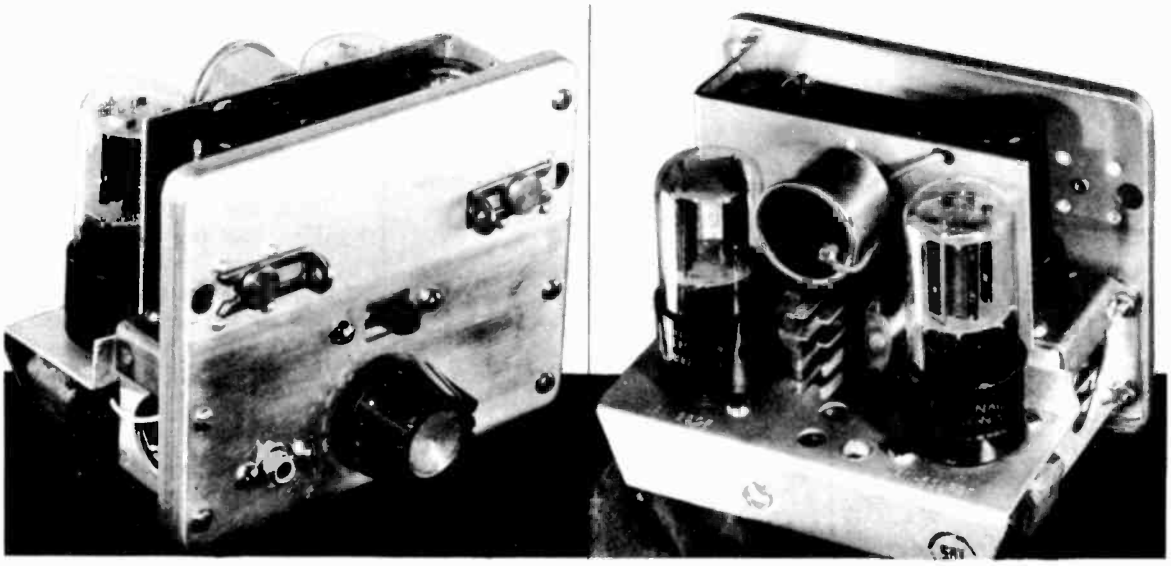

Fig. 1. Equalizer-suppressor amplifier as built on surplus preamplifier chassis.

Simplified Dynamic Noise Suppressor

C. G. McPROUD

A three-tube preamplifier combining low-frequency equalization and a new type of dynamic noise suppressor for use with magnetic pickups.

ONE of the most outstanding circuit developments in the audio field to be publicized during the last few years is that of the dynamic noise suppressor. While its performance is a definite improvement in record reproduction over fixed filter circuits, it cannot be denied that the circuits are somewhat complicated, and considered by many to be beyond their capabilities for construction.

In attempting to simplify the noise suppressor problem so that the advantages might be enjoyed by more record users, the writer listed a variety of partially related facts and assumptions, from which the circuit to be described was derived.

1) To reduce noise, it is desirable to employ a low-pass filter.
2) To avoid degradation of musical quality —i.e., a reduction of high-frequency response—the cutoff frequency should be adjustable.
3) For convenience, it is desirable to have the cutoff frequency varied automatically by the signal itself.
4) Constant-k filters usually "sound" better than filters with a sharper cutoff.
5) The qualities of a high-quality magnetic pickup that provide a wider range of signal frequencies also cause the reproduction of a higher needle scratch level.
6) Magnetic pickups are low-level devices, and require both amplification and low-frequency equalization for use with conventional radio-phonograph amplifiers.
7) Since a magnetic pickup is effectively a generator having an internal impedance which is essentially an inductance, a reasonably sharp cutoff can be obtained solely by the use of a shunt capacitor.

Having these basic premises listed, how can the problem be solved *in the simplest manner?*

Design

The use of a magnetic pickup demands a low-frequency equalizer and additional amplification, so the first step in the solution is to set down such a circuit. The high-frequency cutoff may be provided by a shunt capacitor, with the cutoff frequency being varied by changing its capacitance.[1] Suppose, therefore, that the shunt capacitance is supplied by a reactance tube. By varying its grid bias, the cutoff frequency can be changed at will. To make the variation of capacitance automatic requires a side amplifier and rectifier, together with some form of manual control.

Putting these separate elements together, the equalizer-suppressor amplifier is now seen to consist of three sections — the equalized preamplifier, the reactance tube across the input, and a control tube consisting of an amplifier and a rectifier. From this point, then, it is possible to design a wide variety of circuits to perform all of these functions.

One such circuit is shown in the schematic of *Fig.* 2. Built as an accessory unit, it employs a series heater string, a dropping resistor, and a selenium rectifier and filter capacitor, thus operating the heaters from the 115-volt a-c line to avoid overloading the filament windings of the amplifier to which it is connected. Plate current is obtained from a convenient 200-300 volt point in the amplifier with which it is to be used.

The equalized preamplifier consists of the two sections of V_1, a 12SL7, connected in cascade, and employing

[1] *"High Frequency Equalization for Magnetic Pickups,"* on page 48.

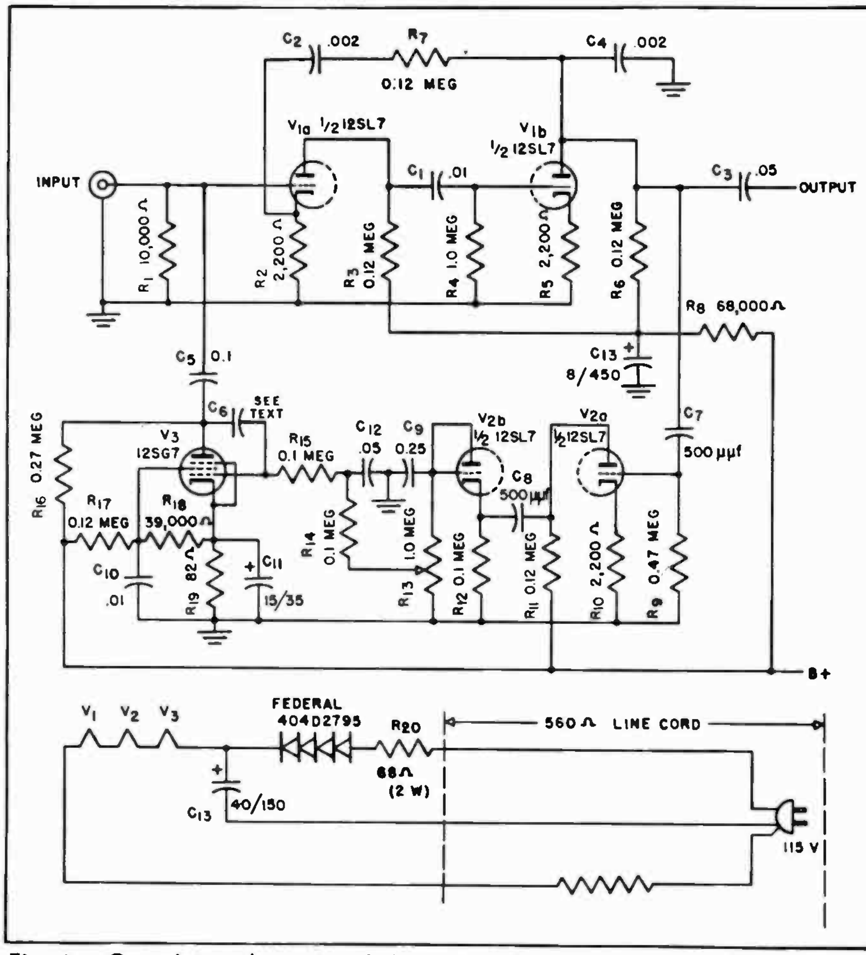

Fig. 2. Complete schematic of dynamic noise suppressor amplifier utilizing single reactance tube directly across magnetic pickup, and furnishing adequate low-frequency equalization to correct for average recording characteristics.

a feedback circuit to provide the low-frequency boost. The voltage amplification of this two-stage amplifier is approximately 25 at 1,000 cps, with a low-frequency boost of nearly 6 db per octave below a transition frequency of 500 cps. This results in a fair compromise for various types of phonograph record characteristics, since the bass tone control on a conventional radio phonograph or amplifier should suffice to make the finer adjustments. However, if desired, C_2 can be made adjustable by a separate switch, using a value of 0.005 μf for a 300-cps turnover, and 0.0015 μf for 800 cps turnover.

The reactance tube V_2 is connected in shunt across the input terminals, isolated by a 0.1-μf capacitor C_5 to keep d-c voltage off of the pickup. The effective capacitance of V_2 is a function of C_6 and the mu of the tube. Therefore, with a given set of operating voltages on this tube, C_6 controls the static cutoff frequency. A value of 750 $\mu\mu$f provides a cutoff that is down 3 db at 4,000 cps with the Pickering Cartridge. This value should be increased to 0.001 μf when used with the General Electric variable reluctance pickup. Without going into the operation of a reactance tube circuit, suffice to say that an increase in the negative bias voltage applied to the control grid causes a reduction in the mu of the tube, with a consequent decrease in the effective capacitance of the tube.

From the chart shown in the previously cited reference, it is noted that for a 4,000-cps cutoff, the shunt capacitance must be of the order of 0.02 μf for the Pickering, or 0.03 μf for the GE. The effective capacitance of the tube is in series with C_5, so it is necessary that C_5 be relatively large, as shown. Since the maximum plate voltage is applied across C_5, its voltage rating must be at least 400 volts. Any high-gain pentode should work in this circuit, but it is desirable to use a tube of the semi-remote cutoff type to obtain smooth operating characteristics. A 12SG7 was chosen for this application.

The side amplifier and rectifier consist of the two sections of a second 12SL7, the first serving as the amplifier, while the second—with the plate and grid connected together—serves as the rectifier. The coupling circuits between V_1b and V_2a and between V_2a and V_2b are so designed that the response cuts off quite rapidly below 1,000 cps, providing a d-c control voltage which is developed mainly from the upper middle frequency range. Thus, low frequencies do not appreciably affect the reactance tube.

However, when the signal contains frequencies in the upper middle range, the rectifier circuit causes a d-c voltage, negative with respect to ground, to be developed across R_{13}, a potentiometer used as the manual control.

Operation

There are several unusual conditions existing in this suppressor. In the first place, the control signal is obtained from the output rather than from the input. The action, therefore, is aided by the raising of the cutoff frequency, since this raising applies a larger high-frequency signal to the side amplifier. In the second place, there is a small contact potential existing across R_{13}. This potential is of the correct polarity (negative) to raise the cutoff frequency. Thus the manual control varies the cutoff frequency gradually at the same time that it increases the sensitivity of the automatic control circuits.

In operation, the equalizer-suppressor amplifier is connected between a magnetic pickup and the usual phonograph input jack. If this connection is followed by the usual RC network to compensate for the high-frequency droop of crystal pickups, this network should be removed. In the schematic, C_4 is used to compensate for the high-frequency boost present in most recordings. The value shown is suitable when the following amplifier and the speaker system is flat. For optimum results, it may be desirable to increase or decrease this capacitance.

When the control R_{13} is in the maximum clockwise position, the response of the equalizer-suppressor is essentially flat from normal records, with no high-frequency cutoff. This is the result of (1) the contact potential across R_{13}, and (2) the d-c voltage developed as a result of the residual scratch. Thus, there is sufficient negative bias applied to the 12SG7 to reduce its gain, and consequently to reduce the effective capacitance shunted across the pickup. If the scratch is objectionable, the control may be rotated counterclockwise until the best balance is obtained between musical quality and noise. In the intermediate positions of the control, it will be noted that the noise is reduced during low level passages, but that the noise appears to increase when high level passages—

containing high freauencies—are reproduced. The more the control is turned counterclockwise, the greater the reduction of noise. Two actions take place simultaneously as the control is turned: (1) the cutoff is lowered gradually, and (2) the sensitivity of the automatic action is reduced. This results in a single smooth range of control from no cutoff at all to a fixed filter with a cutoff at 4,000 cps, with a gradual increase in dynamic action over the range of the control.

Construction

The experimental version of this amplifier, shown in *Fig.* 1, was built on a chassis available as a surplus item. However, the amplifier is not limited to such a construction, and any suitable small chassis is suggested If there is an adequate supply of heater voltage, or if the unit is being constructed as a section of a complete amplifier, 6.3-volt tubes should be used instead of the 12-volt types, and their supply obtained in the usual manner from the power transformer. However, if the equalizer-suppressor amplifier is to be added to an existing radio phonograph, it is advisable to provide a separate heater supply, as shown in the schematic. The connections shown are for use with a 560-ohm line cord and a 200-ma selenium rectifier, furnishing a 150-ma d-c supply for the three 12-volt heaters in series. Since no signal voltage appears across the control potentiometer. it may be mounted on the front panel or the phonograph motor board in a conveniant location. Input and output connections should be shielded. The unit shown in *Fig.* 1 was built with a switch to cut in or out the suppressor section, but this was found to be unnecessary. The single control is adequate for all operation.

Parts Hints

The voltage rating of C_9 and C_{12} need not be over 150 volts, so hearing-aid type capacitors can be used to conserve space. The product of R_{14} and C_{12} controls the attack time, which should be short enough to permit operation without appreciable delay, yet long enough to prevent opening the filter circuits on "pops" or "ticks." As shown, the delay is only 5 milliseconds. The release time is the sum of the products of R_{13}-C_9 and R_{14}-C_{12}, 255 milliseconds in this instance. It appears satisfactory in subjective tests, and since there are no accepted standards for these values, such tests must be relied upon for determination of optimum values. The potentiometer C_{13} is linear.

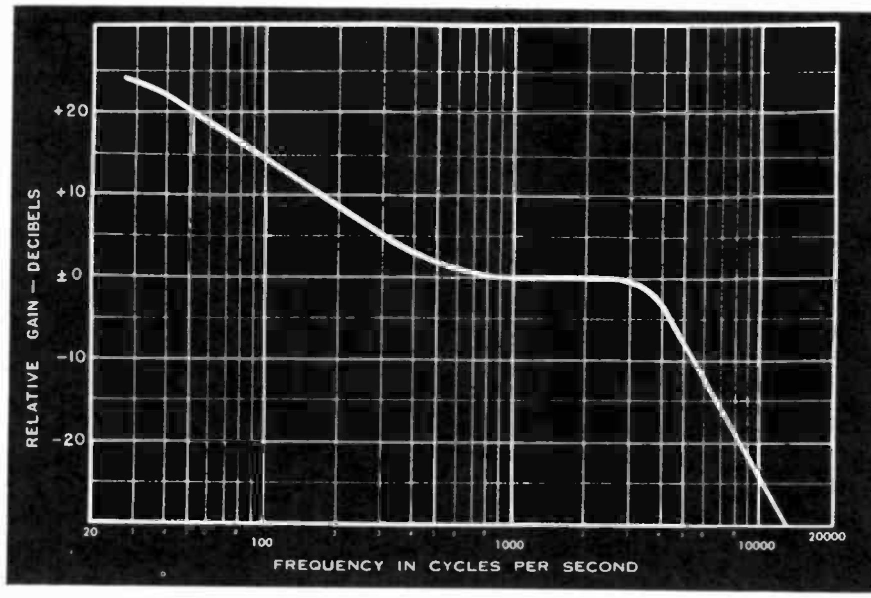

Fig. 3. Curve of equalized preamplifier with control at minimum, showing cutoff at 4,000 cps and a droop of 15 db per octave above cutoff.

Operation

Under normal operating conditions, the voltage on the plate of V_3 is approximately 15 volts with no signal and with the control at the maximum counterclockwise position; 40 volts at the maximum clockwise position. In the presence of high-frequency signals with the control at the clockwise position, the voltage at the plate of V_3 is approximately 160. The screen potential is approximately 32 volts with no signal.

The voltages at the plates of V_1 are about equal, approximately 80 volts; the cathode potentials, also about equal, are of the order of 1.0 volt. The voltage at the plate of V_2 is 180; at the cathode, 2.0. A contact potential of 0.7 volts appears across R_{13} with no signal. The rectified d-c voltages across R_{13} with signal from a frequency record reach a maximum of about 40 volts at frequencies above 500 cps. These measurements were made with a vacuum-tube voltmeter having an input resistance of 15 megohms. The plate supply was 300 volts, and the potential across C_{13} was 120 volts.

Advantages and Limitations

This equalizer-suppressor amplifier has several advantages over the more complicated noise suppressor in that it is much simpler to construct and requires fewer parts. There are no complicated adjustments required in the construction. Since only one control is furnished—or needed—this suppressor is much easier to use effectively. However, it is limited to use with magnetic pickups, and is not usable on radio tuner outputs or with crystal pickups. While some effect could be obtained, the cutoff rate of 15 db per octave is available only when the source is inductive. It does not have as great flexibility as the H. H. Scott Dynamic Noise Suppressor, but for those who must occasionally compromise cost with performance, it is a definite improvement over the use of capacitors providing fixed cutoff frequencies.

Additional Notes

The original experimenation with this suppressor was carried out with a Pickering cartridge, which has an output in the vicinity of 50 millivolts, somewhat greater than that available from certain other types. For this reason, those who use this device with GE or Audax cartridges may encounter some difficulties with respect to proper dynamic operation.

Some improvement may be gained by the addition of high-capacitance, low-voltage electrolytics across R_5 and R_{10}. Values ranging from 20 to 100 μf have been tried, with satisfactory results. The addition of these capacitors gives some increase in gain through both the signal circuit and the side amplifier, with the result that a greater signal is impressed on the rectifier, V_{2b}, thus giving a greater control voltage for the grid of the reactance tube, V_3. Another change which has given good results is to substitute a 6SJ7 for the 6SG7 indicated for V_3. When used in conjunction with the two electrolytic by-pass capacitors previously mentioned, satisfactory operation of the suppressor should result.