Ageing of magnetic tape: A critical bibliography and comparison of literature sources

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The results of a search for published information on the effects on magnetic tape of age and wear due to environment are listed as a bibliography, together with a critical assessment of the gaps in knowledge in this field and the value of each source of references.

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Realisation of the importance of the 'information explosion' has led to many proposals—experimental and practical—to use computers and magnetic tape for information storage and retrieval, both for scientific and business information. The storage of archival information on magnetic tape raises the question of the effect of age—can information be stored for decades on magnetic tape without loss of information? Will such information be legible to a computer many years after being recorded? To try and answer such questions research has been done to establish what is known about this subject and what, if anything, remains to be done.

The objects of the search

A search was made by the Scientific Documentation Centre for information on the effects of wear, environment and age on all types of magnetic tape. Although the study was concerned mainly with magnetic tapes suitable for use with a computer, information on the effects of age on tapes for other application is included in the bibliographic part of the paper. Information was sought that would allow the useful life of recorded tapes to be assessed for varying storage conditions and with varying amounts of wear.

The Centre is very much aware of the importance of assessing the merits of different sources of scientific and technical information. Recording and assessing the sources of this information therefore formed a further object of the project.

Sources searched

The following publications were searched directly:

A. *Science Abstracts*, 1950–1966.
B. *Information Processing Journal*, 1962–1965.
C. *Computing Reviews*, 1960–Aug. 1967 (excluding 1966).
D. *Computer Abstracts*, 1961–Aug. 1967.
E. *Electronics and Communication Abstracts*, 1958–1966.
F. Scientific Documentation Centre—file on Information Retrieval 1963–1967.

To reinforce this coverage, approaches were made for information to the following organisations:

G. Federation Internationale de Documentation (complete files searched).
H. Aslib (complete files searched).
J. British Computer Society.
K. National Computing Centre.
L. B.B.C.
M. Council on Library Resources Inc.
N. I.C.T. Ltd.
O. IBM United Kingdom Ltd.
P. E.M.I. Ltd.
Q. U.S. National Bureau of Standards.

Several of these organisations gave valuable assistance, and grateful acknowledgment is made to those who helped.

In the bibliography the source of each reference is indicated by the letter shown above. Though an extensive search was made we have no doubt there may be other references. A number of the references included were of fringe relevance only but were included for the sake of completeness.

The bibliography

A list of the references found is given in the annex. The list gives bibliographic details of those papers where information on the effects of age on magnetic tapes was found, and the source(s) through which each reference was located are recorded. Copies of the most relevant references were studied to assess the quality of the information they gave and in the hope of finding further references. In the annex to this report very brief summaries of the contents of some of the papers are given.

The limitations of the information found

The information found has been considered in relation to the three possible causes of deterioration (*a*) environment, (*b*) age and (*c*) wear.

(*a*) *Environment.* The application of magnetic tape devices to a wide range of uses including missiles and

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space projects, has led to research on the effects of environment. The conditions for ideal storage have been defined and the limits of environment for long-term storage can be identified. The restrictions to be imposed to prevent demagnetisation of tapes, however, have not been so well defined and there seems to be no explicit information on the effects, if any, of natural or unnatural electrical disturbances over a prolonged period in the vicinity of stored tapes. We know, for example, of a case of loss of information from tapes due to their carriage on London Underground trains, and the effect of magnetic field might well be considered further.

(*b*) *Age*. This subject seems to have received the least consideration, perhaps because the proposals to use magnetic tape as an archival store are comparatively recent and because of the protracted nature of ageing tests. Such work as has been done so far is limited to storage for periods of months rather than of years. There seems to be little published information on which to assess ageing effects, related to such things as print through, loss of data, tape tension and reel size, with tapes to be recorded, used and stored for periods of decades. A difficulty here is the lengthy periods involved, but some useful information on the effects of age might be obtained by comparative tests using old recording machines and comparing old tapes from them with newly recorded ones. Studies of ageing effects on film base might be helped also by analogy from the condition of old cinefilms.

(*c*) *Wear*. The effects of wear are covered to some extent in the bibliography. It is a matter of file organisation to ensure that wear on tape is minimal in relation to the information it contains, but over the long periods being considered wear may impose serious limitations.

The effects of wear on tape used as an archival store may be avoided by storing an additional copy of every tape which is consulted frequently. Whether the original tape should be retained permanently or the copy should become the archival tape may depend upon the type of information carried (Miranber, reference 13).

Sources of information

The sources through which the references selected were found are listed below and it is indicated after each how far the search was made. In many cases the indexes used are of fairly recent publications, e.g., the S.D.C Information Retrieval files, and do not go back very far in time; the search made then covered all the existing parts of the publication.

Conclusions

An extensive literature search has been made seeking information relating to effects of wear, environment and ageing of magnetic tapes. The 48 references found are listed in the annex to this paper.

It will be seen from the bibliography and from the comments above that significant gaps exist in our knowledge of the effects of age on information stored for long periods on magnetic tape. Before this medium is extensively used for archival storage these gaps should be filled by experimental studies on ageing effects.

Table 1

Source	*No. of References*	*Coverage*
A. *Science Abstracts*	16	16 years. 1950–66
B. *Information Processing Journal*	3	3 years. 1962–5
C. *Computing Reviews*	9	6 years. 1960–7 (excluding 1966)
D. *Computer Abstracts*	6	6 years. 1961–7
E. *Electronics and Communication Abstracts*	—	8 years. 1958–66
F. Scientific Documentation Centre—file on Information Retrieval (no retrospective information on computers or magnetic tapes available).	2	Complete file, 1963–7
G. Federation Internationale de Documentation	1	Search made of complete internal files up to 1966 for S.D.C.
H. Aslib	2	Search made externally and internally for S.D.C., including search of internal files up to 1966
Q. Magnetic Tape and Ink Character Standards and Measurement Techniques, U.S. National Bureau of Standards Project 451.2119 (Preliminary note)	7	
Other sources listed		
No references were obtained from sources J–P		
Miscellaneous sources		
R. *Brit. Tech. Index*	2	
S. Magnetic Tape Recording by H. G. M. Spratt	2	

Comparison of sources of information

As this was an extensive literature search, including searches of the major abstracting sources, a record has been kept of the source(s) used to locate each reference, and the numbers of items from each of the seventeen sources searched are listed. No one source provided anything approaching comprehensive coverage of this subject, and only five out of the 48 references found were found by more than one source.

Annex

Bibliography of Papers on Ageing of Magnetic Tape

Reference	*Source*
(*a*) *Environment, but sometimes covering age or wear*	
1. Deriving Maximum Utilisation from Computer Tape D. Armes *Computers and Automation*, Vol. 13, November 1964. 'Discusses functional aspects, recording process, performance reliability, care and storage.'	D+H
2. Magnetic Tape Trends—Effects of Stray Fields on Magnetic Tapes. Ampex Corporation.	Q
3. Care and Handling of Magnetic Tape. Control Data Corporation.	Q
4. Computer Tapes and their Care. G. Cole *Data Processing*, Vol. 2, pp. 11–16, November 1960. 'Discusses some precautions against fire, humidity, demagnetisation, dust and shock which are necessary for preservation of tapes.'	C+H
5. Evaluation of Magnetic Tape R. W. Jack *Inst. and Control Systems*, Vol. 35, pp. 54–58, July 1962. 'Includes tests for storability and for flaw detection.' 8 refs.	C
6. Problems of Digital Recording. L. A. Ormond *Inst. and Control Systems*, Vol. 34, pp. 51–57, August 1961. 'Discusses amplitude errors, skew errors, distortion, signal drop-out and storage and handling of tapes.'	C
7. Precision Magnetic Tape. J. M. Ricci *Datamation*, pp. 51–60, 12 October 1966. 'Discusses physical characteristics, causes of drop-out and precautions for handling and storing.'	C
8. How Environment Affects Magnetic Recording Tape. C. B. Stanley *I.R.E. Trans. Space Electronics and Telemetry*, SET 6, Vol. 1, pp. 19–24, March 1960.	A
9. Tape and Microfilm Storage. *Systems*, Vol. 5, pp. 21–25, September/October 1964. 'Major requirements, including storage, of tapes and microfilm stores.'	B
10. Get Maximum Reliability from Digital Magnetic Tape. K. Taylor *Contr. Eng.*, Vol. 8, pp. 113–115, October 1961.	C
11. Preservation, Packaging and Packing Levels. Federal Standard No. 102*b* (January 1963). U.S. Government.	Q
(*b*) *Specifically the effects of age*	
12. Permanent Storage Media. P. C. Constant *Inst. and Control Systems*, Vol. 34, pp. 262–264, February 1961. 'For many methods of permanently storing data including magnetic tape an account is given of factors affecting long term storage.'	C
13. Recovery of Diffusion Deteriorated Signals. W. L. Miranber *IBM Techn. Disclosures Bull.*, Vol. 5, pp. 28–30, June 1962. 'How signals deteriorated with time according to a diffusion process can be recovered by an iterative operation on the Fourier transform of the deteriorated signal.'	D

Reference	*Source*
14. Is Magnetic Tape Long Lived? J. T. Mullin *Audio*, Vol. 49, pp. 19–21, 1965.	F
15. Properties of Base Material used for the Manufacture of Magnetic Recording Tape. E. Schmidt *J. Audio Eng. Soc.*, Vol. 8, pp. 52–57, January 1960. 'Review of relative properties including effects of age.'	A
16. A New Professional Magnetic Recording Tape. E. Schmidt *J. Audio Eng., Soc.*, Vol. 1, pp. 10–16, January 1953. 'Data tape having long term storage facility and greatly improved shrink and swell factors.'	A
17. Viewpoints on the Appreciation and Selection of Data Stores. Tibor, Szentivanyi *Tajekoztato*, No. 6, pp. 73–91, July 1961. (In Hungarian.) 'Reviews characteristics of most often used data stores. Compares role in computer, storage capacity etc. Finally examines their reliability and life time as well as conditions necessary to keep them running.'	C
(*c*) *Specifically the effects of wear*	
18. A Comprehensive Look at Magnetic Tape Rehabilitation. E. P. Brandeis *Data Processing Mag.*, Vol. 7, pp. 28–32, October 1965. 'Includes details of cleaning, recertification and repair of tapes.'	B
19. Dropouts in Instrumentation Magnetic Tape Recording Systems. R. H. Carson *I.R.E. Trans. Audio*, AU-10, pp. 112–20, July/August 1962. 'Relative effects of tape, machine, reels, recording processes, environmental dirt, tension etc. on drop out count.'	D
20. Surface Deterioration of Magnetic Recording Tape. L. Hiam and S. W. Chaiken Report on Stanford Research Institute Project FMU 3528 (July 1965).	Q
21. A Study of the Chemical and Physical Properties of Magnetic Recording Tape. F. Nash, R. F. Brown *I.R.E. Trans. Audio*, AU-10, pp. 70–71, May/June 1962. 'A Study of chemical and physical properties of magnetic tape, including wear properties.'	A
22. The Wear of Magnetic Recording Tape and Solubility of the Binder. F. Nash *I.E.E.E. Trans. on Audio*, AU-11, p. 77, 1963.	F
23. High Stability Tape for Data Processing Systems. A. Rusch, C. P. Lascaro, E. Beekman *Electro Technology*, Vol. 72, pp. 91–95, December 1963. 'Improved tape to prevent elongation, permanent set and flaking of magnetic coating.'	D
24. Investigation of Magnetic Tape Wear Characteristics—Development of a Tape Wear Simulator. J. Scheiman, R. Schwartz *I.E.E.E. Internat. Convention Record* (U.S.A.), Pt. 2, pp. 189–194, 1965. 'Includes recommendations for specification of tape wear.'	A
25. Magnetic Tape having a Binder Mixture of Polyurethane Resin and a Copolymer of Vinylidene Chloride and Acrylonitrile. K. P. Talley U.S. Pat. 3-144-352. Issued 11 August, 1964. 'A long wear tape—850,000 cycles.'	B
(*d*) *Miscellaneous*	
26. Magnetic Tape Specification. G. Balmain *Brit. Kinematography*, Vol. 44, pp. 191–193, June 1964.	R
27. Mass Storage: a Broad View. T. H. Bonn *Proc. I.E.E.E.*, Vol. 54, pp. 1861–1870, December 1966. 'Characteristics of available hardware requirements of mass storage and problems to be resolved.' 21 References	D
28. An Up-to-date Review of Mass Storage. W. J. Broderick *D.P.M.A. Quarterly*, Vol. 2, pp. 1–18, July 1966. 'Discusses storage in terms of capacity performance and price.'	C

Reference	*Source*
29. Accidental Printing in Magnetic Recording. E. D. Daniel, P. E. Axon *B.B.C. Quarterly*, Vol. 5, pp. 7–22 (Winter 1950–51).	A
30. The Reproduction of Signals Recorded on Magnetic Tape. E. D. Daniel, P. E. Axon *J. Inst. Elec. Eng.*, Pt. 3, Vol. 100, 1953.	S
31. A Comparison of Disks and Tapes. H. Hess *Comm. A.C.M.*, Vol. 6, pp. 634–638, October 1963. 'Evaluation of tapes *v.* disks.'	C
32. Contrôle des fichiers permanents sur bandes magnétiques. A. Hirchaud *Revue Française de Traitment de l'Information*, (Paris), Vol. 8, No. 1 (1965).	G
33. *Digital Magnetic Recording.* A. S. Hougland John Wiley & Sons, 1963 (£3). 'Mass storage principles, theory and storage media.'	D
34. Thermoplastic Recording Tape Systems. N. Kirk *J. Soc. Motion Picture and Television Engr.* (U.S.A.), Vol. 74, pp. 666–668. 'The properties of a good recording tape are outlined and the new organic thermoplastics developed are discussed.'	A
35. Storage Systems—Present Status and Anticipated Developments. H. P. Louis, W. I. Shevel *I.E.E.E. Trans. Magnetics* (U.S.A.), MAG. 1, Vol. 3, pp. 206–211, September 1965. 'New technologies and concepts are reviewed and fundamental barriers identified.'	A
36. Performance of High Output Magnetic Tape. L. B. Lueck, W. S. Wetzel *Electronics*, Vol. 13, March 1953.	S
37. Magnetic Tape Recording Material. C. D. Mee 1963 *Proceedings of Intermag. Conf.* (I.E.E.E. 1963). 'The design criteria for magnetic recording tapes are considered with respect to desirable physical and magnetic properties.'	A
38. The Assessment of the Reliability of Magnetic Tape for Data Processing. R. Noble *J. Brit. Inst. Radio Engr.*, Vol. 20, pp. 737–742, October 1960. 'Reliability rather than age.'	A
39. Reducing Magnetic Tape Printthrough. F. Radocy *Electronic Industries* (December 1957).	Q
40. Magnetic Recording Tape. H. G. M. Spratt *Wireless World*, Vol. 57, pp. 88–91, March 1951; pp. 149–151, April 1951.	A
41. Magnetic tape—State-of-the-Art. E. Schmidt *Instr. and Control Systems*, Vol. 37, pp. 121–122, June 1964.	A
42. Basis and Development Trends of Magnetic Tape Measurement Techniques. H. Volz *Frequens*, Vol. 15, pp. 218–226 (July 1961). 'The application and advantages of magnetic tape recording techniques in the field of measurements and data storage are revised.' 31 references.	Q
43. Magnetic Printthrough, its Measurement and Reduction L. J. Wiggins *J. S.M.P.T.E.*, Vol. 58, pp. 410–414 (May 1952).	Q
44. Magnetic Recording 1888–1952. C. F. Wilson *I.R.E. Trans. Audio*, AU4, pp. 53–81, May/June, 1956.	A
45. Magnetic Tape Research. *Inter. Sound Eng.*, Vol. 1, pp. 206–207, September/October 1963. 'Research on Agfa professional tape.'	R

Reference	*Source*
(*e*) *Literature valuable as a source of references*	
46. Magnetic Recording 1900–49. J. Crerar Libr. Bibl. Ser. No. 1, 66, p. 1950. '399 Abstracts and Titles.'	A
47. Magnetic Stores. K. Sattelberg *Arch. Tech. Messen*, 304, Jo83–5. 'Includes Tapes and Long List of References.'	A
48. A Contribution to the History and Systems of the Magnetic Storage Technique. H. Volz *Hochfrequenztech U Elek Aust.*, Vol. 74, pp. 47–56, May 1965. 'History 1900–62.' 162 References.	A

Book Review

Handbook for Automatic Computation. Vol. 1, Part *a*, *Description of ALGOL* 60, by H. Rutishauser, 323 pp. Vol. 1, Part *b*, *Translation of ALGOL* 60, by A. A. Grau, U. Hill and H. Langmaack, 397 pp. (Berlin: *Springer-Verlag*. Part *a*, DM 58; Part *b*, DM 64.)

In the words of the publishers 'the aim of the Handbook for Automatic Computation is to supply the computing scientist with a selection of tested algorithms. . . . written in the algorithmic language ALGOL 60'. The first two parts, which are reviewed here, are introduced to provide the theoretical background and are concerned with a description of ALGOL 60 and a description of translating ALGOL 60, respectively.

Part *a* restricts itself to the IFIP subset of ALGOL and thereby eliminates discussion of the more controversial aspects of the language. This is in keeping with the stated intention for the whole handbook in that all programs shall either adhere to this subset or the deviations shall be clearly stated. The collected algorithms will then run successfully with most existing ALGOL compilers. The bulk of the book was modelled after lectures given at the Swiss Federal Institute of Technology, Zurich.

There seem to be two possible strategies for writing a book such as this. One is to exhibit the revised ALGOL report (and/or the IFIP subset) and to supplement these by examples so chosen that they illustrate the semantic content of the language, highlighting any areas of ambiguity. The other is to reformulate the definition of ALGOL and to illustrate this in like manner. Both methods are used here. To my mind the revised ALGOL report still serves as the best available definition of the language, although the syntactic diagrams presented do constitute a useful alternative viewpoint. The value of the work lies in the fact that it does enable the reader to obtain a clear impression of how the ALGOL language can be used to solve numerical problems, not with elegance alone but also with effect and with economy of effort. In consequence it can be claimed to supplement the revised ALGOL report in a very desirable manner.

Part *b* is concerned with an ALGOL translator whose main purpose quite escapes me. It transforms an unspecified dialect of ALGOL into the symbolic assembly language for a non-existent machine. The presentation of the translator program, which takes more than half of the available space, is in the style of a novel written in an original form of ALGOL, complete with Greek, Gothic and other symbolic notation. It is extremely curious that all questions of syntax analysis and statement recognition are largely ignored, being assumed to have been performed in an undiscussed pre-preparatory pass, whilst it is pedantically footnoted that a symbol, which approximates the reflection of a question mark, is used to denote ; in an ALGOL comment. It is just this type of inconsistency which leaves me with the feeling that the book is not a good introduction to compiler writing. The written text is mainly concerned with questions of storage allocation and choice of object code, and can be used to build up a reasonable picture of the state of a compiled ALGOL program for an 'average' implementation. This can be used to illustrate the basic inefficiencies of machine utilisation which comprise the premium paid to gain the many advantages in using a language such as ALGOL. The increased readability obtained through presenting the translator program written in 'ALGOL' itself highlights one of these advantages. It becomes apparent that the first entry into the procedure 'check for the same identifier in the same block' on page 175, during the initialisation of the identifier list, prejudices the entire translation.

This is not the first venture of the publishers into the production of a Handbook of this type, which is intended to be used by workers in the field. In particular I am familiar with their Handbook of Physics and a very useful set of volumes it is. If the Handbook for Automatic Computation maintains the standard set in other fields then undoubtedly the volumes will constitute a very desirable addition to the literature. However, one would hope that they have the strength of mind to keep to the two ideals of a restriction to the IFIP subset and to publish only tested algorithms. It is with these features that the primary value of the Handbook rests.

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