference was a concern. In typical fashion, Simons set up a test bed at the laboratory at Southampton with 100 feet of bundled cables strung on poles. The crosstalk was intolerable. But Kirk came up with a solution called HLD, or “high loss dirt” <Kirk 1992, 41>. If the cables were buried in individual trenches a foot or so apart, it was assumed there would be enough separation underground to attenuate the crosstalk.

When it came to installing the cables on site, however, it was found that there was no HLD in Dubuque. All they had was rocks, and the contractors refused to dig the trenches. Although they had approval to plow the cables into a railroad embankment, the contractor ignored Jerrold’s instructions and lashed the four cables together on the aerial pole line. As was expected, the pictures were

fine, individually. But with all channels in operation, the crosstalk was horrendous. So Kirk designed a special matrix that he called a “de-hubbubber.” It was a type of “ghost canceller,” with 12 knobs for individually adjusting R, L, and C (resistive, inductive, and capacitive) components to cancel the coupling between each of the four cables. The matrix was based on the concept of the telephone hybrid for separating inbound and outbound voice signals. It worked beautifully—until rain changed the intrinsic coupling between cables and the whole thing fell apart <Simons 1992, 42-45>. Then Ecker and other field engineers were sent out from Jerrold to Dubuque to juggle those 12 knobs, trying to keep the crosstalk down.

THE JERROLD CABLE THEATRE®

According to Milt Shapp, “The only feasible method by which a successful paid TV service can be brought to the American public is by means of wired systems” <Jerrold Electronics 1957, 1>. He saw subscription television as the logical and inevitable future for CATV.

In 1955, Kirk undertook a comprehensive and detailed technical analysis of the code security, costs, and operational problems (e.g., installation and service, public

relations, collection, and billing) of each of the three proponents of scrambled broadcasting. International Telemeter had proposed a coin box in the home. Zenith and Skiatron proposed that the subscriber would mail back a list of programs watched, automatically recorded on a punchboard or printed circuit card in the subscriber's home <Jerrold Electronics 1955b, 32>. For the analysis, Kirk assumed that subscription television would be sold on a program-by-program basis but suggested as an alternative the monthly "season ticket" arrangement that continues to be the most widely accepted arrangement for premium pay-cable since the advent of satellite relay in the late 1970s. He concluded that, "... technical problems, as well as operational business problems render the scrambled broadcast system thoroughly impractical" <Jerrold Electronics 1955b, 3>. Shapp challenged the three proponents to join Jerrold in "public tests to prove or disprove the security of their codes" <Jerrold Electronics 1955b, 8>. There were no takers.

Shapp and Kirk opposed the very concept of scrambling to protect broadcast subscription programs. Ironically, they contended that, "... the wired system has none of the security weaknesses of the coded broadcasts. It utilizes no coding. Programs are available only to

subscribers ‘tapped on’ the system. Illegal taps are easily detected either visually or electronically. Methods typical of telephone service [can] separate paying customers from those who do not pay. The wired system is tested and basically foolproof’ <Jerrold Electronics 1955b, 7, 8>.

They were certainly right about the operational and public relations problems that did, in fact, doom broadcast subscription television in the early 1980s. But as we now know, adequate security for premium programs on wired systems depends necessarily on scrambling, or encryption. It turns out that, even on wired systems, scrambling codes and algorithms are far more vulnerable to the assaults of sophisticated piracy than Kirk and his associates acknowledged in 1955. All things considered, however, the operational superiority of wired systems over broadcasting for pay-TV now seems obvious.

The 1957-1958 Bartlesville home theater project, as described in [chapter 4](#), was arranged by Shapp and Henry Griffing, president of Video Independent Theatres. It was designed primarily to test the willingness of people to subscribe to a movie service. There was little need to test technical feasibility. The 38-mile coaxial cable plant constructed by Jerrold, separate from the existing CATV plant, was conventional in all respects, except that it was

owned by Southwestern Bell and leased to Griffing's Vumore. The service was provided on the season ticket basis. Thirteen first-run movies were offered on one channel and 13 reruns on the second channel for \$9.50 per month. Nonpaying homes would simply be disconnected at the tap. Henry Griffing did not want meters in the home, and a satisfactory central metering system for program-by-program billing (PBPB) was not yet available.

By early 1958, Kirk and John Nardontonio were working on a billing and collection system that Shapp and Zal Garfield were hoping to use with a prospective Jerrold Cable Theatre® demonstration in Dubuque, Iowa. In an internal monograph dated May 18, 1958, Kirk presented a comprehensive description of the system for PBPB <Kirk 1958>.

Kirk's PBPB system is reminiscent of the "store and forward" impulse pay-per-view (IPPV) arrangement developed much later for two-way cable. Kirk's system used two downstream channels, 8-14 MHz and 20-26 MHz, for premium programming (strictly analog at that time). A control box in the home enabled the subscriber to select one of the two channels to be converted to a VHF channel suitable for reception on the subscriber's TV set. Selection of a premium channel would operate a pair of

mechanical latching relays arranged to store billing information as to which channel, if any, had been selected.

Each subscriber's box was interrogated periodically from the head end on one of up to 2,048 separately encoded channels by an addressed signal transmitted downstream to all subscribers at 1-kHz intervals in the band 501-2,548 kHz. The response signal, carrying the billing information, was transmitted upstream at 262 kHz. After the response was received and recorded at the head end, another signal was sent to unlatch the relays in preparation for another program. All of the components for the PBPB system were constructed and tested in the Jerrold laboratory. The PBPB system was too late for Bartlesville, and Kirk left Jerrold in 1958 before it was ready for demonstration at Dubuque. Simons presented a paper on PBPB to the SMPTE convention in Miami in May 1959.

In 1959, Jerrold provided equipment for another, more expansive test of pay-TV on cable in a portion of the existing Paramount Pictures CATV system in Etobicoke, Ontario, a suburb of Toronto. The experiment ran for about two years and was terminated with indeterminate results. The time was not yet ripe.

DISTRIBUTED GAIN AND OTHER BROADBAND AMPLIFIERS

Kirk had considerable experience with distributed gain amplifiers while working at the Naval Research Laboratory on telemetering data from the A-bomb tests in Nevada and the Pacific. He built the first Jerrold Model 522, which was a direct copy of the SKL distributed gain amplifier. Simons redesigned the 522 and says this was one of the few times he was able to improve on Kirk's designs <Simons 1992, 46, 70>.

In 1957, Jeffers was responsible for the development of the LSA-795 sub-low band vacuum tube amplifier, designed to operate between about 7 and 95 MHz. It had two stages of distributed gain amplification and push-pull in the output stage to reduce second-order distortion. This is probably the first time push-pull circuitry was used in CATV amplifiers. The major customers for the LSA-795 were Southern Bell Telephone Company, the South Carolina statewide Educational Television Network, and the Bell Telephone System, which requested a full push-pull version of the LSA-795 for its own coaxial cable network. The Bell System had also installed many of the vacuum-tube SCA-213 single-ended distributed gain

amplifiers.

Jeffers tells an interesting story about another fully push-pull amplifier built for the Bell System called LSA-410, operating at 40 to 100 MHz. Bell engineers complained that the second-order distortion was not up to specification after 44 cascaded amplifiers. Upon investigation, it turned out that they had inserted a single-ended SKL amplifier at the tenth repeater station without thinking of the consequences. When the SKL amplifier was replaced with the Jerrold push-pull model LSA-410, the second-order distortion product was almost unmeasurable <Jeffers 1994, 31-33>.

Ragone and Jeffers built a broadband, stagger-tuned amplifier called Univamp from which they learned that too much gain can be an enemy. The Univamp had some 40 dB of gain and was abandoned, although not before it was listed in Jerrold catalogs. Then, they switched to an amplifier called the Uniband, or UBC, with 24 to 26 dB of gain. It was a three-stage amplifier. The input stage was devoted primarily to optimizing noise figure. Distortion was optimized in the output stage. Jeffers says that optimum noise and distortion performance for such a three-stage amplifier is achieved with overall gain of about 17 to 20 dB, plus 6 or 7 dB reserve for AGC. More gain

than this is just “kidding yourself.”

Jeffers also tells about encountering “hunting,” or oscillation by the automatic gain control (AGC) system in the UBC. Whenever there was a temporary loss of signal, the AGC would try to bring the signal back up. When the gain got too high, the system would collapse and start over. Initially they used short-time constants for quick AGC response but soon learned that the very slow rate of change of attenuation with temperature could be compensated with a much longer time constant to prevent hunting for a stable condition and the tendency for transients to ripple through the chain <Jeffers 1994, 26-29>.

DIRECTIONAL COUPLER TAPS

After moving into the Byberry Road laboratory at Hatboro in October 1955, Simons developed and patented <Simons 1962> the directional coupler tap to replace pressure taps, which he considered quite unsatisfactory. While trying to work out a directional coupler for cable, he pictured in his mind one of the lessons he had prepared for the Central Radio School in Kansas City back in 1947. His lesson plan included a drawing to show that the

direction of power flow from source to load could be determined just by looking at the polarity of the voltage and the direction of current flow. With this in mind, he conceived the principle of the directional coupler: samples of the current and voltage in the feeder add when they are in-phase and power flows; they subtract when out-of-phase and power is attenuated. Implementing Simons' directional coupler was considerably simplified when ferrite (magnetic iron compound) cores became readily available for the RF transformers.

Simons wanted to demonstrate, to his own satisfaction, that the inherent impedance mismatch represented by pressure taps could cause serious picture degradation due to reflections. He set up several hundred feet of cable with pressure taps uniformly spaced along the length of the cable. This would dramatically demonstrate that the discontinuities resulting from the pressure taps were, in fact, much worse than those resulting from directional couplers similarly spaced. However, Jerrold was severely criticized for using this as a sales feature at a national show, since the uniform spacing represented the absolute worst possible case. Entron was furious, since its FasTee pressure tap had turned out to be a substantial and rather dependable source of revenue

over several years. It is true that in practice taps are more likely to be randomly spaced, resulting in less cumulative reflection. Nevertheless, Simons' worst case test effectively dramatized the hazard of pressure taps, although probably exaggerating its impact. The comparison with directional couplers led to their widespread use and the demise of the pressure tap <Simons 1992, 56-57>.

THE TRANSISTORIZATION CHALLENGE

About 1962, the growing use of transistors in communications brought a tremendous and painful challenge to Jerrold's engineering staff. Everyone was quite comfortable with vacuum tubes and what could be done with them, as well as their limitations. But they were completely bewildered by the transistor. They did not know how it worked or what to do with it. So, they hired several transistor engineers who taught them about *beta*, *n* and *p* carriers, and other things they needed to know. But the transistor engineers knew nothing about RF engineering. When Jerrold's engineers had learned enough to proceed on their own, the transistor engineers were laid off.

Simons then tackled the conversion of the distributed gain vacuum-tube SCA-213 amplifier into a transistorized version. The breadboards produced by this effort were tremendously complex; the circuitry was a nightmare. It did work with reasonable output and gain, but the price and the circuitry were unacceptable. In the meantime, a senior Jerrold technician—not even an engineer— named George Duty built a two- or three-stage transistor amplifier using a stud transistor. It was designated “TML,” for transistor main line ([Figure 5.4](#)). A prototype TML was placed on the roof at the laboratory, where it ran for an entire year with absolutely no change in gain <Simons 1992, 85-87>. The TML was, in fact, Jerrold’s point of entry into the transistorized future.

It soon became clear to engineers that the large transistor currents required to meet severe linearity requirements would result in generation of considerable heat. The development of heat sinks and effective dissipation became critically important. Ironically, Henry Abajian of Westbury Electronics, generally credited with producing the first transistor amplifier for CATV about 1956-1957 <Milestones 1997>, felt he needed to provide small heaters in the chassis in the extreme cold in northern Vermont. These amplifiers were probably limited to one or

a few channels and not subject to the composite triple beat buildup in multichannel amplifiers. It was, in part, because of misapprehension regarding cold weather performance that SKL's nonengineering board of directors balked at transistorization.

By 1964, as vice president of Jerrold, Simons called on companies such as Philips in The Netherlands, Siemens, Motorola, RCA, TRW, and other major transistor manufacturers. He says, "I practically got down on my knees begging them to make a transistor with high f_t (high-frequency cutoff), lots of current, and stud mounting." He told them what a big market CATV was going to be, but they seemed unimpressed. However, RCA must have been listening, because they did produce the 3866, which had the high-frequency cutoff and gain characteristics Simons had specified and was rated at 5 W. Although not stud mounted, the 3866 transistor was developed by RCA apparently to overcome the limitations of the stud transistor used in the TML <Simons 1992, 87>.

Starline One ([Figure 5.5](#)) was the successor to the TML series. Built by Norman Everhart under Simons' direction, the Starline One used four stages of 3866 transistors in a double feedback configuration. It had

matched input and output. It was a well-designed amplifier and appeared to be performing beautifully in Canada and the northern United States. But down south, when it got hot, as one operator described it, “They died like flies.” In the course of failure analysis, Jerrold’s lawyers stumbled on an internal RCA memorandum in which RCA’s own engineering department recommended that the 3866 be derated to no more than 3.5 W, although the published safe operational rating on which Jerrold had relied was 5 W. In retrospect, Simons believes that even at 3.5 W the 3866 would still be overrated. Jerrold won the ensuing damage litigation. Evidently, a welded connection inside the 3866 packaging could not survive the temperature rise to which it was exposed. The designers of cable television equipment soon recognized effective heat dissipation as a critical factor in both electrical and mechanical designs <Simons 1992, 88>.

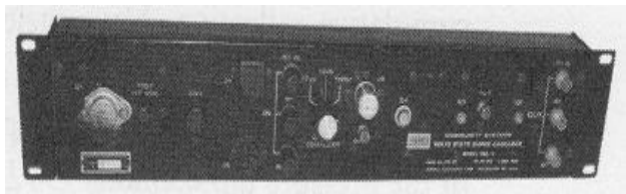


Fig. 5.4 Jerrold’s first transistorized amplifier—

Model TML

***Courtesy National Cable Television Center and
Museum***

Fig. 5.5 Jerrold's Starline One transistorized amplifier

Courtesy Jerrold Electronics Corp.

Starline One was also the first amplifier to use the die-cast housing developed by Eric Winston and George Burell, whom Shapp had hired away from Dalck Feith to specialize in the production of parts. The water-resistant, die-cast housing Burell and Winston worked out was a tremendous improvement. Until this development, amplifiers were built on conventional aluminum chassis, placed in large, pole-mounted sheet metal cabinets with hinged doors or covers.

The Bell Telephone Companies were intrigued not only by the new strand mounted die-cast enclosure for the Starline One amplifier but also by the modular design that featured plug-in pads, equalizers, and feeder-makers as well as the amplifier itself. This type of enclosure removed the equipment from the pole and eliminated the rat's nest of interconnecting cables required for the bulky vacuum-tube amplifiers. This was at the time when the Bell System was excited over the lease-back operations and was wiring "like crazy," especially in Michigan and the Midwest. Western Electric, the purchasing arm for the

entire Bell System, wanted to buy equipment on a monthly basis, but it was against their policy and practice to buy off-the-shelf equipment. They told Frank Ragone, “We don’t buy anything unless it has a set of specifications. We even buy toilet paper to KS specs, and when someone has 25 years with the company, we honor him with a diamond tie clasp, purchased to KS specs.”

So, Jerrold negotiated with Western Electric. Ragone said, “What they literally did was to take Jerrold specifications off the technical data sheets and rewrite them as KS specs.” In addition to electrical performance, however, the KS specs detailed the characteristics of the die-cast enclosure, including its vulnerability to water leaks with reduced internal air pressure. Moreover, they adopted procedures for statistical quality assurance testing, largely developed by Simons. On the basis of the KS specs, Jerrold did a good steady business with Western Electric. As Jerrold’s sales people said, “The check was always there at the end of the month.” Soon, the entire CATV industry was complying with KS specs, which were sometimes mistakenly assumed to refer only to the die-cast enclosures.

But where did the designation “KS” come from? According to what Ragone was told—and he doesn’t

vouch for its authenticity—quality assurance procedures for all Western Electric purchases were developed many years ago by a man named Kelly, and the Kelly specifications became known as “KS” <Ragone 1999, 48>.

The next step was the Starline Twenty. By this time, stud transistors were used with plenty of heat sink to ensure against a repetition of the Starline One disaster. It was designed to carry at least 20 channels at 6 MHz each, using single-ended amplifier stages limited to a single octave to avoid second-order intermodulation. Actually, the split-band amplifier was capable of carrying 21 channels plus the FM band. Five TV channels were carried in the low band at 54-88 MHz plus FM at 88-108 MHz. Sixteen TV channels were carried in the high and mid band at 120-216 MHz. The air navigation band of 108-118 MHz was avoided out of an abundance of caution. There is no explanation as to why the 21-channel amplifier was called Starline Twenty except that 20 is a nice round number. The discrepancy found its way into the 1972 FCC Cable Television Report and Order, which mandated “20-channel capacity,” and even into engineering circles. To confound the confusion, the single-ended, split-band amplifier was originally introduced in 1965 merely as Starline and was offered only for 12-channel operation in

the standard low and high VHF bands allocated by the FCC.

For demonstration purposes, however, Simons assembled a 20-channel, single-octave amplifier operating at 120-240 MHz to promote Starline 20 at the 1965 NCTA Convention in Denver. At 5 o'clock a.m. before the show, he finished building the rack of equipment to generate 20 live television pictures and a special set converter to display the pictures on a TV receiver <Simons 1992, 90>. This was a couple of years before the Mandell-Brownstein patent for the dual heterodyne set-top converter <Mandell and Brownstein 1967>.

Hybrid integrated-circuit (IC) gain blocks include lumped constant-circuit elements (e.g., resistors, capacitors, wires) embedded in a silicon substrate. A separate high-power transistor was packaged with the silicon chip in a sealed housing, with external electrical leads and heat conductors. Jeffers explained why Jerrold chose to use the so-called quad arrangement at one time in the development of its transistor amplifier line. The quad device was manufactured to Jerrold specifications by Power Hybrids, Inc. It was a quasi-integrated circuit in which four discrete solid-state devices were packaged together with all circuit elements except the transformers.

It was much less expensive and operated on negative 27 V dc. This was an important consideration, because the Starline products were designed for negative voltage and all of the ICs available at the time required positive voltage. There were other advantages with respect to lower temperatures and ready access to circuit components. But, replacing defective quad units in the field proved to be much more difficult than replacing true hybrids <Jeffers 1994, 39-40>.

The anticipated market for expanded capacity coincided with the development of solid-state transistor technology. Jerrold engineers recognized that the single-octave limitation imposed by harmonics and second-order products on the Starline amplifier represented an inefficient use of bandwidth. The classic solution to second-order nonlinear distortion is the push-pull circuit configuration. With vacuum tubes, which have gain that tends to decline over time, the push-pull configuration required special arrangements to maintain proper balance between the two sides under varying conditions of voltage, temperature, and aging. Because of the inherent stability of the transistors, however, balance remains remarkably stable without operational adjustments. After the learning experience provided by the TML, Starline

One, and the demonstration model single-octave Starline, all subsequent Jerrold amplifiers were push-pull with at least 20-channel capacity.

At least some of the Starline amplifiers utilized the Hewlett-Packard (HP) IC chip amplifier, in which the transistors and most of the associated circuitry were contained in a compact, stud-mounted circular package, a little more than 1 inch in diameter and not more than $\frac{1}{4}$ inch thick. Jerrold soon found out that HP had not adequately provided for heat dissipation. Moreover, it was hard to get used to the inaccessibility of the circuit components.

There is an intriguing story that, although apocryphal, demonstrates how poorly the leading technology companies understood that the linearity requirements for CATV equipment were often more exacting than for other commercial or military applications. In the course of his search for suitable transistors, Simons visited the HP Laboratories at Colorado Springs, Colorado. HP had prepared demonstrations and tutorials in an effort to convince Simons, as vice president of Jerrold Electronics, that the HP chip amplifier would be ideal for broadband CATV amplifiers. Simons was both

knowledgeable and skeptical. After a couple of days of presentations, Simons told the HP engineers that Jerrold's Starline amplifier would outperform anything the HP chip amplifier could show and gave them one for test and evaluation. Legend has it that HP sheepishly reported back that Simons was indeed correct. Although Anaconda Electronics did, in fact, incorporate the HP chip into its line of CATV amplifiers, it was soon superseded by the TRW and Motorola hybrid gain blocks. The hybrid gain blocks that are now in common use incorporate such external components as ferrite inductors along with the chip in a single compact package.

HEAD END DEVELOPMENT

Frank Ragone was primarily responsible for the head end developments in the late 1950s. Channel conversions were often required, as in Philadelphia, to put all channels in the low VHF band or to avoid adjacent channels. Certain conversions were also "taboo," because of unavoidable beats in the desired channel caused by harmonics of the local oscillator, or other spurious intermodulation products. The forbidden conversions could only be achieved by dual conversion at additional

cost. In any case, the conversions had to be custom made to fit each individual situation.

By the late 1950s, operators began looking to microwave to receive additional signals from stations too distant to pick up directly. Ragone recalls an early experience with CATV microwave relay that proved to be a bit embarrassing. George Milner was engineering vice president for Cablecom General, a multisystem operator in the Southwest. He was planning microwave relay to receive additional services at several of Cablecom's CATV systems. At that time, microwave systems were designed for baseband video and audio input to the transmitter and output at the receiver. The only available equipment at the time was designed for use at broadcasting studios. Milner wanted Jerrold to provide CATV-type equipment, meaning high quality at lower cost. Ragone says, "George was a very aggressive, outspoken operator. When he wanted something, he wanted it!" So, Ragone got the job of developing Jerrold's type TM modulator and TD demodulator products. He described the products and their technical features at the 1958 NCTA Convention in Washington, D.C. In an aside, Ragone recalls that the moderator of that panel happened to be the author of this book.

Baseband equipment was a real challenge for CATV technicians, most of whom had become fairly proficient in dealing with the RF distribution plant. But virtually no one understood the basics of the television signal. When shown the modulators and demodulators, they would say, “What’s this?” And they were told, “Oh, this will process your microwave signals and put them on the VHF spectrum. You put the cable in here, and tweak this knob and tweak that knob, and you’re on your way.” It was a good product, but it was tough to put it in operation.

Ragone tells the story about “...one of my boo-boos in life.” If you wanted to capture a fringe signal, you had to be very careful about adjacent channels. So, he says, “I designed adjacent channels in this product that were, like, 60 dB down. Great! But the very nature of the rapid attenuation required for trapping caused a deterioration in picture quality we now recognize as delay distortion.”

In 1958, Milner took one of the first products to Clarksdale, Mississippi, installed it, and got it working. “The phones went off the hook back in Philadelphia,” said Ragone, “and I was on an airplane.” Milner was furious. He said, “Look at this picture, off-the-air.” Ragone said, “It was all snowy, with ignition noise interference, airplane flutter, co-channel interference—you name it.”

“Now,” Milner said, “look at the picture *after* we go through your demod-remod (demodulation and remodulation).” “Much better,” said Ragone. “Ignition interference was suppressed quite a bit. There was no semblance of airplane flutter. But the buttons on the policeman’s uniform (in the picture) were shifted an inch!” Milner asked, “What is that? You dummy, you have distorted the picture. You have caused a delay in the picture elements!”

Ragone can laugh about it now. It looked good at the lab. The sweep response was excellent. But he took the products back to Philadelphia and redesigned them with some compensation for delay and eased some of the sharp deep traps. Baseband 10-kHz and 20-kHz cochannel traps for the demodulator were also designed in the lab, with sweep generator. They would get rid of cochannel all right, but the picture was worse with the traps than with the interference! Ragone acknowledges that he got a fast education in delay distortion from these two experiences <Ragone 1999, 32-33>.

By 1960, however, they had developed the very successful vacuum-tube dual heterodyne (double-conversion) signal processor called the Channel Commander. The Channel Commander used a

conventional 12-channel mechanical turret tuner, such as was generally used in home TV sets. A local oscillator converts the signal received on an antenna to the standard intermediate frequency (IF), with aural carrier at 41.25 MHz and visual carrier at 45.75 MHz. A second fixed tuned local oscillator converts the IF to the desired output channel frequency. Filtering to reject the local oscillator, adjacent channel carriers, and other spurious products is provided at IF. The sound signal in conventional TV sets is processed as a subcarrier on the main visual carrier (described as intercarrier sound). However, in the Channel Commander processor the gains at visual and aural carrier frequencies are controlled separately and automatically in order to overcome the frequency-dependent fading encountered over long propagation paths. Moreover, this arrangement permits adjusting the aural carrier independently to minimize the risk of interference with the next higher visual carrier.

The vacuum-tube Channel Commander, or Commander I as it came to be called, was quite successful, although it was not without problems. Many of the difficulties would be overcome in the later transistor models, Channel Commanders II and above. The concept of the dual heterodyne signal processor for head ends

was adopted for products manufactured by Ameco, Scientific Atlanta, Blonder-Tongue, and several Canadian and European suppliers.

Jeffers tells of difficulty encountered in the first transistorized version, the Channel Commander II, because the delayed AGC was designed to start reducing the overall gain too soon. The turret tuner used in the vacuum tube version had its own AGC, designed for television receivers. They had not taken the time to understand how to make the transistor model perform as well as the old vacuum-tube tuner. He acknowledges that none of the Jerrold engineers were experienced in television receiver design and that Jerrold lost considerable market share to Scientific Atlanta by inexperience and failure to concentrate effort on the head end <Jeffers 1994, 48>.

MEASUREMENTS AND INSTRUMENTATION

Simons' special expertise was in the field of measurement and instrumentation. He was responsible for the famous, but now obsolete, 704-B field-strength meter (FSM), more properly called the signal-level meter (SLM), which he developed at the glass factory between 1951 and

1953 ([Figure 5.6](#)). He actually built an FSM in 1940 when he worked for RCA after graduating from engineering school. Simons explains, “It was—don’t laugh—truck portable” <Simons 1992, 23>. CATV operators had previously been using homemade adaptations of television receivers, such as the RCA 630-TS, with a microammeter in the AGC bus. Clearly, CATV needed a more practical, properly designed, tunable instrument for measuring signal power levels in coaxial cable.

Even in 1951, Simons believed that, “It was almost inevitable that midband would show up.” Simons was so impressed with the Mallory Inductuner he had evaluated for Sylvania, that he built the 704-B around it <Simons 1992, 25>. Not only was it very good electrically but it was also continuously tunable, without band switches, over its very wide range. Simons built what might be called a “breadboard” model, using sheet copper bent with pliers because he did not have a brake. It was powered with a vibrator power supply and a 6-V automobile storage battery slung underneath with a webbing strap. Simons says, “You could hardly lift the whole affair, but it worked” <Simons 1992, 28>. Hickman’s observations in 1953 (see [chapter 7](#)) indicate that the “breadboard” model of the 704 was sent to Hoffman Television Laboratories in

Los Angeles to be refined into what became the classic 704-B FSM. Simons believes the B model represents a change in the intermediate frequency, perhaps from 21 MHz in the A version to 44 MHz in the B version.

Fig. 5.6 Jerrold's Model 704-B signal level meter
*Courtesy National Cable Television Center and
Museum*

Until the mid-1970s, the 704-B was the standard selective RF voltmeter accepted by all cable TV operators and equipment manufacturers. It was even used by television broadcast engineers participating in the 1956-1959 Television Allocations Study Organization (TASO). The 704-B was truly the workhorse of the industry for more than 25 years.

Long before CATV, useful television signal power level was considered to be 1 mV measured at the end of the 75-ohm coaxial down lead from the antenna, equal to 13.3 nW (billionths of a watt). It was more convenient, therefore, to specify signal power levels in terms of the decibel ratio reference to 1 mV across any 75-ohm terminal.

It may have been Shapp who decided that Jerrold would use the term dBj as the decibel expression for relative signal level. For obvious reasons, that term was not popular with other manufacturers, who preferred the generic designation dBmV (decibels relative to 1 mV across 75 ohms). The problem with this term was that it

was sometimes misunderstood to be a voltage ratio rather than power. To avoid both confusion and the appearance of competitive promotion, it seemed preferable to use modifying letters without commercial connotation or perhaps even without specific technical significance. One logical idea was dBn for decibels re 13.3 nW. However, that would be too easily confused orally with dBm, which has long been firmly established with reference to 1 mW. In 1974, the Canadian Cable Television Association (CCTA) informally proposed to the Canadian Metric Commission that the unit dBmV be renamed the Sim in commemoration of the outstanding pioneer work carried out by Ken Simons <Hancock 1974>. It never happened.

Then, about 1975, Simons came to an NCTA engineering committee meeting with the suggestion that we use dBc instead of dBmV; the “c” was meant to signify cable. By pure coincidence, three Canadian CATV equipment manufacturers, Delta Electronics, Benco Television Associates, and Cascade Electronics had just merged and were advertising the joint operation as Delta-Benco-Cascade, using the acronym DBC. It was back to the drawing board, and the dBmV terminology has become firmly established and generally understood to represent power level referenced to 1 mV across 75 ohms.

Since Delta-Benco-Cascade no longer exists, the dBc terminology was resurrected to express the ratio of the power of intermodulation (IM) products or other undesired signals relative to the visual carrier. As such, dBc is always a negative number, since the undesired products must necessarily be much less than the carrier. On the other hand, random noise, which must also be much less than the carrier, is universally expressed as a positive decibel ratio of carrier-to-noise power. It can get confusing, but the terminology may now be too deeply embedded in practice to be changed. *[Author's Note: The recently published book by Ciciora, Farmer, and Large (1999) page 448 defines intermodulation in terms of positive ratios of carrier-to-distortion.]*

The development of cable television brought with it an almost complete vacuum of instrumentation. Oscilloscopes with which to view waveform had to be developed. Kirk had high praise for the oscilloscope that Simons and his cousin developed but did not have the financial means to take to market. Equipment such as RF voltmeters, power meters, and frequency-measuring equipment available before the war was primitive and unsuitable. It is remarkable that the CATV pioneers, as well as the early television inventors, were able to achieve

so much with so little equipment for accurately measuring the phenomena with which they were experimenting on a daily basis.

When he first started to work for Shapp in 1951, Simons tried building a completely satisfactory wideband sweep generator. He knew the value of an instrument that could produce a continuous and instantaneous graphic display of signal power level versus frequency from his experience at RCA. His efforts to build such a sweep generator continued for five or six years. Jerrold had obtained a Kay Laboratories Mega-Sweep, based on the beat frequency between two military surplus klystron oscillators. It was very wideband but too inconvenient for use on the factory production line. So Simons redesigned it, using two ball-bearing butterfly capacitors left over from the war. It was driven by a 60-Hz synchronous motor, with a commutator switch on the shaft to change the frequency range. With this instrument, workers on the assembly line could see the high-band and low-band responses superimposed on each other. This was used for quite a while and established the need for an even better broadband sweep.

Simons got into what he called “some very exotic designs” before the Jerrold model 900 sweep generator

evolved. Kirk and Winston provided substantial assistance and counsel. Simons started with a military surplus “wobulator,” a mechanical device, usually vibrator-driven, arranged to “wobble” the resonant frequency rapidly back and forth. The surplus Wobulator used 6J6 vacuum tubes in various circuit arrangements. But the model 900 did not come together until Winston got into the picture. Simons describes it this way:

We eventually came up with a sliding short circuit in a tube about an inch in diameter with a pencil triode as the oscillator. We were able to go out to 900 MHz and to beat-frequency [up to] 300 or 400 MHz. This was done using a Quam loudspeaker motor to drive a variable capacitor. At that time, of course, there were no adequate varactors [a voltage controlled oscillator], so this was the only choice we had, the only choice I knew of. I can remember time after time after time having Mr. Shapp come up behind me while I'm working and saying: "When in hell are you going to be finished, Simons?" And I would say: "When it works, we'll sell it." And that's the way it was <Simons 1992, 55>.

Simons devised a way of keying in a reference signal

to produce a line on a scope. He said, “As far as I know, that was a unique approach to the problem.” He explained, “I keyed a reference signal into the detector at 10 kHz, at the same time shutting off the sweep. The 10-kHz signal was measurable on an ordinary voltmeter to provide a voltage reference for the sweep trace” <Simons 1992, 39>. The Navy was one of the best customers for the model 900, especially after Simons and Winston devised a scheme they patented and called the gearshift. It produced a very stable narrow bandwidth sweep making it possible to zoom in on a critical portion of the sweep.

The need to compare sweep traces resulted in the model FD-30 comparator. This was simply a vibrating mercury-wetted switch used to transfer an oscilloscope or other detector between a component under test and a reference standard. It was characteristic of the Jerrold engineers to avoid ostentatious high-tech terminology in favor of language more appropriate to working crews and technicians than to engineers. Thus, the FD-30 was known colloquially as the “flicker-dicker,” reminiscent of the vocabulary often coined by ham radio operators.

Simons said that most of what he knows about cascaded repeater characteristics he learned from the publications and experience of the Bell Telephone

Laboratories and Western Electric. He was enormously impressed with the Western Electric method of operation, and he considered their way of specification to be “impeccable.”

As shown in Bell Labs reports, the useful dynamic range for CATV amplifiers is limited on the low signal level side by the lowest acceptable signal (or carrier)-to-noise ratio. On the high-level side, dynamic range is limited by overload distortion. Overloading results in cross-modulation, in which a ghost picture from another channel is superimposed onto the desired picture or in intermodulation beat interference. Simons developed the method for quantitatively measuring visible cross modulation that, for a time, was adopted as standard NCTA procedure for specifying overload performance. The Simons/NCTA procedure was based on synchronously modulating all carriers, except the carrier under test, with a square wave. A wave analyzer detected the percent residual modulation on the otherwise unmodulated carrier.

However, for reasons not understood at the time, Simons and others discovered anomalous cross-modulation behavior in an occasional individual amplifier. For example, cross modulation measured in a particular

amplifier might decrease 3 dB for every 1-dB reduction in output signal level, instead of 2 dB as predicted by theory in a normally “well-behaved” amplifier. In another peculiar case, cross modulation actually got worse as the output level was decreased <Simons 1970, 1079>.

Although the anomalous conditions were relatively rare, Simons developed another more reliable technique, in which many channels are carried. For cable TV, visual (picture) carriers are assigned frequencies at nominally equal 6-MHz intervals. Based on studies conducted several years earlier by the Bell Telephone Laboratories, Simons analyzed the transmission characteristic for equally spaced multiple-cable TV carriers. He demonstrated, mathematically as well as experimentally, that most of the very large number of possible combinations of any three visual carriers tend to occur in large groups, called triple beats, clustered closely around the visual carriers. The ratio of the combined power of the cluster to the carrier power is defined as the composite triple-beat (CTB) ratio. This method is more repeatable and reliable than the cross-modulation method, especially when all carriers are unmodulated. It has become the universal standard for specifying overload distortion in electronic amplifiers and the characteristic distortion in

optical fiber systems. Simons has provided a comprehensive analysis of the mathematical foundation for this and other measures of nonlinear intermodulation <Simons 1970>. A similar analysis was presented in Simons' 1968 technical handbook, the Red Book. An example of a triple beat is presented in [appendix C](#).

Simons developed the bridge method of measuring return-loss, or the reflection coefficient in coaxial transmission lines. He apparently applied for a patent on the return loss bridge. However, Andrew Alford, a prominent manufacturer of laboratory equipment for microwave facilities who had been building similar bridges for several years previously, held a prior patent <Alford 1956>. Although Simons believed that his patent was more general than Alford's, he did not pursue it further.

Simons also showed that by tuning the cable termination of the return loss bridge for minimum reflection, the accumulated reflections from minor periodic structural deformation of coaxial cables could be isolated from reflections due to mismatched impedance. The resulting measurement defines Structural Return Loss (SRL) as the specific characteristic of a particular piece of cable, often considered a figure of merit.

Whether the return loss bridge should be terminated in the nominal 75-ohm resistive load for qualifying coaxial cable or tuned for minimum reflection was the subject of heated debate between Walter Roberts of Superior Continental Corporation, predecessor to Comm/Scope, and Herbert Lubhars of General Cable. Roberts maintained that since the cable, in practice, was to be terminated in nominal 75 ohms, it should be qualified against true 75 ohms <Roberts and Wilkenloh 1970>. Lubhars explained that unless the cable is terminated in its actual conjugate impedance (i.e., tuned for minimum reflection), the bridge measurement necessarily depends critically on the electrical length of cable between source and load. Thus, the inherent characteristic of the cable would be obscured because of standing waves <Lubhars and Olszewski 1968>. The Structural Return Loss, with the bridge tuned for minimum loss, has now been widely accepted for specifying the inherent characteristics of coaxial cable. Tragically, Walt Roberts was killed several years ago in the crash of a small plane.

JERROLD'S LEADERSHIP

Shapp's vision of community-wide distribution of

television by wire was inspired by the development of Tarlton's system at Lansford. Jerrold Electronics became the first major manufacturer to market equipment nationwide specifically for use in CATV networks. With its team of competent and pragmatic engineers, combined with Shapp's promotional skills and the ability to provide financial and engineering support for customers, Jerrold's leadership position has been widely and continuously recognized. While it is difficult to document "first" with respect to important technical innovations, it is not unreasonable to note that Jerrold has often been at the forefront in most of the important developments in cable television, including:

- Almost from the beginning, Jerrold identified critical conditions for cascaded amplification, drawing on the studies and experience reported by the Bell Telephone Laboratories, the MIT Radiation Laboratory Series, the Proceedings of the IEEE, and other professional publications.
- Jerrold led the rationalization of the head end with the introduction of the dual heterodyne signal processor. (Earl Hickman had used the method several years earlier but not as an Ameco product.)

- Jerrold introduced the directional coupler multi-tap.
- Jerrold led the production of operational transistorized main-line amplifiers, although others had been experimenting.
- Jerrold's 704-B field-strength meter was everyone's standard for many years.
- Most of the original work on standard measurement methods and objectives was undertaken at Jerrold.
- Jerrold led the development of specialized instrumentation for cable TV.

Perhaps the most spectacular Jerrold contribution was the dramatic introduction in 1990 of DigiCipher technology into the HDTV proceedings at the FCC, many years after the engineering achievements described in this chapter. This single blockbuster contribution marked the beginning of the new digital television era.

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NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center

and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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CHAPTER 6

Entron, Inc.

HENRY M. “HANK” DIAMBRA¹

THE ORIGIN AND EARLY HISTORY OF ENTRON ARE LARGELY THE STORY OF HANK DIAMBRA ([Figure 6.1](#)). Unlike Milton Shapp, who delegated most responsibilities to competent employees, except for strategic planning and oversight, Diambra often found it necessary, especially in the early days, to assume the functions, if not the titles, of president, CEO, comptroller, sales manager, chief engineer, grunt, and (at times) janitor.

Diambra is a first-generation American, born in 1924. Both parents, Gualdiro (Walter) and Mary, were born in the ancient walled city of Sene Gallia, Italy, on the Adriatic Sea. As a kid growing up in Mount Vernon, New York, in Westchester County just outside The Bronx in the mid-1930s, Diambra became interested in radio and electronics, experimenting and learning through amateur radio and reading whatever he could get his hands on. He was an excellent student, with an unusually retentive mind.



Fig. 6.1 Henry M. Diambra

*Courtesy National Cable Television Center and
Museum*

As an honor student at A.B. Davis High School in

Mount Vernon, he was privileged to take a number of college courses for full credit in the sciences while he was still in high school. He wrote a senior paper in 1940 titled "The Peacetime Uses of Nuclear Energy." He had just been reading about nuclear fission and the work being done in Germany. Harold Urey was at Columbia University and Enrico Fermi had just emigrated from Italy to America. The English department was so startled by the paper that they handed it over to the physics department. Diambra was more interested in the practical applications than in the physics of nuclear fission, a pragmatic emphasis that characterized his CATV endeavors.

In 1941, after finishing high school, he enrolled in the RCA Institute technical training program in Lower Manhattan, New York City. In order to support himself, he took a job in Bridgeport, Connecticut, which meant commuting from Mount Vernon to Bridgeport and then to downtown Manhattan for classes.

When World War II started, he found himself working in the factory at Bridgeport, 13 hours a night, 7 nights a week. The Institute would have to wait. However, he entered the Air Force (actually at that time, the Army Air Corps) as a cadet and was able to continue his education, acquiring the equivalent of two years of

college training. He flew missions as navigator in the South Pacific and was in the Philippines when Hiroshima was bombed. Upon returning from military duty, with the rank of first lieutenant, he reentered the RCA Institute. However, in 1946, before he could complete the course, he married and moved to the Washington, D.C., area. The training he had begun before the war at the RCA Institute was finally completed at Capital Radio in Washington, D.C.

Master Antenna Television for Leese Electric Company

Shortly after his marriage, Diambra became service manager for an electrical appliance company, implausibly owned by the long-established and well-known M.A. Leese Optical Company in the District of Columbia. Even more noteworthy is the fact that, on October 12, 1925, Martin A. Leese launched the first commercial radio broadcasting station licensed by the FCC in Washington, D.C. The original call letters, WMAL, are still in use today, although under different ownership.

Leese's children, Loraine Leese Good and Martin Leese, Jr., established the Leese Electric Company. One of Leese Electric's biggest customers was Trageron, the

enormous Washington estate of Ambassador (to the Soviet Union) Joseph P. Davies. As a Leese employee, Diambra was called upon for an incredible array of customized electronic work for the ambassador. He installed a custom shortwave antenna facility at the dacha the ambassador had brought back from the USSR and an elaborate system to distribute radio and music throughout the main residence, with remote controls built into the furniture to operate professional record changers. About 1949, Davies told Diambra that he liked baseball and wanted to have television in Trageron. This simple request started the investigations that marked Diambra's entry into the world of CATV.

Leese Electric was trying to sell television receivers. By 1949, there were four television stations in operation in the District of Columbia. Leese Electric could not even demonstrate television sets in their own showroom on Woodley Road, because it was so deep in the shadows of an apartment building canyon. The building did not have a master antenna system and there was no way to get the television signals off the roof. As service representative, Diambra had to respond to the complaints of customers who were "teed off" about the lousy pictures they received. Rabbit ears were no answer. They were not only

unreliable but it was hard to explain to customers why they had to be reoriented from channel to channel and why they worked well in one apartment and badly in another. Diambra said, “Nobody could quite understand that, because AM radio didn’t work that way!”

During his service calls, Diambra had discovered the Kennedy-Warren, a large apartment building on Connecticut Avenue overlooking Rock Creek Park, one block south of Woodley Road. When it was built in about 1930, it was equipped with a large, elaborate receiving antenna for AM radio and a master distribution system with wires in conduit to each apartment unit. Since radios were now equipped with built-in ferrite loop antennas, the master antenna system was no longer needed. However, Diambra saw that the radio distribution wires could serve as pull-wires for TV coaxial cables. This would be a logical place to experiment with television distribution on coaxial cable <Diambra 1993, 9>.

Jerrold and George Edlen

Diambra spent many frustrating weeks trying to find a way to distribute signals from a remote rooftop antenna to multiple TV sets in the Kennedy-Warren apartments,

the Leese Electric showroom on Woodley Road, or the rooms at Trageron. Then, by sheer chance, he heard about an outfit in Philadelphia that was building equipment to do just what he was trying to do. This was the Jerrold Electronics Corp. Diambra called to inquire about it, but got little satisfaction. Then, about three weeks later, George Edlen ([Figure 6.2](#)) walked into Leese Electric looking for the person who had called Jerrold to inquire about what they were doing. Diambra asked, “What are you talking about?” Edlen responded, “Oh, we were surprised that you knew so much about what we were doing without ever having used any of this stuff.”



Fig. 6.2 George G. Edlen (deceased)

Courtesy Henry M. Diambra

Edlen, a graduate physicist and employee at MIT's Radiation Laboratory during the war, was sales

representative for Jerrold. He handled a variety of products, including sheet metal for Frank Macintosh's famous high-quality audio power amplifiers, along with Jerrold's antenna boosters. He knew Dalck Feith very well and may have represented his sheet metal business.

Diambra and Edlen talked until midnight. Edlen described Jerrold's distribution amplifier that is bridged across the feeder line to provide enough signal for taps to the individual TV sets on display. Edlen warned that the Jerrold bridgers did not have any preamplification. But Diambra said, "Who needs preamps when I can spit at the rivets at every tower in town? My problem is: what do I do with 2.5 volts across a dipole on the roof?"

Diambra's challenge in large Washington apartments was exactly the opposite of the problems Jerrold was dealing with in Lansford. Signals picked up on rooftop antennas on Washington apartment buildings were so strong that attenuators and filters were required to avoid overload and interference. The preamplifiers needed in Lansford to receive weak signals from Philadelphia were not only unnecessary in Washington but actually created problems. Diambra complained frequently that "Nothing that Shapp sent down would even remotely work" <Diambra 1993, 16>.

Diambra's solution for the Woodner apartments, for example, with 1,310 units on 16th Street at Piney Branch Parkway, was a totally passive network with appropriate filters and attenuators to bring the levels of all stations down to reasonable equality. High-powered television transmitters less than 2 miles away were quite capable of producing a couple of volts at the terminals of the receiving antenna. Even today, it is difficult to keep such strong signals out of the sensitive tuners in the TV receivers.

When he learned about Diambra's installation in the Woodner apartments, Shapp was absolutely furious. The only Jerrold components were the taps, and they were invisible to the public. Diambra was summoned to the "woodshed" in Philadelphia to explain. Don Kirk was called in to evaluate Diambra's claim that although the Jerrold amplification equipment had worked well everywhere else, it was totally unsuitable under the high ambient signal levels present at the site of the Woodner apartments. Kirk took one look and said, "What do you need a system for?" And Diambra said, "Yes, I could do it with a wet rope! And Milt wants to know why I don't stick preamps in." Diambra pointed out that the coaxial cables between the wall outlet and the TV set were

effectively unterminated not only at the TV set but at the capacitive taps as well and acted like an antenna picking up the strong signals. The F-connector had not been developed yet, and the Workshop Associates connectors, which were the only thing available, were of poor quality. Diambra protested that he had done the best he could under the circumstances. Kirk agreed that he would not have done anything differently, and Shapp paid the invoice <Diambra 1993, 18>.

George Edlen put into service for Jerrold a composite master antenna system for the Campbell Music Company in Washington, D.C., in 1950. Like the Malarkey Music Company in Pottsville, Campbell Music sold television sets along with pianos and sheet music. Because of Diambra's obvious familiarity with TV reception in Washington, Edlen suggested that Diambra put in a few hours helping with the installation. Together, they made the Campbell Music system play. Shapp had the equipment chrome-plated to highlight the successful completion of what Jerrold claimed to be the first master antenna system in the mid-Atlantic region <Diambra 1993, 10>. However, RCA Antennaplex had already been installed in major New York hotels, such as the Waldorf Astoria, where Malarkey saw it in 1949.

Edlen, a physicist and not an electronics man, realized that selling sheet metal and antenna boosters was not practicing physics. After completing the Campbell Music installation, he decided to be more independent of Jerrold without completely severing the association. Edlen was so impressed with Diambra's skill, experience, and contacts that he suggested they join forces full-time to sell, install, service, and develop master antennas in the Washington, D.C., area, using Jerrold equipment wherever possible.

The Bellmore Company

Meanwhile, Diambra had been working with Bernard Bellmore, an electrical contractor in Washington, to install TV cables in apartment projects. Diambra had instructed Bellmore's electricians regarding the special care necessary to avoid kinks or short circuits that could seriously damage the vulnerable RG-59/U coaxial cable <Diambra 1989, 49>.

On September 1, 1951, Diambra, Edlen, and Bellmore formed a new company, the Bellmore Company, completely separate from Bellmore's electrical contracting business. Bellmore would provide experienced and

properly trained union labor for pulling cables, as well as some of the financing, leaving Diambra and Edlen to carry on the business of selling and installing Jerrold equipment.

Bellmore had a friend named Segal who, after a series of bankruptcies, had become wealthy in the liquor business. Among other real estate investments, Segal had acquired the old 1920s Carlin Apartments on P Street, adjacent to the bridge over Rock Creek in Washington. Incidentally, Diambra notes that the garage in the lower level of the Carlin Apartments was the scene of the “Deep Throat” contacts with Dustin Hoffman in the movie *All The President's Men* <Diambra 1989, 67>. Also, at the lower level next to the garage, stood a row of small shops, all vacant and run-down. An arrangement was negotiated for Diambra and Edlen to operate Bellmore Company out of two of these shops, virtually rent-free, in the business of installing master antenna systems in large and small apartment buildings <Diambra 1993, 11>.

During 1950-1953, coaxial cable was largely unavailable for nonmilitary purposes because of the Korean War. Shapp requested help from Washington attorney Henry Kanee to obtain waivers of the restrictions with respect to coaxial cable. Kanee,

Bellmore's long-time personal friend and bridge partner, was introduced to Diambra to find out what might be behind Shapp's request. Kannee had been personal secretary to Franklin Roosevelt for more than 30 years, long before Roosevelt became president. Kannee presented the argument that CATV served the public interest by facilitating the dissemination of information about the war to the public. Perhaps because of his long Democratic associations, he was successful, and the Reconstruction Finance Corporation (RFC) allowed Jerrold to purchase coaxial cable. According to Diambra, Kannee's success in gaining the release of coaxial cable for CATV marked the "birth of the national cable television business" <Diambra 1993, 12-13>.

Cable Suckout at Quantico

In 1952, the Bellmore Company bid successfully on a contract to install a television distribution network through the officer's quarters and barracks at the Quantico Marine School, about 40 miles south of Washington, D.C. With this project, the Bellmore Company began to apply its vertical distribution experience to the horizontal configuration. They also

learned about the need for amplification in a situation where the TV signals were not “so hot they melted the rivets.” And, it was here that they learned about a frustrating defect in coaxial cable that could only be detected in runs of thousands of feet instead of the few tens of feet needed to feed a transmitting antenna on the roof or a receiving antenna on a short mast.

They ran cable from attic to attic, in building after building, tying them all together. Jerrold’s equipment was designed to use surplus RG-59/U flexible coaxial cable. Diambra soon realized that they would need either lower loss cable or more than 1/10-V output (+40 dBmV) available from Jerrold’s amplifiers. But the C-52 connectors Jerrold provided would not fit the lower loss RG-11/U size cable, and Diambra thought he should be able to buy amplifiers with the higher output power and wider bandwidth needed. Jerrold promised to deliver a new line as soon as it was released—maybe in three months. But Bellmore had contract obligations to be met much faster than that. So, once again, Bellmore was installing a system that had been bid for Jerrold, but the only Jerrold equipment that could be used was the taps, and even they did not fit the RG-11/U cable. Diambra was literally building most of the equipment for the Quantico Marine

installation.

Diambra has an amusing anecdote about an installer named Bob Duggan working for him at Quantico, who later turned up in Hollywood films made for television. According to Hank, “Bob was the only guy who ever fell through a ceiling installing RG-11/U—right into a Colonel’s bedroom—right in the middle of the bed. Surprised the Colonel’s wife no end!”

When they put signals into the Quantico network, everything came out fine at the end of the line, except channel 7. There was no channel 7. Back at the antenna site, an excellent channel 7 picture came off the antenna into the RG-11/U trunk cable manufactured by Amphenol. Edlen carefully explained that this could not happen. But it did.

So Diambra, never bashful about using the telephone, called Amphenol in Chicago, the cable manufacturer, and was referred to Dr. Rudolph Soria, director of engineering. Soria was nonplussed, to say the least. Surely Diambra must be joking. What he was being told just cannot happen. After being assured in no uncertain terms that this was no joke, Soria asked that the cable be sent back to the factory in Chicago for

examination to determine what Bellmore was doing wrong. Diambra was not about to pull down the cable already installed but, instead, said he would personally fly to Chicago and bring with him a reel of cable. He told Soria, “I want to meet with you, and I want to see you make channel 7 come out of this cable.”

Soria and his staff could not make channel 7 come through that cable. Diambra was right. He soon became good friends with Soria and Charlie Camillo, the design engineer who later became president of Amphenol. The cable was acting like a very high Q (i.e., very narrow) notch filter, creating a huge hole in the transmission curve right at the channel 7 visual carrier frequency, with about 64-dB excess attenuation.

Investigation revealed that a capstan involved in the dielectric extrusion process had an eccentric, galloping-type motion that put a tiny iterative bump at precise intervals along the cable. These iterative bumps were precisely spaced at just under 12 inches, which happened to be exactly a quarter wavelength at channel 7. Although the effect of such a minor discontinuity would be negligible in short lengths, the cumulative effect gets worse as the length increases. Soria indicated that by changing gear ratios in the extrusion machinery, they

could change the spacing of the bumps and shift the frequency of the “suck-out.” Where would Diambra like to have the “hole”? Diambra responded that a hole in the FM band, 88-108 MHz, would be acceptable. Amphenol modified their processing and discovered other eccentricities in the complex braiding machinery as well. They replaced the cable for Quantico at no charge with the “hole” in the FM band.

However, they would not compensate Bellmore for the lost time and labor expense for removing and replacing the defective cable. As a result, Bellmore not only lost its profit margin but took a \$4,000 actual loss on the project. At a time when they were desperately looking for a little cash to get ahead, this loss was devastating. Edlen had to go without pay while Hank had to take over Edlen’s responsibilities for the technical maintenance of apartment systems <Diambra 1993, 20-24>.

Tarlton reports a similar experience at Williamsport, Pennsylvania. He was hired by Shapp to make sure the system was properly installed and operated in accordance with Jerrold’s responsibility under the service agreement. They had planned a grand opening at a downtown hotel in Williamsport, where, as Tarlton says, “We would simply throw a switch, and—lo and behold—there we

have television!” However, for two or three weeks before the grand opening, there were problems. They had pictures but no sound on channel 4. The Jerrold engineers who were called in from Philadelphia determined that the problem was in the coaxial cable manufactured by Plastoid in New Jersey. Like Soria and the engineers at Amphenol, the Plastoid engineers traced the problem to an eccentricity in the extruding machinery that put repeated bumps in the cable. The bumps could not be seen or felt, but the cumulative effect in a long line functioned as a very sharp trap, precisely at the frequency of the channel 4 sound carrier <Tarlton 1993, 35>.

The “FasTee”

At Quantico, they had to use the Jerrold 1401 Multel tap with C-52 fittings for RG-59/U cable. Adapting to the larger, lower loss RG-11/U with a short jumper cable and PL-259 connectors was awkward. Neither the 30-ohm C-52 nor the 50-ohm PL-259 matched the 75-ohm impedance of the coaxial cables. It was a bad arrangement, but nothing better was available. Moreover, Edlen had seen early on that in order to survive they would need to develop something they could sell in quantity to support the

expensive research and development they were doing. So, Diambra and Edlen spent a year and a half developing what they believed to be the first truly practical tap that was weather-proof, “idiot-proof,” self-piercing, nondrilling, and easily installed on RG-11/U cables in the field under adverse weather conditions.

The device, known in the industry as a pressure tap, was patented in 1954 ([Figure 6.3](#)), with Edlen and Diambra named as co-inventors <Edlen and Diambra 1954>. They gave it the proprietary name FasTee and sold them “by the bushel.” Diambra claims it kept them alive for 11 years. But it also gave Jerrold a severe jolt. “You see,” says Diambra, “one of the other things the FasTee did, which people don’t realize, was to change drastically the character of the distribution plant.” The FasTee meant that tapped RG-59/U distribution lines and 1401 Multel taps were now obsolete. The Jerrold service agreement would require replacement at no cost to the purchaser, a situation Diambra was not reluctant to exploit. Moreover, as Diambra gleefully reports, FasTee sales were killing Shapp.

Nov. 9, 1954

G. G. EDLEN ET AL

2,694,182

IMPEDANCE-MATCHING TAP-OFF COUPLER FOR WAVE TRANSMISSION LINES

Filed Feb. 20, 1953

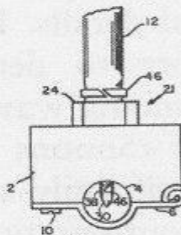


Fig. 1.

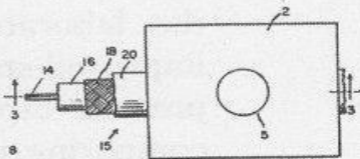


Fig. 2.

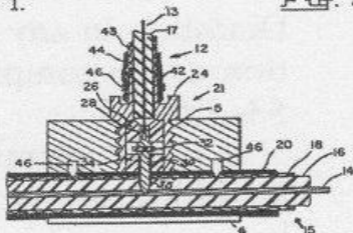


Fig. 3.

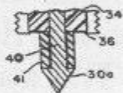


Fig. 4.

GEORGE G. EDLEN
HENRY M. DIAMBRA
INVENTORS

Fig. 6.3 Entron's Fas Tee patent drawing

Source: U.S. Patent Office

Meanwhile, Jerrold had its own pressure tap, based on the idea that Jerrold's first design engineer, Don Kirk, and George Edlen had developed about 1950. At that time, Edlen and Diambra were still on congenial terms with Shapp. Edlen was selling Jerrold equipment for master antenna systems, and Diambra was installing and maintaining them for a fee. Edlen frequently visited at Kirk's home in Clinton, Maryland, while Kirk was still working at the Naval Research Laboratory in the District of Columbia and moonlighting as a Jerrold consultant. Together, Kirk claims, they conceived the idea of a tap that could be attached to RG-11/U coaxial feeder cable without cutting and splicing.

Kirk believes that he and Edlen built the first pressure tap in his basement, although he took no steps to patent the device, nor to document Edlen's part in its development, at a time when Edlen was drawing commissions from Jerrold as a salesman. But by 1953, events were moving rapidly. Edlen's association with Diambra had become formalized and their relations with Shapp had already turned sour. Kirk complained bitterly

that it was improper for George Edlen to apply independently for the patent on behalf of Entron <Kirk 1992, 50-54>.

Word was received that Jerrold had prepared an exhibit for an NCTA convention in southern California purporting to demonstrate grossly inferior performance of a large number of FasTee taps that were installed in a length of cable wound up on a large reel, concealed from view. The exhibit was seen as showing that FasTees produced enormous standing waves, while the comparison line, which was thought to comprise Jerrold's version of the pressure tap, appeared to be relatively clean. It was a "blind" demonstration, with everything taped up so it could not be inspected.

Diambra was hot with fury, charging that the demo was "rigged" with FasTees spaced uniformly to produce the worst case cumulative effect, probably unterminated, using selected tap values that show the lowest return loss. They suspected that this was an invidious and grossly unfair demonstration deliberately comparing the worst case FasTee arrangement against Jerrold pressure taps of high value and best return loss, randomly spaced, and properly terminated.

Of course, they could not know for sure and Jerrold was not about to provide technical details. However, Simons describes a similar setup he devised at the laboratory to demonstrate, for his own satisfaction, the significantly improved standing wave performance provided by directional coupler taps over pressure taps <Simons 1992, 57>. It is not at all clear that this test facility for comparing uniformly spaced directional coupler taps and pressure taps in the worst case configuration was, in fact, the demonstration that had so angered Diambra. In any case, the demonstration was perceived as a gross misrepresentation of the comparative merit of the two types of pressure taps <Diambra 1993, 53-57>.

While Diambra was trying to devise a strategy to counter the devastating Jerrold demonstration, Kannee remarked, “You know, this is more than a marketing ploy. This is a legal problem.” “What do you mean?” “This could be technical fraud.” After consulting with patent attorneys Max Libman and William Hall, they decided that Jerrold’s version could constitute infringement of their patent rights. The attorneys and expert witnesses advised, correctly as it turned out, that the outcome might turn on the semantic definition of the word *insulation*. At Hall’s recommendation, a petition claiming that Jerrold

infringed on Entron's FasTee patent was filed in the Third Circuit in Baltimore before a judge who had shown a strong tendency favoring plaintiffs. Ironically, on the very day they filed, a new judge who had doctoral degrees in English and English Literature from Oxford was assigned to sit on the case.

In the Entron FasTee, an insulated stinger is forced through the cable jacket, shield, and dielectric to make contact with the center conductor without being short-circuited to the shield. For Jerrold's design, a special tool was used to cut a hole through the jacket, shield, and dielectric. The hole was large enough for a bare, uninsulated stinger to be inserted to make contact with the center conductor without shorting against the shield braid. Diambra claimed that the empty hole drilled in the cable for Jerrold's stinger served exactly the same purpose as the insulating sleeve on the FasTee stinger. However, Entron's experts were unable to convince the court on this point. Thus, the claim against Jerrold for infringement of the FasTee patent was denied because of the semantic interpretation of the word *insulation*.

Of course, Shapp was elated. Later, however, when Jerrold signed a consent decree to settle anti-trust charges, misuse of the FasTee patent was one of the

factors involved, and Diambra eventually won an amicable settlement <Diambra 1989, 150-164>. Although some pressure taps remain in service in a few of the older systems, they are no longer considered acceptable because of their inherent impedance mismatch and vulnerability to leakage and moisture contamination.

BEYOND THE FASTEE

At about this time in late 1953, Edlen received a call from Robert J. McGeehan in Pottsville, Pennsylvania, who had a potential customer and wondered if Bellmore could supply the equipment. After meeting with McGeehan, Edlen was very excited. “There is potentially a big bunch of money to be made that’s coming up with these cable systems, if we can design equipment for it.” McGeehan was a salesman, primarily selling stoves for the Seagler Corporation, and he was associated with Francis Heimbach, whose specialty seemed to be in slot machines and coin-operated dispensers. They wanted to sell equipment and figured there were a lot of towns in Pennsylvania that could use something like Malarkey’s system in Pottsville. It appeared that Shapp was selling direct in Pennsylvania.

Diambra protested, “George, we are not a design house. We are not a manufacturing company. We do installation and design for systems.” They did not have the expertise or the funding to design and build total systems. They had no knowledge or experience with constructing outside plant. Nevertheless, not wanting to let an opportunity slip by, Diambra and Edlen went to Front Royal, Virginia, where Jerrold was in the process of installing a community-wide TV distribution network. They wanted to see what Jerrold was up to and to learn what they could about designing and building a TV system throughout an entire community.

After seeing what was happening in Front Royal, Diambra said, “I had to reorganize my entire thinking about the business. We were talking about huge amounts of signal in the Washington area... whereas Front Royal was out in the hills. Looking for signals is a different story.” He said to Edlen, “OK, let’s try an experiment, without too thoroughly affecting Bellmore and its operations. Let me design a piece of equipment that could serve McGeehan’s purpose.”

Drawing on Edlen’s background at the MIT Radiation Laboratory, they decided to investigate distributed gain technology. Several CATV equipment

manufacturers recognized the advantages of the distributed gain vacuum-tube amplifier. However, Fitzroy Kennedy of the Spencer Kennedy Laboratories (SKL) was the only one who took the trouble to take out a license for the prior art patented in London by W.S. Percival, in 1937 <Percival 1935-1937>. Together, Diambra and Edlen searched the literature for information about distributed gain technology. They dissected an amplifier acquired from SKL that was designed to cover the entire spectrum from 50 to 220 MHz. Believing that there was no need to distribute anything above channel 6 (88 MHz), they decided that the excess bandwidth of the SKL amplifier was wasteful and unnecessarily costly.

It is ironic that, in 1953, Diambra was criticizing SKL for “wasted bandwidth” and Shapp’s service agreement was betting that no more than three channels would ever be needed. Yet, even earlier in 1951, Jerrold’s Ken Simons had already foreseen that demand for more than three or five channels would one day require more spectrum than was then available for television broadcasting. He anticipated using the so-called mid-band spectrum between channels 6 and 7 that the FCC had astutely omitted from the broadcast TV allocation plan because of harmonics and second-order intermodulation <Simons

1992, 25>.

Nevertheless, Diambra proceeded to design a low-band distributed gain amplifier that could be built with fewer vacuum tubes and at less cost and lower maintenance expense than the SKL 50-220 MHz amplifier. He designed the critical inductors for the delay lines to be wound by hand on a form. It was Edlen's task to produce the 10 copies of Diambra's prototype model for McGeehan to deliver to his customer. Edlen, as a production-oriented person, said, "The only way you are going to make money, Hank, is not building by hand. We've got to make these things on line." So, Edlen took the coils Diambra had designed to a coil winder who asked what turned out to be a nearly fatal question, "Do you want these coils dipped, or not?"

The production amplifiers were beautifully hand-soldered, not by production line workers but by three technicians. But when they were put to the test, none worked "worth a damn." With only five days to McGeehan's promised delivery deadline, which was around Christmas 1953, Edlen said, "Maybe you need some help, Hank." Diambra had friends on Connecticut Avenue at the National Bureau of Standards—Milt Sanders, Jack Rabinow, and Max Libman. One night,

Sanders was looking at the amplifiers and said, “Well, Hank, did you consider the Q of these circuits with all this junk on them?” (Low values of Q indicate excessive signal power loss.) Suddenly, Diambra went to his locker and said, “George, here are the samples I gave you. The coils you had made are nice. But I am going to have one of these amplifiers built up with my hand-wound coils.”

The next day it was tested. “It worked, like a ton of bricks,” Hank said, “almost exactly the way it was planned.” Sanders had spotted the problem. The coating on the coils had so reduced the Q of the circuit that it could not do the job. Diambra said to Edlen, “We were so close to the problem we never figured a little cosmetic coating could wipe out the performance. Take out all that garbage, and we will be in business.” So, working over Christmas 1953, Bellmore rebuilt the 10 amplifiers that McGeehan had sold, even before he knew whether or not they would work <Diambra 1993, 33-34>.

South Williamsport and Styroflex Cable

McGeehan’s customer was a group called Lycoming Television in South Williamsport, Pennsylvania. They were desperately trying to catch up to the way Shapp was

roaring ahead with a distribution system in Williamsport across the river. Lycoming's engineer and organizer was Leonard Ecker, a graduate of Georgia Institute of Technology who later became a Jerrold employee <Ecker 1994>. One of the Lycoming shareholders turned out to be the same Francis Heimbach who had been working with McGeehan.

Lycoming Television had bought some equipment from John Walsonavich at Mahanoy City, but it did not do the job. Jerrold refused to sell equipment to Lycoming because they were in competition with Shapp's group across the river in Williamsport. As Diambra understood it, the financial backing provided by investment bankers J.H. "Jock" Whitney and Fox-Wells for Jerrold's Williamsport project was based on three important concepts embodied in the Jerrold service agreement:

1. No one needs more than three channels since there are only three networks.
2. The service agreement is the only way to ensure that systems will be properly built and maintained.
3. Jerrold would not sell to competition, even for apartment houses.

Another group was working with Bob Genzlinger, a Philco consultant, to build CATV in Williamsport. Under these circumstances, Lycoming and Ecker decided to buy the 10 amplifiers from McGeehan, the ones that Diambra reluctantly agreed to build as an “experiment.”

They all received the Philadelphia stations on the mountaintop called Eagle’s Mirror. Ecker had warned Diambra that the “...mountain was a tough mountain hike.” Amplifiers would be extremely difficult to maintain. There was a road across the top of the mountain, up one side and down the other. The round trip from Ecker’s office to the antenna site was about 18 miles. Ecker tells the story of Frank Ragone, who at that time was working for Genzlinger. Ragone got his Jeep stuck on the mountain and had to abandon it. Ecker thinks it may still be there. One day Ecker went up the mountain in his Jeep; “There was this big brown bear, fuming and snorting at me, and I’m honking my horn and doing everything I could think of to make the bear get out of the way. Nothing doing. He wouldn’t budge. So I say ‘the heck with it,’ then turned around, drove down and came back up the other side of the mountain” <Ecker 1994, 13>.

There were other hazards on the mountain. Ecker tells about when his kids were small. It was football season

and the kids were pestering him. So, he decided to go up the mountain and watch the football game on the TV set at the antenna site. When he was working, he normally wore knee-length boots, “because,” he says, “rattlesnakes really can’t get up very high, and neither can water moccasins.” While watching the game in the little plywood shack, his conscience began to bother him. His wife was stuck down in town with the kids, and they were probably bothering her. So he decided to hustle back down. “It was a beautiful day in the fall of the year, with the sun shining nicely. I took the first step down (we had built the shack up on about three concrete blocks), and got stung by the rattler. I knew the worst thing I could do was to get terribly excited and start flying around; the faster your blood circulates, the more it spreads the poison. ... I went back in the shack, called 911, laid down on a cot and stayed as still as I could. The ambulance picked me up and took me to the hospital. By that time, my ankle was huge. I was in the hospital for three days with anti-venom shots. I got over it” <Ecker 1994, 15>.

They had good pictures at the antenna site on Eagle’s Mirror. With RG-11/U cable, at least four amplifiers would have to be mounted on poles on the side of the mountain. And they still had another 3.5 to 4 miles

down the road before they could begin to connect subscribers. Clearly, they were going to need cable with much lower loss so the amplifiers could be spaced much farther apart. Moreover, the costly experience with the channel 7 “suckout” at Quantico, caused by Amphenol’s “galloping capstan,” left much skepticism about the likely performance of long runs of RG-11/U cable. And Diambra was not even aware of the similar channel 4 sound problem Jerrold was having with Plastoid cable across the river.

A friend of Diambra’s in the broadcasting business had used a low-loss air dielectric cable, called Styroflex, and wondered whether that might be useful for the South Williamsport run. Styroflex was manufactured in Germany primarily for connecting high-power radio transmitters to tower-mounted antennas, in 2¹/₈-and 3¹/₂-inch sizes, in 300-foot lengths. Upon investigation, Diambra learned that the Felten and Guillaume company was the sole source for Styroflex.

The outer conductor of Styroflex is seamless aluminum tubing. The center conductor is copper wire or tubing of proper diameter. The dielectric is mostly air, with the inner conductor centered and held in place by means

of a polystyrene tape spirally wrapped around the center conductor. The manufacturing process, unique to Felten and Guillaume at the time, required drawing the aluminum tubing through a die of proper size over the inner conductor with its polystyrene tapes in place. A similar technique is used currently in the manufacture of aluminum cable with foam polyethylene dielectric.

In the United States, Phelps Dodge Communications, in Rome, New York, was the sole representative for Felten and Guillaume products. When Jack Lemly, Phelps Dodge sales representative, learned that Diambra would need many miles of a product normally sold by the foot, he promptly went to South Williamsport to find out what this was all about. Compared with the normal cable orders for high-power transmitting antenna down leads, the potential market for CATV was truly staggering. A deal was negotiated, and Lemly made arrangements with the factory in Germany to produce $3/4$ -inch 75-ohm Styroflex in 1,000-foot lengths on 6-foot reels.

The decibel signal loss in $3/4$ -inch Styroflex is about one-fifth that of solid polyethylene RG-11/U, but it had never before been used for CATV and would be very expensive. Diambra then went to the Lycoming board of

directors (after Ecker demurred) to make the case for replacing the cable presently in place with Styroflex. The board was satisfied that the plan was both sound and necessary. Diambra then became a sales representative for the product distributed by Phelps Dodge.

In addition to the crucial problem of funding the expensive Styroflex, other problems had to be solved. The $3/4$ -inch Styroflex was stiff—you could hardly bend it by hand. Only crews that were used to hanging heavy primary power transmission cables could handle it. The solid sheath cable would require expansion loops and special tools to form them. Connectors were expensive, and the crews had to be trained in proper installation techniques. They ignored warnings by telephone people regarding the risk of moisture damage, because of the prohibitive cost of pressurizing the air dielectric cable.

Pictures at the antenna site were good. With the Styroflex in place, amplifiers were needed only at the antenna site and at the garage they were using as a base of operations at the bottom of the mountain. The pressure on Ecker and Diambra was enormous. A working demonstration had been promised for Monday. At 6 a.m. Sunday morning, after working day and night all through

the weekend, the two sat down, frustrated and exhausted, outside the garage where they were to make their demonstration. Diambra said, “We were still trying to figure out why good pictures went into this end of my equipment, but the stuff coming out downtown was nothing but black screens with great big circular white polka dots running loose all over the pictures on every channel.” Utterly baffled, they tried three or four different TV sets without effect. Sitting on the curb in complete silence, Ecker said to Diambra, “What did you say?” Diambra said, “I didn’t say a damn thing—Why?” “I heard voices.” And Diambra said, “Len, if there are any more days like this, we’ll both hear voices.” “No, listen, listen.” And right from the top of the pole, Diambra was listening to voices. The sounds were clearly coming from the equipment, like something trying to resonate. Then it stopped, and just as he turned to come down the pole, it started again. They both cried out, “It’s a voice! It’s the police department!”

Together, they began to suspect that the entire spectrum below channel 2 was being transmitted in the amplifiers. To check, Diambra rushed back to Washington and brought back one of the first Kay Mega-Sweep instruments, which he describes (with a bit of

exaggeration) as “about the size of a Sherman tank,” and swept the system. Sure enough, at frequencies below channel 2, there was a cacophony of police, amateur and commercial radio transmissions, and electrical machine noise that saturated the amplifiers, causing the “polka dot” effect.

They missed the Monday demonstration, because Hank took all the amplifiers back to Washington, where he designed, installed, and swept high-pass filters so the amplifiers would not pass any signals below channel 2. He also made another change so that, by trimming two inductors, the amplifier gain could be equalized to compensate for cable attenuation. It was later called the “EquaLine” and patented <Diambra and Edlen 1958>. The revised amplifiers were installed, and the overall system response was swept, segment by segment, with the Kay Mega-Sweep. Shapp had often argued, with unwarranted authority, “You don’t sweep systems! You have a field strength meter to measure signal levels!” So Diambra really demonstrated the value of system sweeping in South Williamsport.

Success! Channels 2, 4, and 6 were delivered beautifully to downtown South Williamsport. They were, according to biased observers, twice as good as Shapp’s

across the river. The Styroflex cable meant much shorter amplifier cascades, substantially reduced noise and distortion, and no need for amplifiers on the mountainside that would have been enormously difficult to install and maintain. There were some wild thoughts about trying to chase Shapp out of Williamsport by taking Diambra's amplifiers across the river. But Diambra protested, "I don't have any more. These are not in production. These are handmade... I have to gear up a company first. We are not in the manufacturing business. These were supposed to be a demo. We'd like to be paid!" <Diambra 1993, 34-49>.

The Five-Channel Experiment

Since Diambra's amplifiers were already broadband and the results with channels 2, 4, and 6 were so rewarding, Ecker urged Diambra to build a pair of selective preamplifiers at the head end for channels 3 and 5. He wanted to upstage Shapp, since Jerrold was providing only channels 2, 4, and 6 across the river in Williamsport. Of course, the preamplifiers had to be properly adjusted to avoid spillover into the adjacent channels. When the installation was completed, with only a single amplifier to bring the signals down the mountain and three more to

bring the signal to the center of town, the pictures on all five channels (2, 3, 4, 5, and 6) were magnificent.

At any rate, Diambra said, “The five-channel experiment caused chaos across the river.” Shapp first denied that it happened, then tried unsuccessfully to “build equipment to drop in to the existing strip systems.” According to Diambra, “It must have caused heartburn with J.H. Whitney.” The service agreement had promised that “...should there ever be more than three channels, we will give them to you free.” So, the Williamsport people said “OK, start producing!” Jerrold could not do it with drop-in modules. A new generation of amplifiers was needed. According to the *NCTA News Bulletin*, Jerrold displayed its new five-channel equipment on October 15, 1953, at Mahanoy City, using “individual channel amplifiers,” commonly called strip amplifiers. The *News Bulletin* reported that John Walson laid claim to a “first” by distributing five channels on his system at Mahanoy City in 1953, presumably with the Jerrold five-channel equipment <Phillips 1972, 9-10>. Diambra credits Hank Abajian with building the first five-adjacent-channel distribution systems <Diambra 1993, 43>. Simons thinks that it was Vic Nicholson who “discovered that you could put channels in between the other channels without

getting into trouble” <Simons 1992, 26>.

According to Diambra, Shapp complained furiously about his use of Styroflex in South Williamsport. Shapp said, “Hank, what the hell are you doing selling cable? You should be selling equipment. It’s going to kill both you and me.” Diambra responded, “No, Milt, I’m selling systems; I don’t know what you’re selling.” He had demonstrated that pictures delivered on five channels at South Williamsport, using low-loss cable and broadband distributed amplifiers, were clearly superior to pictures delivered on three channels across the river, using RG-11/U cable and much longer cascades of narrowband, single-channel strip amplifiers.

Entron Established

The success at South Williamsport convinced the Bellmore group, now including Bob McGeehan, that they understood what was needed for cable television. They believed that they knew how to design equipment to serve needs that had not even been identified by others. They now had a wide-ranging knowledge of equipment available but not yet considered for cable TV, and they were experienced in designing, building, selling, and

installing distribution systems, both vertical (in high-rise buildings) and horizontal. They had contracts to provide new master antenna systems and to maintain systems already installed. They were no longer affiliated with Jerrold. They had moved from the shops on P Street to one of the Carlisle apartments on Columbia Road where they maintained the Carlisle's master antenna system.

It was time to look for help. An ad was placed for a full-time employee who could do electronic design engineering. In 1954, Heinz Egon Blum walked in the door. He had arrived in Portland, Oregon, only five days earlier from Germany, via Greece and Australia. During the War, Heinz had the unenviable experience of having been in Buchenwald. He and his wife had friends in Washington and had seen the ad in the newspaper. Blum worked for Diambra and Entron for 26 years, eventually becoming director of engineering <Diambra 1993, 49-50>.

By this time, the Carlisle landlord was beginning to object to the idea of a manufacturing operation in an apartment. So, Bellmore rented a warehouse that had been part of a real estate and junkyard ("salvage engineering") operation in Bladensburg, Maryland, a Washington suburb. Then, early in 1954, the Bellmore Company was incorporated as Entron, Inc., a name Edlen coined from

ENgineering elecTRONics. Diambra, Edlen, McGeehan, and Blum were the active principals of Entron. The others were Bernard Bellmore, who provided skilled union installation labor, and his long-time friend, Henry Kannee, who served as secretary/treasurer and in-house counsel <Diambra 1989, 57>.

Frostburg, Maryland, and Palm Desert, California

At a trade show in 1953 or 1954, McGeehan ran into Holland Rannells, owner of the Potomac Valley TV system in Cumberland, Maryland, managed by his son-in-law Buford Seville. The Cumberland system was a hodgepodge of Jerrold, RCA, and others and had lots of problems. After Entron reengineered some sections and installed Entron's EquaLine distributed amplifiers and FasTee taps, Rannells said he wanted to build a system in Frostburg, about 12 miles west of Cumberland. Since pictures could not be received anywhere in or near Frostburg, the problem presented to Diambra was how to transmit signals from the Cumberland head end by coaxial cable. The total cable run to Frostburg from the head end on a mountaintop about 15 miles (by road) east of Cumberland could be as much as 27 miles. Even with $7/8$ -

inch Styroflex, at least 25 amplifiers would have to be cascaded with passband limited to the five VHF channels. It was a tall order.

Variation in cable loss with temperature is about 0.1 percent per degree Fahrenheit. In 27 miles of cable, the change in cable loss between 5°F and 95°F at channel 6 would amount to about 45 dB. Thus, total amplification at channel 6 would have to be varied by an amount approximately equal to the entire gain of two amplifiers. To deal with this, a special amplifier was needed to automatically adjust both its gain and slope in such a way as to maintain channels 2 and 6 at reasonably constant output levels.

Forrest E. (Ed) Huggin was assigned the task. Huggin had a doctorate, probably in physics, and had been responsible for devising the equipment used in the atomic bomb tests to record the triggering pulse before the explosion could vaporize everything, including the South Pacific island of Eniwetok. Huggin applied for a patent in 1955 on his ingenious solution for the automatic control of gain and slope in CATV amplifiers <Huggin 1960>. Entron called the device EquaTrol.

Although functionally equivalent to a modern, two-

pilot automatic slope and gain control (ASGC), EquaTrol used vacuum tubes, polarized mechanical relays, and Barber-Coleman servomotors to adjust the inductors. Entron later found an electronic device whose inductance could be varied according to a dc bias current that could have greatly simplified the EquaTrol. Approximately two dozen prototype units, plus spares, were built and installed in the run from Cumberland to Frostburg. They served their purpose quite adequately for many years. No others were ever manufactured.

The EquaTrols built for Cumberland were much too expensive. Moreover, they were big and heavy and the utility poles to which they were attached tended to vibrate severely due to the wind and heavy trucks rumbling along the highway. The vacuum tubes and mechanical relays obviously were vulnerable to vibration. This was before the days of die-cast, sealed housings, and the EquaTrol amplifiers were not immune to weather <Diambra 1993, 73>. Seville donated one of these units to the Cable TV Center and Museum, but it could not be found for a photo. ([Figure 6.4](#) is a schematic drawing of the EquaTrol.)

Several years later, Diambra encountered another system at Palm Desert, California, that had been installed with low-loss K-14 coaxial cable, probably manufactured

by Graybar for the Bell System. The outer braided conductor of K-14 is $1\frac{1}{4}$ inches or so in diameter, covered with a protective plastic jacket. The dielectric is solid polyethylene, and the cable is almost as stiff as an iron pipe. The normal experience is that coaxial cable loss increases with rising atmospheric temperature, resulting in weaker signals and noisier pictures. On the other hand, as temperature drops, the expected decrease in cable loss as outside temperature drops tends to drive the signals into overload distortion. Curiously, the Palm Desert installation behaved in exactly the opposite manner.

Perplexed for some time, Diambra was finally able to attribute this apparently anomalous behavior to thermal inertia. Although the outer jacket that is exposed to direct sunlight becomes quite hot, the temperature of the dielectric rises very slowly and cools off slowly when the sun goes down. When the air cools at night, the dielectric retains some of its warmth from exposure to the sun during the day and cools slowly. But at midday, the dielectric has still not warmed up. Thus, temperature of the dielectric and its attenuation seem to be out of phase with the outside temperature <Diambra 1993, 67>.

Service and Accessories

It was clear that few, if any, of Entron's potential customers would know how to make a whole system play. Merely manufacturing distribution equipment would not be enough. Even a good distribution amplifier could be copied. Entron would have to provide services, including assistance in franchise acquisition; system design; technical counsel during construction; assistance in obtaining financial support; and training in operations, marketing, and administration. These were similar to some of the services promised in Jerrold's service agreement.

Diambra had seen Jerrold's service agreement backfire in Williamsport, with its promise to provide more than three channels at no charge if they ever became available. Moreover, he had embarrassed and infuriated Shapp in Williamsport by using expensive, low-loss air dielectric trunk cable with RG-11/U tapped feeder cable, which Jerrold's connectors and taps did not fit. Entron was determined to "bust the service agreements wide open," not by litigation, but by providing more appropriate equipment with comparable services included as part of the deal.

George Edlen developed the "buster." Diambra says,

“George put in about 80 percent of the effort—I put in 20 percent—to develop the first honest-to-God tap that was both weatherproof, idiot-proof, field-proof and no parts.” It was called the FasTee, and Diambra says, “It kept us alive for 11 years” <Diambra 1993, 51>.

March 15, 1960

F. E. HUGGIN ET AL

2,929,062

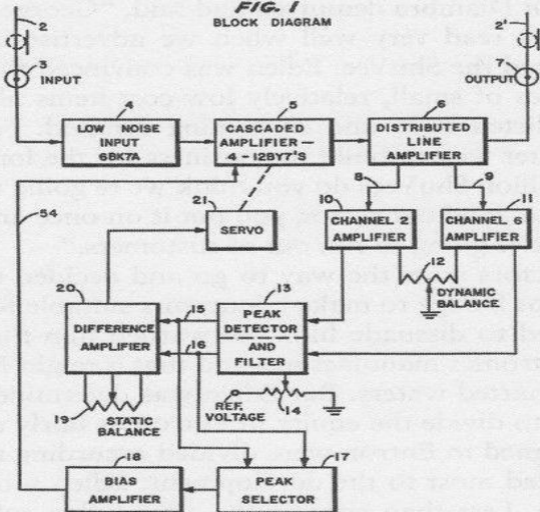
AUTOMATIC FREQUENCY-COMPENSATED GAIN CONTROL FOR

MULTI-CHANNEL TELEVISION DISTRIBUTION LINES

Filed Aug. 29, 1955

5 Sheets-Sheet 1

FIG. 1
BLOCK DIAGRAM



INVENTOR

FORREST E. HUGGIN

HENRY M. DIAMBRA

WARREN E. DIDRA

BY

Max L. Libman

ATTORNEY

**Fig. 6.4 Entron's EquaTrol patent drawing, as used
in Cumberland, Maryland**

Source: U.S. Patent Office

Feb. 19, 1957

H. M. DIAMBRA ET AL

2,782,379

DIRECTIONAL LINE SPLITTING COUPLER

Filed Dec. 24, 1953

2 Sheets-Sheet 1

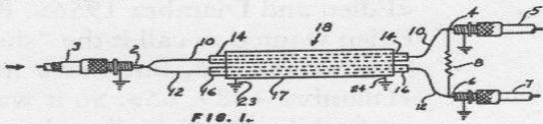


FIG. 1.

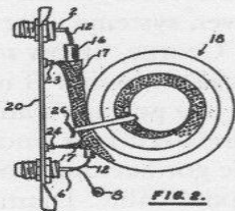


FIG. 2.

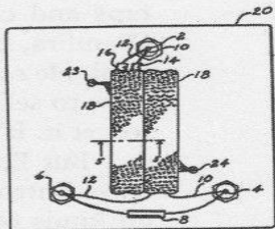


FIG. 3.

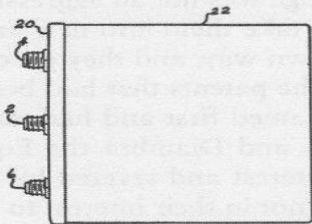


FIG. 4.



FIG. 5.

INVENTORS

Henry M. Diambra & George G. Edlen

BY *Man L. Libman*

ATTORNEY

Fig. 6.5 Entron's AccuraSplit, similar to SKL's Model 427

Source: U.S. Patent Office

In 1953, Diambra and Edlen applied for a patent on a directional line splitter ([Figure 6.5](#)). It used two lengths of coaxial cable connected in parallel at one end with a resistance shunt across the center conductors at the other end <Diambra and Edlen 1957>. They called it AccuraSplit and used it to good advantage in the apartment buildings where the ambient signals were so strong. Signals fed in to the common port would be transmitted with about 3-dB attenuation to each end of the shunt but with high attenuation from end to end of the shunt. Actually, this was inspired by an early version of the SKL Model 427 splitter that consisted of a length of coaxial cable with two center conductors that had to be soldered in place. Apparently, Harvey Firestone of Motorola held a patent on the idea. "Except," as Diambra said, "they just sold you three and a half feet of cable. Impossible! Where the hell are you going to hang open cable?" So Diambra put it in a blister can, much like the SKL Chromatap, but sealed and waterproof, with F-connectors. It was awarded what he called "a rare design patent." He also proposed using it as a two-way diplexer to permit multiplexing bidirectional

signals on the same coaxial network <Diambra 1989, 42, 51>.

Edlen's "ShuVee" Tragedy

Edlen also developed and patented a solderless connector for RG-11/U cable <Edlen and Diambra 1956>. Because of the way in which it was to be assembled, Edlen wanted to call it the "shove-it." But Diambra demurred and said, "George, I hate to tell you, but that's not going to read very well when we advertise it" <Diambra 1989, 65>. So it was designated the ShuVee. Edlen was convinced that profitability lay in selling large quantities of small, relatively low-cost items like taps and connectors for which he predicted large and continuing demand. For Diambra, however, systems were the better way to build the business for the long haul. He said to George, "How many million ShuVees do you think we're going to have to sell to make a living? If it's such a good connector, you put it on once and forget it. It's not like postage stamps. You're going to run out of customers."

But Edlen believed taps and connectors were the way to go and decided to leave Entron. He got backing from Phelps Dodge to make connectors suitable for all kinds of

coaxial cable. Diambra tried to dissuade him. He warned him that Phelps Dodge was not an aggressive electronics manufacturer and that it might be difficult to take them into new and uncharted waters. But Edlen was determined to go his own way, and they proceeded to divide the equity in Entron as fairly as possible. The patents that had been assigned to Entron were divided according to who was named first and had contributed most to the development. Edlen took the ShuVee and Diambra the EquaLine. Less than six months after Edlen sold back his interest and severed his connection with Entron, Phelps Dodge decided that it was not in their interest to make the connectors. But he had already moved his family to Yonkers when the blow fell. Edlen committed suicide <Diambra 1993, 61-62> apparently about March 10, 1958, the date on which his services as chairman of TASO subcommittee 2.5 suddenly ended. He was replaced the next day by Argyle Bridgett <Television Allocations Study Organization 1959>.

Bell Canada—Midland, Ontario

About 1956-1957, one of Entron's directors, George Bookbinder, suggested that Diambra go to Midland,

Ontario, Canada, to meet with Bill Cranston who owned the local newspaper and whose father ran the Toronto *Daily Star*. Cranston was an influential figure in the small town of Midland, less than 10,000 population. Diambra arrived at the Royal York Hotel in Toronto, where Bookbinder introduced him to Lolle Schmidt before the 80-mile drive north to Midland. Schmidt was a former Dutch resistance fighter during the German occupation. Bookbinder had been with the Office of Strategic Services (OSS) during the war and they knew each other. It was Schmidt who had been personally responsible for enabling Ernst Leitz to move the entire Leica camera factory and a remarkable group of high-level engineers out of Germany, just ahead of the Russians, to resettle in Midland.

Cranston introduced Diambra to the Pillsbury people who were also located in Midland. They had money and wanted television to work in Midland. Since 1952, channel 6 CBLT (changed to channel 5 about 1976) had been in operation in Toronto, nearly 80 miles from Midland. A new station, CKVR-TV, began operation in 1955 on channel 3 in Barrie, less than 30 miles from Midland. Buffalo channels 2 and 4 were marginally receivable with network programs from the United States.

First, they would need to acquire lease rights to attach cables and equipment to the poles belonging to Bell Canada. At the Bell engineering office in Beaver Hall Hill, Toronto, they were advised in plain terms that Bell Canada does not rent poles to anyone. In all fairness, they did try to explain that this policy was not simply a matter of philosophic strategy. They had very short poles and claimed that their pole plant was in such poor condition that massive pole change-outs would be required to provide proper clearance for TV cables <Diambra 1993, 81>.

The plan Bell Canada had adopted for Shawinigan Falls, Quebec (northeast of Montreal), was to build the system and lease it back to the operator. They had selected the SKL amplifier with 50-220 MHz bandwidth. They had been advised to avoid converting the high-band channels to low-band because: (a) adjacent channel operation would not work and (b) customers would be confused if the programs were not carried on the customary channel numbers. Diambra said, "Well, gentlemen, let me put it this way, without debating the matter. I can point you to dozens of systems where the opposite of those points is, in effect, working. Adjacent channels do work. Customers don't really care. Once they

have tuned to a channel, they don't have any allegiance." He did recognize that broadcasters don't like it, because they advertise themselves by channel number rather than call letters.

For Midland, Diambra proposed a low-band VHF system with five adjacent channels, which would require half as many amplifiers. He saw no need for the extra bandwidth provided in the SKL amplifiers. Entron proposed automatic gain control to offset variations in cable attenuation due to temperature changes, thereby making maximum use of the gain-bandwidth capability.

Diambra made friends with Bell Canada engineers and conducted lectures about gain-bandwidth, cascades, temperature effects, and cost effectiveness. He even spent a long weekend at the home of a staff engineer named David Stevenson. Working together on Stevenson's dining room table, they developed a Bell Standard Practice (BSP) document, which was based on the Entron design for Midland. Within two weeks, they were ready to build Midland. Entron was to supply the material, engineering, and know-how. The system operated for $7\frac{1}{2}$ years without a contract under Bell Canada's experimental authorization. Entron subsequently

obtained a Bell System standard KS designation for its passive devices, which were used throughout Canada.

The Barrie Problem

They soon discovered that they were having unusual problems trying to receive channels 2 and 4 from Buffalo, New York. At a distance of about 150 miles, the received signals were, naturally, quite weak. In his 1993 oral history, Diambra said “110 miles,” which is the distance from Buffalo to Barrie <Diambra 1993, 97>. Unfortunately, CKVR-TV, operating on channel 3 at Barrie, was about 30 miles south of Midland, at almost exactly the same azimuth as the Buffalo stations. Irving Kuzminsky, hired by Entron directly out of the University of Maryland Engineering School, was assigned the daunting task of constructing a stable filter with 110-120 dB attenuation (a trillion-to-one power reduction) at channel 3, without significantly degrading the weak Buffalo signals on channels 2 and 4.

With this filter installed in the antenna downloads at Midland, the interference from channel 3 was largely eliminated. Although Diambra priced the filter at \$16,000, he gave it to the Midland system at no cost, enjoying

considerable marketing advantage as a consequence. While investigating this problem, Diambra demonstrated with a spectrum analyzer in a van at positions 10 miles in all directions from Barrie that CKVR-TV was operating without the normally required “splatter filters.” Despite strenuous protests to the Canadian authorities, he was unable to persuade them to take corrective action. Nevertheless, the filter manufactured by Kuzminsky worked well at Midland. A similar situation occurred in 1956 at Magog, Quebec, when CHLT-TV commenced operating on channel 7, causing serious interference with reception of channel 8 from Mount Washington (Poland Springs, Maine) <Diambra 1993, 97-106>. Diambra again provided a Kuzminsky filter, at no cost, to clear up the interference <Diambra 1989, 181—182>.

Cable Powering

While negotiations were in progress with Bell Canada regarding the system in Midland, Diambra took the opportunity to explore with the engineers suitable criteria for transmitting 60-Hz electrical power on primary coaxial trunk cables to drive the amplifiers. It was determined that 60 V would be both safe and sufficient to drive the power-

hungry vacuum tubes.

The first cable-powered system installed by Entron was at Nacogdoches, Texas, in about 1959 for Bob Rogers, of TCA Inc. (Texas Community Antenna) <Diambra 1993, 84-86>. Cable powering was also used in the systems Entron built in Canada. Primary power was coupled to the coaxial cable through a 60-Vac Sola-regulated power transformer and a low-pass filter. Moreover, each amplifier also had a small Sola-regulated transformer to compensate for the voltage drop in the coaxial cable.

Cable powering makes it possible to locate amplifiers according to the RF requirements without being concerned about accessibility to primary power. Moreover, it substantially reduces the number of electrical service drops required to power the network. Unfortunately, many power companies still require meters at every power drop, notwithstanding that power consumption is readily determined without metering and is quite constant. Jim Palmer at CECO (the name was later changed to C-COR) reports using cable powering as early as 1953.

Vacuum Tubes

The useful life of vacuum tubes became a critical issue. The distributed gain amplifier design was especially vulnerable because it required so many tubes. As vacuum tubes age, their cathode emission declines, resulting in reduced mutual conductance. Thus, vacuum-tube aging was likely to cause the TV signals to fall below acceptable levels. Replacing 4 to 12 gold-grid 6AK5s every few months at \$3 to \$6 each became an objectionable expense, particularly since the aged tubes were still useable for other applications. Working with Arinc, leading experts in aeronautical radio electronics, Entron learned that vacuum-tube life could be extended greatly by operating the filaments at a tightly regulated 6.05 V instead of the specified 6.3 V.

About 1957, Diambra sent Blum and his wife to Germany to visit Blum's mother, with the special assignment to visit the European vacuum-tube manufacturers to look for tubes that would be particularly useful for CATV equipment. Blum had an uncle at the Philips Vacuum Tube Division and brought back several experimental Amperex tubes that not only had high gain-bandwidth but also high reserve power. He also brought

back the first of the 20,000-hour tubes. Competition with Jerrold, and especially Shapp, was intense, and Diambra believed that his introduction of new vacuum tubes was effective <Diambra 1993, 83-84>.

Resignation and the Move to Westinghouse²

About 1958, Entron established a separate publicly held entity, International Cable Corporation (ICC), to develop CATV franchises at Vero Beach and other communities on the east coast of Florida. In 1959, Entron itself became a public stock company. Serious conflicts began to arise among the directors, rooted in the divergent philosophies and goals between system operation and the manufacture and sale of equipment.

As he pondered these conflicts, Diambra realized that the CATV equipment manufacturing field was becoming crowded and that the industry was likely to be dominated by the Bell System, with its unlimited financial resources and prestige. The philosophical split in the ICC presented a perfect opportunity for him to divest his interest in both Entron and ICC and shift his career to pure operations, with overtones in equipment and system design.

Diambra became chairman of the board of Entron in 1962 and retired completely in 1964. To succeed him as president, he brought in Jim Lahy who had left the Dage Company, which he had managed for many years in Michigan City, Michigan, building cameras primarily for industrial purposes. Diambra continued a close relationship with Blum and Kuzminsky. He kept telling them, "Hey, you guys are slipping further and further behind. Transistorization is now upon us and your competitors are starting to rap on my door. I can't tell Westinghouse that we won't buy from someone like Palmer, C-COR. ...You've got an antiquated vacuum tube system that is killing us from the standpoint of power." Entron did build a line of transistor amplifiers that were technically successful, but it was too late. Because of the devastating economic and regulatory conditions facing the industry in the late 1960s, Entron was unable to sustain the strong position it had enjoyed for a decade and a half <Diambra 1993, 112-114>.

After retiring from Entron, Diambra set about developing franchises, in which he had an ownership interest, for Westinghouse in Florida and Georgia. These systems also served as a field laboratory for Entron developments. For example, he had Entron develop forced

ventilation to cool the tubes and extend their life. They placed manifolds over the tubes, ducted to an outside, ball-bearing, 50,000-hour fan with solid aluminum blocks to aid in heat dissipation. He developed an extensive microwave network linking the systems for program exchange and carried on innovative experiments for metering and supervision of electric power distribution and control.

Entron's Contributions

Pioneering claims to be “first” at anything are always subject to challenge. Claims that are carefully qualified as to particular periods of time, specified geographical locations, or carefully delineated characteristics may be technically correct, although preceded under slightly different circumstances. Except where the commercial advantages of patents are involved, pioneers are often rewarded more with honor and prestige than with fortunes. Diambra claims to have introduced a number of important pioneering developments in CATV systems. His claims to priority are not unchallenged, but their importance is uncontested. These include

- Carriage of five adjacent channels.
- Adjustable equalization and high-pass filtering (Equaline).
- Segment-by-segment system sweeping in the field.
- Low-loss, aluminum sheath, air dielectric coaxial cable (Styroflex).
- Cable powering.
- Automatic slope and gain control (Equitrol).

It is clear that Hank Diambra was often “ahead of his time” in anticipating developments that have now become standard practice.

REFERENCES AND ADDITIONAL READINGS

NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center and Museum. These oral histories are also available via the Center’s web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center’s web site may not correlate with the page numbers cited here.

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CHAPTER 7

Ameco, Inc.

J. EARL HICKMAN¹

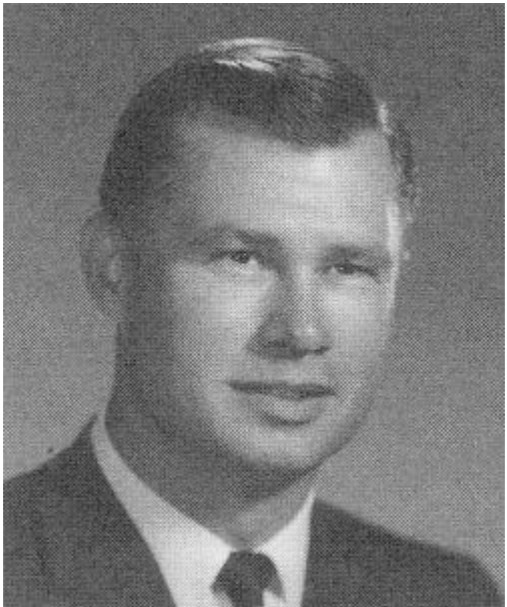


Fig. 7.1 J. Earl Hickman

*Courtesy National Cable Television Center and
Museum*

EARL HICKMAN (FIGURE 7.1) WAS BORN IN

NOVEMBER 1925. While in high school in Bisbee, Arizona, he worked part time for the Copper Electric Company sweeping floors and doing odd jobs, including some electronic construction for a two-way radio system for the Cochise County Sheriff's Department. Hickman then obtained his second class and first class commercial radiotelephone licenses and did some announcing for Copper Electric's radio station, KSUN in Bisbee. While working for Copper Electric, he studied amateur radio books and mastered the Morse code by listening to the airwaves. By 1943, a year after graduating from high school, he had taught himself enough so that he could join Southwest Airways as radioman at Falcon Field near Phoenix. At Falcon, he not only maintained the radios in a fleet of trainers but also installed electronic intercoms in 64 Stearman biplanes to replace the gosports—acoustic speaking tubes that enabled the instructor to speak to the student but not vice versa.

Then, in December 1943 Hickman joined the U.S. Air Corps. Although aptitude tests pointed him toward pilot training, which he wanted very much to do, he was repeatedly sidetracked. At one time, he was assigned to Drake University in Des Moines. Hickman says, "They shipped me out to Des Moines, Iowa, to a college training

detachment because they were eventually going to make me an officer, and they had to teach 18-year-old kids how to be gentlemen.” At Drake, he picked up 32 units of college credit, doing well in math and physics. While waiting patiently for an opening to pilot school, he volunteered for gunnery school. He graduated in the top 5 percent of his class, although he says he “never did hit the sock.” He was out of the Air Corps in October 1945, one month before his twentieth birthday, and still upset that he never had a chance to fly as a pilot.

Shortly after obtaining his amateur radio license (W7JJN) in 1945, Earl Hickman met Paul Merrill (W7PMJ) through ham radio. Merrill was general manager of Gila Broadcasting Company, with radio stations in Globe-Miami, Coolidge, and Safford, Arizona. KWJB at Globe-Miami was the flagship. Merrill was not only a ham radio operator but also held a first class radiotelephone operator’s license and had participated actively in radio broadcasting since the mid-1930s, both as engineer and manager. His younger brother, by 15 or 16 years, is Bruce Merrill, known and respected in the cable TV industry as president of Ameco, a CATV equipment manufacturer. In 1964-1965, Bruce Merrill also served as chairman of the National Cable Television Association (NCTA), the

industry trade association.

Merrill had a profound influence on Hickman's life. Hickman's father was killed when he was just a baby. Merrill was like a father to him. "I learned a lot of things from Paul about business. I've never known anybody of a higher moral character than Paul Merrill. I just couldn't say enough good things about him. He was really my favorite guy."

By June 1949, Hickman decided that he could not go further in the electronics world without a professional degree. He had read everything ever written by Dr. Frederick E. Terman, dean of the school of engineering at Stanford University and for many years the leading authority in radio and electronics engineering <Terman 1943>. Hickman was good at the mathematics that an electrical engineer needs, but there were many gaps that could only be filled with a formal engineering education. Merrill easily recognized the young man's potential. Communicating only by ham radio, Merrill provided Hickman with a "job of convenience," working nights at KGLU in Safford while attending classes at Gila Junior College.

When Hickman transferred to the University of

Arizona at Tucson, Merrill set him up as chief engineer at KCKY, Coolidge, about 65 miles north of Tucson. “That was a neat job,” Hickman says. He worked 18-hour shifts on Saturday and Sunday, in addition to doing maintenance. Still, he was able to carry 17-19 credits, and earned his bachelor of science degree in 1952. During his sophomore year, he rebuilt the studios at KGLU. During his junior year, he put a new AM radio station on the air in Winslow, including installing and adjusting its two-tower, medium-frequency (MF) directional antenna and proofing the performance of its cardioid (heart-shaped) radiation pattern. In his senior year, he designed and built a 1-kW AM transmitter for KCKY, replete with inverse feedback.

Ever Hear of Community Antenna Television?

Near the end of 1952, Merrill asked Hickman if he had heard of community antenna television. “No, what is that?” Hickman replied. Merrill then told him the story of Martin Malarkey’s system in Pottsville, Pennsylvania, as told in the December 1952 issue of *Electronics* magazine <Carroll 1952>. Hickman acknowledged that he knew nothing about community television; in fact, he knew

almost nothing about television. He says, “I could take a bunch of field measurements and calculate the RMS field of a directional antenna and calculate the ground conductivity and all that sort of stuff, you know, which made me, as country bumpkin radio engineers go, a cut above average for that time. But I didn’t know anything about television” <Hickman 1992, 14>.

So, Merrill went to talk with Hickman in the Quonset hut at the University of Arizona in which he lived with his wife and two children. Merrill asked Hickman if he thought they could build a community television system in Globe-Miami, where some 7,500 households appeared to be within reach. Hickman’s quick response was, “Why not?” “At that early age I was not only immortal but I could do anything” <Hickman 1992, 15>.

But he hardly knew where to start, not even knowing how television worked, let alone how to build a cable television system. Merrill rounded up manufacturers’ brochures for the RCA Antennaplex equipment that Malarkey had used in the Pottsville system described in the *Electronics* magazine article. Antennaplex was an outgrowth of the wired radio facility developed by RCA to distribute broadcast radio signals to hotel rooms and apartments. In 1945, it was upgraded to distribute

television signals to the NBC offices and studios in the RCA Building in New York and served as a master antenna system in hotels and apartments <Fink 1947; Kallmann 1948>. It was installed in the Waldorf Astoria hotel guest rooms. This is where Malarkey saw it in 1949 and quickly recognized that it could be used to bring television to homes in Pottsville. Merrill and Hickman threw in their lot with RCA and became the Southwest representatives for Antennaplex.

In early 1953, the only television stations in Arizona were the Meredith station KPHO-TV in Phoenix on channel 5 and the Gene Autry station KOLD-TV in Tucson on channel 13. During the winter of 1952-1953, Merrill and Hickman selected a receiving site for channels 5 and 13 on Madera Peak. The site was about 4¹/₂ miles south of Globe-Miami, about 70 miles east of the Phoenix TV transmitters, and 85 miles from Tucson.

Although clear proof of “first” in any complex endeavor is often elusive, it is believed that the Madera Peak head end was the start of the first CATV system in Arizona. Phoenix channel 12 came on the air while they were building the head end. In little more than a year, channels 3 and 10 would be activated in Phoenix and

channel 4 in Tucson. Channels 5, 13, and 12 were converted with RCA Antennaplex converters at the Madera Peak head end to channels 2, 4, and 6, for transmission on strip amplifiers down to Globe-Miami. (Actually, Hickman may have used channel 5 without conversion.) Even using low-loss K-14 coaxial cable with solid polyethylene dielectric, it took a long series string of amplifiers for the $4\frac{1}{2}$ miles to Miami, in addition to the 7 miles to Globe. It wouldn't work. Hickman recalls that their longest run eventually would require about 54 cascaded amplifiers for the entire system. It soon became apparent to Hickman that the Antennaplex configuration with 60-dB gain (including the preamplifier) at 60-dBmV output would simply not work. So, he split the Antennaplex amplifiers into two 30-dB amplifiers and found he could get much better signal-to-noise ratios. But he still could not get a quality signal down that $4\frac{1}{2}$ -mile mountain run. The double-tuned strip amplifiers were not going to do the job for long cascades. The double-tuned Antennaplex strip amplifiers were simply not broad enough nor flat enough and clipped off most of the sidebands. Antennaplex would not do the job.

Amplifiers were not the only problem with the

Madera Peak antenna site for the Globe-Miami system. There was no power available for either the head end or the series of amplifiers on the run down the mountainside. The cost of extending utility power would be absolutely prohibitive. The logical solution was to use the coaxial transmission line for both RF and electrical power. The center conductor of K-14 cable was about the size of No. 9 copper wire; its loop resistance for 4.5 miles was more than 20 ohms. It was quickly apparent that the voltage drop on K-14 cable for a dozen Antennaplex amplifiers (at 150-180 W each), plus power for the head end itself, would have to be transmitted at considerably more than 120 V. So, Hickman used a 220/2,400-V pole pod (transformer) with 110 V on the primary, transformed to 1,200 V on the secondary. He made up his own networks to bypass the 60-Hz energy around the VHF amplifiers and put the 1,200 V on the underground K-14 cable running up the hill. In 1952, this may have been one of the first instances of cable powering. It is probably the only instance ever of cable powering at 1,200 V <Hickman 1992, 17>.

Hickman was aware that the Jerrold Electronics Corp. in Philadelphia was manufacturing equipment especially for community television systems. But when Merrill

attempted to purchase Jerrold equipment, he ran into Jerrold's notorious service agreement. In order to purchase Jerrold equipment, he had to agree to pay \$5 out of each connection fee (about \$125 at that time) and 25 cents out of each monthly service charge collected (typically \$3.75 a month at that time). In return, Jerrold promised to keep the customer informed of new developments and to provide system design and consulting services for additional fees. Paul Merrill found this not to be to his advantage <Hickman 1992, 20>.

About this time, Hickman became aware that Spencer Kennedy manufactured distributed gain amplifiers. He read Fitzroy Kennedy's 1949 paper on the chain amplifier <Rudenberg and Kennedy 1949> and read "all that stuff" that Lou Ridenauer and others had to say about amplifiers in the Radiation Laboratory Series <Valley and Wallman 1948>. He experimented with SKL amplifiers and says, "They were actually pretty good. They were about as good as you can do with twelve 5654s or 6AK5s in a distributed gain amplifier." But Hickman had already installed cable with amplifier stations spaced for channels 2 through 6 and could not properly space the SKL amplifiers that were designed for channels 2 through 13. However, they thought, "Channels 2 through 6 was about

as good as anybody would ever want to do anyway.” Then Hickman adds, “That shows how wrong we were” <Hickman 1992, 25>.

Antennavision Is Formed

It was going to take money and an organization to pursue the development of community antenna in Globe-Miami. So, in 1953, under Paul Merrill's leadership, the officers and directors of Radio Associates, the operating company for Gila Broadcasting, formed a company called Antennavision. The new company was formed to build and operate the system in Globe-Miami and to handle its responsibilities under the agreement with RCA Antennaplex. Antennavision was capitalized at \$10,500, with seven shareholders investing \$3,500 each. The shareholders were: Paul Merrill; Bruce Merrill, Paul's brother who is an accountant; Nelson Wyrick, married to the widow of Paul Merrill's son who was killed in World War II; Willard Shoecraft, manager of KWJB, the Globe-Miami radio station; Bill Parody, manager of KCKY, the Coolidge radio station; Edward Furman, business manager for Gila Broadcasting and owner of the radio stations; and Earl Hickman.

Hickman's total available assets at the time consisted of \$1,000 cash and a 1950 Hudson on which he was able to borrow another \$1,000. Because of the importance of his technical skills, he was carried for the remaining \$1,500 as "sweat equity" <Hickman 1992, 22-25>.

The purpose of Antennavision was to build and operate cable television systems. The group's experience in broadcasting convinced them that it would be better not to build equipment if they could avoid it. At that time, RCA Antennaplex did not have a complete line of equipment for cable TV networks. For example, RCA did not have a practical subscriber tap. They had no line extenders, and simply tapped the trunk. Moreover, they had found out that the Antennaplex amplifiers could not successfully be cascaded for the long runs they needed.

Upon completing his studies at the University of Arizona in 1952, Hickman moved back to Safford. He had read an article in the 1948 MIT Radiation Laboratory Series on stagger-damped, double-tuned circuits for broadband RF amplification <Valley and Wallman 1948>. So he built a broadband amplifier on his dining room table, using the stagger-damped, double-tuned concept. It was a two-tube amplifier using 6BK7 high- μ twin triodes. Later, he added another tube, providing nominal gain of 26 dB or

so spaced at about 20 dB of cable loss (at channel 6). According to Hickman, it was strictly trial and error.

They had no test equipment in those days. Hickman used a vacuum-tube voltmeter (VTVM) to measure signal levels. “Oh, it was terrible!” he says. With its high impedance and lack of frequency selectivity, it was hard to guess what was being measured. Then, RCA arranged for him to obtain a TV test set from Hoffman Television in Los Angeles. Hickman says, “I guess it was portable, to the extent that it had two handles on it—it was moveable. It was a 12-inch television set and it had a meter on the face, up in the corner that worked in the AGC circuitry. ... It was an RCA 630TS chassis. ... You had a calibration chart so you could read signal levels with it, if you were lucky. You could switch to the various channels and read the signal levels. It wasn’t very good.”

While he was in the laboratory at the Hoffman plant, Hickman saw a field strength meter about the size of the Jerrold 704-B mounted on top of its battery box. He thought it was probably a prototype, although it may have been a production model. Hickman was particularly impressed with it because it had a continuous tuner. He had the idea that it was being developed there in the Hoffman Laboratory. Apparently, the selective RF

voltmeter (incorrectly called field strength meter) that Ken Simons put together with sheet copper and an automobile storage battery had been contracted out to Hoffman for production <Hickman 1992, 97-100>.

CATV pioneers in the early days, both operators and equipment manufacturers, simply jumped into the business without the knowledge or tools they needed. As Hickman says, “We literally had to invent, if you will. You know that necessity is the mother of invention, and out of necessity we simply had to improvise equipment. ... Oh, I can remember those days real well; when you just literally would scribble on the nearest cardboard box the design of some new piece of equipment. Quite often, it wasn’t very elegant to begin with, but that’s the way we did things” <Hickman 1992, 101>.

Antennavision Manufacturing and Engineering Company (Ameco)

Just as Martin Malarkey’s activity in Pottsville became a focal point for people all over the country, Merrill’s friends began asking about Hickman’s broadband amplifier. Hickman had a little building in Safford—about 1,200 square feet—where he began

building amplifiers for Merrill's friends. In 1954, the Safford operation began doing business as Antennavision Manufacturing and Engineering Company, Ameco for short. Ameco was later incorporated and, in 1956, moved to Phoenix and built a substantial office, laboratory, and factory building. Under the leadership of Bruce Merrill, with Hickman as chief engineer, Ameco became a major supplier of equipment for cable TV. However, they were never quite able to overtake Jerrold for first place share of the market before collapsing in the mid-1970s.

By this time, they had built just about every kind of amplifier you could build. Hickman was an avid reader of technical journals on electronics. He remembered an article he had seen a few years earlier by Fitzroy Kennedy about distributed gain amplifiers designed and manufactured by the Spencer Kennedy Laboratories (SKL) in Cambridge, Massachusetts <Rudenberg and Kennedy 1949>. He tried building distributed gain amplifiers using impedance matching networks at the input and output instead of the coaxial input and output lines in the SKL amplifier. Hickman believed that the crude impedance match using coaxial input and output lines was an undesirable aspect of the SKL design, adversely

affecting its frequency response. He concentrated on trying to build effective matching networks. A paper by Russell Yost of Motorola on the subject of multipole matching networks became the basis for the design of all matching networks for Ameco amplifiers. Hickman was not able to identify the Yost paper and suggested that it may have been an unpublished internal document at Motorola <Hickman 1992, 31>.

Before moving to Phoenix, Antennavision built one of the first microwave links for CATV in order to relay signals from the Phoenix and Tucson TV stations to the cable system planned for Silver City, New Mexico. This was in 1954. Signals were received on Heliograph Peak at 10,000 feet elevation, about 14 miles south of Safford in the Pinaleno Mountains. This is some 130 miles from Phoenix and more than 70 miles from Tucson. Hickman believes that the 92-mile propagation path from Heliograph Peak to Silver City may have been the longest 7-GHz microwave path in service at that time.

Propagation over such long paths is frequency sensitive, and Hickman was experiencing severe differential fading between the aural and visual carriers of the VHF television signals received at Madera Peak as well as at Heliograph Peak. The automatic gain control

(AGC) of both visual and aural signals in the receiver was determined by the strength of the visual carrier. Thus, the sound was likely to be distorted when the high gain required for a weak visual carrier caused the aural carrier to overload, or noisy when reduced gain for a strong visual carrier allowed the aural carrier to fall below the FM noise threshold levels. Selective fading was so bad at Globe-Miami that, Hickman says, "I finally, out of desperation, broke it clear down to video and audio, and just remodulated a modulator with it. Eventually, I moved the antenna site and solved the problem." For the microwave feeds at Heliograph Peak, the separately controlled video and audio were applied directly to the klystron microwave modulator.

He began using individual processing of visual and aural carriers, probably in 1954, while he was still working at Safford. It was certainly before moving to Phoenix in 1956. At first, Hickman used the 21-MHz IF band commonly used in early monochrome TV sets but later changed to the current standard 41-47 MHz IF band. Jerrold did not introduce its proprietary vacuum tube Channel Commander, a dual heterodyne signal processor, until 1962. Later, Ameco introduced a transistorized version of the dual heterodyne signal processor, called

the Channeleer, probably in 1966, followed by a Scientific Atlanta version in 1967. But, Jerrold's vacuum tube Commander in 1962 was clearly the first processor available to the CATV industry. It never seemed to Hickman, in 1954, that separately processing visual and aural signals at IF was unique or patentable, because all he was doing was just copying TV sets. However, it was much more elegant than the mechanical solution concocted in the Pacific Northwest, where a motor-driven servo arrangement was used to control the levels of the separate visual and aural IF sections in an RCA 630-TS television receiver. In later years, IF processing was found to be appropriate for many other functions, such as scrambling, descrambling, carrier insertion, switching, and data transmission, not only for head end signal processors but also for modulators and demodulators.

It soon occurred to Hickman that, "One of the neat ways to feed the audio information over the microwave link was simply to feed the 4.5-MHz intercarrier beat out of the Conrac... instead of using the 6.8-MHz subcarrier generator in the microwave transmitter." In doing this, he was not following any leads. He just had a job to do in Safford. He modestly declines to comment on who first had the idea of feeding the 4.5-MHz intercarrier signal

straight through to the klystron impeller <Hickman 1992, 29>.

A modulator is essentially a miniature TV broadcast transmitter, operating at a few milliwatts instead of tens of kilowatts. Hickman had become thoroughly disenchanted with the commercial modulators available at that time. So he said to Larry Wilson, a recent addition to the four or five engineers working with him at Safford, “Larry, I’ll tell you what I want you to do here as a first project. I want you to build a good modulator to work with the microwave links.” Hickman was primarily interested in modulators for the Antennavision systems. However, by 1956 they had produced a vacuum-tube modulator they thought might be suitable for marketing to the industry as the “Ameco-Tran.” A production line was put in operation in Phoenix, and Bruce Merrill began selling them to the many friends he was making in the CATV business. Milford Richey’s first project after joining Ameco in 1957 was to finalize the AmecoTran modulator product.

The vestigial-sideband (VSB) filter was a big problem with which Ameco had to deal in their early modulators. The classical amplitude modulator (AM) generates both upper and lower sidebands, representing the video information. To conserve scarce spectrum, the National

Television Standards Committee (NTSC) determined, in 1941, that part of the lower sideband could be eliminated without degrading the pictures. The part that is not totally eliminated is called the vestigial sideband. Picture degradation is likely to occur if the cutoff is too sharp, and interference to adjacent channels will occur if the cutoff is too broad. The design of a properly shaped VSB filter was challenging, to say the least.

The “Not-Quite-Video” Concept

When the Ameco operation moved to Phoenix in 1956, it was clear that Bruce Merrill’s objectives were in the manufacturing business while Hickman was primarily dedicated to the Antennavision CATV systems. Hickman considered himself to be an amateur, just trying to make things work, keep them working, and make them work better.

Still working out of the little shop at Safford, Hickman began to meet other engineers working in CATV, particularly the Jerrold people who generally dominated industry equipment shows. Through one of those encounters, he learned of the Jerrold experience in Dubuque, Iowa, with “not-quite-video” (NQV) for long

transmission paths. Don Kirk had conceived the idea of converting all the TV channels down to the 1-7 MHz band, using a separate coaxial cable for each channel and taking advantage of low loss at low frequencies. In order to overcome severe cross-view between the tightly bundled cables on aerial messenger strand, Kirk proposed burying the cables and using what he called “HLD” (high loss dirt) to reduce the cross coupling (see [chapter 5](#)). As he listened to the story, Hickman said, “It occurred to me why they had to have the dehubbuber. And I had an idea around that, you know.” He was probably already thinking of phase lock. “But naturally, I didn’t work for Jerrold, so I didn’t get into that. ... But the reason I brought it up was because some people try to lay claim to originality in what they do” <Hickman 1992, 34-36>.

Later in his cable experience, Hickman had occasion to recall Jerrold’s Dubuque adventure. Ameco adapted the NQV concept to cable TV in Huntsville, Alabama, in 1967, and in the Discade™ system installed a year or two later in Daly City and Broadmoor, California. However, Hickman used the band 7-13 MHz, less than a full octave, to avoid interference from in-band second-order products. By tightly phase-locking the signal carrier frequencies to a constant reference frequency and using solid sheath

aluminum cable with sleeved connectors, cross-view interference was effectively eliminated <Hickman and Kleykamp 1971>.

Two-Way Transmission

Antennavision developed a simple television studio in Miami, Arizona. The 4¹/₂-mile run down from Madera Peak was split to feed Miami in one direction, Globe in the other. It was perhaps late in 1955 that Hickman began looking for a way to feed the local origination signal upstream from Miami to the split, then downstream to Globe. He says, “I designed, as far as I know, the very first complementary filters used in cable television for reverse feed on the same cable” <Hickman 1992, 44>. Using equations from Terman’s engineering textbook <Terman 1943>, he fabricated complementary high/low-pass “diplex” filters with which to separate the upstream transmissions at frequencies below 20 MHz from downstream transmissions above 54 MHz on the same coaxial cable. They were “m-derived” filters, based on Terman’s engineering textbook equations in which *m* is a design constant related to the sharpness of cut-off. Hickman designed the filters for $m \approx 0.6$, representing

reasonably sharp cut-off without the cost and complexity of multiple intermediate filter sections. Hickman called his crossover filters CF-33, because the crossover was at 33 MHz, the geometric mean between the lower edge of downstream channel 2 at 54 MHz and the upper edge of the 10-20 MHz band he planned to use upstream. While this was certainly one of the first two-way arrangements, Hickman says, “I didn’t invent them; I just designed them” <Hickman 1992, 44>.

Frequency Modulation

Instead of the conventional VSB/AM television modulation, Hickman decided to experiment with frequency modulation with fractional modulation index such as was used in microwave links of that time. This was about 1955-1956. He said, “It just seemed like FM was kind of a neat way to do it.” Instead of the normal sawtooth sweep voltage in a Kay sweep generator, he applied baseband video voltage to the repeller of the variable frequency klystron oscillator, causing its frequency to vary in direct proportion to the video voltage. This was mixed with the output of the normal fixed frequency klystron oscillator to generate a beat

whose frequency was centered at 15 MHz, frequency modulated with maximum deviation of ± 5 MHz.

Hickman called attention to the fact that his FM modulator was operating in the single-octave band of 10-20 MHz. “Even in those days,” he said, “I was smart enough to avoid the harmonic relationship that was one of the downfalls of the company that later had the FM system up in New York.” He was referring to the Quasi-Laser Link and the FDM/FM Airlink multi-channel FM system developed by the Laser Link Corporation and described by Dr. Joseph J. Vogelmann <Vogelman and Kamen 1970; Vogelmann and Knight 1971; Vogelmann and Reader 1972>.

The experiment with frequency modulation was an exciting success. “It just worked beautifully,” Hickman said. “This thing that I designed just worked beautifully. I’ll never forget that I fed that sucker clear into Globe, Arizona, and took it off the line after going through all those amplifiers and all these complementary filters and all that kind of stuff. It was just a beautiful picture.” Bruce Merrill immediately fell in love with it and said, “We’ve got to share this with the world” <Hickman 1992, 41-46>.

Very quickly, Bruce Merrill sold a system to Ken

Gunter, a radio station operator who was trying to start CATV in San Angelo, Texas. Hickman found that they had an 18-mile RG-11/U run with some 57 cascaded amplifiers. They were using an amplifier manufactured by John Campbell in Irving, Texas, later trading as CAS Manufacturing Company, but they could not get any of the three channels through the 57-amplifier cascade. At the end of the line, Hickman's sweep generator displayed three narrowband resonant response traces, looking for all the world like "three fingers." Hickman said to Gunter, "How would you like it if I could get you one good channel?" Gunter said, "I'll take it!"

After realigning all the amplifiers in the chain and concentrating on only one channel, he was able to get a reasonably broad response at 66-76 MHz for the FM transmission. "I turned that sucker on," he says, "and there was a beautiful one channel of television in San Angelo, Texas. I could have become the mayor, you know. They would have given me the town." He had brought three sets of equipment, but there was no way he could have squeezed even the AM signals through that cascade let alone two more FM signals <Hickman 1992, 46-48>.

Although the FM system worked very well, it did not

become a marketable Ameco product. Another company, Catel, took the FM technology to market. Technologically, the results were excellent, but only for signal transport on super-trunks. Distribution by FM to subscribers would require FM to AM conversion at the customer premises at unacceptable cost. Optical fiber supertrunks have largely supplanted the need for FM signal transport on coaxial cable.

Open-Wire Transmission Line

Probably early in 1958, a fellow by the name of Scotty Gray came to Phoenix to talk with Bruce Merrill about open-wire transmission lines (a pair of unshielded, untwisted wires separated by as little as $\frac{1}{2}$ inch or up to 5 or 6 inches). Hickman was not in the meeting, and Gray apparently convinced Merrill, at least temporarily, that Hickman was “just a clean cut incompetent” because he had not used any open wire line in the Antennavision systems. So, Merrill put Ameco in the business of buying open-wire line hardware from Gray, not for resale but for use in Antennavision systems.

Hickman was distressed. He told Merrill what was

going to happen. After making several open-wire installations in Antennavision systems, it all came out just the way Hickman said it would. Radiation was an open invitation to theft of service. Open-wire lines were sensitive to weather conditions. There were impedance matching problems resulting in some ghosts. It was hard to make a turn without throwing in a large transmission discontinuity. Hickman says, “I fought, clawed, scratched, and did everything I could do, short of just plain out and out resignation over open-wire transmission lines” <Hickman 1992, 39>.

Later, about 1963, Gray tried to persuade Matty Fox, Hollywood movie producer, and Pat Weaver, a former NBC president, to use his “black box,” a magical open-wire tap-off for the pay-TV venture they hoped to establish in Los Angeles. However, opposition by broadcasters and theater owners succeeded in putting the issue to a referendum (subsequently declared illegal). Although they had achieved 50 percent penetration of some 50,000 homes passed, the referendum failed and the venture went through Chapter 11 bankruptcy without definitively testing Gray’s open-wire transmission line devices.

Gray’s black box apparently contained a transmission

line stub to tap signal off the open wire line while loading it just a little. It was roughly equivalent to the multi-taps Hickman designed for Ameco based on lumped parameter transmission line segments with 75-ohm characteristic impedance. In order to make them cheap, Hickman says they were directional only in the lower tap values but not in the higher ranges <Hickman 1992, 37>.

Hickman Resigns, Becomes Vice President of Kaiser-Cox CATV

The year 1958 was a very bad one for equipment manufacturers. It was also a bad year for the national economy in general. Growth of new systems was at a standstill. There were no more cities and towns large enough to attract new cable systems that were not already served by one or more local or nearby TV stations. Conventional wisdom seemed to say that people would not subscribe to CATV if they already had access to one, two, three, or more local TV stations. Why would people pay a cable company for programming already available *for free*? Although 1958 was indeed a very bad year for CATV equipment manufacturers, operating systems already in existence, such as Antennavision, continued to

do well, and Antennavision was subsidizing Ameco's manufacturing business to keep it solvent.

At this time, there were about 20 to 25 employees at Ameco, including production, marketing, and engineering. Early in 1958, Paul Merrill came to a board of directors meeting and said, "I'm tired of taking all the profit out of the CATV operations and putting it into this dumb thing called Ameco." Paul Merrill was the leader of the seven shareholders and claimed he had the four votes, including Hickman's, that would be needed to shut down Ameco. The next day, Bruce Merrill bought out Paul's share and then had the votes to continue the operation <Richey 1994, 13>.

Hickman clearly respects and admires Paul Merrill and his brother Bruce and speaks well about both. This was a most uncomfortable time for Hickman. Building systems and making them work to the best of his considerable ability were his primary interests. With Paul Merrill's solid encouragement, he had provided, almost single-handedly, the technological basis for Ameco. However, Hickman began to feel that he was really a burden to Ameco, which was having trouble raising enough money to pay salaries <Hickman 1992, 50>.

In June 1958, he resigned and went to work for Kaiser in Phoenix. His departure, just as the founding organization was disintegrating, was probably not entirely coincidental. A year or so later he sold his 14 percent share in Antennavision to Bruce Merrill, including subsidiaries Ameco and the Antennavision Service Company organized to provide common carrier microwave service and later known as American Television Relay (ATR). About this time, Bruce Merrill also bought out the remaining shareholders to become the sole owner of Ameco.

At first, Hickman's work at Kaiser was totally unrelated to cable TV. Before long, however, he was back in the business of manufacturing equipment for cable TV as vice president of manufacturing and engineering for the newly formed Kaiser-Cox. But that is another story, briefly told in [chapter 13](#). A lot of things happened between 1958 and 1966 when Hickman returned to Ameco. He says, "In fact, probably most of the good things that happened at Ameco happened during those eight years that I was gone. And I can't claim responsibility for any of those good things that happened" <Hickman 1992, 55>. He remained with Ameco for about a year while Milford Richey settled in to his new assignment with Ameco.



Fig. 7.2 Milford Richey

Courtesy National Cable Television Center and

Museum

Milford Richey ([Figure 7.2](#)) was born in 1928 in St. Johns, Arizona, a small town close to the New Mexico border. Both his parents were born in Arizona, and his grandfather drove an ox team into the state. During the Great Depression, they milked cows, raised chickens, and sold eggs and cream to get money for an austere existence. For the young Richey, however, it was a happy and comfortable time in a devoted family.

Shortly after graduating from St. Johns High School in 1945, he was accepted into the military and was sent to a Navy electronics school for a year, graduating number 1 in his class. From there, he went to Arizona State University at Tempe. Since this was before they had their accredited engineering department, he received a bachelor of science in electronics.

While still in school, he worked nights for Phoenix radio station KOOL. By that time, KPHO-TV was already in operation on channel 5, and NBC affiliate KPNX had just started operations on channel 12. Radio stations KOOL and KOY had finally settled a bitter contest at the FCC by agreeing jointly to own and share time on channel 10, the only available VHF assignment. (Channel 3 had

been authorized but was not activated until 1955.)

Richey, who was now working full-time at KOOL, was chosen to build the transmitting facility for the new television station, KSAZ-TV, on channel 10. He and an engineer from Dumont built the transmitter on South Mountain adjacent to the channel 5 and 12 facilities. They built the transmitter from scratch, components and all. The station began operation in October 1953. About a year later, Richey was named chief engineer. At 26, he was the youngest staff member in his department. Several years later, after an impolitic clash with the general manager, he was fired. Not long after, in 1957, he was hired by Bruce Merrill to learn the ropes at Ameco before Hickman left.

Hickman and Richey were jointly responsible for developing the Ameco-Tran modulator, using the 4.5-MHz intercarrier sound as a subcarrier. They believed this was the first modulator using 4.5-MHz aural subcarrier instead of baseband audio. There have been claims, apparently unsubstantiated, that the Ameco-Tran was actually a copy of the Jerrold Teletrol vacuum-tube modulator using 4.5-MHz aural subcarrier. It seems most likely, however, that it was pure serendipity rather than plagiarism that led Hickman and Jerrold's Frank Ragone to the same idea at about the same time.

Richey's early days at Ameco were devoted primarily to developing and installing the equipment for the expanding common carrier microwave network organized as American Television Relay (ATR). Its predecessor, the Antennavision Service Company, had been responsible only for microwave serving the Antennavision cable TV systems. Microwave relay was becoming an important part of cable TV to relay signals from distant broadcasting stations not affiliated with a national network. Distant signals were essential for many CATV systems to provide customers with programming not carried by the local stations. The advent of satellite relay 20 years later initiated the development of a flood of new programming that could be delivered at much lower cost.

Conventional microwave equipment in the late 1950s was designed to operate at baseband video and audio. For multihop relay, this meant demodulation and remodulation at every repeater site, resulting in cumulative signal (and picture) quality degradation. To overcome this problem, AT&T and others introduced the idea of the heterodyne microwave repeater, in which the signals were handed off from the microwave receiver to the repeater transmitter at an intermediate frequency (e.g., 70 MHz) without demodulation. Richey arranged with

Collins Radio in Dallas to build an IF heterodyne system for long-haul video microwave. The results were fantastic. ATR built a relay network from Palm Springs, California, to Yuma, Phoenix, Globe, and Safford, Arizona, extending on to Silver City, New Mexico; El Paso, Texas; Albuquerque, New Mexico; and into southern Colorado. The equipment is still in operation. ATR was sold to the late Bob Magness, founder of Tele-Communications Inc. (TCI—now part of AT&T), for Western Microwave, which was later sold to MCI.

By the early 1960s, Bruce Merrill's strategy for increasing sales of microwave service and distribution equipment was to persuade potential system operators and investors that new systems could prosper with programming from TV stations too far away to be received without microwave relay. To this end, Richey and the Ameco staff concentrated substantial effort on developing microwave for new systems that might not otherwise be able to exist. This led to extensive lobbying at the FCC and Congress, largely against the vigorous opposition of the broadcasting industry. Bruce Merrill's aggressive efforts in this regard led to his election as national chairman of the NCTA in 1964-1965.

Glen Canyon in Page, Arizona

Probably about 1959, shortly after Hickman left Ameco, construction of the Glen Canyon Dam on the Colorado River near the northern border of Arizona at Page was about to begin. Weak, noisy reception of a daytime radio station in Flagstaff and occasional skip television reception represented the only entertainment available for the construction workers expected to swarm into town. (Skip television is received by sky-wave signals that skip beyond normal ground-wave range, by reflection from the ionosphere.)

To overcome this deficiency, the Bureau of Reclamation solicited parties interested in providing cable TV service in Page. Ameco's common carrier affiliate, Antennavision Service Company, accepted the challenge. They immediately undertook an intensive campaign to develop a microwave network from Hutch Mountain, 30 miles southeast of Flagstaff, with two repeaters on the Navajo Indian Reservation out in the middle of nowhere. Hickman had built the Hutch Mountain microwave site several years earlier to feed signals to the system at Winslow, Arizona. Under intense pressure from a competing group, the Bureau of Reclamation gave

Antennavision just 21 days to deliver cable TV service in Page before granting the authority to the other group. So, Richey had just three weeks to build a three-hop, five-channel microwave relay network under the most adverse conditions imaginable.

On the twentieth day, late on a Saturday afternoon, with microwave paths aligned and technicians at each of the three sites, pictures on one channel began to come through. People had come up from Page to the receiving site, looking at pictures through the door of the equipment shack. Then, as more channels began to come in, people brought TV sets from home to watch. When it started to rain, they got in their cars and watched TV through the car windows! They were hungry for TV.

To meet the deadline, RG-11/U coaxial cable with copper braid outer conductor had been strung on Arizona Public Service electrical supply poles. In many cases, where house trailers were parked directly beneath the TV cable, residents discovered that they could get excellent pictures by just sticking an antenna on the roof close to the TV cable—and it was *free!* The RG-11/U cable was leaking like a sieve.

Aluminum Cable and Gilbert Connectors

In his TV broadcast experience, Richey had used some 50-ohm, solid sheath aluminum cable made by Rome Cable in New York. So, he went back to Rome and arranged with Jack Woods, marketing manager for Rome Cable, for a special order of several reels of 75-ohm aluminum cable, which was not at that time a standard product. He would replace the RG-II/U cable with Rome's solid sheath aluminum and put a stop to the signal leakage.

But, there were no connectors for aluminum cable. Hickman had found the old standby PL-259 connectors were a frustratingly poor match for the 75-ohm amplifier termination ports. Ameco engineers had remodeled the PL-259 and offered it as a product. But it was not compatible with the solid sheath aluminum cables. A new connector simply had to be invented to protect the Page system from hemorrhaging its very lifeblood through leaky braided cables.

Jim Connor had worked with Hickman as a technician in the early days of the Globe-Miami system as well as at Kaiser. By 1960, he was purchasing agent for Ameco, and he drove race cars on weekends. Connor was well aware

of the problems with the PL-259, and he knew that Richey needed connectors to go on those $1/2$ -inch aluminum cables. So he said, "Hey, automotive copper connectors will fit the outside of that so we can just put a swedge fit on those with a little compression ring." "Fine," Richey said, "that's great. Now what are we going to do for the center conductor?" Connor said, "I've got a good idea." Teflon was new at that time, and was one of the first plastics that could readily be machined. Connor continued, "I have a friend who has a lathe and often makes parts for my race cars." So Connor and his friend took a small piece of copper tubing, just barely larger than the center conductor, and slit both ends. Then they pushed it through a hole drilled in a piece of Teflon and machined it in the lathe to be just slightly larger than a $1/2$ -inch brass nipple. Using a drill press, they carefully forced the Teflon into the brass nipple, and Richey had an effective splice. By inserting the brass nipple through a hole in the chassis, securing it with a back nut, and soldering (or clamping) the center conductor to the circuit input, he had an effective chassis connector that was a much better match to the 75-ohm cable than a PL-259 <Richey 1994, 20>.

Jim Connor's friend was Earl Gilbert, a wholesale butcher by trade, who had established his little machine shop as the Gizmo Manufacturing Company, a contract screw machine plant. Gizmo's main product was a speed reducer for Sears Roebuck's band saw. But soon Gilbert was producing connectors, not only for the Antennavision CATV system at Page but for Kaiser-Cox, Ameco, and Anaconda as well. He changed the company's name to Gilbert Engineering Company and in 1969 sold the business to Transitron Electric Company. A few years later, Gilbert was fired by Transitron and brought suit. It is said that he started Pyramid Industries to manufacture connectors, among other products.

About 1975, while Gilbert Engineering was still an autonomous subsidy of Transitron, Bob Spann joined the staff. He had been an engineer with Anaconda Astrodata until the company began terminating its cable TV business. In 1986, the bank finally separated Gilbert Engineering from the foundering Transitron and put Spann and three colleagues in charge.

Jim Connor was killed in a freak accident in his own race car. He was a brilliant young man whose career was tragically cut short.

Jerrold Electronics Corp. was also manufacturing connectors designed by Eric Winston for solid sheath aluminum cable. In 1973, Winston introduced the integral sleeve inserted between the dielectric and the aluminum sheath to ensure a stable and secure grip by the connector back nut, a feature that has been incorporated into the Gilbert and other connectors <Winston 1973>.

The “free” television reception at Page came to a screeching halt when the leaky braided cable was replaced with solid sheath aluminum, using the just-invented but primitive “Gilbert” connectors. All the subscribers came back, and Bruce Merrill and Richey began to consider building a cable manufacturing plant in Phoenix.

Richey went back to Rome and said to Jack Woods, Rome Cable’s marketing manager, “Jack, we need to build a cable plant in Phoenix.” Woods said, “Phoenix is the right place to put it.” One of the problems in making foam dielectric coaxial cable at that time was that they had to put it in ovens to bake the moisture out. Woods said, “If we did it in Phoenix, we wouldn’t have to bake it; we would just sit it out in the sun.” Richey said, “Let’s do it.” However, they wondered whether the cable TV market was reliable enough to support the enormous investment in such a plant. In the end, they hedged by designing the

Ameco cable plant primarily to make electrical supply wire and cable. The 75-ohm coaxial cable would be a by-product. Woods was hired away from Rome Cable to direct and manage the Ameco cable operation. Woods brought Sid Mills, an experienced coaxial cable engineer at Rome, to provide the engineering skill and supervision <Richey 1994, 27>.

Phelps Dodge, Times Wire and Cable, General Cable, Superior Wire and Cable (predecessor to CommScope), and others quickly moved to join Rome in supplying the growing demand for solid-sheath aluminum coaxial cable. After several years, Ameco Cable was taken over by Systems Wire and Cable, which eventually was sold to Scientific Atlanta.

The Environmental Test Chamber

The effect of temperature changes on the attenuation of coaxial cable was recognized early. The temperature coefficient is reasonably independent of frequency at 0.1 percent of the decibel attenuation ratio per degree Fahrenheit. However, since the attenuation of a given length of cable is roughly proportional to the square root of frequency, the thermal changes are also frequency

sensitive. To compensate for thermal changes, SKL first hung a temperature sensor outside the amplifier housing to measure the ambient temperature and adjust the amplifier gain accordingly. Others varied both slope and gain in accordance with the detected voltage of one or two pilot carrier signals, according to prearranged algorithms.

In his oral history interview, Richey said, “One of the things that we knew is that cable was sensitive to temperature, and we knew it was a problem. We had a theoretical notion about how cable behaved, but we needed to find out how to design amplifiers that would compensate for the actual effect of temperature on the cable.” So, he partitioned off a space at the end of the Phoenix laboratory, insulated it heavily, and installed a big air conditioning and heating unit. This climate test chamber was designed to accommodate a simulated 32-amplifier trunk cascade, connected together with solid sheath aluminum coaxial cable wound tightly on reels. Ambient temperature in the chamber could be varied between about -20°F and $+140^{\circ}\text{F}$ within a 24-hour period. The Ameco amplifiers appeared to be performing superbly in the chamber but, Richey says, “We had difficulties with our amplifiers and AGC in the field because we had

designed to what we thought were real conditions, but turned out to be unreal.” Finally, over a long period of time, they realized that although the ambient temperature cycled correctly, the temperature of the dielectric and center conductor inside the cable changed very little. So they reduced the capacity to 10 cascaded amplifiers, wound the cable much more loosely on the reels, and allowed up to 48 hours to approach thermal stability at minimum and maximum temperatures <Richey 1994, 24>.

Other equipment suppliers had used small environmental test chambers, generally limited to a single amplifier unit. The Ameco chamber appears to have been the first large enough to accommodate a cascade of amplifiers and normal size coaxial cable. However, it was soon copied and probably improved upon. Large-scale temperature test chambers have been of substantial value in defining the successful characteristics of an automatic gain and slope control system.

The Challenge of Transistors

When Richey joined Ameco in 1957, a low-band, channel 2-6, broadband, stagger-damped, double-tuned vacuum-tube amplifier was just about the only product

they were manufacturing. They had previously produced channel 2, 4, and 6 strip amplifiers. Hickman had done a splendid job with the low-band, broadband amplifier, using the stagger-damped double-tuned circuits. Richey called it “an excellent amplifier, a beautiful design.” But the time was coming to consider the full 12-channel bandwidth.

Bruce Merrill and Milford Richey frequently took time at the end of the day to contemplate strategic plans for the company—determining what products should be developed and reviewing goals and achievements. At one of these sessions, Richey discussed two options: (1) follow SKL’s lead with a distributed gain amplifier or (2) get into the new era of transistorization. He hastened to add that he knew absolutely nothing about transistors, which had come along too recently to be included in the university curriculum. Going to market with a look-alike, “me-too” product was not an attractive option. Perhaps Ameco could condense the transistor learning curve with help from the experts. They decided first to find out what help they might get from the Motorola semiconductor division just starting up in Phoenix.

Motorola was very proud of its Mesa series transistor. They considered it far superior to anything else

that had been developed, particularly with regard to its high-frequency capability. However, its f_t (the highest frequency for which the gain is greater than unity) was only 50 MHz, which was clearly not good enough. Nevertheless, Ameco ordered a batch and started experimenting. They developed a system called emitter tuning, apparently never used before, with which they found a few Mesa series transistors with useful gain up to as high as 300 MHz.

Motorola could not believe it until they saw it with their own eyes. Richey showed them the test bench he had set up to test transistors, with square-wave modulation on 12 FDM (frequency division multiplexed) television signals, at frequencies up to 300 MHz applied to the transistor in the test jig. If the operator could see cross modulation, the transistor was rejected; if not, it was considered a “good” transistor. Although Richey drew diagrams for Motorola, they did not succeed in replicating his test procedure. Instead, Motorola agreed to send Richey a barrel (30-gallon size) of Mesa-series transistors each week. Richey would select the good ones and return the rest. Sometimes, the yield was only 1 percent or 2 percent. But then, 10 to 15 percent tested “good.” So Richey took a batch of good ones over to Motorola and

said, “Whatever you were doing on this batch of transistors was right, but this other batch was terrible.”

It took a long time, but they finally found out what was making the difference. If the saw used to slice the semiconductor crystals were sharp, the yield would be very low. But a dull saw, which left a ragged, serrated edge, had a fantastic effect on the high frequency capability of the transistor—the duller the saw, the higher the frequency for useful gain! Texas Instruments also got the idea, and soon everyone was able to supply transistors with good capabilities at high frequency <Richey 1994, 6-8>.

This was 1958-1959. About this same time, or perhaps a little earlier, Dr. Henry Abajian of Westbury Electronics used transistors in amplifiers he built for his own small CATV system in Vermont <National Cable Television Center and Museum 1997, 32>. Richey’s investigations with Motorola marked the debut for equipment suppliers into solid-state technology for cable TV. Nevertheless, it would be a decade before it could truly be said that the transistor was replacing vacuum tubes.

Now, they knew they could get transistor gain at VHF frequencies, but none of the engineers working at

Ameco knew anything about transistor circuitry. So Bruce Merrill contacted a friend at the California Institute of Technology who recommended the graduate student Ameco hired to help move them up the learning curve. They also hired Bill Rhinefelder from Motorola, a young engineer who had worked with the Mesa series transistors. Ameco staff engineers Jim Connor and Vic Tarbutton also participated in this project. Together, they designed a 10-stage amplifier that was entirely dc powered.

Irving Kahn, founder of the TelePrompter Corporation that had developed the widely used speaker's cueing device of that name, had acquired the CATV system in Great Falls, Montana, about 1960. Kahn was always trying to take advantage of new technology and was quite willing to accept the risks involved when new technology is put in service before it has been fully tested and proven. Kahn had learned from Bruce Merrill about the experimental transistor amplifier that Connor and Tarbutton had put together. He invited Merrill to test the amplifier in his Great Falls system. Ten cascaded amplifiers were required for the trunk run from the Great Falls head end to the distribution center. The existing vacuum-tube amplifiers had to be removed from the aerial

pole line and replaced with 10 new transistor amplifiers.

This was in the middle of a Montana winter. It was a tough experience for engineers born and raised in Arizona and southern California. They were barely able to endure the subzero temperatures, even at midday. They found some relief in the heat dissipated by a Kohler generator used to power their test equipment and a Chinook wind that raised the temperature up to freezing at midnight. “Oh, it was gorgeous!” Richey says of the experience.

After installing their 10 experimental transistor amplifiers, they went to the office to evaluate the performance. Richey says, “The monitor screen was not a blank. It clearly displayed two things—noise and hum—but no pictures.” So, they took down their amplifiers and put the vacuum-tube equipment back to restore normal service to the customers and returned to Phoenix with tails between their legs. Kahn called Merrill the day after the fiasco to say, “Failure is just the beginning. Fix it and come back.” It was a remarkable testimony to Kahn’s can-do philosophy <Richey 1994, 9-10>.

In the postmortems, Richey and his engineers came to see that they had overlooked an important requirement of serial amplifier circuit design: “The gain of each stage

must exceed the noise figure of the preceding stage; otherwise, the noise soon overtakes the signal,” as it did in Great Falls. The 10-stage amplifier designed by the Cal Tech graduate student simply had too little gain per stage. They also realized that it was not possible to filter or regulate induced 60-Hz hum out of the dc cable powering. The Great Falls experience had taught Richey and the other engineers and technicians at Ameco a great deal about transistors. They were convinced that they could take it from here, and they let the student go back to school to finish his research project.

After the Great Falls attempt, they decided to try something in between and built an amplifier with transistor first stage but vacuum-tube output stage. It was very difficult to align because of the difference in impedance at the interface between transistors and vacuum tubes. They took it to Clay Center, Kansas. Richey would align each amplifier for a particular position. The technician, “Red” Shutz, would install it and bring the next one to Richey. It was difficult because test equipment, such as sweep generators, signal-level meters, and spectrum analyzers, were still primitive and not readily available. They got the small Clay Center system to work, but it was the only system ever built with hybrid

equipment <Richey 1994, 47>.



Fig. 7.3 Ameco's "NO STEP" Model ATM-20 line extender amplifier

*Courtesy National Cable Television Center and
Museum*

Floyd Stewart, one of Ameco's technicians, was a genius at transistor circuit design. He and Ray Stouffer came up with a two-stage, 20-dB amplifier, which they took to the Western Cable show in Palm Springs late in 1960. Because they were in a hurry, they put it in a blister can tap box that could be mounted directly on the pole. However, fearing that linemen might use it for climbing the pole, they put a decal on the top labeled: NO STEP ([Figure 7.3](#)). It quickly became known as the No-Step Amplifier, a designation it never lost. The No-Step turned out to be a popular line-extender amplifier, claimed to have quite favorable intermodulation characteristics <Richey 1994, 11>. Jerrold did not agree, however. Frank Ragone says that when they were able to get their hands on a No-Step, tests revealed the "performance was horrible." He says, "Oh I can remember Ken Simons, especially, saying 'Ah this will never work. It's such poor performance.'" However, he acknowledges that "people were fighting to buy the thing, knocking down the door at Ameco to buy them" <Ragone 1994, 59>.

The No-Step is generally considered to be the first

transistor amplifier actually marketed to the cable TV industry. Similar circuitry was packaged in a hermetically sealed cylindrical housing ([Figure 7.4](#)) that became quite popular. SKL adopted the cylindrical packaging (see [chapter 8](#)) for its first attempt at transistorization, and Craftsman tried at one time to copy Ameco's cylindrical amplifier ([chapter 12](#)). It was expected that the small, cylindrical amplifiers would not have to be clamped independently to the strand but could be lashed along with the cable. There were some who considered this to be a sort of "lossless cable." Reality, however, was more complex.



Fig. 7.4 Ameco's hermetically sealed cylindrical amplifier

*Courtesy National Cable Television Center and
Museum*

About this time, a young man named Don Nelson, who was also very good with transistor circuitry, joined the Ameco staff. He was primarily responsible for the interstage diodes used to provide AGC control. Nelson later went to Scientific Atlanta where he participated in developing the feed-forward technique. In 1961, they took a full new series of transistor trunk and distribution equipment to Santa Barbara for the system being developed by Harry Butcher, General Eisenhower's communication aide during the war.

In his oral history interview, Bruce Merrill expresses the opinion that by using Motorola's individual transistors worked into the amplifier circuits, Ameco had produced the first fully transistorized amplifier on the cable TV market. "But," he goes on to say, "when TRW came out with the solid-state, integrated circuit chips, they had solved some problems that Motorola never solved. So, Ameco had a few years of very high recognition but we did not get on the chip bandwagon when we should have. We stayed with the technology we developed with Motorola too long. That led to the

eventual demise of Ameco” <Merrill 1991, 36>. Probably, however, that was but one of the significant factors leading to the unfortunate outcome.

Surface Wave Transmission—G Line

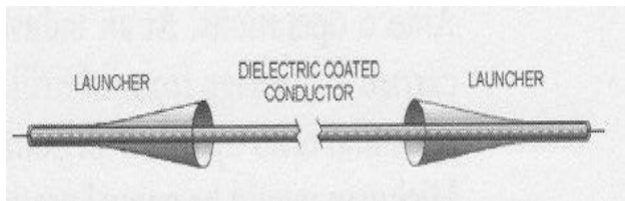


Fig. 7.5 The G-Line, surface wave transmission line

Courtesy CEO

Richey was not involved in the Scotty Gray open-wire line misadventure. However, he did have some experience with the surface wave transmission line, more commonly referred to as G-Line after its inventor, George Goubau, a German scientist who came to the United States immediately after World War II. G-Line consists simply of a single wire coated with $\frac{3}{8}$ inch of polyethylene <Goubau 1954>. The theory of the G-Line is that so much

of the transverse electric and magnetic (TEM) electromagnetic field is concentrated in the dielectric that there is no need for an outer conductor. A long, tapered diameter launcher, which looks like a narrow-mouth conical horn, provides the transition between G-Line and 75-ohm coaxial cable ([Figure 7.5](#)). The combined loss in the dielectric and launchers is about one-tenth that of $3/4$ -inch aluminum cable <Taylor 1991>.

Since there is no outer conductor, the insulated wire has to be suspended from supporting structures with nylon rope. Moreover, corners have to be turned gradually, like a trolley wire. Lightning and static discharge also present serious problems, since there is no way to drain the static charge accumulated between launchers. “So, what I did,” Richey says, “was put a 6-dB pad on the input and output of every unit, and when the lightning hit, it would blow the pad. Fine. You go out and throw it away and put another one in, because if you didn’t do that, it would blow out everything.”

The fatal flaw in the G-Line, however, was that its losses were dissipated in radiation, not heating. Richey says, “There was more signal coupled to a barbed wire fence directly underneath than on the G-Line itself.”

Antennas placed close to the wire, and especially at the launchers, are quite effective for stealing signals. Richey installed the G-Line along an almost uninhabited and nearly perfect straight line from the system in Winslow (east of Flagstaff) to provide entertainment for the technicians at an isolated radar base several miles to the west. It worked beautifully for many years, until the base was dismantled and abandoned <Richey 1994, 30-31>. Another G-Line installed to carry signals received on McDonald Pass to a cable system at Helena, Montana, also worked well but was discontinued because of rampant theft of service along the way.

RICHEY JOINS COLLINS RADIO AND HICKMAN REJOINS AMECO

In his 10 years with Ameco (1957-1967), Richey made substantial contributions to cable TV technology. In addition to developing broadband transistor amplifiers, he introduced solid-sheath aluminum cable, initiated the development of the Gilbert connectors, introduced foam-filled taps, and developed a complete line of directional taps.

Richey had purchased Collins microwave equipment

for Ameco's common carrier ATR network, which became rather extensive. In 1967, he resigned from Ameco and accepted an offer to work with Collins Radio in Dallas. Based on his contacts in the cable TV industry, he soon took over Collins' marketing department. Before he left Collins in 1973 to return to Ameco, he had increased their annual gross sales of microwave equipment from less than \$1 million to more than \$40 million <Richey 1994, 34-39>. Richey stayed at Ameco until 1977. After building and operating the system in his hometown of St. Johns and other cities, he is now deeply engaged as a consultant, equipment supplier, and system owner in the MMDS industry, sometimes called by the oxymoron "wireless cable."

In the mid-1960s, Bruce Merrill brought in George Green, a financial expert who had worked with Greyhound's investment team to assist in managing the Ameco operations. At an industry meeting in Los Angeles early in 1966, Green carried a message from Merrill to Hickman. Merrill wanted Hickman to come back and head up a new organization to be called Ameco Engineering Company. Hickman would be named president and compensated at a rate 50 percent higher than he was making at Kaiser-Cox. It was an offer he

couldn't refuse. So, after eight years with Kaiser-Cox, Hickman rejoined the Ameco team in March 1966.

When Hickman rejoined Ameco, they were working on a contract with General Dynamics to build the equipment for transmitting three channels of video and audio signals to and from the National Aeronautics and Space Administration (NASA) Launch Complex 39 (LC-39) at Cape Canaveral. They were designing not only the broadband (54-88 MHz) RF amplifiers but also the modulators and demodulators for what was to be the key link through which the world watched the first moonwalk. When Hickman inquired about the status of the LC-39 project, Bruce Merrill said, "Oh, we're just about ready to deliver on it." In his oral history Hickman says, "You see, what Bruce didn't know was that he was equating spending the development money with being ready to deliver. They had spent the development money, but they had no product to deliver. Now comes where I pull the fat out of the fire for him" <Hickman 1992, 58>.

Upon investigation, Hickman learned that the project engineers were having trouble with ghosts and other forms of degrading waveform distortion. He quickly recognized these as the consequence of envelope delay (phase shift) problems associated with the filters,

especially the vestigial-sideband (VSB) shaping filters in the modulators. John Pranke, one of the engineers on the project, had come to Ameco with Jack Woods and Sid Mills from Rome Wire and Cable. Hickman says, “John Pranke was... a darn good electrical engineer, very conversant about coaxial cable, because I guess he was the engineering know-how at Rome Cable.” So Hickman assigned him to the LC-39 project. With guidance based on Hickman’s experience with filter design, Hickman says, “Pranke was able to work that thing out to a successful conclusion. Of course, we overran the contract in doing it, but Ameco didn’t wind up in court.” The equipment was delivered on time but not within budget. In fact, Hickman says, “Bruce Merrill took a bath on the project” <Hickman 1992, 57-60>.

Hickman believes that the amplifier developed for the LC-39 project probably had more uniform frequency response, along with a low noise figure and favorable intermodulation characteristic, than any low-band VHF broadband amplifier available at the time. Shortly after completing the LC-39 project, the same amplifier was used for a five-channel head end run at Charleston, West Virginia, in 1968 <Taylor and Janes 1970>. By this time, there was not much demand for amplifiers limited to the

low VHF band, and the LC-39 amplifier never really became a standard product line.

Hickman was not satisfied with his second tour at Ameco. “I just simply was not able to straighten out the mess that existed at Ameco when I went to work there—the technical mess that was involved. It wasn’t just technical. The problems were deep-rooted and I just never could straighten it out. And I feel bad to this day that I couldn’t do it. ... It seemed like I met with obstacles at all turns. Like, for instance, I knew for a fact that Ameco should spend the development money to build a good push-pull amplifier, because I could see that was the way we were all going. ... Before I left Kaiser, I had put the ball in motion for the push-pull Kaiser amplifier. I thought that I would do the same thing over at Ameco. I just simply was not allowed to do it. Rather than develop a transistorized push-pull amplifier, I had to try to convince people that single-ended amplifiers were just as good—which they were not, as far as second-order distortion is concerned. They just simply were not, and how could I tell good and qualified engineers that their ideas were all wet? But that is essentially what I had to do” <Hickman 1992, 63>.

Upon his return to Ameco, he found himself in a

crash program. He had 30 days to prepare a single-ended product that was only partially developed for display as the Pacesetter series at the NCTA Convention at Miami Beach in June 1966. They did it—they got the Pacesetter to the show in 30 days! Hickman asks, however, “Now, what kind of an amplifier can you produce in 30 days? They sold a lot of Pacesetter equipment that was just literally hashed together” <Hickman 1992, 60>.

Hickman says, “Bruce wanted to do something that was drastically different. I think that is why he wanted to get in with Scotty Gray, you know. He wanted to do something that was drastically different from what everybody else was doing. And that is why we spent so much time at Discade™ and all kinds of weird things. We used to say that Bruce didn’t believe in ‘designing’ equipment— he believed in ‘divining’ equipment. ... Bruce was not a technical man, but he got too deeply involved in the technical end of his business” <Hickman 1992, 64>.

The Channeleer

After completing the LC-39 project, Ameco arranged with Gary Gramman, founder of the Dynair Company in

San Diego, to design and produce a good transistor television modulator to be marketed under Ameco's logo. Apparently, Ameco never did develop a demodulator for the market.

In 1962, shortly after Hickman left Ameco to join Kaiser, Jerrold introduced its Channel Commander heterodyne signal processor, originally using vacuum tubes but later transistorized. This equipment effectively eliminated the array of converters often required at the head end to adapt the off-air channel frequencies to the bandwidth available on the cable. With the heterodyne signal processor, any input frequency would be converted first to an intermediate frequency and then up-converted to the desired output frequency. The signal processor could handle any combination of channels without regard to the "prohibited conversions" inherent without the intermediate conversion. It was a great idea on which Ameco determined to capitalize.

When Hickman returned to Ameco, he assigned Gay Rogness the task of designing an Ameco equivalent of the Jerrold Channel Commander. Hickman calls Rogness the "granddaddy" of the Ameco solid-state (transistor-based) heterodyne signal processor known as Channeleer. However, in 1967, before he had finished the

project, Rogness resigned to become the head of the new cable TV division of Anaconda Astrodata. John Pranke was designated to complete the job. The first model Channeleer was displayed at the NCTA Convention in Chicago in 1967; by 1969, it had been installed and tested in Charleston, West Virginia, and elsewhere.

Ameco planned to display a complete, operational, 20-channel, Channeleer head end at the 1970 NCTA Convention at the Palmer House in Chicago. John Pranke had completed assembling and testing the display and was ready to dismantle it for shipping to Chicago. Jack Woods had a truck scheduled to carry a load of cable in the general direction of Chicago. There was easily enough room to accommodate the prewired and assembled Channeleer head end. They said they could pack it up and ship it intact so it would not have to be reassembled in Chicago.

However, Hickman had serious misgivings. In 1946, a 250-W radio transmitter he was to install for a radio station in Douglas, Arizona, had been shipped by boat from the East Coast through the Panama Canal to Los Angeles and then to Douglas. Delayed still further by a dockworkers' strike, when it finally arrived the transmitter was so completely scrambled ("homogenized" was

Hickman's description) that it had to be totally rebuilt, right there on-site in Douglas.

Downplaying Hickman's concerns, Bruce Merrill and Woods thought shipping the prewired Channeleer display seemed like a good idea. So, it was loaded up and sent on its way to Chicago. However, that beautiful 20-channel head end that John Pranke had labored over so lovingly arrived in Chicago almost totally demolished. Most of the components had dropped to the bottom of the relay racks in which they had been shipped. Only one of the 20 Channeleers survived in condition to be turned on and used. They had no choice but to set it up in the booth to show that the Channeleer did, in fact, exist. While the hapless display generated considerable sympathy for Bruce Merrill and Ameco and, above all, for John Pranke, it was a painful experience for all concerned <Hickman 1992, 91-94>.

Shortly after this experience, Pranke moved over to Theta-Com, the successor to Kaiser-Cox. Pranke brought with him the expertise developed at Ameco and jumped right in to the development of Theta-Com's big push-pull transistor amplifier that became their stock in trade for many years.

Discade™

About 1968, Hickman was faced with the challenge of designing a long head end run carrying seven or eight channels in Huntsville, Alabama. In order to provide the highest possible performance quality, Hickman applied the NQV (not-quite-video) concept, adapted from Jerrold's experience in Dubuque, Iowa. All channels were transmitted in the 7-13 MHz band on separate solid-sheath aluminum coaxial cables, bundled together with the messenger strand on an overhead pole line. The visual carriers were phase-locked. Hickman reports that they had no problem with crosstalk, even without sleeved connectors, the importance of which had not yet been discovered. With head end signal levels at +70 dBmV and cable loss of 0.25 dB per 100 feet at 13 MHz, excellent performance (53 dB CNR) was achieved over a 4.25-mile run without repeaters <Hickman and Kleykamp 1971>.

Building on the success of the NQV installation at Huntsville, Hickman proposed to Bruce Merrill the possibility of introducing innovative network architecture based on NQV and channel selection by remote switching. The British Rediffusion Company that had installed similar systems throughout the United Kingdom

had long touted the switched network architecture. Merrill liked the idea. He was always looking for ways to distinguish Ameco from the competition. The new architecture was called Discade™.

Hickman and Gay Kleykamp, the staff engineer who had worked on the project, presented a technical description of Discade™ at the IEEE Convention in New York on March 22, 1971 <Hickman and Kleykamp 1971>. The Discade™ system evolved as a means for dealing with the following problems:

- Long haul with minimum degradation.
- Direct pickup interference.
- Expanded channel capacity without a set-top converter.

The original Discade™ system comprised 20 channels, each carried in the 7-13 MHz band on separate coaxial cables. Carriers were phase locked to minimize the effect of crosstalk. Repeater stations contained 20 amplifiers (plus one for FM), spaced about 5,000 feet apart. Area distribution centers (ADC) with a capacity of 48 switching modules were bridged to the trunk along the way. Dis-cade™II was an upgrade, providing two

channels for each cable at 34-40 MHz and 22-28 MHz. This halved the number of cables required and reduced the exposure to crosstalk. Although the higher frequencies also reduced the repeater spacing by half, the trade-off was probably favorable.

Subscribers were provided channel-selector boxes with channel ID display windows and either a rotary switch or push-button keypad. The selector switch simply pulsed a solid-state shift register at the ADC to activate the desired channel. It was a primitive sort of pulse code modulation (PCM), with pulses essentially at dc, no carrier required. Hickman designed an innovative switch arrangement at the ADC, based on a lumped parameter transmission line to provide negligible shunt loading when several customers selected the same channel. A fixed-frequency converter was activated for each customer to change the frequency from NQV (not quite video) to channel 3 (or 4) for reception on the TV set. Hickman is particularly proud of the channel dial indicator, which is based on the Möbius strip. By twisting a length of flat ribbon before joining the ends into a continuous belt, the resulting strip is found to have only a single, continuous surface on which the channel numbers 1-20 were printed.

Discade™ was installed at Daly City and Broadmoor, California. A different version was installed at Disney World, near Orlando, Florida, in which each separate cable carried a different program at the standard intermediate frequency (IF) of 41-47 MHz. Although Discade™ was technically well executed, it did not meet with much success for several reasons. First and foremost, it was considerably more expensive than the almost universally adopted tree-and-branch architecture with set-top converter. Moreover, substituting the subscriber selector station for a set-top converter did not eliminate the confusions and irritations caused by abandoning the normal operational features of conventional TV sets. Although some may have considered large bundles of coaxial cable hanging from overhead pole lines to be rather unsightly, this did not become a big issue <Hickman 1992, 65-69>.

Hickman Retires from Ameco

Hickman left Ameco for the last time in January 1972 to establish and operate his own complex of cable TV systems. Bruce Merrill brought Jack Blanchard in as president of engineering to replace him. After leaving

Ameco, Hickman accepted a consulting assignment to evaluate the Quasi-Laser Link <Vogelman and Reader 1972> being installed by Joe Vogelmann in Colorado Springs, Colorado, for George Milner, chief engineer for Cablecom General. This was a frequency-modulated, multichannel microwave link (belying its name, the Quasi-Laser Link had nothing to do with lasers). Hickman found that it was noisy and loaded with intermodulation. They had ignored many of the classical pitfalls in FM technology. He says, "It was my painful duty to have to explain to them mathematically why it did what it did; how phase distortion ultimately showed up in much the same way in FM as intermodulation in AM." Vogelmann resisted, "clawing and scratching all the way" <Hickman 1992, 79-82>.

Most of the engineering techniques used by Hickman and Richey were based on the application of already published technology in situations not previously encountered. Innovation was a matter of necessity. Hickman powered the Globe-Miami head end on Madera Peak with 1,200 V on K-14 coaxial cable, well before Entron's first cable-powered installation at Nacogdoches, Texas, in 1959, although this could hardly be considered a realistic precedent for the industry. It was about 1955

when Hickman decided to use the 4.5-MHz aural subcarrier instead of baseband audio as input to a microwave transmitter. A few years later, Richey had Collins build IF heterodyne microwave equipment for Antennavision. Richey thinks that he may have installed the first solid-sheath aluminum and foam polyethylene coaxial cable at Page, Arizona, about 1959. Under Richey's direction, by 1960, before Jerrold's TML, Ameco was producing transistor amplifiers. Although Hank Abajian is frequently mentioned as the first to use transistor amplifiers for CATV, he did not market such a product.

Neither Hickman nor Richey were much concerned with being "first." They simply wanted to use their remarkable technological skills and innovative genius to make systems work. In this regard, they were not much different from other CATV equipment pioneers. Earl Hickman is now busy in El Cajon restoring and rebuilding antique aircraft, often World War II vintage.

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CHAPTER 8

Spencer Kennedy Laboratories

MOST EQUIPMENT SUPPLIERS FOR CABLE TV HAD ROOTS IN THOSE SEGMENTS OF THE CONSUMER ELECTRONICS INDUSTRY RELATED TO THE RECEPTION OF TELEVISION SIGNALS. Milt Shapp's Jerrold began with Don Kirk's little set-top booster. When Paul Merrill and Earl Hickman brought Bruce Merrill and others in to form Ameco, they were already building their own equipment for distributing television signals in Globe-Miami, Arizona. Entron was a marketing and installation spin-off from Jerrold, based on Hank Diambra's conviction that he could do it better. Like Jerrold, Blonder-Tongue started with a TV booster placed at the top of the antenna mast instead of set-top, like Jerrold's. Magnavox was a receiver manufacturer. The roots of Spencer Kennedy Laboratories (SKL) and Scientific Atlanta (SA), on the other hand, were in the military-industrial complex.

FITZROY KENNEDY

Fitzroy Kennedy's active technical leadership in SKL was largely phased out in the early 1960s. He died in 1988. The technological oral history project for this book was organized too late for an interview regarding the work he had started at SKL. The technological history of SKL, therefore, has been documented in interviews with Robert Brooks (1992), Argyle "Socks" Bridgett (1992), and Dr. Jakob Shekel (1992), key engineers throughout most of SKL's cable TV activity.

Kennedy was a brilliant young engineer from the Massachusetts Institute of Technology (MIT) who got started about 1948 producing an electronic filtering system (Model 300) used in periscope housings on submarines and in testing the strength of aircraft wings. The Woods Hole Institute used Kennedy's filters in research projects to filter out extraneous noise. George Ray, Victor Porkony, Bill Simon, Harrison "Hap" Horn, and other engineers from the MIT/Harvard scientific community joined with Kennedy as they expanded to other products on government contracts. They worked on such projects as ground control approach radar for Air Force bases and optical systems for nuclear submarines.

Seeking financial support for his endeavors, Kennedy went to the New England Merchants Bank in

Boston. Their banking officer was Art Snyder, who later became an important lender to SKL and much of the fledgling cable TV industry. Snyder introduced Kennedy to Donald Spencer of Scudder, Stevens & Clark, the Boston investment banking firm that represented the historic and very wealthy Brewster family. A famous family forebear, William Brewster, came to America on the *Mayflower* in 1620 and helped the Pilgrims settle Plymouth Colony.

Spencer was a financial man and became Kennedy's financial advisor. He was not an engineer like Kennedy and the other bright young people who were doing the creative work. Together, Spencer and Kennedy persuaded George Brewster to provide the equity portion of the capital funding, which was never offered to the public. Understandably, the Brewster family wanted someone with a financial background running the company in which they were to have a major financial interest. About 1949 or 1950, Spencer was installed as president, and the company name became Spencer Kennedy Laboratories, Inc. <Brooks 1992, 36-38>.

SKL was housed on the second floor of a loft building in Cambridge, Massachusetts, above a barroom, across Massachusetts Avenue from MIT. Before extra

ventilation was installed, the large space was terribly uncomfortable in summer. About 1957, the operation moved across the Charles River to 1320 Soldiers Field Road in Brighton, still close to the wellsprings of technology at Harvard and MIT. Personnel included 7 or 8 engineers, an equal number of technicians, and some 30 or so production workers. Lester Smith became SKL's first chief engineer, after obtaining his master's degree at MIT in 1950. He worked for RCA after receiving his bachelor's degree at Georgia Tech <Bridgett 1992, 10>. Many of the engineers and technicians were part-time employees. Bob Brooks, Bill O'Neil, and Adrian Roy were among the group of co-op engineering students from Northeastern University who were employed at SKL at various times.

From the beginning in 1948, SKL (and Kennedy's group before SKL was organized) produced specialized wideband oscilloscope amplifiers under license from Electrical and Musical Industries (EMI) in London. Marconi-EMI was a holding company comprising the three-way merger of the British H.M.V. (His Majesty's Voice) Gramophone, in which RCA held a substantial interest, with Columbia Gramophone and Marconi Wireless Telegraph.

George Ray was one of the early engineers who

remained with SKL until the end. Under license for patents covering transmission line techniques used for radar during the war, Ray developed a pulse generator in which a charged transmission line could be quickly discharged through a mercury-wetted contact. Pulses as short as $1/10$ of a nanosecond duration (*$1/10$ of a billionth of a second*) could be produced, depending on the length of the transmission line. In combination with SKL's traveling-wave tube oscilloscope and the wideband distributed gain amplifier, the pulse generator was also used for time domain reflectometry (TDR). TDR is a means for determining the distance to a fault in a coaxial cable, and the nature of the fault itself. Using radar techniques, a very short pulse sent out on the coaxial cable is reflected back from any kind of fault or discontinuity in the cable. The time required for the pulse to make the round trip is measured and converted to distance. The characteristics of the reflected pulse provide information as to the nature of the fault. TDR technology facilitated the development of the SKL distributed gain amplifier, but it would be another 10 years before the technology would find general application in CATV equipment design and network maintenance <Bridgett 1992, 25-28>.

SKL was also licensed to use the British patent issued in 1935-1937 to Dr. W.S. Percival, chief scientist for EMI. The Percival patent described what is now widely called a distributed gain amplifier, sometimes referred to as a chain amplifier <Percival 1935>. In 1949, Kennedy co-authored a paper with H.G. Rudenberg, presenting a mathematical analysis of the chain amplifier. Although this paper makes no mention of potential CATV applications, it does provide significant empirical information regarding its practical implementation <Rudenberg and Kennedy 1949>. A brief, nontechnical explanation of the distributed gain amplifier is given in [chapter 3](#), mostly by nontechnical analogy.

Kennedy well understood the enormous advantage of the distributed gain arrangement over interstage coupling for wideband applications. By 1949, SKL was already building the Model 200 pulse amplifier with 200-MHz bandwidth using distributed gain technology for government clients. Model 200 had a single stage and was used as a pulse amplifier attached to an oscilloscope. The Model 202 was also a 200-MHz amplifier, but it had two stages of distributed amplification for higher gain. When he first learned about CATV, probably about 1950, Kennedy immediately recognized that by stretching the

Model 202 bandwidth to 216 MHz it could be an ideal amplifier for transmitting the entire TV and FM radio bands through CATV networks like those springing up in Pennsylvania and the Pacific Northwest.

About 1952 or 1953, the Amplivision Corporation in Los Angeles, an affiliate of the International Telemeter Corporation (ITC) and Paramount Pictures, began marketing a copy of the SKL distributed gain amplifier. It was a 12-channel amplifier with two stages, each of which used six 6AK5 vacuum tubes. Kennedy was outraged because Amplivision was not licensed to use the Percival patent that was still in force <Bridgett 1992, 38-39>. SKL's attorneys brought suit, and Amplivision had to discontinue its distributed gain amplifier product. Amplivision was also the assignee of the famous Mandell-Brownstein patent for the set-top converter <Mandell and Brownstein 1967>.

ARGYLE "SOCKS" BRIDGETT¹



Fig. 8.1 Argyle W. “Socks” Bridgett

Courtesy Argyle W. Bridgett

Argyle “Socks” Bridgett ([Figure 8.1](#)), born 1916 in Quincy, Massachusetts, started at MIT in the class of

1937 but dropped out for a time before and during the war. He completed the bachelor of science in mathematics and physics at MIT in 1946, with a goal of becoming a scientist and pursuing an active interest in engineering and ham radio.

In 1951, after teaching physics at Franklin Technical Institute in Boston, he decided to go back into engineering. During his interview at SKL with Lester Smith and Kennedy, they talked, incredibly as it seemed to Bridgett, about wiring entire towns for television. By this time, however, Ed Parsons' community antenna system in Astoria, Oregon, and Martin Malarkey's system in Pottsville, Pennsylvania, had already been reported in *Popular Mechanics* <Gibbs 1950> and *Electronics* <Carroll 1952>.

Bridgett presented a paper at the third annual NCTA Convention in 1952 in New York, showing that the theoretical maximum carrier-to-noise ratio in a cascade of identical amplifiers would be achieved if the gain of each amplifier were equal to $10 \log = 4.34$ dB (where is the exponential number = 2.718) <Bridgett 1952>. Simons and others have also shown that for a given spread between carrier-to-noise and carrier-to-intermodulation ratios, the theoretical maximum reach for a cascade of identical

amplifiers would be achieved if the gain of each amplifier were $20 \log = 8.69$ dB. For various reasons discussed in the Simons paper, the practical maximum reach is achieved at higher gain <Simons 1970>.

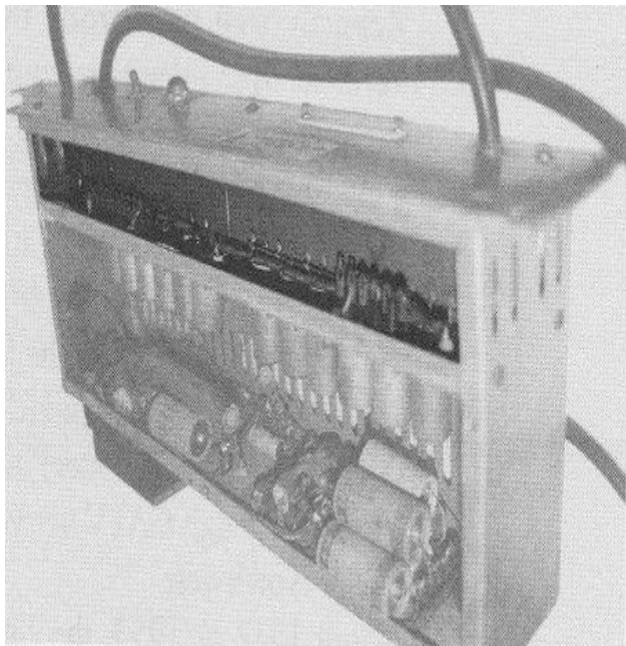


Fig. 8.2 SKL Model 212 chain amplifier, with cover removed to show delay line coils

Courtesy National Cable Television Center and Museum

A young engineer named Charles “Chuck” Kennedy (no kin to Fitzroy Kennedy), a teacher at a technical institute, was employed part-time at SKL in the late 1940s. His assignment was to broaden the bandwidth of the Model 202. He left SKL shortly after Smith came in as chief engineer and Bridgett took over the task <Bridgett 1992, 13-14>. The product, designated Model 212 ([Figure 8.2](#)), was completed about 1951 or early 1952 and was destined to achieve fame and popularity as a CATV chain amplifier.

In designing a chain amplifier, meticulous balancing of the impedance of the input and output delay lines measured over the entire frequency band is critical. The only available sweep generators were crude instruments, intended primarily for repair shops. Bridgett spent countless hours tediously plotting measured impedance against frequency, point by point. Endless repetitions after each adjustment produced literally tons of data. “Boy, I have notebooks with plots of this that you

wouldn't believe," says Socks. "But, hey, when it was done, you had a precise product." Later on, they obtained a Kay sweep generator, using klystron oscillators that could be precisely calibrated. Moreover, the TDR technology that George Ray developed made it possible to see what was happening at each grid and plate junction of the delay lines, greatly facilitating the development of SKL's distributed gain amplifiers.

Lindy Haynes was a sheet metal worker at SKL. Bridgett says, "I'll tell you, we couldn't have made the [Model] 212 without a man like Lindy Haynes." He designed the mechanical mounting for the 6AK5 vacuum tubes, coils, and capacitors with such extraordinary precision that when the components were snapped into place, their electrical characteristics were always exactly the same <Bridgett 1992, 23-27>.

The Bell Telephone Systems, especially those in Canada, expressed considerable interest in the SKL broadband amplifier. In the early 1950s, Bell Canada was generally unwilling to lease space on its poles to unaffiliated cable TV companies. Instead, they would install the cable and amplifiers and lease the facilities back to the operator who would then be fully responsible for its operation and maintenance. Hank Diambra's experiences

in Canada in 1956-1957, as reported in [chapter 6](#), provide an interesting perspective on Bell Canada's interest in SKL equipment.

At this time, about 1951, Jerrold was still struggling to adapt its single-channel strip amplifiers to the rigorous demands of cascaded operation in Lansford, Pennsylvania, and elsewhere. Diambra had not yet organized Entron and was still using Jerrold equipment, which he promptly modified to meet the various situations he encountered. Ameco did not yet exist and Earl Hickman and Paul Merrill had not even started to think about CATV at Globe-Miami, Arizona.

Thus, in 1950, the SKL Models 200 and 202 oscilloscope amplifiers and the expanded band Model 212 by 1951 were the only wideband amplifiers on the market. Western Electric, as the primary supplier for the Bell Systems, saw no reason for more than five channels of TV, plus the FM radio band, in Canada or the United States and requested SKL to modify the Model 212 amplifier. The result was the Model 211, limited to the low-band VHF and FM bands, strictly to satisfy Western Electric <Bridgett 1992, 15-16>. Both the 211 and 212 were certified for Bell System installations and were very successful products.

Except for Western Electric and the Bell Systems, however, the cable industry was not yet interested in broadband equipment. SKL's amplifiers were significantly higher priced than Jerrold's. Because the industry saw no immediate need for more than three channels, they resisted SKL in favor of the more conventional, lower-priced, single-channel designs from Jerrold. However, by 1956 or thereabouts, both Jerrold and Entron were marketing distributed gain amplifiers, more or less copied from the SKL designs, and C-COR had developed its own version. Ameco was using the stagger-damped double-tuned broadband circuits.

The Model 427 splitter (power divider) was another SKL product for which Bridgett was responsible. It used a piece of shielded cable with two center conductors, approximately one-quarter wavelength at the center of the low-band VHF TV spectrum (~65 MHz). At the center of the high band (~195 MHz), therefore, it was approximately three-quarters wavelength. The two center conductors were joined together at one end for the input. A 150-ohm resistor was connected across the two outputs at the other ends of the two conductors. All of the outer conductors were connected together with leads as short as possible <Bridgett 1992, 51>.

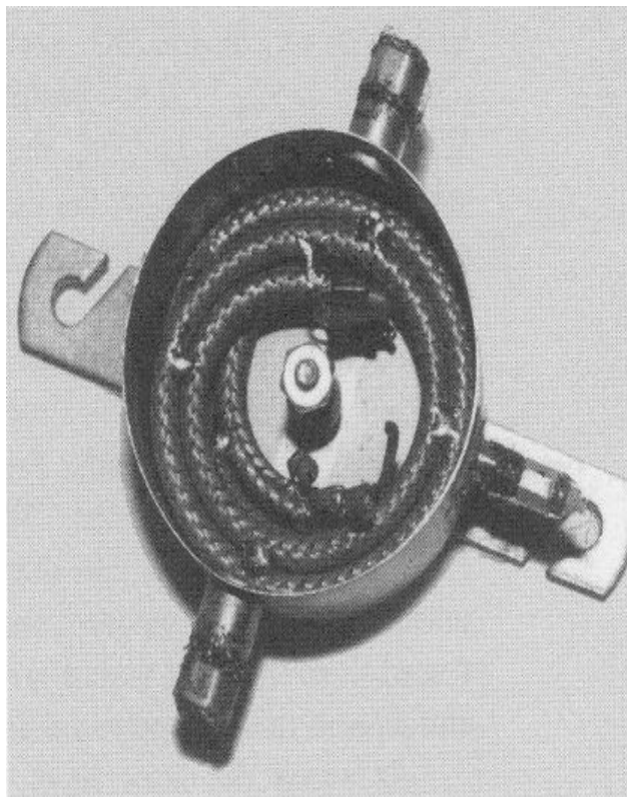


Fig. 8.3 The SKL Chromotap

*Courtesy National Cable Television Center and
Museum*

Approximately 30 inches of twin conductor coaxial cable were coiled up in a rectangular housing. The Model 427 was similar in performance to the Entron Accura-Split (see [Figure 6.5](#)), except that while Entron used two single-conductor coaxial cables <Diambra and Edlen 1953>, SKL used two conductors within a single sheath <Shekel 1955>. Initially, the Model 427 was simply soldered into the coaxial feeder line without enclosure or connectors. Soon, however, the coaxial cable was coiled up and packaged in a cylindrical blister can and designated Chromatap. The center conductor of the coaxial feeder was crimped to a solder lug, and the cable shield was clamped with spring-loaded “hose clamps” to a connecting sleeve ([Figure 8.3](#)). Subsequently, a Multitap housing was built to provide multiple output splitters, based on cascaded 427 (Chromatap) type splitters with military type-N connectors. These splitters provided substantial isolation between output ports in the VHF TV bands but not in the midband (108-174 MHz). Insertion loss was nominally 3 dB minimum, and tap losses were in

nominal 3-dB increments. SKL soon adopted the military 75-ohm, type-N connector that was standard for all of its products until the late 1960s. They never used the PL-259 “UHF” connector.

The Trouble Starts

Bridgett had some direct experience with transistorized control of elevators in multistory buildings and was already monitoring developments for possible application at SKL. In the mid-1950s, Pierre de Bourgnecht joined the SKL engineering staff to work with the electronic filters SKL was developing for government contracts. He was an engineer who had just come from Switzerland with considerable knowledge of solid-state physics. At that time, Don Spencer was fascinated with the prospective benefits of transistors.

Considerable friction developed about 1959 or 1960 when it became apparent that de Bourgnecht was likely to replace Bridgett as chief engineer. Lester Smith, Bridgett, and Win Bemis soon left SKL to form a new company called Imaging Instruments, Inc., based on developing various applications for Raytheon’s storage tubes—TV picture tubes with memory.

Bridgett says they did get some “good fat contracts,” mostly with government agencies, and were able to make a name for themselves in products using image storage tubes. However, after completing the original tasks, they did not get enough new work to sustain the business. Smith stayed with it, but Bridgett and Bemis returned to SKL, perhaps about 1962, after de Bourgknecht was gone <Bridgett 1992, 17-18>. Bridgett had been chief engineer before he left SKL. When he returned in 1962, the chief engineer was Dr. Jacob Shekel, who had worked at SKL while in the doctorate program at MIT and had just returned after a hiatus for mandatory military duty in Israel.

About 1968 or 1969, according to Shekel, new management came in and started to run the company “more like a business” than an engineering company. Shekel added that, “Maybe I used the term ‘business’ almost in a pejorative way. There were massive layoffs. People who had been with the company since its inception were just sent out.” Workers were pitted against management <Shekel 1992, 17>. Bob Brooks says that there “was quite a bit of unrest in the manufacturing group of the company, and they voted to go union, because the union convinced them that that would save

their jobs” <Brooks 1992, 75>. The congenial atmosphere that had prevailed for more than 20 years was gone.

At about the same time, Bridgett had a problem with George Wayne. Bridgett says, “George Wayne was one of the guys who was going to be an angel for SKL—the man who was going to save the company.” According to Bridgett, at the end of World War II, Wayne sold out the company he had organized during the war and with which he had made a lot of money on “aiming for radar and artillery” <Bridgett 1992, 4, 19>.

Shekel, as chief engineer, assured Bridgett that he would not be affected by the layoff. But Wayne had been giving him a hard time. So, in 1969, Bridgett said simply, “I’m sorry. I’ve got to go.” He then accepted an invitation to join George Duffy, founder of Colonial Cablevision in Massachusetts, as a full-time engineer with a share in the ownership of the small multiple-system operation. After the system was fully operational, Bridgett began to take on consulting clients until his retirement near San Diego.

DR. JACOB “JAKE” SHEKEL²



Fig. 8.4 Jakob Shekel, Ph.D.

*Courtesy National Cable Television Center and
Museum*

In 1954, shortly after Brooks had started working for

SKL as a co-op student from Northeastern, Jacob Shekel ([Figure 8.4](#)) found part-time work at SKL to help finance his doctoral studies at MIT. Shekel was an Israeli born in Poland. At age 7, his family moved to what was then Palestine. Most of his childhood and education were in Israel. He received the degree of ingenieur in 1948 from the Technion in Haifa, Israel. As part of his work before coming to MIT, he published several papers on the characteristics of lumped constant and coupled transmission lines, similar to the grid and plate lines used in the SKL distributed gain amplifier. At SKL, Shekel began learning about cable TV, doing some design and testing on distributed gain amplifiers and accessories such as equalizers, taps, splitters, and couplers. In 1957, he received his doctorate from MIT. Obligated by his Israeli citizenship, he returned to Israel for military service during the Yom Kippur War. In 1961, he advised SKL that he was again available. SKL was pleased to offer him a position. In a few years, he was appointed chief engineer.

Shortly after starting to work with SKL, Shekel produced a comprehensive and rigorous mathematical analysis of various circuits based on two-conductor shielded cable <Shekel 1955>. He not only explained the operation of the Model 427 splitter but also extended the

theory to show how it could be used as a directional coupler covering the entire VHF band, 54-216 MHz. The Series 460 power dividers, based on Shekel's analysis of the two-wire coaxial cable, were true directional couplers with low insertion loss and good isolation across the 54-216 MHz band.

One of the ideas Shekel developed after his return to SKL in 1961 was a device to compensate for the thermal characteristics of coaxial cable. The attenuation of coaxial cables varies with temperature at the rate of 0.1 percent per degree Fahrenheit. Losses increase as the temperature increases and decrease when it gets cold. This could cause the amplifiers to overload when temperatures drop at night, producing distorted pictures. But, in the heat of the day as the temperature increases, the signals could become weak, with snowy (noisy) pictures. Moreover, total cable loss at channel 13 as well as the change with temperature is twice as great as the total loss and thermal change at channel 2. Conventional automatic gain control (AGC) compensates for the average variation in cable loss but not for the frequency-dependent variation.

To deal with this problem, SKL used a small temperature-sensitive resistor called a thermistor (they called it a *bliffy snifter*), hanging loosely in space, outside

the amplifier. The thermistor sensed the ambient temperature and automatically compensated for the change in cable loss by adjusting the slope of the amplifier (i.e., the difference in gain at high and low frequency), according to theoretical calculations.

The trouble with this arrangement was that the cable temperature was not necessarily the same as the atmospheric temperature. Black-jacketed cable in direct sunshine is likely to be much warmer than the atmosphere. And, because of thermal inertia, bare aluminum cable in the shade may never completely warm up. In the classic AGC system, the average signal level or, in some cases, the signal level at a particular frequency is sensed and the gain adjusted to hold the level constant. However, the thermal characteristics of coaxial cable require greater adjustment at higher frequencies than at lower frequencies.

By means of voltage-sensitive resistors (or capacitors), an equalizer network can be varied to adjust the slope as well as the gain, an arrangement called automatic slope and gain control (ASGC). This was better than the *bliffy snifter* but still required predicting changes in cable loss under unknown temperature conditions. After his return from Israel, Shekel developed the two-

pilot ASGC system with a low-frequency pilot controlling the gain uniformly at all frequencies and a high-frequency pilot controlling the slope. Shekel also discovered an innovative way to provide two-pilot ASGC in distributed gain amplifiers. “By using two amplifying paths and having a phase difference between the two paths, the combined amplifier has a slope. By changing the phase difference, you can change the slope. So, we ended up actually making an amplifier... based on the distributed gain principle but with gain and slope that could be changed by sensing high pilot and low pilot.” The concept was patented and incorporated into the SKL Model 222-A amplifier <Shekel 1992, 6-7; Brooks 1992, 49>.

During 1960-1962 while Bridgett was away from SKL, the Model 212 was upgraded to Model 222, incorporating Shekel's automatic gain and slope arrangement. While the gain of Model 212 was essentially uniform over the entire passband, the gain of the Model 222 was sloped; that is, it had less gain at the low-frequency end than at the high-frequency end of the passband. When he came back to SKL, Bridgett said, “The Model 222 was a piece of junk,” apparently referring to certain construction details with respect to the coil design <Bridgett 1992, 25>. However,

Brooks says that the Model 222 was even more successful than the Model 212 <Brooks 1992, 48>.

In the early 1950s, Bill Headley and Win Bemis joined SKL to work closely with Western Electric and the Bell Systems in the United States and Canada. Headley worked as vice president and sales manager and Bemis as chief systems engineer. About 1957, with Ford Foundation support, two extensive closed-circuit TV educational projects were initiated by Bell Systems in Washington County (Hagerstown), Maryland, and the entire state of South Carolina. Shekel and other SKL engineers designed the Hagerstown system based on the Model 212 amplifier. Jerrold designed the South Carolina system with a push-pull sub-low (7-95 MHz) amplifier <Shekel 1992, 7, 8>.

Both used multichannel round-robin ring topology with coaxial cable looped through each participating school. A specific dedicated channel was assigned to each classroom equipped with a camera for the use of a TV teacher. TV sets in every participating classroom were connected through a tap to the coaxial ring network. The signal from the teacher's camera was inserted into the network through the tap port, and all signals traveled in the same direction around the ring. A channel-blocking

filter in the tap in each designated classroom kept the teacher's camera signal from colliding with itself after traveling around the ring. Students in all connected classrooms, whether equipped with a camera or not, could view whatever channel was tuned on the TV set. While not truly bidirectional, this was an innovative way to enable each television teacher to talk to many classrooms.

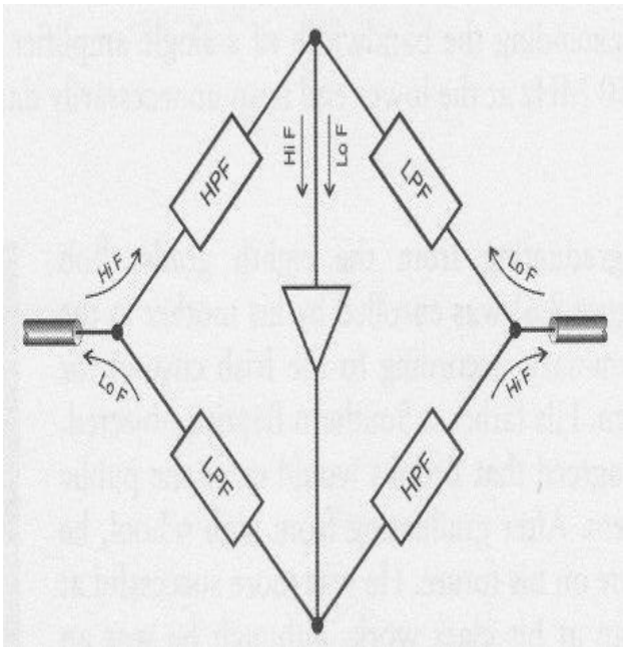


Fig. 8.5 The SKL two-way amplifier (TWA) configuration

Shekel also worked on another unique project,

designing the high-low split system for two-way transmission on coaxial cable. His design comprised a passive bridge arrangement in which the coaxial trunk cable was connected at two corners and the amplifier at the opposite corners. High pass filters in one arm of the bridge allowed signals at frequencies greater than 50 MHz to be amplified and travel downstream on the cable. Low pass filters in the other arm allowed signals at frequencies less than 30 MHz to be amplified in the same amplifier and to travel upstream on the same cable. This was SKL's two-way amplifier (TWA). Shekel says jokingly, "We dropped the acronym to avoid confusion with Trans World Airline" ([Figure 8.5](#)) <Shekel 1992, 8, 9>. A similar arrangement is described in U.S. Patent No. 2,974,188 to H.M. Diambra, March 7, 1961, filed December 1956.

It may have been at the NCTA Convention in 1962 that SKL demonstrated its two-way concept. This was probably the first time the industry had come face-to-face with the idea of using the CATV network for transmission in both directions at the same time. Later in the decade, the idea was being touted so effectively that the FCC included in its 1972 Rule Making a mandate for two-way capability. Chairman Dean Burch said at that time, "[If] cable is going to be just another way of moving broadcast

signals around, [it would be] hardly worth the ulcers involved... (Remarks to NCTA Convention, May 1972). The mandate was subsequently overturned in the Supreme Court (*Midwest Video*).

Nevertheless, all cable TV equipment suppliers now provide optional modular facilities for bidirectional operation. For practical reasons, such as the disparate requirements for forward and reverse network design and operation, separate forward and return amplifiers are used rather than SKL's bridge arrangement.

Moreover, extending the bandwidth of a single amplifier downward to 5 MHz instead of 50 MHz at the lower end is an unnecessarily daunting challenge.

ROBERT A. BROOKS³

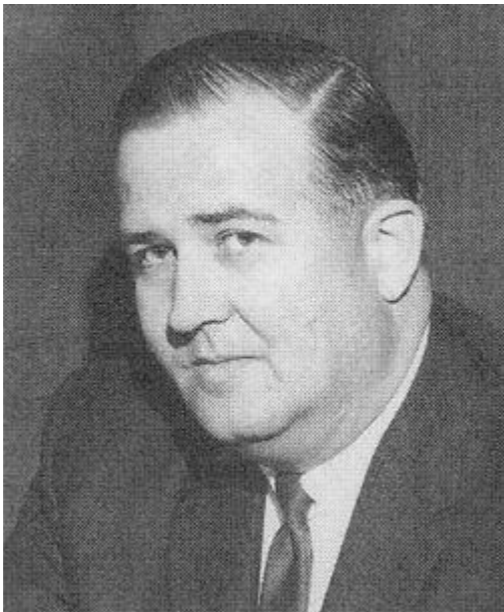


Fig. 8.6 Robert A. Brooks

*Courtesy National Cable Television Center and
Museum*

After graduating from the eighth grade, Bob Brooks

([Figure 8.6](#)) was enrolled by his mother in the Catholic Seminary, according to the Irish custom for the first-born. His father, a Southern Baptist, objected, and it was agreed that Brooks would enter the public school system. After graduating from high school, he would decide on his future. He was more successful at football than at his class work, although he was an honor student in German, Latin, and mathematics. After graduation in 1948, Brooks chose to play football for Otto Graham at the Coast Guard Academy, but at age 16, he was not eligible to join the Coast Guard. So, a year later, the year of the great million-dollar Brinks Robbery, he enrolled in the prelegal course at Northeastern University.

College meant football and sports to Brooks, and he was discontented with book work. In 1950, he dropped out of school and joined the Navy. There he received training in electronics, including radar. He was recommended for flight training by Lt. James Stockdale who later became vice admiral and was awarded the Congressional Medal of Honor while serving as senior naval officer in captivity in Vietnam. In 1953, Brooks left the Navy, married, and re-entered Northeastern University, this time in the school of engineering. He graduated in 1958, some four years after he was hired by

Lester Smith as a young co-op engineering student, alternately working for 10 weeks as a laboratory assistant for SKL and attending classes for the next 10 weeks.

About 1956, Win Bemis asked to have Brooks assigned to help with the design of the towers and antenna arrays for importing distant signals, because of his facility with mathematics. Cochannel interference was a particularly vexing problem for reception of distant signals, and Brooks applied the well-known principle of antennas spaced for phase cancellation in the direction of the undesired signal.

The phase cancellation nulls in the radiation pattern of a phased array are quite sharp. Unless the individual antennas are precisely spaced and oriented, the nulls could be several degrees off the actual bearing of the undesired signal. Brooks and Bemis developed a device called a cochannel filter. Because of the pattern of frequency offsets established by the FCC, cochannel interference causes 10-kHz (in some cases, 0- or 20-kHz) beats. The cochannel filter was often misunderstood, as intended to severely attenuate the effect of cochannel interference. Actually, its function was just the opposite. The SKL cochannel filter was, in fact, a device to selectively amplify and display the magnitude of the 10-

and 20-kHz beats as an aid in adjusting the array to minimize the cochannel beat.

Brooks arranged to have the antennas mounted to the tower on structural steel gates hinged to a tower leg. By swinging the gates, the antenna spacing could be adjusted so as to minimize or eliminate the beat enhanced by the cochannel filter. This technique was most effective in situations in which the angular difference in bearing of the undesired and desired signals was greater than about 20 degrees.

The antenna phasing could also be adjusted by means of delay lines inserted in one of the antenna leads. To facilitate this adjustment, Brooks developed a tapped delay line, consisting of sections of coaxial cable arranged so that varying lengths could be switched into the antenna lead while using the cochannel filter for observing the magnitude of the cochannel beat. Once the required delay and phasing had been determined, the gates would be locked in place and the coaxial lead cut to proper length <Brooks 1992, 39-43>.

SKL pioneered use of the cochannel beat detector, variable delay line, and hinged mounting gates as exceptionally useful tools for dealing with cochannel

interference. It is too bad they were not more widely used. However, the fairly high back and side lobes characteristic of Yagi antenna radiation patterns tended to mask the effectiveness of the phased array. The log-periodic antennas introduced by Scientific Atlanta in 1960 were, in many cases, at least as effective and required no precise adjustments in the field. By the 1980s, cochannel interference problems largely disappeared as satellite program relay displaced off-air reception of signals at great distance.

Brooks used a Cessna 172, rigged with antenna and licensed by the FAA for experimentation, to conduct flyover field-strength probes for site selection and determination of tower height requirements and antenna placement. SKL produced the Series 450 line of preamplifiers, converters, and other head end products. However, they never attempted to build modulators, demodulators, or heterodyne signal processors.

The Cylindrical Amplifier at the Emerald Coal Mine

About 1960, SKL received an equipment order for a video system to monitor the movement of coal on an automated conveyor system that Westinghouse Electric

Company was building for the Jones & Loftus (J&L) Emerald Coal Mine outside Pittsburgh. Pierre de Bourgnecht designed the coaxial network amplifiers for distributing signals from cameras placed at the mine faces before the coal was loaded onto the conveyor belt. This design was unusual in several respects. It was SKL's first transistorized product. The various stages were mounted on wafers placed in a $1\frac{1}{4}$ -inch tube that was only slightly larger than the coaxial cable. Because of the housing, it was called the "cylindrical" amplifier (see [Figure 7.4](#)). It was installed in-line and could be lashed in place along with the cable. Moreover, it was dc-powered (direct current), and the dc voltage itself was varied according to the signal level to provide AGC. The gain decreased as the voltage increased. This was the Model 250 series, and it was seen as an innovative design. Brooks oversaw and directed its installation and testing. It performed beautifully <Brooks 1992, 45-47>.

In fact, the Model 250 series was so satisfactory at the Emerald Coal Mine that Homer Bergren, a prominent pioneer multiple system cable operator in the Pacific Northwest, authorized installing the cylindrical amplifier system in his cable TV network at Grants Pass, Oregon.

Low Davenport, another pioneer operator in the Northwest, was general manager at Grants Pass. Brooks also took charge of this project. But this time, it didn't work. They tried everything but simply could not control the signal levels.

As Brooks explains, they had forgotten that the system at the Emerald Coal Mine was located in the mine tunnels, entirely underground where the temperature was virtually constant, day and night. At Grants Pass, it could be 80°F at noon but 20°F at midnight. Variations in dc power losses in the cable due to temperature changes were causing wildly improper AGC action. Furthermore, they were never able to completely eliminate the 60-Hz hum induced by power lines into the dc supply voltage that served also to control the AGC <Brooks 1992, 48>.

De Bourgknecht took the system back to the laboratory to try to devise satisfactory changes in the design. He was unsuccessful and, shortly thereafter, he resigned. Apparently, he discovered there was more money to be made in real estate than in engineering and is reported to have done well after leaving SKL <Shekel 1992, 15>. The Model 250 series dc-powered cylindrical amplifier did not become a catalog item. However, it was adapted to become the Model 271 antenna preamplifier,

and the cylindrical housing was used for the patented Model 400 thermatic equalizer <Brooks 1992, 97-98; Shekel 1992, 20-21>.

The Model 260 Series Transistor Amplifier⁴

Shekel and other engineers at SKL believed that a good case could be made for dc powering, which has a number of advantages over ac powering. Rectifiers and voltage transformers would not be needed and voltage regulation would be simpler. Telephone networks have always been dc-powered. With proper engineering and care, they believed galvanic corrosion could be avoided. However, in the real world of the cable TV marketplace, customers perceived the risk of corrosion with dc cable powering to be unacceptable. Rather than undertake the uphill task of proving that properly designed and installed dc power would not damage the connectors, SKL decided to upgrade Model 250 to a new 260 series with ac power.

The transistor trunk amplifier in the series was Model 265, installed in a small (10 inch \times 4³/₄ inch \times 2³/₄ inch), rectangular cast-aluminum housing. A simple cover plate

was bolted at the four corners to a $\frac{3}{8}$ -inch flange. A flat, very thin rubber ribbon provided little protection against moisture and none against signal leakage. The Model 265 included some thermal compensation for changes in cable attenuation but not AGC. The trunk was designed to use five Model 265 transistor amplifier sections with thermal equalization, followed by a Model 222A vacuum-tube distributed gain amplifier section with external, high pilot AGC. For longer cascades, an external, low pilot, automatic slope control was included with the Model 222A amplifier at every twelfth repeater station, in addition to the AGC, to correct residual slope deviations. The Model 265 trunk amplifier and the accessory line extenders and bridgers were designed with discrete transistors. Hybrid gain blocks were not yet available.

While working on the development of the 260 series, Shekel made a thorough investigation of the anomalous third-order cross-modulation effect in certain amplifiers sometimes referred to as poorly behaved. The ratio of third-order distortion (e.g., cross modulation) relative to the carrier level in a well-behaved amplifier increases by 2 dB for every 1-dB increase in output level, as predicted in theory. In a poorly behaved amplifier, however, the

distortion may actually decrease at some point as the output level is increased. Shekel found that this anomaly was due to cancellation effects at higher orders (fifth, seventh, ninth, etc.) and cannot be relied upon <Shekel 1992, 29-30>. Later, as a Jerrold engineer, he published a significant paper demonstrating, both analytically and empirically, the validity of his earlier hypothesis <Shekel 1973>.

The Model 262 wideband transistor high-level distribution amplifier developed by Shekel was a direct result of what he had learned in the course of his investigation regarding third-order distortion. The Model 262 was a high gain amplifier, rated at 50 dB, two and a half times as much as was generally considered normal. However, the Model 262 could be operated at 20 dB (100 times) greater signal output power than the Model 265 with no more distortion. Bridgett and others had shown that the theoretical maximum length for a cascade of identical amplifiers would be achieved when the gain of each amplifier was 8.7 dB. However, there are applications, such as tapped distribution lines (feeders), where maximum output power is more important than maximum length. The Model 262 was a highly desirable product. It did not enjoy the popularity it deserved, partly because of

SKL's internal problems.

The introduction a little later of the distortion-canceling feed-forward technique effectively overtook the SKL Model 262 high-gain/high-output amplifier. In the late 1960s, George Ray put together a crude feed-forward demonstration using two Model 212 amplifiers, delay lines, and couplers to show the feasibility of the method. SKL never carried the idea any further.

Comm/Scope

Coaxial cable is required for CATV networks as well as distribution amplifiers and accessory equipment. Through its contacts with the Bell System, especially in Canada, SKL encountered the Superior Cable Company in Hickory, North Carolina, who supplied the Bell System with coaxial cable for the L3 transmission network. The outer conductor of the Superior coaxial cable comprised a longitudinal copper tape formed into a tube (0.375 inch outside diameter) with an unwelded, butt joint seam along its length. The dielectric consisted of polyethylene discs spaced an inch or two apart. The center conductor was a solid copper wire. Attenuation was about equivalent to 0.5-inch aluminum sheath cable with polyethylene foam

dielectric. Structural return loss, a measure of the uniformity of construction, was of the order of 40 dB, substantially better than the 26-30 dB specified for extruded solid-sheath aluminum cable.

Superior Cable began making coaxial cable with a welded-seam, corrugated-copper (or aluminum) outer conductor using either solid or foamed dielectric. SKL actually installed corrugated aluminum sheath cable in its Lafayette, California, system in the late 1960s. Within no more than two years, the outer conductor was reduced to powder as a result of corrosion due to moisture. Superior Cable soon abandoned the corrugated sheath cables and switched entirely to extruded solid-sheath aluminum cable with foamed dielectric.

In the early days, SKL consistently recommended Superior Cable, although there was no gentleman's agreement like the one between Milt Shapp of Jerrold and Larry deGeorge of Times Wire and Cable <Shekel 1992, 19>. Shapp agreed to buy and recommend Times' coaxial cable exclusively, rather than manufacture its own brand of coaxial cable, while deGeorge agreed not to manufacture electronic equipment. Superior Cable Company became a division of Superior Continental Corporation, which soon consolidated into the

Comm/Scope Corporation. Much later, Jerrold and Comm/Scope were merged into the General Instrument (GI) family. Comm/Scope has since separated from GI.

Adequate Funding Denied for Transistor Research and Development⁵

During the period 1962-1963, it had become obvious to Shekel as chief engineer, Brooks as chief systems engineer, and Bill Headly as vice president marketing that SKL would have to become much more aggressive about transistorizing their products. The Model 260 series was a hybrid, nowhere near competitive. Headley had been with SKL almost as long as Brooks (or longer) and was still having to push obsolete vacuum-tube equipment while Jerrold, Ameco, and Entron were beginning to market solid-state equipment. However, they were simply unable to convince the SKL board of directors that several million dollars would be required to develop a line of transistorized products that could reasonably ensure survival in the competitive marketplace.

At one time, Don Spencer had anticipated the importance of developing transistor amplifiers. Even

before de Bourgknecht resigned, Spencer had quietly commissioned Dick Berwyn, a former SKL engineer who had become an independent consultant, to design a transistor product for SKL. Berwyn had been in charge of the CATV work at SKL when Bridgett was hired in 1951, but had left shortly thereafter. Spencer implied that Berwyn might be asked to take over the CATV activity again. But Berwyn never came up with a design SKL considered suitable for production <Bridgett 1992, 73-74>.

The board may have been influenced by Spencer's conservative but nontechnical impressions from conversations with Hank Abajian of Westbury Electronics on Long Island, New York <Brooks 1992, 57-58>. Or, it may have been skepticism expressed by Dr. Walter Albersheim, the Bell Telephone Laboratories engineer whom Spencer had brought in as chief engineer about 1960. Abajian's transistor amplifier, installed in his brother's system in Vermont in the late 1950s, was probably the first use of transistors in an operating TV system. However, he had experienced difficulties with temperature effects. In the cold winter, he had even installed tiny 10-W heaters in each chassis in order to keep the transistors operating properly.

Notwithstanding his earlier fascination with

transistors, Spencer apparently feared that it might prove too difficult to control their performance in the hostile outdoor environment generally encountered in CATV installations. For whatever reason, the board was dissuaded, over Brooks' strenuous objections, from funding aggressive development of transistorization. In retrospect, this failure probably marked the death knell for SKL. They struggled on for several more years but could never recapture the superior position they had enjoyed with the Models 211, 212, and 222 chain amplifiers.

Brooks had been chief systems engineer for SKL's operating CATV systems until about 1964 when Spencer asked him to move into marketing. As Brooks tells the story, Spencer called him into his office and said, "You are now going to become an executive in the company, Bob. I don't know any other way to say it than straight out. No more loafers and argyle socks. You will wear a tie and you will wear appropriate shoes and socks. And I think it's about time that you put your beer drinking days behind you. If you find it necessary to drink, scotch and soda would be much more appropriate for someone in your position." Thus, it was a new, more formal Bob Brooks who was introduced at dinner that evening to H.I. "Irv" Grousbeck and his Harvard Business School student

Amos “Bud” Hostetter. Brooks and the SKL organization provided initial guidance in the CATV world for the two young men who would become Continental Cablevision, the third largest multiple system operator <Brooks 1992, 53-55>. In 1996, Continental was merged into U.S. West, the Bell System Regional Holding Company (RHC). The name was changed to Media One; in 1999, it was acquired by AT&T.

To this day, Fitzroy Kennedy is known as one of the more brilliant engineers to come out of the high-tech environment associated with MIT and Harvard. Spencer was well liked, a real gentleman. He ran the company like a family; he was the father figure <Shekel 1992, 18>. Bridgett commented that, even without air conditioning in the original second floor space on Massachusetts Avenue, “...it was a marvelous place to work—with a fine bunch of people to work with. I can’t imagine a better group.” It was a marvelous place to work. Everybody had a good time <Bridgett 1992, 22>.

Brooks said, “I thank God that I started my business career with the Fitzroys [Kennedys] and the Donald Spencers and the Bill Headleys. ... Their business ethics were so high it was unbelievable. They would lose a sale rather than do or say something that was incorrect. ...

They wouldn't embellish any of their specifications. ... They would be conservative. They would never really market... the way their competitors used to market." This was the perception, not only of the staff but of the customers as well. Brooks adds, "And I think that was one of the reasons why they had difficulty as a group of Boston engineers, with that high an ethic, to get out and compete in a world that they really didn't understand" <Brooks 1992, 33-34>. Nevertheless, because of the board's unwillingness to move ahead, Brooks was ready to think about leaving SKL.

Brooks Goes With Anaconda

Early in 1965, Anaconda Wire and Cable Company had developed a new type of coaxial cable called Sealmatic for the independent telephone companies. It used a longitudinally wrapped aluminum ribbon with a bonded seam instead of extruded aluminum tubing. They were using SKL amplifiers with the Bell System seal of approval, but they planned either to develop their own line of equipment or buy a company. When they learned that SKL was privately owned, they quickly made an offer. Spencer and the board were initially very pleased and

entered into serious negotiations. In the end, however, Brewster and Spencer decided not to sell <Brooks 1992, 59, 60>.

Anaconda was quite disappointed. A month or so later, they invited Brooks to meet with them in New York to discuss the possibility of becoming chief engineer of the communications system division of the Anaconda Wire and Cable Company in Sycamore, Illinois. Feeling that SKL was not doing well in 1965 and frustrated because the board would not fund the development of transistorized products, Brooks accepted the offer, resigned from SKL, and moved his family to Sycamore. Less than a year later, the division was merged with Anaconda Astrodata. Brooks moved the whole outfit, and his family, to Anaheim, California.

While Brooks was at Sycamore, he was introduced to Arie Zimmerman who wanted to transfer to Brook's division from research and development. He came to Anaheim where he joined Brooks on patents for the first cable TV system analyzer <Brooks 1992, 63>. Later, Zimmerman and others organized the Phasecom company to produce the phase-locked head end that he and Israel "Sruki" Switzer (and others) had designed and patented <Switzer et al. 1973>. The Phasecom head end was

designed to minimize distortion in multichannel systems by tightly locking the frequency of each channel to a harmonic (multiple) of 6 MHz called harmonically related carriers (HRC). Switzer is an outstanding and influential consulting engineer, known for innovative professional achievement, who pioneered CATV in Lethbridge, Ontario, and elsewhere in Canada and the United States.

At that time, about 1967, Frank Drendel was a student at Northern Illinois University working part-time for DeKalb-Ogle Telephone Company, an SKL customer. However, the company had been sold to Continental Telephone Company (unrelated to Continental Cablevision), and the chief engineer of DeKalb-Ogle entreated Brooks to hire Drendel so he would not have to be laid off. Thus, Brooks was instrumental in bringing Drendel into the industry. Drendel rose rapidly. He became a principal in Microwave Associates and the conglomerate Ditec Corporation. He is now the chairman of CommScope, Hickory, North Carolina, a coaxial and optical fiber cable manufacturer and successor to Superior Electric Company and the Valtec optical fiber company. For several years, CommScope was a division of General Instrument (formerly Jerrold). However, it has recently reemerged as an independent corporation.

Brooks had hardly settled in California when he was notified of a plan to move him into the “fast track” leading to upper management of Anaconda, a plan that would have required moving his family to Mexico for two years. While this invitation was being considered, Charles Patterson, who had been named president and CEO of SKL, solicited help from Brooks to see what could be done to save SKL from receivership. Since neither Brooks nor his family wanted to move to Mexico, he politely rejected Anaconda’s offer and agreed to return to SKL in 1967 as vice president and general manager of the operating CATV systems SKL had acquired over the years.

Gay Rogness, the engineer who had worked with Earl Hickman at Ameco on the Channeleer signal processor, moved over to replace Brooks at Anaconda-Astrodata. Bill Rheinfelder, an engineer hired from Motorola by Ameco for assistance in transistor developments, also came over to join Anaconda-Astrodata.

Managing the Downtrend

Spencer suffered severely from emphysema and retired to Arizona about 1966. In the short span of two

years, SKL had fallen from a premier cable equipment supplier to near insolvency. Charles Wright was designated by the Merchants Bank to replace Spencer as president of SKL. Wright brought in Dennis Parks from AT&T as chief technical officer and George Green for marketing. Green had become involved with cable TV in the early 1960s while seeking investment opportunities for the Greyhound Bus Company. He came to SKL directly from Ameco where he had been an adviser to Bruce Merrill on financial and marketing matters. Green brought to SKL a badly needed and effective sales team, but he did not enjoy harmonious relations with the engineers <Bridgett 1992, 82>.

Wright was soon replaced with Charles Patterson, a Northeastern University graduate with a military aviation background. Patterson discussed with Brooks what might have caused SKL's problems. "In all of the memos and all of the documentation I've gone through," Patterson said, "and all of the people I have talked with, one common vein keeps coming out. If they had done the transistor work that Brooks and Headley and Shekel had asked for, everything still would be fine" <Brooks 1992, 72>.

Headley had already left, and someone was badly needed to take over the entire sales and marketing

operation. So, Brooks turned to a young lawyer he had met in California named Dick Loftus who did not actually practice law but who Bob considered would be a marvelous marketing manager.

Denied the opportunity to develop their own brand of transistor equipment, SKL continued trying to come up with something different that would distinguish it from the competition. If they could not win the quantitative battle for market share, they wanted at least to find a niche with specialized products of outstanding quality. They developed the Model 215 Long Line Amplifier for the 20-100 MHz band, using transistors in the input stages and a vacuum-tube distributed gain amplifier output stage. It had a low 5-dB noise figure, automatic level control (ALC), and low distortion. It was intended to fill the gap for long head end runs and special applications such as the educational projects at Hagerstown and South Carolina. But the CATV market was no longer interested in vacuum-tube equipment, not even the once widely recognized high-quality Model 212 or 222 amplifiers.

It was Green who said to the engineers something like this, "It is very nice to be innovative and inventive, but you have to look at the bottom line. You cannot fight success. We should try to do what succeeds in the

marketplace” <Shekel 1992, 23>. At this time, the Jerrold Starline One transistor series was leading the way. It was quickly recognized that simply asking the production department to copy the Starline One would not work. So, the engineers conducted a detailed and comprehensive analysis of the circuits, the transistors, and the other components. Bridgett was impressed by the sophistication of Ken Simons’ design. He was especially impressed with the use of negative feedback over the entire bandwidth. “Only Ken Simons would dare do that!” he declared <Bridgett 1992, 80>. However, they found that sufficient attention had not been given to heat transfer and were convinced that the RCA transistor in the Starline One would fail. And it did. The Starline One transistors “dropped like flies” in the Mississippi heat. However, SKL engineers were not reluctant to adopt the circuitry while attempting to correct the thermal problems. The result was Model 7000, designated for promotional purposes as Color Burst.

The housing was identical to the Jerrold Starline One housing, except that it was colored blue and had somewhat different external markings. It had the same two cylindrical cavities to accommodate filters for the AGC pilot carriers. The SKL design did not use the cavities, so

they added a firm ridge to the housing under the cavities so that it would not be possible to plug a Jerrold module into the 7000 housing. Initially, in the Model 7000, the AGC made use of an incandescent lamp to detect the pilot carrier current and the current from a photocell to adjust the gain. This was soon replaced with PIN diodes, which are solid-state diodes used as detectors <Bridgett 1992, 79-85>.

The ColorBurst/7000 had been successful from an engineering viewpoint. It was certainly the equivalent of the Starline One, overcoming problems from the start that Jerrold had to correct in its later models. But it was not readily distinguishable from Jerrold's product. It was widely perceived in the industry as a copy of the Jerrold product, a desperation move. When Brooks returned in 1967, he energized George Ray, one of Fitzroy Kennedy's original associates, to lead the effort to develop a quality transistorized product line that would be a worthy successor to the Models 212 and 222 vacuum-tube chain amplifiers. Brooks believed SKL had a good product on the drawing board that could give them a step up on the technology <Brooks 1992, 80>.

Meanwhile, before Brooks came back, a merger in principle had been negotiated with Adams-Russell. Jerry

Adams was enthusiastic, and this merger seemed likely to provide the infusion of new money and management needed to avert the seemingly imminent collapse of SKL. At the last minute, Adams-Russell's auditors requested an inventory of the three warehouses SKL had maintained in California, North Carolina, and Florida. The assets behind the SKL stock to be exchanged as part of the deal included a warehouse inventory carried on the books at more than \$1 million.

Brooks himself led the inventory team and was astonished to discover that the inventory, carried as work in progress, actually comprised almost nothing but obsolete and worthless vacuum-tube equipment. There was nothing there that realistically could be sold or salvaged. This represented a significant reduction in the valuation of SKL assets. Serious as this was, it was compounded by unrest among the employees over the downsizing undertaken by the new management. Persuaded that a union could save their jobs, the employees voted to organize in an official National Labor Relations Board election. Under these circumstances, Adams reluctantly decided that Adams-Russell could not consummate the deal <Brooks 1992, 74-76>.

At about the same time, however, Charlie Patterson,

the designated CEO, was seriously incapacitated in a lawn mower accident at his home in Potomac, Maryland. He was transferred by ambulance to a Boston hospital so he could be as close as possible, but Brooks had to take over as de facto CEO for the company during its most difficult days. Moreover, while conducting the warehouse inventory, Brooks was bitten by a black widow spider and lapsed into a coma for two and a half days with a prolonged recovery period.

POSTMORTEM

The departure of Fitzroy Kennedy by 1960, the founder who had provided the engineering skill and vision, seems to have left SKL without clear goals or strategic guidance. Between about 1959 and 1970, there was considerable personnel churn at SKL. Shekel's four-year absence was involuntary due to circumstances totally beyond his or SKL's control. But the departures of Lester Smith, Socks Bridgett, and Win Bemis were triggered by discomfort with de Bourgnecht as chief engineer. Smith never returned. Bridgett came back until the final days and Bemis came back for a year or two. Brooks left in 1965, returned two years later, and left again

in 1969. Bill Headley left about the time George Green's marketing team came in. Brooks commented that he would never have brought Dick Loftus in for marketing if he had known the Adams-Russell deal would collapse.

George Ray was the only original engineer who stayed till the end. Perhaps the most definitive indication of the malaise was the absence of continuity in technical leadership. In the decade from 1960 to 1970, there had been at least eight chief engineers or chief technical officers.

The uncertainty and lack of clear and credible prospects had demoralized the staff. Patterson and Brooks, the last CEO (albeit de facto), resigned in 1969, leaving control of SKL to bank-appointed officers. It was quite clear that SKL was stalled, not going anywhere. Its original line of wideband pulse amplifiers, pulse generators, variable electronic filters, and the instrument line were successful, and SKL was still highly respected. But it had never been able to move beyond its initial successes. Orders continued to come in without aggressive marketing.

Before the failure of the Adams-Russell merger, Patterson and Brooks had merged several of the SKL

cable systems into the new MSO formed by Monty Rifken and Roy Little as American Television and Communications Corporation (ATC), later to become Time-Warner. With the collapse of the Adams-Russell deal, the bank terminated its financial support. The block of ATC stock was sold, and Dick Leghorn bought the rest of the cable systems that SKL owned in order to pay off the bank loans.

In 1970, Shekel resigned to join the academic staff at the University of Maryland as a visiting professor, in charge of the undergraduate office. He was responsible for the computer installation at the college of engineering, an experience that prepared him to provide significant leadership by introducing computers in the design of equipment for cable TV as well as in network operations. After two years, however, he found that the university environment, at least at Maryland, was too isolated from the real world of engineering. He missed the excitement of seeing his work go out the door and the opportunity to interact with users of the equipment. So, in 1972, he got in touch with Jerrold and was gladly made a part of their team, where he made significant contributions.

While with Jerrold, Shekel developed a significantly improved impedance bridge that was able to measure very

high return loss with considerable accuracy to 1 GHz (1,000 MHz). He was awarded a patent, assigned to Jerrold who licensed manufacturing rights to Texscan. Shekel introduced Jerrold to computers and developed a system he called Play Cable, later expanded and designated Intelelevision by Jerrold. Shekel left Jerrold in 1978 to join American Science and Engineering in Cambridge, Massachusetts, to develop distribution systems for electrical power load control. He retired in 1989 and is currently doing consulting work and teaching at Northeastern University in Boston <Shekel 1992, 32-37>.

George Ray and Bill O'Neil got together with Roger Wilson (from the Jerrold organization) to form a company called Amplifier Design and Service (ADS) in Waltham, Massachusetts. ADS was licensed by SKL to service, modify, and improve the ColorBurst/7000 equipment. When O'Neil joined ADS, he developed a feed-forward amplifier that could be dropped in to replace the SKL Model 262 high gain-high output amplifier developed by Shekel but no longer available for upgrades and rebuilds. In 1975, Jim Grabenstein, chief engineer of Potomac Valley Cablevision, installed O'Neil's feed-forward amplifiers in his Cumberland, Maryland, system and enthusiastically reported on the successful operation <O'Neil 1975;

Grabenstein 1975>.

Finally, about 1970, Scientific-Atlanta, Inc., of Atlanta, Georgia, purchased all of the remaining assets of SKL, except the original seminal instrumentation business. SA was later to reveal that the only asset they really wanted was the cast housing for the new transistor amplifier Ray was developing but which never made it to the marketplace. O'Neil became an SA employee for a time, but Ray refused to leave the Boston area. Irving Kahn, former president of TelePrompTer, stepped in to provide financial support for Wilson and O'Neil to develop products for optical fiber transmission. This operation became General Optronics and was moved to Princeton, New Jersey.

And so it came to pass that Spencer Kennedy Laboratories, the company that had been nicknamed the Cadillac in recognition of the high quality and correspondingly rich pricing of its CATV products, was dismantled down to the instrument company it had been 20 years earlier.

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CHAPTER 9

Scientific Atlanta, Inc.

THE ORIGIN OF SCIENTIFIC ATLANTA, INC. (SA), IS BEST TOLD IN THE FOLLOWING EXCERPT FROM THEIR IN-HOUSE NEWSLETTER *SCIENTIFIC ATLANTA WORLD*.

Six Georgia Tech engineers got together in the summer of 1951. They had some ideas that they thought might be a basis for a business. So in October, 1951, they got a corporate charter for the Company, which was then known as Scientific Associates, Inc. ...

There was no model for what an electronics company should be. Most engineers who formed companies thought that there would be a big opportunity to do research and sell engineering services. Glen Robinson had the idea that designing useful products and manufacturing these products was the way to help the Company grow and to provide jobs for people in the community.

The first product was designed in an old garage on Virginia Avenue. It was an antenna-pattern

recorder that Glen, ...and others thought was needed for the expected electronics and communications boom. It was built with the aid of some machine tools borrowed from Paul Dispain. When it was completed, Glen put the recorder in the back of his 1950 Plymouth station wagon and took it to customers in Maryland, Connecticut, and Massachusetts. Four of the first five prospects who saw the equipment bought at least one. Since then, over 2,000 antenna-pattern recorders have been sold <Scientific Atlanta 1976>.

THOMAS D. SMITH¹



Fig. 9.1 Tom D. Smith

*Courtesy National Cable Television Center and
Museum*

Tom Smith ([Figure 9.1](#)) was born in 1934 in Drew,

Mississippi, population 1,000, in the Mississippi Delta cotton country about halfway between Memphis and Jackson. Even at age five or six, Smith was fascinated by shortwave radio, listening while twisting the knobs and reading about shortwave and amateur radio. He often listened to the local ham radio operator in the 160-meter band by tuning his AM radio just above the top end of the broadcast band. He did this until the war ended the transmissions. One summer during high school he earned enough money painting the school building to buy a Hammarlund HQ129X shortwave receiver. His parents were divorced, and his mother was struggling just to get him through high school. Jackson was the nearest place he could go to take the FCC amateur license examination, and he could neither afford the amateur equipment nor arrange transportation to Jackson. Thus, it was not until after graduating from college in 1956 that he was finally able to get his ham license.

In the summer of 1951, after finishing his junior year in high school, he began working as a flunky in a local radio and television repair shop owned by Rudy Riley. In order to provide much better TV reception, Riley persuaded a few of his closest neighbors to pool the \$100-120, which they might spend to put up individual rooftop

masts and antennas, to receive the Memphis and Jackson TV stations, each about 100 miles from Drew. With the pooled resources, Riley was able to put up a much taller tower with high gain antennas. The neighbors' TV sets were connected to the community antenna with balanced, open-wire transmission line. The neighbors were able to enjoy much better reception than would have been possible with individual rooftop antennas. One of Smith's tasks while working for Riley was to bend up the sheet metal, punch the holes, and wire up what Riley called the "isolation amplifiers." This was Smith's introduction to community antenna television (CATV).

Young Smith's imagination was excited by the rhombic antennas that Riley designed and installed to provide TV reception for each of the separate households in isolated family farm groups. Wires were strung on four telephone poles in an open field so that the legs of the rhombic were about 70 feet long (5 or 6 wavelengths at channel 5), with the long diagonal pointed toward Memphis. Smith was fascinated with the idea that these wires and poles could be arranged in a particular way to bring in TV signals better than just a piece of wire. With Riley's encouragement, Smith was determined to study electrical engineering at Mississippi State. As part of his

senior research project, he investigated and reported on antenna modeling and master antennas for television. In his paper, he extended the master antenna idea to CATV, although there was almost no published material for reference. In 1955, Riley built a CATV system in Drew with a rhombic antenna and Entron amplifiers. The trunk line went right past the Smiths' home, and the Smith household was the first customer off the head end.

When he received his bachelor of science degree in electrical engineering in 1956, Smith knew that he wanted to be an antenna and microwave engineer. He accepted an offer at a "very attractive salary" to work in the antenna and microwave laboratory of the Chance-Vought company near Dallas. During his three and a half years at Chance-Vought, he learned about log-periodic, frequency-independent antenna arrays and had opportunity to pursue in-depth his interest in antenna modeling about which he had written as a college senior.

The Log-Periodic Antenna

The log-periodic antenna was originally developed about 1956 at the University of Illinois college of engineering at Urbana. Although not strictly frequency

independent, the log-periodic configuration is a practical implementation derived from the idea put forth in 1954 by V.H. Rumsey that “a structure entirely definable by angles, without any characteristic length dimension, should have properties that are independent of frequency.” R.H. DuHamel and D.E. Isbell are credited with the array of dipoles whose relative dimensions and spacing are scaled according to the logarithm of a constant called the period <DuHamel and Isbell 1971>. The low frequency limit of the log-periodic antenna bandwidth is determined by the size of the antenna. The upper frequency limit is determined by how accurately the elements are scaled. The family of frequency-independent antenna arrays, including the log-periodic array, was particularly useful for slotted surface antennas on aircraft to avoid the drag of stub antennas in supersonic flight. Thus, it was while working in the laboratory at Chance-Vought that Smith acquired expertise in log-periodic design and operation and enthusiasm for its potential use in television reception.

Until the introduction of the log-periodic array in 1957, the most popular antenna for television reception was some version of the Yagi (or Yagi-Uda) antenna array, named for its inventors <Yagi 1928>. Introduced in 1927,

the Yagi antenna is a parasitic array. That means that only one dipole in the array is directly connected to the receiver. The others “feed on” that one by inductive coupling. Because of this, the Yagi is susceptible to undesired influence by structural members such as the tower legs, braces, down leads, etc. On the other hand, all elements of the log-periodic antenna are directly fed, greatly reducing structural influence. The front-to-back and side lobe ratios of the log-periodic array are significantly better than for Yagi arrays, and performance as to gain, impedance match, and beamwidth is much more uniform throughout the bandwidth with no significant dropouts.

In 1958, Smith left Chance-Vought “to get rich” at a small company in Mineral Wells, Texas, called All Products Company (APC). The name was later changed to Antenna Products Company. APC had been doing a large business in aluminum towers and residential TV manufacturing and then moved into HF and VHF antennas for military use. Smith continued work on log-periodic antennas, including some used as backup systems for NASA’s Project Mercury. He also designed three sets of Yagi arrays for John Campbell’s CATV system in Mineral Wells. This was Smith’s first experience

at selling products to a CATV operator. Incidentally, Smith first met Campbell while responding to a complaint about leakage from Smith's ham transmissions into Campbell's CATV network.

In spite of Smith's hard work (60-70 hour work weeks for more than two and a half years), APC was broke and the assets were offered for sale. Since the APC assets involved antennas, Glen Robinson and Bill Davenport, principals of Scientific Atlanta, expressed an interest in purchasing the assets. Although they decided not to buy the company, they made an offer to Smith and a few other APC engineers to come to work at SA. In 1961, Smith joined SA as an antenna and microwave engineer. At this time, perhaps 90 percent of SA's business was government oriented. Scientific Atlanta was selling \$400 million worth of antenna-pattern-measuring equipment and positioners to military and NASA facilities, with about 5,000 employees <Smith 1992, 17>. Smith introduced broadband log-periodic feeds for parabolic dishes and for arrays to be used on the antenna pattern ranges. He designed antennas for low frequencies as well as microwaves and dual polarized antennas with crossed log-periodics. None of these projects had anything to do with CATV.

Scientific Atlanta Nudged Toward CATV

By 1963, Robinson had made the strategic decision to get SA into more commercial areas in order to become less dependent on military and government contracts. Staff engineers were encouraged to present ideas for commercial applications of the technologies that had been developed for government projects. Smith had accumulated some knowledge of CATV and realized that systems were being constructed all across the country. So, he sought out his old friend Rudy Riley to ask what he considered to be the two most pressing needs in the cable TV industry for electronic devices. Riley suggested a need for: (1) a better antenna for reception in the presence of cochannel interference and (2) a cheap, broadband directional coupler tap.

The pressure tap was being widely used in CATV systems, notwithstanding its inherent mismatch and vulnerability to moisture contamination and signal leakage. Ken Simons had already introduced the directional coupler tap at Jerrold. Entron's AccuraSplit <Diambra and Edlen 1953> and SKL's similar Model 427 tap were based on a different concept, using resonant coaxial cable with dual center conductors. Smith tried to

replicate SKL's directional coupler Chromatap concept on a printed circuit board but soon realized that this would not be successful. So, he concentrated on the log-periodic antenna and designed an antenna that could receive the entire high VHF television band from channel 7 through 13 (174-216 MHz) with gain of 10 dBi (that is, dB relative to a hypothetical isotropic antenna that would have the same reception sensitivity in all directions).

The key to rejecting cochannel interference is minimizing reception (or transmission) of signals from the side and rear directions, that is to say, the side and back lobes of the horizontal plane radiation pattern. Smith had once observed a group of helical (corkscrew) antennas stacked in a diamond configuration as part of a shipboard missile-tracking system. He thought, "Why in the world are they doing it that way? What is the advantage of that?" He and his officemate at that time, Homer Bartlett, were designing antennas for Scientific Atlanta. They discussed it a while, and Smith said, "That is essentially a binomial array."

Smith and Bartlett concluded that the diamond array is equivalent to a three-element array in which the top and bottom elements of the diamond, taken together, constitute a virtual element in the center of the diamond,

with current equal to twice the current in each of the side elements. The side elements are spaced a full wavelength apart, so the virtual center element is one half wavelength from each of the side elements. An array of three identical antennas in line, spaced one half wavelength or less, is a binomial array when the received (or transmitting) currents are in phase and in the ratio of 1:2:1. This is the ratio of the coefficients of the three terms resulting from squaring an algebraic binomial: $(a+b)^2 = (1)a^2+(2)ab+(1)b^2$. The directional pattern of such an array has a single main lobe and theoretically zero side or back lobes. Clearly, the missile-tracking antennas were designed to take advantage of the binomial effect of the diamond configuration and to avoid locking onto side lobes while tracking a missile. In contrast, the conventional Yagi quad stacking configurations with two pairs of vertically stacked antennas mounted side by side not only have a rather large back lobe but are likely to have fairly large side lobes <Smith 1965>.

Because SA had really become the dominant provider to government and industry of antenna range facilities and services for precision measurement of antenna radiation patterns, Smith's log-periodic antennas and binomial arrays were subjected to the most

comprehensive tests imaginable. Although other antenna manufacturers were also equipped with antenna pattern ranges, none could match the sophistication and precision of the SA test range.

But, SA did not get into cable TV without a struggle. Robinson, as president, and Davenport, as chief financial officer, encouraged and supported Smith in the development of antennas for the cable TV industry. But many of the technical people at SA were disparaging, doubtful that there was really a significant market, since most people were able to receive four or more TV channels without cable. Even worse, many tended to consider CATV technically shoddy and perhaps even less than respectable.

The first test array was installed on Alan McDonald's tower in Athens, Georgia, in 1963. McDonald wanted to receive channel 13, Macon, for the new cable TV system he was building. He was concerned about the risk of cochannel interference from channel 13 in Asheville, North Carolina, 120 miles to the north. The high-band diamond array antenna was installed at the top of the tower. Without being able to compare with another antenna, the test was inconclusive. A more exciting test was soon to come.

Scientific Atlanta's first participation in cable TV gatherings was at the 1964 NCTA Convention at the Bellevue-Stratford Hotel in Philadelphia. Scientific Atlanta did not have a booth or a hospitality suite. Smith was the only representative, with a mission of testing the market for the log-periodic antenna. A year later at the 1965 Convention in Denver, SA shared a booth with National Theater Supply and displayed a small model of a log-periodic antenna along with some descriptive literature. Smith was again the only SA representative, although his wife came with him this time. He was able to talk with people and describe the features of the new antenna.

The Dramatic Test at Monroe, Louisiana

In addition to Rudy Riley, Alan McDonald, and others he had met in Philadelphia, Smith spoke with William L. Ross, Bill Daniels' chief engineer. Together, they arranged for a field test of the log-periodic antenna on channel 3 in Monroe, Louisiana. Monroe is 103 miles due east of channel 3, Shreveport, and 103 miles due west of channel 3, Jackson, Mississippi. Daniels had spent untold amounts of money trying, without success, to find an antenna configuration with which channel 3,

Shreveport, could be received without cochannel interference from Jackson. Karl Kandell was the manager in Monroe.

The log-periodic diamond array for channel 3 that SA called Quadrate was huge ([Figure 9.2](#)). The maximum length that the SA sheet metal presses could handle was 12 feet, which determined the length of the four U-channel booms to which the antenna elements were attached. The diagonals of the diamond array were about 16 feet long, top to bottom and side to side—one wavelength at channel 3 visual carrier frequency. The entire array weighed 2,000 pounds. Although a thorough structural analysis had been made, eyebrows raised at the thought of mounting such an enormous structure on the tower. Moreover, it was to be mounted as a cantilever with the full 12 feet extended out from the tower. It was indeed scary, especially since the quad-stacked Yagi already on the tower weighed only a couple of hundred pounds. But the Yagi did not work. Daniels was already considering installing a microwave relay at substantial cost for the Shreveport channel.

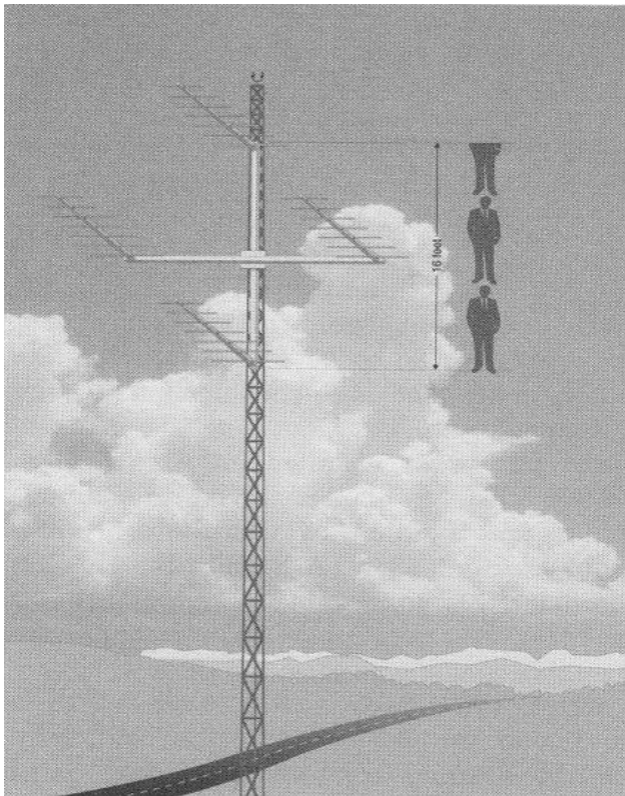


Fig. 9.2 Scientific Atlanta's huge, tower-mounted, channel 3 log-periodic antenna

Courtesy Commonwealth Design Group

This time, Smith wanted a truly meaningful comparison. While the crews were assembling the SA log-periodic antenna on the ground, Smith and his assistant, Blair Bensen, carefully examined the pictures received on the quad-stacked Yagi array already mounted at the top of the tower. The TV set could not make up its mind whether to sync on Shreveport or Jackson and there was a strong 10-kHz cochannel “venetian blind” interference pattern. The riggers then hauled the SA antenna up the tower and secured it just below the Yagis, pointed in the general direction of Shreveport. Using a signal-level meter connected to the download, Smith and Bensen supervised the orientation to maximize the signal. Another look at the Yagi pictures confirmed what they had seen before. Only then did they switch the monitor over to the new SA antenna.

Smith says, “It was the most dramatic thing I had ever seen! It was as if Jackson had gone off the air! You couldn't see a single trace of cochannel in the picture.” Karl Kandell's eyes got as big as saucers and he ran to

the phone to tell Daniels that SA had solved his channel 3 problem <Smith 1992, 27>. It was an extraordinary demonstration. Daniels made a special trip to Monroe to see it. He was on his way to make a circuit of state association and other meetings, but the SA antenna was the heart of his story. He really got on the SA bandwagon. As a result, SA began to get a lot of antenna orders. Because SA was virtually unknown and new in the cable TV business and because there had been so many false starts and misleading promises in this young industry, SA offered money-back, satisfaction guarantees to customers.

The remarkable fact is that the antenna project was profitable from day one, notwithstanding that it was priced much higher than Yagi with equivalent gain. It was priced so that it could be manufactured in the SA shop at a decent profit. Scientific Atlanta at that time was not a low-cost, high-volume manufacturer. They were still primarily in the defense business in which high volume production meant four, five, or six units a month.

Then, Smith began to get worrisome telephone calls from customers whose antennas had literally fallen off the tower. As the calls accumulated, it appeared that the problem was with the huge low-band antennas. There

were no calls on the channel 7-13 model. Smith could see lawsuits. Someone could get hurt.

Production had been contracted to Southern Tool Company in Anderson, Alabama. Based on a study of the photos they had received, the failure appeared to be at the ends of the horizontal boom of the diamond array, right where they attached to the backing structure. They set up a model in their high bay test area and shook it vigorously. Initially, the backing structure consisted of a fabricated rectangular steel pipe about 2 inches on a side. The antenna boom was bolted to a flat plate welded to the rectangular pipe. Because of the cantilever mounting, the stresses generated by bouncing the antenna up and down were concentrated at the corners of the rectangular pipe. It did not take long for the pipe to crack at the corners, eventually allowing the antenna to break away and fall free.

The rectangular pipe was changed to a tubular pipe, converting the stresses into a torsion load. In hindsight, Smith feels they should have known better in the first place. All customers were contacted and told they would be supplied with a new antenna backing structure at no charge and that SA would reimburse them for any reasonable costs to replace the entire rigging. Smith

believes they got more orders as a result of being frank, honest, and straightforward and not trying to dodge the bullet. One customer, George Milner of CableCom General, called to say, “It sure is nice to find an honest vendor in the cable television business” <Smith 1992, 31>.

There were many anecdotal expressions of astonishment at the improvement experienced when SA log-periodic antennas were installed to replace Yagi antennas, which were supposed to have comparable gain. SA single log-periodic antennas, as well as the dual horizontal and diamond arrays, were rated conservatively, based on analysis of comprehensive data taken on the SA antenna test range (likely with greater precision than was available anywhere else at that time). Studies made by Smith and Bensen in 1966 (unpublished) suggest that the published gain figures for Yagi antennas almost certainly overestimate the stacking gain and fail to make proper allowance for the proximity effect of the mounting structure.

Smith had developed a slide rule with which to predict received signal strength in order to recommend antenna type and tower height required. Later, he arranged for a consultant at Georgia Tech to develop a program for a computerized signal survey. The program

would include critical data for all TV stations listed in the *Television and Cable Factbook*®, including channel number, effective radiated power (ERP), antenna height above average terrain (haat), latitude and longitude, and network affiliation (if any). Propagation was based initially on the FCC propagation curves but later on the Bullington nomographs (Bell Telephone Laboratories) and the National Bureau of Standards “Technical Note No. 101” to include terrain effects beyond 10 miles. The program would automatically search out all TV stations within 500 miles of the cable TV antenna site and calculate the predicted signal level at the terminals of the recommended SA log-periodic antenna. The computerized signal survey was a service provided at no cost to potential customers and was a great marketing tool <Smith 1992, 47-51>.

With the gratifying success of Smith’s log-periodic antenna venture, Glen Robinson was anxious to expand the product line. It was Smith’s decision to concentrate on the head end, where he felt they had some expertise. Moreover, competition in the distribution business would be tough and they had no leverage within the company with which to get up to speed in a business in which they had no experience.

Smith decided to hire an engineer to develop a pole-

mounted preamplifier. He probably did not know it at the time, but Milt Shapp's first Jerrold product was a set-top preamplifier called a booster. Ike Blonder and Ben Tongue started with a better idea: a mast-mounted booster, remotely powered and controlled. Smith knew of cases where reception of a weak signal might be blocked by overload due to a strong adjacent signal and believed a preamplifier designed to overcome this problem would be a marketable product. To develop a new preamplifier for the cable TV industry, Alex Best was brought into the SA family <Smith 1992, 40>.

ALEX BEST²

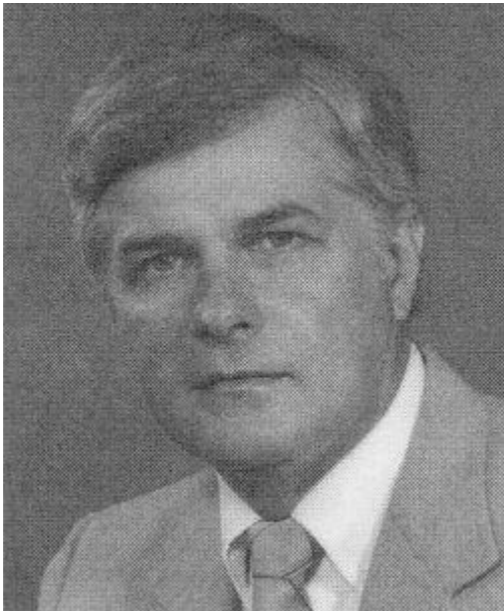


Fig. 9.3 Alex Best

*Courtesy National Cable Television Center and
Museum*

Alex Best ([Figure 9.3](#)) was born in Augusta, Georgia,

on February 14, 1941. He enrolled in the Georgia Institute of Technology in 1961, after completing two years of pre-engineering at the junior college in Augusta. He received his bachelor of science in electrical engineering from Georgia Tech in 1963 and accepted an appointment to enter the RCA electronics training program. After sessions in Cherry Hill, New Jersey, and Burlington, Massachusetts, he was sent to Indianapolis to work with RCA's receiver engineering experts, Gordon Rogers and Jack Kelly, in the design of consumer electronic television and radio products.

Best had not been a ham radio licensee and was eager to learn everything he could about electronics. Color television was just beginning to take hold in 1963. His work at RCA gave him opportunity to learn how TV works and how a TV receiver is built. His thirst for knowledge was not diminished during the week, so he applied to a radio/TV repair shop to work on weekends. They had no openings; that is, not until he said he would work for nothing. After all, as a single man, he already had more money than he had ever seen in his whole life. So, they put him to work as a salesman, not in the repair shop as he really wanted. But it was a good experience.

Gordon Rogers had a patent, one of many, on keyed

AGC to activate the AGC only during the synchronizing interval to minimize the effect of noise during the active picture-scanning period. One project on which Best worked was improved keyed AGC. He was amazed to find that they were still using vacuum tubes in this project. In the 1930s, Rogers had been instrumental in starting the idea of cable radio in his hometown in South Carolina. So Best had some introduction to wired RF communications, even while working at RCA in Indianapolis.

In 1964, Best married a girl he had been dating in Augusta and brought her to Indianapolis. He says, “I was a southern boy with red clay between my toes. There was one January when I was living in an apartment, and I shoved the door open and snow was level with the hood of my car! I knew at that moment that this was not going to work over the long haul. Because basically I’m a hot weather person. ... So, in 1965, I decided to go back to Georgia Tech and get a master’s degree” <Best 1993, 12>.

To help with the cost, he took a job with the Georgia Tech Experiment Station. In an accidental encounter, the type that shapes our lives, he inquired of the man working next to him, after hours, “What are you doing there?” The man said, “Well, I know some people at this little company here in Atlanta called Scientific Atlanta and I’m working

on a preamplifier for them.” And Best said, “Really? Tell me about it. I know a little bit about television.” It turned out he was working on a cavity filter for the front end of a preamplifier for TV. Best was intrigued and said, “Who are you doing this for?” The man replied, “I’m doing this for a fellow named Tom Smith that I know out there. He asked me to do a little consulting on the side for him” <Best 1993, 12>.

In September 1966, Best received his master of science in electrical engineering from Georgia Tech and immediately had an offer of employment at SA. To Smith, a bright, enthusiastic, well-educated young engineer like Best must have seemed ideal and his experience in television receiver design a delightful bonus. By this time, they were teaching solid-state physics (transistors) at Georgia Tech, and Best had worked with an analog computer—before the modern digital computers. For the better part of 20 years, the team of Tom Smith and Alex Best pioneered the development of SA as a major supplier to the cable television industry.

Smith put Best to work on designing a better pole-mounted preamplifier and companion power supply than existed at that time. Jerrold had a good solid-state, single-channel preamplifier with cavity filters at the input. Best

got the idea of using field-effect transistors (FET) instead of the bipolar devices, taking advantage of the square law transfer characteristic to minimize third-order distortion (e.g., cross modulation). He put a cavity filter in front of the first stage and double-tuned circuits at the output of both the first and second FET amplifier stages. This preamplifier had more selectivity and 20 dB better cross-modulation performance than the state-of-the-art Jerrold piece had. But, with numerous hand-wound coils, it was expensive to build and the double-tuned circuits were more temperature sensitive than Jerrold's. They sold a lot of preamps but never made a penny on them <Best 1993, 17-18>.

Smith introduced a trick he learned at Chance-Vought for diplexing antennas. Use of matched power combiners (i.e., splitters) results in 3-dB gain reduction with consequent 3-dB lower carrier-to-noise ratio. By calibrating the downlead for channel A to one-quarter wavelength at channel B and the downlead for channel B to one-quarter wavelength at channel A, the two downleads can be combined with a simple T-connector. The channel A downlead looks like an open circuit at the channel B frequency and vice versa. Smith believes they were the only ones in the industry to use this technique

<Smith 1992, 41-42>.

The Heterodyne Signal Processor

As soon as the preamplifier was completed, Smith came to Best's office and presented an instruction manual for a Jerrold Channel Commander, the vacuum-tube model. Benco Television Associates, of Toronto, made the only other heterodyne signal processor available at the time, also using vacuum tubes. Smith said, "Alex, I want one of these, made with transistors, for the next NCTA trade show, nine months from now." Best responded, "OK, what is it?" Smith said, in mock amazement, "You mean you don't know what that is?" And Best came back with, "I haven't got a clue what that is" <Best 1993, 19>.

A heterodyne signal processor is a type of television receiver. The input channel signal is converted to an intermediate frequency (e.g., 41-47 MHz) where it is filtered to separate the sound channel, reject adjacent channel signals, and provide a proper response for the vestigial sideband. Automatic gain control is provided separately for the visual carrier and the aural carrier. After being separately processed, the visual and aural IF carriers are recombined. The intermediate frequency is

then up-converted to the channel frequency for distribution on the cable TV network. Additional functions include a substitution carrier switched automatically whenever the received visual carrier is lost for any reason and a variety of program options.

Smith then revealed that SA was bidding on a complete, eight-channel, turnkey head end for the system at Gainesville, Texas. They won the job and ordered eight tube-type Channel Commanders from Jerrold to be delivered on-site. “So,” Best says, “in 1966, I was sent out in the middle of a cow field in Gainesville, Texas, about 100 miles south of Oklahoma City, to install and set up these Channel Commanders. ... It certainly made a lasting impression on my life. I remember watching the cows come home every day. They would pass right by the head end” <Best 1993, 19>. But he got the job done and quickly learned what a processor was all about and what were the good and bad points of the Jerrold Channel Commander. He came back to Atlanta to tell Smith that he was ready to take a shot at designing a solid-state model.

This was still 1966. Best had only been on the job since September. “But you know,” he says, “I was a loner at SA by necessity, because there was no one I could go to at SA that knew anything about television.” They were

the leading manufacturer of antenna measurement facilities but had no expertise in television. Their one success in cable TV was the log-periodic antenna. Smith had completed his engineering degree at Mississippi State, worked with Rudy Riley on some small cable networks, and had experimented as a ham radio operator. But Best says, “He didn’t really know anything about television. . . . He had a cursory knowledge, but he had no in-depth knowledge.” Smith himself says, “I put Alex to work on developing a solid-state signal processor. That was quite a task, and it was done basically by Alex himself. He didn’t have a whole lot of help.”

Best was quite overwhelmed by it all. Nevertheless, he started out designing the IF amplifier, with which he had some experience from his work at RCA. “At that time,” he says, “we didn’t have a spectrum analyzer. I designed this thing with a sweep generator and a 704-B tube-type field-strength meter.” He did not have the advantage of TDR, wideband oscilloscope, network analyzer, impedance bridge, frequency counter, or any of the sophisticated test gear found in today’s laboratories. As the project progressed, Smith and Best were trying to come up with something innovative. Best had an idea. “Gee,” he says, “you know the first thing you do when

you put these things in a rack is to set the levels. So, why don't we design the meter into it? ...This was a great idea." In retrospect, however, customers preferred the model without a meter.

They displayed a prototype Model 6100 at the NCTA Convention in Chicago in June 1967. "To be quite honest," Best acknowledges, "those things were, in many respects, not up to the same level of performance as that Jerrold tube-type version." It was particularly rich in spurious signals generated by the transistors, which are not very linear. Best points out that it was probably the attempt to eliminate spurious emissions, not only from the SA processor but other solid-state processors as well, that brought about the set of rack-mounted elliptical bandpass filters that became popular at this time <Best 1993, 22>. As Smith says, in hindsight, "It was primarily because of our inexperience. ... If we had been smart, we probably could have put external filters in the design." The main competitor at the time was Jerrold's vacuum-tube Channel Commander, which had problems because of the loop-through coupling to combine the outputs of several Commanders. "We didn't know it at the time, but we soon learned," Tom says.

Before taking the prototype to the 1967 NCTA show,

Smith conferred with the heads of the manufacturing facility at SA who were experienced in price determinations. In order to set a price for the Model 6100 Processor, they obtained cost estimates for materials and assembly labor and calculated overhead and marketing costs. Smith anticipated that Ameco would introduce a solid-state processor and that CAS Manufacturing Company (John Campbell) might do so as well. It seemed almost certain that Jerrold would have one, but they were late in announcing it. Pricing must provide a reasonable chance for a decent profit while recognizing the impact of discounts. Smith says, "I really had no idea how they were going to price those things, and I didn't have any contacts that I could call... or maybe I wasn't smart enough to think about calling contacts in the industry. So I priced it at \$1400."

Ameco did, in fact, show its Channeleer for the first time at the 1967 NCTA Convention. Jerrold was there with its new solid-state Channel Commander II. CAS also displayed its version of the solid-state processor. Smith was delighted to find that his price was a little higher than the others but not more than about \$200. "Whew!" he said. "Maybe we are going to do something in this business after all!" Actually, it was probably desirable

that the SA product was priced slightly above the pack <Smith 1992, 28-30>.

Modulator and Demodulator

Smith had developed good relations with Vikoa, a company that was doing a lot of turnkey projects at that time and preferred to use SA as a head end supplier rather than Jerrold or Ameco, both of whom were competitors for Vikoa's distribution equipment. He had hired Dick Walters as marketing manager and had convinced the company to form a separate manufacturing operation for the cable TV products. About 1967 or 1968, they moved into a strip mall a couple of miles from the main facility, with 40-50 employees. Mechanical components were still made at the main shop and the antennas were fabricated by Southern Tool.

About this time, Smith met Henry "Hank" Diambra, founder and former president of Entron. Diambra had retired from Entron in 1964 to develop several franchises in south Georgia and Florida for the Westinghouse Electric Company. Diambra was developing an extensive microwave network to relay channels 2, 5, and 11 from Atlanta, as well as signals from other cities, to the

Westinghouse systems in Dublin, Milledgeville, Swainsboro, Thomasville, and Valdosta, Georgia, and in Tallahassee, Florida. He was dissatisfied with the Jerrold and Conrac peak demodulators and impressed on Smith the need for a good, high-quality, synchronous demodulator to eliminate the distortion inherent with peak detection of vestigial sideband signals. (In synchronous demodulation, the modulated carrier wave is multiplied, or heterodyned, with a local oscillator whose frequency is precisely equal to that of the carrier. The product includes a zero frequency, or dc component, plus the baseband video and sound subcarrier. This process is sometimes called product demodulation.)

Another engineer was hired to design the Model 6200 Demodulator. The work proceeded slowly, but the product was finally brought to market shortly after the Model 6100 Processor. The Model 6200 was similarly packaged but without some of the convenience features Best had provided in the Processor. Although it appeared to work quite well at first, it had a long-term stability problem with synchronization. When it lost sync, Smith called it “the best picture scrambler you ever saw” <Smith 1992, 55>.

The next product was the Model 6300 Modulator,

with low-level modulation at IF replacing the down-converter of the processor, feeding a modified IF amplifier with vestigial sideband filter. The up-converter was essentially the same as the one designed for the 6100 Processor. There were not many applications for modulators at that time. Most systems would have several processors in the head end racks. An occasional system would have one or two modulators for locally originated signals such as the weatherboard camera focused on various meteorological instruments or a news teletypewriter. However, the microwave relays for distant TV signals would require both demodulators and modulators, and this looked like a developing market.

Shortly after the 1967 NCTA show, Smith and Best decided to conduct a technical seminar at the new CATV facilities to enable industry engineers and technicians to observe in greater depth what SA was doing. During that seminar, Best discovered a characteristic of the solid-state processor he had not previously noted. He had designed the IF amplifier with a forward AGC transistor in which gain was reduced by increasing, rather than decreasing, the bias current. Unfortunately, increasing the current also increased the loading on the coils, broadening and skewing the frequency response. The impact of this effect

on video signal quality was demonstrated when a seminar participant (actually, Archer Taylor) asked to see the response to a multiburst test signal. While the multiburst signal was very flat at maximum gain, the response rolled off at both ends when the gain was reduced. Until then, Best had not focused on the increased coil loading. He thought he had done something quite good <Best 1993, 24>.

It was very difficult to set up the processor to keep spurious signals below threshold and provide flat response over a realistic dynamic range. Best found that he was spending a lot of time with the manufacturing group, helping to get the product in condition to deliver and be properly installed. He began tracking deliveries, because he knew that he would be called upon to help most of the customers on-site to achieve acceptable installations. Best says, “I was the only person that knew how to make them work, so that’s how I ended up in the field.”

The “Ghost” Expert

By this time, larger systems were being built with several receiving sites feeding signals into what was

being called a head end hub. This was also a distribution hub where signals from one or more remote receiving sites were reprocessed before being transmitted on the trunk cables. One of these head end hubs was in Tiffin, Ohio, now a part of the Fostoria system. After about six months, they called SA to help them figure out why all their signals appeared to have trailing ghosts. It was installed in the summer; now it was winter. Could snow on the ground create the problem? Where could the ghosts be coming from? Best drew the elliptical diagrams that might help to locate potential reflection points, such as a new silo or large building. It was a mystery. He had no quick answers.

Best flew into Tiffin one night and bought a local newspaper before checking in to the motel. Reading the paper in bed that night, he spotted an alarming story headlined: “Ghost expert arrives in town.” He had not a clue as to what he was going to do. If public anger about those ghosts was so newsworthy, he feared they might string him up before he could leave town if he couldn’t figure out what was causing them.

By comparing pictures on a TV monitor at the antenna with pictures at the processors, it became clear that the ghosts were not due to multipath reflections.

Recalling articles published in the cable TV trade press about nonuniform envelope delay, Best theorized that the ghosts were probably due to phase shifts in the IF filters in the processors. By reprocessing signals at the hub, after processing initially at the antenna site, minor ghosts were multiplied into serious ghosts. There was no antenna problem that could be “fixed.” But even worse, there was no way to “fix” the processors in the field. Best was embarrassed that he had to leave without correcting the problem. It should be noted here that he did not experience any difficulty leaving town, as he had feared he might (e.g., necktie party or a bath in tar and feathers) <Best 1993, 26-28>.

After about three years, Best says, “I met a lot of nice people in the field, and I traveled a lot of places... but I saw this was not going to work. I was going to become a field engineer, not a design engineer.” The field experience was enormously valuable, but the time had come to design a better processor. So, John James was brought in to absorb the practical experience Best had learned. James would take over the field engineering work so that Alex could get to work on a new and improved Model 6150 Processor.

Relieved of his field engineering duties, Best was in a

better position to redesign the processor. By now he had a General Radio envelope delay measuring instrument. For the first time, he was able to see the U-shaped envelope delay curve resulting from phase errors associated with the IF filter, which was measured in nanoseconds versus frequency across the passband. He also had the help of another engineer, Jack Chastain, who designed a three-section delay equalizer to compensate for the delay introduced by the IF filter. Best was impressed with the improvement in the processor response to the 2T sine-squared test signal when the delay equalizer was inserted. The Model 6150 Processor incorporated the three major electronic improvements that Best described in a paper presented at the 1974 NCTA Convention in Chicago <Best 1974>:

1. Delay equalization
2. 60-dB adjacent carrier rejection
3. Spurious signals reduced below noise

Best's introduction of the delay equalizer was an important contribution to the state-of-the-art in cable TV technology. Additional features available in the redesigned 6150 Processor included capability for various IF switching options, battery power, standby carrier

modulation, and phase lock.

An important and useful feature of the 6150 processor, as well as the 6250 demodulator and 6350 modulator, was their modular flexibility, with nine interchangeable modules facilitating various switching and other options. However, the series of mechanical connections through which the signal passed from module to module made the 6150 inordinately vulnerable to connector failure. With the help of Gilbert and other connector manufacturers, this weakness was largely overcome. Nevertheless, modular flexibility was abandoned for later designs <Best 1993, 32>.

By this time (1973-1974), the need for an improved modulator was recognized. More systems were using microwave for the distant signals needed for an attractive package of cable TV programs in addition to those that could readily be received off-air. Moreover, with the leadership of SA's president, Sid Topol, among others, interest was growing in the potential use of geosynchronous satellites to relay programming not available from terrestrial broadcasting. Both microwave and satellite reception would require video modulators for transmission on cable TV networks.

The Surface Acoustic Wave (SAW) Filter

The Model 6350 Modulator was developed to replace the Model 6300. It was to be packaged in the same modular configurations as the Processor and Demodulator. Best was aware that it would be subject to envelope delay problems similar to those of the Processor. He set about to design an elaborate and sophisticated eight-pole, vestigial-sideband (VSB) filter to be followed with a delay equalizer. It was a cumbersome thing and a beast to tune, but that was where he was headed.

In his interview, Best says, “I have to confess... I’ve always considered that maybe, if I brought anything to the cable industry in those days, it was the use of surface acoustic wave filters and the advantages they offered. I would like to tell you that it was all my genius planning. But I was sitting at my lab bench trying to tune this damn eight-pole filter when a company called Sytec knocked on my door and came in.” The salesman handed him a little widget. “Ever see one of these?” he said. “No. What is it?” “Well,” the salesman went on, “essentially, it is a solid-state bandpass filter, made of lithium niobate.” More specifically, it was a surface acoustic wave device configured as a bandpass filter.

The Sytec engineer explained the physics of the SAW filter and described its performance characteristics. In addition to very high selectivity, a SAW filter could be designed with almost any desired phase characteristic. It is an integrated circuit (IC) device fabricated by photolithography on the piezoelectric lithium niobate crystal substrate. It is in a small package. Unlike the eight-pole lumped constant filter that Best was designing, it does not have to be tuned.

Best thought it sounded wonderful. He drew for them the amplitude and phase selectivity characteristics he needed and they left. In about two months, they came back with a SAW filter, custom designed to Best's specification. By this time, he had just about completed the exacting and tedious task of designing the eight-pole filter and delay equalizer. Both the SAW filter and the eight-pole filter would be priced the same, at about \$90. However, the 20-dB insertion loss of the SAW filter would require additional amplification. Moreover, internal reflections in the SAW filter would have to be suppressed to prevent annoying long-delay echoes at about half a horizontal scan line (25-30 microseconds). After going back and forth several times, Best decided to give the SAW filter a try. He put it in the vestigial sideband of the

new modulator and took it to a trade show in 1975 <Best 1993, 35-38>.

Best has made important contributions to the state-of-the-art, first with the delay equalizer in the Processor and then the SAW filter in the Modulator. Until the SAW filter came along, envelope delay deviations were responsible for the most mysterious, elusive, and generally misunderstood television picture impairments. Scientific Atlanta was first, but soon the SAW filter became an integral part of all modulators. The gift for finding something good accidentally is known as serendipity. The genius lies in recognizing serendipitous opportunity and being wise enough to exploit it.

Best was never comfortable using the SAW filter in the Processor because of its inherently large insertion loss. It was one thing to accommodate the SAW filter insertion loss with a locally generated, high-level, clean carrier. It was quite another matter to overcome so much insertion loss without still further degrading a weak carrier, already received with more or less noise and other impairments. However, SAW filters today have much lower insertion loss and are now used in virtually all modern television receivers. This probably accounts for a significant part of the picture improvement in home TV

sets during the last decade or so.

The market for demodulators was never very large. By this time, however, interest in baseband (video and audio signals as they come directly out of the camera or microphone) was beginning to grow. Mainly, this was due to an increasing need to relay programs by microwave systems, which were generally baseband. Moreover, interest in program switching, which is best done at baseband, was also expanding. A new, improved Model 6250 Demodulator was developed with a redesigned synchronous detector system and vestigial-sideband (Nyquist) filter. It was repackaged in the nine-module form that had been developed initially for the 6150 Processor.

Scientific Atlanta was probably unique in offering a demodulator with synchronous detection. True synchronous detection requires phase-locking a local oscillator to the incoming visual carrier frequency, the amplitude of which is varying with the video waveform, nominally between 1 V during the synchronizing interval and 0.125 V at white level. Depending on operation at the transmitting station and on the characteristics of the demodulator AGC, carrier voltage at white level may actually go to zero, resulting in loss of phase lock and more or less picture impairment. The revised 6250

Demodulator used a new IC chip called quasi-synchronous. Although it did not actually phase-lock a regenerated carrier to the incoming signal, the resulting performance was practically equivalent to the true synchronous detector. A switch was provided with which to substitute a conventional peak detector for comparison.

An unanticipated bonus with the Model 6250 Demodulator was that many more were sold to television broadcasting stations than to cable TV operators. It was an excellent tool for measuring broadcast transmitter performance, with characteristics priced at \$2,000 that were virtually equivalent to the Rhode and Schwartz Demodulator at \$10,000 to \$15,000.

UNPROFITABLE PRODUCT LINES

In the early 1970s Scientific Atlanta did develop a few product lines that failed to achieve profitable markets. The Omnibus Crime Bill promoted by President Lyndon Johnson in the late 1960s gave Smith an inspiration. He thought that a security monitor channel for viewing at home, as well as monitoring fire and burglar alarms, would be a natural extension of cable television. His initial idea

was to use frequencies in the HF region (3-30 MHz) for return transmission on a separate overlashed RG-59/U coaxial network. He had a group working to produce a product line called Security Alert. Marvin Roth described the system in detail in a paper presented at the 1971 NCTA Convention in Washington, D.C. <Roth 1971>. At the 1980 NCTA Convention, Smith presented “Review of Present State of the Art of Residential Fire and Burglar Alarm Hardware” <Smith 1980>.

The two-way cable market did not develop in the early 1970s as expected. However, in 1971, the Security Alert system put Smith and SA in touch with the Rollins Protective Services Company in Atlanta, who had acquired the Orkin Exterminators and were developing a proprietary wireless burglar alarm system. Smith’s cable division developed the wireless product, and SA became sole supplier to Rollins for more than two million transmitters and hundreds of thousands of control units over a 10-year period. This gave SA valuable experience in real volume production that carried it into the next level of manufacturing cable TV distribution equipment <Smith 1992, 61-62>.

The cable TV industry took up the remote security alarm business in the early 1980s, mainly to strengthen

franchise applications. But interest dissolved after a brief whirl, as operational complications were encountered without compensating revenue potential. One of SA's few customers was a municipally owned cable system in Monroe, Georgia. In addition to monitoring fire and burglar alarms, they used some SA VHF radio-operated switches that Smith's group had developed for peak load management (PLM) of electrical energy. In 1977, SA participated with Georgia Power Company in a test involving more than 3,000 customers. Energy management has continued to be a good business for SA <Smith 1992, 70>.

The idea for developing microwave relay links was proposed by a group at SA who had developed some solid-state 12-GHz equipment for internal security monitor purposes within their own facilities. John Dillon, a Harvard MBA who later became CFO of Cox Enterprises, was hired from Coca-Cola to manage the new project under Smith's jurisdiction. Technically, they had a good product, but they were up against formidable competition for the meager cable TV market from Microwave Associates, which was marketing a solid-state microwave link for remote television. When Topol became president of SA in 1972, after spending his entire career in

microwave relay, it didn't take long for him to say, "Hey, this project goes! Let's kill it right now!" <Smith 1992, 57>.

THE DISTRIBUTION BUSINESS—SCIENTIFIC ATLANTA'S PRODUCT LINE

Scientific Atlanta had become the leader in supplying quality head end equipment to the cable TV industry. But, as cable TV began to spread into the larger urban markets, there would be much more need for distribution than head end equipment. Scientific Atlanta had achieved an excellent reputation in the industry for quality products, engineering, service, and integrity, but they were not participating in the major part of the cable TV market. They would have to get into the distribution business.

They were aware that Spencer Kennedy Laboratories had come on hard times in 1969-1970, and both the company and the product line were up for sale. Tom Smith says, "I was pretty much involved in [the evaluation and acquisition]. John Dillon... helped me in the process of trying to establish what the product line was worth."

Smith was particularly impressed with the innovative modular arrangement George Ray was developing for line

amplifiers. “To my knowledge, as I recollect right now,” he says, “they were one of the first to come up with this idea of individually enclosing and shielding in separate modules the functions of trunk amplifier, bridger amplifier, power supply, and AGC.” He saw it as an advantage both for testing on the production line and for maintenance, and he liked it. He also liked the cast housing, which was initially an aluminum sand casting but was adaptable to die-casting. SKL had simply not been able to invest in the die-cast.

“The other feature I liked about it,” Smith says, “was an integrated trunk line center conductor seizure and RF connector. The seizing mechanism also formed part of the RF connector, and the modules had slip-on F-fittings that... provided a good, constant impedance match from the 75-ohm cable into the... amplifier.” Another feature SKL had, which SA really never developed, was a mid-split two-way reverse module with cut-off around 108 MHz rather than 30 MHz.

“But anyway,” as Tom recalls, “I think we paid \$125,000 for all of the design and the castings, and their trunk line inventory—what little there was at the time.” They wanted to hire Bill O’Neil, one of SKL’s engineers. Although he came to Atlanta for a short time, he did not

stay. The SA amplifier was still using discrete transistors. Smith and the design team, Larry Clayton, Jack Chastain, Charlie Curry, and others, converted the output stage to accommodate the TRW hybrid chips. In the end, they had completely redesigned all the electronics they had acquired from SKL. They even had to rework the SKL cast housing to eliminate porous leaks, learning a great deal about die-casting in the process. “I guess the main thing we got out of that acquisition,” Smith said, “was the commitment to get into the distribution amplifier business” <Smith 1992, 84-87, 90-91>.

Competition was formidable. One reason SA hesitated to get into the distribution business was the enormous risk in turnkey contracts. To deal with this, SA established a subsidiary called Scientific Atlanta Services, Inc., with E.B. Chester as manager. Chester was a mechanical engineer with an entrepreneurial restlessness who had worked at SA for a number of years. He did a good job but became involved in running battles with Bob Holman, the marketing manager. Smith says, “I finally had to let E.B go. E.B. thanks me now for that... because he went into the cable operation business and he is now a rich man” <Smith 1992, 88-89>.

In order to become a full-service provider for cable

TV, SA purchased the Systems Wire and Cable facility, which had been acquired from Ameco and in turn, had been acquired from Rome Cable. Nat Marshall came over with the acquisition to manage the operation. They also acquired the rights to the Anaconda Sealmatic cable, using a longitudinal aluminum tape outer conductor with bonded seam. After a few years, however, they realized they would not be able to compete effectively against Times or CommScope and withdrew from coaxial cable manufacture.

Back in the late 1960s, SA developed a distribution line quite unrelated to their historical expertise. They acquired a patent to increase the shelf life of meats by flushing out the oxygen in the package and replacing it with carbon dioxide or nitrogen. It worked very well. The only hitch was that shelf life of meat was not a problem in the United States. Their business turned out to be primarily in the Caribbean and other underdeveloped countries.

The business was located in the same building with the cable TV division. When they lost so much money that they decided to get out, the cable division fell heir to a large, well insulated meat cooler. By installing a high-powered air conditioner, it became a very effective

environmental test chamber. When they moved the cable division to Gwinnett County in the mid 1970s, they installed their own, more sophisticated environmental test chamber <Smith 1992, 93>.

400 MHZ DEVELOPMENT

It must have been about 1978 or 1979. Best had just been made engineering manager over the cable engineering group that was preparing quotations for the group seeking the Atlanta franchise. At the time, they were quoting on 300-MHz equipment, but the Atlanta group said, “We want you to quote for us, for the Atlanta franchise, a 400-MHz broadband amplifier.” Best went to Jim Hart, the distribution expert at that time, and told him they were being asked to quote on 400-MHz equipment. Hart said, “Hey, Alex, we have a hard enough time getting these things flat to within those tenths of a dB that we have to propose for 300 MHz. I just don’t see how it’s technically possible.” So Best went back and told the Atlanta group, “We don’t think we can do it.” That was the wrong answer! They said, “If you can’t do it, then you don’t get the job.” Best said, “Fine.” But they went over Best’s head and told management, “If you want this job,

then it is going to be 400 MHz.” Scientific Atlanta could hardly afford to lose such a major job in their own backyard. So they agreed to 400 MHz. The 400-MHz hybrids did happen, the system was delivered, and it worked, although not without a good deal of heartburn.

At least two expert engineers said it couldn't be done. Best says, “I guess that's another example of engineers being too honest. They may not tell you the right answer, but they tell you what they think is the right answer at that time” <Best 1993, 30>.

THE 6700 CONVERTER DISASTER AND RECOVERY

It was about 1979, and SA had been experiencing a remarkable string of successes. As Best said, “It just seemed like everything they did seemed to work.” So, undaunted, they said, “Boy, we'll just make a better set-top converter.” Best and Jim Farmer spearheaded the task. TRW and Motorola had just made available hybrid gain blocks, selected from production batches for performance at 400 MHz. This news sparked pandemonium in the franchise wars. Everyone was promising 400 MHz, but there were no 400-MHz set-tops. So when SA announced that it was preparing to offer a 400-MHz converter, a flood

of orders began to roll in.

Meanwhile, Best and Farmer had examined the Standard Components tuner used by other converter manufacturers and realized that it had too many labor-intensive gimmicks and twisted wires. They set about to design a tuner using the technique they were good at—putting components on printed circuit (PC) boards. About three months before they put this in production Farmer and Best realized it was not going to work. Best says, “Unfortunately, we had gotten ourselves between a rock and a hard place. SA had accepted a lot of orders. Franchise commitments were based on getting systems up and operating within the promised time frame.” When Best told Cox Communications, “We’ve got this converter here but it’s not ready,” they said, “I don’t care. You will deliver when you said you would deliver” <Best 1993, 50-51>.

They put this ill-fated converter, known as Model 6700, into production. It had crosstalk between the various compartments and frequency drift in the output was severe. Everyone recognized the almost certain disaster being built into this product. But it had taken on a life of its own. It couldn’t be stopped. They knew they were heading for a stone wall, but there was no stopping.

At one time, SA was producing a thousand of these boxes a day and selling them at \$70 apiece. They were costing \$90 to produce. Scientific Atlanta was losing \$20,000 a day, in addition to the immeasurable damage to their reputation. It was not a fun time to be at SA. It was a costly way to learn the lesson: “Don’t take orders until you have a working model” <Best 1993, 48–51 >.

Smith says, “Everybody... recognized the potential and almost certain disaster being built into it.” In hindsight, he says, “We had really no experience in trying to manufacture so sophisticated a product in such large volume and at such low cost.” They had decided to manufacture the converter in the United States rather than off shore as was the practice of other manufacturers of consumer electronics products. They had a good labor pool in Atlanta (although at higher cost) and believed they could maintain better control of the project at home. Some Buy American sentiment may have been involved in the decision as well. But Smith says, “We really did not have the horsepower... not the engineering horsepower, not the manufacturing horsepower to put on it... to really insure that it was going to get off on a good start” <Best 1992, 75-76>.

Jack Kelly, executive vice president; Jay Levergood,

president of the CATV Division; and Alex Best flew to Japan to meet with a number of companies about producing set-top converter boxes to SA specifications. They selected the Mako Division of Matsushita, one of the largest and most experienced electronic manufacturers in Japan, and shut down production in Atlanta. By remarkable coincidence, it was December 7, 1981, when the Matsushita people showed up at SA to start the so-called technology transfer process. The resulting Model 8500 series of subscriber terminals has been quite successful <Best 1993, 53>.

ENTERING A NEW ERA

Sid Topol came to SA in 1972 with a conviction that geosynchronous satellites were destined to play a major role in the development of cable television. Scientific Atlanta had already established a satellite communications division called SATCOM and had designed satellite receivers and earth stations for Intelsat. Earth stations were priced at \$100,000, with satellite receivers at \$25,000. Those prices would not work for cable TV, so the cable division decided to design its own receiver to be priced at \$3,000. Smith and Peter Pifer

described the features of the 7.6-meter (25-foot) antenna and a low-noise preamplifier and receiver at the 1973 NCTA Convention <Smith and Pifer 1973>.

From a personal point of view, Smith said, “Some of my own ego satisfaction has been that I sort of acted as an entrepreneur for Scientific Atlanta in three significant fields: (1) I started them in cable, and that’s by far their largest business; (2) I started them in wireless security, and for 10 years that was a good, profitable contributor—we made over two million wireless transmitters; (3) I came up with the concept of energy or load management, which is still a good business for SA today.” In 1974, with the cable business in the doldrums, SA sent Smith to Harvard for the 14-week project management degree (PMD) program. Upon completing the course, the Rollins business had grown to the point that it needed a full-time manager. Since the cable business was slack at that time, Smith moved out of the cable division to work with both Rollins and the energy management projects. After the famous 1975 satellite relay of the Ali-Frazier boxing match in Manila, the cable business took on a new expansive life. Smith returned to the cable division for a brief period in the early days of the Model 6700 set-top converter fiasco. In retrospect, he says, “I didn’t really appreciate it

at the time, but the cable business had outgrown me and my capabilities.” So he returned as full-time manager of the load management project until leaving the company in 1984 to become president of King Marine Electronics in Clearwater, Florida. At the time of the interview, he was living in Plant City, Florida, as a consultant, with Best and Cox as clients <Smith 1992, 69-74>.

By 1986, Best was working with a subsidiary company on B-MAC (multiplexed analog components, model B, using time-compressed digital modulation) for satellite transmission. Although he was now more of a high-level technical salesman than a bench design engineer, he was not looking for a job when he had a call from a headhunter claiming that an Atlanta-based firm was looking for a vice president of operations. Obviously, it did not take a soothsayer to figure out that this was Cox Communications. Best had dinner with Jim Robbins, president, several times before overcoming his unease at making such a major career change. He successfully made the transition and enjoys the challenges of operations as much as he enjoyed his 20 years in manufacturing <Best 1993, 61-64>.

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CHAPTER 10

C-COR Electronics, Inc.

IT IS SAID THAT ONE OF THE TOP-10 MULTIPLE SYSTEM OPERATORS ONCE TOLD JIM PALMER, FOUNDER AND PRESIDENT OF C-COR, THAT HE COULDN'T BUY C-COR EQUIPMENT BECAUSE PALMER EXPECTED HIM TO PAY FOR IT. While the story may well be apocryphal, it is not inconsistent with Palmer's no-nonsense, pay-as-you-go philosophy of business management. C-COR has enjoyed a reputation for high-quality, reliable products at prices considered to be high but generally fair. The established price list with the published dollar volume discount schedule was consistently nonnegotiable, clearly distinguishing C-COR from other CATV manufacturers.

JAMES R. PALMER¹



Fig. 10.1 James R. Palmer

*Courtesy National Cable Television Center and
Museum*

Jim Palmer ([Figure 10.1](#)) was born in Nebraska. Both

pairs of grandparents homesteaded in Nebraska. His father was born on the homestead property; his mother, in a sod house in Nebraska. Palmer's frugal attitudes were a product of the dust storms and hard times that were particularly rough on Nebraska during the Great Depression. In 1941, he graduated from high school in Kearney. He received a Regent Scholarship to the University of Nebraska, without which he could not have afforded the \$50 tuition. In order to meet other expenses, he worked at several jobs, the last of which was with American District Telegraph as night operator and guard, from midnight until 8:00 a.m. In spite of long hours on the night shift (48 and 52 hours in some weeks), he earned higher grades in his second year than in his first, in which he received the award for highest scholarship in the college of engineering.

In 1943, after two years at the University of Nebraska, he enlisted in the Navy and was sent to Iowa State University, where he was allotted four semesters in the Navy V-12 program. By taking 20 and 22 credit hours per semester, he was able to get his bachelor of science in electrical engineering degree in 1944 with a 3.95 grade point average. His only "B" was in electronics from John D. Ryder, a renowned professor of electrical engineering,

author of seven textbooks on electronics and circuit theory, past president of the Institute of Radio Engineers (IRE), and former editor for IRE and its successor, the Institute of Electrical and Electronics Engineers (IEEE).

By the time he had completed further training at Columbia Midshipman School, officer electronic training at Bowdoin in Maine, and the MIT Radar School, the shooting war was over and he was assigned as an electronics officer on a destroyer in the East China Sea.

Upon discharge from the Navy in 1946, Palmer went to work for General Electric (GE) in the advanced engineering training program at Schenectady, where they taught students to think creatively with emphasis on problem solving. He worked for GE for five years in Schenectady and later in Philadelphia, involved as project manager to develop a mechanical rectifier to convert ac to dc, with mechanically driven contacts that opened and closed 60 times a second. Although the project was successful, it was gradually made obsolete by solid-state rectifiers.

Jim and Barbara Palmer were married in 1948, and a few years later, because GE salaries had fallen well below the norm, he took a job as an electrical engineer with

United Engineers and Constructors. However, he did not like commuting in Philadelphia and began looking for another job, with new interests and new directions.

In October 1953, he went to work for Haller Raymond and Brown (HRB), a military electronics research and development company in State College, Pennsylvania, predecessor to HRB Singer, which is now part of Raytheon. Barbara Palmer was familiar with the State College area, and Jim found the prospect most attractive, both as to the community lifestyle and the professional opportunity at HRB. One of his first assignments involved a system for transmitting radar displays to remote locations over telephone lines.

He also did a study for the Signal Corps for Army aircraft communication and navigation. Palmer says, "That gave me an interest in flight that I didn't have before, although my father was a pilot in the First World War." Then, pointing to a broken propeller hanging on the wall in his living room, he says, "This was a propeller that he broke in 1919. Taxiing in a field of leaves, probably at Moffett Field, there was a ditch. He didn't see it. The plane nosed over, busted the prop, and he kept it" <Palmer 1992, 4>. Palmer became a pilot and flew his Skymaster, not only to his vacation home on Grand

Cayman Island but also to customers' projects, national trade shows, and other business activities. As he prepared to leave State College Airport by car, he was likely to warn the passengers who had just come in with him in the Skymaster that "Now begins the dangerous part of the trip."

HRB Initiatives in Television

In 1947, Dr. Walter Brown and a group of HRB personnel organized a company called Central Pennsylvania Corporation for the purpose of obtaining an FCC construction permit and license for a television broadcasting station. After several years of effort, they were not successful. In 1951, they decided, instead, to build a community antenna TV (CATV) system in Bellefonte, county seat of Centre County with about 6,000 population, a dozen or so miles northeast of State College. Initially, it carried only the Johnstown channel 6. Later, they added the Lancaster channel 8 and Altoona channel 10, converted to channels 2 and 4 for the three-channel low-band system. It is interesting to note that open wire line was used initially for the antenna site run, although coaxial cable was used in the distribution system. A

separate entity, State College Television Cable Company, was organized to build a CATV system in the city of State College. While the antenna site was originally located on the roof of Walter Brown's home, it was later moved to the water tower at the university, near the Nittany Lion Inn, and finally to a more permanent site.

Still another venture, Centre Video Corporation (named for Centre County), was organized originally to function as a distributor for Jerrold equipment. However, the dealings with Jerrold and Milt Shapp were difficult, fraught with arguments and acrimony. Therefore, in 1953, they formed yet another company to build equipment that they could not purchase elsewhere. This was Community Engineering Corporation, shortened for promotional purposes to CECECO. They had one full-time and two part-time employees and built amplifiers and other equipment initially for such unaffiliated systems as Benson, Minnesota; Staunton, Virginia; and Palmerton, Pennsylvania, as well as for the Centre Video systems.

Until December 1954, Brown was primarily responsible for all of these television enterprises. Palmer was not involved. Then, one day, the technical director and Brown called Palmer in and asked, "Would you be willing to look after the little organization we have started

outside HRB? Your responsibilities as general manager would be separate from your regular full-time work at HRB. Compensation would be paid in the form of stock in the organization.” At that time, CECO had total annual sales of \$24,000, and a negative equity of \$10,000. “Obviously,” Palmer comments, “if I could have read a balance sheet, I wouldn’t have taken the job. But I couldn’t.” So, he agreed to do it. He says, “I started with HRB in October of 1953. This exchange took place in December 1954, which I marked as my entrance into the cable television industry” <Palmer 1992, 5>.

Palmer Becomes President of CECO

At first, CECO simply plugged broadband distributed gain amplifiers, designed by Dr. Brown, Fred Thompson, and other HRB personnel, into the Jerrold WADO chassis and power supply. They covered the band 50-100+ MHz, using 6AK5 vacuum tubes with nonresonant, lumped constant delay lines in grid and plate. Then later, they housed the distributed gain amplifiers in galvanized steel boxes that could be clamped to a messenger strand attached to utility pole lines.

Early in 1956, the part-time, moonlighting task of

“looking after” the CECO operation had become a burden for Jim Palmer. It was consuming 40 hours a week, on top of the 40 hours full-time for HRB. According to Everett Mundy, who became a CECO employee later in 1956, it was also about that time that Dr. Brown, the prime mover in these developments, died in a drowning accident <Mundy 1991, 26>. “So,” Palmer says, “we (CECO principals) went up and down the streets of State College, and sold stock to our friends and neighbors, and I went full time. I became president on August 1, 1956, and was stuck with it for the next 31 years.” On August 3, CECO became the major owner of Centre Video Corporation, which in turn was the majority owner of State College Television Cable Company as well as the Central Pennsylvania Corporation. Palmer says, “Three days after having assumed the presidency of the manufacturing company, CECO, I became very much involved in cable television operation for the first time” <Palmer 1992, 11>.



Fig. 10.2 Robert E. Tudek (left) and Everett I. Mundy
Courtesy Tele-Media Corp.

EVERETT I. MUNDY²

CECO had been getting technical help, on a project basis, from Everett Mundy ([Figure 10.2](#)), a research associate employed by the Engineering Electronics Group at Penn State University. So when Palmer became full-time president of CECO, with both manufacturing and system operation responsibility, he and vice president Floyd Fisher offered Mundy stock options to join CECO full-time and set up a research and development and production test department. Previously, they had been sending equipment over to HRB for final tests.

Everett was an only child, born in Lewistown, Pennsylvania, in 1924, raised in a religious family. His mother taught for 13 years in a one-room schoolhouse, near Horningsford, and was active with the Church of the Brethren in Lewistown. His father worked for the *Lewistown Sentinel* as a stone hand. “In the printing business,” Mundy explains, “a stone hand is the fellow that sets up the pages as the print comes off the

linotype. ... Eventually, he got lead poisoning as a result.” His father started to build custom radios as a hobby, as Mundy says, “before you could go down the street and buy them.” Everett had a corner in the workshop on the second floor of their home, where he got his early exposure to radio technology.

In his junior year in high school, Everett switched from the academic program to the vocational school, in the drafting and electrical departments. The instructor steered him to an apprenticeship in a radio service shop, and then to a job as transmitter engineer with radio station WMRF in Lewistown. He also worked weekends at the airport, and soloed an airplane at the age of 16, the same age he got his driver’s permit.

After graduating from high school in 1942, he worked briefly as an electronics technician equipping military aircraft for special missions and reworking them for major maintenance. He then signed up with the Army Air Corps for training as a flight instructor and finished his tour by delivering an airplane to Bellefonte, Pennsylvania, for the university. After re-enlisting in 1945, he was assigned to the Air Corps and wound up as an instructor/engineer with the Free French, in B-26s. After discharge, he was employed in the experimental department of the Piper

aircraft company in Lock Haven, Pennsylvania. While he was working for Piper, he met and married a young lady from Bellefonte. The Mundys have three children, a daughter and two sons. After working for several companies as an electrical technician, and a tour of active duty during the Korean War, Everett Mundy came to Penn State University as a research associate. While at the university, he was recruited to work with CECO.

Shortly after Mundy started with CECO, the head end site serving all of State College was moved from the water tower location. A small, separate system serving parts of the college campus, including the president's house, was connected independently to the water tower head end. While working in the laboratory, Mundy says, "An emergency came up where I needed some equipment. We still hadn't removed the equipment from the water tower." Then he thought, "Boy, I have over there just what I need in this emergency." So, he went over and stripped three or four channels of equipment out of the rack. "And suddenly," he says, "our emergency was cured." Palmer was curious, and came into the lab to ask, "How'd you get this thing going so quickly?" Mundy replied, "I went over to the water tower and I just stripped out some equipment." "Oh, my God!" Palmer said, and Mundy

wondered, “What’s wrong?” Palmer explained, “The agreement is that it stays there until the cable on campus to the president’s house can be tied in to the State College system.” Mundy recalls, “That created quite a fuss. Needless to say, I worked late that evening getting the system on campus back on the air!” The president of Penn State at the time was Milton Eisenhower, brother of the president of the United States <Mundy 1991, 28-29>.

The design people at HRB were developing UHF converters, some of which would be used in translators in the West. The first family of converters they developed went into Towanda, Pennsylvania. They didn’t work, and Mundy was assigned to go over and try to make them work—in the wintertime. He had been there three days and came to the conclusion that he had to reduce the Q of the multiplier chain in the local oscillator circuit because it was unstable. So he called in the system manager and said, “I want you to go downtown to the dry cleaners and get me some soft-iron coat hangers.” The manager looked at him like he was nuts. Mundy said, “Don’t ask why—just get me the coat hangers.” He then removed the tank coils in the multiplier chain and replaced them with coils made out of the coat hangers. He put the converters in service, and says, “I guess they were still there until they

rebuilt the antenna site” <Mundy 1991, 40>.

NAME CHANGED TO C-COR

Before Jim Palmer became president, there had been a problem with the use of *engineering* in the Community Engineering Corporation (CECO) name, since the original principals were Ph.D.s, not engineers. The matter was resolved when Palmer, a registered professional engineer in five states, became president. But they also had a problem using CECO as a logo. As Palmer says, “There were actually many companies using the name CECO, but the one that had the name registered was Century Lighting. They had trademarked CECO for a system of lights for use in the broadcast industry. They thought there would be a chance of confusion there. They went at us with a vengeance, and they were serious!” According to Mundy, CECO first simply replaced the letter *E* with a hyphen to read “C-CO,” without altering the phonics. But they discovered several other companies using that acronym. “In fact,” Mundy says, “I used to work the IEEE show every year for C-CO. I was always the one that went down ahead of time to set up our booth at the Coliseum [in New York City], I arrived at my booth location and

there was C-CO equipment, but it wasn't my equipment!" <Mundy 1991, 29>.

So, as Palmer says, "We coined the name 'C-COR'—just pure coinage. It maintained the same place in the alphabet, generally in the first of the 'C's.'" The new name was trademarked, protected, and, as Palmer says, "We proceeded to make C-COR stand for quality—quality electronic equipment, quality amplifiers" <Palmer 1992, 6>.

C-COR AND CENTRE VIDEO

Palmer decided that, for volume production, they would have to "get out of the model shop" for housings and chassis. Aluminum housings were fabricated, with a Z-shaped chassis for the Model 100-A distributed gain amplifier. The grid line was mounted on one side of the Z and the plate line on the other side. Gain was 22 dB, which was C-COR's standard for quite some time. Initially, the tubes were 6AK5, but later these were replaced with the military version, 5654.

CECO had been using cable powering before 1954 when Palmer first became associated with them. Mundy says, "...Between Jim and me, we had several of Dr.

Brown's original workbooks. I reviewed those work books and... found out that he [Dr. Brown] originated cable powering." Mundy says, "We powered whole antenna sites with the coax going up the mountain. This was all pioneered by Dr. Brown." In one case, at Bellefonte, the television feedline was subject to damage due to ice formation. Although power was already available at the head end site for an aircraft beacon light, Brown found that enough heat loss was developed in the feedline carrying ac power to the head end to cope with icing most of the time <Mundy 1991, 36>.

Palmer says, "I think we can safely say that Community Engineering Corporation—from its incorporation in 1953—always built wideband distributed gain cable-powered amplifiers." However, he points out, "The WADO retrofit was not cable-powered, because it used the Jerrold power supply" <Palmer 1992, 10>. C-COR limited the passband of its distributed gain amplifiers to the band 54–100+ MHz, probably for the same reason that Western Electric asked SKL to reduce the bandwidth of its Model 212 amplifier that operated up to 220 MHz: "Who needs more than five channels anyway?" Palmer also decided to change the design from the autotransformer they had been using before he became

president to a custom-designed unit with isolated secondary.

C-COR was not licensed to use the distributed gain amplifier circuit patented in England by Dr. W.S. Percival. Although they were aware of some German developments in distributed gain amplification, apparently no investigation was made with regard to possible patent infringement. Neither Diambra nor Jerrold was licensed for the Percival patent, yet both had developed distributed gain amplifiers using SKL as a model. It was in this same time period, 1953-1954, that the Amplivision Corporation, an affiliate of International Telemeter, was advertising its copy of the SKL Model 212 distributed amplifier without license. Fitzroy Kennedy was outraged, and SKL attorneys forced Amplivision to discontinue, yet no action was taken against Entron, Jerrold, or C-COR.

CENTRE VIDEO SPUN OFF FROM C-COR

In addition to Dr. Brown, Dr. Haller, and Fred Thompson of HRB, various Penn State personnel participated part-time in Centre Video activities. Floyd Fisher, director of continuing education at the university, was part-time vice president, director, and general

manager of Centre Video. William Christopher, assistant controller at Penn State, was part-time treasurer and director at Centre Video. Dr. Marsh White, professor of physics, and Dr. Phil Walker, head of the fuel science department, were members of the Centre Video board of directors. Jack Wilkinson, whose brother was Penn State's attorney, was also a member of the Centre Video board. Other members of the board, including Jim Palmer and his wife Barbara, were not affiliated with the university. Although several Penn State personnel played significant roles in the activities of Centre Video and its affiliated organizations, Penn State University itself had no direct involvement <Tudek 1997, 28-30>.

For several years, working closely with the HRB research and development group, half of C-COR's research and development work was for the government, developing competitive products, such as single octave UHF amplifiers and IF amplifiers for spectrum analyzers. For example, they installed the first amplifiers and distribution systems in the missile pads at Point Arguello, California, using sophisticated amplifiers that were simply cable TV amplifiers modified to suit the purpose. However, with several HRB and Penn State University personnel involved in C-COR management, and the

emergence of direct product competition, conflicts of interest were beginning to develop. Moreover, according to Mundy, “The question was whether C-COR would go on and become a generic electronics research and development firm, or whether it would concentrate on the cable television industry needs. ... Even though the entities were all owned by C-COR, the investors hadn’t necessarily come in through the same door. Some of them were basically oriented as cable investors; some were oriented as manufacturing investors” <Mundy 1991, 44>. So a decision was made, about 1965, to spin off Centre Video, with its affiliates, as a separate entity, still owned by C-COR but independently managed.

Mundy requested assignment to the Centre Video division. Initially, however, they split his time 50-50 between C-COR and Centre Video so that he could continue with the antenna site work in which he was then involved. At Mundy’s suggestion, they hired George Dixon to take over the engineering responsibilities as chief engineer, and later vice president, of C-COR. When Tom Kenly came over from HRB, Mundy was released to devote full time to Centre Video.

FRANCHISING ACTIVITIES

In March 1965, Palmer brought Robert E. Tudek ([Figure 10.2](#)) into the organization, replacing Floyd Fisher as vice president and general manager of Centre Video. Tudek says, “He [Fisher] had been told that he had to make up his mind as to whether he was going to work full time for Centre Video, or stay with the university, and he chose to stay with the university.” Tudek was a graduate *cum laude* of the University of Pittsburgh, with a major in speech and a minor in psychology. After graduation, he worked for Pennsylvania Blue Cross/Blue Shield and the Muscular Dystrophy Association. Tudek says, “[Palmer] was interested in me because I had absolutely no experience in cable or anything like it. He didn’t want to have to retrain me, so to speak” <Tudek 1997, 21-28>.

When Palmer became full-time president of CECO, State College Television Cable Company had 280 subscribers and the Bellefonte Central Pennsylvania Corporation had 500 very irate customers. Jim says, “Because of quality of service... we were about to be thrown out of town. I think maybe both systems had about 1¹/₂ channels.” However, by 1965, Centre Video had overcome these problems and expanded into the boroughs of State College, Bellefonte, Milesburg,

Boalsburg, and Centre Hall, and all the townships surrounding State College and Bellefonte. In all, there were about 9,000 subscribers: 7,000 in State College and Bellefonte and 1,000 each in Kane and Towanda <Tudek 1997, 27-28>.

Shortly after joining Centre Video, Tudek suggested that the board of directors authorize him to apply for the franchise in his hometown of Glassport, a suburb only a few miles south of Pittsburgh. According to Tudek, Palmer immediately objected, saying, “How could you possibly build a successful cable TV system in Glassport, which is in the Pittsburgh television market?” Palmer pointed out that there were already five television stations in Pittsburgh. He said, “As you know, gentlemen, you can only get one signal in State College.” Palmer claimed that people in the Pittsburgh area could get five stations, compared to the one in State College. But Tudek demurred, saying, “That’s not true,” and Palmer said, “What do you mean?”

Tudek explained, “Because of topography, they can’t get one or more of the networks. In some valleys, they can’t get CBS, and in others they can’t get ABC, depending on the way the valley happened to run.” In Glassport, he said, “Some people could not get ABC.

Although the transmitter was located right over the top of the hill, 18 miles south of Pittsburgh, the signal went right over my hometown of Glassport.” And then, north of Pittsburgh in Aliquippa, he said, “You had a valley that went east and west where they couldn’t get [CBS and NBC]” <Tudek 1997, 32>. Mundy said, “Believe it or not, everybody thought areas like Pittsburgh were poor cable areas. That wasn’t so. ... It was the reception problem that really made this a market for cable” <Mundy 1991, 48-49>.

Tudek and Mundy soon became an aggressive and highly effective franchising team. By the 1970 NCTA Convention in San Francisco, after four and a half years under Tudek’s leadership, Centre Video had won 69 of the 75 franchises for which they had contested, primarily in the mountainous regions surrounding Pittsburgh. They had gone head-to-head with the big operators, such as Jerrold, which provided funding in return for equity at a time when bank loans were virtually nonexistent, and Irving Kahn’s TelePrompTer. They also came up against General Electric, Time-Life, and Pittsburgh’s pioneer broadcaster KDKA, as well as Art Rooney and sons, who owned the popular Pittsburgh Steelers football franchise. And they won most of them <Tudek 1997, 31-71>.

By the mid-1970s, Centre Video had grown to become

one of the larger multiple system owners (MSO). For a variety of reasons, Palmer wanted to get out of the system construction and operations responsibility in order to concentrate on engineering and manufacturing. Palmer was an electrical engineer by training, profession, and inclination. Tudek says, “He wanted to make a contribution in his field. I think he saw the future and knew a lot of what was going to occur in the future by virtue of his background” <Tudek 1997, 71-72>.

Moreover, Centre Video was coming to the point where its performance bonds required that it begin construction and activation of the franchises it had acquired. The capital required to build the franchises in the Pittsburgh area was difficult to raise. Tudek says, “We met all their construction deadlines, and never defaulted on any obligations.” But it had become necessary to consider the sale or merger of Centre Video with a larger organization that could provide additional financial muscle. The first opportunity was Columbia Broadcasting System (CBS), which had investigated and was ready to enter serious negotiations. But, as Mundy recalls, “I had the fellows from CBS with me in my airplane over Pittsburgh... the day the FCC was to make the decision on whether or not newspapers and radio people had to divest

their cable connections that were common to their other operations. ... Sure enough, ... it came over the [low-frequency radio in the airplane] that, in fact, they would have to do that. That killed the deal.”

That is when Tele-Communications, Inc. (TCI) came along. And so, on February 16, 1971, Centre Video was merged into TCI, in a tax-free exchange of stock. Mundy says, “Little did we know it, but at the time that took place, we were stronger than TCI!” <Mundy 1991, 55>. It was more than two years later, in 1973, that John Malone resigned as president of General Instrument (Jerrold), to become TCI’s president and CEO. Nearly 30 years later, American Telephone and Telegraph Co. (AT&T) acquired TCI, along with the Centre Video systems.

ACHIEVEMENTS BY 1976

A 1976 C-COR catalog listed the following achievements in the first 20 years that Palmer had been president.

- 1953 First messenger-mounted cable TV equipment
- 1953 First low-band distributed gain (chain)

amplifier

- 1953 First cable powering
- 1954 First pilot-controlled automatic level control system
- 1956 First “ultra-low noise” preamplifier; 3-4 dB noise figure
- 1965 First use of integrated circuits in the control circuitry, not in the amplifier stage
- 1966 First high-output solid-state equipment
- 1968 First use of modulated pilots
- 1969 First use of heat fins on castings
- 1970 First UHF converter with crystal oven and a Schottky mixer (see Glossary)
- 1971 First ac power port for trunk amplifier stations (Palmer says in his interview, “Well, we’re reaching there.”)
- 1972 First MATV (master antenna TV) amplifiers with CATV quality
- 1973 Introduced hub-site, multiple-output amplifier
- 1975 dc-to-dc standby power source
- 1976 First loop-back two-way amplifier with automatic reversing

Some of these developments were clearly preceded

by others in the CATV industry, for example, the low-band SKL distributed gain amplifier. Some may have been developed independently by others at about the same time. Nevertheless, the significance of these technological innovations is attested to by the extent to which they have been copied, improved upon, or independently adopted by virtually all suppliers. Palmer believes that no other supplier used both cable power and distributed gain technology so universally from the beginning.

Designing and manufacturing equipment for cable TV, primarily for its own systems in Bellefonte and State College, was the principal objective of the original CECO. It is clear that, under Palmer's leadership, C-COR was strongly focused on leading-edge technology, as well as the practical day-to-day operations of cable television networks. In 1970, Derald Cummings investigated the potential use of infrared and optical transmission in CATV links <Cummings 1970>.

Like the other CATV equipment suppliers, C-COR had to build much of its own test equipment. Palmer says, "We also built a sweep generator, which was a revolving open-air capacitor driven by a little induction motor, which would sweep the low band... and since an induction motor was not synchronous (with the 60-Hz

power) you could detect hum on the system. Because the hum would move across the screen” <Palmer 1992, 12>. They also built a marker generator to calibrate the sweep trace. For signal level measurements, they used the Jerrold 704B meter. In 1970, George Dixon, vice president and chief engineer of C-COR, presented a paper on the special test equipment requirements for CATV <Dixon and Kenly 1971>.

C-COR was widely recognized for its preamplifiers with unusually low noise figures of about 3-4 dB for both VHF and UHF reception. While they did not try to enter the headend market with heterodyne signal processors, demodulators, or modulators, the C-COR low-noise preamplifier was unique. By comparison, the published noise figure for the SA Model 6000 preamplifiers was 4.5-5 dB. For its preamplifier, C-COR designed a sheet metal cavity for UHF, with a screw in the back for tuning. Initially, the cascode circuit was designed around the GE 6299 planer triode vacuum tube. This was later replaced with the GE 7077 developed specifically for UHF television reception. C-COR also produced traps to attenuate the aural carrier and a variety of equalizers and filters ancillary to head end installations.

“Another early thing that we did was the pilot-

generated automatic level control system. ... We may well have been the first to do that," Palmer says. "And later on," he continues, "I think we were the first to use two pilots. And we used that first in amplifiers that we supplied to Sruki Switzer [then McLean Hunter's chief engineer]... for the antenna site run from 17 miles west of Mississauga [Toronto suburb]" <Palmer 1992, 16, 17>. Variations in signal strength due to diurnal temperature changes were controlled in single-channel strip amplifiers, such as the Jerrold W-series, as well as in the early broadband amplifiers by means of classical AGC. These circuits, arranged to hold constant the average rectified dc voltage of the multiplexed RF signal, were called automatic level control (ALC). However, deep fading on one channel might cause large level changes in channels that otherwise would have been stable, yet fail to control the fading channel. In 1954, CECO (i.e., C-COR) inserted an unmodulated (CW) signal called a pilot carrier. Conventional AGC, referenced only to the pilot carrier, was used to maintain the pilot carrier at a constant output level by adjusting the overall broadband gain of the amplifier. C-COR's pilot was at 74 MHz in the 4-MHz frequency gap between channels 4 and 5. Propagation fading of individual received TV signals would be

controlled separately for each channel at the head end, in signal processors or strip amplifiers with separate AGC for each channel.

By 1965, C-COR cautiously began to include transistors and other solid-state devices in the products offered to the industry. The first step was to use transistors in integrated circuit (IC) chips in the AGC circuitry. By 1968, broadband amplifiers covering the band 54-216 MHz—VHF channels 2-13— were in general use in the industry. Midband frequencies, 120-174 MHz, and frequencies above 216 MHz could now be used with the dual heterodyne set-top converter. Much greater compensation for change in cable loss due to temperature changes is required at channel 13 than at channel 2. Thus, the expanded bandwidth called for some kind of system for automatically controlling both the gain and slope (AGSC) of repeater amplifiers. The typical procedure was to adjust the gain so as to maintain the pilot carrier at constant level and automatically vary gain at other frequencies in accordance with a predetermined algorithm. For extended bandwidths to 216 MHz or higher, however, the effect of ambient temperature change could not be predicted with sufficient reliability. Therefore, two pilot carriers at widely separated frequencies were used to

establish two fixed points on the predicted slope curve for greater accuracy.

In 1968, C-COR was the first to apply modulation to the pilot carriers to improve the stability of the control system. The great advantage of modulated pilots is the absence of a dc component in the rectified voltage to be amplified. Initially, the modulation waveform was more or less trapezoidal but constant for uniform envelope transfer characteristics <Dixon 1970>.

In 1966, C-COR offered a fully transistorized amplifier with a unique high output level arrangement. According to Palmer, “We stayed with stud-mounted transistors in a cascade—I guess you would say in a modified cascode configuration—for quite a while, even after others were using the hybrid amplifiers” <Palmer 1992, 20>. Other providers at the time used a single power output transistor, with a power splitter to feed up to four feeder lines. C-COR used an interstage 2-way or 4-way splitter to feed the signals to two or four power output transistors. Thus, instead of dividing the power of a single output transistor among several feeder lines, the full power of each output transistor was available for each feeder line with the same degree of intermodulation distortion. Although not copied by other suppliers, this arrangement

was apparently a first. It was certainly a precursor to the parallel hybrid device (PHD) that was introduced as power doubling (PD) by Magnavox in 1983 <Staiger 1983>, and as the magic tee by Jerrold in 1984 <Reichert 1984>. However, in the PHD (or PD) arrangements, the outputs of the two power hybrids are recombined in phase in a single output with reduced intermodulation distortion. At about the same time, C-COR engineers, Joseph Preschutti, vice president for engineering, and John Pavlic, engineering manager for distribution products, were pioneering the analysis and development of feed-forward technology for expanding the reach of coaxial cable television networks <Preschutti 1984; Pavlic 1983>. Push-pull circuitry was incorporated in all C-COR amplifiers designed to carry channels at frequencies outside the VHF bands allocated by the FCC for TV channels 2 to 13 <Palmer 1992, 43>.

Palmer says in the interview, “We came up with the philosophy that the amplifier spacing was a function of system size, which it is. And I did an IEEE paper in 1966—and you did some work for me on that” <Palmer 1966>. Based on this concept, C-COR produced amplifiers with 32-dB and 40-dB gain in addition to the standard 22 dB. Palmer says they were quite successful with the 32-dB amplifier, which was used in a lot of systems <Palmer

1992, 22>. A group in the 3M Company in St. Paul, Minnesota, which was developing a rural telephone system, talked with Palmer about using coaxial distribution facilities. One of their scientists called Palmer and said, “You know, if we get to looking at these systems, we ought not be stuck with a fixed spacing. We ought to space these amplifiers at different spacing, depending on the length of the run.” So, Palmer said, “Well, that’s very interesting. ... I’ll send you a paper on that.” Palmer commented in his interview, “That was the only place where somebody was really excited about that capability [of multiple spacing]” <Palmer 1992, 24>.

It is not surprising that C-COR may have been first to make a comprehensive study of heat dissipation for their solid-state amplifiers. Palmer says, “We had always been very much aware of heat... the heat dissipation. This was an area where I felt I had something specific to contribute... I had taken a General Electric in-house course on thermal design, heat dissipation—used a book by Cane and other internal General Electric information. [This] really led us to the use of fins on our cast aluminum housings, and beryllium oxide as an electric insulator that is also a decent heat transfer agent.” At one time, they investigated (at considerable cost) the feasibility of using

the exceptional heat transfer and electrical insulation properties of synthetic diamond. Palmer was an investor and board member of Diamond Materials, Inc., which was trying to produce artificial diamond material for such purposes. He says, “We were using vapor deposition methods. Had some success, but we were too early and did not have enough money to back it up. The Japanese are doing a lot, and there is a diamond materials consortium at the Materials Research Laboratory at Penn State. ... I’ve lost enough money on diamonds for a while” <Palmer 1992, 31>.

Perhaps his background in professional military and industrial engineering, rather than consumer electronics or amateur radio, predisposed Palmer to focus attention on reliability. Large sales were made to Warner-Amex, Manhattan Cable, New York Times, Minnesota Mining and Manufacturing (3M), and others on the basis of an unusual record of reliability. Consistent with the reliability emphases were the studies by Derald Cummings and Joe Preschutti regarding surge protection of CATV amplifiers that resulted in marketing effective protection devices <Cummings and Preschutti 1975; Cummings 1972>.

A significant event established reliability as an important and distinctive characteristic of C-COR

equipment. The 3M company came to C-COR regarding a novel system concept for a coaxial cable telephone network. They had chosen C-COR because of reliability. Palmer tells the story, “To determine what our reliability was, they visited cable systems, talked with repair technicians, and audited their repair records. They did this for half a dozen companies, then got to a system that was C-COR and found out that there were drastically fewer repairs than other systems. ... After we got that... information, we started analyzing our own repair information—repair cost as a function of sales volume.” Palmer was not surprised, because he had determined that equipment manufactured by C-COR should be conservatively engineered and produced without cutting corners. Inspired by the confidence expressed by the 3M project personnel, C-COR began to consistently advertise its inherent reliability. They set 100,000 hours mean time between failures (MTBF) as a commitment <Palmer 1992, 25>.

Palmer’s conservative engineering philosophy was demonstrated by C-COR’s continued use of individual stud-mounted transistors and discrete circuit components after other suppliers had begun using IC chips and hybrid gain blocks. C-COR used some ICs in their AGC control in

1965 but not in amplifier stages until later. Palmer says, “I think our sticking with discretely a lot longer than others was based on the reliability.”

About 1974, Palmer began to establish a close relationship with the hybrid device manufacturers. Every year, he visited both Motorola and TRW, usually at vice presidential levels in the corporate structure. By 1976, the industry was having a hard time getting hybrids. The manufacturers complained that they were not profitable, yet CATV suppliers were screaming for more hybrids. “Look, the solution is simple,” Palmer said to Motorola, “raise your prices.” “But we can’t... TRW over here... It was a classic lesson in supply and demand and price elasticity. Motorola could not believe that a supplier would urge them to raise their prices <Palmer 1992, 29>.

C-COR was the first to market amplifiers with bandwidth rated at more than 300 MHz. By selecting hybrids that would perform well up to 340 MHz, Palmer was able to get a jump on his competitors. By 1979, the growing availability of 400-MHz hybrids sparked steady pressure in the cable TV market for wider and yet wider bandwidths and channel capacity. C-COR was, in fact, the leader in developing the experimental 1-GHz amplifier for the Brooklyn-Queens project in New York, using discrete

devices, however, not hybrids.

C-COR was always profitable but never sought to reach market share approaching Jerrold's. C-COR was an engineering company, managed and controlled by its professional engineer president with the advice and consent of the board of directors. Its marketing efforts were low-key but effective and consistent with their engineering approach. Suppliers commonly tout the high quality of their products. Palmer's conservative engineering philosophy appears to have given the term *high quality* unusual credibility. Palmer was neither willing nor financially positioned to offer financing for his customers. C-COR established a discount schedule based on dollar volume of purchases and declined to negotiate further discounts in order to make a sale.

With the TCI merger in 1971 about to close, assuring development of the franchises they had won, Everett Mundy and Robert Tudek left Centre Video and organized a new firm called TeleMedia. For more than a decade, they acquired, developed and operated new and existing franchises, including several Bell Telephone System lease-back operations. At the time of Mundy's oral history interview, TeleMedia had approximately 325,000 subscribers.

In 1986, Jim Palmer resigned as president of C-COR. He and his wife have endowed a Chair in Telecommunications Studies at Pennsylvania State University, and a Chair in Electrical Engineering at Iowa State University. They have made the lead gift for expansion of the Museum of Art at Pennsylvania State University, now called the Palmer Museum of Art in their honor. They are active in collecting fine art, both for themselves and the Palmer Museum. Each of them serves on boards and committees of various nonprofit charitable and educational organizations. They have traveled extensively throughout the world.

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CHAPTER 11

Blonder-Tongue Laboratories, Inc.

ISAAC S. BLONDER¹

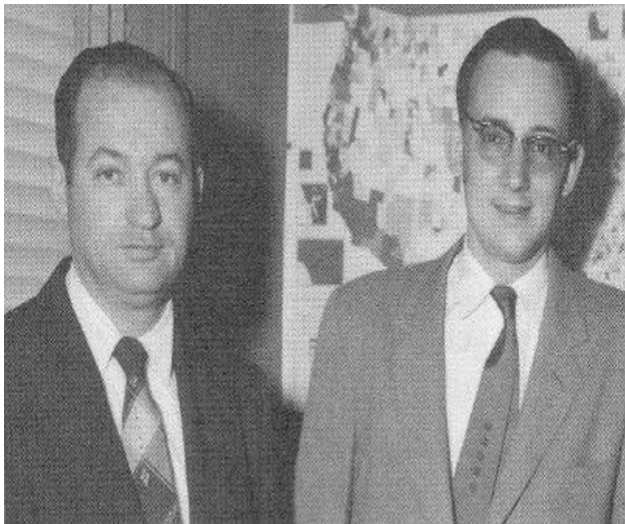


Fig. 11.1 Isaac “Ike” S. Blonder (left) and Benjamin H. Tongue

Courtesy Blonder-Tongue Corp.

HERE IS THE STORY OF IKE BLONDER ([Figure 11.1](#)) in his own unique, inimitable, and sometimes self-deprecating words, partly from one of his columns in *Communications Technology*, which he called “Dinosaur Droppings,” and partly from his oral history interview.

I have been told many times that I would have been better off being a comedian in the Catskills than an engineer in a company—but, all right...

Who am I? Why do I qualify as a Cable Dinosaur by age and experience? I was born in New York City, June 24, 1916. I moved to rural Connecticut in 1922 and grew up at the same time as radio and TV... and always in a fringe reception area. Crystal radios were the principal means of radio reception in the early twenties. Almost every household had long wire antennas strung from the house to adjacent trees. (I will add one thing I didn't put in the article: When there was any kind of electrical disturbance, the darn things would snap! Every house would

have those things snapping with nervous housewives complaining.)

Anyway, you listened to a crystal radio, with earphones of course, and you could sit until dawn, listening to one station after another across the country—because each station pretty much had a unique frequency that was not interfered with by some other. As nighttime came along, the signals would have the ability to skip, so you heard the whole country.

My father had a garage; I was a grease jockey until the end of my college career. I never could get my fingernails clean, by the way. That stuff acts just like a tattoo. The earlier automobiles had expensive radios. ... I was educated, so I repaired the radios and electronics in automobiles. I had a great time.

In 1940, I got a master's degree in physics from Cornell. No job. Finally, in 1941, General Electric's personnel department in Bridgeport, from the depths of a generous heart, took me on as a trouble shooter in the radio factory, at \$40 a week. But they said, "Please don't tell anyone that you have a degree, because the factory doesn't like to have people in it with a degree."

I am going to add one more thing: I got fired five times within the factory—for telling the truth. (Ike never explained this!)

Several months later (1942), I got a letter from the United States offering me a position in the Army, for one year, to engage in research. When I got to Fort Monmouth, I learned that the research was being a radar officer in the British Army (for one year—then in the U.S. Signal Corps) in England. ... I ran half a dozen radars in Cornwall. Very interesting experience. I enjoyed it—luckily no bombs dropped on me.

Four years later (1946), out of the Army, strong on radar, weak on physics, I found a job with Panoramic Radio Corporation, where I met Ben Tongue. Although he was very young, he was the most qualified engineer they had... and they had some excellent engineers.

At Panoramic, I was quality control engineer. I wasn't designing the original units, but when they wouldn't work in the factory, I would take the units and redo the circuitry so as to optimize <Blonder 1993a>.

BENJAMIN H. TONGUE²

Ben Tongue ([Figure 11.1](#)) attended Northwestern University in Boston, Massachusetts, between 1942 and 1945. During the war years, the normal cooperative work-study program was severely compressed. He worked his way through college as a night telephone and elevator operator, on duty 111 hours a week. With 4F classification, Tongue received his bachelor of science in electrical engineering in June 1945, after only three years. He had several job offers: Raytheon offered \$40 a week; RCA, \$35; and Federal Radio Telephone/ITT, \$37.50. He accepted the job with ITT because he wanted to get into their new radio manufacturing division. It was not to be. He was assigned temporarily to the wire transmission division with assurance that he could transfer to the radio division shortly. After three months, the War ended and the president of ITT froze all jobs. He was stuck, but the company generously allowed him to spend half time looking for a new job.

He landed a job with Panoramic Radio Corporation, founded by a Frenchman, Dr. Morcel Wallace. While in France, Wallace had received several patents on spectrum analyzers that could be used with radio receivers to

monitor signal activity on each side of the frequency to which the radio was tuned. They had been doing well, but when the War ended, their production contracts were canceled. They had lots of surplus parts and believed that the returning soldiers who became radio amateurs would create a market for Panadapters for their ham rigs. They were successful, for a time. But sales began to fall off, and Panoramic Radio was forced to downsize from about 150, until eventually only seven people were left. Tongue was made chief engineer at the age of 27.

Shortly after he joined Panoramic, Tongue recalls working at a bench on a bandpass amplifier when a fellow in an Army uniform came around and stood behind him, watching what was going on. He engaged the man in conversation and learned that he had been stationed in England in the Radar Corps and was now out of the Army and looking for a job. The fellow in the Army uniform had been directed to Panoramic by his Army friend, Robert Rines, who happened to be acquainted with a lawyer for Panoramic Radio. Rines' father was patent attorney for G.W. Pierce, inventor of the Pierce Crystal Oscillator and well known as a pioneer in the field of electronics engineering. The fellow in the Army uniform was Ike Blonder, who accepted a job with Panoramic. Blonder left

in 1947, but Tongue stayed on until 1949.

Blonder still wanted to be in physics. So, he went to City College and became an instructor in engineering physics (1947-1948). He discovered that teaching was boring. The students did not want to listen to physics. They only wanted to listen to engineering, get their degree, and get a job. Teaching a physics course was like being in the basement: No one wanted to be there.

Blonder was uncertain what he wanted to do next. He traveled across the country in his 1940 Buick trying to sort things out. When he came back, he started a company called Blonder Manufacturing to make test leads for electronic instruments, but it did not generate enough revenue to survive.

Then, in 1948, a friend at TeleKing Corporation in Manhattan asked him if he would like to get into the new field of television. It was an attractive idea, and he took the job. TeleKing built cheapened versions of RCA television receivers, such as the old Model 630 and the Novel 10. The earliest receivers could only tune the low-band channels 2-6. Blonder designed a continuous UHF tuner; "el cheapo," he calls it. He replaced the 300-ohm twin-lead in the laboratory with braided shield coaxial

cable lines isolated with cathode follower amplifiers, so that each engineer in the laboratory could work with relatively clean signals from the antennas on the roof. He was soon given the responsibility of chief quality control engineer at Tele-King.

But even the braided shield coaxial cables in the United States were not good enough for the project at Tele-King. Blonder says, “I could lay lines down from one end of the laboratory to the other... and by the time I got to—let’s say—a hundred feet away from the starting point with single shielded braid, the two would be just as if they were coupled together with a coupling device.” He goes on to say, “Very often, if you wanted any real shield, you had to put them inside a metal conductor—pipe” <Blonder 1993b, 13>.

Blonder tells a funny story: “It might as well be funny,” he says. “When I was in the British Army, and I took over some radars, the radars were pointing in one direction, where the airplane was supposed to be. In reality, the airplane was 30 degrees away!” He discovered that the coaxial cable they were using had solid lead sheath outer conductor. With vibration, the lead would crack, creating phase problems and pointing errors. Regular inspection and repair corrected the problem

<Blonder 1993b, 11>.

Then, there is another story, in a later context, about a Mr. Weiner at Ellenville, New York, who was so dissatisfied with braided shield coaxial cable that he had a special cable custom made, using a wide copper foil ribbon wrapped around the dielectric. It worked very well, until oxidation at the overlap destroyed the shielding integrity. This was probably before Times Wire and Cable discovered the same problem with its Type 408 strip braid cable. “You know what they used to do?” he asks. “They used to send the technician up with a sledge hammer and they would give each length of cable a sock with the sledge hammer so as to break the copper oxide and make a connection” <Blonder 1993b, 13–14>.

Speaking of his work with the technicians at Tele-King, Blonder says, “Technicians really, although they are very capable, they are usually not equipped to look at the fundamentals of a problem. If you have a fundamental problem, you have to approach with fundamental engineering.” Or, “Even physics,” the interviewer adds. Blonder picks up on this, saying, “...now I found that in my entire career in physics, that the physicists couldn’t make anything work. I don’t mean to knock physicists, but the motion picture projector they were using (in class)

usually broke down—some ‘A’ student had to come in (and fix it)” <Blonder 1993b, 15>.

Blonder stayed with TeleKing for a couple of years. “My problem,” he says, “was that basically I am an inventor. I would come up with an invention, and nobody would want to buy it. The only way to get an invention out is to have your own company. Nobody else is foolish enough to put the darn thing on the market” <Blonder 1993b, 6>. He had kept in touch with Ben Tongue. In fact, until Blonder started his cross-country trek, they shared a basement apartment in the Brownsville area of Brooklyn, habitat for the notorious “Murder Incorporated.” Over the years, they had accumulated a motley assortment of electronic equipment, including a TV set Blonder had designed and built, before there were any kits. Both wanted to be in business for themselves, and they agreed that something related to television might be worthwhile.

BLONDER-TONGUE

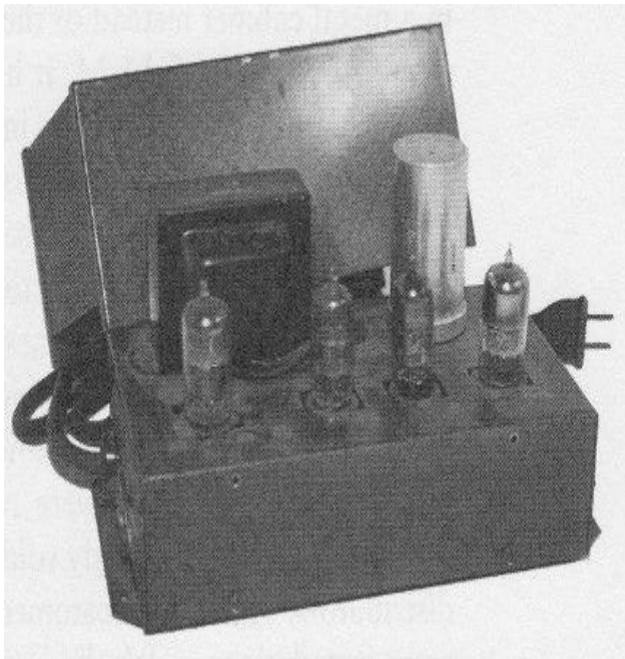
TV reception at that time was not very good. Sensitivity was low and noise figures were high. Pictures were often snowy. It was even a challenge for people living in Manhattan to receive channel 13 from across the

Hudson River in New Jersey. So, they conceived the idea of a mast-mounted, single-channel booster with a stepping motor to control the tuning remotely from the TV set. Late in 1949, they built a prototype, but it never went into production, because Ben had a better idea. He invented a coupling circuit with high gain bandwidth product (U.S. Patent No. 2,710,314) for a broadband booster that would amplify all 12 channels without having to be tuned. The four-tube booster had 20-dB gain with a pair of two-stage amplifiers, each using Tongue's interstage coupling circuit. When the two outputs were combined, the overall response looked like a three-pole bandpass in the low band, a three-pole bandpass in the high band, and a big suckout in the middle.

Start-up in Yonkers

In January 1950, Blonder and Tongue pooled their financial resources, amounting to about \$5,000 in loose cash, plus all their accumulated electronic parts and equipment, a 1937 Willys, and the 1940 Buick. With only an idea but no product, they registered their infant partnership as Blonder-Tongue Laboratories. They rented a former dance hall in Yonkers with 1,200 square feet at

ground level and another 800 square feet in the basement. Blonder says, “It is kind of funny. The first week we were there, the police roared up with their lights going and challenged us. They thought we were bookmakers, like the people who used to be in the store. They were very disappointed when they found we were engineers” <Blonder 1993b, 6>.



**Fig. 11.2 Blonder-Tongue CA-1 Antensifier
(commercial version of HA-1)**

Courtesy National Cable Television Center and

Museum

They proceeded to implement Tongue's idea for a fixed tuned broadband booster, to be called the HA-1 Antensifier and packaged for commercial service as CA-1 ([Figure 11.2](#)). The circuits had to be carefully neutralized to prevent oscillation. The noise figure was about 9-10 dB. Blonder designed a thermorelay so that the booster would be turned on automatically with the TV set, whether mast-mounted or set-top. With the help of various acquaintances Blonder had made at TeleKing, they were able to have a few chassis made and to obtain various components on credit. They built 500 of these units at first—"very slowly," Tongue recalls. They were made to sell for \$49.50 retail, \$20 to distributors.

They started production of the model HA-1 Antensifier on the ground floor, then expanded to the basement, with about 50 employees in all. The sales representatives for the Centralab Corporation, with whom Blonder had dealt at TeleKing, offered, as a favor, to show the HA-1 at the Chicago Parts Show in May 1950. It was a hit. There was nothing else like it. Competing boosters had manual channel switches or continuous tuners. Eventually, they must have made more than 10,000 boosters before they were supplanted by improved

versions. By the end of the year, they had net total sales of \$32,785.23 for a net profit of \$5,420.21. In the first four months of 1951, net sales were \$161,508.06, for a net profit of \$40,232.38 <Tongue 1993, 18>.

Incorporation and Move to Mount Vernon

In 1951, the partnership was reorganized and incorporated as Blonder-Tongue Laboratories, Inc., with Ben Tongue as president, Ike Blonder as chairman of the board, and Robert Rines, Blonder's Army buddy, as counsel and patent attorney. Then, they moved from Yonkers to a 6,000-square-foot garage in Mount Vernon for more space.

They exhibited several new products at the 1951 Chicago Parts Show, including an improved version of the HA-1 Antensifier using another of Ben's interstage coupling patents to get more gain-bandwidth product. When they discovered that the HA-1 was being used in MATV apartment systems and in some very small CATV systems, they produced a commercial version. It was mounted in a metal cabinet instead of the leatherette-covered wooden case (for the set-top model) designated CA1-M. It had both 75-ohm and 300-ohm input and

output ports. At the show, they also introduced two-way and four-way 300-ohm splitters and distribution amplifiers, DA-2 and DA-8, with two and eight output ports for feeding multiple TV sets.

Blonder says, “According to my inside information, the amplifiers were copied by everybody else in the business. We had the first broadband amplifiers. But the reason why we didn’t become big in the cable business, it is very simple... couldn’t get paid. The cable people did not pay for one year, because they had no money. I can’t blame them. They were running on shoestrings, and we were running on shoestrings, too. So we only sold to people who could pay us. They were the parts distributors. And their customers were the home TV installations and the apartment installations. ...We did build a line of cable equipment at one time. Perfectly good amplifiers—cable equipment quality. But the same problem—I couldn’t finance the cable companies” <Blonder 1993b, 16>.

Move to Westfield

In 1952, with 150 employees, they were again running out of space and moved to a building in Westfield, New

Jersey, with 18,000 square feet. According to Tongue, “We introduced our first broadband, mast-mounted amplifier in Westfield. This turned out to be very, very, very popular among the very rural CATV systems.” Used with very low-loss ladder line, the preamplifier could be located as much as a mile away from the head end <Tongue 1993, 25-26>.

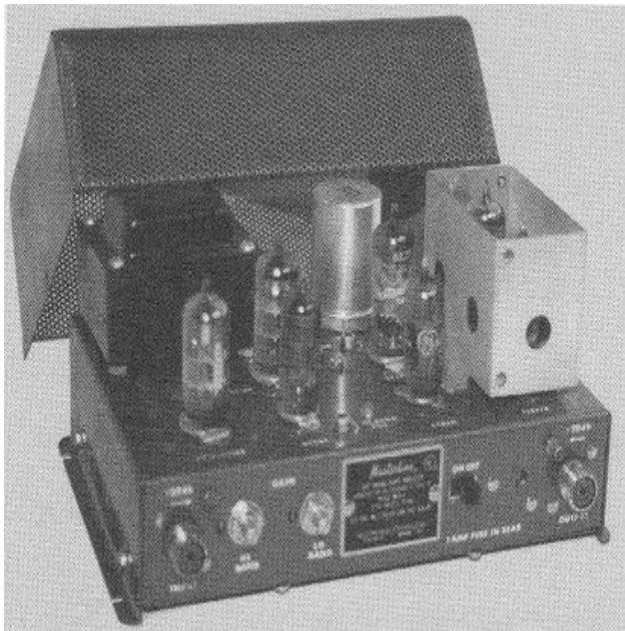


Fig. 11.3 Blonder-Tongue Model MLA main line amplifier

Courtesy National Cable Television Center and Museum

Here, they also produced the MA-4, with power supply, combiner, and four single-channel, plug-in strip amplifiers. Tongue called the MA-4 “a very, very dreary, juniorized version of the RCA Antennaplex” <Tongue 1993, 25>. The first UHF converter, the BTU-1, was produced at Westfield, designed and patented by Blonder. Tongue then designed a signal-level meter (i.e., field-strength meter), using miniature hearing-aid vacuum tubes with 1.4-V filaments. Fred J. Schultz and J. Glaab described the field-strength meter in a paper published in a trade journal <Schultz and Glaab>. Following a distinguished career at Blonder-Tongue, Oak Communications, and Manhattan Cable, Schultz returned to his native Switzerland where he has been actively engaged for many years in cable TV developments. Glaab moved from Blonder-Tongue to General Instrument (Jerrold) where he is a senior engineer. The first Blonder-Tongue vidicon TV camera, called the TVC-1, and several video monitors were designed and produced at the Westfield plant. At one time, there were as many as 325 employees at Westfield.

The split-band, vacuum-tube main line amplifier (MLA) developed at Westfield was widely used in CATV ([Figure 11.3](#)). With 40-dB nominal gain, the MLA used

three tubes in the low band (54-108 MHz) and four tubes in the high band (174-216 MHz). It was a low-noise broadband amplifier, using an innovative patented circuit that Tongue invented to neutralize the grid-plate capacitance in a common cathode triode that would otherwise cause undesirable oscillation. The 12BY7 tube, originally intended for high-level baseband video output, was used to obtain high output capability for the MLA, apparently for the first time in any RF application. The MLA was designed to work with an AGC unit, providing separate composite AGC in each band. Start-up systems, unwilling to sign Jerrold's service agreement and dismayed at the cost of the SKL and other available amplifiers, were attracted by the \$100 price for the low-band MLA and found it to be highly reliable in service.

The MCS was a single, channel strip amplifier with 40-dB gain for use at the head end of MATV and CATV systems. The MCS amplifier had four vacuum tubes: a cascode (low-noise circuit using a pair of triode vacuum tubes) input, two pentode vacuum tube stages, and an AGC detector and amplifier to provide 20-dB control range. In order to achieve stable high gain with AGC, Tongue invented a suppressor grid pentode neutralizing (feedback-minimizing) circuit, which he covered with a

patent. The MCS had a bridging output for combining the outputs of several strip amplifiers. Moreover, a pair of MCS amplifiers could be cascaded for very weak signals, with up to 80-dB gain and 40-dB AGC range. Referring to the 1976 *TV Factbook*, Tongue says, “These amplifiers were used, we understand, in about one third of the Nation’s cable systems at one time. Now, this includes all the very small systems—Mom and Pop systems” <Tongue 1993, 30>.

Move to Newark

In 1955, a strike was instigated at the Westfield plant by organizers for a union allegedly dominated by communists and expelled from the Congress of Industrial Organizations (CIO). According to Tongue, the organizer turned out to be an FBI infiltrator gathering information on the union. Blonder-Tongue’s response was to move all the factory equipment in many large trucks, overnight, to a new prearranged location in Newark, New Jersey, on McCarter Highway. They had the equipment up and running before the union found out what had happened. Another union, the International Brotherhood of Electrical Workers (IBEW), soon organized the plant at the new

location and continues to represent the employees <Tongue 1993, 33>. When the factory operations at the McCarter Highway location became crowded, about 1957, they took a lease on the old post office/parcel-post building on Ailing Street, adjacent to the Newark railroad depot, for their headquarters and the closed-circuit video equipment products.

At Newark, the line of head end channel converters was expanded in the same family as the MCS strip amplifier. One converter design used a tunnel diode as an oscillating mixer, operating at 1 mA current and powered by a single D-cell that lasted about a year. As initially designed, it worked well; however, when the antenna leads shifted in the wind, the oscillator frequency was modulated slightly. So Tongue made another invention, also patented, to make the frequency independent of the antenna terminal impedance. This converter continued as a very successful price leader from about 1964 until General Electric stopped making the tunnel diode in 1970. At Newark, they brought out a very high output strip amplifier called Power Drive with 5 or 6 V rms output using a TV horizontal drive vacuum tube.

The Development Laboratory

In Newark, they established an advanced development laboratory where they produced a low-cost video camera, the TC-1; a transistorized vidicon camera, the TTVC; and a projection monitor, the PV-1. They hired an engineer, retired from the Navy Research Laboratory, who was convinced he could design an electrostatically deflected vidicon with which they hoped to reduce the high cost of the video camera. They designed a clean room with high vacuum facility for cesium deposition and other purposes. The electrostatic vidicon did not work, and they were running out of money. So they closed down the operation. Blonder explains it this way, “The reason for our quitting is very straightforward. We purchased the vidicon tube from RCA for \$175, and... [sold it] for about \$350 out of our house. About 1960, in came a Japanese camera at \$187. So, I immediately put 50 people out of work, closed down a building in Newark, and dumped the inventory. Familiar story, isn’t it?” <Blonder 1993b, 31>. However, they did use the advanced development lab for a project under contract with the FAA for designing voice intelligibility-enhancing equipment to be used in conjunction with the aviation black box used for recording conversations in the cockpit of commercial aircraft.

While they were still producing video gear, they were asked to provide cameras for a concert by Artur Schnabel, celebrating the reopening of the Newark Symphony Hall. Video monitors were placed in the lobby to accommodate the overflow crowd. Blonder-Tongue supplied the video facilities, and Ike Blonder posed with the great pianist for a photograph.

High-Fidelity Audio

About 1963, Blonder-Tongue decided to enter the audio high-fidelity (hi-fi) market. They brought out an FM/AM radio, FM radio, FM/AM tuner, a 10-W audio amplifier, and a loudspeaker. Blonder participated in the TV stereophonic sound committee activities. Tongue developed a graphic equalizer with nine controlled frequency bands in the audio range, which they called the Baton. Other graphic equalizers on the market required expensive iron-core inductors for the individual band filters. To keep the price well below the competition, Tongue invented a circuit using a single triode (vacuum tube) to give the response of a single tuned circuit with Q of about 1. The Baton sold well, but the idea of having to adjust two graphic equalizers for stereo was too

complicated for the consumer. It was, however, adopted by radio station WMTA in New York and used on the air as “the listening man’s filter.”

Sales of hi-fi equipment were brisk for a time but started to slack off when stereo came in. As Blonder says, “The customer cannot recognize audio quality. ... Stereo/audio, although it’s been improved, and I was on the committee that set it up, nobody used it at home. ... Without speakers about 15 feet apart, while you’re sitting in the middle, you don’t hear stereo” <Blonder 1993b, 23>. They decided not to pursue the stereo market and discontinued audio production in 1969.

A broadband TV antenna that Blonder designed and patented, called Prisametric, was launched at a new location on McCarter Highway in Newark. Blonder also invented a broadband UHF antenna called the UHF Guard to complement the line of UHF converters. They also produced an antenna rotator. In 1960, Tongue developed what he believes may have been the first broadband MATV solid-state amplifier, designated the BT-3.

The Benco Acquisition

In order to expand into the growing translator (i.e., TV repeater) business in 1960, Blonder-Tongue purchased the Canadian company, Benco Television Associates, run by Philip Freen. In addition to the translator products, which included a heterodyne signal processor, Benco had a bandpass filter suitable for CATV. When the translator business began to dry up, Benco was sold back to the Canadians about 1964. Benco was then merged with Delta Electronics and Cascade Electronics to form the Delta-Benco-Cascade Company known as DBC.

Blonder pushed strongly for a project called Bi-Tran that he had conceived (and protected by patent) to put two pictures on one channel. The idea was to display one picture with constant polarity and the second picture superimposed on it but with polarity reversed in alternate fields. Thus, the blacks and whites in the second picture simply cancel out. Ben says it worked quite well. However, it was too expensive and was dropped.

Financial Crisis

These projects were fun and presented exciting challenges, but they cost a lot of money. Tongue says, "Perhaps we weren't keeping an adequate eye on the

expenditures versus the income. We got a terrible shock when the accountant said we had a very large loss for one of those years around 1964 or 1965. It looked as though the cash was going out so fast that we were going to have to close our doors” <Tongue 1993, 42>. They decided they would have to change their management arrangements. Tongue had concentrated entirely on engineering, overseeing the staff engineers and generating creative solutions with his special professional expertise. Blonder had engaged mainly in sales and forward-looking concepts for new products and business ventures, including active participation in wide-ranging engineering committees and seminars.

It was at this time (May 1965) that the channel 47 UHF station Blonder had started as a 25 percent owner came on the air. They agreed that their operations would have to be sharply curtailed and that the employee to whom the day-to-day operations had been delegated should be dismissed. Tongue then took over the responsibilities of CEO and undertook a comprehensive review of the operations that had expanded to seven separate locations in Newark. Massive layoffs had to be ordered. The company got on an even keel again and became profitable.

Move to Old Bridge

By 1969, with operations at so many locations and with conditions in Newark deteriorating, it had become dangerous for personnel, especially women, to work overtime after 5 p.m. The Ailing Street location was convenient to trains and buses, but the other locations were more difficult. So, they decided to move again and consolidate the operation under a single roof. They bought a tract of land in Old Bridge, New Jersey, and started construction of a new facility. The first production was moved from Newark to Old Bridge in July 1970.

When the FCC adopted rules, about 1973, requiring that all new TV sets must be capable of receiving UHF channels, an enormous market was created for the BTU-2 UHF converter, successor to the BTU-1 that Blonder had designed. It became the standard for the industry and was sold in large numbers under the Sears and Radio Shack labels. They also manufactured UHF converters in many different types, styles, and functions, particularly for MATV and CATV head end applications. Some had IF stages, some did not. Some were in metal housings, others in different types of plastic housings.

Transistor Technology

The move to Old Bridge marked the accelerating transition from vacuum-tube to solid-state (transistor) technology. Here, they brought out the TVN modulator, which sold well in connection with TVRO (satellite) users, private as well as SMATV and CATV operators. The mast-mounted broadband and single-channel transistorized preamplifiers developed in Newark in 1956 became a very good profit center. Then they brought out transistorized heterodyne signal processors and developed a line of more professional products that seemed to be well received, before CATV became interested in using the midband channel frequencies. However, they were not financially able to redesign the equipment to accommodate midband and just let that business go downhill.

For many reasons, Blonder-Tongue's business has always been more successful with small, mom-and-pop operators than with the larger CATV systems or group owners. Both Blonder and Tongue point to Jerrold's ability to provide financing for its customers, even to the point of taking ownership positions. Blonder and Tongue had started their business, like Milt Shapp, with virtually

nothing in the way of financial backing. However, Shapp managed to gain the confidence of such substantial investment bankers as J.H. Whitney and Fox, Wells, whose assistance in financing Jerrold's customers became a major marketing asset.

Blonder-Tongue maintained neither regional sales offices nor a large internal sales force to make regular personal contacts with cable TV operators and multi-system operators. They did not sell directly to customers. Blonder-Tongue products were sold primarily through sales representatives. The reps dealt with parts distributors whose customers were making the individual home and apartment installations. For that reason, Blonder-Tongue equipment was directed toward that market.

Blonder-Tongue equipment was designed to provide good and reliable performance at low cost. It earned its reputation as the Cadillac of MATV. Because of their marketing strategy, Blonder-Tongue equipment did not become a major factor in CATV. Nevertheless, the performance of the MLA and other broadband vacuum-tube amplifiers and head end gear was at least equal to if not better than other equipment available to the early CATV operators. The low cost was especially attractive,

achieved by minimizing nonessential bells and whistles and expensive packaging without cutting corners regarding performance and reliability.

Tongue says, “In fact, our broadband amplifiers were pretty high performance at low cost, plus highly reliable. We designed for reliability.” For example, he says, “We always made sure that the low impedance was in the grid so that, if tubes started getting some grid current and getting gassy, it didn’t develop a positive bias on the grid, thereby ruining the tube.” Blonder says, “You have to understand one thing: we never over drove any item in our line... no tube would work at its full rating... no part would work at its full voltage rating... no transformer was operated at full power. Everything had a margin built in, because I didn’t trust the manufacturer. ... We always designed to the low edge of the average. The specs that we put out were all minimum, not typical. People didn’t know that when they bought our stuff” <Blonder 1993b, 44>. It was while they were in Newark that they began to get more and more of their product in CATV systems, but still in the small market, mom-and-pop systems.

Blonder was asked in the interview, “How does an engineer go at designing a product for manufacture and sale?” His reply:

You give an engineer with creativity a project and he will go ahead and design it. Then, as soon as he has finished it, he will figure another way to make it better. Then, new transistors and other components come along which could improve the performance. In reality, practically no engineer will complete a project in the assigned time or assume that it is ready for market. The chief engineer has to make a judgment as to whether, in truth, whatever is accomplished in the laboratory is capable of being turned into a product for sale. This is usually a judgment that is at variance with that of the engineer. So, the chief engineer's job is to say, "No more work. Put it out!" <Blonder 1993b, 1>.

Ike Blonder's candid comments comparing his own engineering skills with Ben Tongue's are also worth quoting directly:

...we had Ben Tongue, remember. Ben Tongue could do anything. Ben is a super engineer. I am not. I have been able to do things, but I think more from desperation than from the skill he has. Oh, by the way, do you know the kind of engineering I did? When somebody else couldn't do something, and it

was just sitting there, I would go in. What other choice do you have? And the way I got it done was to eliminate the approach they were using—that I didn't understand either—and go to an approach which I was capable of doing—which approached it in a different way and got the job done. That's about the only way you could survive as an engineer. If you tried to match somebody else's skill, and you don't have it, it's not going to work. I had skill in certain areas, and I used it <Blonder 1993b, 51>.

UHF BROADCASTING

Blonder became a promoter of allocating all television broadcasting in the United States to the UHF spectrum, as is the case in Great Britain and most of Europe. This was clearly the intent of the FCC, and the all-channel receiver rules in 1973 were intended to advance that proposition. Blonder put his money where his mouth was by obtaining the license for a UHF TV station on channel 47, which began broadcasting in New York in 1965. It was a bare bones, shoestring operation that had the lowest possible quality “because I didn't have any money, and believe you me, we were putting out bad stuff.” They tried to

figure out what they could broadcast that would bring in some revenue. They tried German, Italian, Polish, but it was not until they went into Spanish that they discovered the untapped market. Business went sky high. The fact that UHF reception was difficult made no difference. The supposedly uneducated Spanish population in New York very quickly discovered how to receive the Spanish programs. They found the station when no one else could. The program did the selling, never mind the quality of the picture.

Then, in 1974, a new station owned by Blonder-Tongue began broadcasting on channel 68 from a transmitter located in West Orange, New Jersey, and three years later a license was obtained for a channel 60 translator on the World Trade Center, repeating channel 68. Blonder later invested in channel 68 in Boston and bought one eighth of channel 54 in Baltimore. He had become an active proponent of subscription television. Stimulated by the work at International Telemeter (Paramount), Skiatron, and Zenith (Phonevision), Blonder-Tongue initiated research and development on pay-TV in 1955. In March 1977, channel 68 New York became the first operational subscription TV (STV) television station, beating channel 52 Los Angeles by less than a month.

The Blonder-Tongue station carried programs by Wometco Home Theater, using the patented scrambling technology invented by Blonder. The station was sold to Wometco in July 1977.

More recently, Blonder obtained permits to use channels 27 and 28 for high-definition TV (HDTV) experimentation, located on a rooftop at the Stevens Institute of Technology in Hoboken. Blonder has substantial misgivings, not about HDTV technology but about consumer acceptance. His experience suggests that improvements in the subjective quality of sound or pictures are not likely to overcome the necessary cost premium. He considers HDTV to be “a perfect example of excessive engineering for the home” <Blonder 1993b, 54>. It is widely recognized that the value of high resolution may only be appreciated with large screen displays (e.g., 50-inch diagonal or larger) in enormous consoles for direct view CRT (cathode ray tube) or on a large flat panel. But, he says, “The large flat panel has an enemy—called a *housewife*—that is bound to win” <Blonder 1993b, 55>.

Since 1953, Blonder has been experimenting with 3-D photography. His interest extends to the technology of 3-D television and the psychophysiology of depth perception. The problem with 3D has always been a

strong aversion to wearing special glasses to realize the 3-D effect. Blonder has spent considerable time and effort in 3-D research and attending conferences and even demonstrations. In fact, he is currently broadcasting 3-D on his experimental channel 27, 24 hours a day, to be viewed with special liquid crystal glasses. In spite of enormous technical problems and excessive costs, Blonder predicts, as a rather biased observer, that they will be solved.

NESSIE

It seems that Blonder has very little time in which to become bored. As a member of the Academy of Applied Science (AAS), Blonder has spent most of his summers at Loch Ness in the Scottish Highlands, in what some might call the chimerical quest for Nessie, the beloved but elusive Monster of Loch Ness. Robert Rines, his long-time friend, patent attorney, and corporate colleague, is also a member of the AAS and once took a picture of the monster's flipper (or tail). Blonder reports that there have been more than 3,000 documented sightings, of which about 10 percent have survived the most skeptical evaluation. "The first recorded observation," according to

Blonder, “concerned St. Columbia (in 565 AD) who commanded the monster in the name of God to ‘go back with all speed,’ and thereby saved the life of one of the heathen Picts” <Blonder 1988>.

BLONDER-TONGUE PATENTS

Between them, Ike Blonder and Ben Tongue had close to 60 or more patents assigned to Blonder-Tongue. Bob Rines, Blonder’s old Army buddy and corporate counsel and shareholder, was their patent attorney. Blonder described their company policy on patents as “defensive, not offensive.” They got patents so they would not be sued. Many times an engineer may use a circuit or device without knowing whether it is in the public domain or protected by patent. As a company, Blonder-Tongue was always willing to pay for the use of patented inventions.

For instance, by 1960, they were doing about \$1 million a year in sales of industrial video cameras, on which RCA claimed patent rights. Upon investigation, Blonder-Tongue’s patent attorney said, “their claim was specious.” Nevertheless, rather than litigate, Blonder-Tongue paid the 1.5 percent royalty. Blonder believes the

royalty was so low because the validity of the patent had already been challenged in court and they were willing to take whatever they could get.

Blonder got a patent on the chain amplifier that was eventually validated by the Supreme Court. The challenger was a professor at the University of Illinois who got the idea for his patent from a government program at Wright Air Force Base. The court ruled that the professor was not the inventor.

Blonder provided the following list of patents, chronologically by patent date. Many of these patents have been assigned either to a Blonder-Tongue company, Blonder and Tongue jointly, or individually. It is believed to be a reasonably complete listing. Copies of most of these patents have been presented to the National Cable Television Center and Museum.

Name of Patent	Inventor	U.S. Patent No.	Patent Date
Thermorelay Element	Blonder	2,609,466	Sept. 1952
Wideband Spectrum Analyzer	Tongue	2,661,419	Dec. 1953
Electrical Connector	Blonder	2,682,649	June 1954
Wideband Amplifying System	Tongue & Blonder	2,710,314	June 1955
Wideband Amplifying System	Tongue	2,710,315	June 1955
Attenuation Equalizer	Tongue	2,733,413	Jan. 1956
Amplifier System	Tongue & Blonder	3,761,022	Aug. 1956
Multisignal Electric System	Tongue	2,761,135	Aug. 1956
Wideband Neutralized Radio Frequency Amplifier	Tongue	2,761,023	Aug. 1956

Name of Patent	Inventor	U.S. Patent No.	Patent Date
High-Frequency Transmission Line Coupling Network	Tongue	2,776,408	Jan. 1957
Neutralized Amplifier System	Tongue	2,778,934	Jan. 1957
Tunable Electrical Circuit Elements	Blonder	2,778,943	Jan. 1957
Electron Tube Stabilized Amplifying Circuit	Tongue	2,790,036	April 1957
Wideband Distributing Amplifier	Tongue	2,815,406	Dec. 1957
Amplitude Stabilizing Oscillating Circuit	Tongue	2,833,924	May 1958
Radiation Receiver Sensitivity Control	I. Horowitz	2,833,957	May 1958
Electrical Line Tapper	Blonder	2,843,827	July 1958
Phase Detector and Oscillator System	I. Horowitz	2,848,617	Aug. 1958
Balanced Mixer	Tongue	2,857,511	Oct. 1958
Electronic Protective System	I. Horowitz	2,860,283	Nov. 1958
Cable Insulation Cutter	Blonder	2,903,064	Sept. 1959
High Voltage and Impulse Supply System	I. Horowitz	2,906,918	Sept. 1959
Electrical Cable Coupler	Blonder	2,914,740	Nov. 1959
Transmission Line Tapoff	Tongue	2,914,737	Nov. 1959
Demodulator	I. Horowitz	2,937,274	May 1960
Electronic Tuned Circuit	Tongue	2,983,876	May 1960
Transmission Line Connector and the Like	Blonder	3,474,390	Oct. 1960
Electrical Cable Connector	Blonder	2,970,184	Jan. 1961
Pulse Sharpening Circuit	I. Horowitz	2,968,766	Jan. 1961
Transmission Line and Method of Making Same	Tongue & Blonder	2,977,553	March 1961
Coupling Reducing Apparatus	Tongue	2,986,706	May 1961
Electron Tube Stabilized Amplifier	Tongue	2,999,985	Sept. 1961
Transmission Line Connector	Blonder	3,001,169	Sept. 1961
Electrical Clamp and Connector	Blonder	3,016,510	Jan. 1962
Variable Gain Transistor Circuit	I. Horowitz	3,023,369	Feb. 1962
System for Wideband Neutralization	Tongue	3,044,022	July 1962
Transistor Amplifier System	I. Horowitz	3,063,020	Nov. 1962
Scrambled TV Apparatus and Method	Donato D'Agostino	3,069,492	Dec. 1962
Phase Shift Reducing Apparatus	Tongue	3,071,735	Jan. 1963
Transmission Line Clamp and Connector	Blonder	3,083,349	March 1963
Audio Tone Control System	I. Horowitz	3,116,462	Dec. 1963
Electrical Connector Locking System	Blonder	3,129,992	April 1964
Electrical Outlet Attachment	Blonder	3,131,985	May 1964
Secondary Emission Prevention	I. Horowitz	3,134,043	May 1964
Attenuator System	Blonder	3,144,625	Aug. 1964
Multiple Point Electrical Connector	Blonder	3,144,290	Aug. 1964
Transmission Line Connector	Blonder/Sampson	3,154,362	Oct. 1964
Unilateralized Transistor Relay System	Tongue	3,156,872	Nov. 1964
Transistor Interstage Coupling Circuit	I. Horowitz	3,162,820	Dec. 1964
Mast Mounting Clip and Bracket	Blonder	3,166,284	Jan. 1965
Method of and Apparatus for TV Reception	Tongue & Blonder	3,175,033	March 1965
Clamping Strap Assembly	W.F. Sampson	3,176,368	April 1965
Video Amplifier System and Method	I. Horowitz	3,196,361	July 1965

Name of Patent	Inventor	U.S. Patent No.	Patent Date
Electrical Coupler	Blonder	3,208,033	Sept. 1965
Amplifying Relay Power Supply	Tongue	3,239,774	Mar. 1966
Semiconductor Negative Resistance Structure	I. Horowitz	3,247,429	April 1966
Direct Current Coupled Alternating Current Transistor Amplifier	I. Horowitz	3,249,884	May 1966
Directive Antenna	Blonder/Schonfeld	3,259,904	July 1966
Electrical Coaxial Connector	Blonder	3,293,592	Dec. 1966
Electrical Outlet Locking Cover	Blonder	3,293,588	Dec. 1966
Converter Apparatus	I. Horowitz	3,309,612	March 1967
Switching Circuit	Blonder	3,323,042	May 1967
Apparatus for Producing Mechanical Oscillations Suitable for Controlling Sweep	Blonder	3,329,909	July 1967
Tunnel Diode Converter System	Tongue	3,332,022	July 1967
Wideband Transistor Amplifier System	I. Horowitz	3,329,904	July 1967
Balanced-to-Unbalanced Impedance Transformer	Tongue	3,360,731	Dec. 1967
Antenna Element Locking Mechanism	Blonder	3,365,722	Jan. 1968
Wideband Transistor Amplifier	Tongue	3,413,563	Nov. 1968
Combined VHF-UHF Dipole Antenna Secondary Lobe and Ghost-Reduction Antenna Transmission-Line System	Blonder	3,509,574	April 1970
Wideband Low Distortion Alternating Current Amplifier	Blonder	3,596,272	July 1971
Broadband Aperiodic Attenuator Apparatus	Tongue	3,605,031	Sept. 1971
Constant Resistance Adjustable Slope Equalizer	Tongue	3,624,561	Nov. 1971
Apparatus for Decoding Scrambled Television and Similar Transmissions	Tongue	3,868,604	Feb. 1975
Yagi-Type Antenna and Method	Martin Sperber	4,095,258	June 1978
	Blonder	4,218,686	Aug. 1980

REFERENCES AND ADDITIONAL READINGS

NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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Ike Blonder has been a prolific and eclectic writer. Many of his papers and Blonder-Tongue products may be found at the National Cable Television Center and Museum.

CHAPTER 12

Philips Broadband Networks, Ltd.

THE MEZZALINGUAS^{[1](#)}

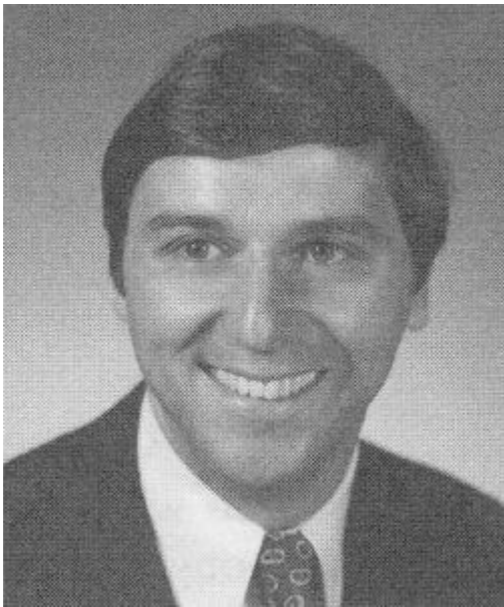


Fig. 12.1 Daniel N. Mezzalingua

*Courtesy National Cable Television Center and
Museum*

Author's Note: The narrative that follows is based, in part, on the interview with Dan Mezzalingua at his office in East Syracuse on May 18, 1998. In considerable part, however, it is also based on the book Mezzalingua: Memoirs of an Italian-American Family by R. Harrison Huston (better known to many of us as Bob Huston, one-time publisher of the trade journal CABLE NEWS). According to Dan, "The book was really published [in 1997] just for the family. So we really don't give it out to too many people" <Mezzalingua 1998>.

DAN MEZZALINGUA (FIGURE 12.1) IS NOT AN ENGINEER, IN THE TRUE SENSE OF THE WORD, but his story parallels, in many respects, that of the engineers who pioneered equipment manufacturing for cable television. Between 1963 and 1981, Mezzalingua transformed the little Craftsman Electronics Products Company, started in the 1950s by Oneonta Video (New York), into one of the three leading cable TV equipment suppliers. The history of the company now known as Philips Broadband Networks, Inc., begins with Mezzalingua.

The Mezzalingua dynasty began in 1882 when Dan's grandfather, Donato Mezzalinqua (originally spelled with

a “q”), was born in the Province of Conpobasso in southern Italy. The Mezzalinqua lineage in Italy goes back to 1273 A.D. Donato left the hardscrabble farm in the barren mountain valley to seek work in Napoli (Naples). At the age of 21, he married Marietta Lombombard. In 1904, a son named Genaro Mezzalinqua was born. Shortly thereafter, Donato joined his two older brothers in America, hoping to find a better life for himself and the young family he was leaving behind while he looked for work. He found a job in Manlius, near Syracuse, New York, shoveling coal 12 hours a day, 6 days a week, into the blast furnace at the iron foundry. Before his infant son was a year old, Donato was able to send enough money for Marietta to come by boat from Naples to Ellis Island in America and by rail to Syracuse, plus \$20.00 for food and everything else. How she made that trip across the stormy Atlantic with an infant and little money in cramped, unventilated steerage quarters with neither bunks nor sanitary facilities is the saga of a proud, courageous, and resourceful woman, undaunted by the most frightful experiences imaginable <Huston 1997, chapter 1>.

Grandfather Donato was perceptive and hardworking in his relentless pursuit of a better life for his family. He persuaded the president of the foundry to help him obtain

a bank loan for a small shop in which the pot-bellied stoves manufactured at the foundry could be sandblasted to a smooth and more attractive finish. Later, he purchased a greenhouse business and several trucks with which he contracted to deliver all of the ore and coal used at the foundry, much faster than was possible with horses.

He later told his children and grandchildren, “Open your eyes and opportunity might be sitting right in front of you. When you see it, use your head and you just might have something that someone wants” <Huston 1997, 55>.

When Genaro Mezzalinqua was five years old, a kindergarten teacher suggested changing his name to John and replacing the “q” in his last name with a “g,” apparently because it would be easier to write. So, Dan’s father became John Mezzalingua ([Figure 12.2](#)), the oldest of the 10 children born before Marietta was 30 years old <Huston 1997, 44-45>.



Fig. 12.2 John Mezzalingua

*Courtesy National Cable Television Center and
Museum*

John learned at an early age from his father Donato

about work and discipline and, above all, about family and responsibility. When John completed the seventh grade, his father reluctantly allowed him to leave school and go to work. This was in 1917, when Italy's entry into World War I on the side of the Allies had caught the attention of the Mezzalinguas of Manlius. Barely a teenager, John quickly found work at the foundry.

After the War, John Mezzalingua took a second job working in the greenhouse business his father had bought. Long before direct mail became standard advertising practice, he wrote letters to each member of the country club, inviting them to get fresh flowers from a family in the community they knew and trusted. It worked. The greenhouse business flourished until the Great Depression began to take its toll. Then he looked for new opportunities and soon had several trucks delivering milk from the dairy farms to the collection point. He also used his trucks to supply the foundry with the parts and machinery they needed, becoming what is now known as a manufacturer's representative.

At the age of 27, in 1931, John Mezzalingua married Carmella Minozzi from another proud and resourceful Italian family, now settled in the north side of Syracuse. They had three children: Mary Jane, the oldest; Daniel

Nicholas, born September 26, 1937; and Gloria, the youngest <Huston 1997, 86, 89>. Mutually supportive families like the Mezzalinguas and the Minozzis were able to persevere through the difficult 1930s, buttressed with John's vision, energy, and persistence, and a productive garden and chicken house.

PRODUCTION PRODUCTS COMPANY, INC.

The depression hit the foundry at Manlius very hard. As layoffs began in the late 1930s, the trucking, floral display, and manufacturer's representation businesses suffered. With three small children, John Mezzalingua needed another enterprise to support his family.

Thinking about all the screws needed to assemble an automobile or home appliance, he borrowed from the bank to purchase an automatic screw machine that could convert metal rods from the foundry into several thousand screws an hour. By 1939, as the United States began gearing up for war, the materials he could produce with his automatic screw machine became important; after Pearl Harbor, they became crucial necessities. The little machine screw shop was incorporated in 1943 as Production Products Company, Inc. (PPC). The timing was

right. PPC was very profitable <Huston 1997, 87; Mezzalingua 1998, 4>.

Daniel Mezzalingua's father quit school after the seventh grade in order to work at the foundry during World War I. He was determined that his son do better in school and get a college education. But Dan was a laid-back, happy-go-lucky youngster who was too young to be impressed by the hardships of the Depression and had little enthusiasm for school. So when he reached high-school age, his father sent him to nearby Manlius Military Academy, a perfect place for a boy who needed to learn about discipline. This was a successful move. When he came out of the academy, Dan was ready and eager to enroll at Syracuse University. He graduated from the Maxwell School of Public Administration in June 1960 with a bachelor of arts degree in political science. In the fall, he enrolled at the New York University Law School but left after the first semester. He went to work for Olivetti for a few months, then signed up for a six-month tour of active duty as a reserve officer in the U.S. Army. In November 1961, Dan Mezzalingua returned to Manlius to drum up work for his father's screw-machine job shop <Mezzalingua 1998, 44>.

ONEONTA VIDEO AND CRAFTSMAN ELECTRONICS PRODUCTS, INC.²

In the late 1950s, PPC manufactured C-52 coaxial cable connectors under contract to a small electronics firm in Philadelphia, the Jerrold Electronics Corporation. Tony Katona, one of the early engineers at Jerrold, was PPC's point of contact. About 1962, Katona left Jerrold to join Al Ferone and Bill Calsam in Oneonta, New York. Ferone and Calsam started the Oneonta Video CATV system about 1954 <*Television and Cable Factbook* 1998>, with Ferone providing most of the funding and Calsam doing most of the technical work. Like other pioneer CATV operators, they found that the few suppliers they knew about—Jerrold, Entron, and Spencer Kennedy Laboratories (SKL)—either could not or would not deliver the small but necessary parts and equipment when they needed them. So, they formed a separate company called Craftsman Electronic Products, Inc., to make their own passive equipment, primarily power dividers (called splitters) and the balun transformers that provide a proper interface between the 75-ohm coaxial cable and the 300-ohm antenna terminals that were then common on TV sets. Working part-time in the basement, system maintenance

technicians wound coils and assembled parts in blister cans. For seven or eight years, Calsam developed Craftsman into a nice business, selling equipment they had designed for their own use to other operators, mostly in nearby New York and Pennsylvania.

When Katona came to Oneonta, he introduced Ferone and Calsam to PPC and John Mezzalingua with whom he had become well acquainted before leaving Jerrold. Katona suggested that PPC make C-52s and the larger F-connectors for Craftsman, as well as Jerrold, to resell. Actually, Dan says, “[Ferone and Calsam] seemed to have a stronger base of support on reselling things like passives and connectors.” Jerrold was focused more on selling and installing total systems than selling component parts <Mezzalingua 1998, 45>.

Shortly after joining PPC as salesman, Dan Mezzalingua drove the 100 miles or so down to Oneonta to meet Ferone and Calsam. It was an intensive learning experience. Dan was fascinated to learn about the small-town entrepreneurs in Pennsylvania and Oregon who put up antennas on tall towers on a nearby hilltop where they could get TV reception from stations 75 to 100 miles away. He was particularly impressed by the fact that they could collect a monthly service fee for delivering those signals

on wires to homes in the valley where there was no reception <Huston 1997, 95>.

PPC ACQUIRES CRAFTSMAN ELECTRONIC PRODUCTS, INC.

At first, Dan was thrilled at the large orders he was getting from Craftsman for the products PPC was now delivering to Oneonta. The more he learned about this new business called community antenna television (CATV), the more he began to see its enormous potential. And like his father and grandfather before him, he began to study how they could take advantage of the opportunity his grandfather had said "...might be sitting right in front of you."

After only a few months, Katona abruptly left Oneonta Video. Then, during one of Dan's trips to Oneonta early in 1963, Ferone said, "Look, we really don't want to be manufacturers. We're really cable operators. Why don't you guys make all this stuff?" To which Dan replied, "We know how to make connectors, but we don't know how to make passives and splitters and all that stuff." They said, "Oh, don't worry about that. We'll help you do it."

Dan was intrigued. It looked like an opportunity to do more than just keep on making equipment for a good customer. To expand the business by selling PPC-manufactured products in direct competition with Craftsman was unthinkable. But, what if PPC were to buy Craftsman outright and run it themselves? Ferone and Calsam had promised technical help. It was exciting to contemplate the prospect of expanding their parts business, as new CATV systems developed and prospered.

John Mezzalingua was pleased that his son was talking with such enthusiasm about CATV. And he liked the way Craftsman kept increasing their orders each month and always paid their bills promptly. But Dan had bigger ideas, and finally went directly to his father and said, "Dad, let's buy Craftsman." Intent on selling his father on the idea, he went on, "The potential of CATV is truly astounding. CATV is going to grow and grow and the industry is going to need a tremendous amount of equipment. You know, 25 years from now, the entire nation will be wired for cable television. Just think how many millions of connectors and matching transformers the people who are going to build the cable systems are going to need" <Huston 1997, 95>.

Daniel Nicholas Mezzalingua was only 26 years old in 1963 when Production Products Company, Inc., acquired Craftsman Electronic Products, Inc. Dan assumed the role of president and CEO of the wholly owned affiliate, with his father as chairman of the board of directors. Although commonly owned, a strict “firewall” was maintained between the two companies. PPC manufactured the components, just as they had done previously for Jerrold. Craftsman assembled and marketed the completed products. John Mezzalingua ran PPC; Dan ran Craftsman. The arrangement worked very well.

As a PPC affiliate, Craftsman simply continued selling connectors for braided shield coaxial cables, splitters, and balun transformers, mostly indoor devices manufactured in the PPC machine shop. From time to time, Craftsman would use Calsam’s technicians at Oneonta for technical assistance. They also had considerable help from SageCraft in Norwich, New York, about 40 miles southeast of Manlius, who wound coils for them and made parts that PPC was not equipped to handle <Mezzalingua 1998, 70>. Moreover, Calsam graciously introduced Dan to important system operators such as Bill Daniels, Glenn “Tubby” Flinn, Frank Thompson, and the group in Seattle, who quickly became loyal customers.

Dan had already discovered in the *Television and Cable Factbook* that CATV systems were located everywhere in the United States, not just New York and Pennsylvania. In June 1963, he went to his first National Cable Television Association (NCTA) Conference in Seattle, attended by nearly 700 operators. He discovered that he could talk to multiple system operators (MSO) without calling separately on each individual system. He began attending state association meetings and found that he had far more prospective customers than he had imagined possible. Craftsman's market could extend from coast to coast.

But he also discovered that there were a lot of equipment suppliers, many of whom had elaborate display booths at the NCTA show. He was the new kid on the block with formidable competition. Moreover, he recognized that Craftsman products had nothing special to offer. They were neither novel nor particularly better, and Craftsman was not set up to assure prompt delivery. As he pondered the situation, he began to see that to be successful he would have to increase substantially Craftsman's production capacity, acquire additional staff and space for research and development, and establish a production quality control department. Some competing

vendors were known to wait for sizable orders before committing to production, often causing slow and unreliable delivery schedules. Craftsman would have to do better by building shelf inventories of completed products for immediate delivery. They would have to begin manufacturing components in-house rather than purchasing from outside sources. Finally, they would have to develop a sales force and put in place an effective advertising program.

Clearly this would require much greater investment than they had anticipated. When Dan returned from the 1963 national trade show a few months after acquiring Craftsman, he headed directly to his father's office. "Dad, we need more money—a lot more money." His father, thinking Dan was talking about a salary increase, asked, "How much more do you think you need?" But Dan was not thinking about his personal income. Having in mind the cost to expand the plant, retool, and hire new people, Dan calmly told his father, "At the very least, a million dollars."

John Mezzalingua was stunned. Dan and his father laugh about it now, but this was the moment of truth for Craftsman Electronic Products. Dan's enthusiasm and solid homework soon sold his father on putting

everything the family had into cable television. Within about 30 days, a 2,500-square-foot addition to the machine shop was ready to be occupied, and Dan was busy assembling engineering, production, and sales teams that grew to perhaps as many as 50 people <Huston 1997, 112-118>.

In the interview, Dan said, “Yes. I think what I said to him was that if we really want to get in this thing, we are going to have to really spend some money. And my father—God bless him—is the kind of guy—like, you know, not too unlike some of the early cable pioneers. ... Some of the metal rod that was sent into the machine shop came in boxes. And he had a guy take the wood from the boxes. And he would use those as two-by-fours to build offices from. So, I mean, he used everything. He even straightened out the nails!” <Mezzalingua 1998, 67>.

In April 1965, Dan Mezzalingua and Kathleen Damico were married. They soon had six children, four girls and two boys. Dan insisted that each of his children should work in some other company for at least three or four years before becoming permanently employed at PPC. As of 1998, Karen, 32; John, 31; and Laurie, 30, were already taking their place alongside their father in the management and operation of the firm <Huston 1997, chapter 6>.

Bill Bresnan was executive vice president of American Cablevision, the Jack Kent Cooke group of cable systems that later merged with TelePrompTer. About 1966, Bresnan asked Dan at one of the many trade shows, “What are you guys doing about taps?” Dan replied, “Well, everybody is using pressure taps.” “Nah,” Bresnan said, “the market is really going to switch. Why don’t you take a look at the Spencer Kennedy Laboratories (SKL) tap? They make a good tap, better than pressure taps.”

Then, a little while later, Dan made a sales call at TelePrompTer in Elmira, New York. He spoke with Austin “Shorty” Coryell, a skilled technician who was working for TelePrompTer at that time. “Shorty, what do you think?” And Shorty said, “Look, you’ve got to make a SKL tap.” And Dan said, “I don’t have the first idea on how to make a tap.” So Shorty pulled out an SKL tap, the one that had the original wire rope type cord inside ([Figure 8.3](#)). Actually, it was a coiled up piece of dual conductor coaxial cable representing one-quarter wavelength at low-band VHF (~65 MHz) and three-quarter wavelength at high-band (~195 MHz). SKL was selling these for about \$22 <Mezzalingua 1998, 8>.

So, Dan decided to make a tap. He hired an engineer

of Chinese origin named S.W. Pie who did not understand a thing about CATV. Pie spent a lot of time on the road between Manlius and Elmira working with Coryell. Dan says Coryell was primarily responsible for designing the tap. However, Coryell demurs, saying he only did a lot of the testing for Craftsman. What evolved was a parallel transmission line on printed circuit boards. Using printed circuit boards rather than coils of coaxial cable not only cut production time and cost substantially but also improved the uniformity of the product.

For help in designing the circuit boards, Dan approached the University of Syracuse Research Corporation, which was just beginning to shift its emphasis from military projects to more commercially marketable products. This was a directional tap to be inserted in the feeder line. It had input and output connectors for the feeder and one for the tap-off port, all mounted in a housing that contained the circuit board. The physical arrangement was modular so that splitters could be added for multiport uses <Mezzalingua 1998, 7-9, 73-76>.

The Craftsman tap worked out very well. They sold them by the tens of thousands at about half the price of the SKL tap and less than the price of Jerrold's multitap.

Bill Bresnan decided to go with Craftsman products. Bob Huston says in his book that this marked a turning point for Craftsman, because of Bresnan's recognized and highly respected profile in the cable TV industry <Huston 1997, 121-122>. However, the minimum insertion loss of the tap was 3 dB and it was limited to the high- and low-band FCC channels. When systems began using the midband (between channels 6 and 7) and superband (above channel 13), this type of tap became obsolete.

Having sold Craftsman to PPC, Calsam no longer wanted anything to do with manufacturing. Furthermore, Ferone and Calsam were distressed by the ominous regulatory developments at the FCC in the late 1960s and decided to sell all of their systems to the Newhouse family of broadcasters and newspaper publishers in Syracuse (for \$4.5 million, according to Dan). This became the nucleus of the Newchannels cable TV multiple system operation (MSO).

Some time after PPC bought Craftsman Electronic Products, Calsam introduced Dan to Anthony "Tony" Cerrache, owner of the fairly large CATV system in Ithaca, New York. As Dan tells it, "Tony was very anxious to get into the manufacturing of amplifiers. He started making a lot of stuff for himself because he couldn't get delivery,

and the kind of delivery he was getting—they felt they could put better components in and make better amplifiers.” His design engineer, Paul Rubellus, was an expert in solid-state (transistor) technology. Dan says, “Paul Rubellus did so much work with solid-state components that he literally put TRW into the hybrid chip business.”

According to Dan, “The only people who were making them were with Motorola. TRW was coming around but they had no manufacturing status in the cable TV business, until Rubellus got them going. And they ultimately hired him and he became a project manager.” TRW ultimately became Craftsman’s principal supplier. Dan says, “They were far and away superior price-wise to Motorola... and just better quality, on time delivery, and just a much more nurturing attitude toward wanting to get into the business, from the bullheaded—like, ‘Who are you guys at cable?’—kind of like doing us a favor.”

So, Calsam brought Cerrache and Dan together and said, “Why don’t you make amplifiers at Craftsman?” Cerrache was interested in working with Craftsman and even considered taking an equity position. Cerrache started out with vacuum-tube amplifiers, but Rubellus later developed a transistor amplifier that Dan considered

excellent and superior to either Ameco's or Jerrold's transistor amplifiers <Mezzalingua 1998, 48-49>.

At about this time, Ameco was selling a line extender amplifier packaged in a small hermetically sealed cylindrical housing, painted black, with connectors on each end. A line extender amplifier is a relatively simple, low-cost amplifier used to drive television signals through the taps to which customers are connected. Ameco was selling them "by the tens of thousands," according to Dan. Responding to what appeared to be popular demand, Craftsman decided to build a similar cylindrical line extender amplifier.

Again, Dan turned to the Syracuse University Research Corporation. According to Dan, Syracuse Research designed a "fairly good" amplifier, but it was much too expensive. Syracuse University Research had still not scaled down its military experience to the reality of commercial economics. Cerrache and Rubellus worked closely with Craftsman, making suggestions, giving advice, and doing a lot of testing as the amplifier developed.

Ameco had been buying connectors from Craftsman as well as connectors that Earl Gilbert had designed and

manufactured specifically for Ameco. “But,” Dan says, “as soon as we came out with that cylindrical amplifier, Bruce Merrill got so damn mad that he cut us off in terms of making any more connectors. And we never went anywhere with that damn amplifier. We played around with it. We tested it. We made a few pieces, sent it around, and it pretty much died” <Mezzalingua 1998, 10>.

Dan decided then that he really did not want to get into the amplifier business, at least not at this time. He did not have the sales force or the setup to support it properly. So, about 1967, Cerrache made a deal to sell his amplifier business to American Electronic Laboratories (AEL). He also sold his cable systems to Newhouse, according to Dan, for \$10 million.

Irving Kahn was president of TelePrompTer, then the largest CATV group operator, and an effective spokesman for cable TV in the financial community. Probably about 1968, Kahn came to Dan Mezzalingua and said, “Dan, you’ve got to make a set-top converter.” Dan responded, “But we don’t have the foggiest idea!” Then Irving said, “All I know is that you’ve got to have something with buttons on it so I can sit in my chair, and I don’t want to move from my chair.” At that time, Philip Hamlin, formerly sales representative for Jerrold in the Pacific Northwest,

was manufacturing a set-top converter with a sliding-tab channel selector patterned after a popular telephone number index. Instead of selecting a page from the alphabetic index, the sliding tab could be set to select a TV channel. Kahn was making it quite clear that he wanted buttons, not the Hamlin slider. Hubert “Hub” Schlafly, TelePrompTer’s engineering guru and vice president, added that the box had to be big enough for a two-way module for pay-per-view and all the other applications they envisioned for the future of cable TV.

So Craftsman built a set-top box with buttons on the top! It had a pay-TV button and a long umbilical cord to connect to the TV set. Dan guesses they may have built 50,000 of these devices. “That was truly a two-way device,” he says today, “because everything we shipped out, we got back!”

It was a debacle. The oscillator frequency drifted like mad. “Oh they were all over the place,” Dan admits. Somewhat defensively, Dan says he had asked Kahn, “What do you want to pay for these devices?” And Kahn said, “I want to pay something like \$35.” “But Irving,” Dan protested, “that is going to be tough to do.” Kahn was adamant. “All I’m paying is 35 bucks!” And so, Craftsman’s converter, like the cylindrical amplifier, simply

died <Mezzalingua 1998, 16–18>.

In due course, Dan and his father also applied for franchises to build and operate cable TV in the small towns surrounding several cities in central New York State, sometimes in competition with the Newhouse broadcasting and newspaper group. However, a Newhouse representative began to raise the ethical and legal questions that had plagued Jerrold and other vendors: “Do you want to be a manufacturer or do you want to be in the cable operations business? You’d better choose up which side you want to be on.” But, Dan said, “Why can’t we be in both? Jerrold was in both sides of the business. Bruce Merrill was always in both sides of the business.” And they insisted, “No, we don’t want you to compete with us. If you are going to go for these cable systems, we are not going to buy anything from you.” So, Dan says, “We just opted to back out of that business. We opted to stay with what we felt we knew better” <Mezzalingua 1998, 64-65>.

HTV AND MAGNAVOX

By late 1969 or early 1970, the CATV equipment manufacturing market was changing. Spencer Kennedy

Laboratories had sold their CATV equipment rights to Scientific Atlanta. Kaiser CATV was about to become Theta-Com. General Electric and RCA were experimenting with entry into the CATV business. Dan and his father, recognizing the limitations of the resources available to them, said, “Boy, we’d better find ourselves a partner.”

In 1968, Dr. Alwin Hahnel and two other former Stromberg-Carlson engineers formed an organization called HTV, Inc., in Rochester, New York, to build electronic equipment for the cable TV industry. HTV claimed to be the first to include all necessary equipment for two-way transmission in the amplifier housing right from the start. This was the unique feature with which they hoped to enter the cable TV marketplace. At that time, other equipment suppliers were providing the two-way feature only in an optional separate housing. It was not until after the 1972 FCC Report and Order that all major suppliers began to include modular “two-way capability” within the main amplifier housing. The founders of HTV had expected that telephone companies would be their principal customers. But when a 1969 FCC Report and Order excluded telephone companies from direct participation in CATV operations, Dr. Hahnel and his associates began to look for a way out.

David Coe was HTV's marketing manager. Coe is a CATV engineering pioneer who continued to own and operate the system he had built in 1953, in Bainbridge, New York, about 15 miles southwest of Oneonta. He became acquainted with Dan Mezzalingua about the time PPC acquired Craftsman. Before leaving HTV in May 1970, Coe introduced Dan to Hahnel. Dan was favorably impressed with Hahnel and his associates and the products they were developing, although manufacturing output was still quite limited.

Amplifiers were really the main thrust of the CATV equipment manufacturing business. In order to get into the amplifier business in a big way, Dan felt that Craftsman really needed to have a recognizable household name, which HTV clearly did not have. Investors with no background in the CATV industry sought assurance that their equipment suppliers were completely credible and firmly established. Dan's interest in HTV was put on hold for the time being.

By 1970, Craftsman had become an eligible bachelor, as it were, open to suitable merger proposals. Dan Mezzalingua was well known and respected by an ever-widening circle of cable TV people. Craftsman products were earning superior commendation, and Dan was widely

admired for his straightforward and enthusiastic style. Dan and his father were first approached by Westinghouse. Shortly thereafter, Robert H. Platt, who at that time was president of the Magnavox Company, flew in from Fort Wayne, Indiana. He had great ideas. He saw the TV receiver manufacturing business beginning to lose profitability. The Japanese were already shipping table model color TV sets, and it was just a matter of time before they would get into the full range of floor models. Platt did not want Magnavox to be totally dependent on the receiver business. The military business was also declining, and he was looking for new opportunities. He really wanted to take Magnavox in a different direction, to get into cable TV equipment. "Now, we're really committed to it," he told them. Magnavox was a well-established and well-heeled manufacturer of television receivers with a widely recognized name.

No one was more surprised than Dan Mezzalingua when Magnavox came in with an offer they could not refuse. In November 1970, Production Products Company, Inc., and Craftsman Electronic Products, Inc., were merged into The Magnavox Company, through an exchange of stock. PPC and Craftsman became the Magnavox CATV Division, with Dan Mezzalingua as president. To put this

merger in perspective, Dan points out that at that time, Craftsman's annual gross sales amounted to just over \$5 million, while The Magnavox Company had gross sales of more than \$500 million. For comparison, he says Jerrold was doing less than \$100 million and Hewlett-Packard, the giant computer and test equipment manufacturer, was doing only \$160 million a year <Huston 1997, Mezzalingua 1998, 15–16>.

Ironically, the television receiver divisions of Magnavox and other TV set manufacturers were notably antagonistic to cable TV. Perhaps this attitude reflected a natural empathy with many television broadcasters who perceived cable TV as a predator threatening their commercial livelihood. Even to this day, the consumer electronics industry is not really comfortable with cable television and continues to resist cable's efforts to negotiate compatibility between the TV set and the cable network. The Magnavox discussions with Craftsman and PPC did not come through the receiver division, more than likely to avoid the element of "us versus them."

Dan Mezzalingua saw the merger as an end to worrying about raising the capital needed to convert ideas into marketable products. He also saw Magnavox as the way Craftsman could get into the turnkey installation

business, which at that time was an essential requirement for sales to investors who knew nothing about building systems. John Mezzalingua, on the other hand, was not entirely comfortable with the idea of working for someone else after a lifetime of independence. Nevertheless, because of Dan's enthusiasm and success with Craftsman, he agreed to the deal with Magnavox.

The Magnavox Company really had no direct experience whatever in the cable TV business. But they were quite anxious to get into the amplifier manufacturing business. Dan told them, "If you are going to get in the amplifier business, you shouldn't just start from scratch. Maybe you could pick up something and leapfrog the development curve, because you would want a little bit of a different twist." Then he said, "Let's go up and talk to Dr. Hahnel, at HTV up in Rochester. He is a small company. I think they are struggling. I don't think they have a wide market presence. While David Coe has been in the business, he is just one guy. I think they're undercapitalized. And I believe Dr. Hahnel would be a perfect spokesman for the business. The most important thing is that he is the only one who is doing true two-way on the trunk line."

So, Magnavox CATV acquired the assets of HTV and

brought them to Manlius. Hahnel and his associates retained the HTV corporate entity as a vehicle for franchising activity. In retrospect, Dan feels they should have kept the company together in Rochester. “When you buy a company,” he says, “you really are buying the people, not just technology and equipment that you can readily duplicate. You should leave it right where it is, in its present culture and everything else. When we started manufacturing, it was just like starting from scratch. We didn’t have the proper chef who really understood the mix.”

Initially, Magnavox began by building the HTV amplifier in the existing factory at Fort Wayne, Indiana. It was essentially a Jerrold solid-state amplifier but with the built-in two-way feature. They really struggled at first and came out with an amplifier that, Dan frankly admits, was not performing well at all. The facility at Fort Wayne was well equipped for producing primarily military communications equipment purchased on military budgets. However, it soon became apparent that the costs of production were much too high to support competitive pricing in the cable TV industry, and amplifier production was moved back to Manlius. They simply scrapped everything they got from HTV and all previous Craftsman

amplifiers and prepared to start over from scratch. They were determined to produce amplifiers worthy of the Magnavox name <Mezzalingua 1998, 54>.

Dan Mezzalingua was proud of the new ideas coming out of his research and development group and set about putting together an engineering team that would establish Magnavox CATV Division as a major cable TV equipment vendor. To provide experienced professional engineering leadership, Dan brought Caywood Cooley in as vice president of engineering <Mezzalingua 1998, 55>.

Cooley was one of the earliest pioneer engineers to work with Milton Shapp at Jerrold Electronics, along with Don Kirk, Ken Simons, Hank Arbeiter, and others. Then, about 1966 or 1967, Kahn recruited him for TelePrompTer as vice president of engineering. At that time, TelePrompTer was the largest group owner of cable TV networks. Kahn and Hubert “Hub” Schlafly, Kahn’s long-time engineering partner and senior vice president, were active promoters of cable TV as the logical medium for pay-TV and other two-way interactive services.

In the early 1970s, Jerrold was in a period of transition and restructuring. In 1971, Shapp, founding president of Jerrold, was inaugurated to the first of two

terms as Governor of Pennsylvania and was no longer a part of the Jerrold operations. The tragic and untimely death of Jerrold's new president, Bob Beiswanger, left a serious leadership vacuum. John Malone, the whiz kid who became president of Jerrold for a few years before he was named president of Telecommunications, Inc. (TCI), tried to wake them up with different ways of doing things. Many of Jerrold's old-timers found this to be an appropriate time to move on to other endeavors.

Cooley had the opportunity to bring in a number of experienced former Jerrold engineering personnel, such as Maqbool "Mac" Karachi and Greg Tresness. Magnavox had already hired some engineers from GE. Thus, the Magnavox engineering team combined the talents and experience of the Jerrold people, the people they had hired from GE, and the Syracuse University Research people they had on staff. Dan recognized that, "The Syracuse University people did not know anything about cable TV, but with the Jerrold people in the mix, it just worked out beautifully."

Cooley led the effort to create a Magnavox amplifier that would significantly improve on the Jerrold amplifier. Dan Mezzalingua acknowledges that "... to this day, the Magnavox [amplifier] is nothing more than a repackaged

Jerrold amplifier with all the mistakes out. Everything that the operators were complaining about, Magnavox just simply corrected. ... Jerrold couldn't do it because the volume was so low at that time, and the castings were so expensive that they had to kind of Band-Aid certain things. Jerrold had it partially done. What the operators wanted was more modularity so you could literally empty the whole case. And we took off all the 'handles,' as they call them [accessible manual trimmers], so that the cable operators couldn't get in there and just kind of 'juice' up the signal when things were down and flat" <Mezzalingua 1998, 13, 55-56>.

Thus, although the amplifier circuit design was basically the same as Jerrold's, it was one of the first to use the TRW hybrid integrated circuit chip. The performance was rock solid, and the elimination of the need for manual trimming adjustments led to greater precision and stability in system layouts. The total modularity, introduced for the first time in the Magnavox amplifiers, provided substantially greater flexibility in design and has been universally adopted by the other suppliers. The result was well received in the marketplace. As Dan says, "We enjoyed quick success with that amplifier. At the time, of course, you had to finance cable

systems, and we were at a disadvantage there. The customers didn't want to build them—they wanted turnkey—and that was always hard. But that amplifier really took off—like crazy” <Mezzalingua 1998, 56>.

In response to the gathering momentum for pay-TV on cable in the early 1970s, Magnavox developed a one-channel set-top descrambler. It was about the size of a pack of cigarettes and was priced at about \$12. At that time, before the advent of satellite relay, pay-TV programs were provided by videotape, circulated from system to system by mail. There was no need for multichannel descramblers; it was hard enough to program just one premium channel. The Magnavox descrambler was a great success, until the introduction in 1976 of Tanner's patented \$5 positive trap, manufactured by T.E.S.T., Inc. <Tanner and Rist 1976; Becht 1976>. Both the Tanner positive trap and the Magnavox descrambler were designed to restore a single TV channel that had been deliberately distorted for security, without a set-top converter to interfere with the normal operation of the TV set. Although the methods were different, Magnavox could not overcome the enormous cost advantage of the Tanner positive trap.

About 1973, Cooley and the Magnavox CATV

research and development group put together a novel pay-TV billing and authorization system. The individual subscriber terminal had four switches: standard TV, premium A, premium B, and Accept. An interactive data exchange module (IDEM) with appropriate descrambling codes was installed at the output of a feeder amplifier, which could serve up to 32 customers. Even without two-way amplifier modules, the passive lengths of cable between amplifiers were used to carry return billing data stored in the customer terminal back through the taps to the IDEM, where the billing information was to be stored on magnetic tape. It was a kind of forerunner to the store and forward system of impulse pay-per-view (IPPV) <Forbes and Cooley 1973>.

NORTH AMERICAN PHILIPS CORPORATION

The declining profitability of the receiver business was of serious concern to the Magnavox Company. After a while, Dan felt this concern was diverting attention from any significant role that Magnavox CATV Division might play in the threatening political and regulatory situation faced by the cable TV industry or the affairs of its trade association, NCTA. The Magnavox Company had

adequately funded the CATV Division, according to Dan, but engineering and public relations support was fading. There was some skepticism in the industry as to whether the Magnavox Company was still as firmly committed as Robert Platt had once indicated <Huston 1997, 128>.

Then, in 1974, the Magnavox Company was acquired by the North American Philips Corporation. Thus, Magnavox became part of Philips N.V., one of the world's largest electronics companies, with headquarters in The Netherlands. Dan Mezzalingua, as president of the Magnavox CATV Division, would have access to technical research and financial resources beyond those available to any other company in the field. In 1976, the new owners changed the name to Magnavox CATV Systems, Inc., a North American Philips Company.

Dan and his father were pleased that North American Philips wanted them to continue to run the affairs of the Magnavox CATV Division, but they wondered what would be the impact of this most recent merger. North American Philips acquired Magnavox primarily to have a presence in the United States for television sets. Their whole thrust was toward shavers, television sets, and the whole range of appliances. They really knew nothing about what other branches of the Philips family were

doing in Europe with regard to cable television. For example, a Philips company operated the cable TV system in Brussels with perhaps 140,000 subscribers. However, the acquisition of Magnavox CATV served to link North American Philips more closely with the Philips cable TV interests in Europe. About 1977, Magnavox CATV Systems signed an agreement with Philips Cable TV Division of The Netherlands to pool engineering, marketing, and manufacturing resources for a joint sales venture in Europe. Magnavox CATV now had an international market for its product line <Mezzalingua 1998, 23-24>.

One result of the cooperative arrangement was the first proprietary Power Doubling™ amplifier (designated parallel hybrid in the public domain) based on the integrated circuit hybrid developed by Amperex specifically for this application. Amperex is the Philips affiliate in The Netherlands long associated with vacuum-tube and transistor research and developments. The Power Doubling™ circuit doubles the power output of an amplifier without increasing intermodulation distortion (CTB), thus affording greater reach for each amplifier or fewer amplifiers for a given line length <Staiger 1983; Reichert 1984>.

Magnavox CATV Systems developed an addressable tap about 1976, with which customers could be disconnected or reconnected remotely without dispatching an installer truck roll. It required only one-way signaling from an inexpensive word processor developed by Magnavox that could handle up to 100,000 subscribers. According to Bob Huston, the \$500 Magnavox processor replaced a \$5,000 minicomputer <Huston 1997, 149>. The Magnavox addressable tap was well accepted and led the way toward addressable premium program security.

The Magnavox Company always had the feeling that the functions of the set-top interface would eventually be incorporated into the TV set itself. It did not happen, mainly because of the relentless pressure to drive down the cost of the TV set. Notwithstanding Craftsman's unsuccessful venture with the set-top converter in 1966, Dan Mezzalingua still thought that a lot of set-top converters would be sold before becoming obsolete. In the 1980s, after Dan had moved on to other ventures, Magnavox CATV Systems did try again to introduce a line of addressable set-top converters with spectacularly unsatisfactory results.

According to Bob Huston, five or six years after

North American Philips took over The Magnavox Company, Magnavox CATV had gross sales in excess of \$50 million annually. They had finished building a 1,200-mile plant in Albuquerque, New Mexico, and cable systems in New Haven, Connecticut, and France. Telekabel of Vienna announced that the Magnavox MX-504 amplifier would be used in a 450,000-subscriber system in Austria, the largest in the world at that time. They had received a multimillion-dollar contract for six systems across the United States <Huston 1997, 151-152>.

In 1980, more than five years after taking over The Magnavox Company, Peter C. Vink, chairman and chief executive officer of North American Philips, paid a visit to the Magnavox plant in Manlius. He came to express his pleasure with the performance of the Magnavox CATV Systems. Dan Mezzalingua had nurtured the little Craftsman Electronic Products Company into a major cable TV equipment manufacturing organization and industry leader <Huston 1997, 154-155>.

RESIGNATION AND PPC BUYBACK

In May 1981, North American Philips told Dan that they were going to shut down the manufacturing of

connectors and the other products that had been manufactured under John Mezzalingua's Production Products Company (PPC) umbrella. "We are no longer interested in the original equipment manufacturing (OEM) business." They would purchase finished products rather than machining and processing the raw material themselves. This would enable them to concentrate on the research and design of mainline amplifiers and other big-ticket items rather than what they apparently considered to be nickel and dime products not worth fooling with.

When John Mezzalingua heard about this, he was delighted and quickly said to his son, "Let's buy back the business," to which Dan, just as quickly, replied, "Good idea." The buyback was entirely friendly. They could not use the name Production Products Company because someone else had picked it up when they sold the business to Magnavox. However, they could still use the PPC logo. So, they formed a new company called John Mezzalingua Associates, Inc. John will be 95 years old in 1999 and still oversees the business, with the indispensable participation of his large and competent family. Dan is the active president and chief executive officer, directing a thriving international business in connectors and other specialty products for cable

television under the well-respected PPC logo <Huston 1997, 173-175>.

In a surprise announcement on September 14, 1981, Dan Mezzalingua resigned as president of Magnavox CATV Systems to form a new company called Octagon Scientific; the company "...would become involved with the development of home hardware for pay and cable television." He explained only that "North American Philips and I had different opinions as to where the company should be going. Magnavox and Philips were geared toward television sets. I was geared toward television equipment. I also liked to look toward long-range strategic goals, they didn't, at least not where cable was concerned" <Huston 1997, 159-160>.

In 1992, long after the Mezzalinguas had departed, the company name was changed to Philips Broadband Networks, Ltd., and remains to this day one of the leading equipment vendors for the cable TV industry.

POSTSCRIPT

Dan Mezzalingua organized the Octagon Scientific Company in September 1981. By December, the team he

assembled had established the requirements for an addressable converter-descrambler. By January 1982, he had a joint venture agreement with Regency Electronics in Indianapolis to manufacture the product. The fully tested prototype was ready to present to the NCTA Convention in May 1982. The unit was named ROMAN, an acronym for Regency Octagon Modular Addressable Network. It was the hit of the show. A \$2.7 million purchase by Newhouse Broadcasting launched Octagon Scientific in great style.

ROMAN was designed to be compatible and interchangeable in all respects with Jerrold's addressable box, a forerunner to today's open architecture. While most operators were comfortable with Jerrold, they also wanted alternatives in case Jerrold could not deliver for some reason. Jerrold refused to share the addressable codes, so Dan's crew used a bit of reverse engineering to break and replicate the Jerrold code for ROMAN <Mezzalingua 1998, 30-31>.

But in 1983, Regency decided to take the manufacture of ROMAN to Taiwan. Dan considered building his own factory to manufacture the converter and other products but anticipated that price competition would eventually force him to go offshore. Rather than become an importer

of products made outside the United States, he sold Octagon Scientific to Regency.

Dan then set up as a system broker to take advantage of the booming investment in new systems in major markets. There were plenty of excellent opportunities, but the experience with vacillating buyers and sellers in the face of fierce competition became frustrating to the point of futility. So, he turned back to what he knew best and determined to take the connector business to the international market. Dan's son John is senior vice president, directing the international sales division, and his daughter Laurie is public relations administrator for PPC, running dog and pony shows for PPC products from Beijing to Australia.

REFERENCES AND ADDITIONAL READINGS

NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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CHAPTER 13

Other Cable TV Equipment Suppliers

THE PRINCIPAL SURVIVING CABLE TV EQUIPMENT SUPPLIERS in the United States today are General Instrument (formerly Jerrold; for a brief time, known as Next Level), Scientific Atlanta, and Philips Broadband Networks. Blonder-Tongue also continues to produce equipment quite suitable for cable TV, while retaining its dominant position in master antenna TV (MATV). Texscan has been acquired by Antec Corporation, which is rapidly becoming a significant vendor of cable TV equipment. The explosive technological expansion during the 1990s, both in cable television and telecommunications, has spawned an enormous armada of fledgling firms dedicated to supplying needs about which the CATV pioneers could only dream.

Other firms have from time to time played significant roles in providing ancillary facilities for cable TV. They made important contributions by supplying such items as power supplies, battery standby facilities, test equipment, character generators, routing switchers, commercial

insertion systems, interface devices (e.g., set-top converters), and countless other component products useful to the cable television system. There may be no vendor quite like George Acker who has been turning up faithfully at cable TV exhibits to sell nothing but lashing wire. He's been doing this since the early 1950s when the pioneers first began to lash coaxial cable to steel messenger strand. Distributors and manufacturer's representatives, such as Davco, Jerry Conn, Jack Pruzan, Toner, and many others, have provided technical services as well as a broad selection of equipment. Comm/Scope and Times Fiber Communications have played critically important roles by supplying coaxial cable and conducting research on cable transmission theory without becoming directly involved in electronics manufacturing.

For practical reasons, this volume is focused primarily on the experiences of those pioneer engineers and technicians representing the genesis of the cable TV equipment manufacturing business. The companies briefly described in this chapter did not survive as major equipment suppliers to the cable TV industry. They either no longer exist or have been merged into other existing or discontinued organizations. Nevertheless, each in its time sought to capitalize on and even improve upon the work

of the pioneers who started from scratch and contributed in varying degrees to the early technological history of cable TV. The information in this chapter is based on the experience and imperfect recollections of the author, primarily without oral history documentation.

KAISER CATV—KAISER-COX

In 1958, Earl Hickman resigned from Ameco, Bruce Merrill's CATV equipment manufacturing company in Phoenix, Arizona. Hickman was the technical genius behind the early success Ameco enjoyed as an equipment supplier for the new CATV industry. However, by 1958, the company was in trouble. Hickman left, because he felt that he was a burden, and went to work as senior engineer for the Kaiser Aerospace and Electronics Corporation in Phoenix, Arizona (see [chapter 7](#)).

Initially, his work at Kaiser had nothing to do with CATV. Then, about 1962, he did some consulting work on the side for a fellow who needed technical help with a CATV system he was building in Douglas, Arizona. Hickman wound up buying the system at a very favorable price because it was badly in need of rebuilding. He could not afford to buy the amplifiers he needed, so he built

them in his spare time while working at Kaiser. After all, he had designed and built a lot of them for Ameco.

His boss saw the amplifiers he had built and said, "That seems like a pretty good idea." Kaiser was in the military aerospace business, but Hickman's boss thought it might be desirable to do something in the civilian marketplace. Almost inadvertently, Hickman was responsible for initiating the Kaiser CATV Division. They hired a couple of young engineers, Don Gregory and Dick McMillan, and started to build a line of cable television equipment. They first showed the product at the National Community Television Association, Inc. (NCTA) exhibition at Denver in 1965.

Leonard Reinsch, head of the Cox newspaper and broadcasting enterprises and formerly President Truman's radio secretary, was an active and vigorous participant in Democratic politics. About 1960, he organized Cox Cablevision and became an effective proponent of cable television and leader in industry affairs.

At the time of the 1965 Denver NCTA exhibition, Edgar Kaiser and Leonard Reinsch met in Atlanta, Georgia, along with Earl Hickman from Kaiser and Dick Hickman (no kin), who was Cox Cablevision's chief

engineer, and other top personnel. A new organization called Kaiser-Cox emerged from the meeting. Earl Hickman was designated vice president for manufacturing and engineering. In March 1966, Bruce Merrill made him an offer he couldn't refuse, to be president of a new Ameco Engineering Company, starting at 50 percent more than he was making as head dog at Kaiser-Cox <Hickman 1992, 54-59>. Not long after that, Cox decided to get out of the manufacturing business, and the enterprise reverted to Kaiser CATV.

THETA-COM

About 1966, Irving Kahn, founder and president of TelePrompTer, established a company called Theta-Com, with his engineer and cofounder, Hubert "Hub" Schlafly as vice president. Theta-Com's primary objective was to develop and produce multichannel amplitude-modulated link (AML) microwave equipment for CATV. By 1972, Theta-Com acquired the Kaiser-Cox operation and became a full-service equipment supplier to the cable TV industry. After several years, Hughes Electronics took over from Theta-Com the manufacturing and marketing of AML equipment. About 1978, Texscan acquired the

manufacturing and marketing of distribution equipment from Theta-Com.

GTE SYLVANIA

About 1971, GTE entered the CATV supply business through its subsidiary, GTE Sylvania, Inc., at Seneca Falls, New York. O.D. Page and Dan Lieberman were key marketing and engineering personnel, with significant participation by Walter Wydro as engineering consultant, formerly chief CATV engineer at AEL. By 1979, the operation had moved to El Paso, Texas, as the CATV division of GTE Products. About 1984, Texscan acquired the entire GTE CATV Division.

TEXSCAN CORPORATION

Texscan was a small instrumentation company in Indianapolis, Indiana, founded in the 1960s by Carl Pehlke as president and Jim Luksch as vice president. About 1970, Texscan purchased the Jerrold instrument division to the great dismay of Ken Simons who had pioneered the development of measurements in CATV. The principal measurement and instrumentation techniques used in the

industry today were first developed by Simons. Larry Dolan was the principal measurements and instrumentation engineer at Texscan and later formed the Wavetek Corporation to specialize in cable TV instrumentation.

The acquisition of Theta-Com about 1978 startled the industry. Texscan had been a small, quiet company producing test equipment at prices that were particularly attractive to cable TV engineers. On the other hand, Theta-Com had become a significant competitor to Jerrold, SKL, Ameco, Scientific Atlanta, and others. Engineers accustomed to seeing Texscan in a modest booth at the trade show were amazed at the huge new Texscan booth dominating the show as effectively as Jerrold had in past years. Texscan's expanded economic base enabled it to make significant contributions in the precision and reliability of the equipment and techniques for measurements in cable TV.

The primary business of the expanded Texscan, however, was supplying distribution equipment to the cable TV industry. The Theta-Com lines were further developed and eventually supplanted with new designs. Within a brief period in the early 1980s, Texscan made numerous additional acquisitions, including the CATV

division of GTE Sylvania. These were intended to leapfrog development time and expense by taking advantage of research and development already accomplished. Another such acquisition was a small manufacturer specializing in television tuners, the critical component of the set-top converters Texscan planned to produce.

For various reasons, Texscan found it necessary to file Chapter 11 bankruptcy in the late 1980s. After several years of supervision, the corporation was reorganized, with William Lambert as president. Lambert was a co-op engineering student in 1959, working at Philco with Don Kirk. When Kirk and Dalck Feith formed K&F Microwave Company, Lambert went along with them. He became a Jerrold engineer when Kirk sold his interest in K&F to Jerrold in 1965. After several years in research and development engineering at Jerrold, Lambert moved to Canada in engineering sales. He had become president of Jerrold Canada when Texscan asked him to take over the reorganized company. Texscan has recently been acquired by the Antec Corporation. Carl Pehlke died shortly after the reorganization, and Jim Luksch has taken over the Blonder-Tongue organization.

ANACONDA ASTRO DATA

Early in 1965, Anaconda Wire and Cable Company developed a new type of coaxial cable for the independent telephone companies. The outer conductor of the new cable, marketed as Sealmatic, was a longitudinally wrapped aluminum ribbon with a bonded seam. Anaconda had been supplying Spencer Kennedy Laboratories' (SKL) amplifiers with the Bell System seal of approval, but planned to either develop their own line of RF distribution equipment or buy a company to do so. When they learned that SKL was privately owned, they quickly made an offer. Initially, Don Spencer and the board of SKL were very pleased and entered into serious negotiations. In the end, however, they decided not to sell.

Anaconda was quite disappointed. A month or so later, they invited Bob Brooks, SKL's chief systems engineer, to consider becoming chief engineer of communications for Anaconda. The CATV division was later transferred to Anaconda Astrodata and eventually to Anaconda Electronics. Anaconda CATV recruited several engineers from Ameco, including Gay Rogness, who became director of engineering; Bob Spann, who later took over the Gilbert Engineering connector business originated at Ameco; Arie Zimmerman, who later founded Phasecom to manufacture head end equipment; and Vic

Tarbutton, who later joined Century III. Brooks left in 1967 to preside over the demise of SKL's CATV activity, but Anaconda continued until about 1979 when a new company called Century III took over what was left of the Anaconda CATV operations <Brooks 1992>.

PHASECOM

Arie Zimmerman, Bert Rosenblum, and Lucius La Fleur established the Phasecom Corporation about 1971 to design and manufacture head end processors and modulators. Phasecom was 50 percent owned by Maclean-Hunter CATV Ltd., a subsidiary of the Canadian magazine publisher. Israel "Sruki" Switzer, a well-known and highly respected cable television engineering consultant, was chief engineer at Maclean-Hunter CATV.

In addition to providing new, much more compact packaging, the Phasecom head ends could be phase-locked to the harmonics of a 6-MHz comb to generate coherent harmonically related carriers (HRC) under a patent issued in 1975 to Switzer, Zimmerman, and others and assigned to Phasecom <Switzer et al. 1973>. The patent covered not only the HRC channeling plan but also an arrangement for adjusting the relative phases of the

multiplexed carriers to minimize or reduce their combined peak-to-peak amplitude (Switzer called it “phase phiddling”). By reducing peak excursions, it was claimed that intermodulation distortion could be minimized.

HRC was widely adopted and is still in service in some systems today. Although the phase-adjustment technique was demonstrated to be effective, it was rarely, if ever, installed for operational service. It has recently been shown in the laboratory, however, that reducing the peak excursions is also effective in avoiding clipping interference to digitally modulated transmissions.

CENTURY III

Century III, under Vic Tarbutton’s leadership, continued to produce many of the former Anaconda products in Vancouver, British Columbia, including a status monitoring system. Its most notable product was probably the feed-forward amplifier developed by Tarbutton when he was at Anaconda. It was installed in several systems in the United States. But feed-forward technology was not well understood in 1980, and experience with the Century III amplifier was not wholly satisfactory. In the late 1960s, SKL engineers began to

take a serious look at feed-forward design. Before reaching any conclusions, however, SKL terminated its entire CATV activity. Former SKL engineers George Ray and Bill O'Neil then formed Amplifier Design and Service (ADS) to carry on under a license from SKL. O'Neil developed a feed-forward amplifier as a drop-in replacement for the high-output SKL Model 262. It was used with good results in Cumberland, Maryland, but ADS was not in a position to produce it for the market. By 1983, interest was growing in feed-forward for extended reach and expanded channel capacity. C-COR, Jerrold, and others led the way, but Century III quietly dropped out about 1984.

VIKOA (VIKING)

Arthur Baum started the Regal Wire and Cable Company, probably in the early to mid 1940s, to produce zip-cord wire for the military. Legend has it that sometime later he found a machine in a junkyard for fabricating braided shield coaxial cable and added that to the product line of another company he had formed called Viking Cable Manufacturing Company, Hoboken, New Jersey. By the 1950s, he was producing RG-11/U and RG-59/U cables

to meet the growing CATV demand as well as a variety of military cables. Baum, referring to the willingness of the military to buy anything labeled “zip-cord” regardless of its quality, once said to the author, “Why should I provide a quality product when they will buy anything?” Unfortunately, Baum’s companies could never entirely overcome the perception that such an attitude continued to infuse its products and services.

Sometime in the late 1950s or early 1960s, the name was changed to Vkoa because of a conflicting prior claim to the Viking name. Donald Dworkin was hired from Blonder-Tongue as the first qualified engineering professional to help develop a line of electronic equipment for the CATV market. Dworkin subsequently became the head engineer for the New York Times cable TV franchises in New Jersey and later for Warner-Amex and Time-Warner. In the early 1960s, Arthur’s son, Robert, came into the management of the business and his older son, Ted, with an engineering education, became involved in the technical operations.

Vkoa began production of solid sheath aluminum cable in the conventional manner, with a draw bench capable of handling 2,500-foot lengths. Then Baum brought in a machine from France that was designed to

produce continuous lengths of seamless aluminum coaxial cable from bulk materials without prefabrication. It was a complex mechanism that they were never able to operate successfully over long enough periods to be profitable.

Vikoa developed a full line of broadband amplifiers, passive couplers and splitters, directional coupler taps, and even pressure taps. Vikoa sold head end processors and modulators manufactured by CAS and later by Scientific Atlanta. At its peak, Vikoa became a full line supplier to the cable TV industry and gained a significant market share with designs that were consistent with industry practice. However, quality control was not entirely adequate. Vikoa disappeared in the early 1980s.

ELECTRONIC INDUSTRIAL ENGINEERING, INC.

About 1971, Jack Thompson and Don Chandler brought Electronic Industrial Engineering, Inc. (EIE), into the development of equipment for cable television. Thompson had several patents on security for pay-TV and saw cable TV as a prospect for development. EIE actively promoted two-way cable technology and may have been the very first to alert the industry to serious problems with ingress and noise accumulation in the 5-30

MHz upstream transmission band. EIE encountered all of the problems due to loose connectors, cracked cable, leaky housings, common mode intermodulation, aggregate noise, and others, in what was described as a devastating experience.

RCA COMMUNITY TELEVISION SYSTEMS DIVISION

RCA had followed CATV developments at least since RCA Antennaplex equipment was installed by Martin Malarkey in Pottsville, Pennsylvania, and by Paul Merrill and Earl Hickman in Globe/Miami, Arizona. About 1973 or 1974, the RCA Laboratories at Princeton, New Jersey, set up a small CATV group composed of competent and experienced cable TV engineers and technicians enticed from Jerrold, Vikoa, and other cable equipment suppliers. After several months, the operation was shut down, and some of the staff found employment with General Electric in Lynchburg, Virginia, where GE proposed to commence manufacturing broadband equipment for CATV. At one of the NCTA shows, GE even displayed a photo of an amplifier with the General Electric logo overprinted on the incompletely masked but readily identifiable Kaiser-Cox logo. The suspected merger of Kaiser-Cox with GE was

probably never a serious prospect and did not occur.

Finally, about 1974, RCA acquired the EIE, Inc., organization and staff and committed significant resources to a new RCA Community Television Division, located in North Hollywood, California. RCA became an important competitor, with outstanding head end and broadband distribution equipment. By 1977, they moved to Van Nuys, California, and changed the name to RCA Cablevision. The operation was terminated about 1983.

CAS MANUFACTURING COMPANY, INC./TOCOM

John Campbell started CAS Manufacturing Company probably in the early 1950s. Like several other manufacturers of equipment, Campbell built equipment for his own system in Mineral Wells, Texas, and then offered it to others. By the late 1960s, CAS became a division of Avnet. The product line included head end signal processors and modulators as well as line equipment, taps, and other ancillary items. In 1972, the firm became independent under a new name, Tocom, representing "total communications." By 1980, Tocom offered addressability, a two-way remote alarm security system, and soon a two-way vehicular traffic control system. In

1984, Tocom was acquired by General Instrument (Jerrold) and, by 1990, the name Tocom was discontinued and the separate product line was dropped.

OAK COMMUNICATIONS, INC.

About 1969 or 1970, Oak Manufacturing Company, a division of the large industrial complex Oak Electro/Netics Corporation, began producing the Mandell-Brownstein patented dual heterodyne set-top interface, assigned to Amplivision Corporation, an International Telemeter subsidiary <Mandell and Brownstein 1967>. International Telemeter was primarily interested in developing subscription television as an outlet for Paramount's motion picture product. They invented many ingenious ways to restrict access by making the picture viewable only after proper payment and authorization and to collect the money from subscribers. Interest in wired television led naturally to developing distribution equipment.

Amplivision manufactured a broadband distributed gain amplifier with 12 6AK5 vacuum tubes. It so closely resembled the SKL chain amplifier, which was licensed under the Percival patent, that SKL's attorneys brought suit, and Amplivision had to discontinue the product. The

parent company, Paramount, became an early participant in the development of television with its experimental license for W6XYZ in Los Angeles. In 1947, W6XYZ went commercial as KTLA.

The Mandell converter produced by Oak Manufacturing Company was originally designed with the 12-channel mechanical turret VHF vacuum-tube tuner that was used almost universally in home TV sets at the time. However, it was soon transistorized with varactor (voltage-sensitive reactor) tuners capable of converting a growing number of additional channels to the typical output on channel 3 (60-66 MHz) or channel 4 (66-72 MHz). Programmable descrambling was added to provide security against unauthorized (i.e., unpaid) access to premium programming. For a few years, Oak set-top converters were virtually the only such devices generally available to the CATV industry. Its success inspired competition from companies such as Zenith and Pioneer not previously engaged in CATV equipment manufacture, as well as Jerrold, Magnavox, Scientific Atlanta, Texscan, Hamlin, and many others.

In 1978 or 1979, Oak added the Total Control scrambling encoder and addressable descrambling decoder for pay cable. At the same time, they developed

an encoding system suitable for over-the-air broadcast subscription television (STV) and commenced operation in Los Angeles of one of the first STV systems in the world. The STV development led Oak to become a leading provider of highly secure video transmission systems for terrestrial and satellite broadcasting as well as for cable TV.

The Oak broadband line amplifiers developed in the 1970s for cable TV distribution were not well accepted in the industry, and Oak's principal products were the converters, descramblers, and encryption products. Unable to surmount competition from Jerrold and other manufacturers producing and selling set-top converters with addressable descrambling, Oak abandoned its rights. Through a convoluted chain of acquisitions, TCI ended up with effective control of the Mandell patent and sponsored a patent infringement complaint against Jerrold. The case was settled out of court. Although Oak Communications continued to operate, it was no longer a factor in the cable television industry.

AMERICAN ELECTRONIC LABORATORIES, INC.

At the close of World War II, the American

Electronic Laboratories (AEL), at Lansdale, Pennsylvania, was established to design and manufacture high-power transmitters for AM and FM radio broadcasting. By the mid-1960s, they acquired the amplifier manufacturing group established by Tony Cerrache <Mezzalingua 1998, 55> and began the development and manufacture of distribution equipment for CATV. Dr. Leon Riebman was president of AEL and Walter Wydro was CATV chief engineer. Wydro later worked with Sylvania as a consultant. About 1971, a subsidiary firm called AEL, Inc., was formed to manufacture and market the CATV products, which were now transistorized. By 1978, however, the company had discontinued its CATV operations.

HOLT ENGINEERING

In the late 1940s, although the exact date is controversial, a group of entrepreneurs led by John Walsonavich (later changed to Walson) built a system for distributing television to homes in Mahanoy City, Pennsylvania. Luther Holt and Jack Warner, who may have been involved in that early system, subsequently established a company to build and market amplifiers and

other equipment. The firm was terminated sometime in the late 1960s.

CANADIAN SUPPLIERS

Cable television developed somewhat later in Canada than in the United States, since the first Canadian television broadcasting station did not begin operations until 1952. The business started with MATV systems, typically within range of U.S. TV stations near the Canadian border. By the mid-1950s, new Canadian firms were being established to manufacture and supply equipment for Canadian CATV operators as well as MATV and CATV operators in the United States. The following is a partial list of such companies:

- Cascade Electronics, Inc., Fred Welsh and Son
- Benco Television Associates, Philip Freen; sold to Blonder-Tongue in 1960; sold back in 1964
- Delta Electronics Ltd., G.A. Allard
- Delta Benco Cascade Ltd. (DBC); merger about 1973
- Electroline, Inc.
- Lindsay Specialty Products Ltd., John Thomas,

Lindsay, Ontario

- Triple Crown Electronics, Ltd., C.J. Evans

REDIFFUSION, LTD.

The British company Rediffusion Limited was formed in the late 1920s to provide wired distribution of radio programs received on the roof of multiple-dwelling buildings in London. The radio signals were demodulated and distributed to individual apartments as audio (not radio) signals. This was called relay service, without which clean radio reception was often difficult and uncertain.

The history of the development of the Rediffusion television relay system is described by Kenneth J. Easton in his book *Thirty Years in Cable TV: Reminiscences of a Pioneer* <Easton 1980>. Easton joined Rediffusion in 1947 as engineer-in-charge and played a substantial role in the development of the television relay service in Great Britain. It began in March 1949 at the London Clinic. Since only three audio programs were being distributed in the four-pair cable already in place, the TV signal was transmitted at 45 MHz IF on the vacant pair to be viewed on rental TV sets.

The London Clinic system was soon modified to use not quite video (NQV) frequencies, somewhat like Jerrold's Dubuque, Iowa, project. Signals were transmitted over balanced pair screened cables (called Qwist) to special cable-compatible rental receivers tuned to the NQV frequency, with a switch to select the proper pair. Television receivers (and other appliances) are more commonly rented in Great Britain than in the United States for various reasons, perhaps cultural as well as cost. Easton has this to say about the Rediffusion system that evolved, "This technique formed the original basis of the very considerable TV relay business operated by Rediffusion and other similar companies in Great Britain today [1980]....

The Rediffusion system could not economically accommodate the growing number of TV programs relayed by satellite. Rediffusion systems in many parts of the world have been abandoned in favor of coaxial and HFC networks. Rediffusion, Ltd. has been terminated.

REFERENCES AND ADDITIONAL READINGS

NOTE: Page numbers cited for the oral histories refer to documents on file at the National Cable Television Center

and Museum. These oral histories are also available via the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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Apparatus for Reducing Distortion in Multicarrier
Communication Systems. U.S. Patent No. 3,898,566,
August 5, 1975. Application filed February 1, 1973.

EPILOGUE

For Better or for Worse

CABLE TELEVISION IS LINKED TO TELEVISION ITSELF AS WITH AN UMBILICAL CORD. It shares the genes of television's greatness as well as its mediocrity. In an important speech in 1958 to the National Radio and Television Directors Association, Edward R. Murrow clearly foresaw both the promise and the dangers of television:

Unless we get off our fat surpluses and recognize that television in the main is being used to distract, delude, amuse and insulate us, then television and those who finance it, those who look at it and those who work at it may see a totally different picture—too late. ...The instrument can teach, it can illuminate; yes, and it can even inspire. But it can do so only to the extent that humans are determined to use it to those ends. Otherwise it is merely lights and wires in a box <Murrow 1987>.

Television has shrunk the world. War and famine, bigotry and hatred, earthquakes and hurricanes make

nightly appearances in our family rooms. Elections are decided even before the last polling places have closed. In 1967, Nicholas Johnson, then a member of the Federal Communications Commission (FCC), wrote,

[Television] shapes our minds and our morals, elects our candidates, and motivates the selection of commodities with which we surround ourselves. It tells us most of what we know about the world we live in (and decides what we are not going to know) <Johnson 1967>.

In 1968, reflecting Murrow's concerns, the U.S. Congress established the Corporation for Public Broadcasting (CPB). To a considerable degree, the CPB, through its offspring the Public Broadcasting System (PBS), has fulfilled the dreams of E.B. White in a letter to the FCC:

Noncommercial television should address itself to the ideal of excellence, not the idea of acceptability—which is what keeps commercial television from climbing the staircase. I think television should be the visual counterpart of the literary essay, should

arouse our dreams, satisfy our hunger for beauty, take us on journeys, enable us to participate in events, present great drama and music, explore the sea and the sky and the woods and the hills. It should be our Lyceum, our Chataqua, our Minsky's and our Camelot. It should restate and clarify the social dilemma and the political pickle. Once in a while it does and you get a quick glimpse of its potential <White 1967>.

Thanks to the venerable, if not quite sacrosanct, free speech amendment to our Constitution, the United States cannot merely by government decree significantly alter what former FCC Chairman Newton Minow once called a "vast wasteland." The protection afforded by this constitutional barrier against government intervention in program content encouraged radio broadcasting pioneers to seek financial support from advertising rather than governmental subsidy, as is the practice in Great Britain and most of the rest of the world. Ironically, both Commerce Secretary Herbert Hoover, originally responsible for managing the radio spectrum, and RCA's David Sarnoff, the dominant force behind the development of commercial broadcasting, objected to the use of radio for advertisements <Lyons 1966, 136>.

Hoover considered it “unthinkable”; Sarnoff and other radio pioneers thought it “unseemly” <Inglis 1990, 66>.

Eugene McDonald, president of the Zenith Radio Corporation, one of the “... shrewdest and boldest strategists in the radio business” <Lyons 1966, 275>, argued that direct subscriptions by viewers would be needed to support the enormous costs of television programming. Convinced that advertising revenues alone could not do the job, Zenith developed and patented the Phonevision™ scrambling system in 1947 <Hilliard and Keith 1992, 114, 134-135>. Several remarkably ingenious schemes devised to provide for conditional access to scrambled programs and fee collection were tested in Hartford, Connecticut, Los Angeles, and other markets. In 1968, after years of debate and investigation, the FCC authorized subscription television and established appropriate regulations. Ten years later, KWHY-TV in Los Angeles (channel 22) broadcast the first pay-per-view television with classic movies <Hilliard and Keith 1992, 224>.

However, broadcast subscription television was overtaken in the 1980s by the seductive appeal of “free TV” and the practical obstacles encountered in trying to detect and terminate unauthorized reception of programs

broadcast over the air to widely scattered locations, especially in remote areas and multiple-dwelling buildings. Thus, except for the government subsidy to CPB and the voluntary public contributions to PBS affiliates, commercial advertising emerged as virtually the sole revenue support for broadcast television.

Until the 1970s, wired television systems were limited almost entirely to distributing the signals of land-based television broadcasting stations. Elaborate antennas erected on a mountaintop or tall tower were literally community antenna television facilities, from which the popular acronym CATV arose. CATV was not only politically and legally prevented from altering the content of broadcast television programming but, until the 1980s, was also technically unable to offer significant alternatives.

This began to change after October 1, 1975 (Philippine time), when Home Box Office (HBO) used satellite transmission for the first time to relay the Ali-Frazier heavyweight prize fight from the Philippine Islands (the “Thrilla in Manila”) to CATV head ends in Florida and Mississippi. Using satellites instead of terrestrial microwave or videotape exchange, Cable TV is now able to offer 150 or more distinct program networks, many of

which are dedicated largely to movies and programming of interest to particular segments of the population, often referred to as niche programming. Premium programs, typically movies and special events, require payment of a surcharge either for viewing all programs on one or more specified channels for a month or for access to a single program designated as “pay-per-view.”

It is said that, “Maximization of the audience is the business of commercial television” <Goldin 1967, 232>. The views and preferences of advertisers are necessarily important considerations in planning broadcast television programming. For maximum results, advertisers want programs that are culturally and intellectually compatible with the greatest possible proportion of the general population. This is the least common denominator.

On the other hand, maximization of subscriber revenue is the business of cable TV. Thus, cable TV provides a variety of program choices, not only for mass audiences but also for diverse elite segments of the population. Of course, it also provides outstanding facilities for the convenient reception by subscribers, not only of the local TV broadcast programs but also of locally originated public, educational, and government (PEG) access programs not carried on over-the-air

broadcasts.

Many cable pioneers expected that subscriber fees rather than advertising revenue would provide financial support for the kinds of programming that appeal to small but loyal audiences. "Who pays the piper, calls the tune." In fact, paying subscribers do have greater access than "free-TV" broadcast viewers to a wide variety of programming throughout the day and night. Over-the-air commercial and public broadcasting schedules simply cannot accommodate the enormous selection of movie titles and special events continuously available on many cable channels with multiplex screens and repeat performances at staggered times. Classical music, drama, ballet, and other performing arts are presented from time to time on one or another of the cable networks and on PBS and the national broadcast networks. The public affairs programming provided on cable by C-SPAN includes excellent in-depth literary discussion as well as remarkably neutral and independent political coverage.

It is nonetheless distressing that advertising has begun to intrude in some, but not quite all, of the many fine cable TV programs, almost as grievously as on commercial broadcast TV programs. Moreover, splendid PBS programs are often debased by seemingly

interminable appeals for contributions, with an implicit slogan that might read: “Don’t be a square, Pay your share.” But even more disturbing, the increasing dominance of excessive violence, subtle and explicit sexual innuendo, vulgarity, and irresponsible behavior in so many of the movies and basic cable TV programs produced in recent years has been a disappointment to those who had hoped for something better.

The disappointments of the past must now give way to the hopes and aspirations of the future. Cable television is no longer simply CATV—community television. Poised to move boldly into the information age, the networks of coaxial cable, optical fiber, and electronic devices are already evolving beyond mere entertainment through the Internet. We do not know where these developments will lead, but the impact on society is likely to be as profound as that of television itself, for better or for worse.

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the Center's web site. However, there are no page numbers for the oral histories accessed via the Internet, and page numbers on printouts from the Center's web site may not correlate with the page numbers cited here.

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White, E.B. 1967. Letter to the FCC, quoted on p. 13 in

Public Television: A Program for Action. Carnegie Commission on Educational Television. New York: Bantam Books.

APPENDIX A

Oral History Interviews

FOLLOWING IS A LIST OF THE PIONEER ENGINEERS interviewed for the Technological Oral History Project of the National Cable Television Center and Museum.

Pioneer Engineer	Company Affiliation	Interviewer	Date of Interview
Best, Alex	Scientific Atlanta/Cox	Archer Taylor	Sept. 22, 1993
Blonder, Isaac	Blonder-Tongue	Archer Taylor	Jan. 31, 1993
Bridgett, Argyle	SKL	Archer Taylor	April 17/Aug. 26, 1992
Diambra, Henry M.	Entron	Archer Taylor	Sept. 15, 1993
Ecker, Leonard	Jerrold	Archer Taylor	Jan. 12, 1994
Hickman, J. Earl	Ameco/Kaiser	Archer Taylor	April 16-17, 1992
Jeffers, Mike	Jerrold	Archer Taylor	Jan. 12, 1994
Kirk, Donald, Jr.	Jerrold	Archer Taylor	March 19, 1992
Mezzalingua, Daniel	Craftsman/Magnavox	Archer Taylor	May 18/Nov. 5, 1998
Palmer, James R.	C-COR	Archer Taylor	Oct. 22, 1992
Ragone, Frank J.	Jerrold/Comcast	Archer Taylor	Jan. 18, 1999
Richey, Milford	Ameco	Archer Taylor	March 22, 1994
Shekel, Dr. Jakob	SKL/Jerrold	Mike Jeffers	Feb. 28 and Sept. 1992
Simons, Keneth A.	Jerrold	Archer Taylor	Feb. 18/March 9, 1992
Smith, Tom D.	Scientific Atlanta	Archer Taylor	Dec. 21 and 22, 1992
Switzer, Israel "Sruki"	Consultant	Archer Taylor	June 30, 1993
Tongue, Ben H.	Blonder-Tongue	L. Lockwood	Jan. 3, 1993

THE FOLLOWING ADDITIONAL ORAL HISTORY INTERVIEWS are also referenced in the text of this book.

Interviewee	Company Affiliation	Interviewer	Date of Interview
Brooks, Robert A.	SKL	E.S. Smith	March 26, 1992
Davidson, James Y.	Cable Pioneer	Jim Keller	—
Diambra, Henry M.	Entron	E.S. Smith	May 1989
Malarkey, Martin F.	Cable Pioneer	Kathleen B. Hom	Aug. 22, 1985
Parsons, L.E. "Ed"	Cable Pioneer	Richard Barton	June 19, 1986
Shapp, Milton J.	Jerrold	David L. Phillips	June 12, 1986
Tarlton, Robert J.	Cable Pioneer	Rasmussen	April 1993
Walson, John	Service Electric	Mary Phillips Mayor	August 1987

APPENDIX B

Historic Firsts

REFERENCE HAS BEEN MADE IN THIS VOLUME TO CONFLICTING CLAIMS OF PRIORITY IN THE USE OR DEVELOPMENT OF INNOVATIVE TECHNOLOGY.

Without attempting to arbitrate priority, the information on which various claims are based is summarized in the following tables. The validity of the claims depends, in large part, on their plausibility, supported in part by dated newspaper or trade press reports and various affidavits. Recognition as “one of the first” is due all of the many pioneers who initiated innovative ideas new to them at the time, whether actually first without qualification or not. There may well be others who rightly belong in that honored group but have not pressed their claims.

1. FIRST CATV CUSTOMER CONNECTED

Operator	Location	Estimated Start-up	Comment
Walson	Mahanoy City, Pennsylvania	Claims June 1948, with 727 active connections. Payment for service refused until the end of 1948.	Documentation lost in fire. Claim contradicted by 1950 start-up shown in early <i>Fact-books</i> . Jerrold boosters. Twin-lead, changed to coaxial.
Davidson	Tuckerman, Arkansas	<i>The Tuckerman Record</i> : Saturday, November 13, 1948. One residential connection, 17 outlets in his own store. One public service outlet.	Experimental broadcast of Ole Miss football game. WMC-TV begins regular service December 11, 1948. Coaxial cable. Additional connections later, in Batesville.
Parsons	Astoria, Oregon	His apartment connected November 25, 1948. First paid documented customer by January 1949.	KRSC-TV begins November 25. Twin-lead, changed to coaxial cable. No additional connections until later.
Tarlton	Lansford, Pennsylvania	Connections begin week before Christmas, December 1950.	Shapp visit on day before Thanksgiving, 1950. Coaxial cable. Jerrold. Continuous extension to new customers.
Malarkey	Pottsville, Pennsylvania	Connections begin early in January 1951.	Two weeks after Tarlton. Coaxial cable. RCA.

II. FIRST USE OF SOLID SHEATH ALUMINUM CABLE

Operator	Location	Date
Diambra (Entron)	South Williamsport, Pennsylvania	1953
Richey (Ameco)	Page, Arizona	1959
Barco (operator)	Meadville, Pennsylvania	1962

III. FIRST FIVE-CHANNEL SYSTEM WITH ADJACENT CHANNELS

Operator	Location	Date (Comments)
Diambra/Ecker	South Williamsport, Pennsylvania	1954. Chain amplifier.
Nicholson	(Not stated)	See Simons, chapter 4.
Walsonavich and Jerrold	Mahanoy City, Pennsylvania	November 14, 1953, report in <i>NCTA News Bulletin</i> . Single-channel amplifier.

IV. CABLE POWERING

Operator	Location	Date (Comments)
Parsons	Aberdeen, Washington	1952; 220 Vac
Palmer (Centre Video)	State College, Pennsylvania	1953; 30 Vac
Hickman (Ameco)	Globe-Miami, Arizona	1953; 1,200 Vac/K-14
Diambra	Nacogdoches, Texas	1959-1960; 60 Vac

V. PRESSURE TAPS

Inventor	Comments
Diambra/Edlen (Entron)	Patent filed February 20, 1953; granted November 9, 1954.
Kirk (Jerrold)	Claims invented by Kirk and Edlen at Jerrold, prior to 1953. Infringement suit denied. Misuse of patent cited against Jerrold in 1960 anti-trust action.

APPENDIX C

Triple Beat

THE TRIPLE BEAT¹ IS THE DOMINANT PRODUCT OF THE THIRD-ORDER TERM (i.e., cubed or power of three) in the power series analysis of any three carriers in a multi-carrier system.

The power series equation, in its basic format, is:

$$e_{\text{out}} = k_1 e_{\text{in}} + k_2 e_{\text{in}}^2 + k_3 e_{\text{in}}^3 + \dots$$

where: $e_{\text{in}} = A \cos 2\pi a t + B \cos 2\pi b t + C \cos 2\pi c t + \dots$

The complex trigonometric manipulations represented by the power series result in a set of cosine waves with frequency $a \pm b \pm c$. This is defined as the triple beat.

For example: Consider visual carrier assignments for channels 7, 8, and 9 at 175.25, 181.25, and 187.25 MHz, respectively. As a consequence of nonlinear distortion, beat frequencies will be generated equal to all possible sums and differences of these three carrier frequencies. The particular beat resulting from subtracting the channel 8 carrier from the sum of the channels 7 and 9 carriers is one of the possible triple beats and is nominally identical

with the channel 8 carrier (viz. $175.25 + 187.25 - 181.25 = 181.25$ MHz).

Federal Communications Commission (FCC) rules require cable TV modulators to be offset by ± 0.0125 MHz in the aviation communication bands and ± 0.025 MHz in the air navigation bands, with tolerance of $(\pm 0.005$ MHz. Thus, the composite group of triple beats is clustered mostly within a band about 0.035 MHz centered on a visual carrier. The combined power of the beats in each group, relative to the desired signal carrier power level, is measured with a spectrum analyzer and designated the composite triple beat, or CTB ratio. The total number of triple beats in high-capacity systems is quite large, approximately $3N^2/8$, where N is the number of frequency division multiplexed analog channels. For 750-MHz systems, there would be more than 4,500 triple beats. The combined power of 4,500 beats may be nearly 36 dB greater than that of each individual beat.

Glossary

Addressability—The capability to transmit descrambling and other commands from the head end, with a uniquely coded address enabling reception only at the terminal with matching address. Addressable terminals are typically included in set-top converters, or in some cases, in customer taps.

Analog—The amplitude of the signal wave is proportional to the instantaneous brightness of the continuously scanned scene, or to the instantaneous air pressure of the sound wave.

Antenna Distribution Outlet (ADO)—An electronic device used to couple multiple television sets (or distribution lines) to the main transmission line, with proper impedance match and without loss of signal strength.

Attenuator (Fixed or Variable)—A device designed to reduce the power level of an RF signal wave by a fixed or variable ratio, while maintaining constant impedance.

Automatic Gain Control (AGC)—A circuit designed to

maintain constant output at a designated frequency.

Automatic Level Control (ALC)—A circuit designed to maintain constant the *average* power output of a group of multiplexed channels.

Automatic Slope and Gain Control (ASGC)—A circuit designed to adjust the overall slope of an amplifier to compensate automatically for thermal and other variations in loss in the preceding cable, while maintaining constant output at a particular frequency.

Autotransformer—A transformer with a single tapped winding that provides no dc isolation between primary and secondary.

Balun Transformer—A “balance-to-unbalance” transformer for connecting the antenna terminal on older TV sets to the coaxial distribution network. A 300-ohm winding, grounded at the center (balanced), is coupled to a 75-ohm winding, grounded at one end (unbalanced).

Baseband—The basic video or audio frequency band occupied by the output signal from a camera or microphone; typically 0–4 MHz for pictures, and 0–

15 or 0–20 kHz for sound.

Beat—Unwanted signal at a frequency equal to the difference (or sum) resulting from the mixing of two or more signals.

Beta (β)—A transistor characteristic related to gain.

Bipolar Transistor—A solid-state device with two junctions in close proximity, whose operation depends on both *n*- and *p*-carriers. Characterized by low impedance, and generally lower gain-bandwidth than the field effect device.

Brake—A mechanical device for bending sheet metal.

Broadband—In cable television, the term is applied to amplifiers and other devices designed to transmit a wide enough frequency band to enable transmission of a multitude of TV channels. In the early days of television, before cable began, the term was applied to amplifiers and devices capable of transmitting the bandwidth occupied by a single TV channel. In modern telecommunications, the term varies widely according to specific applications.

Cascade—A group of amplifiers connected in series (i.e., in tandem). The maximum cascade, or cascade length,

is the total number of amplifiers through which the signal is transmitted to the most remote location in the network.

Cascode Amplifier—A special arrangement of two three-element (triode) vacuum tubes, characterized by low noise figure.

Cathode Follower—A circuit in which the output load is connected in the cathode circuit of a vacuum tube, and the input is applied between the grid and the other end of the cathode load. The circuit is used to isolate the input from the output.

Cavity Filter—A resonant circuit comprising a hollow metal enclosure whose frequency is determined by its dimensions.

Chip Amplifier—An integrated circuit, fabricated on a small, thin slice of crystal, usually silicon.

Cochannel Interference—Impairment of the desired channel due to signals received from another station on the same channel.

Complementary Filters—Also called duplex filters. A matched pair of high-pass and low-pass filters in tandem, designed to separate downstream and

upstream signals on the same transmission line. The filter cutoff frequencies are designed to fall in a guard band between the two passbands.

Composite Triple Beat (CTB)—In a frequency division multiplexed network, the combined power of the intermodulation products of all combinations of three carrier frequencies, falling within a specified TV channel, referenced to the desired carrier level in that channel.

Compressed Digital Video—Digital video information processed to reduce the bandwidth required for transmission, by removing redundant information and by increasing modulation efficiency (i.e., bits per Hz).

Converter—A device for changing the frequency of a television channel by means of heterodyne circuits. (See Set-Top Converter.)

Damping—Flattening the peak response of a resonant circuit and increasing its bandwidth by loading it down with increased intrinsic or coupled losses.

Decibel (dB)—The logarithmic ratio between two power levels, one of which may be a predetermined

reference power level. Mathematically, $\text{dB} = 10 \log_{10} (P_1/P_2)$.

Definition—Resolution. Distinctness or clarity of picture. The number of resolvable horizontal or vertical lines in a television display. As in high definition television (HDTV).

Delay Line—A length of transmission line or equivalent circuit, calibrated to delay an RF signal wave by a predetermined time interval.

Demodulator—A television receiver designed to convert the visual and aural modulated RF carriers to baseband video and audio (or to the 4.5 MHz aural subcarrier).

Dielectric—The insulating material separating the conductors in transmission lines and capacitors.

Digital—The amplitude of the instantaneous brightness of the scanned scene, or the instantaneous air pressure of a sound wave, is sampled at discrete intervals, and the measured value at each sample is represented as a binary number, comprised of zeroes and ones. In cable TV networks, the stream of zeroes and ones is modulated on an RF carrier or light wave

for transmission.

Diplex Filters—See [Complementary Filters](#).

Directional Coupler/Tap—A passive RF power divider with minimum loss between the input and output ports (through loss), specified loss between the input and tap ports (coupling loss), and high loss between the output and tap port (isolation). The directional tap has an additional power divider connecting the coupler to 2, 3, 4, or 8 customer tap ports.

Distributed Gain Amplifier—An amplifier in which the signal is applied to the inputs of a group of amplifying devices (vacuum tubes or transistors) in a delayed sequence. The output of each device is added to that of the next device in the same delayed sequence. The output of the system is the sum of the individual outputs. (See [chapter 3](#).)

Double-Tuned—A pair of resonant circuits that are so tightly coupled (technically, over-coupled) as to exhibit two frequency response peaks instead of one.

Drop Lines—See [Service Drops](#).

Dual Heterodyne—A heterodyne process in which the input is down-converted to an intermediate frequency (IF) for processing and back up, either to the input channel or to a different one.

Electrostatic Scanning—In electrostatic scanning, the electron beam in the picture tube is caused to move across the screen by varying the voltage between pairs of metal plates. In most television receivers, the electron beam is moved across the screen electromagnetically by varying the current in strategically placed coils surrounding the neck of the picture tube.

Envelope Delay—The time of propagation of the modulation on a carrier wave between two points in the network. Envelope delay distortion, where the time is not the same at all frequencies, is caused primarily by phase shifts associated with filters. Envelope delay distortion in television may result in color misregistration (the “comic book” effect), or “ghosts.”

f_t —Gain–bandwidth characteristic of a transistor, indicating the highest frequency at which the transistor gain is unity (0 dB).

Feed-Forward—A sort of bootstrap arrangement by which the distortion generated in an amplifier may be subtracted from the amplified but distorted output to produce a theoretically undistorted amplified replica of the input signal. While in reality the result is not so perfect, the improvement is significant (see [chapter 3](#)).

Feeder Lines—Coaxial lines connecting the subscriber taps to the trunk.

Feeder-Maker—An RF power divider (splitter) used to couple a trunk amplifier output to four feeder lines.

Ferrite—An iron compound frequently used in the construction of magnetic core components, such as transformers and inductors.

Field Effect Transistor (FET)—A transistor in which conduction is controlled by an electric field applied between certain electrodes within the device, characterized by high input impedance and high gain-bandwidth.

Field Sequential—An obsolete method for color television, in which three separate fields (i.e., complete pictures) carrying either red, green, or blue picture

information, are transmitted in rapid sequence to be viewed through colored filters in a disk rotating synchronously in front of the television screen.

Field Strength Meter (FSM)—A selective voltmeter designed to measure the voltage of an RF signal wave across a 75-ohm resistive load. As used in cable TV, it is more properly called a Signal Level Meter (SLM), since it is not equipped with a calibrated antenna arranged to convert field strength to signal level.

Frequency Division Multiplex (FDM)—A method for combining multiple channels in a transmission system by assigning a separate frequency to each channel.

G Line—Surface wave transmission line, named after its inventor, George Goubau.

Geosynchronous Satellite—A satellite placed in orbit at a distance such that it appears to be stationary, at about 22,350 miles above the Earth's equator. It is used to relay television and other signals to widely separate receiving points.

GHz—Gigahertz: one billion cycles per second.

Ham Radio—The term used informally for amateur radio. Also ham operators; ham bands.

Heterodyne—A process for converting one TV channel to a different one. The input channel is combined with a local oscillator in a device called a mixer. The result is a pair of channels, each of which carries the modulation, but at frequencies equal to the sum and difference between the input frequency and the local oscillator. One of the pair is selected by means of a bandpass filter.

Heterodyne Signal Processor—A television receiver that converts one TV channel to an intermediate frequency (IF) band, and back up, either to a new channel or to the input channel. (See [Dual Heterodyne](#).)

Hum and Hum Modulation—Undesired modulation of the visual carrier by power system-related frequencies, primarily 60 and 120 Hz (cycles per second).

Hybrid Fiber Coaxial (HFC)—Cable television architecture in which signals are transmitted on light waves in tiny optical glass fibers to distribution hubs, called nodes, where they are converted to radio frequencies (RF) for transmission on coaxial cable to

individual customers.

Hybrid Gain Block—An integrated circuit (IC) amplifier with a separate high-power transistor packaged with the chip, but not integrated in the silicon crystal itself.

Iconoscope—A camera tube in which an electron beam scans the photosensitive surface on which the image is focused, discharging the photomosaic image to form the video signal current.

Image Dissector—A camera tube in which an electronic counterpart of the optical image is scanned across a photosensitive aperture where electrons are collected to form the video signal current.

Impedance Match—Impedance is the ratio between signal voltage and current. The impedance of a transmission line (e.g., coaxial) is the same at all frequencies when the load is properly matched (i.e., effectively equal) to the characteristic line impedance. Transfer of power from a transmission line or other device to a load is maximum when the impedances are properly matched.

Ingress—See second definition of [Leakage](#).

Integrated Circuit (IC)—Also called chip.

Inter-Carrier—The common practice in television receiver design, in which the received aural carrier is treated as a sub-carrier at the intermediate frequency 4.5 MHz below the visual carrier; i.e., the frequency difference between the visual and aural carriers.

Intermodulation—The generation of a very large number of spurious products due to interaction between all of the carriers and sidebands transmitted in nonlinear systems.

Interstage Coupling—The circuits between the input pre-amplifier and the power output amplifier stages, for manual and automatic gain control, equalization, and other purposes.

Klystron—A vacuum-tube oscillator with cavity resonator, modulated by applying a signal to an electrode called a repeller.

L3 Transmission Network—The Bell System designation for a frequency division multiplex (FDM) system for transmitting analog voice channels on coaxial cable.

Ladder Wire—A transmission line comprising a pair of parallel wires separated by insulating strips,

generally an inch or two in length, spaced several inches apart. A form of open wire line.

Leakage—(1) Signal radiation from imperfectly shielded coaxial cable and associated devices. (2) Intrusion (ingress), through imperfect shielding, into the desired signal transmission path by unwanted, external fields.

Line Extender—A feeder line amplifier.

Log-Periodic Antenna—A directional antenna in which the size and spacing of the elements increase logarithmically from one end of the antenna to the other.

Low-Sub Band—The frequency band, generally from about 5 MHz and up, used for upstream transmission (toward the headend). Jerrold designated channels T-7 through T-13 in the frequency band 5.75 MHz to 47.75 MHz.

MATV—Master antenna television system, serving multiple dwellings.

m-Derived Filter—Filter derived from a formula in which m is a design constant related to the sharpness of cutoff.

Messenger Strand—A steel cable attached to utility poles, to which coaxial cables or optical fibers may be lashed for support.

MHz—Megahertz: one million cycles per second.

Midband—Frequencies in the band 108–174 MHz, not allocated by FCC for TV broadcasting.

MMDS—Multichannel Multipoint Distribution Service (known informally as Wireless Cable).

Modulator—A very low-powered television transmitter, operating at tens of milliwatts (1/1,000th of a watt), compared with television broadcasting transmitters at tens of kilowatts (1,000 watts).

Multiplexed—Combined for transmission on a single transmission line.

Multitap—Directional tap.

Mutual Conductance/ μ (μ)—A characteristic of vacuum tubes, related to gain.

***n* and *p* Carriers**—*n*: Negatively charged electrons in a semi-conductor crystal “doped” with a certain kind of impurity that are free to contribute to current flow, *p*: Fictitious particles with positive charge, called

holes, in a semi-conductor “doped” with a different impurity, that are also free to contribute to current flow.

Negative Feedback—The process by which part of the signal in the output of an amplifier reacts on the input signal in a manner that reduces amplification while significantly improving distortion characteristics.

Negative Trap—A sharp notch filter designed to delete the visual carrier of a premium cable TV channel to prevent reception by unauthorized customers.

Neutralization—A method for nullifying the voltage feedback from the output to the input of a vacuum-tube (or solid state) amplifier in order to prevent oscillation.

Noise Figure—Noise is an undesired signal, most commonly observed as “snow” in cable TV, due primarily to random molecular movements. Noise figure is a measure of the proportion of such random noise added by the equipment through which signals are transmitted.

Open Wire Line—Any transmission line composed of one

or more parallel wires separated by insulators in a specified configuration, with no overall conductive shield.

Phase Lock—A system for maintaining RF carrier waves, generated by diverse means, at precisely identical frequency and phase.

PIN Diode—A solid-state diode in which an intrinsic layer (lightly doped) is sandwiched between heavily doped p and n layers. Used as detector in AGC circuits, and for fast switching.

Positive Trap—A sharp notch filter to remove a pre-inserted jamming signal. Called positive because it is required only for paying customers.

Pressure Tap—A tap that can be applied without severing the feeder cable.

Push–Pull Amplifier—An amplifier in which there are two identical signal branches connected so as to operate in phase opposition in order to reduce or eliminate second order distortion (see [chapter 3](#)).

Q—The ratio of reactance to resistance in a coil at a specified radio frequency. The reciprocal of power factor. When the coil is part of a resonant circuit,

maximum Q is at, or near, the resonant frequency. The higher the Q , the narrower (or sharper) the resonant response curve. Low Q means more resistance in the circuit, relative to the reactance, representing greater power loss.

Repeater—An amplifier station required to restore signal power reduced due to attenuation in the cable or other transmission media.

Return Loss—The reflection coefficient, equal to the ratio between input power and reflected power, expressed in decibels, equal to $20 \log$ VSWR (voltage standing wave ratio).

RF—Radio frequency. Frequencies in the electromagnetic spectrum, generally above the highest audio frequencies and below “far-far infrared” light, or roughly from about 60 kHz (0.06 MHz) to 300 GHz.

RG-59/U and RG-11/U—The Joint Army Navy (JAN) designation for 75-ohm flexible coaxial RF cables once used by CATV. Similar cables currently in use for cable TV do not comply with JAN specifications, although often inaccurately identified by the JAN designation of comparable size.

Rhombic Antenna—A large, high-gain directive antenna used in CATV for receiving weak television signals. Four towers or telephone poles are set at the corners of a rhombus, or diamond pattern, 100 to 200 feet on a side, with wires strung on the poles. The long diagonal of the rhombus points toward the transmitter.

RMS—Root mean square. Average power in the radiated field strength of an antenna, or an alternating current. The square root of the average square of voltage (or field strength).

SAW Filter—See [Surface Acoustic Wave Filter](#).

Scanning—The process of sequentially sweeping a narrow beam of electrons, horizontally and vertically, across the phosphor coating on the face of the tube to form a picture on the screen.

Schottky Mixer—A solid-state diode (two-terminal) rectifier, used as a highly efficient heterodyne mixer, especially at microwave frequencies.

Service Drops—Small diameter, flexible coaxial cables connecting customer premises equipment to the taps on feeder lines.

Servo Systems—An automatic arrangement whereby a device is adjusted to a designated position according to feedback information as to its actual position.

Shift Register—Solid-state device equivalent to a multipoint rotary switch.

Sidebands—The band of frequencies, associated with a modulated carrier, containing the picture, sound, or other signal information.

Signal Level Meter (SLM)—See [Field Strength Meter](#).

Sine-Squared Test Signal (2T)—A narrow video pulse (0.25 microsecond duration at half amplitude), sensitive to phase error and envelope delay distortion.

Single-Ended Amplifier—An amplifier with a single input branch, unlike the push-pull amplifier. Single-ended amplifiers are subject to second order distortion.

Single-Tuned—The normal response of resonant circuits, with minimal loss, when lightly coupled to a load.

Skip Television Reception—Reception of sky-wave signals that “skip” beyond the normal ground-wave range, by reflections from ionized gases in the

ionosphere (a layer of the earth's atmosphere).

Sleeved Connectors—Coaxial cable connectors that are provided with a steel sleeve inserted inside the aluminum sheath to make sure that the outer clamping ring will provide a secure grip, unlikely to loosen over time.

Slope—The decibel difference in gain (or loss) at the frequency band edges.

SMATV—Satellite master antenna television.

S-Meter—A device commonly found on amateur radio receivers for measuring the current in the automatic gain control (AGC) circuit as a relative indicator of received signal strength.

Stagger-Tuned—Resonant circuits in the amplifier are tuned to slightly different frequencies—staggered—so as to spread the gain over a wider bandwidth.

Store and Forward—A method for impulse pay-per-view (IPPV) in which billing information is stored at the customer premises for later recovery by automatic telephone dialing or return transmission on the cable TV network.

Stud Transistor—A type of transistor in which a threaded

mounting bolt is electrically part of the transistor, arranged to conduct excess heat away.

Surface Acoustic Wave (SAW) Filter—A solid-state device configured as an RF bandpass filter with superior phase characteristics. The surface acoustic wave is a displacement wave propagated, at frequencies up to several GHz, along the surface of a lithium niobate crystal.

Sweep Generator—A signal generator whose frequency is varied in a predetermined manner for the purpose of determining the transmission response of an electronic device or system over a designated bandwidth.

Synchro System—An arrangement such that the instantaneous angular positions of two or more rotating devices are always precisely the same, whether stationary or rotating.

Synchronizing Interval—The time interval before the start of scanning lines (horizontal), or before the start of separate pictures (vertical), during which the picture screen is blanked out and scanning is synchronized to the source.

Synchronous (or Product) Demodulation—A method for separating the modulation wave from the carrier by means analogous to heterodyne, except that the local oscillator frequency is precisely phase-locked to the received carrier frequency. The difference between the visual carrier frequency and the sideband frequencies is, therefore, precisely equal to the modulation frequencies.

Thermal Compensation—A system of temperature-sensitive components designed so that its slope varies inversely to the effect of temperature on coaxial cable attenuation.

Thermistor—A solid-state device whose resistance is dependent on temperature.

Transfer Characteristic Linearity—The precision with which the output signal power of an RF amplifier varies in direct proportion to corresponding changes in the input signal power.

Translator—A low-power television transmitter licensed for the sole purpose of retransmitting the signal received over-the-air from a designated television broadcasting station.

Trunk—The main coaxial transmission lines between the head end (or optical node) and distribution centers. In HFC networks, the optical fiber transmission lines between the head end and optical nodes may be called super trunks. As a general rule, customers are not connected directly to trunk lines.

Tunnel Diode—A solid-state diode with heavy doping on both sides of the barrier interface, characterized by negative resistance (current decreases with voltage increases).

Twin-Lead—A transmission line comprising a pair of parallel wires, mounted at the edges of a plastic ribbon of uniform width, usually about one-half inch. A form of open wire line.

UHF (Ultra High Frequency)—The portion of the electromagnetic spectrum between 300 MHz and 3,000 MHz (3 GHz).

Vestigial Sideband (VSB)—The transmitted portion of the lower television sideband that has been partially suppressed by a filter with gradual cutoff in the neighborhood of the carrier frequency.

VHF (Very High Frequency)—The portion of the

electromagnetic spectrum between 30 MHz and 300 MHz.

Vidicon—A TV camera tube in which the electrical image is based on photoconduction rather than photoemission.

VSB/AM—Vestigial sideband, amplitude modulation, with most of the lower sideband suppressed. VSB/AM is the standard for analog transmission of the visual television carrier.

Yagi Antenna—A directional antenna with one or two driven half-wavelength dipoles parasitically coupled to a reflector dipole (in back) and one or more director dipoles (in front) mounted in a single plane.

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- Jones, Glenn R. 1994. *Cable Television and Information Infrastructure Dictionary*. 4th ed. Englewood, Colo.: Jones Interactive, Inc.

Notes

CHAPTER 2

1. Parsons 1986; Phillips 1972; Gibbs 1950.

2. Davidson 1998a, 1998b.

3. Davidson claims the first connection was in October, but it is unlikely that the football game was on October 13, 1948, a Wednesday, as sometimes stated.

4. Phillips 1972, Tarlton 1993.

5. Malarkey 1985.

6. John Walson changed his name from Walsonavitch in the 1960s.

7. Malarkey 1985.

CHAPTER 4

1. Shapp 1986.

2. Kirk 1992.

3. Tarlton 1993.

4. Information regarding the Bartlesville project was provided by E. Stratford Smith, who was legal counsel to Henry Griffing.

5. Kirk 1992.

6. Arbeiter 1992; Simons 1986b; Berlin 1986.

7. Simons 1992.

8. Jeffers 1994.

9. Ragone 1999.

10. Ecker 1994.

11. Kirk 1992; Berlin 1986.

CHAPTER 5

1. Tarlton 1993.

2. For additional information, see [chapter 6](#).

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1. Diambra 1993; Diambra 1989.

2. Diambra 1989.

CHAPTER 7

1. Hickman 1992.

2. Richey 1994.

CHAPTER 8

1. Bridgett 1992.

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3. Brooks 1992.

4. Shekel 1992.

5. Brooks 1992.

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1. Smith 1992.

2. Best 1993.

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1. Palmer 1992.

2. Mundy 1991.

CHAPTER 11

1. Blonder 1993b.

2. Tongue 1993.

CHAPTER 12

1. Huston 1997; Mezzalingua 1998.

2. Mezzalingua 1998.

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1. Simons, K.A. 1970. "The Decibel Relationships Between Amplifier Distortion Products." *Proc. IEEE*, vol. 58, no. 7: 1071-86.

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