AREA B

"Record Protection in an Uncertain World"

WORLD CONFERENCE ON RECORDS AND GENEALOGICAL SEMINAR

Salt Lake City, Utah, U.S.A.
5-8 August 1969

STORAGE DEVICES - THEIR POTENTIAL AND RELIABILITY

By

Frederick W. Babbel

STORAGE DEVICES - THEIR POTENTIAL AND RELIABILITY

By

Frederick W. Babbel

"Forever and a day," is an expression that many a bride has heard when she asks her groom if he will love and cherish her always. No doubt the groom felt he was telling the truth, but the facts of history prove that all too many couples get married for better or worse, but not for good.

"What", you may ask, "does such an expression have to do with the potential and reliability of magnetic devices?" At this stage in our history it has real relevance. Magnetic storage devices of the kind we are to consider here are about the same age as a young bride. Those who wish to promote their wares tend to make rather optimistic claims. Those who are trying to forecast the future in terms of what the past can tell them tend to make ultra-conservative predictions.

Our job today is to try and find a reasonable middle ground that is both realistic and full of promise. Producing such a combination requires nearly the blind faith of a twitterpated groom. It is within this framework, however, that we will conduct our examination for discovery.

Since the past can give us some valuable insights into what the future may hold, let us first familiarize ourselves with a brief historical review of the development of magnetic recording devices. I am sure you will find this both informative and interesting.

The concept of recording information magnetically first became operational in the 19th century. Valdemar Poulsen, sometimes referred to as Denmark's Edison, built a device in 1893 known as a "Telegraphone." Steel piano wire was used as the recording medium. In spite of some shortcomings, it worked surprisingly well. Until the development of the vacuum tube, however, some 25 years later, there was no adequate means available for multiplying the signal strength to a desirable level.

This fact did not discourage excited American investors. They raised over $5 million to market a commercial version for use as a dictating machine. The typewriter had just been born a few years earlier and this looked like a good companion tool. The typewriter managed to survive while the Telegraphone died out for lack of sufficient interested purchasers. Nevertheless, an important milestone had been crossed.

From that time the concept of recording information magnetically never died. Independent laboratory experiments continued during the next 35 years, chiefly in Germany. Steel wires and steel bands continued to be the recording media.

Karl Pfleumer, an enterprising German inventor, conducted serious experiments in the late 20's and early 30's in search of another kind of recording medium. The AEG Company (Allgemeine Elektrizitaets Gesellschaft) combined with the I. G. Farben Industry to take over this inventor's experiments and developed the first practical magnetically coated tape. This tape used an iron oxide coating. Its consistency was about like rough sandpaper. A fine powder-like spray would fill the room when the tape was run through the machine, but, thanks to the vacuum tube, it was an immediate success.

The first commercial recorder was marketed in 1935, using a magnetically coated paper tape. Within a short time German radio broadcasters were using this device. Since this tape was so much less expensive than wire and provided better fidelity, buyers began to flood the market even though the mechanism was still somewhat temperamental.

Interest spread to the United States. Two recorders, using steel tapes, were manufactured in this country beginning about 1937. The "Mirrorphone" of Bell Laboratories was considered a quality instrument. Soon it received competition from the "Sound Mirror" produced by Brush Development. Distribution was still somewhat limited, but the idea was taking hold.

During World War II the United States continued development of recorders using steel wire and steel tape. The Germans continued their development of magnetically coated tape for audio reproduction that displayed definite advantages. The needs of both military machines for fast, accurate recording devices insured the ultimate success and acceptance of such magnetic instruments.

Lewis A. Whitaker of Computron, Inc., relates an interesting sidelight, as follows:

"Toward the end of the war, the advancing American army captured intact an improved model of the German Magnetophone. This captured recorder was duly sent back to the U. S. and immediately a minor revolution was started in the American recording industry. The death knell had just sounded for wire and steel tape as a recording medium.

"There is an interesting anecdote tied in to the discovery of the German Magnetophone. Ike used this recorder, along with the captured tape, to make a major speech to the defeated German peoples. Right in the middle of the speech, out bellowed the voice of the Fuehrer imploring all Germans to fight to the end--you guessed it--the tape hadn't erased properly. Needless to say, Ike was mad, and a squad of technicians was red faced for not previewing the speech."

A flood of technicians scrambled to develop the magnetic tape market as soon as the war ended. Magnetic tape and tape machines, very much like our present ones, were available in rich supply within a few years. They are becoming as commonplace in our homes as other appliances. The Three M's (Minnesota Mining and Manufacturing Company), Orradio (Ampex), Reeves Soundcraft, and Audio Devices were among the pioneers in the American industry. Today we have dozens of quality manufacturers all over the world.

From this brief account you can realize that magnetic recording tape is still, relatively, a "new bride" so far as age is concerned. Improvements are being made almost daily in the materials being used and in their capability and durability. We have moved from the earlier paper ribbon coated with a crude red oxide material similar to red barn paint to today's thin ribbon of plastic, usually cellulose acetate or polyester (or Dupont's Mylar). The coatings or emulsions now are highly refined magnetic oxides. Binders are far stronger and longer lasting.

When we speak today of magnetic devices, magnetic tape is by far the most widely used and the medium about which we have the most experience as to its utility and archival qualities. Some of the newer magnetic devices, which are now on the market, lack

a sufficient history to permit valid evaluation. Some of these are the fairly new magnetic discs and magnetic drums, the data files (strips of magnetic tapes), and a newcomer by Magnavox Corporation, known as the Magnacard system. However, since all of them employ a similar principle and use related basic materials, we will confine our examination to the widely-used magnetic tapes.

Let us first take a look at magnetic tapes from the standpoint of their potential.

An interesting summary of tape's basic features, which make it such a desirable instrument, has been provided for us by Mr. N. Borwick in an article published by Electronic Components of November, 1963. Even this summary fails to list other more recent applications which continue to increase its usefulness, but for our present inquiry this list should suffice.

"The reasons for the adoption of magnetic tape in so many varied radio and electronic fields may be deduced from an examination of tape's basic features, most of which are well known:

1. Tape recordings are available for immediate playback without processing, so permitting rapid analysis and re-recording as necessary.
2. Tape recordings may be played back many times without deterioration, so permitting the extraction of every bit of useful information.

3. Tape recordings may be erased, so permitting the tape itself to be re-used as often as necessary.

4. Tape recordings may be edited, by splicing or copying, so permitting data or programme items to be built up or regrouped as necessary.

5. Tape recordings may be multiple-channel, with or without the use of multiplexing techniques, so permitting accurate time and phase relationships to be preserved.

6. Tape recordings give very high-density storage, so permitting several million data points to be contained on a single reel.

7. Tape recordings have a very wide frequency range, from d.c. up to megacycles per second.

8. Tape recordings have a very wide dynamic range, in excess of 50dB.

9. Tape recordings have low inherent distortion characteristics, the onset of overload distortion being gradual rather than abrupt.

10. Tape recordings preserve and reproduce information in its electrical form, so permitting the recreation of events and automatic reduction of data at any time.

11. Tape recordings have the ability to alter the time base, so permitting fast or slow reading of data while preserving the ratios of all frequencies involved.

12. Tape recordings, when made on tape manufactured under close tolerance conditions, give consistent performance, in regard to sensitivity and frequency response, so permitting direct comparison of recorded data from reel to reel and from year to year."

The author then concludes his summary by saying, "This impressive list of attributes of magnetic tape is possessed by no other recording or storage medium. To be fair, however, each medium in current use has one or more features which may recommend it for special duties."

Each of you, I am sure, from your own knowledge and experience could add to this list. Include the factors of economy, availability, and versatility, and we may well conclude that magnetic tapes and related devices can be considered to be excellent storage devices from the standpoint of their utility and potential.

Whether we select such devices or not, must be determined by how well they will accomplish the particular job we have in mind to be done.

Most of us in this World Conference are more particularly concerned with the second aspect of our examination, that of the

reliability and archival or keeping qualities of magnetic devices. Because of our concern for "records protection in an uncertain world," this deserves serious evaluation.

Today there are many formal and informal study groups in Government and in industry coming to grips with the archival properties of tape and similar magnetic devices. Some findings warrant tentative projections and conclusions. Other areas are still too much in the examination stage to justify unqualified statements of fact. Let us examine what we can consider reasonably certain at this time, with the assurance that a rapidly increasing volume of information is becoming available to us almost on a monthly basis. In other words, this is a subject about which we need to keep ourselves informed on a day-to-day basis.

A report published by the Ampex Corporation suggested that the archival properties of tape should be considered from three angles: the magnetic remanence or stability, the physical and chemical stability of the polyester support, and the physical and chemical stability of the magnetic coating. Stated in a little less technical fashion, it is important to assure ourselves of the magnetic stability of the magnetic record and the physical stability of the tape so that after many years we may play the tape on standard reproducing equipment and recover the original record intact.

Based on these three guidelines, the following conclusions were reached:

Concerning magnetic stability, scientific studies confirm the fact that based on the size of the iron oxide particles now in use, we may expect magnetic permanence for at least 100 years. Actual tests have been unable to detect any loss in magnetic properties until the tape temperature is raised to 620° centigrade. At that temperature the magnetic signal is destroyed, but so would be all the tape components. In other words, there are no current tests which have been able to detect any loss of signal with age.

Errors, however, do creep in with age. Dust particles, improper tape handling, exposure to magnetic fields, and similar conditions surrounding the care and handling of tape do pose many problems and represent a potential source of errors and other information problems.

As Mr. Artel Ricks pointed out earlier in his remarks, a recent sampling of 535 tapes by the Air Force Logistics Command found an average of 85.7 errors per reel. This error or drop-out rate suggests that such a record lacks the accuracy and dependability required for an archival record.

The second factor, that of the stability of the tape base, presents some interesting observations.

All precision tapes are presently coated on a polyester base. This base is a single chemical entity, is chemically stable at ambient temperatures, and does not contain solvents, plasticizers, or other fugitive additives. Earlier tapes were not so stable. No meaningful tests seem to have been devised to confirm such stability, but the fact that such tapes have been manufactured for over 20 years with no visible evidence of deterioration over this period of time would suggest that the archival keeping qualities may be considered as a reasonable risk. Future developments and tests will be necessary to establish exact limitations.

In this connection one factor will be of special interest and significance to many of you. For years the factor of humidity has been considered to be a somewhat critical one. A recent report by BASF Computron, Inc., dated May 9, 1969, gives some interesting information concerning humidity. Other independent researches tend to confirm their findings. They state:

"The physical and electro-acoustical properties of magnetic tapes and films are not influenced by humidity, which means that no particular consideration has to be given to the storage of recorded tapes under high humidity conditions. This statement is valid for PVC and Polyester, the base materials which we are using . . . however, not for acetate which is humidity and temperature sensitive, needs air-conditioned rooms, and causes difficulties by shrinking

and becoming brittle after a long storage time."

The other factor which affects the stability of the tape base is the matter of temperature. The base presently used has a transition temperature of 75° Centigrade (167° Fahrenheit). Tests for 72 hours at 100° Centigrade--considerably above the transition temperature--showed no change in elastic modulus, tensile strength, or 2 per cent offset yield strength beyond the experimental error of the test method. The elevated temperature did distort the base since it is higher than the transition temperature. Continuing tests are being made at the transition temperature which should produce other interesting conclusions.

For all practical purposes it would appear that the base material is archivally stable when maintained within the reasonable temperature range of the material itself. It has been suggested by the BASF report, to which I referred earlier, that "in order to maintain a high signal to print-through ratio, the storage temperature must lie between +15° C and +25° C (59° F/77° F)."

This same report makes the further recommendation that "in order to obtain an acceptable signal to noise ratio, even after an extended storage period and at higher temperatures the print-through process can be interrupted by rewinding the recorded tapes once a year." As long as print-through continues to be a major problem, tape must be considered a questionable medium for archival purposes.

The third factor in our examination is that of the stability of the magnetic coating or magnetic mix. Here less conclusive evidence is available.

First of all, the magnetic mix is a rather complex mixture of magnetic pigments, conductive pigments, lubricants, fungicides, preservatives, dispersants, and a polymer binder. It is formulated to have a specific complex of desirable physical and magnetic properties so that the tape can achieve its design specifications.

There have been no tests developed to predict the archival properties of this complex coating. Also, long term age tests are not available since most formulations presently used have been developed within the last several years.

This would seem to indicate that of the three factors suggested to determine the archival qualities of tape, this is the one about which least is known. Until more information is forthcoming, it might be well to follow a suggestion made in the BASF report, which we quoted earlier:

"The stability of the recording on our magnetic tapes and films does not depend on storage time. To which degree a playback level changes with time is only a matter of how often a tape has been used and in this respect particular care should be taken that recorded tapes are only played on well serviced recorders in order to avoid mechanical damage. Cleanliness in using and storing recorded

tapes is a predominant factor. Moreover, any remanence of magnetic heads and tape guides of the recorders has to be avoided in order to prevent the recorded tape from deterioration."

In preparation for this conference I reviewed literally hundreds of documents and technical papers. I became overwhelmed more by what we don't know than by what we know on this subject. In some respects I felt much like the GI on a raft in the Pacific during World War II. He and his companion had been adrift for three days since their ship was sunk. Not a thing but water was in sight anywhere. He turned to his companion and said, "Man, oh man! Have you ever seen so much water in all your life?"

To this his companion replied: "Huh! You ain't seen nothing yet. This is only the surface!"

On August 25, 1967, Sidney B. Geller of the National Bureau of Standards sent a report to J. P. Nigro of the same organization. He concludes the report with a summary which brings our overall problem into rather sharp focus, as follows:

"In the past, the systematically preserved media often had intrinsic archival value beyond its use as an alphabetic information carrier (as for example, legal or historic documents). The present and probably future trends are such that most archivalia will be information that is encoded into abstract symbolic forms. This information will have intrinsic properties which must be considered separately from those of the medium, i. e. content density, cost

per unit content, longevity per unit content, etc.

"Methods for the systematic and very long term preservation of all information decoding keys needed for the recovery of the original information from the abstract contents must be developed. The decoding keys must also include the physical transducers.

"Due to the large increase in new information storage media some sort of archival quality test must be devised in order to make effective decisions. Any choice that is made will be the result of compromise and trade-offs because at the present time no one medium meets all requirements. The choices will be made on the basis of several independent needs, that is, one medium may be chosen for its superior longevity (hard) while another may require good updating capabilities (soft). It may be determined that a soft content medium can be permitted greater volume and lower density while a long-term storage medium must have extremely high information density in small volume. As an exercise, why does the stone tablet which has great longevity fail as a modern medium? It would seem that soft contents with the potential longevity of hard contents would approach the optimum case.

Then he concludes with these two brief observations:

"When the medium choice is being made, the total system which it will require for its operation must be considered as an indicator of 'archival quality'. A complicated system will prob-

ably be more difficult to preserve or recover on a long term basis.

"The relationships of media to the information content should be studied. The resurrection of lost contents and the conversion of the contents into new forms made possible by expanding technologies over the ages should also be considered on a continuous basis."

That summary pretty well brings into focus the long-range problems we face in making our choices. Meanwhile, on the basis of the evidence presently available, we cannot consider magnetic tape at this time to be an adequately reliable archival storage medium or a substitute for hard copy or microfilm for permanent storage.

For the present, at least, it would seem that we must examine other alternatives available to us if we are to safeguard the integrity of information and preserve our vital records in an uncertain world in a practical form for the easy use of generations yet unborn.

Thank you!

BIBLIOGRAPHY OF PRINCIPAL SOURCES

AGEING OF MAGNETIC TAPE: A CRITICAL BIBLIOGRAPHY AND COMPARISON OF LITERATURE SOURCES, P. S. Davison, P. Giles and D. A. R. Matthews, Computer Journal II 241-6, 1968.

ARCHIVAL PROPERTIES OF TAPE, K. Famulener (Ampex), 25 January, 1967.

CAN THE COMPUTER HELP THE ARCHIVIST AND LIBRARIAN?, Artel Ricks, World Conference on Records, August, 1969.

THE CHARACTERISTICS AND APPLICATIONS OF MAGNETIC RECORDING TAPE - PART I, N. Borwick, Electronic Components, November, 1963.

A COMPREHENSIVE LOOK AT MAGNETIC TAPE REHABILITATION, E. P. Brandeis, Data Processing Magazine, October 1965.

COMPUTRON BULLETIN, Lewis A. Whitaker, Published by Computron, Inc. (undated).

DERIVING MAXIMUM UTILIZATION FROM COMPUTER TAPE, George Armes, Computers and Automation, November, 1964.

EFFECTS OF STORAGE ON DIGITAL MAGNETIC TAPE, Reports Phase I and II, Wolf Research and Development Corp., Prepared for Goddard Space Flight Center, (March 28-May 15, 1968).

GUIDELINES FOR LONG-TERM RETENTION OF MAGNETIC TAPES, S. E. Boyer, Jet Propulsion Laboratory, (Draft Copy, May 22, 1969).

HOW MUCH PROTECTION FOR MAGNETICALLY RECORDED DATA?, Gregory M. Dillon, Systems & Procedures Journal, October, 1966.

MAGNETIC TAPE--HANDLE WITH DUE CARE, Charles E. Hearnshaw, Automation, May, 1967.

MAGNETIC TAPE - STATE OF THE ART, Ed Schmidt, Instruments & Control Systems, June, 1964.

MAGNETIC TAPE TRENDS, Ampex Corporation, Bulletins Nos. 1, 2, 3, 4, 6, 8, 9, 10.

MANUFACTURE AND PROPERTIES OF PROFESSIONAL MAGNETIC RECORDING TAPES AND FILMS, J. P. Deriaud, British Kinematography, Vol. 43, No. 4, October 1963.

MONOGRAPHS, Memorex, Nos. 3, 4, 5.

PERMANENT STORAGE MEDIA, Paul C. Constant, Jr., Instruments and Control Systems, Vol. 34, February, 1961.

PERSONNEL, MACHINES AND DOCUMENTATION - ESSENTIAL INGREDIENTS FOR ARCHIVAL INTEGRITY OF COMPUTERIZED FILES, James P. Nigro, National Bureau of Standards, (undated).

PRECISION MAGNETIC TAPE, John M. Ricci, Datamation, October 1966.

PRESERVATION AND STORAGE OF SOUND RECORDINGS, A. G. Pickett & M. M. Lemcoe, Prepared for Library of Congress, 1959.

PROBLEMS IN DIGITAL RECORDING, L. A. Ormord, Instruments & Control Systems, Vol. 34, August 1961.

STORAGE CONDITIONS FOR BASF MAGNETIC TAPES, BASF Computron, Inc.

TAPE DOCUMENTATION AND MAINTENANCE, Everett O. Alldredge, Systems, January, 1967.

TAPE LIFE, William S. Latham, IRE National Convention, 1965.

TAPE STORAGE PROBLEMS, Frank Radocy, Journal of the Audio Engineering Society, Vol. 5, No. , January 1957.

TECHNICAL TALK, Minnesota Mining and Manufacturing Co., Instrumentation Bulletin Nos. 1, 2, 3, 4, 5, 6, 7, 8, 10.