Making analogs with a magnet

study 3

Though equipment has a special significance for analog sound production, anyone can make sound analogs or musical constructs even with very little equipment. Once it is clear that we work with ANALOGIES OF SOUND, we can translate this new principle into action, and the work itself will lead us to conclusions with unexpected consequences. For example, magnets can make music.

I began making analog sound music with a tape recorder (the v.c. synthesizer had not yet been invented). One morning* the following thoughts occurred to me:

> No matter what its origin, the oscillations processed by the tape recorder are converted into a magnetic pattern on tape. The pattern on the tape is a directional sequence of magnetic intensities, a frozen record of the magnetic activity that occurred in the recording head of the machine. To re-animate the pattern we have to MOVE the tape exactly the way it was moving when the recording took place. Thus, the tape, considered as an isolated object, is a ribbon of magnetic material with a magnetic 'drawing' imprinted upon it.**
> Therefore, I could create an analog sound structure simply by drawing a magnetic pattern with a magnet on a length of blank tape.

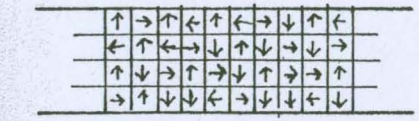
This seemed like a great idea because the procedure is so very direct, eliminating the need for oscillators and the whole

*Fall of 1960

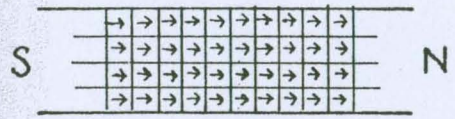
**The recorder I owned at the time of my first study with a magnet was significantly called "Ferrograph".

process of the 'recording chain'. After a period of trying to find out how to do this, I made some effective analogs, mostly percussive in quality, some with duration and others with pitch characteristics.

First, let us briefly review the nature of magnetic imprints on recorded tape. Magnetic tape is made of a plastic backing (eg. polyester) coated with a mixture of a ferrous material (eg. ferric oxide - Fe_2O_3) and a binder (eg. cellulose nitrate). The ferrous material must be finely structured and firmly bonded to the backing.

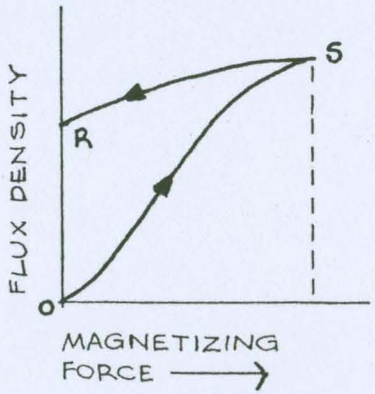


DEMAGNETIZED – RANDOM

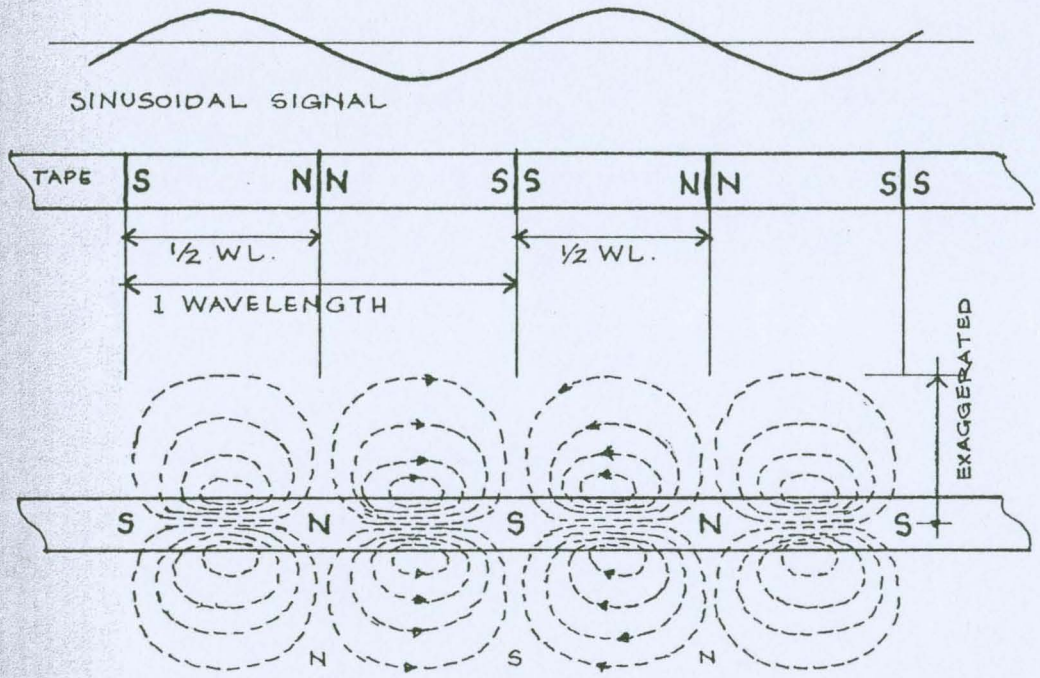


SATURATED – POLARIZED

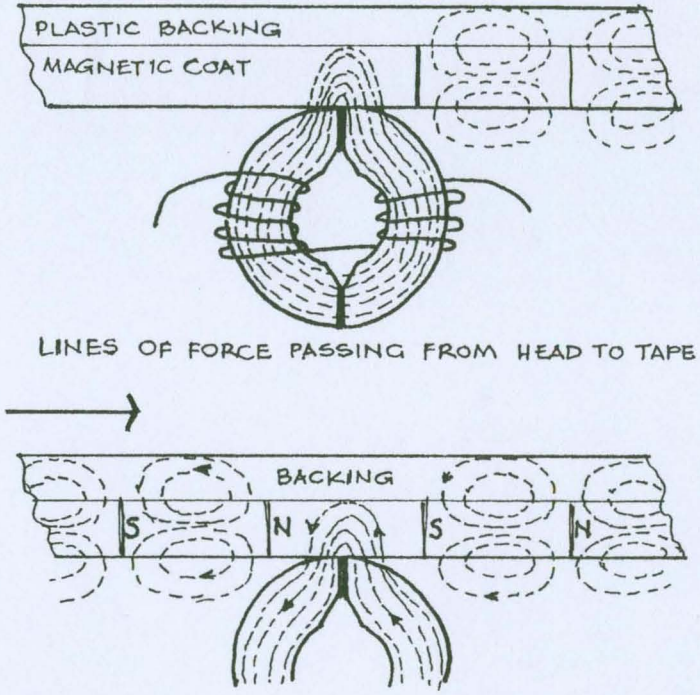
The crystal units of ferric oxide contain eight molecules of Fe_2O_3 in the form of a cube (size $\frac{1}{10}$ micron^3). When heated in a magnetic field, these units elongate and bunch together in DOMAINS. Each domain behaves like a tiny bar magnet. Their orientation is random until they are subjected to a magnetizing force, when the domains rotate to align with the applied magnetic force. If the magnetic force is sufficient, all the domains become oriented to the lines of the force (ie. saturated). But when this force is removed, the magnetism in the Fe_2O_3 reverts from the saturation level to a lower value (ie. remanence). Magnetic remanance is the 'magnetic memory' imprinted in the tape coating.



A signal, or sound analog, recorded on tape is retained as a series of magnetic intensities of alternating polarity. It closely resembles a set of flat bar magnets all strung together in a line, with like poles contiguous. The diagram on the next page shows the relationship of these polarity nodes to the waveform of the signal. We note that the length of each 'bar magnet' is half the wavelength of the signal. The other drawings illustrate by plan and



LINES OF FORCE IN THE TAPE COATING — RECORDING OF ABOVE SIGNAL.



LINES OF FORCE PASSING FROM HEAD TO TAPE

LINES OF FORCE IN TAPE & PLAYBACK HEAD.

exaggerated sections, the direction and pattern of the magnetic lines of flux retained by the Fe_2O_3 tape coating.

The tools for this study can hardly be called equipment. You will need a quantity of standard recording tape; a board or surface on which to work; a small permanent magnet - Alnico or similar alloy - preferably of rectangular section because it provides a surface, an edge, and a point for alternate tape contacts; white editing pencil. That is all. Of course to hear the effects of your inventions you will need a tape player. Any type will do but again, tape players with faster speeds are best.

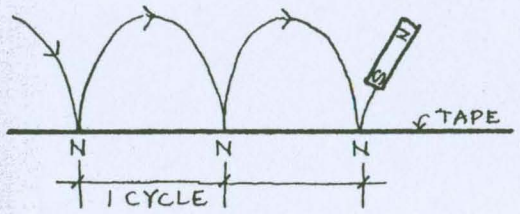
The magnetic analog of a sound is an alternating pattern of

magnetic polarities. From the previous diagram, we can deduce that one pole of a magnet will suffice to create an imprint similar to one node of a recorded oscillation. If we then make a number of successive pole imprints, we can produce a magnetic pattern with some resemblance to the recording of an oscillation. When the frequency (in this case measured by the spacing between pole imprints) falls within the audio frequency band, it will produce sound when played back at the appropriate tape speed.

To start, lay the tape out so that it is held flat. Mark the areas to be worked. Touch the tape a number of times with the edge of the magnet in an evenly spaced succession, lifting the magnet away each time in an arch like motion - see diagram A. Another way is to use the edge of the magnet in short, stroking actions, leaving little gaps between succeeding strokes - see diagram B.

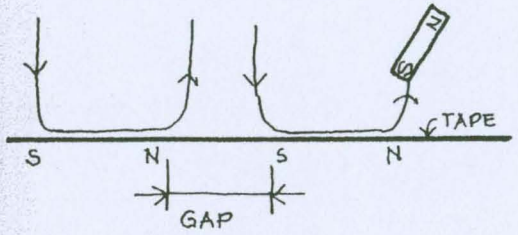
Generally the tape should either be new, or should have been totally erased in an alternating magnetic field. This ensures that the Fe_2O_3 domains are random to begin with. Tape that has been erased with a permanent magnet, has a majority of its domains lined up in one direction, which presents a different starting condition. This too may be used. A section of the tape may be stroked in one

A

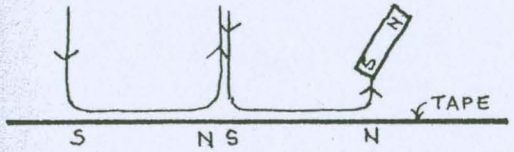


ARCH AWAY ACTION

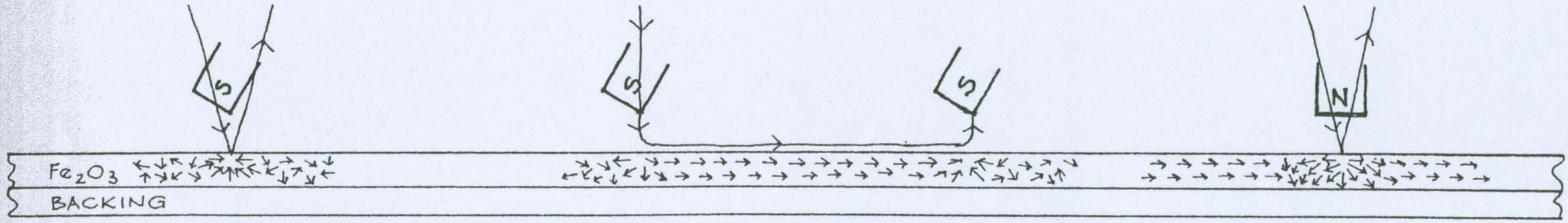
B



WIPING ACTION



WIPING ACTION

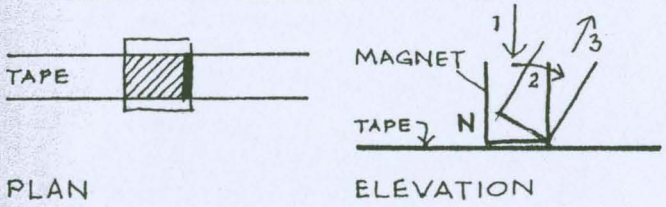
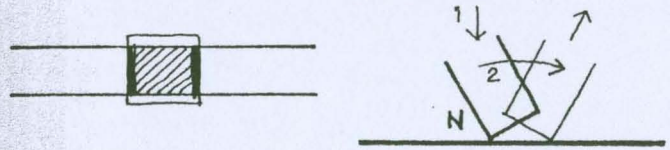
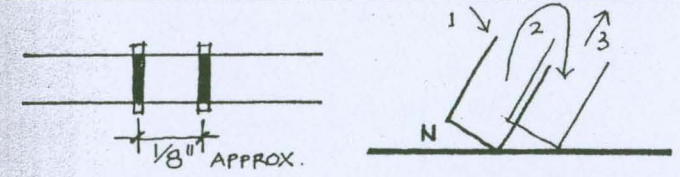
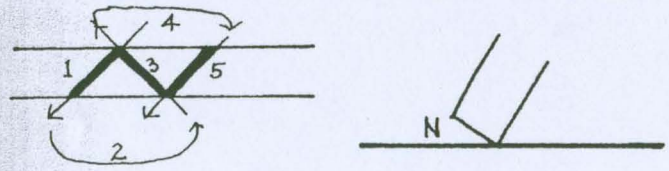


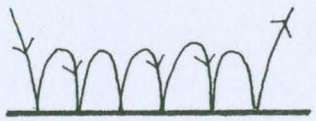
EDGE OF MAGNET WIPING ACTION WITH EDGE OF MAGNET COMPLETE POLE SURFACE

direction so as deliberately to line up all the domains in that section. The opposite pole can then be used in the contact and arch away action (see diag.A) to create the alternating north-south pattern.

The following is a tabulation of hand actions with a magnet, which will result in magnetic imprints on tape. They have been selected from the author's workshop notes because they are usable.*

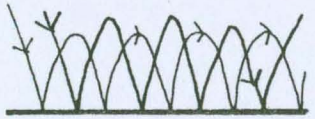
*Written over a period preceding and up to Spring 1964.

	1 place the magnet on the tape, lift one edge away before removing the magnet; 2 pre-stroke the tape and then the same action.
	1 place edge of magnet on tape then rock the magnet over to the other edge and remove; 2 same action but rock the magnet from edge to edge - about 3 times; 3 same action but over a pre-stroked area.
	1 edge down and repeat at 1/8 inch spacing; 2 same but using opposite poles; 3 slide the contacting edge across the tape instead of moving it up and down.
	1 pole edge down diagonally, slide off tape diagonally and criss-cross twice; 2 same action but using alternate poles.

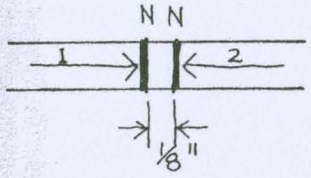


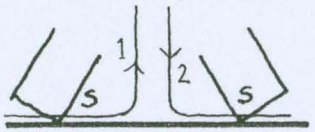
PLAN ELEVATION

1 edge of magnet repeated at $\frac{1}{8}$ inch intervals, mark tape as guide;
2 similar but using sideways slide movement;
3 stroke the tape, then repeat the above.

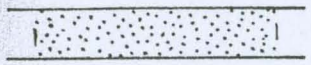


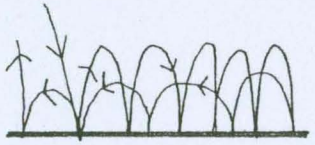
1 edge of magnet used diagonally, repeated, then add another set at right angles to first;
2 similar but using sideways slide movement;
3 stroke the tape, then repeat the above.





1 mark the tape, edge of magnet down 1 cm to the left of the mark, wipe toward the mark and lift magnet;
2 just before the mark, do the same from the right of the mark toward the mark.





1 over a short length of tape, dot the surface with the point of the magnet, try to achieve an even density, the action should be gentle so as not to distort the surface.

Undoubtedly there are many more maneuvers that will create the magnetic patterns desired.

POSTSCRIPT Though unknown to me at the time I made the above studies, A. H. Frisch had already developed an accurate and practical technique for making sound analog tapes magnetically. His method is very well described in "The Magnetic Stencils of A.H.Frisch" (Gordon Mumma) Electronic Music Review #5 January 1968.