SOUND RECORDING ON MAGNETIC MATERIALS

This method of sound recording has found much favor in Europe—advantages and disadvantages are discussed.

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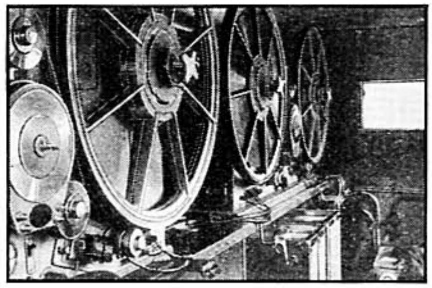


Fig. A, above. The interior of a German steel ribbon sound-recorder truck.

MANY EUROPEAN broadcast stations repeat in the evening hours a part of the most interesting daytime transmissions, as for example, "spot" reports on important happenings recorded during the day, or speeches of statesmen, etc. This method of sound storage, or as the broadcast technicians call it "play-back," is accomplished by various methods, the oldest of which is the wax recording process. But the wax record, although for years the only practical means for sound recording and play-back, does not entirely suit the needs of modern broadcasting because of limitations of its process.

The "lateral cut" method for example (see Fig.A), which is also used for the records for some home-type phonographs, can hardly be utilized to record and reproduce the audio frequencies above 4,000 cycles without great expense, especially if reproduction directly from the wax is desired, a situation which is often encountered in broadcasting. The reason for this is the fact that when the hard steel needle of the pick-up-head is led through the relatively soft wax-composition, the tiny wave cuts (which actually represent the recordings of the higher audio frequencies) are deformed or torn off.

HARDENING BY GOLD SPUTTERING

Since there is usually not sufficient time in broadcast-station operation to press the much harder and more durable shellac records from the original wax "master," another method has recently been used to harden the wax. It is the so-called "cathode sputtering process," by means of which a very thin layer of gold is sputtered onto the recordings on the wax disc. However, this method is not only very expensive but has disadvantages which have not as yet been eliminated.

TYPES OF RECORDINGS

A somewhat superior method to the lateral cut record is found in the vertical sound recording method, often referred to as "hill and dale" recordings (see Fig. 1B). This type of recording reproduces all frequencies up to 6,000 cycles when instantaneous play-back is desired. This method, mainly developed in this country, apparently has not been used in Europe—at least, not for direct play-back from the wax. The reason for neglecting this excellent method abroad was probably due to the tremendous strides which have been made during the past few years in Europe with the steel-*wire* ("telegraphone") recording method, which is now about 35 years old. (It was invented by the Danish scientist, Professor Poulsen, in the year 1900.)

The method by which the steel recordings are made is shown in Fig. 1C. According to the current fluctuations, caused by a microphone, similar strong or weak impulses are magnetically recorded on the steel wire. How this method actually works, may be seen from Fig. 1D. In the upper part of this illustration we see the cross-section of a tremendously enlarged piece of steel wire. The small dashes signify the molecules of the iron, and, as we see, they are arranged in an orderly form if the wire bears no recordings.

WHAT HAPPENS IN THE STEEL WIRE

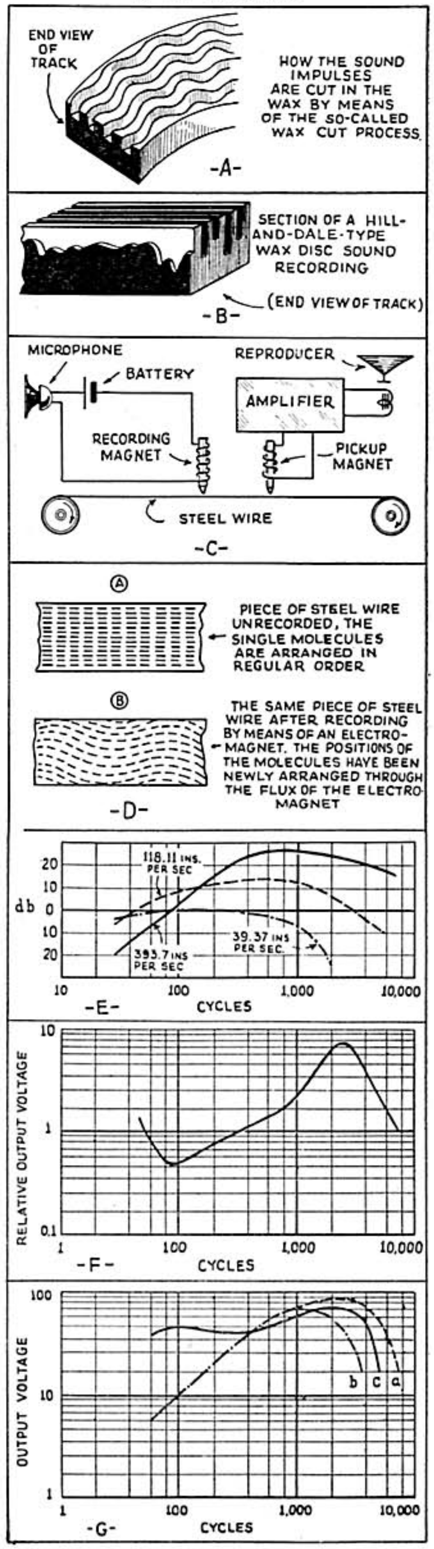
If such a piece of steel wire passes in front of the recording magnet (see Fig. 1C), the molecules will be disarranged because of the magnetic flux emanating from the recording magnet, which moves the tiny iron molecules to a moderately large degree. If such a piece of steel wire with "disarranged molecules" or magnetic recordings, is moved in front of the pick-up magnet, electromagnetic "disturbances" are produced in the pick-up magnet which are an exact replica of the original. Since it is easy to convert electromagnetic flux variations into electrical impulses by winding a coil around the pick-up magnet, the reproduction process is solved quite simply. The minute electrical impulses as furnished by the pick-up magnet-coil are sent at once through an amplifier connected to a loudspeaker, or if radiation to the broadcasting listener is desired, through an amplifier and thence to the transmitter.

Since a wire once recorded can be played-back as often as desired without wearing out, the recording time is theoretically unlimited. Through use of long wires the advantages of this recording method appears at first glance to surpass the qualities of any other.

RESTRICTED FREQUENCY RESPONSE

However, as is often the case, some important disadvantages are involved, as unbiased experiments by the Institute of Technology, Berlin (actually executed by the well-known Heinrich Hertz Institute) indicate. ("Magnetische Schallaufzeichnung auf Stahlbänder," Zeitschrift für technische Physik, 1932, page 593-599, and "Zur Theorie der magnetischen Tonaufzeichnung," Elektrische Nachrichten Technik, 1932, (*Continued on page* 562)

Fig. I, below. Facts concerning magnetic recording on wire and ribbon.



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page 388-403). As Fig. 1E, which is taken from the above-mentioned reports, shows, the frequency-response curve of the steel recording method depends to a large extent on the speed at which the wire passes the recording magnet.

As Fig. 1E indicates, only the frequences between 50 and 2,000 cycles may be reproduced if the speed of the steel wire is one meter per second (about 3.29 ft. per second), but the fluctuations in this relatively small frequency range are about 20 db. The response curve goes up to 6,000 cycles if the speed of the wire is increased to 3 meters per second (9.97 ft. per second) but the fluctuations are increasing to about 25 db. A further increase in speed brings about better reproduction of the highs without large fluctuations in the output but causes a marked decrease in the reproduction of the low frequencies.

This unfavorable characteristic is caused by fundamental qualities of the steel-wire recording process. To obtain a better understanding of the actual conditions which are the governing factors of this recording method we have to keep in mind that the iron molecules, which are the basis of the entire recording process, are tightly bound in the mass of the iron. What this fact involves will be seen from the following description. As long as a low audio frequency is to be recorded (let's take a frequency of 100 cycles, for example), the iron molecules have plenty of time (1/100-second for each cycle) to arrange themselves in such manner that, for each cycle, a corresponding image created by disarranged iron molecules is created in the wire (see Fig. 1D).

SPEED VS. MOLECULE MOVEMENTS

However, in case a higher audio frequency is to be recorded (for example one of 3,000 cycles) considerable difficulties occur. The reason for these difficulties is quite simple, since upon a small area of the wire a great many of the individual cycles which determine an audio frequency of 3,000 cycles have to be recorded. But this is not all that worries the recording engineer. If a higher wire speed is applied to enlarge the area for the recording of the single cycles of an audio frequency of 3,000 cycles (to give an example), *the response curve in respect to the lower audio frequencies decreases considerable* as Fig. 1E indicates! The effect of the increase of wire speed can easily be seen by a comparison of the response curve obtained at wire speeds of 3 and 10 meters per second, with the response curve obtained by a speed of only 1 meter per second.

The reason why the low audio frequencies are so badly recorded when the speed is increased is as follows: If the speed is low, the iron molecules have plenty of time to follow in their movements the large but slow pulsations of the low audio frequencies. But if the speed is increased, the iron molecules cannot make the great swing necessary to record a low-frequency impulse, since the influence of the applied magnetic field passes too fast to give the iron molecules time to make the necessary wide turns. Instead of one or two molecules moved by a single cycle of a low frequency at low speed, twice—or even three times as many—are moved.

NOISE LEVEL VS. HIGH FREQUENCIES

Another factor which lowers the value of the steel-wire recording method is the noise level which increases considerably in the region of the high frequencies (see Fig. 1F). Above 3,000 cycles, the noise level decreases, as Fig. 1F shows, but around 5,000 cycles it is still twice as high as around 300 cycles. This increasing noise level, in connection with the increase of speed necessary to obtain a recording of the higher audio frequencies, which is considerable (10 meters per second), in the case of a frequency of 5,000 cycles, *restricts the application of this recording method to reproduction in the speech range.*

RANGE OF "WIRE" IS ONLY 70-2,000 CYCLES!

Since a speed of 10 meters per second (about 32 ft. per second), would bring about a wire consumption amounting to 118,000 ft. per hour, the main advantage of the steel-wire recording method (long-lasting, continuous recordings) is nullified by the length of the wire required for high-fidelity recording.

However, if only speech is to be recorded and reproduced, the speed may be considerably reduced. The British and the German broadcasting companies which use the steel recording method operate with a speed of 1.5 meters per second (4.92 ft.). The actual frequency range utilized starts at about 70 cycles and goes up to 2,000 cycles. The length of the wire necessary to obtain a continuous reproduction of one hour is about 17,000 ft., a length which is easy to store on a reel of reasonable size.

STEEL "TAPE" INSTEAD OF WIRE

Tests made with steel *tape* have indicated that improved mechanical and electrical operation may be obtained as compared with steel *wire*. The steel tape can be led through the recording and pick-up devices with much less fluctuation than is possible with steel wire. This allows a considerable improvement in reproduction quality and a decrease of the background noise level; an improvement is noticeable in the frequency range between 50 and 100 cycles, where it is usually quite strong because of "flutter" effects. These disturbing flutter effects are difficult to avoid when steel wire is used. The pronounced influence of the background noise in the lower-frequency range due the above-mentioned flutter effects can easily be seen from the left side of the response curve of Fig. 1F.

A very important factor in the design of the steel recording devices is the shape and the quality of the iron used for the recording and pick-up magnets. All the work done in the last 30 years has been concentrated mainly upon the shape of these magnets and the selection of a suitable iron. At present an iron is used in the recording and pick-up magnets which has a retentivity of a negligible value. This iron which is only made in Sweden is called "Holz-Kohlen-Eisen" (charcoal-iron). The steel wire or steel tape used at present is made of an iron of the highest retentivity obtainable, and also is exclusively imported from Sweden.

Another important point often responsible for failure in the past is an incorrect distance between recording magnet (and naturally the pick-up magnet), and the steel wire or steel tape. Contrary to the simplified scheme of Fig. 1C, which shows the method of recording and reproduction, *two* magnets are used in modern steel recorders. Both are arranged in such a manner that they can be moved closer to each other by means of a very fine micrometer drive. The air gap is of great importance to the frequency curve finally obtained, as Fig. 1G indicates.

In Fig. 1G are shown three curves concerning a steel-tape recorder of modern design, which operates with a tape speed of 1.5 meters per second (4.9 ft.). The response curve obtained when the air gap is too narrow is indicated by curve a. Curve b shows the response which is obtained by means of an air gap too broad. The final response curve obtained with the same steel recorder but with properly adjusted air gap and used in connection with an equalizer circuit is demonstrated by curve c. (In Germany, the following constants are used, states the *U. S. Dept. of Commerce:* ribbon width, 3 mm.; thickness, .08-mm.; speed, 1.5 mm.-per-sec.; length, for 30-min. recording, 2,700 m. Reproduction quality is rated as "good"—same as "wax record."—*Editor*)

PRESENT USE OF "IRON" RECORDINGS

The British Broadcasting Company uses steel recordings only to store the news bulletins radiated over domestic stations during the daytime for a play-back over the Empire short-wave stations. (*Music, however, is recorded on wax, because of the limitations of the response curve of steel recordings.*) After the wire has been played back it is led in front of a powerful *extinguishing magnet* which "erases" the previous recordings, and makes the same steel tape or steel wire ready for recording of the news bulletins of the next day.

The German Broadcasting Company, especially, the transmitters in Berlin and Hamburg and frequently the German short-wave transmitter, are using steel recordings for an interesting and much-liked feature of their respective programs. This feature is well known in Germany and abroad under the heading, *"The Echo of the Day."* The German Broadcasting Company has some sound trucks which are completely equipped with steel recording outfits. These trucks are sent each day through the streets of

Berlin, Hamburg, etc., and interview people on the streets about their professions, and opinions concerning interesting daily events. The cars also secretly catch the talk of bystanders when an accident has happened, etc. The interviews are recorded on the steel tape and then transmitted in the evening. *Letters to the German broadcasting station indicate that this feature is the best liked part of the daily program.*

(France now has its mobile trucks for making magnetic "spot" recordings of news events, when and where they occur. See page 556.—*Editor*)

INTERNATIONAL RADIO REVIEW

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fidelity of the radio receiver amplifier and speaker.

THE "FOTOTUNE" DIAL

A NEW TYPE of dial has just been placed on the market in England, according to an announcement in *The Broadcaster and Wireless Retailer* (London).

This new dial which is used in several new receiver models projects the *name of the station on one of two translucent screens*—one for the broadcast band and the other for the long-wave stations. The dial indicator at the same time indicates the wavelength on which the station is being picked up. See Fig. D.

The two wave ranges of the set are chosen by simply depressing or raising the tuning dial.

This dial is a marked relief from the complicated designs which are found on many foreign sets (and American ones, too, for that matter).

A "MEGGER" HAND GENERATOR

THE "MEGGER" type of resistance indicator is used much more in Europe for high-resistance indications than in the U.S. Since this type of resistance indicator requires a high voltage for operation, the need for tiny generators which will supply the required potentials can be understood.

The unit shown in Fig. E was described in the latest issue of *L'Industrie Francaise Radio-Electrique* (Paris). It is a hand-operated unit, having a crank on the side which is geared to the armature of the generator unit.

AN ITALIAN RADIO CHASSIS

AN ALL-WAVE SET of unusual design was shown in the latest issue of *Radio Industria* (Milan). The tuner, shown in Fig. F, is entirely separate from the main chassis. It is a self-contained, and is connected to the rest of the set by only 4 or 5 wires. This tuner contains the R.F., 1st-detector and oscillator coils; the tuning condensers; wave-change switch; and, dial-drive mechanism.

The wave-change switch is equipped with a fan-shaped indicator with the wave-band indications printed in such way that only one shows at a time at the window in the set cabinet.

The main chassis (Fig. G), on which the tuner is supported on springs, contains the tubes, transformers, resistors, condensers and I.F. coils, as well as the indicator portion of the dial.

By dividing the set in this way, the tuner can be more carefully aligned and constructed—and vibration and heating of the regular chassis will have the least effect on its alignment.

SIMPLE CABINET-RESONANCE SUPPRESSOR

MUCH HAS been said lately concerning cabinet resonance, its ill effects and suppression.

A recent issue of *Practical and Amateur Wireless* (London) contained a simple method for padding the interior of the set cabinet to suppress any vibrations which might be set up. This palliative consists of lining the interior of the speaker compartment (especially the sides) with thick layers of newspaper in such way that the edges are held down rigidly, only the middle being allowed to bulge—in this way, air pockets are formed.

This is a trick which most experimenters and radio beginners can try since it does not in any way disturb the set itself.