SOUND TALK

FROM THE MAKERS OF "SCOTCH" BRAND MAGNETIC TAPE

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RECENT PROGRESS IN THE PRODUCTION OF ERROR-FREE MAGNETIC COMPUTER TAPE

Signal dropouts are one cause of error in modern digital computers designed to use magnetic tape as a long period storage medium. Noise pulses which are of sufficient amplitude to act as spurious signals form a second error source. Both dropouts and noise pulses are traceable to discontinuities in the magnetic coating.

During the past year extensive studies have been made of coating defects with the intention of minimizing their occurrence. It was believed that if the discontinuties could be examined and classified there was hope for improving tapes by eliminating the errors at their source. This has been done and the practical results are gratifying.

This paper will explain briefly: (a) our findings concerning the physical causes of errors; (b) the reasons why errors arise from such defects; (c) steps taken to eliminate errors, and (d) a summary of progress made during 1953.

The equipment used for dropout detection records square wave pulses at a rate of 100 to the inch on seven tracks of a half inch wide tape. The recorded tape is read back and if the signal for any pulse falls below 55% of the normal maximum value, an error is recorded. At each error the tape is stopped automatically so its physical cause may be examined under a microscope.

Noise pulses which are counted as errors are located by saturating the tape in one direction and stopping the tape during read back when a noise peak exceeds 8% of the normal maximum signal. Again microscopic examination may be used to find the physical cause of the noise pulse. Generally speaking, dropouts and noise pluses arise from the same causes and both have been grouped together under the name of errors.

Errors have been classified as removable and non-removable. Removable errors arise from loose particle contamination of the coated surface and may usually be cleaned off the tape with a soft brush. Non-removable errors may be caused by oxide clumps or foreign particles which are embedded in the coating. Since removable errors may be eliminated through inspection they are at present considered to be unimportant. The report which follows will be confined to non-removable errors.

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Signal dropouts may be caused by a lack of magnetic coating at the point where a pulse is supposed to be recorded but the early experience of observers led to an explanation based on the more frequent occurrence of small inclusions, called nodules, in the coating. Upon close inspection, these nodules could be classified as oxide clumps, acetate particles, embedded filter fibers, etc. Initially oxide clumps were the most frequent offenders.

Oxide clumps, which protrude from the otherwise flat surface of the tape, force the main body of the tape away from the recording and playback head gaps. During recording the effect of the presence of a nodule reduces the sharpness and the intensity of the recording field. On playback where the rate of change of recorded flux is observed, the already reduced steepness of the flux front is observed from a distance which further reduces the rate of change of flux in the reproducing head. This combination results in a decrease in output which is called a dropout. If the dropout is sufficiently large it constitutes an error.

Similarly noise errors arise from discontinuities in the magnetic coating. The tape is magnetized to saturation longitudinally prior to read out in the noise test. The flux seen by the playback head under this condition of magnetization would be essentially zero for a perfect tape except for small variations in leakage flux from particle to particle of the oxide which causes the normal noise background. However, if a discontinuity in the coating occurs which might result from a pin hole or the inclusion of a particle of non-magnetic contaminate, magnetic poles will form on either edge of the gross discontinuity and the leakage flux will increase well above that due to the physical separation between oxide particles.

As a preliminary step in the elimination of errors from computing tapes a study was made of the error types and their frequency of occurrence. It seemed obvious that if the causes of errors were known we would have a clue to the step in the tape-making process where they were introduced.

One typical example of oxide clumps is shown in Figure 1. When such clumps are encountered during playback they give rise to both dropouts or noise errors providing the clumps are of sufficient size. Figure 2 shows a coating streak where absence of oxide caused both dropout and noise errors. Figure 3 illustrates findings on the frequency and cause of non-removable errors. Each sample represents 24 rolls of 1/2 inch x 2400 foot tape.

It will be seen that oxide flakes, tape distortion and acetate particles were the predominate sources of error in March, 1953. A test run in April, 1953, was designed to eliminate oxide flakes, filter fibers and tape distortion. Tape distortion arises primarily from creases in the tape due to faulty handling during the manufacturing process. The results of the initial experiments are shown in Figure 3. Success was attained in reducing to zero the number of errors from the three sources being studied.

Two runs were made in May in which special precautions were taken to eliminate acetate particles. We were apparently on the right track since both acetate and miscellaneous embedded particles were reduced in frequency of occurrence. The increase in oxide flakes to 1.5 errors on an average pointed up the fact that our April observation was possibly based on too small a sample.

Since better than 50% of the rolls during the last two trial runs were error-free it was decided to turn the process over to production. Figure 4 shows the error count on production runs of relatively large samples. In order to compare the results with previous test runs the bar graphs have been reduced to 24 roll equivalents. The runs illustrated total 664 rolls, 1/2" x 2400'.

In changing to production the classification of errors was refined. Certain defects previously entered under miscellaneous particles were found to be attributable to imperfect backing. The acetate film used as tape backing is cast on large diameter sheets having a polished surface. The film began to show tiny defects which were determined to be repetitive and which could therefore be attributed to a small dent in the surface of the wheel. The errors due to this source are listed as backing defects.

Tape distortion which arises from permanent creases in tape backing occurs most frequently on the edge of the tape. The errors arising from pin holes, filter fibers and streaks now appear to be purely random.

Through studies of errors and efforts to eliminate, errors have been reduced from 3.25 errors per roll in March to 0.18 errors per roll of tape in August.

To a tape manufacturer this means that if special precautions and techniques are used, production waste figures can be held within reasonable limits during runs of computing tape. To the consumer of tapes it means that error-free tapes are available, providing each tape is individually checked by the manufacturer. Alternatively, if the consumer prefers to check each roll of untested computing tape he may expect better than 75 per cent of the rolls to be error free.

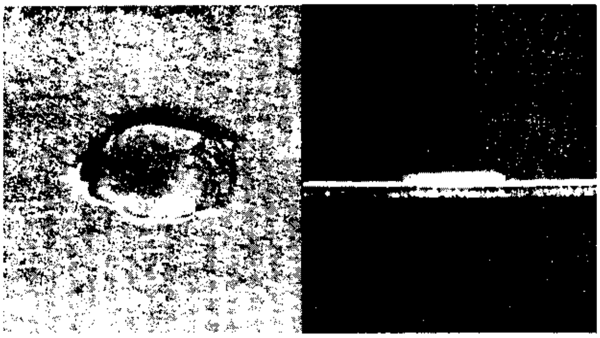

Fig. 1 - Showing oxide flake embedded in coating and cross section of same.

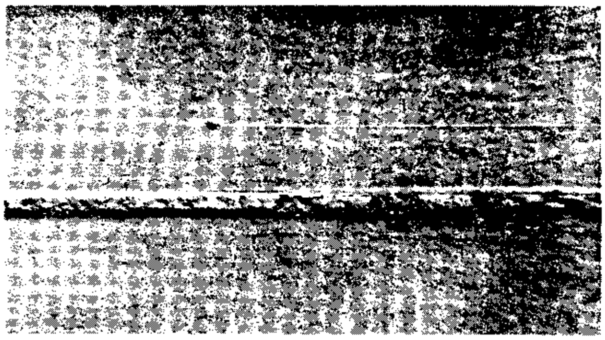

Fig. 2 - Showing a streak in the magnetic coating which results in a deficiency of magnetic oxide along the streak (magnified 50 times).

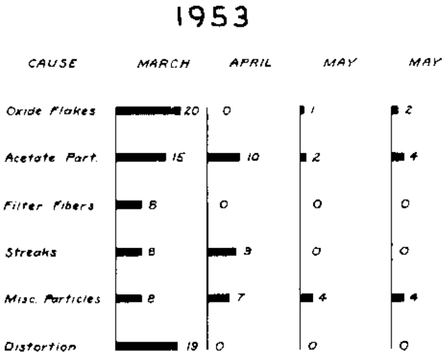

Fig. 3 - This chart shows the number and causes of errors found in four experimental lots of 24 rolls each of tape.

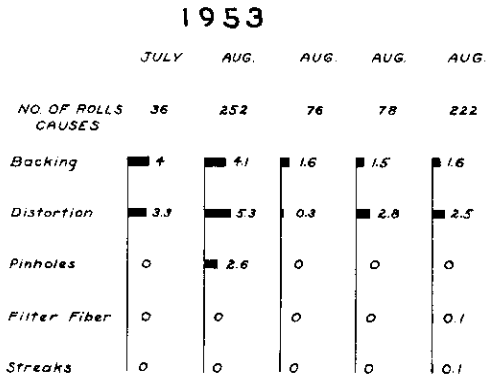

Fig. 4 - This chart shows the number of errors and the number of rolls in certain production runs of computer tape. For easy comparison with Fig. 3 the number of errors has been reduced to the equivalent which would be found in a 24-roll sample.

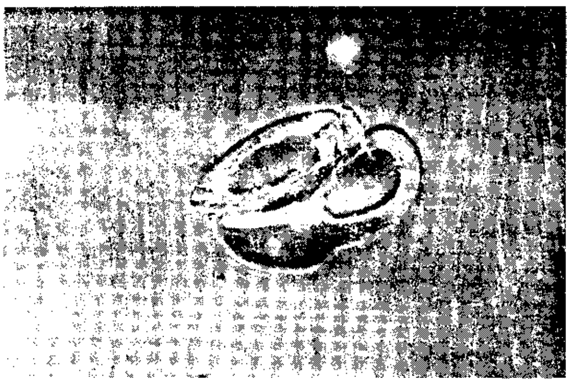

Fig. 5 - This photograph (magnified 25 times) illustrates the appearance of a defect in the acetate backing of magnetic tape. This irregularity is reflected in the magnetic coating and gives rise to an error.

All illustrations represent findings in 1953. Further perfection and improvements will be made in the years immediately ahead.