AUDIO APPLICATIONS OF A SHEET-BEAM DEFLECTION TUBE

J. N. Van Scoyoc
Armour Research Foundation
Chicago, Illinois

Summary

A number of unusual audio circuits has been developed which make use of a sheet-beam tube, type 6AR8. The 6AR8 tube is a miniature double-plate sheet-beam tube which incorporates a pair of balanced deflectors to direct the electron beam to either of the two plates and a control grid to vary the intensity of the beam.

This tube may be connected as a variable gain push-pull amplifier by connecting the input signal between the two deflectors and taking the output differentially between the two plates. When the tube is connected in this manner the amplifier gain is determined by the control grid voltage and may be varied over an 80 db range with negligible distortion.

The applications of this circuit include expansion and compression circuits, remote control of gain and mixing circuits, improved A.V.C. circuits and phase inversion. A number of these circuit arrangements are given in some detail and other applications are outlined.

Introduction

The availability of the sheet-beam deflection tube, type 6AR8, has made possible the development of some unusual audio circuits. The 6AR8 is a miniature double-plate sheet-beam deflection tube which incorporates a pair of balanced deflectors to direct the electron beam to either of the two plates, and a control grid to vary the intensity of the beam. This tube was developed for service as a synchronous detector in color television receivers but its unique design makes it very useful for many circuit functions.

Tube Construction and Operation

A cross sectional view showing the construction of the 6AR8 tube is shown in Fig. 1. With the two anodes tied together and the deflectons grounded the plate characteristics as a function of grid voltage are similar to those of many high transconductance radio frequency pentodes and are not shown. The transfer characteristics for plate current versus deflector voltage are shown in Fig. 2. The center portion of these characteristics corresponding to relatively small deflector voltages is quite linear and it is this portion of the transfer characteristics that is used in the applications to be described.

Basic Circuits

This tube may be connected as shown in Fig. 3 to function as a push-pull, class A audio amplifier. For this method of operation the input signal (either single-ended or push-pull) is applied between the two deflectors and the output appears differentially between the two anodes. With this connection the output signal results from the distribution of the electron beam between the two anodes as a function of deflector voltage. When operating with a fixed voltage between the two deflectors, the magnitude of the output voltage is determined by the intensity of the electron beam and hence by the control grid voltage. Since the deflection characteristics of the tube are not dependent on the intensity of the electron beam, the output voltage may be varied over a wide range with negligible distortion by a few volts change in control grid voltage. Gain variations of 10,000 to 1 have been measured with negligible distortion of the amplified signal.

This tube may serve as a combined mixer and phase inverter when connected as a variable gain amplifier. Two signals are mixed by applying each signal between one deflector and ground. The plate-to-plate signal is proportional to the difference between the two input signals.

As a voltage controlled variable gain amplifier the 6AR8 tube can perform a large number of useful functions. The gain of such an amplifier may be controlled remotely (even hundreds of feet) without signal voltages in the control heads. Only a battery and a potentiometer are needed for remote manual control. The circuit in Fig. 4 shows how two 6AR8 tubes with their outputs connected in parallel provide an effective mixer circuit for two separate input signals. Since the gain of each tube may be controlled remotely by a variable dc voltage, a remote fader or mixer circuit may be obtained without the use of long signal lines with their attendant cost and noise problem. This application should simplify many problems in large sound installations. A plot of attenuation versus grid control voltage for a 6AR8 variable gain amplifier stage is shown in Fig. 5.

Amplifier Design and Performance

A circuit diagram for an actual ten watt audio amplifier with a 6AR8 variable gain preamplifier is given in Fig. 6. The circuit is given to show a typical application of the variable gain amplifier. The oscillograms shown in Fig. 7 illustrate the freedom from distortion obtained with large values of attenuation. The upper oscillogram was obtained from the amplifier just described at full rated output, while the lower oscillogram shows the output of the amplifier with the output reduced in amplitude 60 db by changing the control voltage of the 6AR8 tube. The input signal was maintained at a one volt level for both oscillograms.

A compression circuit is achieved by controlling the gain of the amplifier by a dc voltage derived from the output signal. This circuit is similar in operation to the conventional automatic volume control circuits used in many radio receivers. Large values of compression (up to 30 db) are possible with very low distortion. The transfer characteristics of the compression circuit for different degrees of compression are shown in Fig. 8. All values given are for steady state conditions with a 400 cps input signal.

Special Applications

A variable gain amplifier of this type may serve many applications when used in conjunction with various types of radio receivers. The automatic volume control circuits of most receivers are only partly effective in maintaining constant audio output as the level of the received signal varies. Any degree of correction may be obtained by using all or part of the automatic volume control voltage to vary the gain of the audio amplifier. Under conditions of over compensation strong signals will produce no audio output and only weak signals can be received. For receiving intermittent transmissions such as used in police communications the operation may be reversed so that no audio output results except when a carrier signal greater than some preset value is received. This form of operation is an improved distortion free version of a well known "squelch circuit".

This variable gain amplifier could be readily applied to advantage in Hi-Fi and stereo amplifiers. The functions it could perform would include mixer action, phase inversion, gain control, tone control, and stereo balance control.

The novel construction of the sheet-beam deflection tube provides characteristics which make possible new circuits for the audio design engineer.

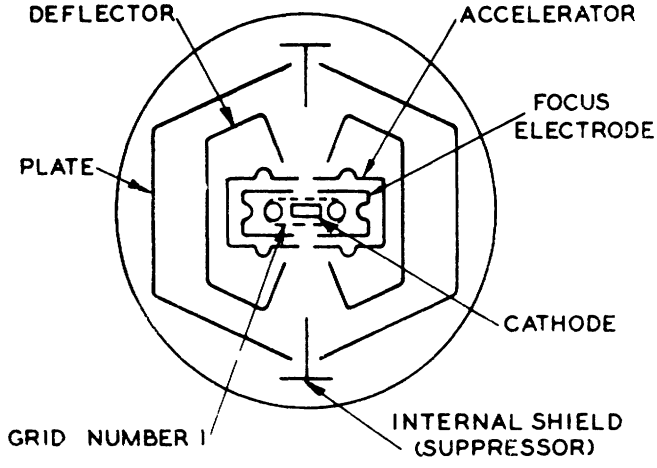

Fig. 1. Cross section schematic diagram of the 6AR8.

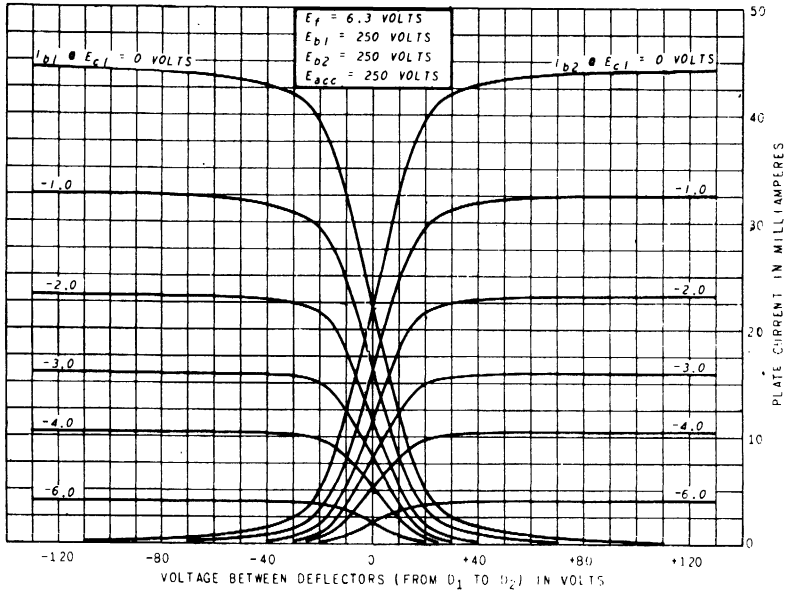

Fig. 2. Average transfer characteristics.

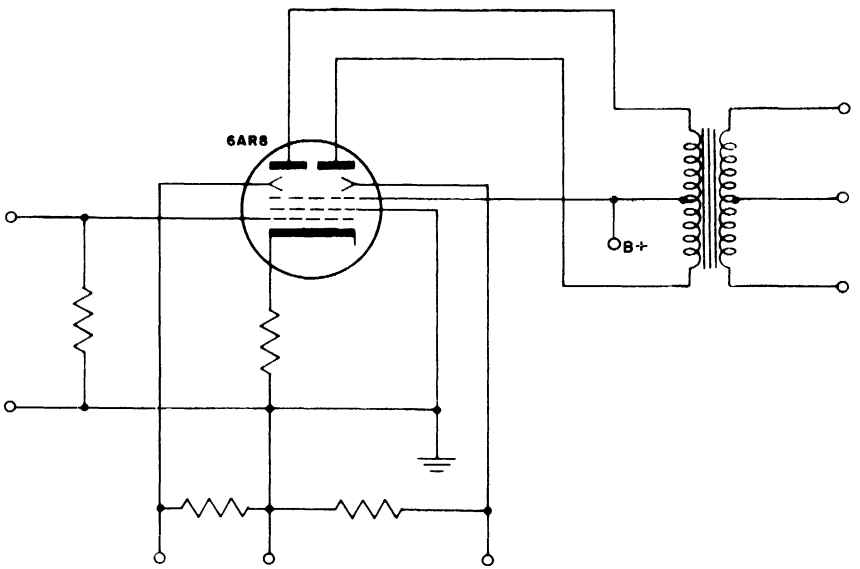

Fig. 3. Basic variable gain amplifier.

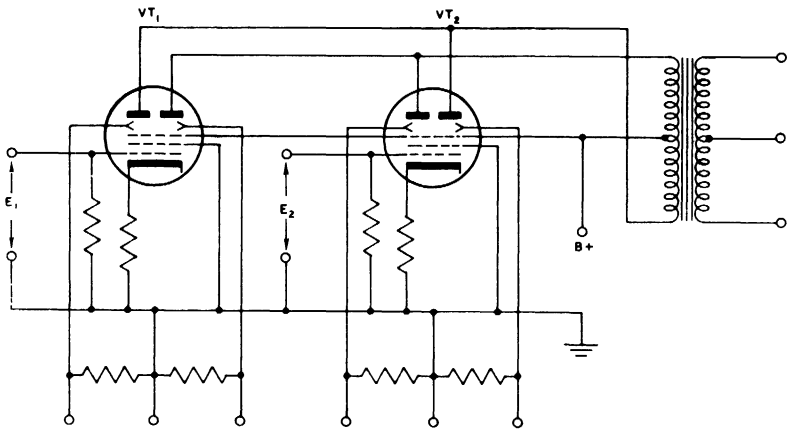

Fig. 4. Circuit for controlling multiple input signals.

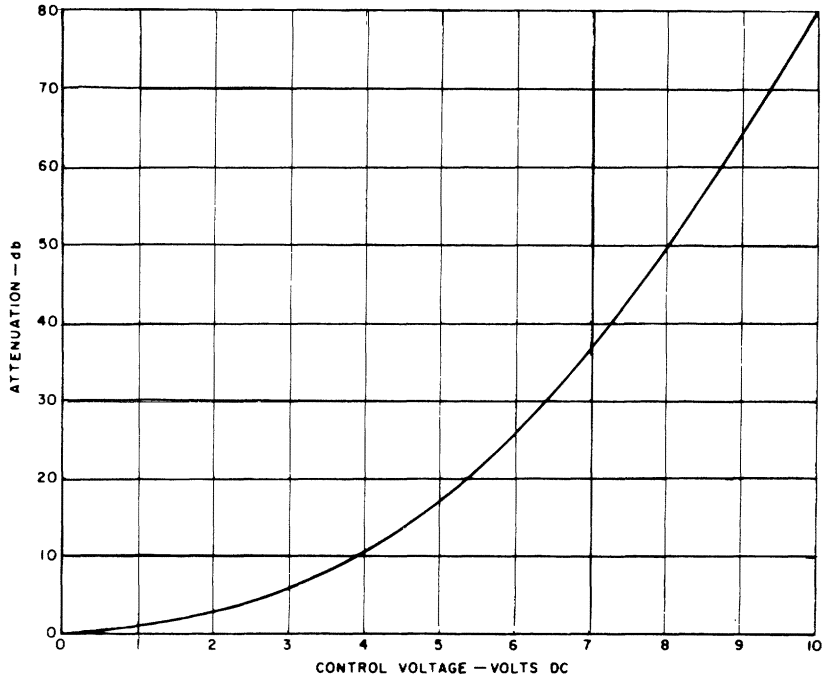

Fig. 5. Attenuation vs. control voltage.

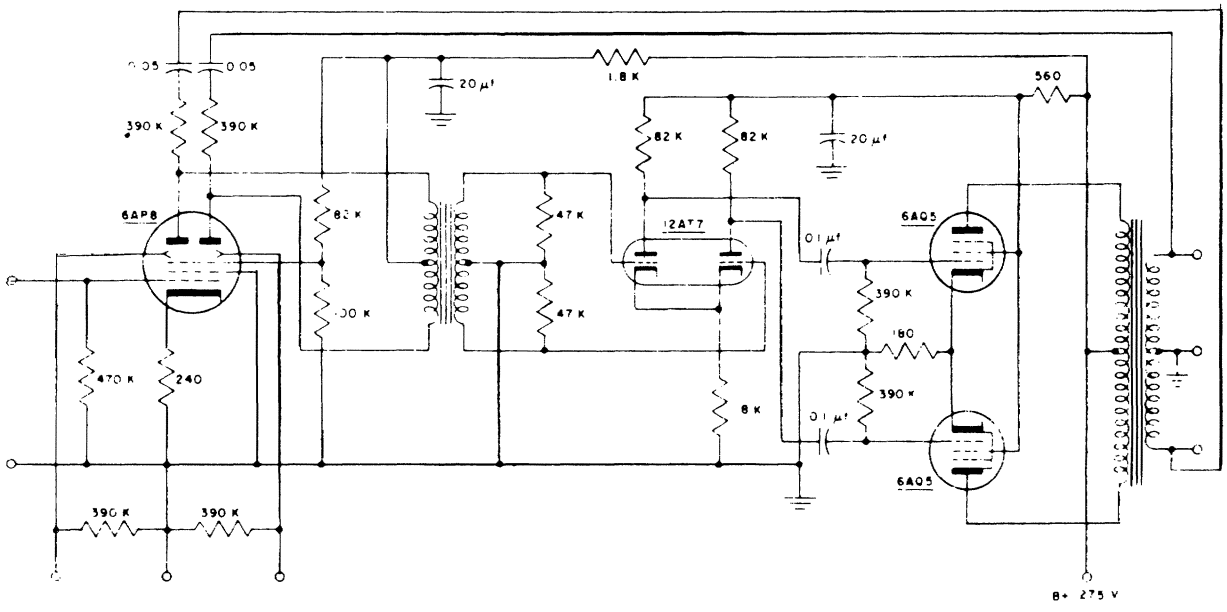

Fig. 6. Audio amplifier with variable gain preamplifier.

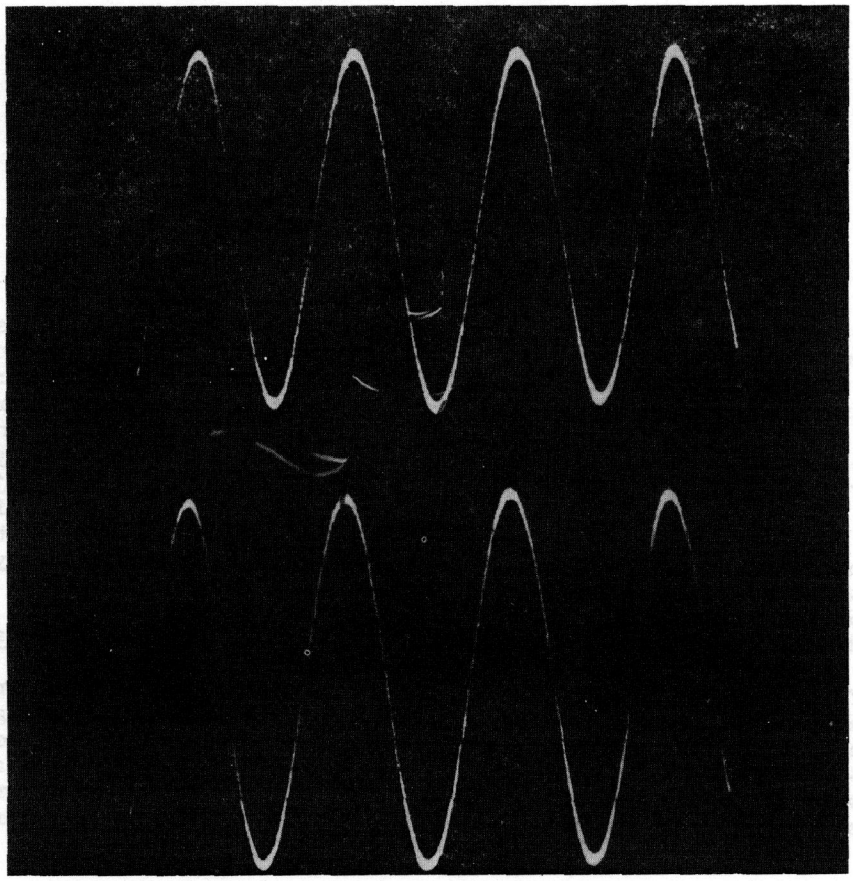

Fig. 7. Amplifier waveforms.

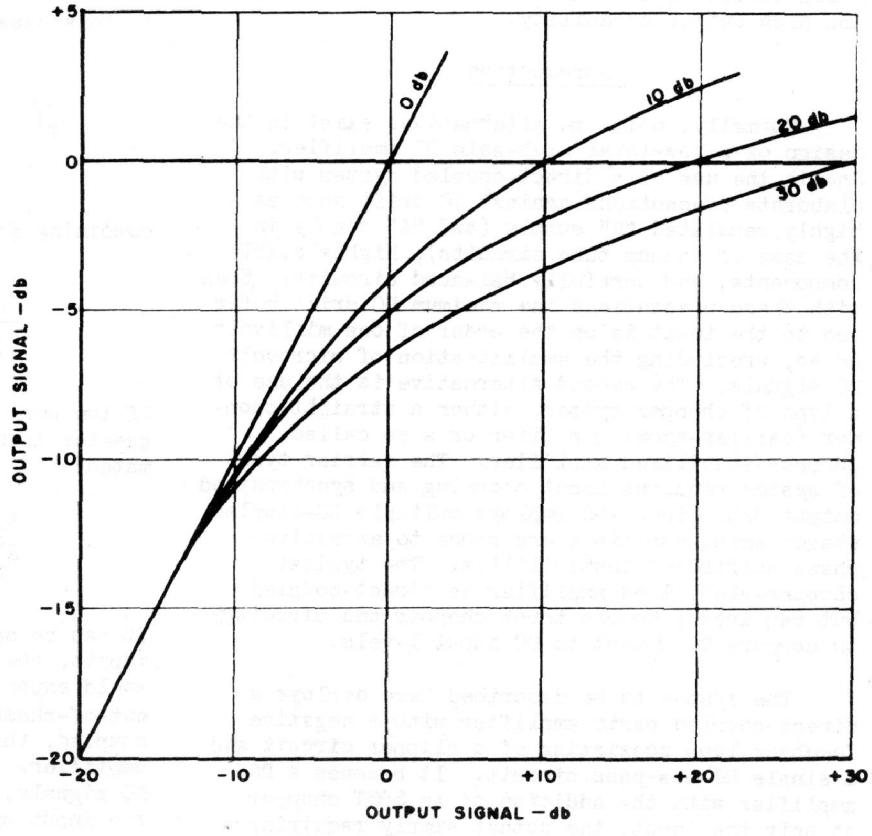

Fig. 8. Compression characteristics.