# Notes On Demagnetizing

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Magnetic tape recording mechanisms, like a majority of other modern technological gadgets, comprise an assemblage of many materials. Predominant among their important working parts is most apt to be that ubiquitous and versatile alloy of iron called steel.

Steel is chosen because it is inherently strong, it can be readily worked into many useful forms and it is relativly cheap. Sometimes it is chosen because of its superior magnetic permeability, the ability to "conduct" magnetism some thousands of times better than any other common material. This property is used to advantage in all kinds of electro-magnetic equipment such as transformers, relays, electric motors and tape recording heads.

Steel for such electro-magnetic components is not only designed for high orders of permeability, but it must also be magnetically "soft" as well, with a very low value of "magnetic memory" or retentivity. In other words, when the influence of any magnetizing force is removed, such magnetically "soft" steel retains a very small amount of magnetism as a residual.

In contrast to the above "soft" magnetic steels, there exists a wide variety of magnetically "hard" steels. These are usually more highly alloyed, they may be heat treated or perhaps work-hardened for strength, wear resistance or hardness etc., wherever superior mechanical characteristics are necessary.

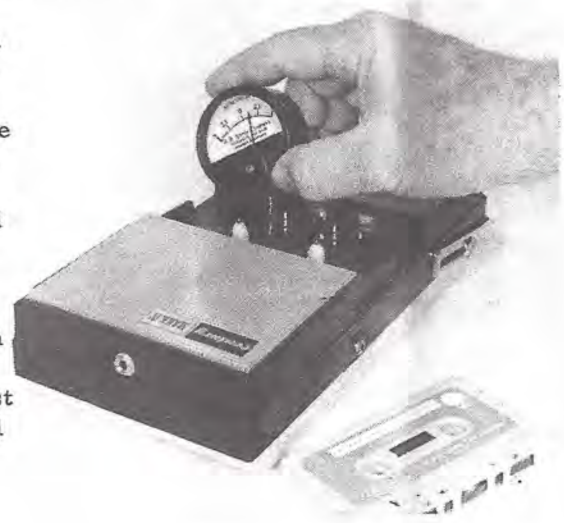
Such magnetically hard materials have a somewhat lesser ability to conduct magnetism but have a relativly good "magnetic memory". Should magnetically hard steel be exposed to magnetism, even if only for a fraction of a second, it will "remember" the exposure by retaining a fair portion of the original magnetism, becoming a secondary source of magnetism in its own right, acting somewhat like a permanent magnet. There are all shadings of magnetically soft to magnetically hard steels, with most mechanical components such as capstans, guides, rollers and springs falling in the middle to hard range so as to obtain superior mechanical strength and wear characteristics.

Unfortunately, but naturally the magnetic coating on recording tape is very sensitive to extraneous magnetism inasmuch as the recorded signal itself is only a modulation of the residual magnetism retained in the thin layer of magnetic coating compound. Exposure to subsequent magnetic fields of any consequence degrades the recorded signal. This degradation is proportional to the strength of such subsequent magnetic field exposure and somewhat to the number of times the tape is played or "wiped" across such fields. Degradation is noticeable as a loss or attenuation of the higher recorded frequencies as well as a noticeable increase in unwelcome background noise, which can amount to several dB.

Steel capstans and guides, usually being made of hard magnetic materials, are often major offenders in retaining unwanted magnetism which tends to degrade the recorded signal every time a tape is played.

Some tape recorders and magnetic sound projectors etc. are inherently bad actors because of "built in" extraneous magnetism in the tape transport area. In such equipment (and nameplates don't always mean too much), capstans and other tape transport components will be found to be rather highly magnetized and tend to stay that way in spite of any normal demagnetizing procedure.

One of the most common causes of such high levels of stubborn magnetism in components is due to their close proximity to an unshielded dynamic loud speaker. Such a speaker is one that has an <u>external</u> permanent magnet, located on the outside of the field structure. This type of field construction generates full magnetic potential between the front and rear of the speaker assembly, creating a strong and extensive stray magnetic field area that can induce high values of undesirable magnetism in any steel tape transport components located in the area. Such loud speakers are o.k. in themselves but their extensive stray field is "poison" in magnetic recording gear. This is in contrast to dynamic type speakers where the field magnet is internal, contained within a steel pot-like structure where most of the magnetic potential appears across the annular voice-coil gap, where it should appear.



Beware of any magnetic sound equipment having built in loud speakers with external magnet type fields that radiate stray magnetism all over the place. These are easily checked with a pocket magnetometer before you buy. If you already have one, the only permanent cure is to remove the offending speaker to a more remote location or replace it with one of the internal magnet, self-shielding type speakers. After making this change, you can then demagnetize the tape transport components with every hope of success.
Some portable recorders have permanent magnet field type drive motors that are efficient from the standpoint of conservation of battery power, but they radiate a rather strong stray magnetic field which, in some cases, encompasses the tape transport area.

There are many other sources of magnetism that can directly or indirectly magnetize steel tape recorder components. Every time an electric current flows, a magnetic field is generated. The intensity of this field is proportional to the amount of current flowing. Whenever switching is done in an inductive circuit there is a random chance of creating a "switching surge" which causes a momentary high current peak. Capacitors, often employed in electronic circuits, can also create high peak charging currents. Often the circuitry includes a multiple turn coil where the magnetic effect of the current is multiplied in proportion to the number of turns. Any steel within the area of such field will become magnetized, a portion of which will be retained as residual magnetism. Care should also be taken not to bring magnetized tools or other magnetic devices near steel tape recorder components. Even the effect of the earth's magnetic field should not be discounted. This source of magnetism is ever with us. Remember- the mariners magnetic compass is actuated entirely by just the horizontal component of force created by the earth's field.

Typical for most of the U.S.A, the vertical component of the earth's magnetic field is considerably stronger than the horizontal component, due to the fact that the field dips down about 70 degrees toward the north. This steep angle of dip is due not only to curvature of the earth's surface but also to the fact that the effective magnetic pole area of the earth is displaced and located considerably below the surface.

Fairly long iron or steel members which may be oriented somewhat parallel with the direction of the earth's magnetic field, will become magnetized due to the fact that their high magnetic "conductivity" tends to concentrate the earth's magnetic field in that area. Rather strong magnetic poles will appear at the ends of such iron or steel members. Steel components brought near such poles will, in turn, become magnetized, the same as when exposed to any other magnetic field source. Very little consideration is usually given to such a possibility. In other words, don't place your recorder too close to the ends of steel pipes, bars or structures oriented either vertically or in a generally north and south direction. It is also well to be alert to the possibility of picking up magnetism from a myriad of electro-magnetic or permanent magnet devices that may have extensive stray fields. For instance, some meter type photometers and many transistor radios contain very strong unshielded permanent magnets.

An instrument known as a pocket magnetometer can be used to discover or determine the magnitude and polarity of such disturbing magnetic fields or residuals. The calibrated magnetometer is quick and handy to use, giving an instant indication of any dangerous levels of magnetism that may be present in components.

It is indeed fortunate that magnetic residuals can be removed from steel components in several different ways. In other words, they can be demagnetized.

One very effective method is to heat the steel red hot then slowly cool in a low magnetic field area. This, however, is obviously not a very practical method for most requirements. A second method is to expose the steel to a carefully controlled magnetic field of opposite polarity, but oriented in exactly the same direction as the original magnetizing field. The intensity of this oppositely polarized field must be an accurately determined fraction of the original magnetizing field. This fraction will vary depending on the type of steel, its heat treatment or work hardening, etc. Determination of such a precise fraction is practically a laboratory procedure and therefore is not a very suitable process either.

A third, relatively simple demagnetizing method is to expose the steel to a magnetic field of cyclically reversing polarity which must have an initial intensity higher than the fraction mentioned in the above described laboratory procedure . This cyclically reversing field is then reduced in intensity so that each succeeding half-cycle, of opposite polarity, is slightly less than the preceding half-cycle but more than the critical minimum "fraction" as dictated by the type of steel involved.

For anything but very heavy steel sections, a convenient source of reversing field for this cyclical demagnetizing is readily available from regular 50 or 60 cycle alternating current power circuits. At these frequencies, the time between successive half-cycles is quite short and the incremental reduction between successive half-cycles is easily kept within the fairly broad, safe range permissible.

The intensity of such a cyclically alternating demagnetizing field can be reduced to near zero by means of a rheostat or a variable transformer, or much more simply by progressively separating the steel and the source of alternating demagnetizing field to such a distance that the field induced in the steel is essentially zero. This is not difficult, nor is the separation distance involved too great because such induced magnetism very nearly follows the inverse square law, where doubling the distance apart will reduce induction to one quarter the initial amount and doubling again, to one sixteenth, etc.

One of the most important points to remember in cyclical demagnetizing is that actual demagnetizing is accomplished <u>only</u> during the incremental reduction of successive half-cycles of the demagnetizing field, or only during that time when the work and the demagnetizer are being separated. Leaving steel to "cook" in an alternating demagnetizing field is of little value unless one might consider the secondary effect of heat being generated in the work due to losses from induced eddy currents.

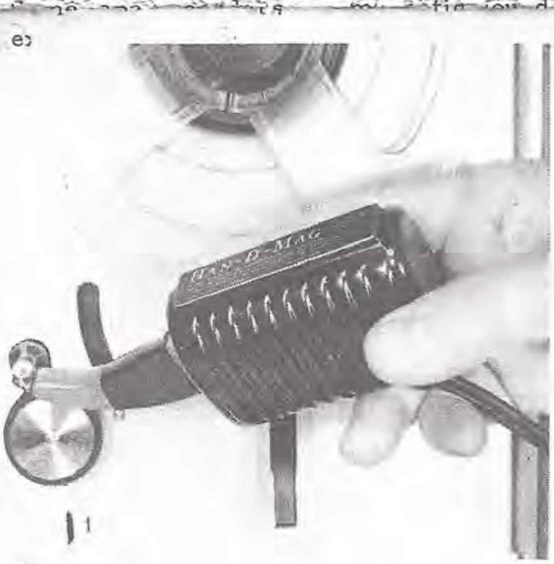
When starting to demagnetize, it is often advantageous to shift angular relationship between the steel work and the demagnetizing field. This can be accomplished by turning the work or by a slight lateral "waving" of the demagnetizer probe before separation. This will insure optimum demagnetizing.

Another important point concerning cyclical demagnetizing is that there must be no interruption of the power to the demagnetizer during separation or the incremental reduction period, even momentarily. If this occurs, the steel will be left in a highly magnetized condition as a result of being magnetized by the last half-cycle prior to interruption. When this occurs, demagnetizing must be repeated.

A third point to remember is that complete demagnetization of steel cannot be accomplished while it is still under the influence of the original magnetizing field or any other stray unidirectional field of any consequence. You can't demagnetize components remaining in the vicinity of a "hot" loud speaker field. On very critical work, even the "bias" caused by induction from the earth's magnetic field can prevent complete demagnetization without the use of special procedures. This effect is particularly noticeable when working with some of the stainless steels and others in the middle hardness range.

The author has had the opportunity to check a number of the probe type "head" demagnetizers and found that their demagnetizing field intensity only averaged 70 to 80 oersteds, with a top of 100 oersteds, when measured at a standard 1/4" distance from the probe. These values of demagnetizing field strength are too low to attain that necessary high initial intensity required for successful cyclical demagnetizing.

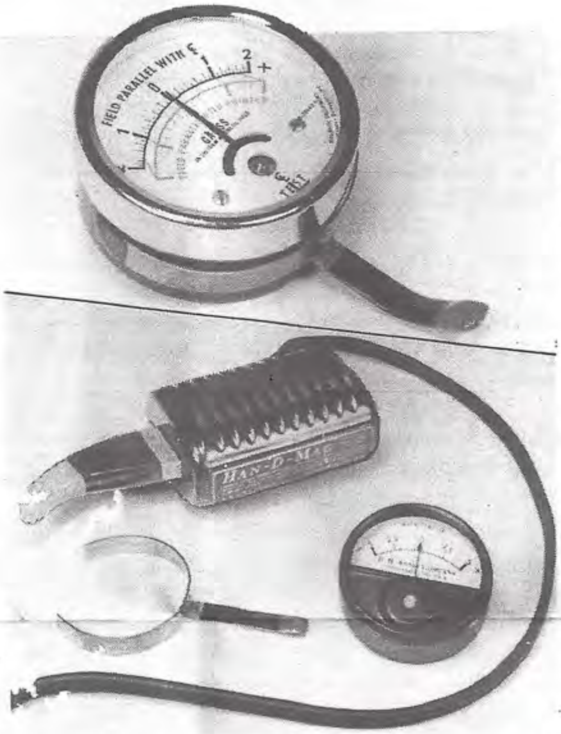
In view of the above apparent need for a more effective probe type demagnetizer, an experimental engineering approach led to the evolution of a considerably more effective, hand held, double ended demagnetizer having a conveniently curved probe at one end with a demagnetizing field intensity of 350-400 oersteds at 1/4". The opposite, flush pole end, measures over 800 oersteds, so powerful it can be used for limited bulk demagnetizing of tapes up to 1/4" wide if a regular bulk tape eraser is not available. In the interest of demagnetizing efficiency, this new "Han-D-Mag" unit made generous use of the best magnetic materials along with increased power input and a carefully designed configuration for practical intermittent operation. Mention of this more efficient damagnetizer created so much interest that it was tooled for production and is now available from R. B. Annis Co. Indianapolis, Ind. 46202




The Han-D-Mag is so powerful that it is not necessary for the plastic coated probe to touch the work, just bring it near, within 1/8" to 1/4" of small magnetized steel parts, wave the tip sideways slightly, then remove slowly, while still energized, at a rate no faster than 3" - 4" per second, to a distance of at least 12" before turning the power off.

Considerable care should be taken with any energized demagnetizer not to bring it too close to valuable recorded tapes. Bulk erasers and the powerful Han-D-Mag should be kept at least 12" away from such tapes. VU meters, ear phones and magnetometers etc. may be considered safe at 1" distance from the probe end and 2" distance from the flush pole end of the Han-D-Mag. Recorded tape should not be brought too close to other strong magnetic field sources such as unshielded loudspeakers, magnetic hooks and paper clamps etc.

The difference between good and bad demagnetizing proceedure and equipment can be quickly determined with the pocket magnetometer.




When using the magnetometer, the bottom, test edge of the instrument is brought in contact with the part being checked. If the part is magnetized, the instrument pointer will move from its normal center-zero scale position. The direction of pointer deflection indicates magnetic polarity of the part being checked. The amount of deflection is a measure of the intensity of magnetization of the steel part.

Magnetometers in the 2 to 5 gauss range are excellent for detecting and measuring residual magnetism in tape recorder components. These instruments, being fairly sensitive, may also show a noticable response to the earth's magnetic field which amounts to about 1/2 gauss. If desirable, this response can be eliminated by tipping the instrument until its staff is aligned parallel with the direction of the magnetic field in the area prior to approaching the work with the test edge. In any event, whether it is convenient to align the staff for zero reading or not, the important thing to note is the change in reading as the work is approached and touched.

Purely as a rule of thumb, any capstan, head or tape transport component that reads much over one gauss should be suspect, when measured with the test edge of the magnetometer in contact with the component, as described above. To explain this more fully, these magnetometers actually measure magnetic field strength in the area of the movement staff which is located some 1/2" to 5/8" from the bottom test edge.

The magnetic field emanating from a small source is non-uniform due to its considerable divergence with distance. Therefore the field intensity at the very surface of the capstan, for instance, will always be of a higher order than the value measured at the instrument staff. While this non-uniform field effect is at a maximum for small size parts, it becomes progressively less as the measured source grows larger and is non-existent in a uniform field. The magnetometer reading is valuable however, as it is directly relative to values of magnetism in the parts being checked. Acceptable levels that are consistant with good recording practice are quickly determined.

Where recessed components are to be checked and it is impossible to contact them with the test edge of the magnetometer, it is quite helpful to attach a magnetically soft probe to the test edge of the instrument so as to better "conduct" magnetism from the recessed component to the magnetometer movement. Readings taken with the probe interposed will not be as high as if the test edge of the magnetometer proper were touching the component but its use will improve remote sensitivity from 4 to 6 times when checking small, inaccessible components that can only be reached with the end of the probe.

Clip-on probes are now available as an accessory for Pocket Magnetometers. The probe assembly consists of a spring clip with a flat, vinyl coated search probe about [illegible] long which [illegible] formed with the fingers so as to better contact recessed components.

It has been said that one really knows very little about a problem until it can be reduced to figures. You may attempt to demagnetize but until you actually measure residual values of magnetism, you really dont know where you are. You have not reduced the problem to figures.