

# HIGH-FIDELITY REPRODUCTION FROM RECORDS

A resume of interesting facts regarding the manufacture and reproduction of lateral and hill-and-dale records.

M. HARVEY GERNSBACK

**E**LECTRICAL reproduction of present-day phonograph records is considered by many to be well-nigh perfect. Actually such a state of affairs is far from the truth. Even by employing the best of pickups, amplifiers, and reproducers it would be impossible to achieve "high-fidelity" reproduction as dictated by the R.M.A. standard (Frequency response flat within 10 db., from 50-7,500 cycles.), which is a very limited one for high fidelity. From a sound engineer's standpoint, the definition of high fidelity would probably be more like this: "A flat response within 2 db., from 20 to 13,000 cycles."

Returning to the phonograph record again, the maximum range possible with present-day equipment is about 50 to 5,000 cycles with less than 10 db. variation. Using ordinary equipment in use in the average home, the response is naturally much less. It is probably safe to say that the range of the "electric" machine in the average home is only about 120-3,500 cycles. That's quite a distance from our "high-fidelity" definition!

In this article we must assume, for our purposes, that the experimenter possesses an amplifier and loudspeaker system which is capable of high-fidelity reproduction since we are going to confine ourselves to discussions of records and pickup devices.

Today there are crystal-type pickups available which have a response characteristic substantially flat from 30-10,000 cycles with less than 5 db. variation. By simple methods, it is possible to tilt this curve so that an increase in response of the frequencies below 1000 cycles takes place (to compensate for the fact that the average record is deficient in frequencies below 1000 and particularly below 250 cycles). There are also available improved magnetic pickups with a response such that when used to reproduce standard records, a fairly flat response is secured from about 50-5,000 cycles. So much for the pickups.

The commercial record of today seldom contains any "material" higher than 5,000 cycles. In fact, it is only within the last year that record-makers have succeeded in recording satisfactorily frequencies this high. No matter how well designed our pickups may be, they will be of little help if the higher frequencies are not recorded.

All operators of electric phonographs are familiar with the problem of needle scratch. This problem is a stumbling block to the perfection of high-fidelity recordings. The very high frequencies, even if recorded, are lost in the unpleasant noise of needle scratch. Needle scratch filters eliminate scratch, certainly, but they also eliminate frequencies above about 3,000 cycles! The causes of needle scratch are intimately associated with the type of material used in the records, the weight of the pickup on the record surface, etc. As far as high-fidelity reproduction is concerned, it would seem that it is impossible of achievement at present.

## "HILL-AND-DALE" RECORDINGS

Probably a great many readers are familiar with the old Edison acoustic-type phonograph which was so popular years ago. The records used in this machine could not be played on the ordinary phonograph as the grooves were in a vertical rather than horizontal plane (as is the case with the ordinary record). (In the ordinary pickup, the needle vibrates from side to side when a record is being played; with the hill-and-dale type of record and pick-up, the needle vibrates up and down when a record is being played.)

The Western Electric Co. experimented with various recording systems several years ago, and as result of its experiments, brought forth a modernized "hill-and-dale" recording system, using electrical recording and reproducing methods. New methods of processing the finished master records were devised and a new type of record material was developed.

The results with this system of recording are remarkable. In the first place, it is possible to record and reproduce a frequency range of about 30-10,000 cycles with a variation of less than 5 db.! Due to improvements in record material, the use of a permanent diamond point as a needle, and also the fact that it is possible with this system to reduce the needle pressure on the record to about 2 per cent (or 40 milligrams!) of that employed on the standard type of record, needle scratch has been practically reduced to inaudibility. It is now possible to reproduce frequencies as high as 10,

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Fig. A  
The application of the cathode-ray oscilloscope to waveform analysis in recording.

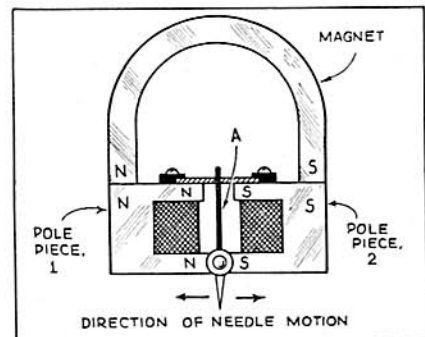


Fig. 1  
The mechanical make-up of the magnetic pickup used for the common lateral-cut records.

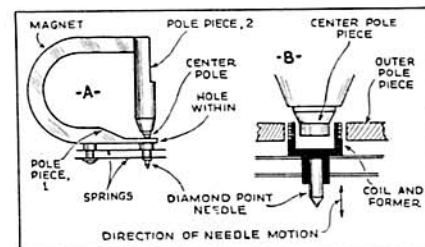


Fig. 2  
Details of the W.E. dynamic hill-and-dale pickup which uses a permanent diamond needle.

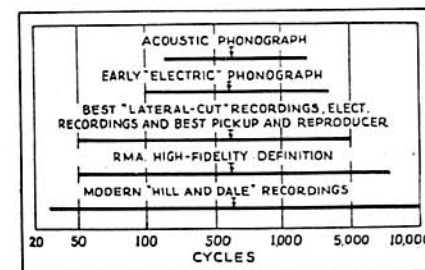
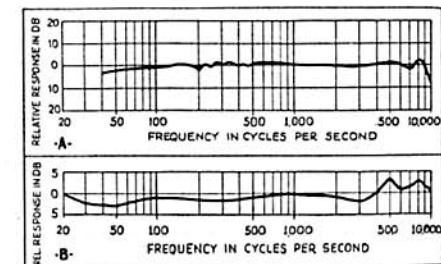


Fig. 3  
A picture of the progress of phonograph recording and reproduction up to date.

Fig. 4  
A—Response of W.E. hill-and-dale recording system (mike, amplifier, recorder and pickup).  
B—Frequency response of a crystal pickup.



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# HIGH-FIDELITY REPRODUCTION FROM RECORDS

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000 cycles without the annoyance of needle scratch.

Long-playing records, making use of slower turntable speeds and closer spacing of the grooves on the records, have been available in the old type records for several years. They have never been successful due to several factors.

First of all, the lower frequencies were severely attenuated on them due to the close spacing of grooves. The high frequencies were also attenuated due to the slower speed of playing. The general volume level of these records was lower, too. (It is necessary to turn up the volume of the reproducing equipment to get the same sound level as with the shorter playing records.)

The net result of this is the introduction of a higher needle scratch level. With so many objections, it is no wonder that these records never met with great favor.

Hill-and-dale recordings due to certain fundamental differences suffer from none of these disadvantages. It is possible to make a slow-speed, closely-grooved record without impairing the high or low frequencies. The volume level of the record can be just as high as with the short-playing record and there will be no more record wear than with ordinary records. With the old style short-playing lateral cut record there are about 98 grooves per inch. With the hill-and-dale system it is possible to increase this figure to somewhere between 125 and 150 grooves per inch, and at the same time record at a higher level than was used on the short-playing lateral-cut record!

By recording at the same level as used on the lateral-cut record it is possible to record 200 grooves per inch with no loss in fidelity of response. This means that a 10-inch record played at 33 r.p.m. will play for 10 to 12 minutes on each side. A 12-inch record will play for 15-20 minutes per side.

Due to the fact that it is feasible to record at higher levels with the hill-and-dale system it follows that a much greater volume range can be handled. It is not so necessary to monitor musical performances to an even level of sound when recording. As a result recordings can be made in which the contrasts between loud passages and soft are more lifelike than is the case with lateral-cut records.

A further advantage of these records due to the light weight of the pickup and the fact that a permanent needle is used is that they can be played thousands of times with no appreciable wear on the records. The recording material generally employed is cellulose acetate.

The pickup employed is of the "magneto-dynamic" type; the same principle is utilized in this pickup as in the common dynamic speaker for this pickup has a voice coil in place of the usual balanced armature arrangement found in the ordinary lateral-type pickup, and a permanent magnet supplies the field flux. (See Fig. 2.)

It is unfortunate that so little commercial use has been made of this vastly superior recording and reproducing system. It exceeds the R.M.A. high-fidelity standard and does not miss by very much the real high-fidelity standard (mentioned in the first paragraph of this article), and even exceeds the range (30 to 8,000 cycles) encompassed by modern so-called "high-fidelity" film recordings.

So far, the only commercial use being made of it is in the field of electrical transcriptions for broadcast purposes. The World Broadcasting System, a producer of these transcriptions is the only concern employing this system.

In closing, comment is made concerning the "telegraphone" (as it is generally called) system of recording sound on a moving metal strip susceptible to magnetic influences. In the past, radio programs from England utilizing the "Blattnerphone" represented the finest that could be offered in "magnetic wire" recordings—yet, fidelity was low and noise-level high; recently, the writer has noted B.B.C. magnetic-wire programs of greatly improved character.



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