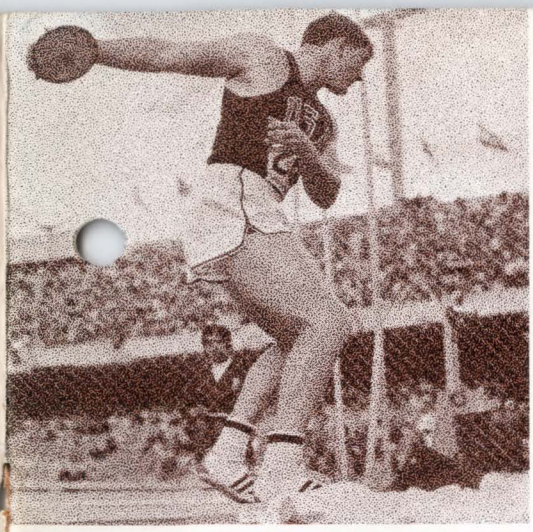

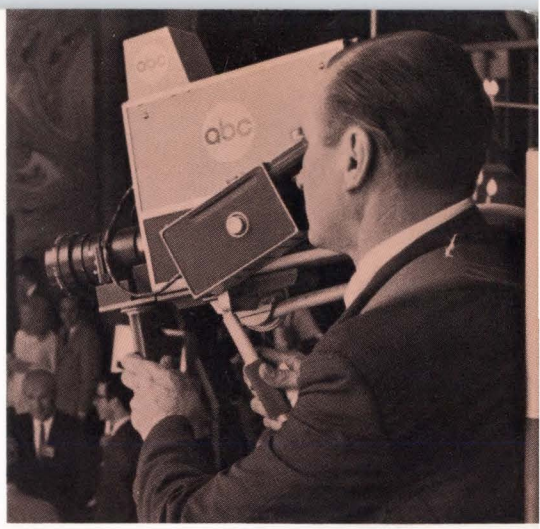

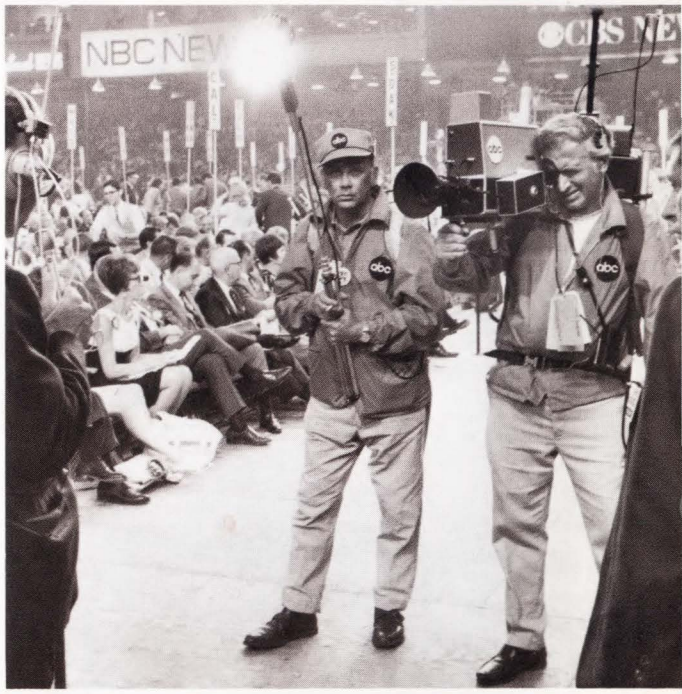

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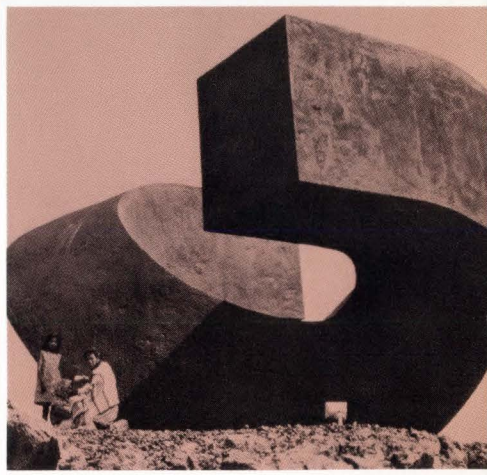

In this issue:

- Television Goes to the Conventions
- German Television
- Computer-Aided Circuit Design

and...

- **The Olympic Games** — *See Special Color Section*

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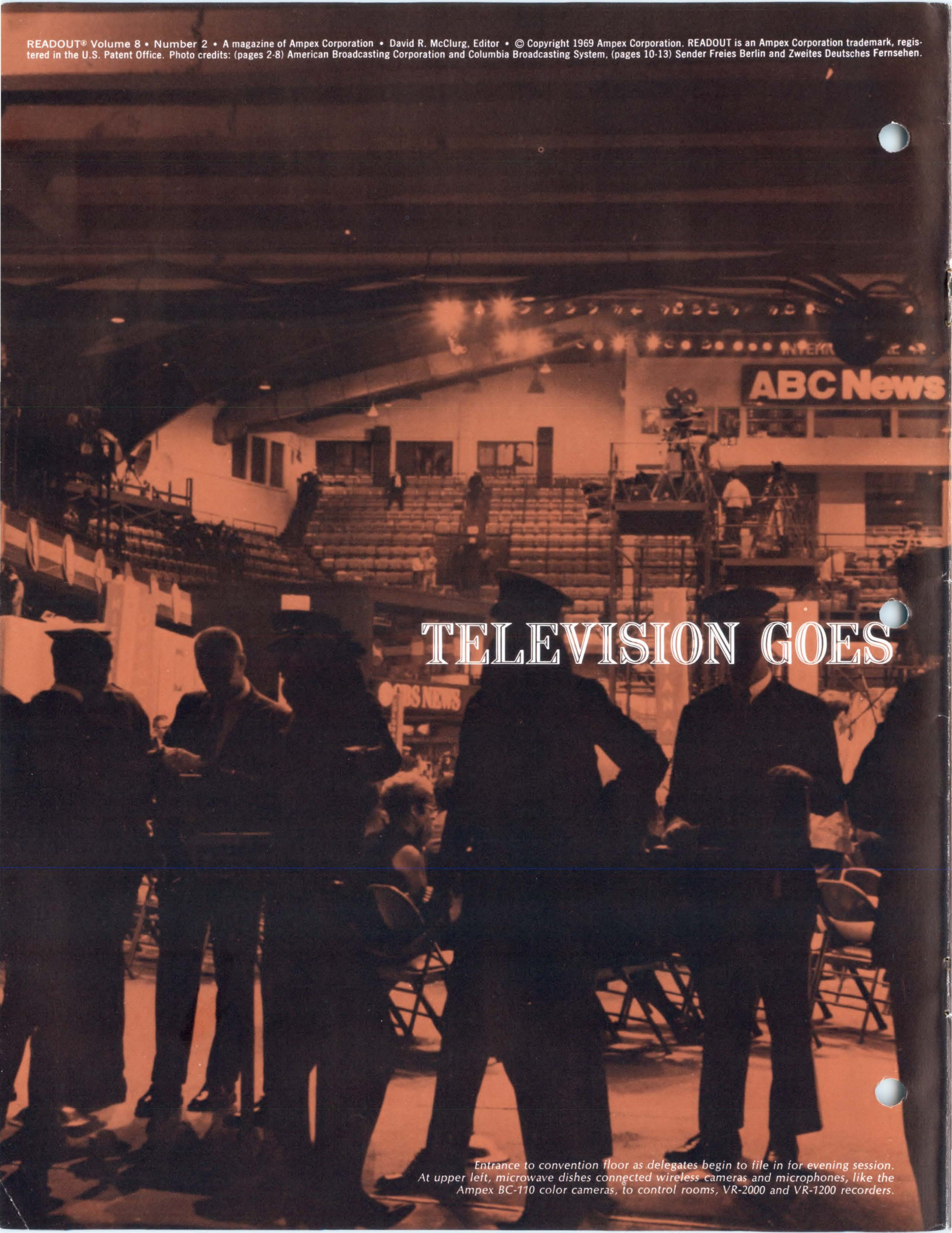
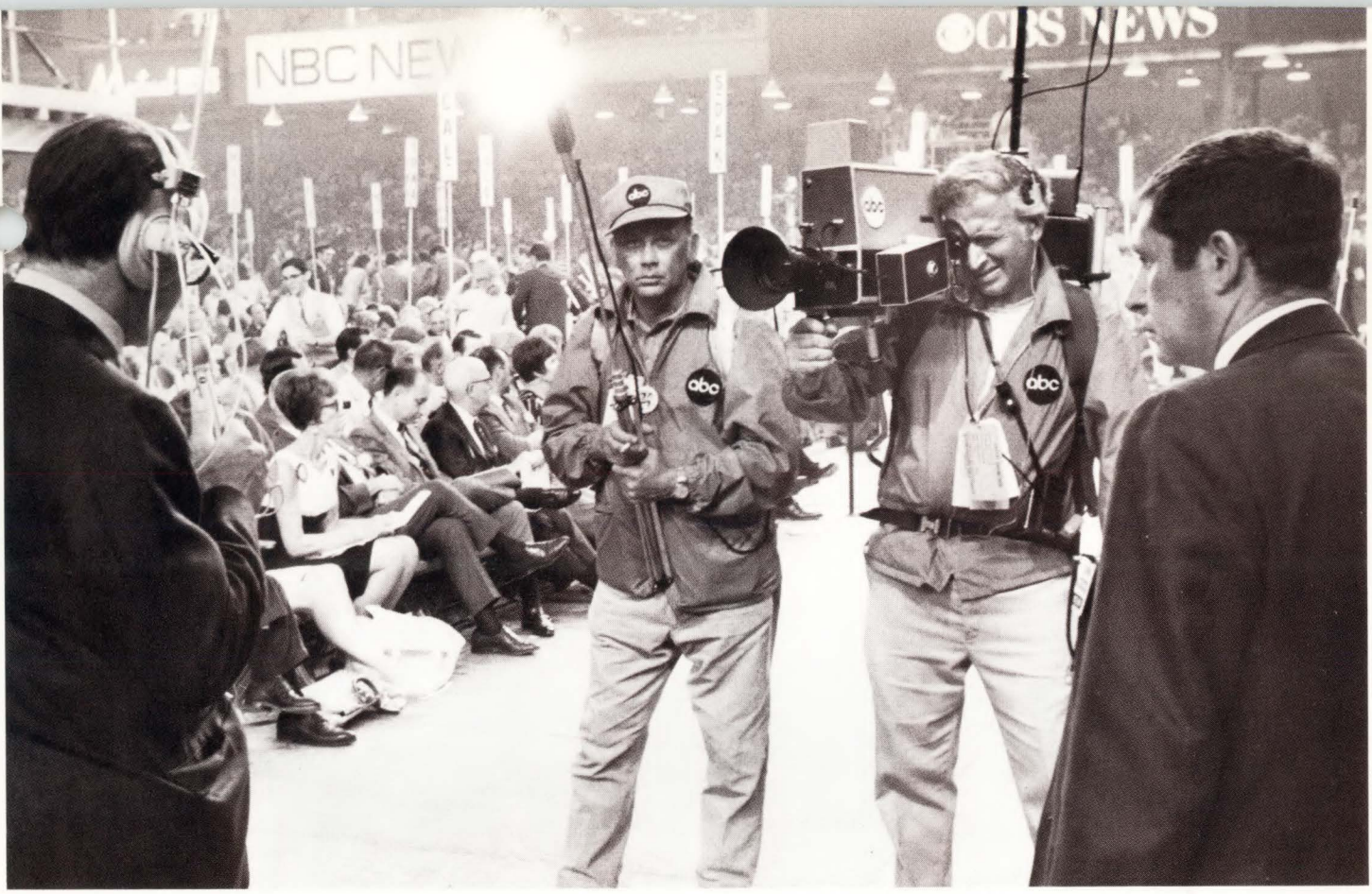


TELEVISION GOES

Entrance to convention floor as delegates begin to file in for evening session. At upper left, microwave dishes connected wireless cameras and microphones, like the Ampex BC-110 color cameras, to control rooms, VR-2000 and VR-1200 recorders.



To get the picture that couldn't be gotten any other way, ABC cameramen used Ampex BC-110 wireless color cameras to capture interviews from the convention floor, hotel suites, and similar locations.

TO THE CONVENTIONS *A Year End Report*

SO PERSUASIVE and compelling are our modern communications technologies and so ubiquitous their coverage of current events, it is difficult for us to realize that some political activities, conventions among them, haven't existed forever. As a matter of fact, the first three presidential elections in the United States had no nominating procedure at all, convention, caucus, or otherwise. The members of the electoral college simply agreed among themselves that it would be Washington twice, and Adams once. By 1800, political parties had emerged and needed some mechanism to choose their candidates.

At first, this was done simply and conveniently, but not always satisfactorily, by a congressional caucus in Washington. Then in 1832, the Anti-Masonic Party, in what was apparently their sole claim to mention in the history books, set up the first political convention. The example of this innovative but short lived group was quickly followed by the National Republicans and Jeffersonian Democrats, so that by tradition and usage, conventions have been in use since that time.

Interestingly enough it is by tradition alone that conventions continue to operate to this day. This is another way of saying that conventions have no basis in our constitution and are not regulated in any way by the federal government. Many state governments, though, exercise control over the selection of convention delegates. Lately, conventions have come under considerable fire as being undemocratic, too confusing, and certainly too long. However, despite suggestions to improve them, to abolish them completely, or to substitute for them a nationwide presidential primary, they seem destined in one form or another to be with us for quite a while to come.

Conventions blend together into a crazy quilt colorful patches from a Barnum & Bailey circus, a Chautauqua debate, and an extraordinary session of congress. They are noisy, exciting, as peculiarly American as the Fourth of July, and just possibly obsolete in the second half of the 20th Century.

Both the Republican and Democratic conventions follow the same basic procedure and order of business. Before the actual balloting begins, a couple of days are spent on party rituals, such as seating the delegates, rules, speech making, and party business. Even before this, a week or so is spent hammering out a platform acceptable to all factions. Nominating candidates for president and vice-president comes on the third day, usually followed by noisy floor demonstrations. These demonstrations used to have more political significance in previous years and sometimes helped sway conventions. (The gallery's chant of "We want Wilkie" is the classic case in point.) More recently, however, hired demonstrators, some of whom cheerfully whoop it up amidst balloons and marching bands for more than one candidate, have made demonstrations lose some of their significance. For this reason, future conventions may permit only delegates to participate. Finally, the voting for presidential nominee takes place. On the fourth day, nominations and voting for the vice presidential choice are the order of business, which with the acceptance speeches of both nominees pretty much wrap up the proceedings.

The job of the communications media is to bring this quadrennial political show to the viewing and listening public as part if its responsibility of informing the electorate.

MOUNTING A CONVENTION REMOTE: Mountains of Work, Millions of Dollars. What does it take to put on television's largest remote? In a few words, mountains of work and millions of dollars. To provide their gavel-to-gavel coverage, CBS and NBC each brought 750 to 800 news people, technicians, and administrators to the convention cities. ABC, with its unconventional convention coverage, used more than 400. Among the radio nets and European correspondents, another 300 souls were present, not to mention the print and magazine people. Network costs were widely publicized as $23 million total for all networks. This doesn't count loss of advertising revenue since the networks can only sell part of the available commercial time to sponsors.

The only practical way to cover remotes of this magnitude (unless they're in New York or Los Angeles) is by pre-wired vans and trailers, even if both conventions are in the same city. While it would seem ideal to put in cabling, studios and booths ahead of time in a convention hall when it is built or remodeled, it simply is too much to expect that it will be suitable for the particular coverage required. The number and location of cameras, the number of recorders, the RF links needed, and the switching involved works out to be different nearly every time. So, when the networks are asked to advise architects and planners on new convention halls, they invariably are reduced to pleading for enough electric power, adequate air conditioning for the stepped up lighting needs of color, and plenty of room to park vans and trucks inside or adjacent to the hall.

1968 CONVENTIONS: Full Color, Wireless Color Cameras, Back-Pack VTRs, Slo-Mo Disc. In keeping with long standing tradition the Republicans held their convention first in early August, followed a couple of weeks later by the Democrats. This year the two conventions were held in separate cities, Miami Beach and Chicago, which presented many problems for communications media.

In terms of television technology, 1968 was set apart by several marked distinctions from earlier conventions. In the first place, all coverage was in color this time. More importantly, a great deal of floor coverage was done with the portable hand-held color cameras, most of them with microwave to eliminate the problem of connecting cables. Similarly, wireless microphones of a new breed came into wide use. Away from the convention floor, back-pack videotape recorders were used for the first time by two nets which added a new dimension to behind the scenes and fast breaking news, particularly in Chicago where tape sped by couriers had to take the place of microwave links. Finally, real on-site production flexibility in high band color was possible this time by the use of still frame ("Slo-Mo") disc recorders and electronic videotape editing so that splice free segments from many different sources could be assembled into programs for replay within the shortest time after the event.

Two of the three networks offered complete coverage, the so-called gavel-to-gavel reporting of CBS and NBC. ABC on the other hand, through a mixture of strict budgets and experimentation put on a 90-minute summary from 9:30 to 11:00 pm, in what they termed their unconventional convention coverage. Besides the three television networks, the European Broadcasting Union, many European radio networks as well as American radio networks (Mutual, Group W, Metromedia) were fully represented.

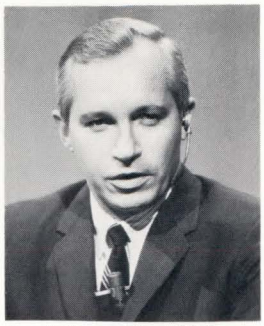
View of convention floor from ABC's booth.

A MULTIMILLION DOLLAR MOVING JOB: From Miami to Chicago. Because the conventions were split between cities some two thousand miles distant, the networks from the beginning planned to install as much equipment as possible in trailers and vans which in theory could be plugged in at each end. Needless to say, the thousands of miles of cable and installation of fixed cameras around the halls made this idealized theory quite a bit more difficult in practice. CBS had over 60 trailers, vans and mobile units. Several of the trailers were put side by side with connecting doorways for office and administrative use. Most of the equipment and the vans were brought in from CBS New York and CBS Hollywood. Connecting the vans together were continuous platforms running among the vehicles. ABC used 13 trailers and only two vans, building the remainder of their required space on site at both the Miami and Chicago convention halls.

In terms of cameras used, the figures represent a big increase over 1964. Both CBS and NBC used about 60 cameras each. ABC with its more limited coverage had about 20. In the case of the pool coverage of the podium and floor, which all of the networks and independents subscribed to, these cameras were supplied and manned in Miami by NBC and similarly by CBS in Chicago. Mutual broadcasting provided pooled audio from each state position on the floor and from the speakers platform. ABC coordinated and integrated RF communications.

HAND HELD COLOR CAMERAS: Linked by RF. Really unique to the camera coverage in the '68 conventions was the first extensive use of wireless color cameras. The ABC units, the Ampex BC-100 "Scrambler," which saw extensive service at football games and the winter Olympics in Grenoble were also used in Mexico City to cover the summer Olympics. This unit uses two Philips Plumbicon* tubes and an RF back-pack module supplied by Microwave Associates. Sharp, brilliant color is obtained at light levels as low as 100 foot candles. It operates on a video transmission frequency of 13 GHz. Similarly, the CBS labs Minicam Mark VI and the RCA M[illegible] pack portable operated at 13 GHz. Complementing the freedom of use and flexibility of

*REG. TM. N.V. PHILIPS' GLOEILAMPENFABRIEKEN



Frank Reynolds, ABC News.

CBS anchorman at the conventions, news correspondent Walter Cronkite.

CBS correspondent Eric Sevareid.

CBS correspondent Mike Wallace.

ABC control booth.

One of three dual VR-2000 equipped recorder stations set up by ABC in Chicago. Girl in foreground is logging a tape during recording to provide a fast access index and archival record. One station had an Ampex HS-100 Slo-Mo recorder for stills and slow motion.

the wireless cameras was a new breed of interference free wireless microphones supplied primarily by Microwave Associates as used by CBS, and Airborne Instruments Laboratory as used by ABC and NBC.

VIDEOTAPE RECORDERS: Studios, Remote Vans, and Back Pack. The increased quantities of equipment applied not only to cameras but to videotape recorders as well. CBS had a total of 21 recorders, topped off by two VR-2000's in Miami and six VR-2000's in Chicago, accompanied by three VR-3000 backpack recorders. The VR-3000's were used with CBS's new color camera to move outside of the arena and pick up important events as they happened. For example, in Chicago five

William F. Buckley and Gore Vidal presented opposing views during ABC's unconventional convention coverage.

CBS mobile units with a typical complement of one VR-1200 and one of their three VR-3000's shuttled between the hotels, the sites where demonstrations might be held, and in nearby environs of the Amphitheatre. CBS converted all commercials to high band tape for replay on two of their VR-2000's from the convention hall. CBS's recorders were in almost constant use recording every minute of the floor coverage, the pool cameras, and pickups from other points in the hall.

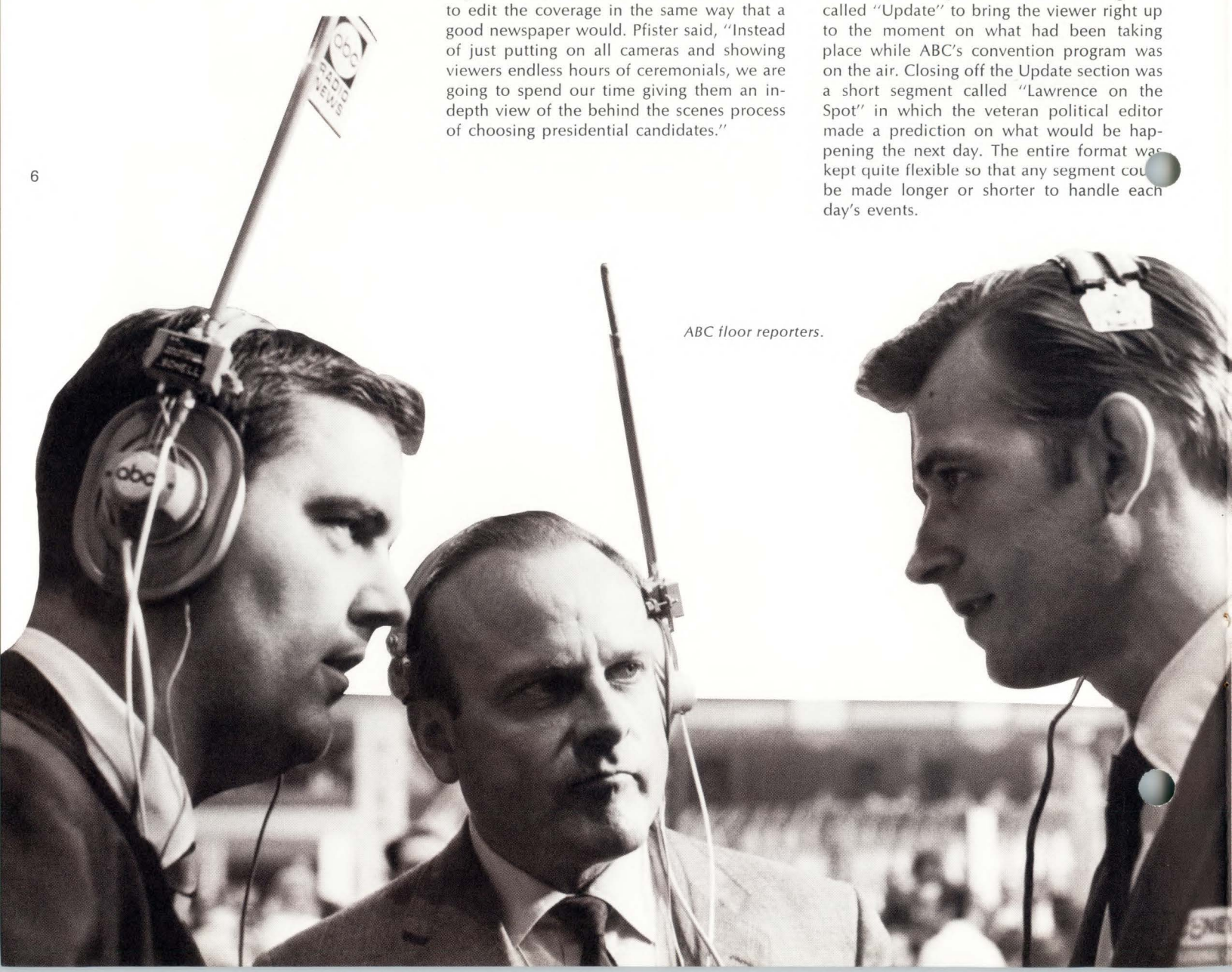
ABC had ten videotape recorders, six VR-2000's (three with Editec) and a VR-1200 at the Amphitheatre. In addition, they had three vans, each with VR-1200's which moved between the hotels and other areas to cover fast breaking news. ABC handled its commercials from the network center in New York or by the local outlet, WBKB.

Because of a communications strike and other delays in setting up in Chicago, the networks were not able to have a microwave link between the downtown areas and the convention hall, as they had in Miami Beach. For this reason the versatility, immediate replay, and color fidelity of videotape recording again proved it value. Fast breaking events were covered by the recorder equipped vans and VR-3000 back-pack units as they happened. The tapes were sped by special motorcycle courier to the Amphitheatre for immediate replay. To handle expected activities at the headquarters hotel without microwave link, CBS put in four extra VR-2000's to work with some 16 cameras at the hotel.

UNCONVENTIONAL ABC NEWS: 90-Minute Coverage. The most interesting and discussed experiment at the convention was the unconventional convention coverage carried by ABC television. The executive producer Wally Pfister divided his 90-minute prime time package into five distinct sections. His idea was to edit the coverage in the same way that a good newspaper would. Pfister said, "Instead of just putting on all cameras and showing viewers endless hours of ceremonials, we are going to spend our time giving them an in-depth view of the behind the scenes process of choosing presidential candidates."

The first segment of the 90-minute program was a 25 to 30-minute instant documentary highlighting a particular theme as anchored by Howard K. Smith. Following the documentary a 20-minute round-table discussion was held by the correspondents who actually covered the floor activities and other behind the scenes action. This section was moderated by ABC News political editor William Lawrence.

The third segment was Insider's Report: a five to six-minute hard news in-depth feature led by Frank Reynolds to focus on some important aspect of the convention that otherwise might get lost in the crush. These reports for example, included studies of the delegates communications set-ups, and the security measures. The fourth segment, running 15 to 20 minutes, featured the incisive and often controversial viewpoints of Guest Commentators William F. Buckley, Jr., and Gore Vidal. Moderating was Howard K. Smith. The final element in the unconventional format was an eight or ten-minute segment called "Update" to bring the viewer right up to the moment on what had been taking place while ABC's convention program was on the air. Closing off the Update section was a short segment called "Lawrence on the Spot" in which the veteran political editor made a prediction on what would be happening the next day. The entire format was kept quite flexible so that any segment could be made longer or shorter to handle each day's events.



ABC floor reporters.

Rear of CBS trailers, part of the 60-odd trailers, vans and mobile units brought to Chicago by CBS.

Group W sent out detailed coverage to eight radio stations in key markets with the help of three Ampex 602 recorders.

Putting together this 90-minute segment was basically an all-day job monitoring and recording significant events. But actual assembly with the aid of electronic editing on the VR-2000 recorders was compressed into the hour and a half or so before the show went on the air. Since it was a mixture of live coverage by anchorman and commentators, plus many news segments recorded during the day, the activity around the three videotape rooms was pretty much of a white flash in the final moments before air time.

All seven of the ABC videotape recorders were in use to produce a typical 90-minute session. Basically, the three rooms, two with two VR-2000 recorders each, the third with two VR-2000's and a VR-1200, were assigned as follows. One room previewed material recorded during the day. A second room recorded the proceedings from the pool camera. A third room either recorded selected material from the first two rooms or it reviewed tapes just brought in from the mobile units.

Stationed at each of the machines as material was being recorded or replayed were logging typists who put down keywords at each minute interval or between minutes if a change of scene or quotable comment had occurred. These logging records are kept with each tape for semi-permanent storage in the ABC library.

Mutual Radio's control room and announce booths showing two Ampex 600 series recorders in use.

ABC's pre-convention coverage also proved the value of the Ampex BC-110 wireless color camera.

Metromedia radio provided coverage to nine stations around the country. Equipment used included Ampex 601 recorder and SA-10 speaker amplifier units.

European Broadcasting Union leased this VR-1200 equipped van from CFTO to record pool coverage and its own floor camera. CBS managed EBU technical arrangements in Chicago. NBC in Miami.

STILL FRAME VIDEO: The "Slo-Mo" High Band Color Recorder. Especially interesting during the airing and pre-preparation of the 90-minute segment was the selection of short segments for still frame recording on the Ampex HS-100 "Slo-Mo" high-band color recorder. On the fourth evening of the Chicago convention, the vice-presidential nominations were taking place. It was also known that the presidential nominee would be arriving and his entry into the hall would be recorded from a pool camera. Many tapes from that day and earlier in the week were quickly scanned, using one, two, or even three recorders at a time to select a wave of the hand, a smile, or a closeup of a candidate and his wife, to record onto the HS-100 disc recorder. This recorder can repeat up to 30 seconds of action over and over again. Transferring back from the HS-100 onto another VR-2000 that is equipped with Editec allows a still frame of a hand wave or particular expression to be stretched out for as long a time as the director wants, to establish a theme idea or mood. In each of the recorder stations, on of the VR-2000's was equipped with electronic editor, so that these inserts from the HS-100 as well as inserts from the other recorders and film chains could be inserted quickly and easily without breakup of the picture.

For the closing sequence on this session, six individual still frame shots were selected showing Vice-President Humphrey waving, Humphrey with his wife, Senator Muskie at the podium, Senator Muskie's wife and the two candidates together, all in still-frame images. Similarly, the HS-100 machine was used at the Republican convention and at earlier sessions of the Democratic convention in the opening and closing sequences to show still frames of significant moments.

FUTURE CONVENTIONS: Unconventional Coverage to Become Conventional? Television certainly plans to be there in force again at the 1972 national conventions. Whether the ABC unconventional summary format will be adopted by the other nets remains to be seen. The best guess is that it might be, but with modifications to tailor it for their own style. In the realm of equipment, hand-held wireless color cameras, back pack videotape machines, and slow-motion recorders have unquestionably proved their value and reliability under fire. These will become, along with newer developments in miniaturizatio a permanent feature in covering television's biggest remote. ■

Special Report:

Ampex at the Olympics

READOUT® Volume 8 • Number 2 • SPECIAL SECTION • A Magazine of Ampex Corporation • David R. McClurg, Editor

Fifteen-story Communications Tower rushed to completion by Mexican Ministry of Communications housed recording, switching, monitoring and microwave transmission gear. Antenna dishes on the roof linked the tower with cameras at the various venues around the city and relay stations to the U.S. and overseas satellites.

More Than 50 Networks Captured Olympic Color and Spectacle for 800 Million World Viewers

MEXICO 68, a graphic symbol splashed in bright colors throughout Mexico City, signified the place and date of the XIX modern Olympiad. Records of all kinds were set here, athletic and otherwise, including a new record of television coverage by more than 50 broadcasting networks from every corner of the earth. It was television's biggest effort by far (requiring for example, 60 videotape recorders), and proved among other things that nations can work together equally as well in the tele-communications arena, as on the athletic field.

MEXICO 68

THE XIX OLYMPIAD

THE ORIGINAL Olympic Games were begun by the ancient Greeks, who carried on these quadrennial athletic contests for some 12 centuries, from 776 B.C. to 400 A.D. The games celebrated amateurism and masculinity, and projected the Greek ideal of perfection in mind and body. The games showed their love of sports and sport heroes, much as the modern games do today.

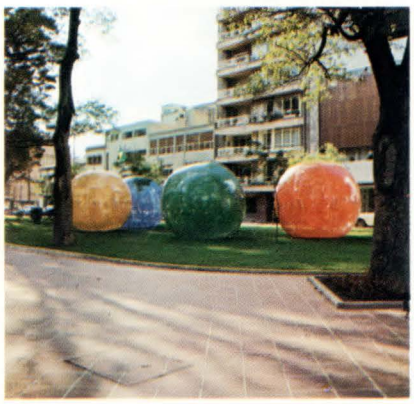
Three words symbolize the Greek ideals of the Olympics: citius, altius and fortius (swifter, higher and stronger). These words are still carried on the medals awarded to Olympic winners.

The modern Olympics began in 1896 with ten nations participating. Very likely the games would have remained buried in history except for the single minded efforts of a Frenchman, Baron Pierre de Coubertin. During the 1880s, archeologists from Germany had rediscovered the sacred valley of Olympia and the ruins of the stadium. De Coubertin visited this site and dedicated himself to re-establishing the games as a measure of amateurism in international sports, both to promote brotherhood and to combat what he felt was a rise of commercialism in sports.

MEXICO 68: 110 Nations, 7900 Athletes. Mexico is particularly suited for the fiesta atmosphere of an Olympics because fiestas have always been one thing the Mexicans do well. However, the choice of Mexico City was questioned at first by those who doubted that it could provide the proper facilities in time for the games.

In all respects Mexico came through. Super highways supplanted dusty roads. The University of Mexico's stadium was expanded to seat 80,000 for the track and field events. A waterway at the pre-Columbian floating gardens of Xochimilco was rebuilt to accommodate 7,000 boating enthusiasts. The existing Aztec stadium, already able to handle 107,000 fans, was designated for soccer. A new sports palace for basketball with a copper panel Geodesic dome was put up specifically for the Olympics. Other sports were held in specially renovated or newly built facilities around the city. New street signs, ticket and information booths, posters, banners, and Olympic symbols all in bright colors added a festive look to Mexico's biggest fiesta ever.

COMMUNICATIONS TOWER: 15 Floors of Television Gear. To handle the requirements of television broadcasting, the Mexican government rushed to completion a brand new 15-story Tower of Communications. This ultra-modern, glass walled structure fits in well with the strikingly beautiful architecture found throughout the capital city. Microwave dishes on the roof top linked cameras at the venues



with the Tower, where recording, switching, and monitoring gear was located. Traversing the floors brought you in contact layer by layer with the largest array of television equipment ever assembled for a remote broadcast. The one link of commonality connecting these 50 diverse network organizations was more than 30 Ampex videotape recorders (of the 60 total) located here. In use constantly during the day and long into each night, these machines taped nearly all events, then were used to edit this mass of material into concise summaries showing the critical matches and record breaking events of the day. It was estimated that at peak viewing times, some 800 million viewers throughout the world were seeing pictures reproduced wholly or in part from this vast collection of videotape recorders. Other rooftop dishes connected with relay stations in the U.S. for cross country and international satellite transmissions. After the Olympics, this building will be taken over by the Ministry of Communications to consolidate several of its operations under one roof.

TELEVISION'S BIGGEST EFFORT—60 Ampex VTR'S, 800 million viewers. Just as the Mexican government began its preparations several years ago for the Olympics, the international television networks also began gearing up well ahead of time. Realizing that the transmission, camera pickup, and recording requirements of a remote broadcast such as the Olympics could not be handled by any network in any city in the world, the networks began their plans to bring in equipment from the outside, working closely with the Mexican Ministry of Communications.

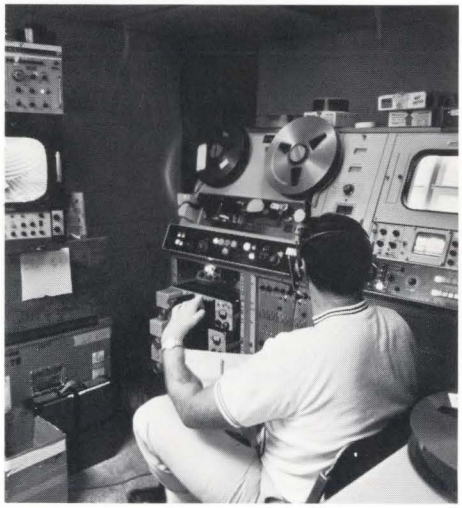
To provide the 50-plus videotape recorders originally estimated as required, Ampex Corporation in conjunction with the European Broadcasting Union, ITV of the UK, the NHK network of Japan and others, began discussing special lease arrangements for videotape recording equipment some two years ago. Included in the lease was full back up by Ampex installation and service engineers who came on location with the equipment, plus spare parts, many of which were hand carried by Ampex personnel traveling between California and Mexico in support of the games. These arrangements plus the network-owned recorders brought to Mexico City made the Olympics an exclusive for Ampex videotape recorders. The grand total was 60, including 23 VR-2000 and 15 VR-1200 studio or van mounted recorders, plus two VR-3000 back pack and three HS-100 disk recorders. Comparing previous games, eleven videotape recorders, all monochrome, were used in Rome in 1960. In Tokyo, it was 46 recorders, all monochrome except for two.

A totally new dimension in Mexico was the hand-held wireless cameras (BC-110) and back-pack recorders (VR-3000) which brought closeup action direct from the stadium floor and the Olympic swimming pool, to supplement the 60 or more fixed cameras. The VR-3000 recorders and BC-110 cameras got pictures that simply couldn't be taken any other way.

ABC-TV: Hand-held Color Cameras and Sl Mo. The American Broadcasting Company, fresh from its triumph in technique and technology at the Grenoble Winter games, came

ABC brought back the unique closeup action of track, field and swimming events with three Ampex BC-110 back-pack wireless color cameras. These cameras and the VR-3000 back-pack recorders provided coverage that simply couldn't be gotten any other way.

This ABC Slo-Mo disc recorder (Ampex HS-100) brought world viewers spectacular coverage of track finishes, swimming and diving events. ABC used two HS-100's, NHK of Japan, one. Stop and slow motion in full color, plus closeups caught by back-pack cameras and recorders added a totally new dimension to 1968 Olympics coverage.



Underneath the Olympic Stadium, this VR-2000 worked in conjunction with an HS-100 to record many events and select segments for slow and stop motion. Scene on monitor at left is from ABC's crane-mounted camera high over stadium.

to Mexico City prepared to do an even better job covering the Mexican Olympics. ABC put on the air more than 47½ hours of coverage during the 16 days of the Olympics, which is almost double the previous record of broadcast hours set at Grenoble. To do this job ABC brought down a staff of 460 people, 45 cameras (32 of them color) stationed at 18 locations around the city, 12 videotape recorders (seven VR-2000, two HS-100, and three VR-1200), 100,000 feet of cable, and several Ampex built mobile vans from WFAA in Dallas, Seros Teleproduction in San Francisco, and ABC Hollywood. To prepare its 47½ hours of air material, ABC actually recorded nearly nine times as much tape, a total of about 400 hours during the two-week games.

ABC control and recording was centered on the 10th and 11th floors of the Communications Tower. Here four VR-2000's and two VR-1200's recorded events throughout the day for review, edit, and assembly into early afternoon and evening broadcasts. An HS-100 "Slo-Mo" disc recorder located here provided still frame pictures and slow motion for the opening and closing sequences on the air masters.

At the Olympic Stadium 16 ABC color cameras caught the action in track and field. Cameras were everywhere, including one precariously mounted on a temporary construction crane 225 feet up and operated by an apparently nerveless cameraman. Underneath the stands, an additional VR-2000 and HS-100 teamed up to record slow and stop motion in full color that so effectively showed the superlative efforts of the individual athletes as world and Olympic records were shattered.

Again adding that entirely new dimension to close up coverage so successful in Grenoble (and ABC's NCAA football coverage) were three BC-110 wireless color cameras. These hand-held units roamed the stadium floor to bring the tight action of field events like pole vaults, long jumps, and hammer throws right onto the home viewer's screen. Similarly, after the start of the swimming and diving events that the U.S. scored so heavily in, ABC moved one of its BC-110 and both HS-100 Slo-Mo units to the Olympic swimming pool to supplement the fixed cameras and provide the spectacular slow motion of diving and the finish of each swimming race.

At the rowing and canoeing races held at beautiful Xochimilco, Marconi Mark VII color cameras in an Ampex built van leased by ABC from Seros Teleproduction in San Francisco captured these events for ABC's VR-2000 and VR-1200 recorders at the Tower.

Besides its own exclusive camera coverage, ABC worked closely with all other broadcasters in producing pool feeds of many events for their use.

CBC CANADA: Dual Language Coverage. The Canadian Broadcasting Corporation came to Mexico City fully equipped to send back its comprehensive coverage in both French and English. Duplicate control, audio, and recording setups were installed in the 10th floor of the Tower. The dual language sections each had two VR-1200 recorders. At the principal venue for each day's activities, a VR-1200-equipped van recorded all events from CBC's two color cameras or from the ABC, EBU or NHK pool cameras. (Six CBC color cameras were leased to ABC for the games.) These

Ampex VR-1200-equipped van brought to Mexico City by Canadian Broadcasting Corporation. Other vans built or equipped by Ampex were the ABC/WFAA and ABC/Seros Teleproduction mobile units.

Immediately following a women's track event, ITV Great Britain recorded this interview in nearby stands with one of its two VR-3000 back-pack recorders. This plus other interviews of the day were assembled on a VR-1200 at the Towers to make up a 15-minute unilateral broadcast each evening.

Editing session at European Broadcasting Union facility in Communications Tower. Many hours of coverage were cut down to concise summaries by EBU technicians for general and unilateral broadcasts via satellite to Europe.

Overall view showing three of EBU's six VR-2000 recorders.

tapes, along with other tapes of events recorded on the four VR-1200's at the Tower were edited alternately by the French and English staffs of CBC for regular evening broadcast to Canada via Mexican and U.S. microwave.

A small studio in the Tower with a color camera afforded a location for interviews and commentary by CBC announcers in either language.

For audio insert and history purposes, dual language recording set ups each used two Ampex AG-350 recorders to record the commentators at the stadiums. Any portion of these, or commentary originating from the studio, could be added to the language versions.

EBU: 43 Broadcasting Organizations. Providing coverage for 43 separate broadcasting organizations, the 135-man team of the European Broadcasting Union had by far the most complex language assignment at the 1968 Olympics. All European countries, plus several Near East countries and Pakistan, partook of EBU services. The method of preparation was to record the main events on six VR-2000 recorders located on the ninth floor of the Tower. Then on a regular schedule, the tapes for each event were replayed into two viewing rooms for review by commentators from each country. Individual announce booths were available to each net so that comments in the native language could be prepared to accompany the video.

Each morning, afternoon, and evening, a one-hour summary assembled from the day's recording was put on the satellite for transmission to Europe. In addition, live transmission of many events went out unedited during the day for recording or broadcast in Europe. All recording in the Tower was done on a 525-line standard, with NTSC color. In London, the BBC, which had responsibility at the games for video, provided a computerized standards converter to change 525/NTSC color to 625/PAL color instantaneously. For SECAM color in France and Eastern Europe, these PAL transmissions were simply recorded in SECAM color on videotape recorders in those countries for rebroadcast during later programming. Audio at the games was handled by the French ORTF network. RAI of Italy, and ZDF and ARD of Germany were responsible for the videotape recording.

Besides the summary EBU coverage, some 19 European networks also did extensive unilateral transmissions. These were made up mostly from edited portions of tapes recorded during the day with special interviews or commentary added.

ITV — GREAT BRITAIN: Two VR-3000 Back Pack Recorders. Certainly the most ambitious of the unilateral efforts carried on by European broadcasters were the on-the-spot interviews and commentary of Independent Television from the U.K. ITV leased from Ampex two VR-3000 back pack recorders and a VR-1200 studio recorder.

The two VR-3000 teams were on the move all day. They recorded interviews with athletes, coaches, medical experts, arrival of important personages, and similar fast-breaking events that benefit from the closeup, live-action feeling brought out so well by the instant replay of videotape. Back in the Tower, these tapes were replayed for editing on the VR-1200 to assemble ITV's daily 15-minute unilateral.

A typical fast-moving day with one of the VR-3000 teams revolved around a special series of interviews with Tim Johnson, the British marathon runner. Capitalizing on the mobility of the VR-3000 recorder, the team first interviewed Tim at the Olympic village about 2 p.m. with the modern high-rise quarters of the athletes as a colorful backdrop. Then the crew sped to Zocolo, the center city plaza of Mexico City, as an example of one of the areas the marathon race would pass through. Here additional footage was shot with the Cathedral and Government buildings adding authenticity and the feeling of the Olympic City. Then, two other locations along city streets and plazas were similarly captured. Shooting of the new footage was completed about 6:30 p.m.

Immediately after the shooting, the tapes were rushed back to the Tower where about 7 p.m. fast editing on the VR-1200 began. From the hour or so of marathon coverage, plus highlight materials brought in from the other VR-3000, a 15-minute program was assembled well ahead of air time. Finally, at 12:30 a.m., the air master was replayed on the VR-1200 during ITV's time slot on the satellite.

Making up the team for this special unilateral activity and the commentary that went with the regular EBU summaries were 32 ITV people (24 technical and administrative, and eight production and direction).

BBC—GREAT BRITAIN: More Than 200 Hours of Coverage. BBC's team at the Olympics was made up of 35 program and engineering personnel headed up by Peter Dimmock, O.B.E., Manager of Outside Broadcast. With five programs daily on BBC-1 in monochrome, and two on BBC-2 in color, the network broadcast more than 200 hours of coverage in the U.K. BBC operated as part of EBU, but also ran its own 30 minute unilateral each day. To complement EBU video coverage, BBC had a special open audio link to London. In addition, BBC used the studios of Telesistema Mexicana to record its commentators using that network's VR-2000 recorders and Marconi Mark VII cameras. These special insert tapes went into the daily unilateral and were also air shipped to London for additional use there.

Besides its extensive coverage, BBC was responsible for video for EBU and made one of the most significant technical contributions with its computerized color standards translator located in London. This state of the art device is a field store delay line translator, developed under the direction of BBC's Peter Rainger. It instantly converted signals via the Atlantic satellite from Mexico in 525-line NTSC color to 625-line PAL color for retransmission and recording throughout the EBU member network countries.

ITV network of Great Britain used two VR-3000's to capture fast-breaking interviews and events. Here a marathon runner views an interview recorded seconds before using the camera viewer which doubles as a miniature monitor for instant replay.

Marconi Mark VII color camera used by Telesistema Mexicano. This was one of seven Mark VII's (plus five other color cameras) used by the network, along with five VR-2000's, three VR-1200's, one VR-1200-equipped van, plus VR-7000 and VR-1000 recorders.

NHK of Japan had one of the largest set ups in Mexico City. Equipment included 16 color cameras at the venues, six VR-1200's, and this HS-200 Slow Motion disc recorder.

Engineer at the ABC Australia facility checks a tape for edit on one of the network's two VR-2000's used in Mexico City.

Two Ampex VR-7000 series recorders used by Radio Manila to record and edit tapes in a one-inch format. Tapes were air-shipped to Manila for release.

NHK — JAPAN: 16 Cameras and Six VTR's. NHK, the Japanese National Network, had one of the most complete installations at the Olympics. Beginning more than a year ago, NHK technicians came to Mexico City to organize their Olympic coverage. Over this period of time, they gradually brought in and checked out masses of transmission, monitoring, and test equipment. All of this was from Japan, with the sole exception of the recorders specially leased from Ampex, six VR-1200's and one HS-100. At the various venues, NHK acted as one of the principal pool camera sources with 16 color cameras picking up the action.

During each day, events of greatest interest to the 67 Japanese stations were recorded on six VR-1200's. From these tapes, two full hours were assembled for satellite transmission to Japan, all in color. To bring out the drama of individual effort, closeups of events were recorded on the HS-100 in slow motion to show such details as the muscle action of weight lifters or jumpers, or the facial expression of a runner during a heat. NHK had a studio adjacent to its recorder area where interviews and commentary were done. Olympic graphic symbols decorated the walls to add to the color of the commentary.

TELESISTEMA MEXICANO. Channel 5 in Mexico City not only supplied local transmissions throughout Mexico, but also provided a good portion of the pool camera coverage at the venues. Over half of its Mexican broadcasts were in color. For pickup at the stadiums, Telesistema used 12 color cameras including seven Marconi Mark VII's. Videotape recording was done on five VR-2000's and three VR-1200's at its recording center. In addition, monochrome recording for syndication to provincial stations as well as Central and South America were done on VR-1000C and VR-7000 recorders. Supplementing the studio recording, one of the two Telesistema color mobile vans had a VR-1200 recorder in addition to its camera chains.

ABC AUSTRALIA. The Australian Broadcasting Corporation brought a team of technicians, program people, and two VR-2000 recorders to Mexico City. The recorders were part of an Ampex shipment to ABC in Australia that was diverted to Mexico so that they were first used for the Olympics. ABC is a government-sponsored network that serves some 39 stations around the country. In addition, for the Olympic games, ABC also provided coverage for an additional 50 commercial stations.

In all, Australia recorded some 150 hours of material. These tapes were edited each day for a regular evening broadcast in Sydney. From there, retransmission throughout Australia took place. Field and track, followed closely by swimming, are the most popular sports in Australia, but other sports are also of interest to Australian sports fans and were recorded during the 1968 Olympics.

RADIO MANILA. Radio Manila serves four television stations in the Philippine Islands. Two of these are linked by cable, the other two replay network releases on duplicate tapes in the VR-7000 format. In Mexico City, Radio Manila used two Ampex VR-7800 recorders for its Olympic coverage. One recorder recorded three to four hours daily of selected events, then the second came into use to assemble a broadcast master for air shipment to Manila. There, the master was broadcast locally and also duplicated for the provincial stations.

An announcer in the Tower added local commentary to each tape, using a special noise cancelling microphone in the same room as the recorders.

TELEBOGOTA AND RADIO CHILE. For service to its viewers in Colombia, Telebogota used a VR-1100 recorder on the 14th floor of the Tower to record selected events. Tapes were air shipped to Bogota for editing and release every evening.

Similarly, Radio Chile recorded on a VR-660 to provide the same service to its viewers via air mail broadcast masters sent to that country. ■

AMPEX

Ampex Corporation • 401 Broadway • Redwood City • California 94063 • U.S.A.

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U.S. TRACK AND FIELD TEAM

PRACTICED WITH "INSTANT REPLAY" RECORDERS

Olympic athletes were enthusiastic about the video recordings that brought an instant replay of their performances at Lake Tahoe.

Videotape recording, television's familiar "instant replay," helped the U.S. track and field team prepare for the 1968 Olympic Games. Payton Jordan, head coach of the team and Stanford University track coach, said the team obtained the closed circuit television recording system for use during its high altitude training program at Echo Summit near Lake Tahoe, California.

The training program included stints in front of the instant replay camera and recorder for most of the track team members. Typically, each group of athletes—pole vaulters, high jumpers, sprinters, weight men—worked out together and their performances were recorded on video tape. Athletes and coaches then gathered around the Olympics video cart to view the playback. After analyzing their own individual performances, athletes returned to the field to iron out weaknesses that were noticed.

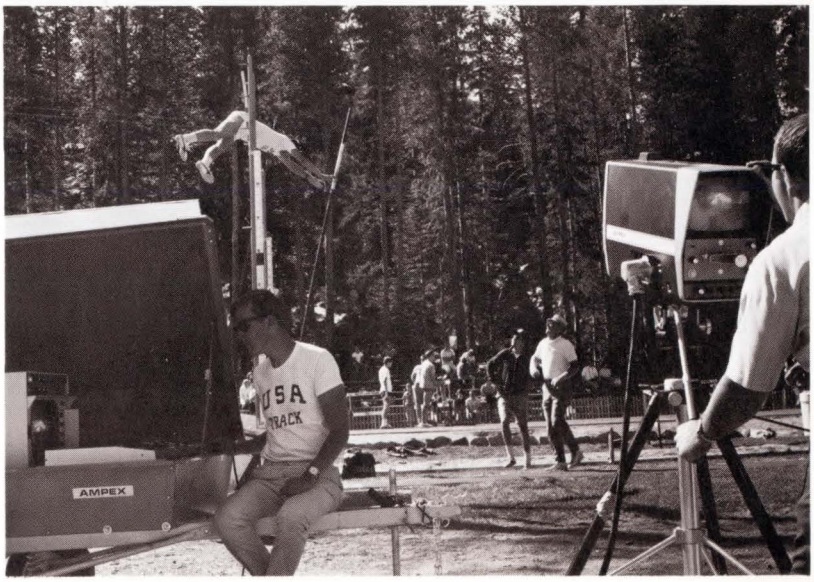
Coach Jordan said that the instant replay unit had been invaluable in helping ready U.S. track and field stars for the tough international competition in the Olympic Games.

The television system was specially designed for the team by Ampex. Packaged in a small auto trailer, it was moved from place to place at the training site by a gasoline-powered golf cart. The system consisted of a VR-7800 portable closed circuit videotape recorder, a CC-323 television camera with zoom lens and remote operating controls. Two viewing monitors were included to let coaches and athletes get that valuable second look immediately after each event.

Jordan said team aspirants were enthusiastic about studying video recordings of their performances. Following the elimination trials that established team members, the coaching staff scheduled videotape reviews as a regular part of the four-week training routine.

"We are confident that confronting these gifted athletes, even those capable of world record performances, with their flaws and strong points alike will enable them to increase their consistency and better prepare them for Olympic competition," Jordan said.

Coach and track team member study replay of form at starting blocks as replayed from this VR-7000 recorder.



High altitude Olympic training camp at Lake Tahoe, California used instant replay from an Ampex VR-7000 and CC-323 camera to help in the training program.

Television WITH Teutonic Thoroughness

It may seem to the casual viewer that television as a form of public communications is quite similar throughout the world. Nearly everywhere we can find the familiar picture tube in the home, cameras in the studio, videotape recorders in the control room, and the jagged pattern of antennas on the skyline. But the thing that marks German television as different from that in many other countries is its concern for the highest technical quality. The German nation is noted for what is usually called a Teutonic thoroughness. In the case of television, this comes out as a pride in maintaining the strictest technical standards so that the best possible picture reaches a viewer anywhere in the nation. Each station and distribution facility has a wide array of measuring devices and technical personnel whose sole function is to continuously monitor all signals from camera to recorder to transmission link.

JUDGING A TELEVISION SERVICE: Study the Test Pattern. As we pointed out in our previous articles on British and French television, the test pattern used by a network sometimes gives a clue to its programming or technical philosophy. In the case of Germany, the test pattern is a no-nonsense series of bars and shadings without pictorial or graphic embellishment. It is in keeping with the planning, order and quality that distinguish German television. In the area of planning, for example, a staff has been selected and is already working on the arrangements for television coverage of the 1972 Olympics to be held in Germany.

On the equipment side too, the thoroughness of the Teutonic mind is evident. Probably one of the few exceptions a German technician encounters to the familiarity of locally produced equipment is the videotape recorders used by the German networks. In Germany, as in most countries of the world, the quest for technical excellence has brought Ampex recorders into the production and distribution of television programming. In all, some 65 Ampex videotape television recorders are used by the two German networks. These include many of the older VR-1000 series, as well as an increasing number of the latest high band models, the VR-2000 and the VR-1200.

A Report of the ARD and ZFD Television Networks of Germany

LEGAL BASIS OF TELEVISION: Public Corporations But Not Government Control. Both German networks have been set up as public corporations and are regulated by legislation from either the state (Länder) or federal governments. The legislation spells out the role of broadcasting as concerning itself with the welfare of the public and not serving as an instrument of the government, a group of people or any individual. Programs are to be democratic, reveal cultural responsibility, and show impartiality. Programs must be aimed at freedom, justice and truth, respect for the rights of the individual, understanding between nations and defense of the basic human rights guaranteed in the constitution.

Both networks receive the majority of their financial assistance from a television licensing fee paid by set owners which is a common practice in all European countries. In Germany this is DM60 or about $15 a year. This compares with $14 in Great Britain, and $17 in France.

TV ADVERTISING: Limited in Time, But in Great Demand. Both networks carry commercial advertising, albeit in a slightly different format than we are accustomed to in the United States. The first channel allows 22 minutes of advertising on each weekday evening, broken into three separate blocks of seven minutes, five minutes and ten minutes. All three blocks run between 7 pm and 8 pm sandwiched between a good night program for children, national news, and local news and weather. The second German network limits advertising to 20 minutes a day, again on weekdays only, broken into four five-minute blocks scheduled at half-hour intervals between 6:15 pm and 8 pm. Even though this doesn't add up to a great deal of advertising, the competition among German sponsors for the available time is very intense.

On the second network, which is more national in scope and is therefore of greater value to a sponsor, advertising totaled $20 million in 1966. This amounts to about 25 percent of the network's total operating budget. In terms of total advertising in all media, this represents about one-fifth of all money spent for advertising. On the first network advertising is also widely used, but is broadcast on a regional basis in the 7 pm to 8 pm period before the nationwide hookup that begins at 8 o'clock.

ARD/SFB

ZDF

ARD/SFB

ZDF

ZDF

ARD/SFB

ZDF (Second Network) and ARD/SFB (First Network Berlin Station) programming.

PROGRAM COMMENT: Emphasis on News and Culture. German television programming relies heavily on news, culture and, to a smaller but important extent, entertainment. The news divisions of the two networks have a large budget for documentaries, political analysis, personality interviews, in addition to coverage of routine news, both local and national, and weather and sports. Culture is another main area. This includes opera, operetta, ballet, classical theatre (Shakespeare, Ibsen, Strindberg, Goethe, and Schiller), plus a good representation of contemporary German drama. For the popular taste, both networks import a good number of series and specials from the United States and Great Britain, besides producing their own situation comedies and melodrama. American programs regularly seen in Germany during recent seasons include Bonanza, Honey West, Car 54 Where Are You, Harrigan and Son, The Fugitive, The Detectives, The Man From U.N.C.L.E., and a variety of documentaries and specials. Just about all of these use dubbed dialog which is done extremely skillfully by professional actors and actresses.

COLOR TELEVISION: Eight Hours per Week in PAL. Color television began in Germany in the fall of 1967 with about eight hours a week broadcast regularly by each network. True to its creed of thoroughness and quality, the Germans improved on the United States NTSC color system, coming up with their own PAL (Phase Alternate Line) system. PAL has now been adapted by all West European countries except France. The PAL system corrects some of the problems of the NTSC system, particularly its sensitivity to color shift, but increases the cost of the home receiver by about 10 to 12 percent.

Total television households in Germany number about 14 million. Nearly all of these can receive the first network and almost 90 percent the second network, which broadcasts on the UHF band. Both networks use the 625-line, 50-field system, now the accepted line standard throughout Europe. Sale of color sets is expected to increase sharply as more and more programs appear in color.

FIRST CHANNEL: The ARD

Germany's first channel was set up in 1950 as a loose confederation of the regionally controlled stations in the nine provinces of Germany (see accompanying table). Formal name of this organization is ARD (Working Federation of German Broadcast Facilities). Each station broadcasts its own local programming but joins the network for national programs in the 8 to 10:30 time slot each evening.

The nine member stations have agreed to the percentage of programming that each will supply to the rest of the network for this evening period. The largest contributors are NDR (Nord Deutscher Rundfunk) in Hamburg, the WDR (Westdeutscher Rundfunk) in Cologne, and BR (Bayerischer Rundfunk) in Munich.

SFB: Sender Freies Berlin. To illustrate ARD operations, we have selected one of the regional ARD stations, SFB in Berlin. SFB stands for Sender Freies Berlin, which can be translated roughly as Radio Free Berlin, so named to set it apart from the East German station. Operating on Channel 7, it began broadcasting in the early 1950s. It has responsibility for eight percent of ARD programming, which is devoted largely to news and documentaries, reflecting the interest of all Germans in their former capital city. Because of the special political situation in West Berlin and its relatively smaller population, the other stations of the ARD provide a grant to help support the Berlin outlet. In 1966, Berlin had about 580,000 television viewers and 910,000 radio listeners.

SFB is now completing a new television facility located adjacent to its existing buildings. This new ultra-modern center will have three large studios: one 800 square meters and two others 560 square meters each. Attached to

each studio will be control rooms for picture, lighting and sound plus staff rooms, storage areas, and construction shops. The large studio will be equipped for both color and monochrome. Several smaller studios are used for live news coverage of commentators and international correspondents.

In the control room area are five Ampex VR-2000's, equipped for color recording and playback. Two are equipped with Editec which enables inserts to be added easily into news and documentaries. An Editec equipped machine is paired with another machine in recorder stations, each machine sharing common monitoring and control circuitry. In addition, four VR-1000's, are also outfitted into dual installations.

The actual program schedule for SFB, as for all German stations, is spelled out by regulations. This calls for certain types of programming during specified time slots throughout each hour of the day and week.

Broadcasting House of Sender Freies Berlin, the first network station in Berlin.

ZDF: The Second German Network

ZDF (Zweites Deutsches Fernsehen) was born in the late 1950s during Germany's post war boom. Instead of having the state government expand their ARD stations, the federal government decided on a new national service using the UHF broadcast band. The enabling legislation for the second network sets it up as a completely separate entity, but it has some carefully defined ties to the ARD. For example, programming executives from two networks must get together regularly to be sure that the viewer has a choice of programs and that shows of a similar type will not conflict with each other in the same period. Also, the first network shares with the second the income from licensing fees paid by television set owners.

An important distinction between the two networks is the more national flavor of the second network. All of the ZDF programs originate from the headquarters and control center located near Mainz. Member stations exchange some material, and, like the ARD, broadcast their own regional news and local interest shows. But the approach and philosophy are definitely national rather than regional in emphasis.

Recently, the ZDF moved into a new color production and transmission facility close to Mainz, on a hill called Lerchenberg. The central control and distribution room fit very well into the Teutonic image of order and planning with its computer room design approach including a raised floor and concealed cable runs. To handle playback of programs for national distribution, two VR-2000's, two 16mm and three 35mm color film chains are used.

ZDF (Second Network) color broadcasting facility at Lerchenberg near Mainz. At right is a garage that houses three VR-2000 equipped mobile vans.

Also, headquartered at Lerchenberg are three color equipped mobile vans. Two have a single VR-2000, the third has two VR-2000's. These mobile vans are on the road constantly throughout Germany for sports, news events, documentaries, and on-site location shooting for dramatic presentations.

Connected by microwave link to Lerchenberg, is the ZDF news center in Weisbaden which records and relays all news programming for the network. Even local news programs from outlying stations come here on microwave or cable to be recorded on six VR-1000 recorders for later broadcast.

Most dramatic and variety programming on videotape is recorded in Munich, and to some extent at the ZDF station in Berlin. Film production is centered in Hamburg. For its tape productions, the ZDF studio in Munich is doing an increasing percentage in color using two high band VR-2000's. The Munich facility also has a VR-1000 used primarily for local news production. In total, the second German network has 24 Ampex videotape recorders extending from the VR-1000C to the high band VR-2000.

SECOND NETWORK (ZDF) FACILITIES

Headquarters: Mainz

Studios:

Berlin	Kiel
Bonn	Mainz
Bremen	Munich
Düsseldorf	Saarbrucken
Hamburg	Stuttgart
Hannover	Wiesbaden

FIRST NETWORK (ARD) TV STATIONS

Location and Resonsibility for Production of National Programs

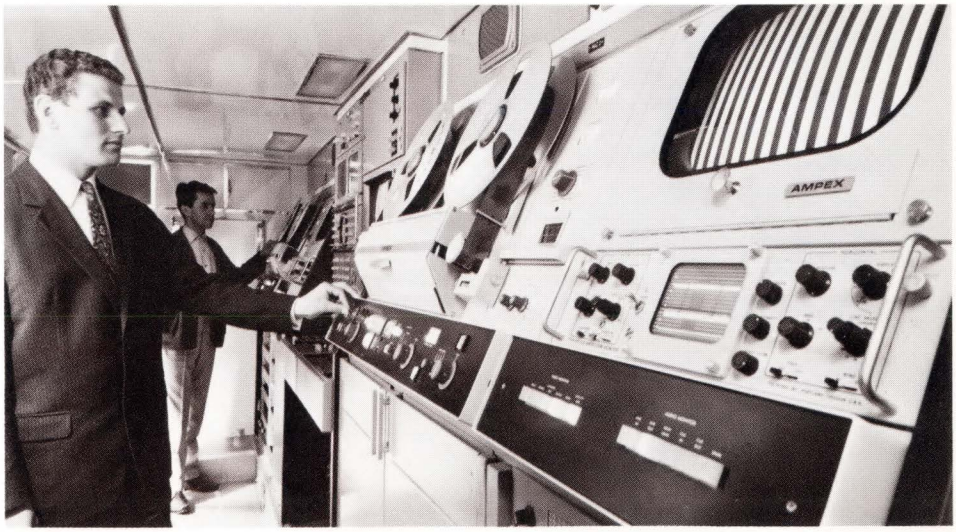
BR (Bayerischer Rundfunk) Munich 17%
HR (Hessischer Rundfunk) Frankfurt 8%
NDR (Norddeutscher Rdfk) Hamburg...20%
SFB (Sender Freies Berlin) Berlin..... 8%
SDR (Suddeutscher Rundfunk) Stuttgart.. 8%
SWF (Sudwestfunk) Baden Baden..... 8%
WDR (Westdeutscher Rdfk) Cologne...25%
RB (Radio Bremen) Bremen..... 3%
SR (Saarlandischer Rdfk) Saarbrucken... 3%

CHANNEL THREE: Educational and Cultural. A third channel in Germany operated by the ARD broadcasts in UHF in three regional areas. The regular broadcast schedule extends from about 5 pm to 10 pm each day, including weekends, from September through June. The three regions covered are north, handled jointly by the ARD stations in Berlin, Bremen and Hamburg, the central handled by HR (Hessische-Rundfunk) in Frankfurt and the south handled by BR (Bayerische Rundfunk) in Munich. Another third program is broadcast by WDR (Westdeutsche Rundfunk) in Cologne.

The Berlin station SFB provides about 20 to 25 percent of the programming broadcast on the third channel in the north. Overall third channel programs divide about half and half between education and culture. Cultural programs are more esoteric and intellectual than those on the first and second channels. For example, avant garde drama, modern dance, and language programming in English, Italian, French, as well as German for Germans is carried. Besides the ARD third channel educational programs, the ZDF has just begun a school service which is running initially from 2 pm to 3 pm each day. ■

Control and recorder room at ZFD (Second Network) color broadcasting facility near Mainz with two of the five VR-2000's located here. The entire ZFD network uses some 24 Ampex videotape machines.

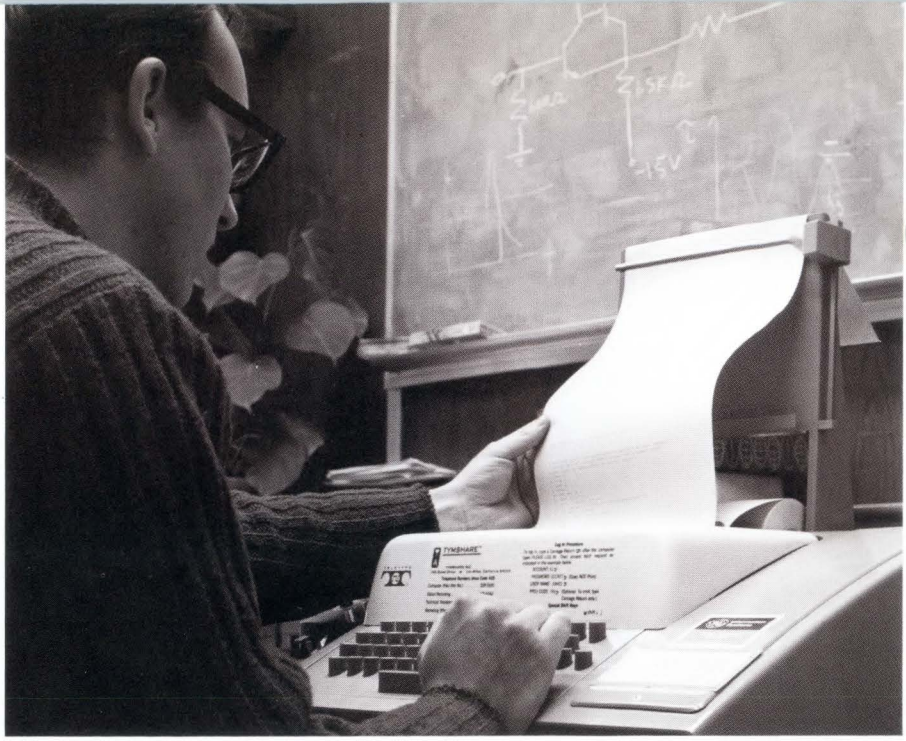
ARD/SFB (First Network, Berlin Station) recorder room in Broadcasting House, Berlin, with one of SFB's five VR-2000's. ARD stations use over 40 Ampex videotape recorders.



Interior of ZDF (Second Network) van headquartered at Lerchenberg near Mainz with two VR-2000 recorders. Two other ZDF vans each have a single VR-2000.

Computer-aided Electrical Circuit Design

by G. C. Temes, Ampex Corporation



INTRODUCTION

The growing availability of digital computers to design engineers has resulted in the rapid development of a new discipline: computer-aided design. Not only does the immense calculating power of a digital computer enable the designer to carry out the exacting analysis and synthesis of circuits on a hitherto unprecedented scale, it has also resulted in completely new design techniques and philosophies and has brought systems previously only accessible to cut-and-try treatment within the reach of paper-design methods.

In a somewhat arbitrary fashion, the operations used in computer-aided circuit design may be classified as follows: 1) device modeling, 2) network analysis, 3) tolerance analysis, 4) circuit optimization, 5) circuit synthesis.

DEVICE MODELING

Circuits containing active or nonlinear devices, such as transistors, diodes, ferromagnetic or ferroelectric elements (or even electron tubes), can be analyzed and their properties predicted accurately only if the computer has adequate information about all these devices. This information is usually provided in the form of an equivalent circuit, i.e., a network consisting of simple RLC elements and voltage or current generators. All element values of this network may depend on the various voltages or currents in the circuit.

The configuration and element values of the equivalent network may be found from experimental results or from the physical theory of the device. In either case, the computed response of the model must approximate the observed response of the device for all conditions of interest. To achieve this, several models are often used alternatively to describe the same device (e.g., a transistor) in its various regions of operation (e.g., active, cut-off, saturated).

NETWORK ANALYSIS

After all physical devices have been replaced by their equivalent circuits, the designer is left with a network containing resistors, capacitors, coils, generators and, in some cases, switches. This circuit can now be analyzed, i.e., its response to any excitation may be calculated. The programs performing this calculation can be classified as ac, dc or transient analysis programs.

Ac analysis programs compute the response of the network to a single-frequency sine wave excitation. The network is assumed to be linear, although, of course, it may contain active elements in the linear regions of their operations. The calculation itself may consist simply of establishing and solving the mesh or nodal equations. The efficient performance of this computation requires the use of the methods of topology and matrix algebra, mostly to simplify the somewhat tedious bookkeeping chores during the calculation. The techniques used to solve the linear system of equations must be a powerful one, since there may be a large (100 or more) number of unknowns.

The dc analysis of linear networks is performed much as the ac analysis. In fact, it is even simpler, since the voltages and currents may be described by real rather than complex numbers. The dc analysis of networks containing nonlinear elements (e.g., the bias analysis of a transistor circuit), however, poses a completely different and much more difficult problem. It leads to simultaneous nonlinear equations, which generally may be solved only using iterative methods, such as the familiar Newton process. The convergence of this process is by no means assured, and it may lead to meaningless answers even in simple cases. In fact, no completely satisfactory way has been found to solve this problem, although many useful methods are now available.

The transient analysis of linear networks may in principle be performed by finding the analytical solution (using, e.g., inverse Laplace transformation) and then evaluating it at specified time-intervals. It turns out, however, that this process is slow and inaccurate for large networks. Some novel techniques of system theory, using the so-called state-variables of the circuit, have proven much more effective in finding numerically the time response.

For nonlinear networks, various techniques are available. One possibility is to establish the differential equations of the circuit and then replace them with an approximately equivalent system of finite difference equations. The choice of the time-step used in solving these equations is critical. An ill-chosen time-step may lead to unnecessarily lengthy calculation or, worse still, to inaccurate results.

TOLERANCE ANALYSIS

One of the most useful applications of computer-aided circuit analysis is predicting the statistical and worst-case effects of element tolerances. The computer must be supplied with the possible upper and lower limits of all element values, transistor parameters and other circuit constants. It will then derive the possible lowest and highest values of the voltages and currents, as well as their standard deviations. A common assumption is that the element variations are small: say, less than ±20% of the nominal values. Then, the derivatives of the voltages and currents with respect to the element values may be assumed to be constants, with great simplifications resulting in the computations. For large tolerances this assumption fails; then the so-called Monte Carlo technique may be used to analyze the effect of element variations. This technique consists of repeated analysis of the circuit, with the element values randomly chosen within their specified limits. If the number of trials is sufficiently large, meaningful information may be obtained on both the statistical and the worst-case effect of the tolerances.

As an extreme case of tolerance analysis, it is easy to find the behavior of the circuit un-

der failure conditions in one or more elements, or for overloading, overheating, power-supply failure, or related conditions, in order to study or implement self-protecting features.

CIRCUIT OPTIMIZATION

The techniques described so far are analytical in nature: the behavior of a given network is calculated. Very often, the reverse of this process is desirable: to a specified response, a network should be found. For a limited class of such problems (mostly filter-design problems) analytical solution is available. However, for most practical circuits containing active elements there exists no exact, step-by-step design process. Then the iterative algorithms of circuit optimization may be resorted to.

A typical circuit optimization program requires, in addition to the specified response, a reasonable initial approximation to the circuit satisfying the requirements. The actual response of this approximating circuit is first compared with the required response. If the agreement is sufficiently good, the process is stopped. If not, conclusions are drawn (by the computer) from the size and shape of the error on how to modify the approximating circuit in order to bring its behavior closer to what was specified. The modified circuit is then again analyzed, and if necessary, further improved. This cycle is repeated as many times as necessary. Sometimes as many as 50 iterations may be needed if the requirements are strict or the initial guess is too far from the optimum. Obviously, the modifying algorithm (usually based on nonlinear programming techniques) as well as the circuit analysis routine used in the calculation should be highly efficient, or excessive computing time may result.

It is of interest to note that optimization methods can also be used in device modeling to obtain optimum match between the observed response of the device and the computed response of the model. Furthermore, "pessimization" may be used to achieve absolutely foolproof worst-case analysis, which the conventional techniques, discussed above, sometimes do not provide.

CIRCUIT SYNTHESIS

There are many important practical problems, especially in the design of filters and delay networks, which have been solved analytically. For these cases, step-by-step design procedures have been available and used for many years. It turns out, paradoxically, that simply programming these time-tested processes for the computer leads to inaccurate results. The reason is that manual calculations were restricted by human limitations to low-degree, simple circuits. In designing such small networks, the inherent ill-conditioning of the synthesis technique does not manifest itself. Using computers, circuits with up to 50 branches may be designed within a few minutes. For such large networks, especially if they are narrow-band selective circuits, the accuracy difficulties become overwhelming.

Recent efforts by circuit theorists have resulted in a novel design technique performed exclusively in terms of a nonphysical frequency variable. This new variable, in effect, transforms sharply frequency-selective networks into non-selective ones, and thereby eliminates the accuracy problem. Typically, the conventional design of an n-branch filter circuit requires n significant digits in the calculation; using the new technique, the same circuit design needs only n/4 to n/3 digits.

COMPUTING HARDWARE

The hardware utilized in computer-aided design may range from conventional batch-type computers through time-shared terminals, to highly sophisticated special-purpose design stations. In its most elaborate form, this design station may contain a small local computer with its own memory, a graphic display unit utilizing a cathode-ray tube and light pen as well as a display memory, and a typewriter for numerical input-output operations. The designer "assembles" his circuits using the light-pen from element symbols displayed on the screen, and types in his initial element values under the control of the local computer. After that, the terminal is connected to a large central computer which carries out the analysis, tolerance study, or optimization as instructed by the designer. The results are graphically displayed on the CRT (with hard copy made if desired) or typed out.

A less sophisticated, but still very useful tool is provided by the time-shared computer terminal. Here, the designer is coupled to a large computer through a typewriter and telephone lines. He is sharing the facilities of that computer with maybe 20 other users; but, nevertheless, he has nearly instantaneous access to it. In situations when a great deal of human intervention is desirable, such as in the case of cut-and-try paper-design or even optimization with dubious initial approximation, this rapid access is of great importance.

Needless to say, batch computers are eminently useful for run-of-the-mill analysis, tolerance investigation and "safe" optimization problems.

EXAMPLE

The steps followed in the computer-aided design of a frequency-selective transistor feedback amplifier may be as follows:

1. A tentative circuit configuration and element values are found by the designer.

2. The linear ac and dc equivalent circuits of all transistors and diodes are found by the designer.

3. The desired dc bias values for all active elements are postulated. The bias resistors in the circuit are then optimized using the computer to provide these bias conditions along with an acceptable power supply drain.

4. The frequency-dependent elements (L, C) and those resistors which do not affect the bias conditions (e.g., those in series with a capacitor or in parallel with a coil) are next optimized to provide the desired frequency-response.

5. Practical tolerances are established for all passive element values as well as for all transistor parameters. Using these, a statistical or worst-case analysis can be performed using the computer to ascertain whether the bias, dissipation, and frequency-response remain acceptable under normal element-variations.

SUMMARY

Computer-aided circuit design enables the designer to obtain reliable and fail-safe circuits without cut-and-try experimentation. Some tasks, such as statistical, worst-case and failure analysis cannot be performed any other way. Others, such as multiparameter optimization, are impractical without a computer.

Ampex is in the forefront of technology in computer-aided circuit design. Many of the available large-scale analysis and tolerance study programs are being utilized, and some smaller special-purpose ones have been created. A large scale, multi-purpose, modern filter design program is being completed. In addition, some pioneering work has been performed in circuit optimization, using both batch and time-shared computers.

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