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One-Inch Type C Video: The Broadcast Standard

The broadcast industry was one of the only segments of the videotape market to have products created by major manufacturers expressly for their use. They were a large and powerful group of corporations, and their budgets were far higher than those of the educational and consumer markets. With the development of two-inch quadruplex video in 1956, the manufacturers were responding to direct complaints by the broadcast networks about their complicated method of kinescoping. In order to broadcast programs on the West Coast at a delay of three hours, employees of the networks would record the broadcast feed from the East Coast, film it onto 35mm film, and rush the film to the developing lab, having it back in the studio to play for broadcast within that three hour time period. With the high cost of film stock, this was enormously expensive for the networks. "American TV operations used more raw film for kines [kinescopes] than all of the Hollywood film studios combined. It was estimated that NBC used more than one million feet of film a month in its New York facility alone to time-shift programs." They were desperate to lower their operating costs, and the answer came with the introduction of magnetic tape.[1] Although two-inch quadruplex tape solved the problem of kinescoping, there was no doubt that it had its own set of disadvantages. Again, the videotape manufacturers were sensitive to the complaints of the broadcasters, and they devised a one-inch video format to meet the demand. It was "smaller, lighter, less

[1] History of Tape Recording Technology. 3 June 2004. The Wayback Machine: tvhandbook.com. 26 October 2007 <http://web.archive.org/web/20040603152849/http://www.tvhandbook.com/History/History_recording.htm>.

expensive, and produces better pictures than the old quad format does."[2] It took several years of prodding by broadcasters for manufacturers to agree to an industry-wide standardization of the one-inch system, named the Type C format, but upon standardization the response was immediate and positive. Within a matter of years, one-inch Type C video became "the new standard for the American broadcast industry."[3]

For over twenty years, two-inch quadruplex videotape dominated the broadcast television industry. It was "the first practical and commercially successful videotape format," and was immediately adopted throughout the market upon its release by Ampex in 1956. The tape was stored on an open reel and read by means of quadrature scanning, which "uses 4 heads mounted on a headwheel spinning transversely (width-wise) across the tape at a rate of 14,400 rpm for NTSC-standard Quad decks". Although far more advanced than the earlier method of kinescoping, there were limits to the technological capability of two-inch videotape.[4] "…Freeze frames are not possible with quad machines, nor is slow motion,"[5] since recording the images transversely results in a segmented recording. Additionally, it was very limited in its uses, for it was created by Ampex solely to satisfy the needs of the broadcast industry and so was never used in any other scenario. Moreover, even within the broadcast industry, it only functioned within the physical studio, as "cameras still had to be tethered to relatively large recorders".[6] Nevertheless, two-inch tape filled an enormous need in the marketplace, and ensured

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[2] Robert L. Hartwig Basic TV Technology. (Boston: Focal Press, 1990) 82
[3] Hartwig 82
[4] "2 inch Quadruplex videotape." Wikipedia. 20 Oct 2007. Wikimedia Foundation, Inc. 3 Nov 2007 <http://en.wikipedia.org/w/index.php?title=2_inch_Quadruplex_videotape&oldid=165772352>.
[5] Hartwig 89
[6] William Murphy. Television and Video Preservation 1997. (Washington: Library of Congress, 1997) 25 October 2007 <http://www.loc.gov/film/tvstudy.html>.

itself a comparatively long lifespan in what would become an industry littered with failed and incompatible formats.

It was the rise of helical-scan technology that heralded the downfall of two-inch quadruplex videotape.[7] "Despite industry acceptance of quad in the late 1950s, Toshiba, in Japan, continued to work on its helical scan approach to video recording," and while there were attempts made at two-inch helical scan recorders, none of them were successful. It was not until 1976 that a number of one-inch helical recorders were introduced (by Bosch-Fernseh, Sony, and Ampex) of a quality high enough to viably compete on the broadcast market. "All three…worked well, and it was clear at least that helical recording had matured," but there existed a fundamental problem with these recorders: they were completely incompatible.[8] This is particularly evident in Designing & Maintaining the CATV & Small TV Studio, a guide which dates from 1976. While praising the "sophistication" of the 1-inch helical recorder, the author also cautions that the wide range of formats is "a bit of a disadvantage, because if you use, for example, an Ampex VTR, your tapes cannot be played on another manufacturer's VTR. Almost every VTR uses a different format."[9] Within each of the videotape recorders, the placement of the video heads was entirely individual, causing the images to be recorded onto the magnetic tape disparately. Therefore, once a tape had been recorded with a specific configuration of video heads, it was only possible for it to be played back on a machine that matched the configuration precisely.[10] This was, obviously, frustrating to

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[7] Dr. Robert G. Nulph. "Edit Suite: Once Upon a Time: The History of Videotape Editing." Videomaker July 1997

[8] History of Tape Recording Technology.

[9] Ken Knecht. Designing & Maintaining the CATV & Small TV Studio. Blue Ridge Summit: Tab Books, 1976. 84

[10] Marcus Weise. Videotape Operations. Woodland Hills: Weynand Associates, 1984. 111

users of one-inch helical-scan videotape, especially since the Sony and Ampex formats were "tantalizingly similar."[11] In the minds of the broadcast industry, the only possible solution was to standardize the formats.

The impetus for the standardization of one-inch helical-scan video was a letter sent to SMPTE in January of 1977 from both ABC and CBS. "The letter reflected the broadcast industry's growing concern over the proliferation of systems with non-interchangeable formats…stressed the need for prompt action and urged the Society to move expeditiously on the matter." SMPTE responded very positively to this letter, and immediately created a 'Working Group on One-Inch Nonsegmented Helical Recorders' to deal with this issue, advertising the meetings of the group in the SMPTE Journal to encourage participation to be as high as possible. This tactic worked, for present at the first meeting of the group were "experts sponsored by all major television networks, several groups of industrial television users, and eight equipment manufacturers – Ampex, Bosch-Fernseh, IVC, NEC, Philips, RCA, Recortec, and Sony."[12] It took a total of ten meetings of the group before a compromise was agreed upon in August 1977, primarily in the areas of "audio head placement and video drum structure."[13] Through the efforts of this group, they were able to create three separate standards for one-inch helical videotape, and this was announced in the December 1977 issue of the SMPTE Journal:

The three one-inch helical formats on which the preliminary technology

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[11] History of Tape Recording Technology

[12] A. E. Alden. "The Development of National Standardization of the One-Inch Helical Video Tape Recording Systems." SMPTE Journal 1977: 952

[13] Albert Abramson. The History of Television, 1942-2000. (Jefferson: McFarland, 2003) 176.

> has now been completed will be identified in the national standards documents as: *Type A* – the one-inch continuous field format introduced by Ampex in 1974; *Type B* – the one-inch segmented format, known as BCN, introduced by Bosch-Fernseh; and *Type C* – the one-inch continuous field format developed through the cooperation of the manufacturers to satisfy the basic parameters as requested by the users, both network and industrial.[14]

Astonishingly, it took less than a year from the creation of the working group dedicated to this task of standardization to the actual creation and publishing of the standard. This work was deemed so important that both Ampex and Sony were awarded a joint Emmy in 1979 "for the development of the compatible one inch type C Format which made possible improved videotape recording, editing and playback."[15]

Draft versions of the technical specifications for the one-inch Type C helical-scan videotape were published in the March 1978 issue of the SMPTE Journal, which included detailed diagrams of video drum size and placement for the recorder, as well as dimensions of the recording path on the magnetic tape itself. "Continuous-field recording in the Type C format is accomplished by wrapping the videotape nearly all the way around the drum…for each complete revolution of the video tip all active television lines in one field are recorded." On the tape there are three separate audio tracks, each 0.8 millimeters wide, two of which are located next to each other at the top of the tape,

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[14] Alden 952

[15] "Outstanding Achievement in Technical/Engineering Development Awards." National Academy of Television Arts and Sciences. 25 October 2007 <http://www.emmyonline.org/tech/applications/ engineering_award_winners_rev3.pdf> 3

while one is located at the bottom next to the sync and control tracks. The top audio tracks are separated by a space of 0.8 millimeters, giving them the ability to be used either as separate audio tracks or for stereo, while the bottom audio track can be used either for audio or for the time code. The sync track is 1.3 millimeters wide, and located directly below the control track, which is 0.6 millimeters wide. The area where the video tracks are recorded diagonally is located in the relative center of the tape, and each video track is nominally 0.13 millimeters wide and 18.5 millimeters long. [16] As for the physical specifications of the tape, it is, as the name states, one inch wide, with a thickness of approximately 1.1 mil.[17] The base is composed of polyester terepthlate, and the magnetic coating of cobalt-modified iron oxide.[18] At a speed of 9.61 ips[19], tapes would usually run one hour in length. Every major videotape manufacturer had one-inch Type C videotape on the market, from Sony and Ampex to Fuji and Scotch, reflecting how wide the existing market for the tapes actually was.

As with two-inch video, which was developed for the broadcast industry and then used only within that specific context, one-inch video was firmly entrenched in the broadcasting studio. "Things like live slow-motion, high speed search at up to 60 times normal speed and multi-channel audio were standard with one-inch videotape. It offered the highest quality picture and sound recording with the highest level of precision available at the time."[20] CBS even went as far as to call the quality of one-inch video on

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[16] David K. Fibush. "SMPTE Type C Helical-Scan Recording Format." SMPTE Journal 87 (1978): 756-58.
[17] Murphy
[18] Murphy
[19] Abramson 177
[20] Mike Loehr. "Edit Points: A History of Videotape Editing." Videomaker May 1995: 3

the same level as 35mm film, with the added advantage of being far cheaper as well.[21] The switch to one-inch Type C, once the standardization had occurred, took place in a relatively short period of time, and it is possible to chart this growth through the annual reports in the SMPTE Journal, beginning in 1979:

> During the first part of 1978, deliveries of quadruplex video recorders were at a high rate. However, as production and delivery of 1-in videotape equipment increased, this trend diminished. By autumn, deliveries of the SMPTE Type B and SMPTE Type C equipment reached significant figures and the adoption of these newer formats by both broadcast and nonbroadcast users continues to accelerate.[22]

Less than two years later, in 1981, the number of networks who had fully adopted the Type C format was soaring. ABC alone was responsible for 155 Type C systems, which amounted for 95% of their total recording studios.[23] The one-inch Type C was not used only for the broadcast news, however, but in any studio situation where its large size would not be an inconvenience. Specific examples of content are rare, except for one mention of CBS, who "equipped Studio 51 in New York with four Type C machines dedicated to the production of an hour-long daytime dramatic serial."[24]

Following the standardization proceedings, Ampex and Sony were the first manufacturers to release Type-C VTRs onto the market, respectively named the VTR-2 and the BVH-1000C, with a price tag of approximately $72,000.[25] These machines were far superior technologically to those utilizing two-inch quadruplex tape, making "high-

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[21] Abramson 175
[22] Frederick M. Remley, Jr. "Television." SMPTE Journal 88 (1979): 295
[23] "Television" SMPTE Journal 90 (1981): 377
[24] Remley 295
[25] Abramson 180-83

quality still-frame, slow-motion and fast-motion playback" possible.[26] Other manufacturers quickly joined Sony and Ampex, improving on their initial designs to create the second generation of Type-C VTRs. Debuting in 1980, RCA's TR-800 "included a new tape transport design that would handle 2-hour reels and a microprocessor-based control system."[27] Sony and Ampex were quick to follow in the example of RCA, releasing the BVH-2000 and VR-80 machines with similar capabilities. In order to keep competing in a rapidly expanding market, Ampex released the first third generation VTR, the VPR-3, in late 1982, using innovative new means to "provide fast, gentle, precise tape handling without damage to the valuable master tape." There were also additional improvements to the tape speed, giving the machine the ability to "cue back to the start of a 30-sec segment and roll in less than 2 sec." As of 1983, less than 5 years after the invention of Type-C, 12 different VTRs were in use within the broadcast industry,[28] and the number of machines produced was equal to that of two-inch quadruplex.[29]

While the status of one-inch video was secure in the studio, the manufacturers were interested in attempting to parlay their success into the portable broadcasting realm as well. With the standardization of the Type-C format, portable production units were manufactured along with their larger studio counterparts. At the time, both two-inch quadruplex and 3/4 inch U-matic portable devices were in use for field reporting:

> Separation between these two formats was great, both in picture performance and features. On one hand, there was the accepted

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[26] Nulph 2
[27] William F. Carpenter. "The Type-C Format – A Moving Target." SMPTE Journal 92 (1983): 923
[28] Carpenter 925-26
[29] Tanimura, Hiroshi, Yoshio Fujiwara, and Thomas E. Mehrens. "A Second Generation Type-C One-Inch VTR." SMPTE Journal 92 (1983): 1274

> quadruplex picture quality, but combined with the complexity and weight of the quad format. On the 3/4-in helical wide, there was the simplicity of the cassette loading and lighter weight, but the performance with the color-under system lacked the picture quality required by a large portion of the teleproductio [sic] market.[30]

With the first and second generation of these portable Type C recorders, their weight was so great that they could not feasibly be used for the purpose they were intended for. Weighing between 45 and 50 pounds, they could only be carted around, and thus cannot be considered to be truly 'portable'. It was not until the third generation that this problem was remedied, with the introduction of the Ampex VPR-5. "The revolutionary feature of this machine is its 15-lb weight, complete with a 20-min reel and battery. This results in a one-person field production operation when used with a lightweight camera."[31] It was made entirely of aluminum,[32] and is so technologically and aesthetically marvelous that it is held in the collection of the Metropolitan Museum of Art.[33] Despite their best efforts, the use of one-inch Type C video did not catch on in field broadcasting, for although the picture quality was superior, the equipment was far too unwieldy when compared with the compact U-matic recorders.

Despite the widespread use of Type C video within the broadcast industry, it simply could not maintain its foothold once digital formats entered the market. "A survey in July 1991 showed that broadcasters expected D-2 digital and one-inch type C formats to share dominance in studio production and that D-2 would compete strongly with Betacam SP by 1994."[34] In the end, D-2 would play only a brief role in the development

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[30] Carpenter 923
[31] Carpenter 923
[32] Abramson 197
[33] Stoffel, Tim. "Ampex 1 Inch Equipment Catalog." 25 October 2007 <http://lionlamb.us/quad/ampex1.html>.
[34] Abramson 239

of the broadcast industry, but Betacam SP would lead to the eventual demise of one-inch video. Betacam was cheaper, smaller, and in the form of a cassette, all advantages over the expensive, open reel Type C.[35] The history of technology is necessarily one of constant new invention, and old technologies are left to be forgotten in favor of the latest development. In its day, Type C was this type of cutting-edge technology that caused broadcasters to abandon their well-used two-inch quadruplex systems. Two-inch tape was very expensive, and so instead of archiving the programs for future viewing, often they would simply be recorded over in an effort to save money. One-inch video was cheaper than two-inch, and combined with the smaller storage size, it was possible to begin to archivally store these broadcast programs for the first time.[36] It is still possible to find old one-inch videotapes sitting in the basements of institutions, although they have no possible way of playing them back. As of 1996, when one-inch VTRs were more prevalent, it was not viewed as an endangered format, "but such tapes are monitored, evaluated, and copied as necessary for programming reasons or for deficiencies in the original transfers."[37] However, it is generally acknowledged at the present that one-inch tapes are in danger. There are fewer and fewer machines still around for playback, and the physical tapes themselves are, as with all magnetic media, beginning the process of deterioration.

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[35] "Betacam." Wikipedia. 30 Oct 2007. Wikimedia Foundation, Inc. 3 Nov 2007 <http://en.wikipedia.org/wiki/Betacam>.
[36] Carpenter 923
[37] Murphy

Annotated Bibliography

Abramson, Albert. The History of Television, 1942-2000. Jefferson: McFarland, 2003.

This book is an incredibly detailed summary of television technology beginning in 1942. It moves slowly year by year, giving innumerable facts and providing photographs of every new VTR that entered the marketplace. Abramson attempts to provide the definitive guide to television history, and it is possible to track the rise and eventual fall of one-inch video through this chronicle.

Alden, A. E. "The Development of National Standardization of the One-Inch Helical Video Tape Recording Systems." SMPTE Journal 86 (1977): 952-57.

This article is a narrative description of the complete process involved with the standardization of Type C. It begins with the letter from ABC and CBS to SMPTE asking them to create a standard, and discusses the creation of different working groups dedicated to this task. There were a number of meetings involved within each different group, and Alden gives lists of these, including the wide range of participants from different sectors of the market, as well as the subject matter that was covered. The standardization of Type C video was a rare effort within the industry to join together, and Alden aptly describes the situations that led to this compromise.

"Betacam." Wikipedia. 30 Oct 2007. Wikimedia Foundation, Inc. 3 Nov 2007 <http://en.wikipedia.org/wiki/Betacam>.

This website is devoted to information regarding the Betacam video format, which was the successor to Type C video. It begins with the invention of the format, and then describes the many different types of Betacam available. It is useful primarily to investigate the features inherent to Betacam that were not present in Type C video, and to attempt to draw conclusions from these features as to the failure of Type C.

Carpenter, William F. "The Type-C Format – A Moving Target." SMPTE Journal 92 (1983): 923-26

This article, written 5 years after Type C video was invented, examines the three different generations of Type C VTRs available, and the technological capabilities of each. It is one of the only resources available that gathers the range of Type C VTRs into one space as well as clearly delineates the differences between them.

Fibush, David K. "SMPTE Type C Helical-Scan Recording Format." SMPTE Journal 87 (1978): 755-60

This article looks at the new Type C technology and provides very detailed technical diagrams and specifications. It describes the parameters of the video drums and video heads, as well as the track configuration of the audio and video tracks on the magnetic tape. Additionally, the processes of audio recording, control track recording, and video recording are given, and space is left at the end of the summary for discussion notes by professionals in the field. As SMPTE was the standardizing body of Type C video, this article is an unimpeachable source for the technical specifications of the format.

Hartwig, Robert L. Basic TV Technology. Boston: Focal Press, 1990.

This book is basically a manual describing every facet of television technology, beginning with circuits and frequencies and proceeding to video special effects. It is a useful overview of the entire technology, including a number of diagrams which aid in comprehension.

History of Tape Recording Technology. 3 June 2004. The Wayback Machine: tvhandbook.com. 26 October 2007 <http://web.archive.org/web/20040603152849/http://www.tvhandbook.com/History/History_recording.htm>.

This website consists of a detailed narrative describing the advent of magnetic recording in 1931 and traces the technology up to the invention of the cartridge tape, with a large segment devoted to the attempts at creating broadcast video. This article was useful in regard to the development of helical-scan technology as compared to transverse scanning, as well as a general account of the history of broadcast recording.

Knecht, Ken. Designing & Maintaining the CATV & Small TV Studio. Blue Ridge Summit: Tab Books, 1976.

This book is written primarily for the average person without much technical experience who wishes to set up a small studio for broadcast purposes. The entire broadcast studio is explained very clearly, including the large variety of video equipment available. As it was written in 1976, it describes a world where there is no one-inch video standard, and it is a clear example of the actual problems studios faced before the standardization occurred.

Loehr, Mike. "Edit Points: A History of Videotape Editing." Videomaker May 1995

This article is a general overview of the history of videotape editing, beginning with two-inch quadruplex video and physical splicing and taping together of videotape. Loehr quickly summarizes the technological advances that led to the advent of electronic editing and automatic edit controllers, and concludes with a discussion of time code editing, and

attempts to predict the future of videotape editing. Type C is provided as one example of the new editing capabilities that were available with time code editing.

Murphy, William. Television and Video Preservation 1997. Washington: Library of Congress, 1997. 25 October 2007 <http://www.loc.gov/film/tvstudy.html>.

This report was produced by the Library of Congress to detail "the current state of American television and video preservation" as of 1997. It is a lengthy report, which covers the range of videotape materials and their preservation needs, the wide variety of television archives and their preservation practices, and provides a National Plan for the preservation of these cultural materials. While Type C video is mentioned only briefly this report is invaluable as a glimpse of the preservation landscape ten years ago, and it is interesting to compare the attitudes then with all the knowledge gained in the intervening years.

"Outstanding Achievement in Technical/Engineering Development Awards." National Academy of Television Arts and Sciences. 25 October 2007 <http://www.emmyonline.org/tech/applications/engineering_award_winners_rev3.pdf>.

This document is a listing of the recipients of the Emmy Award for Outstanding Achievement in Technical/Engineering Development from 1948 onward. This document is proof that Ampex and Sony did, in fact, share an Emmy for their work in developing the Type C format for videotape.

Nulph, Dr. Robert G. "Edit Suite: Once Upon a Time: The History of Videotape Editing." Videomaker July 1997

This article traces videotape editing from its beginning in two-inch quadruplex using a razor to the complex computer-based editing systems of today. It contrasts the differences between the editing systems of two-inch quadruplex and one-inch Type C, and describes how the better editing system of the one-inch Type C was one of the major reasons for its success within the broadcast industry.

Remley, Jr., Frederick M. "Television." SMPTE Journal 88 (1979): 294-97

Every year in May, the SMPTE Journal would produce an annual progress report of the previous year. This 1979 report encompassed new developments in motion pictures, television, photoinstrumentation, photoscience, education, as well as international advances. It provides a detailed look (including photographs) at the new technologies created, as well as summarizes the effect of these technologies on the marketplace. It is possible to chart the effect of a particular product or format through the years using these

annual reports, and they provide extremely useful statistics regarding the acceptance of one-inch Type C video among broadcast users.

Stoffel, Tim. "Ampex 1 Inch Equipment Catalog." 25 October 2007 <http://lionlamb.us/quad/ampex1.html>.

This website is simply "a listing of all known Ampex 1 inch VTRs." The vast majority of them are Type A machines, but there are several Type C recorders at the bottom of the page, several containing links to photographs. This list can be categorized as a fan page for the equipment, as the author very excitedly gives his opinion on the relative merits of each machine as well as what he believes caused their success or demise. It was interesting to contrast these assessments with the more official ones from SMPTE, as the SMPTE annual reports do not contain many theories for why particular machines were not as successful as others.

Tanimura, Hiroshi, Yoshio Fujiwara, and Thomas E. Mehrens. "A Second Generation Type-C One-Inch VTR." SMPTE Journal 92 (1983): 1274-79

This article discusses the new technological advances in the second generation of Type C VTRs. It provides the interesting statistic that Type C has transformed the broadcast industry in only four years, but beyond that is simply a listing of technical specifications and diagrams. The mere fact that a second generation of recorders existed, however, is enough to suggest that Type C was widely used throughout the broadcast industry.

"Television" SMPTE Journal 90 (1981): 375-379

Every year in May, the SMPTE Journal would produce an annual progress report of the previous year. This 1981 report encompassed new developments in motion pictures, television, photonics, education, as well as international advances. It provides a detailed look (including photographs) at the new technologies created, as well as summarizes the effect of these technologies on the marketplace. It is possible to chart the effect of a particular product or format through the years using these annual reports, and they provide extremely useful statistics regarding the acceptance of one-inch Type C video among broadcast users.

"2 inch Quadruplex videotape." Wikipedia. 20 Oct 2007. Wikimedia Foundation, Inc. 3 Nov 2007 <http://en.wikipedia.org/w/index.php?title=2_inch_Quadruplex_videotape&oldid=165772352>.

This website briefly summarizes the history and uses of two-inch quadruplex video. It takes the problems associated with kinescoping as its starting point, and then moves to a

description of the technical specifications of the format. It provides a complete list of product model numbers that used quadruplex video, and concludes with a look at the format in the present day. Since two-inch quadruplex was the format that preceded one-inch Type C video, this article was useful in examining the drawbacks of two-inch quadruplex and figuring out how one-inch improved upon it.

Weise, Marcus. Videotape Operations. Woodland Hills: Weynand Associates, 1984.

This handbook begins with an explanation of television signal and then gives instruction on how to set up a VTR and edit video. Published in 1984, it deals only with one-inch video, which of course was the standard at that time. It is written in a manner of describing a complicated technology to an individual without experience in video, and includes a number of diagrams for greater understanding. It is useful as yet another verification that one-inch video was the predominant format in the broadcasting industry.