Magnetic Recording Materials

It was more than a century ago, in 1888, when Oberlin Smith wrote an article for *The Electrical World*, describing his idea for storing electrical information by means of magnetized particles. Magnetic tapes have since become one of the most accurate, convenient ways to store information as diverse as sound and video signals, controlling impulses for machinery, or data from business and scientific apparatus. In fact, anything that can be converted to an electrical signal can be stored magnetically and later reproduced. Because magnetic storage media can be erased and re-used many times over, such materials also have a great economic advantage over other recording methods.

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It took a decade after Oberlin Smith's article, however, before anyone put into practice a storage system that used magnetic materials. Danish inventor Valdemar Poulsen created a device that could store an electrical signal on a length of magnetic steel wire. He applied for a patent in Denmark on December 1, 1898, and also received a U.S. patent on November 13, 1900.

Poulsen's electromagnetic recording head hooked up to receive electrical signals from a telephone transmitter. A moving steel piano wire passing beneath the head became magnetized in step with those signals. To replay the signal, the magnetized wire moved under the head, producing electric impulses that were transmitted back to the telephone receiver. The "telegraphone," as he called it, could record continuously for 30 minutes—a great improvement over the shorter term disks and cylinders used in mechanical sound-reproduction systems. The steel wire moved over a recording or reading head at a rate of 84 inches per second.

Poulsen took a working model of his telegraphone invention to the Paris Exposition in 1900, where it created quite a stir. Other visionaries at the Exposition speculated on many of the magnetic recorder's later applications, but even with this interest, Poulsen could not find financial backers to put the device into large-scale production in Europe. Finally, in 1903, he and several American backers formed the American Telegraphone Company to manufacture an improved version of the device.

The sound reproduction, though, was inferior to the quality obtainable from the phonograph at the time, and was plagued with distortion and noise. The telegraphone never found wide application, and Poulsen's company eventually failed.

While more information could be stored on a given space of wire than on any of the other common magnetic-storage materials, the sound reproduction suffered from a poor signal-to-noise ratio and "cross-talk," or interference from adjacent recorded layers wound together on the same spool. But the development of other materials for magnetic storage alleviated some of these problems.

In 1927 J.A. O'Neill was awarded a U.S. patent for his process of drying a liquid containing magnetic particles on the surface of a strip of paper, thus creating magnetic tape. Fritz Pfleumer in Dresden received a German patent for a similar process a year later. Some very early machines had used a solid metal tape of magnetic material, particularly Vicalloy (a magnetic stainless steel of 52% cobalt, 11% vanadium, and 37% iron), but the paper or (later) plastic tapes soon proved to be the most useful form of magnetic recording material.

Tape was most often coated with red iron oxide, Fe_2O_3, as the magnetic material. Black iron oxide, Fe_3O_4, was used, produced a stronger signal but was more difficult to erase. In the late 1960s, to meet a demand for the slow tape speed and the extended high-frequency response used in cassette tape recorders, Du Pont began to use a new magnetic material, CrO_2. In the mid-1970s, TDK introduced Super Avilyn, a cobalt-adsorbed ferric oxide particle that equaled the performance of CrO_2 but produced a greater overall output. The 3M Company introduced a tape coated with pure metal-particle (non-oxide iron) in 1978, which gave even better high-frequency response at high recording levels.

The base material for magnetic tape was initially paper, which is less expensive than many plastics and, in some applications, more stable under varying conditions of temperature and humidity. But paper tears easily, and being composed of plant fibers, it cannot be made absolutely smooth. Since even small width distortions will affect magnetic sound reproduction, plastics have proven to be a more desirable base material.

Modern recording tapes are usually made from mylar and other polyester plastics, and are sometimes coated on the back with a conductive material to eliminate static-electricity buildup and also to improve winding characteristics. For the open reel-to-reel tapes, a tape thickness between 1.0 and 1.5 mils is most common, while for enclosed cassettes the tape thickness generally ranges from 0.31 to 0.48 mils.

Even after Poulsen's telegraphone company folded, development continued on different recording and playback systems. At the U.S. Naval Research laboratory, W.L. Carlson and G.W. Carpenter developed an alternating-current bias for magnetic recording and received a patent in 1921. The ac bias reduced distortion and increased the signal-to-noise ratio.

In earlier direct-current-biased recording, the wire or tape was pulled past a permanent magnet that left it fully and uniformly magnetized in one direction or the other. The recording head then introduced a signal, adding to the uniform magnetization of the wire according to the signal's strength.

In Carlson and Carpenter's ac-biased scheme however, the tape is completely demagnetized before use. When the neutral wire passes in front of the recording head, an alternating current is added to the signal current. The ac current has a much higher amplitude than the signal current and a frequency greater than the highest-frequency signal that would be recorded. This means that the ac signal will not be confused with the sound recording. As the tape crosses the gap of the recording head, the magnetic particles are subjected to many cycles of the ac bias current, leaving the tape magnetized proportional to the signal. This allows for a recording with lower distortion and higher signal-to-noise ratio than dc recording methods.

About this same time, Louis Blattner of England built a magnetic recording machine that could synchronize its sound with motion pictures. The British Broadcasting Corporation used his "Blattnerphone," and later the Marconi company purchased it.

Work on Blattnerphone-type devices continued in England, the United States, and Germany during the 1930s. One of the most successful outcomes of this research

was a magnetic film-coated tape based on the 1928 patent held by Fritz Pfleumer and produced by the Magnetophon company of Germany. The Magnetophon company also produced its own player, not surprisingly called the "Magnetophon," which showed that the system could be made practical and at a low cost. At the 1936 Berlin Radio Fair the Magnetophon company demonstrated its system, using a plastic-based magnetic tape manufactured by BASF to reproduce a performance by Sir Thomas Beecham and the London Philharmonic Orchestra.

During World War II the Nazis made extensive use of the Magnetophon and its inexpensive recording tape for propaganda purposes. One widespread application was for prominent officials to record speeches to be broadcast at times and places intended to confuse Allied intelligence. The capture of Radio Luxembourg in 1944 brought the discovery of a giant tape-recording machine that surpassed in fidelity the finest disk recordings of the day.

This device was taken to the United States where the Ampex Corporation in California copied and modified it until magnetic tape recording offered the ultimate in wide-range and noise-free sound reproduction. By April 1948 the first such recorder was delivered to the American Broadcasting Company, where it was used for a delayed broadcast of the Bing Crosby Show.

In 1949 some recording studios began to use the new kinds of magnetic tape for original takes of musical recording sessions. Before this, mechanical disks were cut during the actual performance—but magnetic tape gave not only better fidelity, it could also run for half an hour without interruption, and mistakes could be edited out and new tape spliced in.

The year 1950 brought the realization that scientific data could also be recorded on magnetic tape, and the Ampex Corporation delivered a suitably modified audio machine to the U.S. government.

Now, magnetic recording materials come in many different forms. Drums of neutral material are coated with a magnetic film to record short bursts of information, like that used by computers and other types of data recording. Cylinders of rubber or plastic impregnated with magnetic particles are sometimes used to record short messages in telephone answering machines. Disks coated or impregnated with magnetic material are recorded in spiral or parallel tracks for use in computer disk drives. Magnetic data storage has entirely replaced mechanical methods such as paper tape and punch cards.

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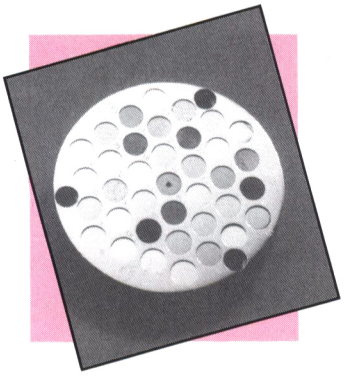

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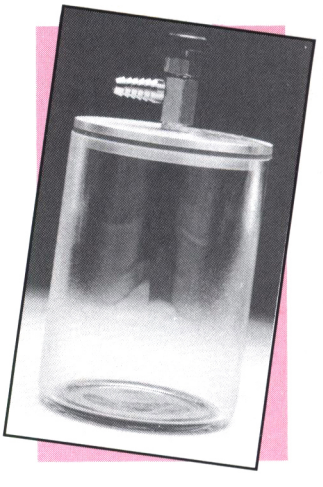

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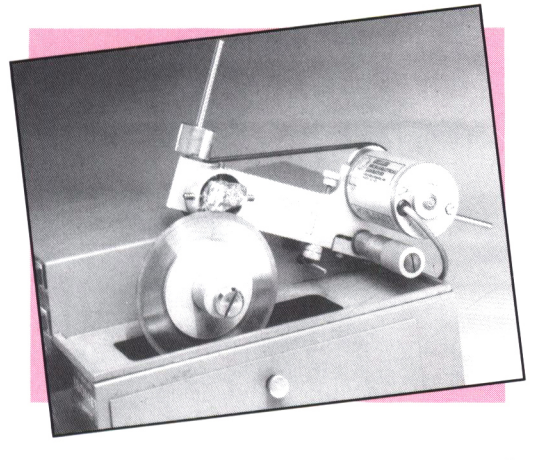

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