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PHONO EQUALIZER DESIGN PLUS PREAMPLIFIER DATA

How to reproduce various recordings with
velocity and amplitude-actuated pickups

By K. E. FORSBERG

MECHANICAL limitations of the disc recording medium have led record manufacturers to adopt a somewhat complex recording characteristic. At frequencies below crossover, a constant-amplitude recording characteristic is utilized to prevent cutting through the lands separating the grooves. Above the crossover frequency, recording is at constant velocity. At the highest frequencies, pre-emphasis is superimposed on the constant-velocity characteristic to minimize the surface noise of the record.

Phonograph pickups may be either amplitude- or velocity-actuated. Crystal and strain-gauge pickups are examples of the amplitude-actuated reproducer, which generates an output proportional to the stylus displacement. Magnetic and variable-reluctance pickups are velocity-actuated reproducers whose output is proportional to the stylus velocity. Because a single reproducer cannot be both amplitude- and velocity-actuated, equalizers are necessary to complement the recording characteristic.

Amplitude-actuated reproducers

Considerable variance exists between the recording characteristics used by the different record manufacturers. However, the NAB lateral characteris-

tic may be used as an average for American-made records.

The NAB lateral characteristic utilizes constant-amplitude recording below a crossover of 500 cycles and constant-velocity recording between 500 cycles and 1500 cycles. Above 1500 cycles the use of pre-emphasis results in a return to a constant-amplitude characteristic. The idealized equalizer requirements for the reproduction of a record based on the NAB lateral characteristics by an *amplitude-actuated* pick-up are presented by the dashed line of Fig. 1. A suitable equalizer is diagrammed in Fig. 1, and the equalizer frequency response is shown by the solid curve.

The solid curve indicates the actual NAB characteristic. The dashed idealized curve is no longer used, even for reference, but it is useful for instruction.

The equalizer design is based on a constant-voltage source and an infinite load impedance. The latter may be had by connecting the equalizer output to the grid of a vacuum tube. The constant-voltage source may be approximated with a low- μ triode preamplifier or by using a plate load resistance of less than 50,000 ohms with a pentode or high- μ triode preamplifier.

British (London frr) recordings differ from the NAB characteristic in the use of a 250-cycle crossover frequency

and in less high-frequency pre-emphasis beginning at 3,000 cycles. The idealized equalizer requirements for the reproduction of British recordings with an amplitude-actuated reproducer are illustrated by the dashed curve of Fig. 2. The solid curve of Fig. 2 is the frequency response of the equalizer circuits shown. (The range of frr's actually goes up to 14,000, with a sharper pre-emphasis after 12,000 cycles.—*Editor*)

A complete equalizer circuit for use with an amplitude-actuated pickup is diagrammed in Fig. 3. This unit may be constructed as a separate preamplifier or the design may be incorporated in a complete phono amplifier. The low- μ twin-triode results in a net equalizer gain of 20 db. A three-position switch permits selection of the NAB, British, or a flat curve. A variable treble-cut scratch filter is included. The dotted curves of Figs. 1 and 2 show the effects of the scratch filter when $R_2 = 0$.

The input resistor R_1 should be selected in accordance with the manufacturer's specifications for the particular pickup used. C_1 must have a reactance, at the lowest frequency to be amplified, of less than one-fifth the input impedance of the amplifier following the equalizer.

If the plate supply is taken from the following amplifier stages, it will be necessary to insert a 10,000-ohm, 10- μ f plate decoupling circuit in the B-plus line to prevent feedback.

The values of the components are not particularly critical, and small alterations in values may be made to complement the idiosyncrasies of the individual pickup. Decreasing the values of R_3 and R_4 will increase the amount of treble boost. Decreasing C_3 and C_4 will move the response curve to the right, raising the frequency at which treble boost begins.

Velocity-actuated reproducers

The idealized equalizer requirement for the NAB characteristic with a

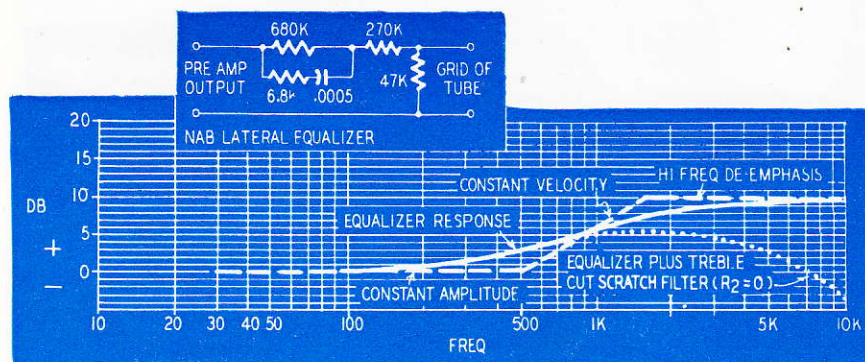


Fig. 1—Crystal equalizer for records made with the NAB characteristic curve.

magnetic or variable-reluctance pickup is shown by the dashed curve of Fig. 4. A bass boost of 6 db per octave below a 500-cycle crossover and a treble roll-off of 6 db per octave above 1500-cycle crossover are required. The two separate equalizer circuits presented in Fig. 4 are recommended. The solid curves represent the individual equalizer frequency response characteristics. The combined effect is shown by the dotted curve of the figure.

The circuits and curves for equalizing British frr recordings with velocity-actuated reproducers are presented in Fig. 5.

Preamp for velocity pickup

A complete equalizer-preamplifier circuit for use with a velocity-actuated pickup is diagrammed in Fig. 6. Two three-position selector switches permit the selection of any combination of bass boost and high rolloff. A variable treble-cut scratch filter is provided for use with noisy recordings. Low-mu triodes provide a constant-voltage generator for the equalizer networks as well as provide a net gain in the order of 30 db.

R1 should be selected to accord with the manufacturer's specifications for the pickup. The reactance of C1 at the lowest frequency should be less than one-fifth the input impedance of the following amplifier. The values of the equalizer components may be altered to provide additional correction for the peculiarities of the pickup. Decreasing R2 will increase the amount of bass boost. Increasing C2 and C3 will lower the frequency at which bass boost begins. Increasing C5 and C6 will lower the frequency at which treble rolloff begins. Capacitor C4 and the 10,000-ohm resistor form a decoupling network to insure circuit stability by preventing any feedback through the high-voltage circuits.

Frequency test records

The over-all performance of the pickup and equalizer-preamplifier combination may be checked most conveniently with a frequency test record¹. The author recommends the Columbia 10003M and 10004M. The response curves obtained with these records should be substantially flat to the point at which high frequency de-emphasis begins. Beyond that point the frequency response should follow either the NAB equalizer curve in Fig. 4 or the British equalizer curve in Fig. 5, depending upon the particular equalizer settings.

Above all, do not be discouraged by deviations of your experimental curves from the ideal. At best, equalization is a compromise between recording characteristics and pickup response variations. The best criterion for the effectiveness of any equalizer is listening pleasure, and the optimum equalizer is the circuit which achieves the most realistic record reproduction.

¹ See "Frequency Test Records" by Richard H. Dorf, RADIO-ELECTRONICS, October, 1948.

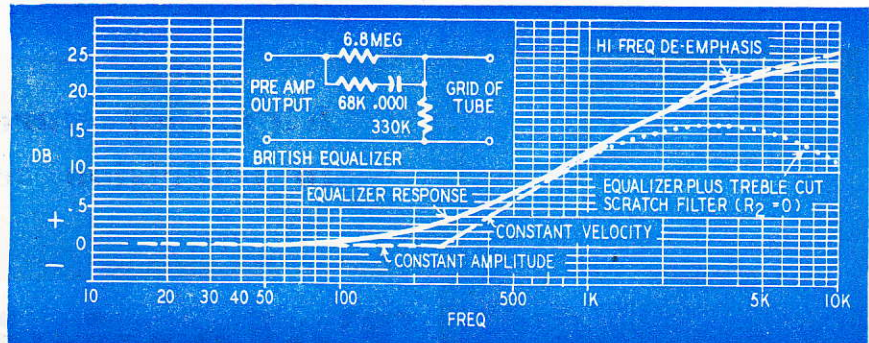


Fig. 2—Frr records played with amplitude pickups require this equalizer.

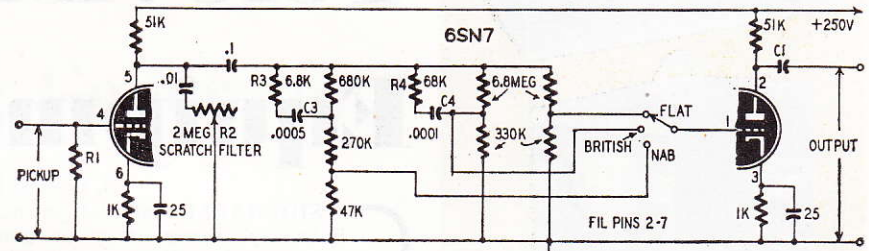


Fig. 3—Selective equalizer for amplitude-actuated pickups has rolloff switch.

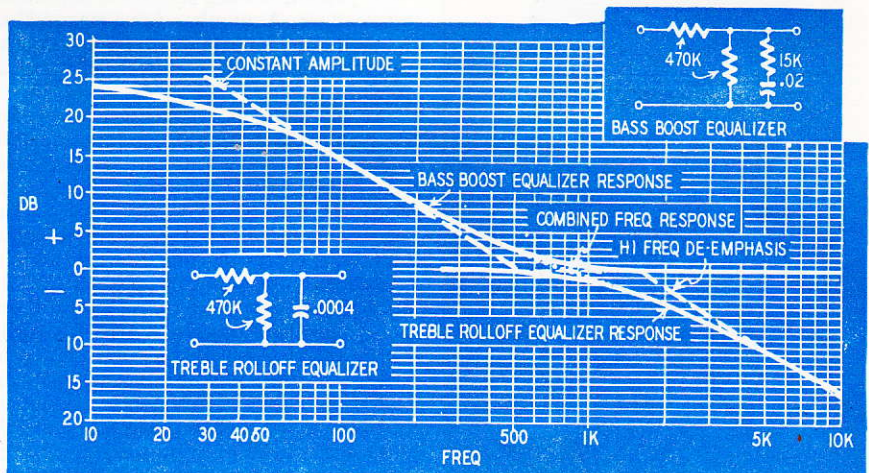


Fig. 4—Velocity-sensitive pickups require these equalizers for NAB records.

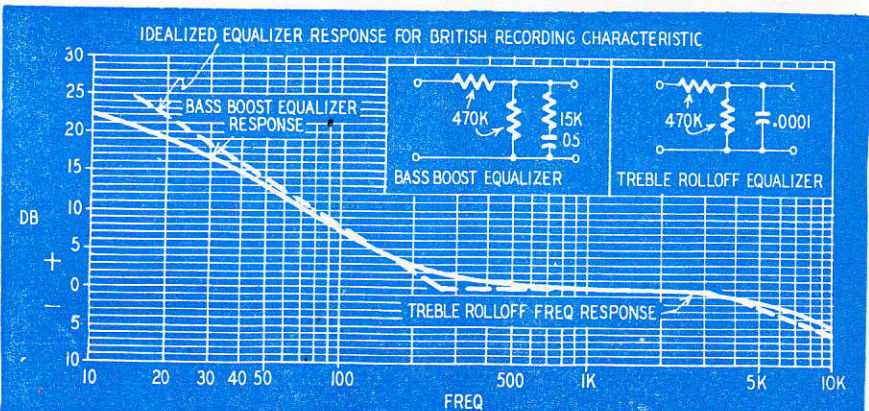


Fig. 5—British frr records played with magnetic pickups require these equalizers.

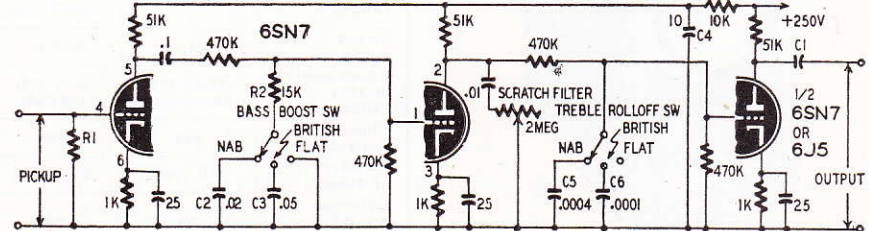


Fig. 6—Constant-velocity equalizer has three-position bass and treble switches.