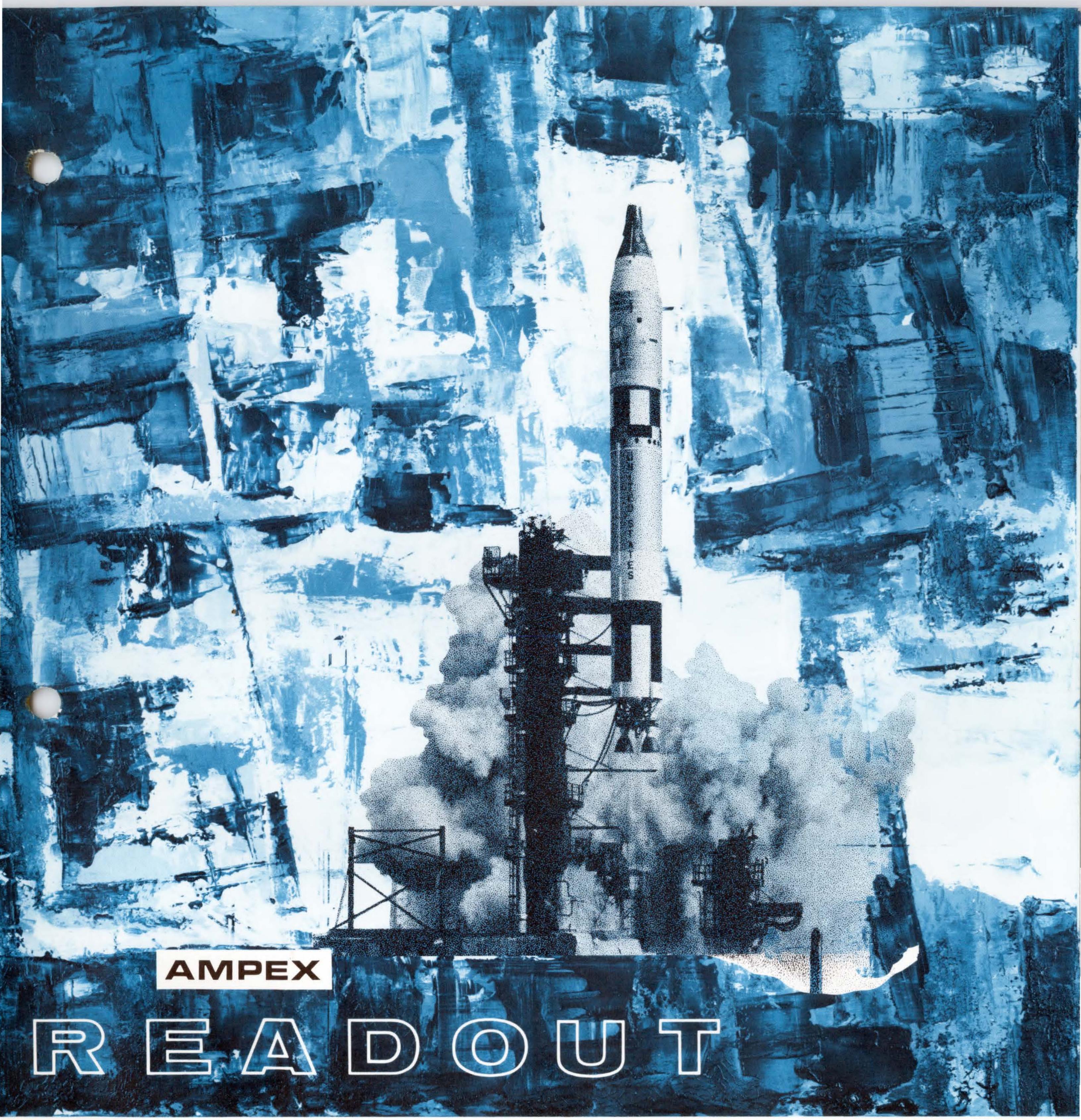


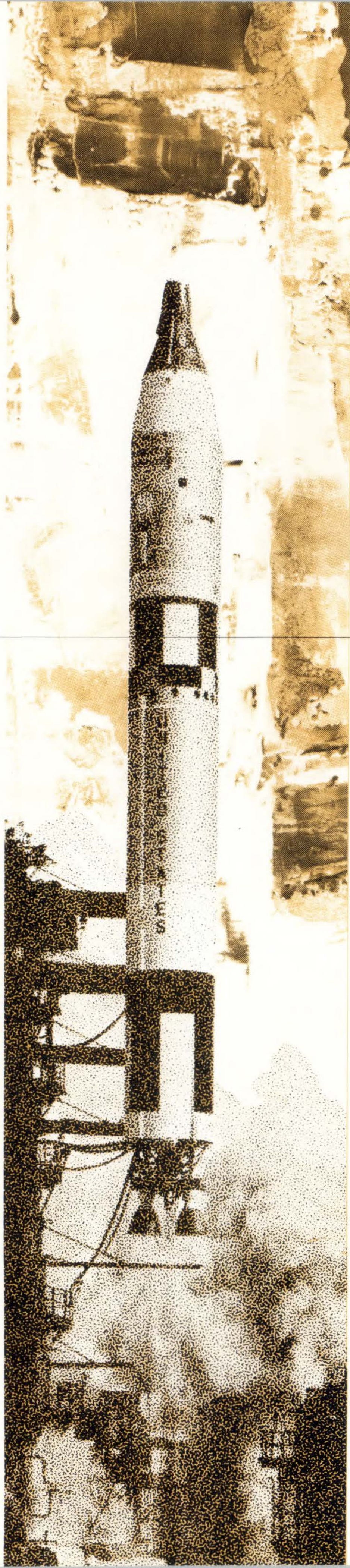
AMPEX READOUT

In this issue:

Advancing Technology in the 20th Century

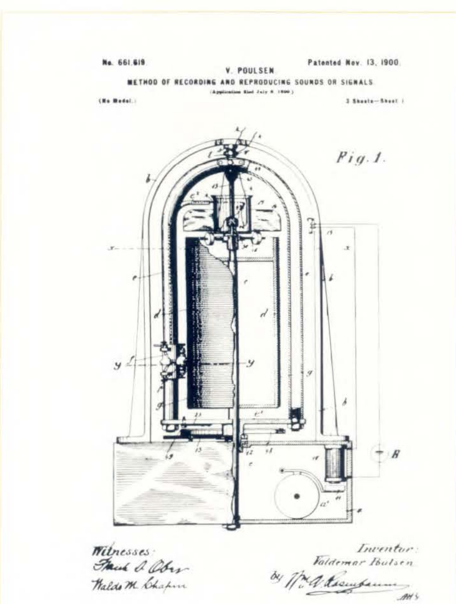
THE MYRIAD APPLICATIONS OF MAGNETIC TAPE

ADVANCING TECHNOLOGY IN THE TWENTIETH CENTURY



The Myriad Applications of Magnetic Tape

Our objective for READOUT magazine has always been to describe some of the myriad applications of magnetic recording and related technologies. In this issue, we have surveyed nearly all of the uses . . . nearly all, because new ones are being devised every day, and we're sure to have missed some.



Drawing submitted with patent application for Telegraphone by Valdemar Poulsen.

The science of magnetics, as applied to recording, is relatively new but the properties of magnetism have been known for thousands of years.[1] The effects of natural and artificial magnets on iron have been the subject of experiments and treatises almost since the beginning of recorded history. During the 18th and 19th century, Benjamin Franklin, Hans Christian Oersted, Clerk Maxwell, Samuel F. B. Morse, and Thomas Edison did much pioneering work on the relationship of electricity, both static and voltaic, to magnetics. Almost surely, such theoreticians contributed to the breakthrough by the Dane, Valdemar Poulsen. To him goes the credit for actually capturing and reproducing sound through the orientation of magnetic domains by an electric current. His first patents were obtained in Denmark in 1898 and the United States in 1900.

These early devices, called variously the Telegraphone or Microphonograph, were seen originally as having application in telegraphy and telephony. But, like the telegraph and telephone, they lacked one significant feature: amplification. DeForest's audio detector and amplifier of 1913 added the chest and lung power to the voice box represented by these early magnetic recorders. Experiments during the 20's and 30's of depositing magnetic oxide on various media were being tried by experimenters throughout the world. Oxide on paper tape was patented in 1927. Also, wire, steel tape, discs, drums, and even rubber, were attempted as recording media. Paper tape eventually won out over other media but was itself soon supplanted by plastic tape.

Magnetic recording on plastic tape was brought to a high level of development in Germany during World War II. After the war, German Magnetophons were demonstrated in this country and Ampex began its own development of a precision recorder for sound reproduction, culminating in the first professional quality recorder, the Model 200, introduced in 1947.

Since that time, magnetic recording's flawless ability to remember sound has been extended into pictures, events, temperature, vibration, seismic disturbances, numbers, and most recently, documents.

[1] For a more complete discussion of magnetics and recording see READOUT, Volume 3, No. 6, *The History of Magnetism, from Magic to Magnetic Tape.*

SOUND RECORDERS:

broadcasting, recording, and space program communications

THE NEED: Produce a device to capture sound, then play it back immediately with greater fidelity than possible before.

Typical recording session using an Ampex MR-70 master recorder. From the master tape a matrix is made from which phono records are stamped.

Gemini Control Center in Houston with Ampex recorders and duplicators are used to prepare sound and written transcripts of Gemini voice communications

Recording sound and music was the first of the myriad applications of magnetic recording and is still the most familiar one to the general public. Sound recording began with Thomas Edison's acoustical horn, then progressed through electrically amplified disc recording to magnetic recording.

One of the very first uses of magnetic recording was by radio stations to replace disc transcriptions. Transcriptions allow stations to broadcast national programs at a time most suitable to the listening audience in each time zone across the country. However, the marginal sound quality, difficulty of editing, and the short life of disc transcriptions was always a problem. Magnetic tape filled the need with improved fidelity and thousands of replays without loss. It also added the important new advantage of instant playback of the tape during program production for a quality check and editing.

Philco's Radio Time, starring Bing Crosby, was the first program to be transcribed on magnetic tape. Crosby, interested in improving the fidelity of his broadcasts, learned of Ampex's plans in 1947 to sell a professional magnetic recorder. After a successful demonstration, Crosby financed production of the first 24 units and placed some of them in the American Broadcasting Company studios. He then immediately made arrangements to have his company, Bing Crosby Enterprises, Inc., become Ampex's first sales distributor. The remaining recorders were placed in key network stations in the four U.S. time zones so that each broadcast would retain the live quality of the original tape. Cost of the equipment and magnetic tape was considerably less than that for disc transcriptions. But of greater importance, with magnetic recording the job of rendering the Philco show became much simpler. The tape could be stopped and started at will; it could be cut, spliced, dubbed and re-recorded without affecting the quality of the final result. The program director found that he could lift a sequence from one show where for some reason it didn't fit, and drop it into another show at a later date. All this could be done so quickly that it became possible to produce several shows in one week giving everyone a rest.

Master recording for phonograph records was another early use of magnetic recording. Here the superior fidelity and the instant playback feature were of such importance that almost immediately magnetic tape was adopted for all master recording for phonograph records. Besides instant playback, the longer playing time offered by magnetic recording means that in longer musical selections the orchestra doesn't have to stop so that a disc can be changed.

As for other uses the first Ampex recorder and its successors have been put to, even a simple listing would fill this entire issue. We have chosen a recent application from the space programs to serve as an example of the reliability and the sound fidelity of audio recorders today.

"Now . . . recorded news from Gemini"

By now, most of us take as commonplace our ability to hear the voices of the astronauts and ground control during space flights. Helping to make this possible is the Public Affairs Office at NASA's Manned Spacecraft Center in Houston. Here, eleven Ampex professional audio recorders and five tape duplicators have the prime responsibility of servicing the news media covering the mission. Every word of air/ground communications between the astronauts and the ground controllers or CapComs is recorded in Real time. Most of the time either simultaneous live release or five-second delayed release is made to the radio/TV networks. A separate recording in five-minute segments is made for rapid typed transcription. Also, it is simultaneously voxed on another bank of recorders to eliminate dead air in those portions that are requested for later dubbing and distribution by various segments of the news media. The original, non-voxed masters are maintained as a permanent historical record. These recorders operate 24 hours a day during the entire mission.

DATA:

man's first look at Mars

THE NEED: Provide a means of collecting vast quantities of test data in a form that can be used with any analytical technique including high speed analog and digital computers.

Recorders Go Scientific

Pinning down the exact time when the early audio recorders were first used to record data is not easy, but it seems to have been quite a bit earlier than many of us would have imagined. The first instrumentation recorder was a modified Ampex Model 301 audio recorder with the serial number 191. It was delivered to the Pacific Missile Range at Pt. Mugu, California (which at that time was called the Naval Air Missile Test Center) in November 1948 for use by Raytheon Corporation in recording some of the early tests on such missiles as the Lark and the Spiro.

The capabilities brought to data recording by Old 191 and its successors are impressive. Perhaps most important, magnetic recording is a dynamic storage medium offering a very wide frequency and dynamic range with low inherent distortion. It preserves data signals in their original electrical form permitting later analysis by the most simple manual devices or the most complex computers, as required by the actual test or experiment itself.

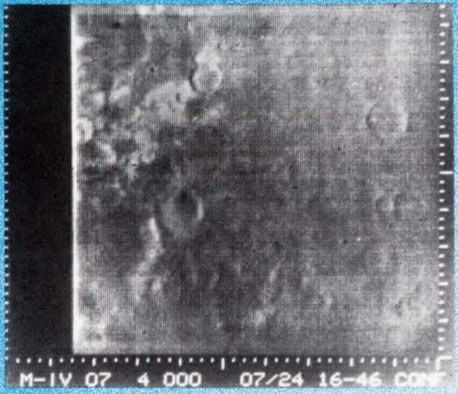
As with audio recorders, data on tape is available for immediate play with no time lost for processing. Tape offers multi-channel recording with the ability to record many million data points on a single channel of tape. Finally, tape provides something which no other medium can, the ability to slow down or speed up the data to match it to the requirements of data processing equipment.

In the instrumentation field, any measurable phenomena, such as those occurring in electricity, mechanics, hydraulics, or physiology, can be recorded on magnetic tape. Just as the instrument panel in your automobile tells you the condition of the motor, generator, gas tank, and other parameters, so the test engineer records this information so that he can compile and analyze the actual performance of a unit under test in a wide variety of changing conditions. With multi-channel magnetic recording, parameters such as temperature, acceleration, vibration, shock, or altitude, can be monitored simultaneously to see the affect of one upon the other.

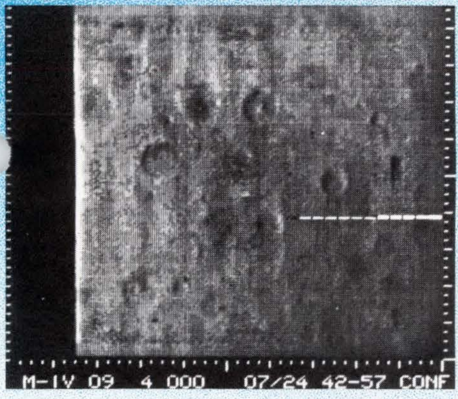
In aircraft and missile testing, the first area where recording was used for data recording, the sheer quantity of data is truly staggering. In the early days of flight tests, the pilot would read the instruments on his control panel, noting his observations on a pad strapped to his knee. As design techniques were refined, test engineers needed more and more data. Measurements were first brought to meters mounted on a panel which was photographed by a motion picture camera. Later, graphic recorders using pen and ink or oscillograph traces on photographic film permitted continuous recording of high frequency information such as vibration and flutter. Many of these techniques are still in use, but the demand for even more measurements and more rapid analysis lies behind the growth of magnetic tape instrumentation.

Today, instrumentation recording is widely used for telemetry (from satellites, missiles and aircraft), static testing, radar and radio transmissions, physiological data, and industrial environmental testing.

NASA/JPL's 210-foot tracking and communications antenna now in use will extend man's radio range to the outer limits of our solar system. Energy as weak as one-billionth of a billionth of a watt can be received by this new antenna.



Man's first pictures from Mars were recorded here at the Jet Propulsion Laboratory, on two of the Ampex FR-1400 recorders at the right. Primary recording was done simultaneously by two other FR-1400's at Goldstone Tracking Station.



Old 191, the original instrumentation recorder, in a photograph taken on its tenth anniversary in November 1958, when it was still in use at Pt. Mugu, California.

Man's First Look at Mars: Pictures from Numbers from 135 Million Miles Away

Magnetic tape is a primary data acquisition technique for recording telemetered information radioed back from satellites and probes. In general, this information is divided into three categories: The first is engineering or housekeeping data about the performance of the satellite itself, its temperature, the condition of its batteries, the position of its antenna. The second is the scientific data which is the object of the mission: pictures of the moon, data on the surface of Venus, radiation belts in space, or the physical condition of an astronaut 100 miles above the earth. The third is command data used, for example, when instruments will be turned on or direction changed.

A dramatic example, perhaps surpassing even the recent pictures from the moon, was the Mariner IV pictures telemetered from Mars, a project of NASA's Jet Propulsion Laboratory in Pasadena, California. Consider what had to take place for man to get his first close-up look at Mars. First the spacecraft made a seven and one half month, 350 million mile trip and stayed unerringly on its course. Its ten-watt transmitter (one hundredth to one five-thousandth of the power of your local television station) sent back intelligible data from a distance of 135 to 155 million miles (in a direct line) from the earth. At a point 20,000 miles from Mars, it was commanded from the earth to switch on its cameras. Then at 10,000 miles from Mars, the now famous picture taking began. Since the spacecraft was at that time 135 million miles in a direct line from the earth, the first signals, even though travelling at the speed of light, took 12½ minutes to arrive at JPL's Goldstone Tracking Station in California.

At Goldstone, the data was recorded on magnetic tape in the form of a six digit code of 0's and 1's (binary bits). These represented a scale of 64 different light levels in digital form taken by the camera as it scanned the surface of Mars. Each picture contained nearly a quarter of a million bits, and took eight hours to transmit at the slow transmission rate used. The coded data was recorded on two Ampex FR-1400 instrumentation recorders, redundantly on two tracks of each recorder. Simultaneous back-up recording by means of microwave link was done on two more FR-1400's in Pasadena at the Jet Propulsion Laboratory. Additional tracking stations at Johannesburg, South Africa, Madrid, Spain and Woomera, Australia, provided additional backup. After computer processing, the result was 21 close range portraits of the mysterious surface of Mars plus data to determine if Mars has a magnetic field, and its atmospheric density. Receiving and recording all 21 pictures took approximately nine days. The pictures covered 288,000 square miles with details 50 times larger than that which had been viewed telescopically. Details as small as two miles wide were visible.

TELEVISION: the miraculous time machine

Television recording in a commercially acceptable form didn't exist at all at one point in time and an instant later emerged full grown to astound the world. Recording pictures had been tried for several years after the introduction of sound recorders in the late 1940's. Then in 1956, Ampex climaxed a four-year top secret engineering project by introducing its VR-1000 Videotape Recorder. This recorder immediately became a kind of science fiction time machine that eliminated those time zone lines on the map of North America. Following its starring role as a time machine it stepped into its other major role, that of a teleproduction device. For the first time the broadcaster and program producer had an electronic device for an electronic medium. It recorded pictures and sound electronically and, most important, played them back an instant later without development or processing. Several important accessories followed, the most significant probably being electronic editing, which permits spliceless frame by frame editing for program assembly and animation effects.

The growth and uses of the videotape recorder in broadcasting have grown as television has grown. Today, videotape recorders deliver approximately half the television programs you watch on your receiver. In particular, the recent upsurgence of color has been paralleled by the development of high band recording and the acceptance of the Ampex VR-2000 and VR-1200 high band recorders. High band recording has not only improved color, but perhaps of more significance, it has permitted production companies and broadcasters to make multi-generation tape copies with no loss in quality so that they can guarantee master quality in all markets.

Studio control room during color teleproduction of the Lawrence Welk show on Ampex VR-2000 recorders.

The Isolated Camera: How to be a Monday Morning Quarterback on Saturday Afternoon

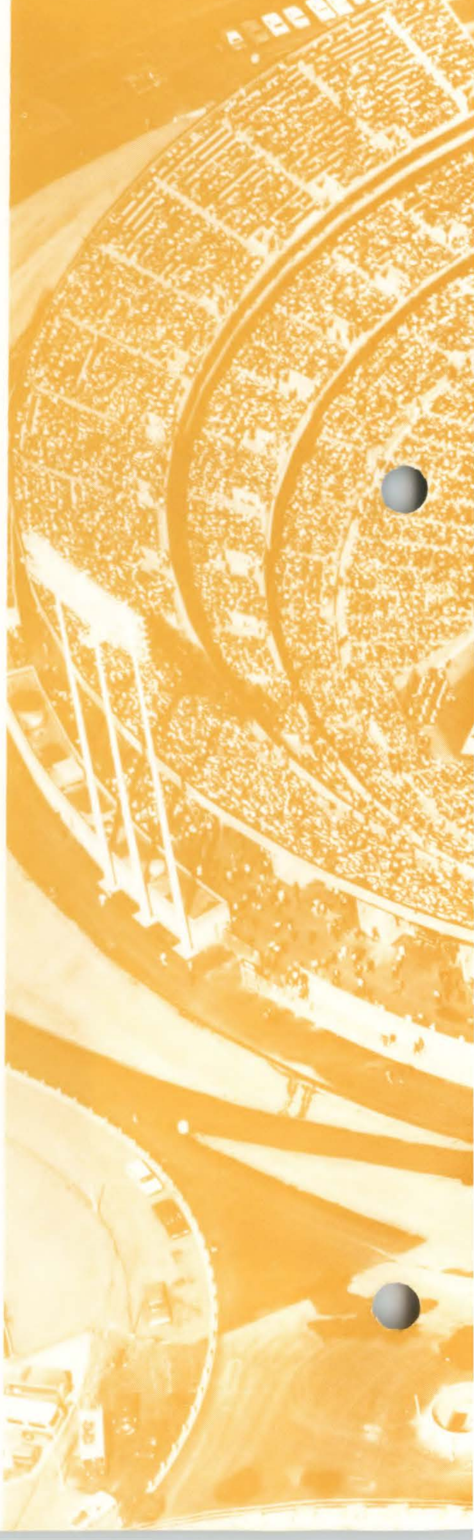
The now familiar phrase, "Let's look at that play on the isolated camera" has allowed all of us to become Monday morning quarterbacks on Saturday afternoon. Widely used in football and baseball telecasting, the secret to the isolated camera technique is in reality the videotape recorder. Network football broadcasters began several years ago playing back recorded highlights of the game during half time and immediately following the game. Then in the 1964-65 season the technique was extended as the so-called isolated camera.

In actual practice the camera may or may not be isolated. In football, one of four or five television cameras covering the game is assigned to follow the direction the ball is most likely to take. It may key on a flanker, a running back, or an end going downfield for a pass. A former football player or knowledgable sports writer is assigned to second guess the quarterback and anticipate the type of play to be called. In baseball the principle is similar. The isolated camera will concentrate on the man on first who may steal second, while main cameras follow the pitcher and batter.

What follows is a unique zoom-in look at the heart of the play. To record the isolated camera coverage, broadcasters may either use a portable tape recorder on site at the stadium, or they may feed the isolated camera signal back to the studio and record it there on a second recorder (in addition to the one that is recording the entire game). In either case, an operator simply runs the tape back to the beginning of the play and stands by for the sportscaster to call for an instant replay.

This added dimension of television sports viewing is a logical extension of the inherent ability of videotape recorders to replay programming immediately. Originally thought of primarily as an advantage in production of television material, instant replay has now become a standard feature in almost all football and baseball broadcasting and will likely be extended to additional sports in the future.

THE NEED:
Develop a device that reco[rds] both picture and sound to provide television with instant playback in producing program material and original quality tape copies so that everyone can see national programming at the same time in each time zone.



GABRIEL MOULIN, JR.

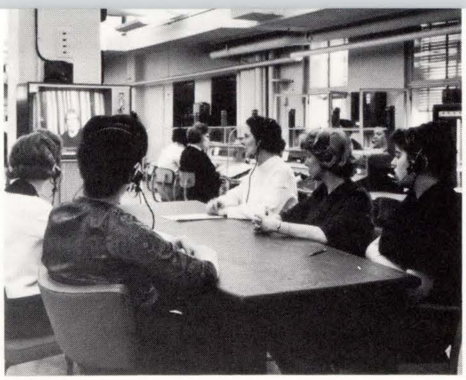
CLOSED CIRCUIT TELEVISION:

more learning for millions

THE NEED: Produce a low cost, easy to operate device to replay instructional material on a flexible schedule, provide better quality and uniformity of instructional material, spread the time and talents of teachers to reach more students, and present close ups for an entire group of people to see without crowding or loss of attention.

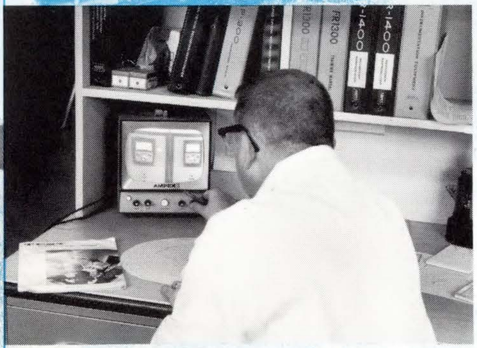
Mobile television production van used by KUON at University of Nebraska for on-site recording.

A chemistry experiment captured on video tape.



Telephone operators at the New England Telephone and Telegraph Company receive training during slack times via video tape.

Producing an industrial training tape at Eastern Airlines.



Watching a shake table via television during environmental testing.

New Communications Tools

Magnetic recording as a communications tool for instructional purposes is a relatively new but logical outgrowth of the uses of television and audio recorders for broadcasting and recording. The real catalyst has been the introduction of lower cost, easier to operate, videotape recorders which enable schools and industry to produce their own instructional materials and exchange materials with other institutions. Production of specialized training tapes is simpler and cheaper than film production. Obsolete tapes may be updated or erased and reused hundreds of times.

Applications of tape recorders in instruction are manifold. Universities, secondary and grade schools use videotape and audio recorders for recording and playing back the instructional programs made in their own studios or aired by educational television stations. They record and analyze classroom activities. They play instructional tapes borrowed from central educational libraries. The courses include music, art, science, engineering, physical training, physical therapy, sports, vocational counseling, and education.

Industry, too, is turning more and more to magnetic recording for the task of training and increasing employee efficiency. Production workers, sales people, maintenance and operations personnel, switchboard operators, airline stewardesses; these are a few examples of the many groups now receiving training with the assistance of magnetic recording. Prerecorded demonstrations or proper job procedures are shown to employees at any time without darkening the room, and in many cases at the employees own work station. Or, a trainee is recorded performing a task, then given an opportunity to see how well he did.

Medicine also has widely benefited in various ways from magnetic recording. Fluoroscopy recorded on videotape recorders shows a moving X-ray picture. Psychiatrists record patient interviews. Delicate operations are recorded for study of surgical techniques. Hospitals tape public health and post partum programs for patient viewing. The military uses magnetic recording for a variety of training functions ranging from landing an airplane on an aircraft carrier deck to assembly and disassembly of the common rifle.

Nebraska Goes Statewide with Television

With the increasing exchange of taped instructional material between schools and industrial facilities, standardization has become a very important factor. An illustration of how one organization has attacked the problem on a statewide level is Nebraska's educational television network. Extending to all levels of academic and adult education, Nebraska's network arose from a five-year study which established the now commonly accepted fact that television helps teachers teach better. Preceding the formation of the network, station KUON at the University of Nebraska, one of the original educational television stations, now serves as the hub and primary production center for the entire system. During the past year, KUON produced approximately 400 taped programs for instructional and non-instructional broadcast. In addition, since mid-1966, 105 tapes were produced using the new mobile production van built and equipped by Ampex.

By late 1966, five stations in a planned seven-station network were in operation. On elementary and secondary level, 34 courses and course guides are broadcast to kindergarten through high school in some 217 public and private schools with over 107,000 students. Additional in-service programming keeps teachers abreast of the latest curriculum and methods.

On the university level, all 24 of the Nebraska higher educational institutions share expert instructors and specialized teaching aids by means of programs on magnetic tape. Subject matter extends through all academic disciplines: language, math, science, humanities, medicine, nursing.

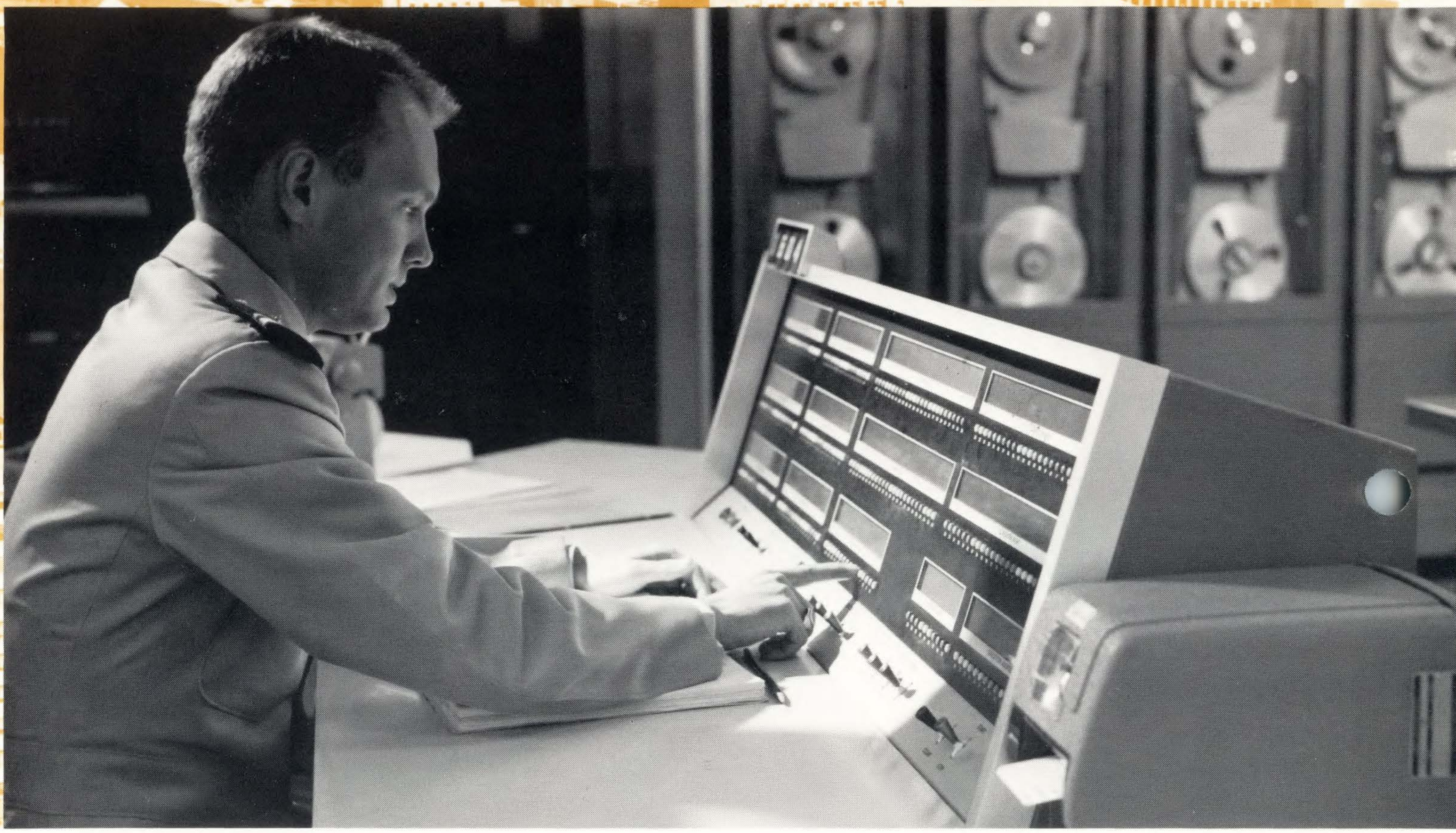
Part of the overall complex in Nebraska is the Great Plains Instructional Television Library, largest instructional television exchange center in the world, which provides taped materials not only for Nebraska but the entire nation. In 1966/67, this pioneer facility booked over 6,400 lesson units to educational institutions throughout the country. At this time, Great Plains has 77 complete courses and teacher guides.

Nebraska's success in bringing statewide organization to its instructional television is being echoed by similar networks in the neighboring states of Kansas, Colorado, South Dakota, Iowa, and Missouri. Possible interconnection between the nearby state networks is now under study. In other parts of the country, New York and Texas have established similar statewide networks.

GABRIEL MOULIN, S.F.

NUMBERS AND WORDS: computer language on tape

THE NEED: A large capacity memory to store more information than punched cards or paper tape, and then read the stored information out fast enough to match the high computation rate of digital computers.



Computer control console of weather forecasting system.

HOME ENTERTAINMENT:

capture the kids on tape

THE NEED:
Provide simpler, less expensive versions of professional audio and video recorders for use in the home.

Sound & Video Recorders for the Home

In the years following development of professional audio and video recorders, scaled down and simpler versions of these machines were being adapted for the home market. Initially quite expensive, they are now being produced at a cost that will soon make it practical for many families to have a complete home entertainment system. Besides the familiar audio recorder for replaying stereo tapes, recording FM stereo broadcasts, children's voices, and the local teenage b[illegible], the most intriguing part of a home enter[illegible]ment system is the videotape recorder. With

Typical computer room in a manufacturing facility where payroll records, inventory, and related information is handled.

Ferrite cores during the early stages of manufacture.

Fresh from its success in sound, television, and instrumentation recording, magnetic recording, in the form of tape and ferrite cores, was next put to use to record digital codes for computers. These codes are made up of numbers, letters and other characters in the "O"/"1" or binary language of digital recording. Binary language was chosen when computers were being converted to electronic form from their mechanical predecessors during the 1940's since electronics is basically a two state system: positive and negative. In electronics, a change can be made from a positive to negative state millions of times a second, so the advantage of devising a two state numbering system which could take advantage of this speed is obvious.

At first, computers were used primarily to solve scientific problems. In fact, they were originally called electronic brains. (A better name today would be an electronic accountant, inventory control system, or records center.) They solved complex equations on the motion of heavenly bodies, the structure of the atom and other studies in higher physics that would take tens or even hundreds of years for trained human brains to solve. But gradually, they came to be used more and more by business, finance and industry. Today, they perform their sorting and computational feats for banking transactions, payrolls, weather prediction, insurance records, and address labels for magazines (to name a few).

Magnetic recording, both tape and ferrite core, was adapted to computer usage because it can store more information (has a higher bit packing density) than paper tape or punched cards. Equally important it can read and write this information faster than other storage devices (has a higher transfer rate). Access speed, another key parameter, is especially fast with ferrite core memories, which Ampex, with its experience in magnetics, has developed in parallel with its tape memories. Core memories are used for shorter term storage of characters and numbers during the actual computation itself. They can read and write in a random mode at microsecond speeds in contrast to magnetic tape where random access in the larger memories can be limited by the serial recording format which may require end to end search of the tape.

As digital computers themselves have become faster and faster, magnetic devices and magnetic tape have been developed to match their higher speeds. In the case of tape memories, several years ago 200 characters per inch was considered to be the maximum amount of information that could be packed on a piece of computer tape. Before long this was raised to 560, then to 800 cpi. Newer systems now operate at 1600 cpi.

Freeing the Computer for Computing: Media Conversion Systems at Work

As speeds have increased, so have the size, complexity and costs of operating digital computers. Whereas a magnetic tape recorder can feed a digital computer at a speed approximating its maximum speed, much data is still retained in the form of paper tape and punched cards. These cards and tape must be sorted and read by peripheral equipment which operates at relatively low speeds. Output of this peripheral equipment is commonly a magnetic tape in the properly coded format to be fed directly into a computer at high speed. In some cases, a smaller supplementary computer is attached to some peripheral card sorting and paper tape reading devices to prepare this input tape without tying up the main frame computer.

A recent solution to this problem is Ampex's media conversion systems. One type converts the data on punched cards to computer ready format on magnetic tape. Another type converts data on punched paper tape to magnetic tape. In either case, the entire conversion is done off-line by a relatively low-cost device without tying up the computer itself. Input speeds to the computer can be increased by about 120 times for paper tape and 2 to 3 times for cards.

these recorders you can make instant home movies for playback through your televsion receiver. Home videotape recorders now record and reproduce black and white pictures; they will soon be extended to color recording. Besides home movies, television programs themselves can be recorded and played back with the home video recorders. Some immediate uses for these new devices are recording programs off the air for viewing at a later time, preserving programs for a permanent file, practicing business and school presentations with instant replay to check on your manner and approach, and making your own visual history books with family scenes.

The Videotape Recorder in use in the home

DOCUMENTS:

automating the paper avalanche

THE NEED: Devise a filing system from which documents can be retrieved in a matter of minutes from a nearby or distant location and compress the entire system so that it occupies a fraction of the space required for conventional files.

A Videofile system operating console for filing and retrieving transportation waybills.

Title insurance executives with a remote viewing station in their office.

Television Meets the File Cabinet

After the development of the videotape recorder and video accessories which enable frame by frame editing, recording documents on magnetic tape was the next logical step. This revolutionary new development is called the Videofile* Document Filing and Retrieval System. The first system has been delivered to Marshall Space Flight Center in Huntsville, Alabama. Additional systems are now being developed for Southern Pacific Railroad and the Bell Telephone Laboratories.

In television, pictures are created by a spot which moves across the television screen to create lines. The number of lines in the picture determines readability. With a Videofile system a television camera or scanner photographs each document and records it electronically on tape as a television picture or image. Each picture occupies one television frame.

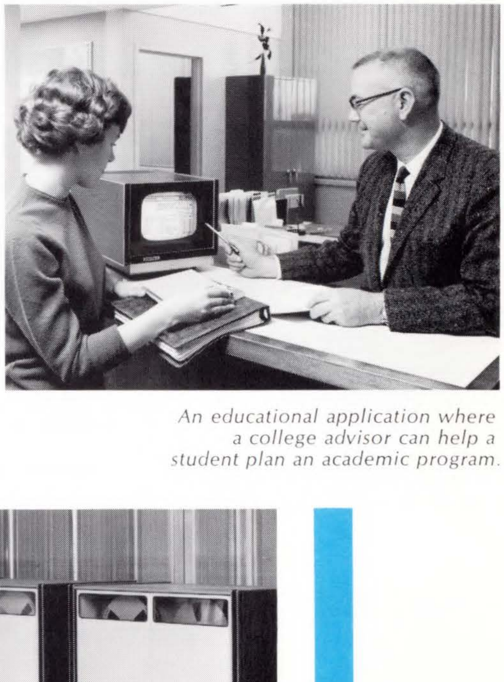
With the Videofile system, the actual document image itself is recorded: no translation into digital computer language is necessary. Once filed, retrieving the documents is quick and easy. It can be reproduced as a printed page (hard copy) or viewed on a television screen (a soft copy). The average time to find a document in a typical Videofile system is less than one minute. Documents may be viewed simultaneously at many locations and kept up to date with the push of a button.

Especially important, no document is ever out of the file or lost. Documents are legible (so that in many cases the original paper copy is not needed). In terms of cost, Videofile systems can in some cases be half as expensive to maintain as large conventional filing systems, depending on usage and organization.

*TM AMPEX CORPORATION

Uses of Instant Television Filing

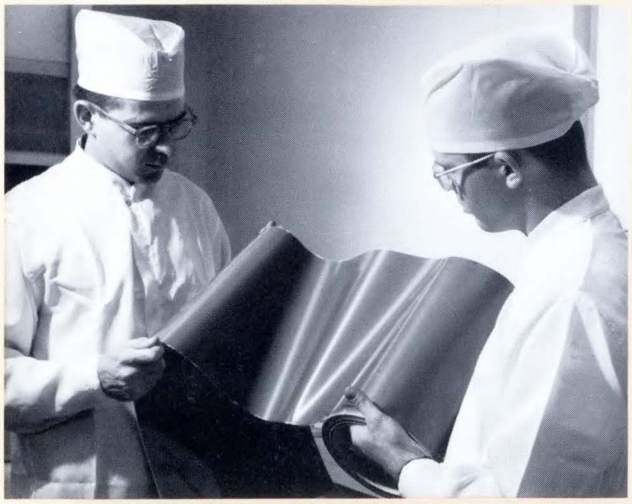
Nearly any file could benefit from this automated system. Among the best examples of those that could profit immediately are the vast file departments with heavy daily usage found in vital statistics bureaus, the transportation industry, insurance and title companies. Other applications are banking files, charge accounts, credit files, employee records, medical records, research libraries, intelligence files, motor vehicle records, criminal files, and court records.

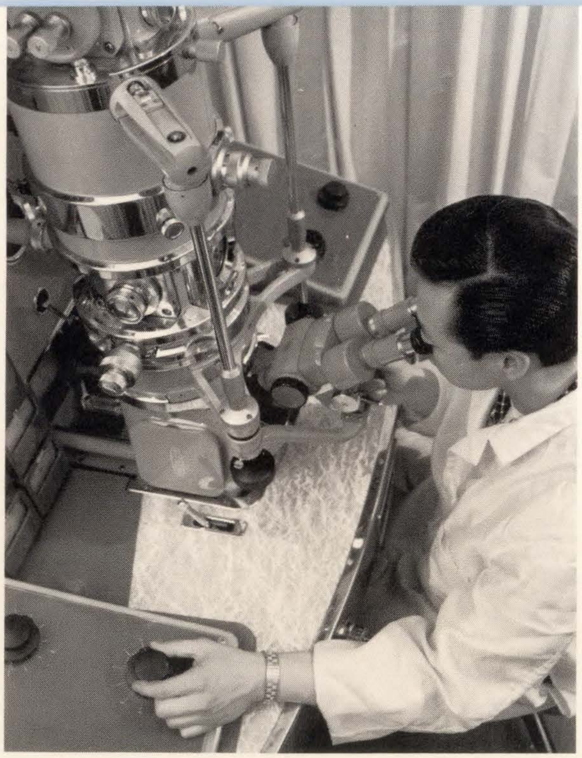


An educational application where a college advisor can help a student plan an academic program.

Overall view of a typical Videofile system.

One of the clean rooms in the Ampex Tape Research facility where oxide formulations are tested for specific use in audio, instrumentation, video and computer tapes.





An electron microscope used by Ampex tape researchers to study surface characteristics of magnetic media.

TAPE: the magic medium

THE NEED: Find a suitable material which is naturally magnetic or on to which a magnetic coating can be desposited, to serve as a recording medium which can be magnetized easily (and will remain magnetized) after exposure to a fluctuating magnetic field.

Steps in Tape Manufacturing

Today, there are four basic types of magnetic tape: audio, video, instrumentation, and computer. Each is manufactured with the same basic principles. In tape manufacturing, the three most important variables are base film, oxide, and binder. These are interrelated, and must be controlled at all times. The base film is commonly polyester plastic. Acetate is still used to some extent, but for precision tapes polyester has largely replaced it. Oxide is a uniform coating of minute magnetic particles contained in a binder. The exact formulation of oxide and binder may involve some 20 or more chemicals, the secret being in how much of each is used. Oxide particles do not occur in a natural state, but are grown in a culturing process to assure uniformity. During processing they tend to cluster and must be separated for uniform coating and even dispersion. The binder has two functions: it causes the oxide to adhere to the base, and it causes the particles to cohere with each other. Within the binder, the particles of oxide are like almonds in a candy bar. Added to the oxide and binder formulation are the 20 or more other chemicals to prevent brittleness, reduce dust collecting static charges, break down surface tension, lubricate the surface, and make mixing and drying easier.

After arriving at a satisfactory oxide formulation to meet wavelength and wear requirements, the next problem is coating it onto the tape. One method is knife coating which is an extrusion process in which the coating is deposited on the tape, then the tape is pulled beneath a sharp edge to smooth out the coating. Another process is rotogravure in which the oxide is rolled onto the tape in much the same way that ink is applied to a roller in a printing process. After coating, the particles are oriented during drying and the tape is dried.

To finish the surface the tape can be buffed or burnished with a brush or passed against itself between pressure rollers to knock off any high spots. This has the disadvantage of exposing bare oxide (like chipping the chocolate off the almonds in a candy bar). Ampex uses a non-abrasive technique of ironing and reshaping the surface of the tape for uniform smoothness in the manufacture of FERRO-SHEEN* tape.

Slitting the tape into the proper width is the next step. This must be perfect in all respects. Several methods are used, most of which are proprietary to each tape manufacturer. Packaging is the last step. This is critical too, to keep out dust and prevent damage during shipping.

Testing for Each Application

The manufacturing process is basically the same for all types of tape. Oxide formulation may differ depending on the wavelengths to be recorded. But perhaps the major difference in manufacturing is the electrical testing, which is directly related to the application.

In computer applications the primary consideration is reliability and minimum dropouts. With computer systems, information is conveyed in small bits which if not recorded properly will cause an incorrect number or character to be read out. In testing computer tape, thousands of individual readings are taken at very small intervals throughout the reel of tape. In contrast, with instrumentation recording, dropouts are less critical because an analog recording technique is used where a continuous change rather than a single discrete bit is being put on tape. Instrumentation tape testing is primarily concerned with the overall continuity of the surface and the response at several short and long wavelengths rather than with dropouts. For video recording, Ampex uses 100% testing in a method almost as comprehensive as for computer tape. Normally a 5-MHz video signal is recorded and dropouts counted throughout the reel. Audio tape is perhaps the least critical in terms of testing. It is normally done on a sample basis because the wavelengths recorded are much longer than in instrumentation recording. Dropouts are less critical than in computer or video recording, since the ear tends to reconstruct the signal if a single point is missing.

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K-FACTOR TESTING . . . A NEW TECHNIQUE IN VIDEO SYSTEMS

By Joseph Roizen, Ampex Corporation

To completely test the electrical characteristics of a video system it is usually necessary to use several instruments. Band pass and frequency response can be determined by a sweep generator. Transient response is usually tested with some form of step function signal such as square waves. Differential gain and phase require specialized equipment with appropriate display devices. The process is time consuming and complex and requires costly equipment for both generation and interpretation of test signals. In most cases, if the equipment under test is in good condition, nothing but the fact that no defect exists is proven.

To simplify video systems testing and reduce the time involved, a single signal (with a proper interpreting device) the Sine squared pulse and bar method has been developed. A special graticule attached to the scope, interprets the signal on a percentage performance basis, providing a direct readout method that can be easily assessed by even non-technical personnel.

Basically, the Sine squared pulse and bar consists of a test signal that is generated as a narrow pulse and a step function square wave (Figure 1). The signal is then applied through the proper gaussian response filter with linear phase and smooth rolloff. The output of the filter consists of a pulse and bar calibrated in T increments and measured as the half amplitude duration of 0.125 microseconds with an upper frequency component of 8 MHz at the corners (Figure 2). A 2T pulse, which is more commonly used in normal American standard television systems, will have a half amplitude duration of 0.250 microseconds and its cut-out frequency is at 4.0 MHz. Foreign standards such as the 625/50 TV system would use a half amplitude duration of 0.2 microseconds and a corner frequency of 5 MHz. The calibrated rise time of the bar is very near the half amplitude duration of the pulse and therefore has essentially the same slope (Figure 3). The low frequency bar has been included in this test signal since the Sine squared pulse alone would not be adequate for the complete check. This particular signal is especially suitable for measuring videotape recorder systems since it has energy only in the bandpass area of the videotape recorder.

It is difficult to test a video recorder with square waves because a very fast rise time pulse will simply meet with what is known as the "brick wall response" of the filters and the limitations of the modulator in the recorder (Figure 4). In this case, the output of the recorder will simply contain very severe overshoots and ringing which will give no indication of system performance at the desired frequencies. If, however, the applied test signal is within the bandpass characteristics of the recorder and a properly calibrated graticule is applied to the scope, it is very simple to determine a K rating factor which gives the overall performance of the machine by analyzing the pulse shape, the bar shape, and the pulse-to-bar ratio.

In transverse videotape recorders especially, where four channels are being considered, the comparison of the pulse and bar signal from each of the four head channels would allow the operator to optimize the channels to each other so that they are all identical. The test signal is first adjusted so that the half amplitude points on the scope match those required by the graticule. Modern waveform monitoring oscilloscopes (such as the Tektronix 529) automatically have the proper sweep rates so as to produce the right half amplitude duration on the graticule supplied with the scope. Once the pulse and bar have been adjusted to the correct amplitude and width the output of the recorder may be utilized to determine how accurately the video recorder is reproducing the signal. The K-factor is then determined by whether the reproduced signal falls within the various calibrated lines on the graticule (Figure 5). A 2% K-factor would be considered very excellent, 4% reasonably adequate for most video band width systems, and anything falling beyond that should be suspect and other maintenance checks must be applied to determine where the defect exists.

K-factor testing therefore is mainly a very rapid means of evaluating the performance of a system without having to go into a great deal of complex and time consuming operations. It is very important that the input signal be of the proper shape and amplitude and not have any rings built into it, since these will greatly affect the ability to read out accurately the performance of the system under test. For color television system testing, new K-factor signals including sub-carrier mixed in with the test pulses are presently being developed.

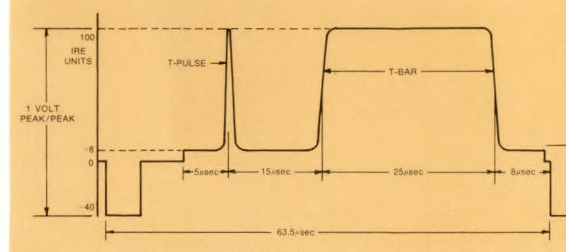

Figure 1. Typical T-pulse and bar signal used in K-factor testing.

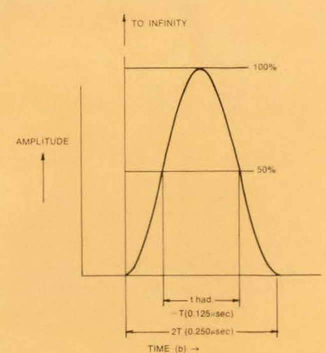

Figure 2. T-pulse signal showing t of 0.125 μsec and 2t of 2.250 μsec.

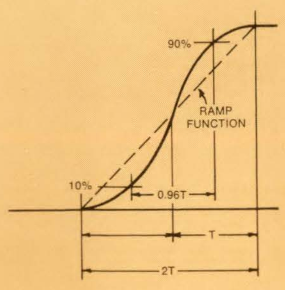

Figure 3. Transient response of T-bar signal.

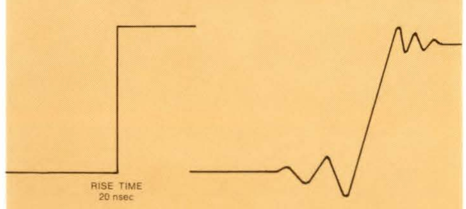

Figure 4. Fast rise time square waves are not suitable for testing because the "brick wall" response of the filters will cause severe ringing.

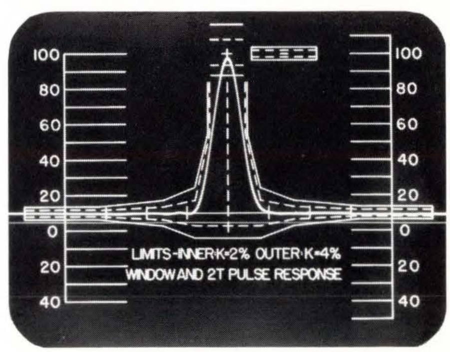

Figure 5. Output waveform showing Sine squared pulse and bar testing of an Ampex VR-2000 Videotape Recorder. K-factor is 0.75%. Special graticule mounts on oscilloscope.

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