The Crosley Auto Expressionator

By
J. A. DOWIE
Chief
Instructor

THE development of automatic volume control and tone control is evidence that Radio designers are striving to improve the fidelity of modern receiver reproduction. Going one step farther in this direction, engineers of the Crosley Radio Corporation have perfected and already incorporated in their medium priced receivers a device which not only offers automatic bass compensation but also expands the volume range of the receiver. This device, the Crosley Auto Expressionator, ingeniously and automatically increases the brilliancy of reception of the musical programs broadcast today and brings closer to reality the Radio engineer's dream of a receiver which will reproduce perfectly all voice and music frequencies.

The depth of modulation employed in transmitters today cannot in general handle a musical rendition in which the intensity of the softest and loudest passages varies more than 100 db. Electrical limitations inherent in broadcasting equipment make it impossible to cover such a wide volume range, and the methods used by broadcasters in bringing their programs to the listener further narrows the range. The limiting factor is usually the ratio of signal to noise level in the various studio and transmitter circuits; under ordinary conditions the greatest volume range used today by most broadcasters is limited to or held within 45 db., approximately one-half the range necessary for true high fidelity broadcasts. The operators of the broadcasting stations have no particular desire to increase this volume range, for effective signal intensity would have to be sacrificed. (The average percentage of modulation must be reduced so that the louder passages may be reproduced without over-modulation. Naturally when the percentage of modulation is reduced, the soft passages will often make the program disagreeable to listeners located in the outer service area of a broadcasting station, by disappearing into the noise level. Many receivers cannot handle wide ranges of volume because of the particular type of detection employed. Thus, the useful signal transmitted by the broadcasting station must be maintained above a given value to insure the large audiences.

Even if broadcasters increased the volume range of their transmitters to 75 db. today, only certain types of music or entertainment, free from large volume changes, would be selected and transmitted. Then, too, large volume changes would be of little value to the listener employing an inexpensive receiver unable to handle the volume range effectively. Of course, if the broadcaster must, due to the many reasons outlined, limit the volume range, the expression of the musical program is usually impaired. To overcome this condition the auto expressionator was developed. It increases the volume range, artificially restoring the brilliancy or depth of the reproduced program.

The auto expressionator, employing a simple Wheatstone Bridge circuit, is connected between the secondary of the output transformer and the voice coil of the dynamic loudspeaker. Inasmuch as it is connected after the detector, any irregularities in detection will be introduced into the output of the receiver; it is therefore necessary to use a form of detection which is free from distortion.

Theory of Circuit

To understand the theoretical operation of this volume-expanding circuit, examine Fig. 1. Note that there are two resistors connected in series with the voice coil of the loudspeaker. It can readily be seen that the voice coil will receive power from the secondary of the output

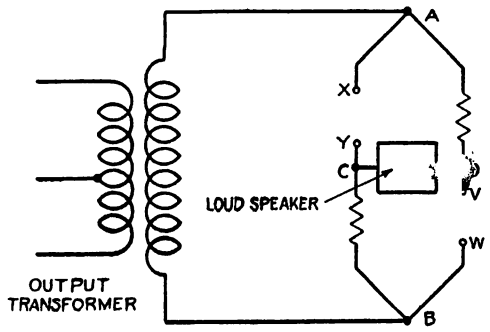

Fig. 1

transformer, even though some power is lost in the series resistors. Now if we connect another resistor of the *same value* across terminals X and Y, and a similar resistor across terminals V and W, the voltage across the voice coil of the loudspeaker will be zero because the circuit will be balanced. Each terminal of the voice coil will receive the same voltage from either A or B; that is, the voltage drop in the resistor connected between A and D will be the same as the voltage drop in the resistor between B and C, all resistors being of the same value. If both terminals of the voice coil are at the same potential, there can be no voltage to operate the diaphragm of the loudspeaker. It is now more evident that the loudspeaker will operate only when the impedances between AD and CB are *not* equal to those between AC and DB. By introducing devices having special characteristics between A and C and between D and B, we will be able to regulate the voltage between points C and D, which is the voltage applied to the loudspeaker. This is essentially the theoretical operation of the auto expressionator.

The Circuit

The actual circuit used in the auto expressionator is shown in Fig. 2. Switches SW_1 and SW_2 are opened and switches SW_3 and SW_4 are closed when the expressionator is to be used; ordinary operation of the set is obtained with the reverse setting of the switches. When the expressionator is removed, the voltage developed by the secondary of the output transformer is applied directly to the terminals of the voice coil of the dynamic loudspeaker. The devices marked X_1 and X_2 are the expressionator bulbs, made especially for the purpose by a special process. The resistance of the filaments of these bulbs is comparatively low when they are cold, but very high when current passes through to heat them. The tuned circuits CL_1 and CL_2 resonate at 40 cycles, and are used to bring up the bass response. The resistors R_1 and R_2 have slightly less resistance than the cold resistances of the bulbs X_1 and X_2. This fact must be remembered in order to understand the operation of the circuit.

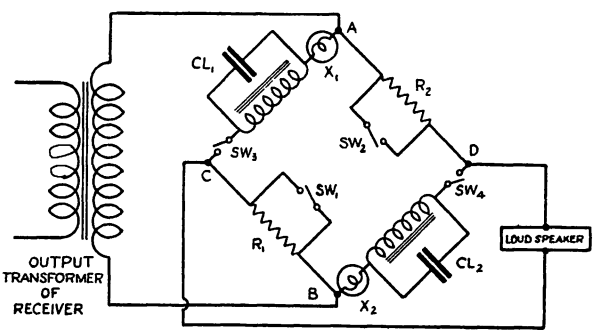

Fig. 2

Operation of Circuit

You will remember that the auto expressionator circuit serves two distinctive purposes, automatic tone compensation and automatic volume expansion. Automatic tone compensation is a highly desirable feature, inasmuch as the conventional type of dynamic loudspeaker generally requires more power at the lower audio frequencies, and in particular below 50 cycles, to give the proper balance between the lows and highs in a high fidelity broadcast.

To analyze the automatic tone compensation circuit, let us assume that a frequency of 40 cycles is applied to points A and B of the bridge by the secondary of the transformer when the expressionator is in use, switches SW_1 and SW_2 being open and Switches SW_3 and SW_4 closed. Since CL_1 and CL_2 offer a high impedance to the flow of 40 cycle current, we may consider the circuits between AC and BD to be open. (The impedance difference between circuits AC and AD will be at least 10 to 1.) The bridge will therefore be completely unbalanced, permitting maximum power to reach the loudspeaker. The bass response is consequently increased as the bridge becomes completely unbalanced. Of course, there will be a power loss (equal to I^2R) in each of the resistors, R_1 and R_2, but any increase in the power supplied by the output stage of the receiver will produce a corresponding increase in loudspeaker volume.

As the output frequency is increased, the impedance introduced into the circuit by CL_1 and CL_2 becomes less and less, dropping practically to zero, and only the resistances of the lamps will remain between points A and C and between B and D (Fig. 2). Remember that the resistance of each expressionator bulb, even when cold, is slightly greater than the resistance of

(Page 6, please)

The Crosley Auto Expressionator (Continued from page 5)

R_1 or R_2. The circuit is therefore in an unbalanced condition at all times, the unbalance becoming greater as the resistance of the expressionator bulbs increases. At low values of power output, when the circuit is most nearly balanced, only a small amount of the total output power is supplied to the loudspeaker. This *decreases* the intensity of the soft passages, and thus expands the volume range in this direction.

As the power output is increased, the expressionator bulbs will increase in resistance, throwing the circuit farther out of balance and causing the application of more power to the loudspeaker. This increases the intensity of the louder passages, expanding the volume range of these passages as well. The expressionator lamps are carefully designed to make expression changes smooth and pleasing. The time lag in the heating and cooling of the expressionator filaments is an important factor, for a change in expression must not occur during a low frequency note. The time lag of the expressionator blubs now in use is between one-fifth and one-tenth of a second.

Although no definite data has been released regarding the amount of bass compensation introduced at 40 cycles, it must be at least 15 db. above the normal output at 1,000 cycles to be of any appreciable value. Likewise no information is given regarding the amount of volume expansion introduced by the auto expressionator, but an increase of at least 10 db. in both directions must be present to give the combination any practical value. This would then expand the volume range 20 db. above the volume range used by the broadcasting station.

The parts necessary for the satisfactory operation of an auto expressionator circuit cannot be selected at random; they must be designed to work together and must be of the proper value. Do not attempt to install an auto expressionator in a radio receiver unless you purchase exact duplicate parts for such a combination, or you will run into trouble. In the first place the power output of the receiver must be doubled, because the expressionator, like any circuit which tends to equalize the over-all frequency response of an amplifier, introduces heavy losses. The receiver should employ class A amplification and have an output of at least 10 watts. Only under these conditions will the auto expressionator circuit function properly. If you have had considerable experience with the operation of similar circuits or with receivers using such devices, and wish to experiment with the installation of an auto expressionator in a radio receiver, purchase duplicate replacement parts, the output transformer, the two chokes, the two condensers, the two resistors, the four section switches and the two expressionator bulbs, as well as the loudspeaker for the complete job, from your Crosley distributor.

In conclusion may I add that the Crosley Auto Expressionator is one of several circuits now being used to change the frequency response and the volume range of a receiver. As yet we do not know how the listening public will receive these new developments; time will tell.