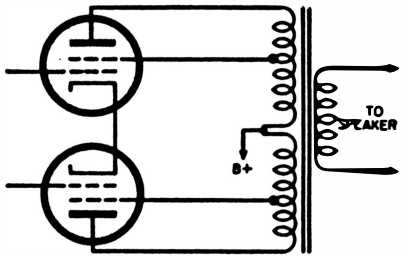


Fig. 2. Basic "Ultra-Linear" arrangement.

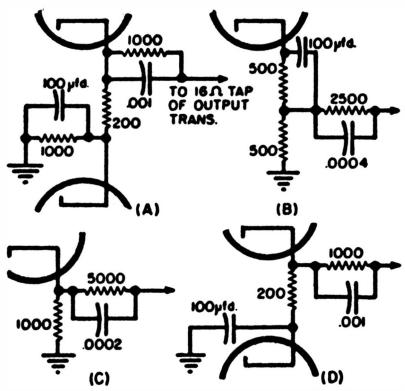


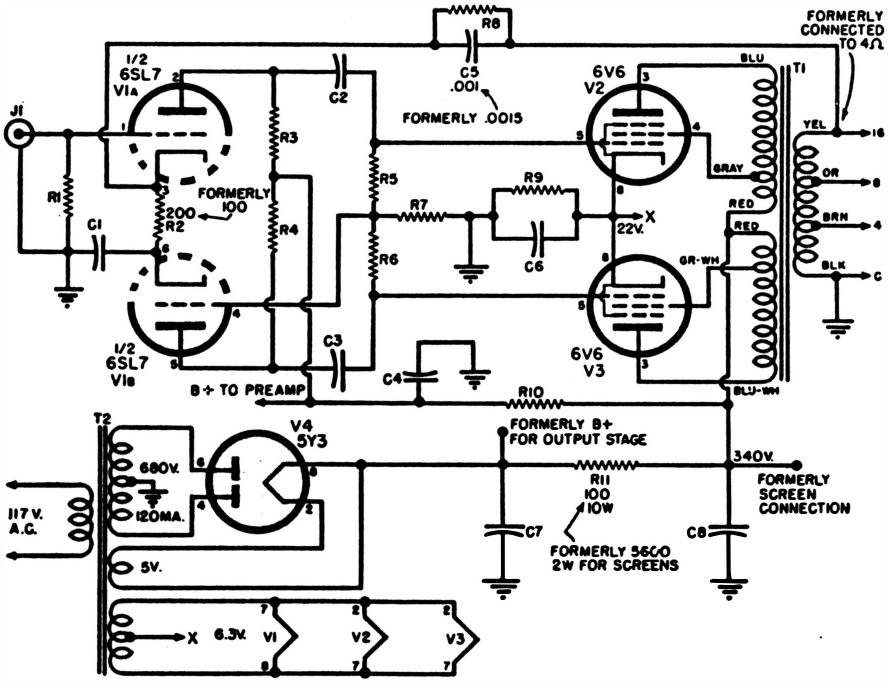
Fig. 3. Various feedback arrangements from voice coil of the output to the cathode of an early stage. See text for discussion.

is coincident with conventional tetrode connection.

Thus the "Ultra-Linear" operating point has been set at a compromise level in which the factors of maximum power output, distortion at various levels, and internal impedance have all been weighed against each other. It must also be mentioned that listening tests at various tapping points *with no feedback around the amplifier* validate this selection of the tapping point. This was done without feedback on the assumption that the best amplifier without feedback would also be the best after the application of feedback. In these listening tests, the triodes fell behind because they could not handle the power (after all, 3 watts is insufficient for musical peaks), the tetrodes were somewhat screechy and boomy (too much internal impedance for satisfactory speaker damping), and the 24% point sounded natural and smooth even without connection of the amplifier feedback loop.

Use of the "Ultra-Linear" circuit involves utilization of an output transformer with the correctly placed taps. A special transformer, the *Acrosound* TO-310, has been designed specifically for this application; and its parameters were selected so that it would not limit the ultimate capabilities inherent in the circuit. For example, its bandwidth has been set at ± 1 db from 10 cps to 100 kc. so as to provide the low phase shift and good transient performance desired in the most critical applications. Similarly, its distortion characteristics complement those of the "Ultra-Linear" circuit and permit low distortion at both high and low levels from 20 cps to over 20 kc.

Fig. 4. The Grommes 100BA power amplifier converted to "Ultra-Linear" operation.



R_1—470,000 ohm, ½ w. res.
R_2—200 ohm, ½ w. res.
R_3, R_4, R_6, R_8, R_7—220,000 ohm, ½ w. res.
R_5—1000 ohm, ½ w. res.
R_9—300 ohm, 10 w. wirewound res.
R_{10}—5600 ohm, 1 w. res.
R_{11}—100 ohm, 10 w. wirewound res.
C_1—100 μfd., 15 v. elec. cond.
C_2, C_3—.1 μfd., 400 v. cond.
C_4—10 μfd., 400 v. elec. cond.
C_5—.001 μfd. ceramic cond.
C_6—40 μfd., 50 v. elec. cond.
C_7-C_8—40/30 μfd., 450 v. elec. cond.
T_1—Output trans. (Acrosound TO-310)
T_2—Power trans. 340-0-340 v. @ 120 ma.; 5 v. @ 2 amps.; 6.3 v. c.t. @ 2 amps.
J_1—Input jack
V_1—6SL7 tube
V_2, V_3—6V6 tube
V_4—5Y3 tube

Circuit Considerations

There are many 6V6 circuits which have become popular, but by far the most commonly used is that in which a twin triode phase inverter is used to drive a pair of 6V6's; and feedback is carried from the output winding of the output transformer to the cathode of one of the triode sections. This basic configuration is simple, practical, economical, and adequate. The a.c. grid-to-grid voltage requirements of the 6V6 output stage are not stringent, and the phase inverter supplies ample drive without the need for an intermediate push-pull stage such as is used in the Williamson-type circuit. Since there are only two stages, the problems of utilizing feedback are simplified (as there is less phase shift in the circuit), and the designer can use less elaborate circuitry and components while preserving a satisfactory margin of stability.

Generally the phase inverter tube is a high mu triode such as the 6SL7 or 12AX7 in order to obtain as much gain as possible within the two stages. Actually, except for gain considerations, the specific type of inverter is of comparatively little consequence—circuit performance is determined almost completely by the mode of operation of the output tubes with respect to bias, supply voltage, and impedance match; the quality of the output transformer; and the proportion of feedback. The voltage amplifier stage contributes relatively little, as compared to the contribution of the output stage, to the over-all quality of the amplifier.

Conversion of these circuits to "Ultra-Linear" operation can be done by substituting an output transformer which has properly placed taps for connection to the 6V6 screens. Generally, this substitution will make an immediate decrease in distortion.

If the original amplifier used a screen dropping resistance, this is removed for "Ultra-Linear" operation; and the screens are connected to the tapping points on the primary of the output transformer. It is important to observe polarity and to connect the screen to the *same* primary side of the transformer as that from which the plate is energized. Otherwise an oscillitory condition will be provoked. Similarly, polarity must be observed between upper and lower output tubes, or the feedback from the secondary side of the transformer may be in the incorrect phase and cause regeneration.

When the screen resistor of the original circuit has been removed, the screen bypass condenser must also be disconnected. This can be readily put to good use by paralleling it across one of the filter condensers of the power supply for extra filtering and lowered power supply impedance.

The only other changes which need be made involve the feedback resistor and feedback compensating condenser which shunts this resistor (or in some circuits bypasses it to ground). The ratio of series resistor to shunt re-