

TELEVISION CAPTIONING FOR THE DEAF

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I. INTRODUCTION AND BACKGROUND

At the end of 1971 although there were in the United States and Canada over 100 million television receivers in use, the hearing-impaired community had been largely deprived of the benefits of television programming. With the exception of some sports events, the sound portion of the program carries a significant part of the intelligence so that without it the program cannot be enjoyed. While the hearing-impaired can be served to a limited extent by the addition of "open captions" to programs, (sub-titles seen on all receivers), viewers with normal hearing find open captions distracting and therefore it is not a general solution to the problem.

It is estimated that there are approximately 500,000 totally deaf individuals and as many as 1.9 million in the U.S. and Canada who are unable to understand spoken language. Additionally there are perhaps 12 million people with various degrees of hearing impairment who could benefit from a captioned TV program. It is perhaps chastening to us as engineers that in the more than 1400 pages of the 1962 50th Anniversary issue of the Proceedings of the Institute of Radio Engineers (one of the predecessor component organizations of the IEEE), no mention is made of the problems of the hearing-impaired or a suggestion that the electronics and communications engineer might be able to produce a solution for these problems. It is an encouraging comment on the progress in our attitudes toward the handicapped that this is no longer the case.

In 1970, the year this story starts, television broadcasters could provide programming understandable to the hearing-impaired either by "signing", that is by means of a sign language interpreter shown on camera, usually in an oval insert in the corner of the picture, or by adding open captions.

Signing is unsatisfactory because it obscures part of the screen action and distracts the hearing audience, while for the hearing-impaired the image devoted to the signing individual is usually too small to be satisfactorily interpreted. Additionally, a significant number of the hearing-impaired are lip-readers for whom sign language is of no value. As mentioned earlier, the alternative (open caption) displays on the screens of all TV viewers and proves annoying to people with normal hearing. What was required was a means for providing "closed" captions, that is captions transmitted by the broadcaster which appear only on the screens of specially equipped receivers without interfering with conventional TV receivers.

In 1971 the National Bureau of Standards proposed a nation-wide time and frequency standards transmission system using data signals time-multiplexed with the composite video signal in the television vertical blanking interval (VBI). The original purpose of the VBI was to send a video signal level which blanks (cuts off) the receiver picture tube electron beam during the interval

in the scanning process when the beam is returned from the bottom to the top of the screen. (If it were not blanked the returning beam would "write" interfering white lines across the TV image.) Since the VBI allowed a comfortable margin for this blanking time, it became possible to place other signals there without interfering with home receiver performance if they were timed late enough in the VBI to occur after the electron beam had completed retrace. Thus vertical interval test signals (VITS) had been added to enable transmission and broadcast facility performance measurements to be carried concurrently with program transmission. Another use for the VBI had been suggested and tested in 1967 by RCA in which a facsimile system using an analog signal was transmitted during the VBI.

Broadcasters believed that the time delays used in synchronizing a nation-wide television network would compromise the integrity of the NBS-proposed precise time and frequency standard, however, the American Broadcasting Company (ABC) suggested that the system could be used to provide a closed captioning service. In order to test the concept an episode of the ABC program "Mod Squad" was sub-titled and broadcast in December 1971 from New York over the ABC network using NBS equipment. It was shown on specially equipped receivers to an audience of educators attending the National Conference on Closed Captioned Television for the Hearing Impaired at the University of Tennessee in Knoxville. The demonstration was repeated again at Gallaudet College in Washington, D.C. in February, 1972. Both of these demonstrations were received with great enthusiasm as well as pleas from the hearing-impaired community that the work be carried forward to fully operational service. An engineering subcommittee of the National Association of Broadcasters with representation from all the major broadcasters was asked to study and report on the technical and economic feasibility of closed captioning, and at the end of 1972 this subcommittee recommended that engineering development and tests of closed captioning should be continued.

Another technical solution for the transmission of closed captions was proposed in 1972 by Hazeltine Research, Inc. HRI proposed a digitally modulated sub-carrier at 2.7 MHz which was band-shared with the video signal in a fashion similar to the color sub-carrier in the NTSC system. Because the spectral energy content of the NTSC television video signal is quite low around 2.7 MHz, a data-modulated sub-carrier level inserted here can be small enough to be essentially invisible on the TV screen but large enough to be readily decoded. Both the NBS and HRI proposals embodied the then novel system approach of multiplexing digital data onto the standard TV signal and combining it with a memory store and character generator at the TV receiver to add text to the TV picture. Receivers without

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the digital signal decoder, e.g., conventional receivers, would be unaffected.

SYSTEM TESTS

Acting on the recommendation of the NAB subcommittee, the Public Broadcasting Service (PBS) then proposed to formally study, develop and test systems for closed captioning for the hearing-impaired. Funding was obtained from the Bureau of Education for the Handicapped of the Department of Health, Education and Welfare (now the Department of Education). Under this program PBS not only developed the technical system and equipment but also techniques for translations of the audio content into suitable captions. These translations must take into account the special language needs of the hearing-impaired. Operating under a Special Temporary Authority from the FCC, PBS started an experimental service of closed captioned broadcasts over the public television network with prototype NBS and HRI decoders. At 12 selected test site locations operated cooperatively by PBS, local public TV stations and schools for the deaf all aspects of closed captioning including character size requirements, program content interest to the hearing-impaired, and signal reception problems were studied. An early fruit of the PBS work was to shift the data signal from Line 1 as originally proposed by NBS to Line 21 which eliminated the problem of interlace disturbance noted in some receivers and which also provided greater compatibility with existing television standards.

Field trials of the revised NBS VBI system and prototypes of the HRI sub-carrier system were conducted during 1974 and 1975. Although the HRI system proved to be very rugged particularly under multipath conditions where the VBI system may be error-prone, some concerns were expressed in the NAB Engineering subcommittee that sub-carrier visibility considerations might limit future receiver developments. These concerns tipped the scales in favor of a VBI data format.

FCC RULEMAKING

After completion of these field tests, and the analysis by Gallaudet College of the viewer reactions at the 12 test sites, PBS filed a Petition for Rulemaking with the FCC in November 1975 to permit using Line 21 for closed captioning in a modified NBS format. The FCC acting with unprecedented speed adopted a Report and Order on December 8, 1976 granting approval to this system. The technical details of the system will not be reviewed here but the considerations which went into the selection of the recommended standard include the need for performance reliability in four situations: (1) in the recording and distribution system normally used in a television plant, (2) in urban areas where multipath causes ghosting and where UHF signals particularly may have coverage problems, (3) in fringe areas or other situations where noisy signals are received, and (4) recording and playback on consumer-type videocassette players. In order to meet these objectives an instantaneous data rate of 503 kilobits/second ($32 f_h$) was selected. This data rate provides, in addition to a con-

ventional sync clock run-in, 16 useful data bits on Line 21 field 1. This supports a delivery system, after allowance for instructional codes, of about 500 words per minute. This is four times the required 125 words per minute for a typical captioned program, while providing reliable service with weighted video signal-to-noise ratios as poor as 23 dB.

By means of the instructional codes, the captions may be placed in up to 4 rows at either the top or bottom of the screen, in any of the six primary and complementary colors plus white and with the capacity for two captioned languages which may be transmitted simultaneously and selectable by the viewer. The system also provides two viewer-selectable channels of full page non-program related text (15 rows of 32 characters).

GOING OPERATIONAL

After this significant step forward in adoption of an approved standard for closed captioning television programs, a great deal of work remained to be done to translate this technology from one of demonstrated feasibility and desirability to full broadcast operation. Industry experience with new technical developments such as color television and stereo sound broadcasting had taught that, no matter how desirable or feasible a new service may be, it requires the assembly of practical programming and production techniques, broadcast equipment and technology, and popularly priced reception devices before the system is accepted by the public and can provide the benefits of its original conception. Therefore in 1976, with funding continued to be provided by HEW, PBS launched a unique comprehensive hardware, software and programming development effort designed to provide a fully operational commercial and public broadcasting captioned program service in the first quarter of 1980.

This program consisted of the following sub-projects:

1. Development of a Caption Editing Console

The first step in the process of closed caption television programming is the preparation, editing, timing and synchronization of the captions which, translated to a VBI data format, are broadcast with the television program signal. This process is labor intensive and requires highly skilled and trained editors. In order to minimize the cost of this key operational process, it was recognized that semi-automated computer-aided editing equipment was required. A Caption Editor was designed by PBS to provide a moderately priced vehicle for the captioning of general television programming material. It can be operated directly by the editor in the broadcast production environment.

The console displays on a television screen either the program picture or the original script text as called for by the operator. By means of a lightpen and keyboard, words may be added or deleted, underlined, italicized and colorized until the exact form of the caption is determined. A microcomputer in the Console automatically provides original script display, performs word processor functions and adds necessary Line 21 system television instructional codes. The caption editor

is free to concentrate on purely creative editorial functions and the operation of the Editor is essentially mechanical.

In actual operating practice a cassette copy of the master program videotape is struck and delivered to the caption editor. The time code reference from the master tape is recorded on the auxiliary audio track of the cassette tape. After completion of the caption preparation and editing, the console automatically prepares a floppy disk complete with all protocol instruction codes. This floppy disk becomes the program caption data source which, when used with a Line 21 Encoder automatically inserts the correctly timed Line 21 data signal into the program video line.

2. Decoder and Home Receiver Development

Of critical importance to the successful launch of the captioning service was the ready availability of a supply of *low cost* reception devices for the new Line 21 system. The key parts in this element of the project were:

- Design, development and production of decoder integrated circuits. This work was done under contract by Texas Instruments who developed and produced a 9 IC chip set suitable for mass production, including 3 entirely new chips specifically for the line 21 standard.

- Design, development and high volume production of low cost caption decoder adapters and decoder-integrated television receivers.

These products were manufactured by Sanyo under order from Sears, Roebuck and Company who marketed and services them. It is estimated that by the end of 1983 about 75,000 Captioning Adapters and TV receivers were in use in the United States and Canada.

3. Establishment of a Closed Captioning Programming Service

Broadcasters had often expressed concern that program producers would be especially sensitive to any editorial changes in the original script required by the captioning process. Although this sensitivity has never become a problem, (program producers have proven extraordinarily supportive), these concerns and the need for confidentiality in the pre-release for captioning of commercial network programs suggested the need for creation of an independent caption programming service unaffiliated with broadcasting companies or program production houses. The National Captioning Institute (NCI) was established as a non-profit organization to provide this caption programming service. It is supported by fees charged for captioning services, and from royalties earned on the sale of decoders (the rights to the IC chip set were vested in NCI as part of the HEW program seed effort). NCI has also continued development of technical and programming improvements to the closed caption system, using some of its earnings for this purpose.

PROGRAMMING

In March, 1980 regularly scheduled Line 21 closed captioned service was begun over both the public and commercial television networks. Initially about 15 hours a week was offered.

Since 1980, a wide variety of closed captioned programming has become available on a regular basis. The entire gamut of TV programs is represented from childrens shows such as Sesame Street on PBS through to escapist entertainment such as Love Boat on ABC. Thirty-five to forty hours a week of prime time shows are now regularly presented in the Line 21 Closed Caption format on the ABC, NBC and PBS networks.

Starting in 1974 during the experimental period of TV captioned programming, the ABC Evening News was captioned by the Boston public station WGBH Captioning Center and distributed daily on an open captioned 5-hour delayed basis over the PBS network. The popularity of this service for the hearing-impaired demonstrated the need for a method of "real-time" captioning, that is direct translation of news programming to closed captions without delay. NCI has developed such a system which combines a "stenotype" shorthand typewriter with a sophisticated computer shorthand translator and Line 21 encoder. Using this system NCI provides Line 21 closed captions on a "live" basis 5 nights a week for the ABC Evening News and the delayed open-captioned version has been discontinued.

The text page capability of the Line 21 decoders is used to provide 2 channels, selectable by the user, of information pages (not related to the transmitted TV program) which, at times when closed captioned programs are not transmitted (although they can be interleaved), give the schedule for captioned TV shows as well as news, weather and sports information. To do this so-called "Smart Encoders" are inserted in the video lines, either at a network control center or local TV station, to permit insertion of Line 21 text data at any location. The Smart Encoder automatically interleaves text and captions in such a fashion as not to interfere with closed captioned programs.

An interesting footnote to the story of captioned programming is the use of closed captions for "commercials". Over 250 advertisers have closed captioned their 30 second and 1 minute spot commercials to help sell their products to the hearing-impaired.

TELETEXT CLOSED CAPTIONING

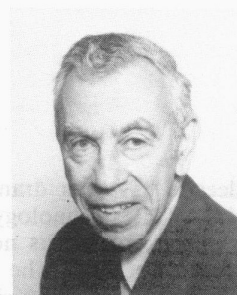
The general teletext format differs from the Line 21 service in that it uses a much higher instantaneous data rate (5.72 Mbits/sec has been adopted) and occupies more VBI lines (two to four in each field is typical). Thus teletext can deliver "magazines" of text pages embedded among which may be program-related closed captions. Both of the proposed North American teletext systems provide for closed captioning in this manner. However, until widespread distribution of consumer teletext receivers, closed captioning by this means has had to be limited. CBS is presently broadcasting over its network 3 to 5 hours of prime time programs, including

the popular "Dallas" show, using the NAPLPS teletext format.

NCI in cooperation with ABC has demonstrated a "transcoder", which translates a Line 21 encoded closed caption program into the teletext format. It seems likely that when teletext service becomes generally available closed captioned programs will be broadcast in both formats.

It is dangerous to single out the efforts of individuals in a large multi-faceted project such as Closed Captioning for television for fear of leaving some significant contributors off the list. Nevertheless, the contributions of Dr. Norwood of the Bureau of Education for the Handicapped of the Department of Education, Mr. Barnathan of ABC, Messrs Ball (now of NCI) and Wells of PBS, and Messrs Davis and Jespersion of NBS should be acknowledged. The National Academy of Television Arts and Sciences has also taken note of this contribution, awarding an Emmy in 1980 jointly to NBS, ABC and PBS for the development of the Line 21 system.

BIOGRAPHY



David Sillman, a native of New York City, received a Bachelors Degree in Electrical Engineering from the School of Technology, College of the City of New York and is a Registered Professional Engineer in the State of Illinois.

He has held research engineering positions at Hazeltine Corporation from 1944 to 1953 and Hazeltine Research, Inc. from 1968 to 1975. From 1953 to 1968 he was with the TV-Radio Division of Westinghouse Electric Corporation where he was Division Engineering Manager. From 1976 until 1983 he was with PBS where he was responsible for the Captioning for the Deaf development program. In 1983 he joined Satellite Television Corporation where he is Manager of Subscriber Terminal Development.

Mr. Sillman has served on a number of IEEE and Industry Committees including the Television Allocations Study Organization and the Cable Television Advisory Committee and is past Chairman of the Broadcast and TV Receivers Group of IEEE (then IRE). He is presented Chairman of the Field Test Panel of the EIA Teletext Committee.