Lateral Feedback Disc Recorder

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How proper use of feedback improves lateral-type recorders.

THE VERTICAL-TYPE FEEDBACK RECORDER introduced in the electrical transcription field about 1938[1] made possible vertical recordings of wider frequency range with reduced distortion and provided a higher degree of uniformity among recorders. This paper describes the W.E. 2A Lateral Recorder, developed around the same general feedback principles as the corresponding vertical feedback cutter.

Although the principles involved are the same for both types, the lateral development presented an entirely new set of problems. For example, in the vertical unit the generated forces are chiefly compressive and tensional and are transmitted from the driving coil to the stylus by means of a thin cone, while in the lateral recorder the member which connects the drive coil to the stylus is subject to forces in shear, and as a result it was found necessary to increase its thickness thirty-fold in order to eliminate spurious vibrations. As will be seen later, it is imperative that the vibrations which are produced by the generated forces be constrained to the mode for which they are intended.

The requirements for an ideal recorder include not only uniform response and low distortion through the audible frequency range, but also the ability to maintain its performance for long periods of time despite temperature and humidity variations and regardless of whether the recording medium is the softest wax or the most resistant lacquer. It can be demonstrated that proper application of the feedback principle to a recorder element will achieve these objectives.

Bell Telephone Laboratories, Inc., Murray Hill, N. J.

[1]Recent Developments in Hill and Dale Recorders, by C. F. Wiebusch and L. Vieth. *SMPE Journal*, Jan., 1938.

Theory

Assume the recorder element to consist of a vertical member attached to a fixed support by a reed hinge and carrying a recording stylus at its free end (*Figure* 1). The element can be vibrated by means of an attached driving coil as in the dynamic-type loudspeaker. Motion of the element induces a voltage in a second (feedback) coil which is proportional to the velocity of the motion, as in a moving-coil reproducer. The recorder is connected to an amplifier system as shown, the object being to move the cutting stylus with a vibrational velocity V whose wave shape is an exact replica of the wave shape of a signal voltage E.

A general expression for the relation between stylus velocity and signal voltage in an electromechanical feedback recorder system has been previously developed.[1] It is desirable to repeat its derivation here, with the terminology applied specifically to the lateral unit. Let

E = signal voltage
E_2 = output voltage of A-circuit amplifier
V = stylus velocity (inches per second)
E_3 = voltage generated by the feedback coil
E_4 = voltage output of the B-circuit amplifier
$E_1 = E + E_4$ = voltage input to A circuit amplifier (1)

All of the above are complex quantities. Let

$$A = \frac{E_2}{E_1} \times \frac{V}{E_2} = \frac{V}{E_1} \qquad (2)$$

and

$$B = \frac{E_3}{V} \times \frac{E_4}{E_3} = \frac{E_4}{V} \qquad (3)$$

where E_2/E_1 and E_4/E_3 are the voltage gains of the A-circuit amplifier and the B-circuit amplifier, respectively, and V/E_2 and E_3/V are respectively the electromechanical transducer conversion factors of the drive coil and the feedback coil. Therefore,

$$AB = \frac{E_4}{E_1} \qquad (4)$$

The product AB thus defines the transmission around the loop formed by the A-circuit amplifier, recorder, and B-circuit amplifier. Substituting the value of E_4 from this equation in (1), we find

$$E_1 = E \frac{1}{1-AB} \qquad (5)$$

which, with equation (2), gives

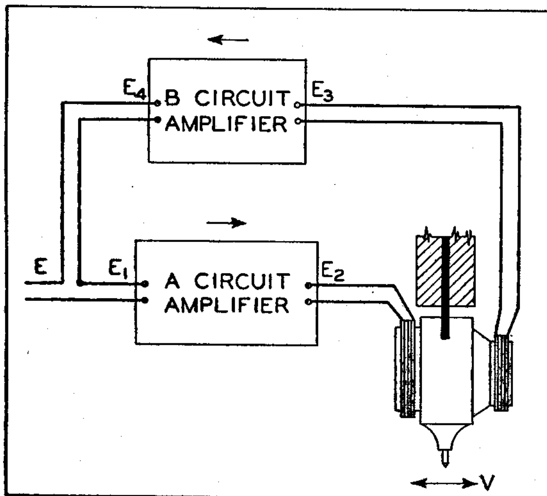
$$V = E_1 A = E \frac{A}{1-AB} \qquad (6)$$

Equation (6) thus determines the behavior of the system (stylus velocity vs. frequency and phase shift vs. frequency) when A and B are known. In particular, when AB is large compared to unity, the condition usually present in the recorder, equation (6) becomes

$$V = \frac{1}{-B} E \quad (AB \gg 1) \qquad (7)$$

which indicates that under this condition the velocity depends only on the signal input E and the factor $1/B$ which can be made very nearly constant.

[Equation (3) shows B to consist of two factors E_3/V and E_4/E_3. For the former to remain constant and independent of the amplitude and frequency of signal voltage E, the feedback coil must meet three conditions: It must be rigidly coupled to the stylus; it must vibrate in a uniform magnetic field; and it must be unaffected by the magnetic field set up by currents in the drive coil. The other factor to be maintained constant, E_4/E_3, represents the



$$E_1 = E + E_4 \qquad (1)$$

$$A = \frac{E_2}{E_1} \times \frac{V}{E_2} = \frac{V}{E_1} \qquad (2)$$

$$B = \frac{E_3}{V} \times \frac{E_4}{E_3} = \frac{E_4}{V} \qquad (3)$$

$$AB = \frac{E_4}{E_1} \qquad (4)$$

$$E_1 = E \frac{1}{1-AB} \qquad (5)$$

$$V = E_1 A = E \frac{A}{1-AB} \qquad (6)$$

$$V = \frac{1}{-B} E \quad (AB \gg 1) \qquad (7)$$

$$V = E \frac{A}{1-AB} + \frac{n}{1-AB} + \frac{d}{1-AB} \qquad (8)$$

Fig. 1. Electromechanical feedback system.