Front panel of the experimental noise suppressor.

Experimental Noise Suppressor

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Complete data on a noise suppressor developed by the General Engineering Department, American Broadcasting Company.

A CHALLENGE, long outstanding in both the broadcasting and home radio industry, is the needle noise or hiss generated in the playback of recordings. Although the ordinary shellac pressing is the worst offender in this respect, the high grade electrical transcription often contains noise components which may prove objectionable, especially on low level musical passages. Electronic noise-suppressing devices have been designed to overcome this difficulty, but for the most part have proved to be somewhat expensive, especially for the home record player. Below is presented a system for noise suppression which needs little or no maintenance and whose initial expense is quite moderate.

Operation

The operation of this suppressor is based, first of all, on the nature of playback noise and its relationship to the recorded program material. It has been found that the amplitude of the noise is approximately constant throughout a recording, irrespective of the amplitude of the recorded program. For high level passages the noise is masked, but for moderate to low level passages, which constitute a greater portion of an average recording the noise may become quite objectionable. Secondly, investigation reveals that the greater part of the noise energy lies in the middle and upper ranges of the audio spectrum. Very little noise is found below 1500 cycles. The third factor which enters into the design of this equipment is the relationship between the peak amplitude of the recorded program to the average amplitude of the noise. The program peaks are approximately 40 db above the noise, and this figure was used for design purposes. With these facts concerning the nature and behavior of playback noise, an instrument was designed whose fundamental basis for operation was first set forth by Dr. H. F. Olson of the Radio Corp. of America's Princeton Laboratories. Dr. Olson's proposal and the final instrument evolved from it centered around the characteristics of the germanium diode, and the principle of selective octave filtering.

In a conventional representation of input vs. output voltages for the germanium diode, (see *Fig. 1*) little attention is given to the load line as it approaches very closely to the origin. The load line for most practical purposes is linear. However, if the portion near the origin is investigated more closely, it will be found that the load line does not remain linear, but curves tangentially to meet the ordinate axis. The point of tangency (approximately 1 millivolt input) determines the practical minimum level at which conduction can occur in the forward direction. Therefore, an effort to adjust the noise level of the recording so that it would fall in this rejection range was made. For reasons of design it was found more desirable to connect two diodes in series, doubling the rejection level and operating the networks at higher voltages. Two sets of series diodes are connected to give full wave conduction essentially linear except for very small voltages. (See *Fig. 2*). With the noise level adjusted to fill the dead zone, the program material has a linear excursion some 40 db higher in level.

Although noise is rejected below the point of conduction, program material of a corresponding level is also rejected. This is not especially noticeable to the ear due to the wide dynamic range of most speech and music, except for some elim-

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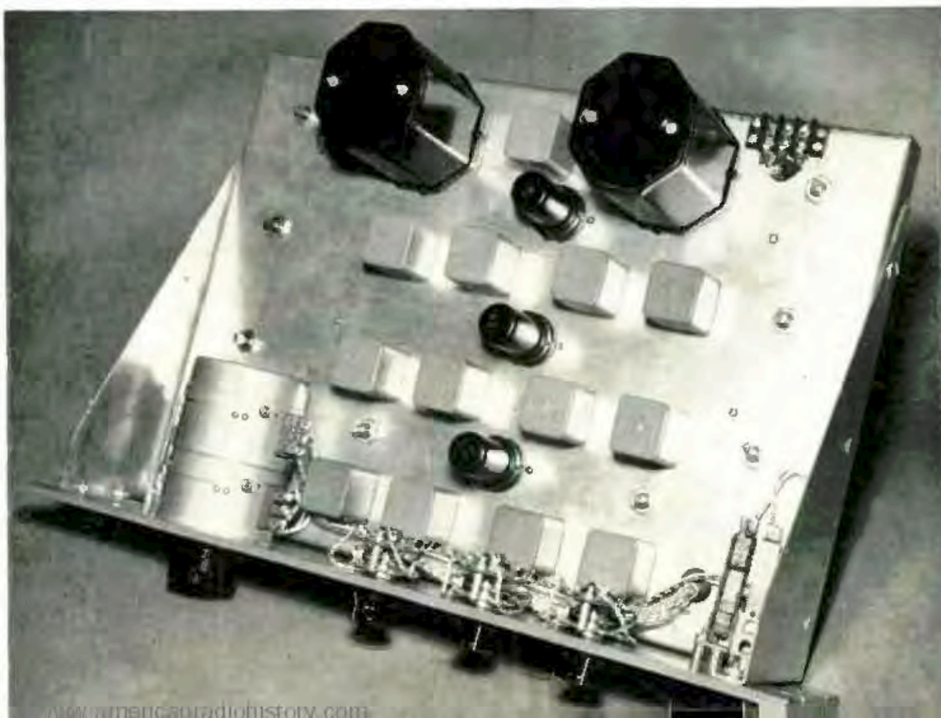
Chassis layout of the experimental noise suppressor.



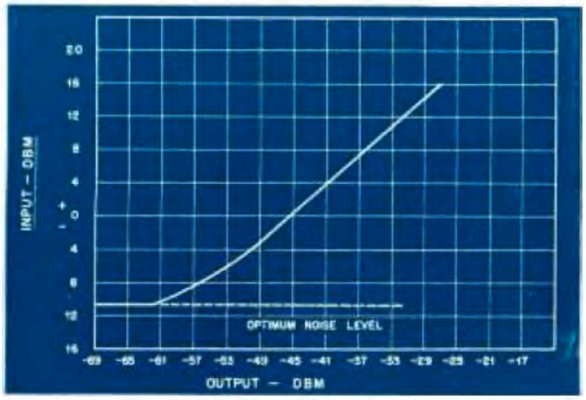
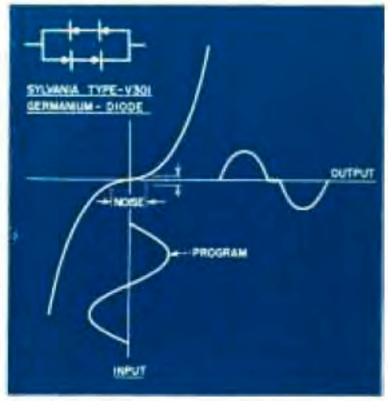


Fig. 1 (left). Suppression characteristic for 1.5 kc to 3 kc channel at 2500 cycles.

Fig. 2. Conduction characteristic of germanium diodes used in the suppressor.



nation of reverberation, or attenuation of sounds inherently low in amplitude such as the spoken letter "S."

Distortion

For signals whose amplitudes are 6 to 12 db above the noise level, serious distortion occurs due to clipping and bending of the load line. It is this distortion that necessitates the use of electric wave filters. Identical filters are used both before and after the diodes. The input filter admits a band of frequencies one octave wide and the output filter passes only this octave and rejects all other frequencies by at least 30 db. The term "all other frequencies" includes not only the program material frequencies, but even more important, the harmonic frequencies or distortion generated by the action of the diodes. The frequency range has been arbitrarily divided into four channels: 0-1500 cycles low pass, 1500 to 3000 cycles band-pass, 3000 to 6000 cycles band-pass, and 6000 to 12000 cycles band-pass. The fact that very little noise occurs below 1500 cycles accounts for this division and subsequent octave relationship. In general, the filters were designed to include the least number of reactors and yet give satisfactory performance. For the low pass filter "m" derived section was chosen. A value of .6 for "m" was selected since both input and output terminate in resistive networks. With the low pass section adjusted for satisfactory operation, rejection at the notch is 38 db, least rejection 21 db and rejection at three octaves is 28 db.

The three band-pass filters are constant K networks whose surge impedance is equal to six thousand ohms as is the impedance of the low pass "m" derived filter. All three band-pass filters behave similarly so far as attenuation is concerned. (See *Fig. 3.*) A frequency response curve through both input and output filters shows approximately 30 db attenuation one octave either side of the roll off frequency. The surge impedance of 6000 ohms was chosen to represent the best relationship between the high signal and low signal bridging resistance of the diodes whose resistance varied from several hundred to over 40000 ohms.

The input and output mixing busses are identical. (See *Fig. 4.*) All four channels are fed by "L" pads with proper building out resistors which are fed in turn from a matching transformer. A variable "T" pad isolates the transformer from the mixing bus. The output transformer is identical with the input and is also isolated from the output mixing bus by a variable "T" pad. The input and output "T" pads are ganged on the same shaft and are reverse connected so that as the input is raised the output is lowered by the same amount, thus achieving uniform level out while correcting for proper noise level into the diodes. A variation of 15 db input results from this arrangement which has proved adequate for correction of differences in individual recordings. A fixed loss of 15 db results from this arrangement. The input bus, which is composed of potentiometers "L" connected and building out resistors, has a fixed loss of 8.4 db. In general, individual adjustment for each frequency range is made with the corresponding input potentiometer to achieve best signal to noise ratio in that band of frequencies. The output potentiometers are adjusted for uniform response through out the entire band and since some adjustment is required at both input and output bus, a mixing loss somewhat greater than 8.4 db is incurred. Therefore, the total loss in the suppressor is on the order of 35 db. With the constants shown in the diagram, (*Fig. 5*), the optimum input level was found to be plus 20 dbm and the resultant output, approximately minus 15.

Crystals

The crystals selected for this equipment are the standard four-element balanced diode modulators mounted in a metal shell provided with an octal base. They are known as the Sylvania type 1N40 Germanium-Diode varistor. In the construction of the filters, UTC

Fig. 3 (left). Individual filter response curves for experimental noise suppressor.

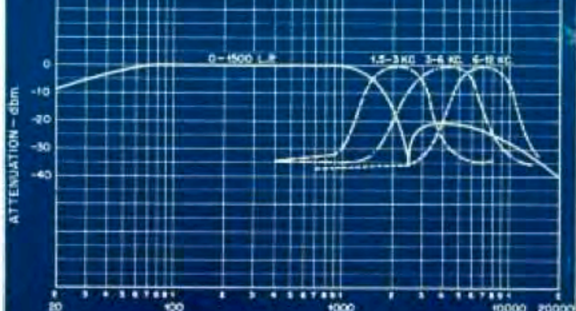
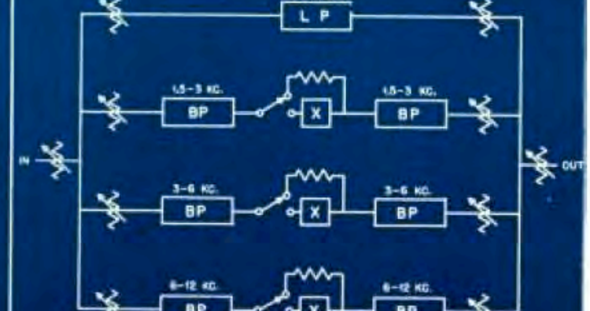


Fig. 4 (right). Block diagram of noise suppressor.



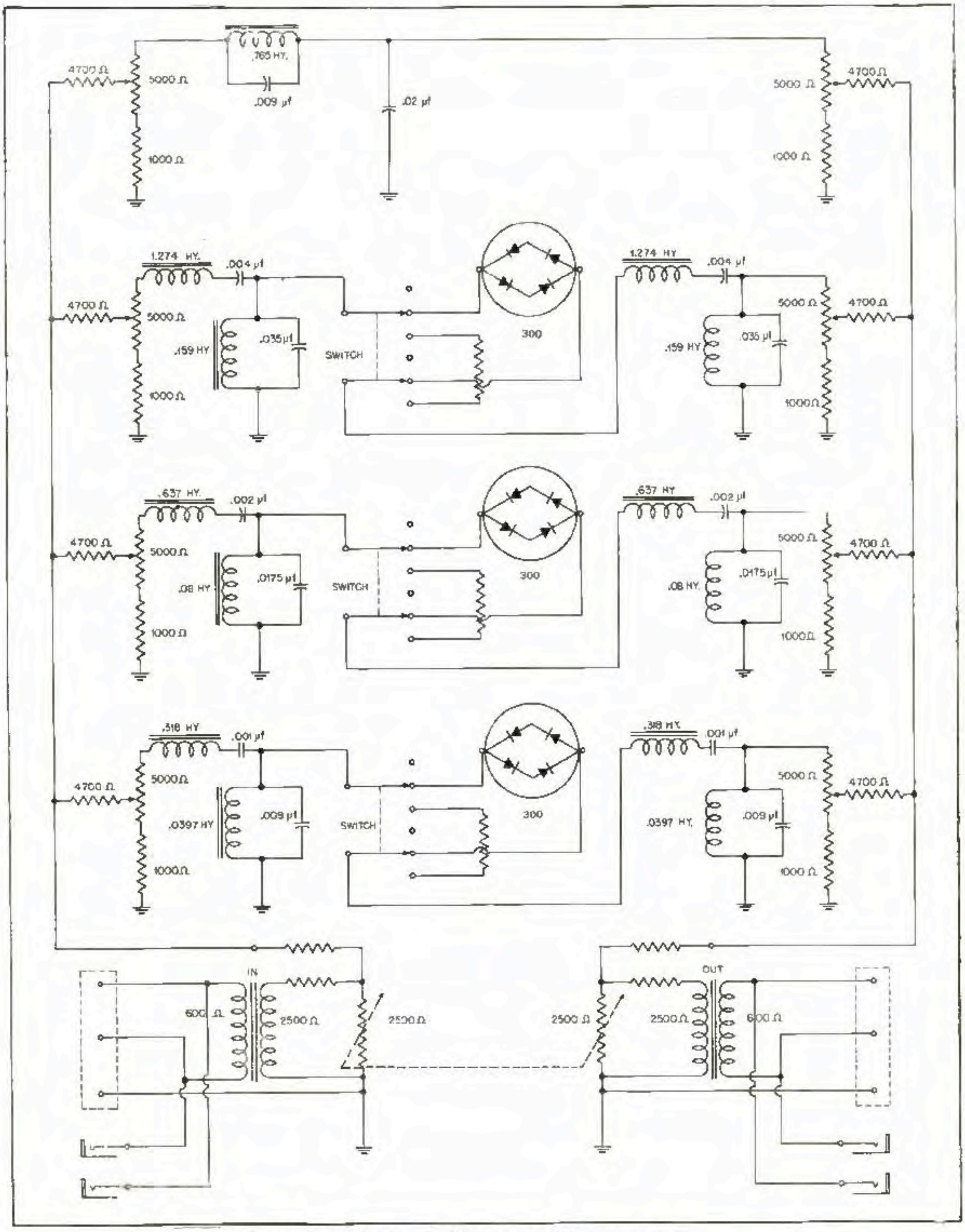


Fig. 5. Complete schematic of the experimental noise suppressor.

variable inductors were selected for the reactive elements. These reactors have an adequate range of inductance, satisfactory Q and permit trimming of the final filter to compensate for stray capacities. The capacities encountered in the filter elements are for the most part odd values and parallel connection of two or more standard capacities is required in many instances to achieve correct values. Small postage stamp mica capacitors are used because they lend themselves well

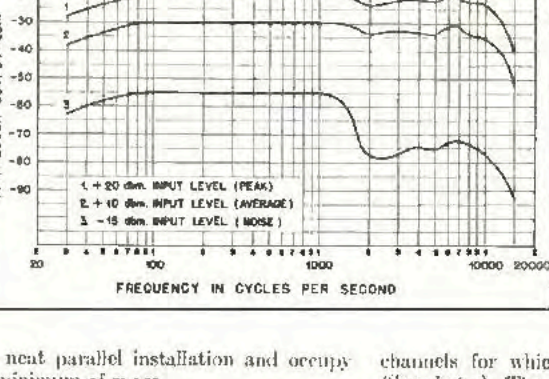


Fig. 6. Frequency response curves showing suppressor action at low level as compared with peak and average levels.

to neat parallel installation and occupy a minimum of space.

The input and output coils are selected to match 600-ohm lines to the mixing buses, whose impedances are approximately 2500 ohms. The mixing bus itself is composed of ordinary composition potentiometers and pigtail composition resistors. Three rotary switches are included on the front panel. Each switch is associated with a pass band. The switches have three positions which selectively switch the diodes into each pass band for suppressor action, replace the diodes with an equivalent resistance for no suppression, or disconnect the pass band completely for test purposes.

The front panel is standard rack width and is 5¼ inches high. (See photo.) The compensated volume control is mounted on the left side of the panel. A double jack for input is located in the lower left corner of the panel and the output jack is mounted directly opposite in the right hand corner. The chassis is No. 16 gauge cold rolled steel. All transformers and reactors are mounted upright on the surface of the chassis and are arranged in rows corresponding to the frequency channels for which they are intended. (See photo.) The potentiometers are also mounted upright through the top surface of the chassis and are located at the input and output of their respective channels. The inductance of the reactors is set with a bridge before being installed in the circuit. After wiring is completed, each individual channel is calibrated separately and trimming of inductors may be necessary to achieve the final band-pass characteristics desired. An audio oscillator is connected to the input terminals and response is read at various points under study with a vacuum tube voltmeter. For a channel response curve through the entire system the input and output pads on all other channels are set to maximum attenuation.

Signal Source

The Clarkston 16-inch sweep frequency record provides an excellent signal source for final testing of the suppressor. With the aid of an oscilloscope connected across the output of the suppressor, the frequency response can be observed and any minor equalizing of levels can be accomplished under practical operating conditions. At the same time the pickup and amplifiers associated with the suppressor may be checked for hum noise and proper gain. The optimum input level is plus 10 VU and distortion throughout the suppressor is less than one-half per cent.

In planning a system which is to include this suppressor, several facts must be born in mind. An input level of plus 10 VU is required which means that a program amplifier must precede the suppressor for practically every application. Secondly, the loss in the suppressor is of considerable magnitude and an amplifier is required to recover the original level before suppression. For example, let us assume that the suppressor is to feed a line at plus 8 VU level. The program amplifier originally driving the line at plus 8 VU must now feed the suppressor at plus 10 VU which presents no formidable stress on the system. However, a booster amplifier will be required to return the output of the suppressor to plus 8 VU, the original level feeding the line. The booster amplifier represents additional equipment in this case and must have 30 db gain and be capable of plus 8 VU output.

In addition to its use for suppressing needle noise, this instrument shows considerable promise when used with magnetic tape recorders. Some other applications that seem worthy of consideration are as follows: The suppressor may be used with applause microphones that are located out over the audience. The applause is unaffected, while occasional coughing or room noise is eliminated. Open air concerts often encounter the problem of automobile horns or other undesirable noises which might be eliminated by using this instrument. And finally, moving scenery on television sets while the program is in progress might be accomplished with less unwanted noise by the use of this suppressor.

Improved Circuit of Goodell Noise Suppressor, using the H. H. Scott system, incorporating the 6B8 tube. Many variations of switching circuits are possible. R1 is often 5-position switch. Circuit parameters and component values are typical of designs for conventional home radio phonographs but are not necessarily identical to those used by any particular manufacturer. 6SJ7s are sometimes used as reactance tubes. Various voltage amplifier tube types may be substituted. 6H6 may be used for diodes.