Magnetic media, especially tape and magnetic stripe cards like credit cards, are often exposed to electromagnetic, x-ray, or other fields. Tests were conducted by the National Bureau of Standards to determine whether airport x-ray devices for screening carry-on baggage, like this one at Dulles International Airport, can erase magnetically recorded media. (The image of the tape in the container is just visible on the screen to the right of the device's operator.) Similar tests were run using metal detectors like the one in the background.

# Erasing Myths About Magnetic Media

by Sidney B. Geller

## Subjected to magnets, lasers, microwaves, radar and even nuclear radiation, magnetic media will usually survive.

There are stories concerning the intentional or accidental destruction of data on magnetic media which have gained considerable credence because they have been repeated so often in various forms. One popular one deals with a computer technician (or night watchman) who attaches a flashlight with a magnetic holder onto the wall of a magnetic tape vault. His action is said to result in a costly loss of important data on many reels of tape through erasure by the flashlight's permanent magnet.

These stories could not be true, as the results of studies performed by the National Bureau of Standards Institute for Computer Sciences and Technology can attest. In conjunction with the Institute's study of computer systems security, the real-life effects (and non-effects) of different types of devices and fields on magnetically recorded data have been tested. A small portion of the results of the tests, the portion dealing with the effects of permanent magnetic fields, has been previously released; but the studies have now gone far beyond the effects of simple magnets to include effects of airport metal detectors, nuclear radiation, lasers, radar, and microwaves. The results indicate that magnetic media are really quite safe from most threats, and that they can be easily protected from those things to which they are susceptible.

In the NBS testing, recorded computer magnetic tapes, digital cassettes, and magnetic stripe plastic credit cards were used as the experimental media. However, the results are also directly applicable to magnetic cartridges and flexible and rigid discs because the magnetic particles used in all of these media are similar gamma ferric oxides.

The principal interest in the studies lay in the cases of subtle data erasure which may not be discovered for some time because there is no visible evidence of physical damage. However, environmental conditions which affect the media materials were also noted. In all tests, a number of control media of the same type always accompanied the test media to make certain that unknown events which might occur in transit did not affect the final results.

Decreases in signal levels from their original values and losses of data caused by the various devices and fields were measured. A signal level loss of less than 50% was not considered to result in a loss of data because the data can be recovered during the normal operations of dp systems through the various reproducing processes.

# ERASING MYTHS

### Magnetic fields

One big threat to magnetic media is permanent magnets. Permanent magnets are simple devices which can produce strong, steady, magnetic erasing fields, and are easily carried and concealed. In addition, they require no external power sources for producing or maintaining their fields.

In one test series, a large horseshoe magnet was placed in direct contact with the outer flange of a tape reel and at various distances from the reel. This magnet produced a field which was considerably more intense than that of, say, a flashlight magnet. In fact, it was strong enough to lift 40 lbs (18 kg). When placed directly against the edge flange of the reel, a signal level reduction of 80% resulted at the beginning of the tape, (See Fig. 1, Page 68). The signal loss decreased continuously along the tape surface from that maximum 80% until a point 350 feet (107 meters) along the tape where the signal level was 50% of the original recording level. At this point, a tape can still be read!

The decrease in signal loss, from 80% down to 50% over 350 feet, is explained by the fact that the layers of tape which are further into the reel experience a progressively weaker magnetic field and therefore a lesser erasing effect.

When the same horseshoe magnet was held 1 inch (25mm) from the edge of the reel, the maximum signal loss was 22%; this signal level reduction would not result in *any* data loss.

Since a magnetic field's intensity falls off approximately as the cube of the distance from the magnet (at 10 inches away from the magnet its field is roughly 1/1,000 as strong as it is 1 inch away), it is impossible for any concealable magnet to cause any data loss on tapes stored 6 inches (0.15 meter) away from the closest point the magnet can be placed.

A considerable amount of further protection is offered by the vault wall when it is made of a ferromagnetic material (i.e., one to which the magnet will adhere) since this reduces the magnetic field strength by "short-circuiting" or shielding the field and reducing the effective erasing capability of the magnet. In fact, the horseshoe magnet produced no discernible signal loss at 1 inch from the tape when a ferromagnetic material was placed between the magnet and the tape. It should be noted however that *almost any small permanent magnet can cause serious erasure if it is placed against the side of the reel or in direct contact with any accessible surface of the magnetic media.*

Another approach to intentional tape erasure sometimes suggested consists of hiding a magnet in a tape vault for a period of time and somehow gradually erasing tapes. However, if a magnet is sufficiently strong to erase a tape (or any magnetic medium), it will do its damage instantaneously or not at all. Time is not a factor. The particles in a recorded tape change their signal levels and magnetic directions in a few billionths of a second.

The amount of erasure which the hidden magnet can produce depends upon the peak value of the magnetic field to which the stored tapes have been subjected. That is, the greatest signal erasure is caused at the instant the magnet is brought closest to the medium because the medium experiences the maximum field strength at this position. As before, the effect of spacing between the tape and the magnet will determine if any loss will occur.

There are many commonplace devices which incorporate permanent magnets as part of their normal configurations, for example, telephone receivers, transistor radio loudspeakers, and voltmeters. Devices of this type were placed in contact with recorded strips of magnetic media and were able to cause small signal level decreases; however, no data losses were experienced.

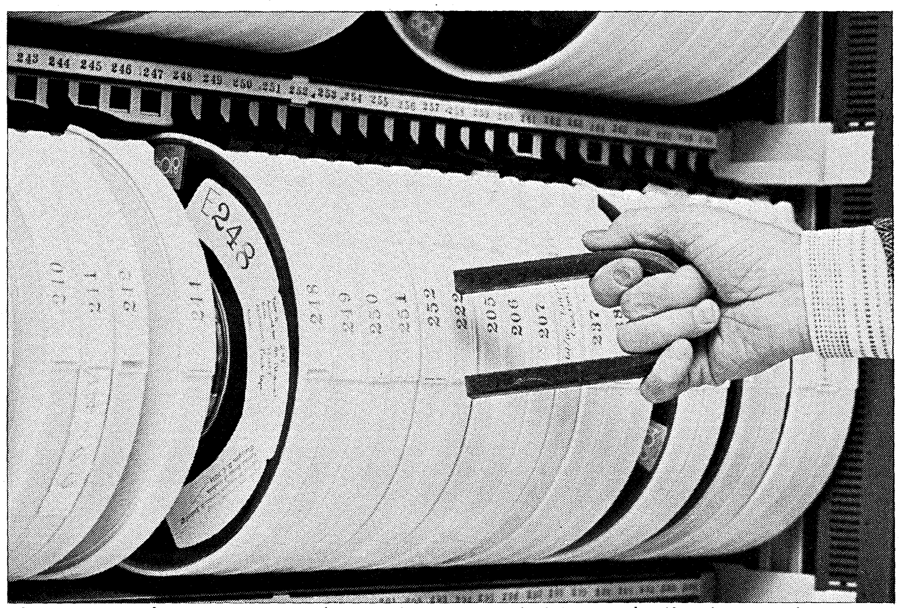
Based upon the preceding experimental results, it can also be concluded that the flashlight story (and all other versions) are completely unfounded.

The field from an electromagnet is almost identical in its erasing characteristics to a permanent magnetic field. It was suggested that a very large electromagnet of the type used in scrap metal yards for lifting materials could be concealed in a van and parked outside a tape installation. Power could then be applied to the magnet through a large number of batteries and the entire vault erased in one burst by a properly aimed field. This approach was tested experimentally at a local scrap metal yard. A large lifting electromagnet was placed over recorded tapes at various heights. At the closest test distance of 1.3 feet (0.41 meter), no data loss was incurred.

It should be noted that the magnetic media read/write head is also an electromagnet. Unfortunately, it is capable of becoming permanently magnetized and causing slight erasure of data while it is in the process of reading a tape or cassette. This can be avoided through the regular use of a handheld head demagnetizing or degaussing device which is readily available.

Varying magnetic fields are produced by and extend into the space around many commonly encountered devices such as motors, generators, transformers, television receivers, etc. In fact, most electrical devices which operate from a power line produce a 60Hz magnetic field.

It was found that when devices such as transformers and motors are encased in shielding materials, they cause no signal erasure even when placed in almost direct contact with the media.



Since tapes, discs, and mag stripe cards are recorded magnetically, they can be erased magnetically, and the greatest threat to them is from a strong, close, magnetic field.

However, it was also found that some unshielded power supply transformers could cause erasure upon contact with the media when they were carrying high current loads. In all cases, electrical equipment which was enclosed in cabinets that provided at least 2 to 3 inches of spacing from the internal electrical components caused no erasure of recorded signals.

### Airport metal detectors

There is considerable concern about

the effects of airport metal detectors on recorded magnetic media which are carried through them. Many of these metal detectors are of the "active" type which fill their walk-through space with their own internally generated varying magnetic fields. Tests were performed on a number of different kinds of walk-through detectors in both the Washington National and Dulles International airports. Recorded computer tapes were moved through in many different locations within the detectors and then tested for a loss of data. There was no observed instance of erasure or data loss. The highest field intensity encountered during the tests was in a unit which was rated at 398 A/m (5 Oe). This field intensity is not capable of producing any significant signal loss as can be seen from Fig. 2 (Page 68).

Recently the production of this highest intensity unit has been discontinued; therefore, most of the detectors which will be encountered in the future will probably generate weaker fields. This trend towards reduced field strength units is highly desirable because of factors which must be considered for detectors that are used with people. A voluntary performance standard for walk-through detectors has been prepared by the Law Enforcement Standards Laboratory of the National Bureau of Standards. This standard recommends that the allowable generated magnetic field in walk-through metal detectors used for law enforcement should be held to a maximum value of approximately 95 A/m (1.19 Oe), a level much too small to cause erasure of magnetic media.

Handheld metal detectors are sometimes used as backup surveillance devices in airports. The magnetic fields generated by these devices are significantly lower in magnitude than their walk-through counterparts. As expected, exposure to these handheld detectors produced no effects on the recorded data even when they were placed in direct contact with the media housings.

Airports pose a variety of potential threats. In addition to the x-ray devices and walk-through metal detectors, there are handheld metal detectors (here one is purposely being passed over magnetic stripe credit cards in the man's breast pocket) and even radar. The results of NBS tests, in everyday environments and in some nearly inconceivable situations, show that magnetic recording is almost accident proof.

### Microwave ovens

Recorded cassettes were placed directly into a microwave oven in order to subject them to the maximum microwave energy. The cassettes were removed after they became warm enough to assure that the microwave field had achieved its full intensity. There was no measured data loss. This also indicated that if any external leakage fields exist around ovens or other microwave devices of similar power, they would be unable to cause any data erasure.

### Radar signals

Recorded magnetic computer tapes are often transported through areas in which radar antenna are transmitting signals, around airports, aboard ships, and in defense installations. A series of radar tests was performed by the NBS Institute for Computer Sciences and Technology with the cooperation of the Radar Division of the Naval Research Laboratory.

Recorded magnetic tapes were irradiated by L-band, C-band, and X-band radar systems; the L- and C-bands radiated 200,000 watts of peak power and the X-band radar radiated 500,000 watts of peak power. The tapes were placed for 10 seconds directly into the radar signal paths at distances of 100 feet (30.5 meters), 50 feet (15.2 meters), and 10 feet (3 meters) from stationary, non-scanning antennas. There was no observable loss in signal level produced at any of these distances by any of the radar units. It is not likely that these radars could cause signal erasure unless the media were at the point of maximum field strength, almost in contact with the antenna. The ineffectiveness of the radar electromagnetic field for erasing signals is again due to the fact that the magnetic component of the electromagnetic field loses its strength very rapidly with distance from the antenna.

### X-rays

All forms of magnetic media are often subjected to x-ray energy in both dental examination and airport surveillance systems. Tests were performed with various recorded magnetic media in both the NBS Dental and Radiation Physics laboratories. The media were subjected to extremely high (lethal) x-ray dosages and no data losses were produced. Recorded media were also subjected to x-ray inspection at the Washington National and Dulles International airports with no resultant loss of data.

### High voltages

High voltages which were generated both at the NBS High Voltage Laboratory and by automobile ignition coils were applied directly across recorded magnetic media. The laboratory voltage generator outputs were increased to more than 15,000 volts until air breakdown occurred between the electrodes. The ignition coils produced arcs which struck directly onto the recorded magnetic stripes on the surfaces of plastic cards. No signal or data losses resulted from these tests. This resistance to signal loss is valid so long as the high voltage fields do not produce excessive arcing which overheats or damages the media.

### Nuclear radiation

A recorded digital magnetic tape cassette was subjected to a gamma-ray dose of approximately 3.0 megarads in the NBS gamma-ray pool. After a 1½ hour exposure, there was no observed data loss from the media. It has been reported that data on recorded magnetic media is able to survive the effects of the electromagnetic energy component resulting even from nuclear detonation providing that the media materials are not damaged or otherwise altered by the radiated energy.

### Automobiles

Magnetic media carried within the passenger compartment of numerous automobiles experienced no data losses. Within the engine compartment, test cassettes experienced very little signal level decreases and no data losses even though they were put into contact with the ignition coil, generator, the starter motor, and the battery cable while starting the engine. Capacitive discharge electronic ignition systems produced no observable changes in the recorded signals.

### Television receivers

Television receivers are sources of magnetic fields, high voltages, and x-ray energy. Tests were performed by placing recorded magnetic media both in the interior and exterior regions of different receivers. Media were placed in close proximity to the high voltage circuits which are also the sources of the x-rays. No signal level losses were observed. It has been suggested that the degaussing coils which are found in color receivers might pose a potential erasure threat to recorded media which are stored on the cabinet. Tests were performed using five different color tv receivers with their chassis removed from the cabinets and with the recorded media placed as closely as possible to the degaussing coils. No signal losses were observed which could be attributed to these coils. However, because of the many magnetic field producing components in television receivers and the many untested models, it is prudent not to use the cabinet tops as a storage space for computer magnetic media.

### Light and laser beams

Recorded media were subjected to light sources ranging from infrared through an intense ultraviolet light source with no resultant data loss. The radiation from a laser beam also has no effect on the stored data if spread over a large area on the surface of the medium. However, a focused laser light beam can be made sufficiently intense to either heat or destroy the physical medium itself. (As a matter of fact, laser beams are used for recording in both of these modes, i.e., heat or "thermoremanent" recording and the medium burning mode. In thermoremanent recording, a sharply focused

## Magnets and Magnetic Recording

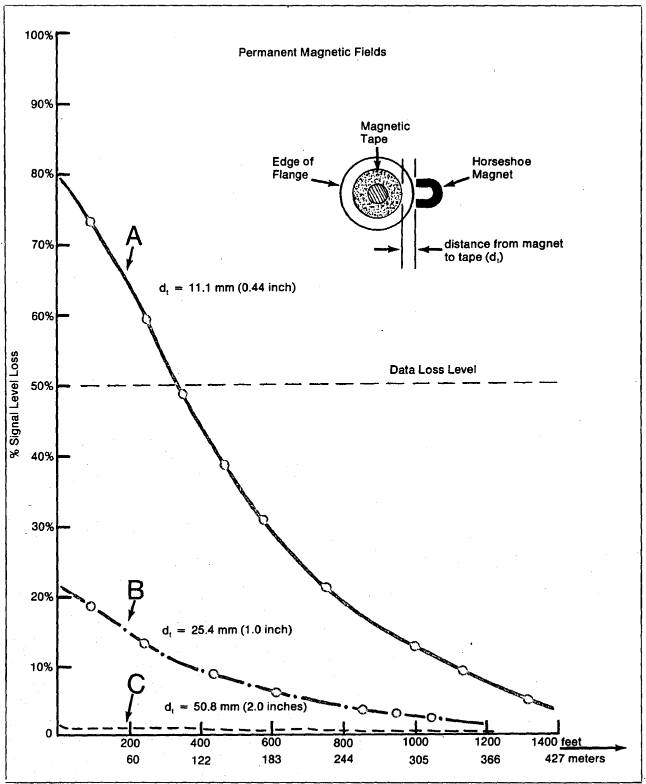



Fig. 1.

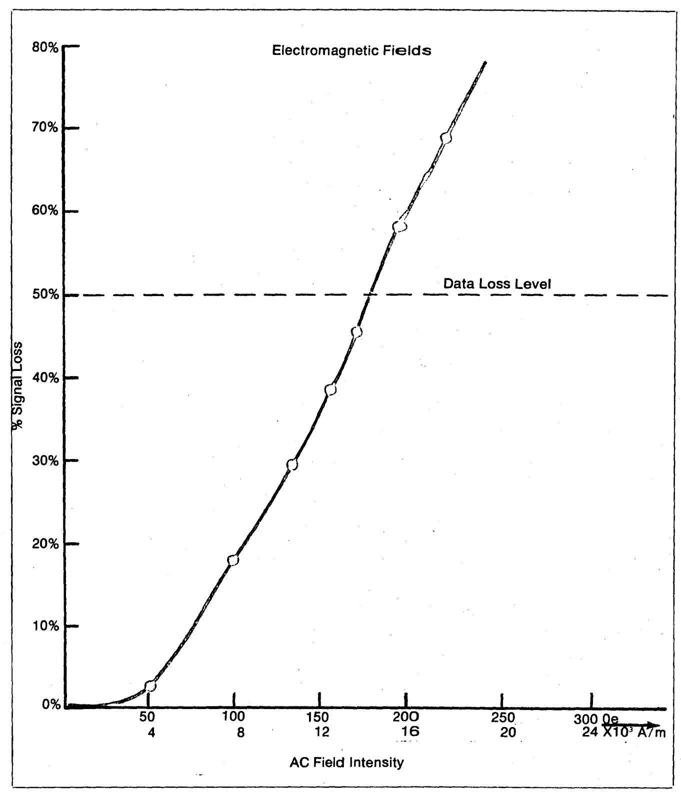



Fig. 2.

The ability of magnetic media to resist the erasure of recorded information depends primarily upon a quality known as "coercivity," which is measured in magnetic field strength units of amperes per meter (A/m) and oersteds (Oe), where one oersted converts to 79.6 amperes per meter. The higher the coercivity of a material, the more difficult it is to record onto or erase information from its magnetic surface.

To completely erase a recorded signal, it is necessary for the strength of the erasing field to be greater in value than the coercivity of the medium. For example, the coercivities of typical magnetic media used in dp applications range from 20,000 to 23,000 A/m (250 to 300 Oe); therefore, any magnetic field whose peak strength is less than these values cannot completely erase a signal recorded on them.

The read/write head of a magnetic tape drive typically has a field strength of 750 to 1,500 Oe. In the tests mentioned in the text, a 1,000 Oe horseshoe magnet was used. Fig. 1 illustrates the magnet's effect on a reel of magnetic tape when placed at distances of 0.44 inches (11.1 mm), 1.0 inch (25.4 mm), and 2.0 (50.8 mm) inches. Since the strength of a magnetic field falls off approximately as the cube of the distance from the magnet (at 10 inches away its field is roughly 1/1000 as strong as at 1 inch away), and since dp equipment can usually read a signal which has fallen to one half of its original recorded level, the 1,000 Oe magnet held 0.44 inches from the tape's surface is capable of erasing the first 350 feet (107 meters) of data. At a distance of 1 inch (25.4 mm) from the tape's surface, the magnet is incapable of fully erasing *any* recorded data.

The field from an electromagnet is nearly identical in its erasing characteristics to a permanent magnet's field, and follows the same inverse-cube law. However, its field strength depends on the current driven through its windings. It has been found that time-varying magnetic fields, such as the 60Hz fields of most electromagnets, follow what may be called the "peak rule." That is, the actual extent of the erasure of the stored data is caused by the maximum field value to which the media is subjected as the field varies through its values. As with permanent magnets, the erasure occurs almost instantaneously.

Fig. 2 illustrates the effects of 60Hz electromagnetic fields on recorded cassettes placed entirely within the fields. Note that even at "zero" distance, a relatively intense 8,000 A/m (100 Oe) field can reduce a recorded signal only by approximately 18%. ❊

laser beam heats up tiny localized points on a special type of substrate which is placed into a magnetic field. As the points cool back to room temperature, they remain magnetized. In the "burning" mode, small localized areas of a special coating are actually burned away—these areas represent the stored information.)

In summary, no response to laser beam energy other than its heating effect can cause a loss of stored data; hence if undetected data destruction at a distance is intended, a laser beam is not a practical technique.

### Pressure

Magnetically encoded plastic credit cards are often subjected to pressures in the pocket, wallet, or in cases. The effects of pressure were tested by placing 2,000 lbs (900 kg) of weight on a number of individual credit cards. There was no loss of magnetically encoded data.

### Heat

It is possible that magnetic tapes, cassettes, or magnetic stripe plastic credit cards will be left in a closed car during the summer. In some areas of the southwestern U.S., the temperature can rise to more than 200°F in some parts of the vehicle. Tests were performed over a range of 100°F (30°C) to 360°F (182°C). It was found that plastic digital cassette housings and credit cards began to physically distort at approximately 200°F (93°C) and could no longer be transported properly by their drives. Two reels of computer magnetic tapes functioned after exposure to 210°F (99°C), and then refused to load into the tape transport after they had been subjected to 230°F (110°C). The only apparent physical change was a loss of tape stiffness. At first, this appeared to be a permanent condition since these tapes had not recovered after six weeks in storage. However, after two months, they began to run again; the data could be recovered, but the oxide appeared to be shedding badly. In such cases, if possible, the data should be copied as soon as possible onto new tapes and the shedding tapes discarded.

It is recommended that computer tapes should be stored in vault temperatures of between 60°F (16°C) to 80°F (27°C) and relative humidities of 40-60%. The operating environment should be in the same approximate ranges as the vault in order to reduce temperature cycling effects.

Every heat test which was performed was terminated due to the physical failure of the media materials and housings rather than the magnetic data energy loss. In order to override these limitations and to isolate the physical effects from the magnetic effect, in one test a recorded plastic credit card was constrained by aluminum plates to prevent warping. There was no data loss observed after the card had been heated to 360°F (182°C) which was the oven temperature limit. Theoretically, gamma ferric oxide particles, which are the prevalent magnetic constituents used in most magnetic storage media, are capable of retaining data up to a temperature of approximately 1247°F (675°C). This temperature is known as the Curie temperature. On the other hand, chromium dioxide particles, used in audio and video tapes, have a Curie temperature of approximately 275°F (135°C) and are therefore far more susceptible to a heat related data loss.

### Cold

Theoretically, the magnetic oxide particles in the media will not lose any of their magnetization at temperatures which are well below their Curie temperature. However they may become stiff and moisture may condense upon them when subjected to very low temperatures. Recorded computer tapes which were stored at −60°F (−51°C) for 24 hours could be read without loss after being dried and relaxed (by careful, slow unwinding and rewinding) in the laboratory environment for one day.

Tapes which have been subjected to extremely low temperatures for long periods of time should be relaxed and dried for a number of days at gradually increasing temperatures to relieve stresses which develop with time. The shrinking of the tape due to exposure to excess cold can produce layer-to-layer adhesion which can then cause tape tearing and surface coating damage in portions of the reel.

Also, tapes which are cycled between temperature and humidity extremes can develop severe stresses within the reel due to the pressures caused by the plastic flow of the tape materials. These stresses can lead to damaged regions on the tapes.

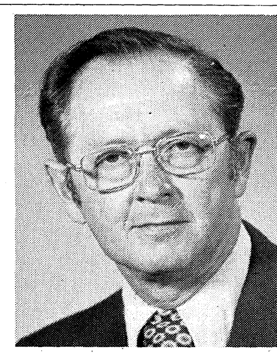
### Time

It has been found that data losses can occur on recorded magnetic computer tapes when they are stored unused in a vault for long periods of time (*Datamation*, Oct. 1974, p. 72). These losses are believed to be caused by the plastic flow tendencies of the tape materials. This flow causes distortions in the physical structure of wound tapes. It has been found that certain recording techniques and densities result in more data losses with time than others. A program of tape exercising can reduce these time loss effects. This exercising usually consists of a regular winding, rewinding, and relaxing the stored tapes in the operating environment.

### Magnetic media are tough

Magnetic computer tapes and discs are reliable storage media whose failures are almost always attributable to the physical deterioration of the media rather than to the deterioration of the data. In fact, the theoretical lifetime of the magnetically encoded data is virtually endless under ideal environmental and handling conditions. Fortunately, many environmental conditions which cause data losses through physical media deterioration can be controlled with housekeeping techniques such as temperature and humidity controls, regular media exercise schedules, and computer operator training.

The study has found that a magnetic field supplies the *only* kind of energy that can cause undetected data destruction without any accompanying physical distortion or damage to the magnetic storage media. It has been determined that normally there is no need to shield the stored data against x-rays, high voltage fields, nuclear radiation, high frequency fields, or light energy. Most important, a spacing of only a few inches is sufficient to protect the recorded media against magnetic fields which are far more intense than are ever found in the normal environment or that can be produced by a concealable magnet. Therefore, the stories of data destruction at a distance by magnets on flashlights and in repairmen's tool boxes are completely unfounded; only direct magnet-to-media contact can cause serious losses. ❋



Mr. Geller is the manager of the Magnetic Media Group of the Institute for Computer Sciences and Technology at the National Bureau of Standards. He has been active in the development of standard reference magnetic media and reference measurement systems.

One of his earlier papers, "The Effects of Magnetic Fields on Magnetic Storage Media Used in Computers," (NBS Technical Note 735, July 1972) is rather well known; it covered a small portion of the subject matter of this article.