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A Television Booster Amplifier

Part 2, Design

By the Engineering Department, Aerovox Corporation

THE AEROVOX RESEARCH WORKER for March, 1949 discussed the factors to be considered in the design of a high-performance television booster amplifier. The present issue will describe the constructional details of a practical booster following these design principles. The booster tunes all currently used television channels, although its performance is most optimum on channels 2 through 6. An artist's sketch of the experimental booster is shown in Fig. 1. It is recommended for use with television sets operating in weak-signal, "fringe" areas where the factor limiting satisfactory picture reception is internal tube and circuit noise. If receiver performance is limited by a high *external* noise level, (due to electrical appliances, automobile ignition, neon signs or atmospheric noise) improvement in the receiver noise figure will not be of much help, since the signal-to-noise ratio for the system is, in effect, predetermined at the antenna.

In Part 1, it was pointed out that the most important requisite of the first stage of a radio receiver operating in the VHF region is a low noise figure. Gain is important, but only if accomplished with negligible noise contribution. It was shown that the desired low-noise performance could best be obtained by the use of triode tubes, which inherently contribute less noise than pentodes, providing means could be found for overcoming certain shortcomings exhibited by triodes when used as r.f. amplifiers. These include the tendency to oscillate when used in the conventional grounded-cathode circuit, and poor gain and selectivity in the grounded-grid circuit configuration. An ideal means of overcoming these undesirable features, while maintaining extremely low-noise performance and sufficient gain, was found to exist in the special Wallman "cascode" amplifier, which uses two triode stages in a relatively simple circuit arrangement. This circuit, as modified for use as a practical television booster, is shown in Fig. 2.

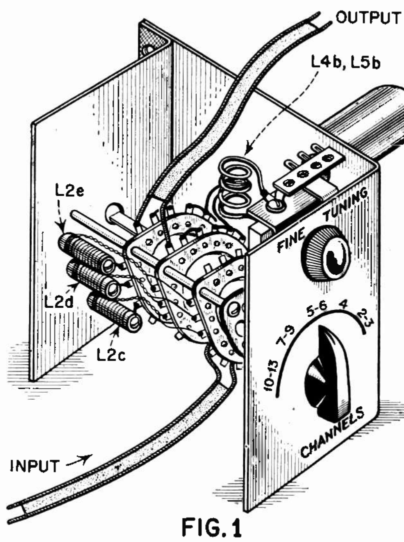


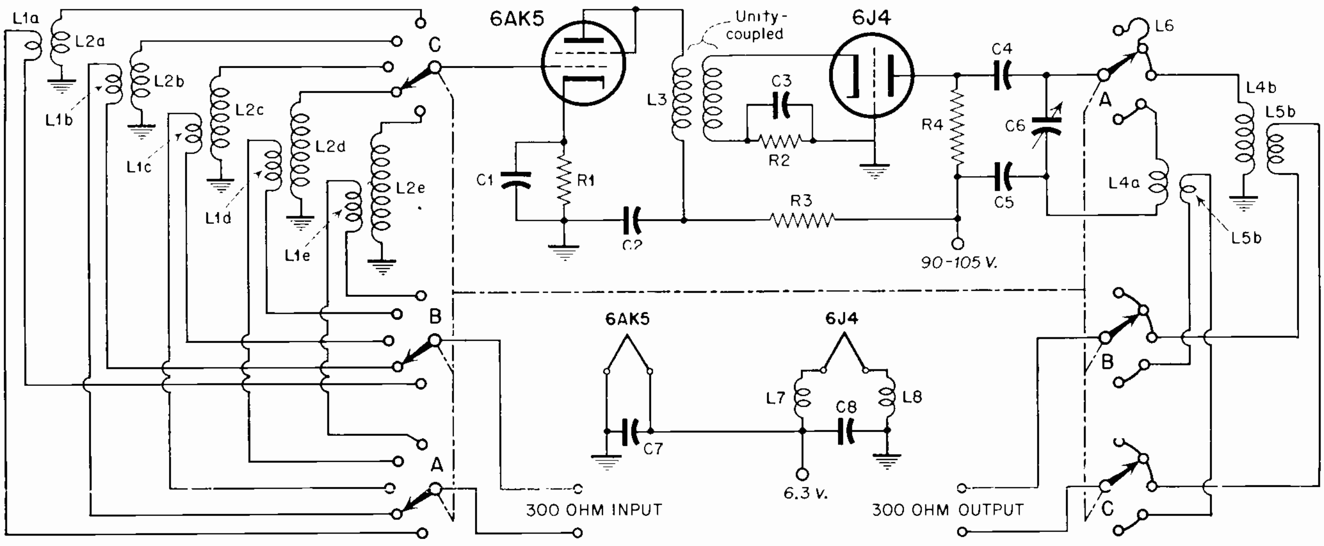
FIG. 1

A triode-connected 6AK5 was chosen for the first stage because of its excellent low-noise performance in band-pass r. f. amplifier circuits. A 6J4 triode was used in the experimental prototype as the grounded-grid second stage for its high transconductance, which contributes to the stability of the cascode and the broadness of the interstage coupling, as was discussed in the March issue. The low output capacitance of the 6J4 also facilitated tuning the high television bands. Where economy dictates, a 6J6 may be used as the second stage with only a small reduction in performance. In this case, one triode section is used. All terminals associated with the unused section are soldered to ground.

A three section, six circuit, five position gang switch is used for selecting channels. Three circuits on one side of the switch are used for switching input grid coils (L2) and antenna coils (L1). Five input coils are used; three for the low band and two for the high band. The circuits on the opposite side of the switch change the output inductance (L4) and the coupling coil (L5) between the high band and the low band.

CONSTRUCTION

In constructing the booster, the usual precautions for wiring VHF circuits must be observed. Lead lengths must be kept to a minimum. Grounding and by-passing must be as nearly perfect as possible. Any laxity in these points invites difficulty in the form of regeneration, which deteriorates noise and band-pass performance. Low-loss insulation should be



C1,C3,C7,C8 - 470 MMFD., MICA (Aerovox Type 1468)
C2,C5 - .001 MFD., MICA (Aerovox Type 1468)
C4 - 50 MMFD., MICA " " "

C6 - 25 MMFD., MIDGET VARIABLE
R1,R3 - 68 OHMS, 1/2 WATT (Aerovox Type 1097)

R2 - 120 OHMS, 1/2 WATT (Aerovox Type 1097)
R4 - 1250 OHMS, 1/2 WATT (Aerovox Type 1097)
ALL INDUCTANCES - *See Table I*

CASCODE TELEVISION BOOSTER
FIG. 2

used wherever possible.

The booster is assembled on a chassis made up of #19-gauge brass or copper sheet stock, drilled and bent as detailed in Fig. 3. Aluminum, although easier to work, is not satisfactory because of soldering difficulties and should not be used. All grounds and the miniature tube sockets are soldered directly to the chassis to insure perfect bonding.

The gang switch used for selecting channels is assembled by mounting three switch sections on an indexing assembly. The spacers are modified so that the sections are spaced one-half inch apart, starting one-half inch from the front-plate. The switch is secured to the rear-plate of the chassis by means of the remaining length of the switch assembly screws which extend beyond the last section. A one-inch spacer is used between the last switch section and the rear chassis plate, which is drilled for the assembly screws and to clear the switch center-shaft. For convenience, the three selector switch decks are designated A, B and C, starting with the one immediately behind the front panel. Fig. 2 illustrates the manner in which the three decks are wired. Coil data for the coils as numbered in Fig. 2 are shown in Table 1.

The input coils (L2, a to e) are mounted on the rear-plate of the chassis close to the terminals of switch section C. The coils for the low television channels (L2, c, d and e) are wound on three-eighths inch diameter ceramic stand-off insulators, five-eights inch long, and tapped for 6/32 screws for mounting. Coils for the upper band (L2, a and b) are self-supported #18 wire, soldered between the rear-plate and the appropriate terminal on switch section C. Frequency adjustment of the coils is accomplished by spreading or compressing turns. The antenna coils, (L1, a to e) are wound on forms made of transparent cellulose tape. A narrow strip of the tape is wound with the adhesive side *out* on a dowel or other round form which is slightly larger than the outside diameter of the input coil (L2) to which the antenna coil is to couple. The #26 DCC wire is then wound close-spaced on the tape with leads about three inches long left protruding at each end. These leads are twisted lightly together and soldered to the proper terminals on switch sections A and B. The antenna coil thus assembled slides freely on it's corresponding input coil and provides some degree of flexibility for adjustment during alignment.

The tube sockets are mounted on the bottom of the chassis so that lead lengths are kept as short as possible. The miniature socket for the 6AK5 first stage is mounted directly under the common terminal of switch section C. The lead to the grid terminal of the tube socket is thus only about 1/4 inch long. The 6J4 tube socket is mounted in the opposite corner of the chassis under the stator terminal of the output tuning capacitor (C6). The common terminal on the output side of switch section A is connected to the upper stator terminal of the tuning capacitor by a short length of #14 wire.

The condenser used for tuning the output circuit (C6) is a 25 mmf.

COIL	CHANNELS	WIRE (AWG)	INSIDE DIAMETER	TURNS	LENGTH
L1a	10-13	No. 26 DCC	3/8"	1	Close
L1b	7-9	"	3/8"	2	"
L1c	5-6	"	7/16"	2	"
L1d	4	"	7/16"	3	"
L1e	2-3	"	7/16"	3	"
L2a	10-13	No. 18 Bare	1/4"	2 1/2	1/4"
L2b	7-9	"	1/4"	3	3/8"
L2c	5-6	No. 21 Bare	3/8"	10	5/8"
L2d	4	"	3/8"	11	5/8"
L2e	2-3	"	3/8"	12	5/8"
L3	All	No. 22 E	3/8"	6 1/2	5/8"
L4a	7-13	No. 18 Bare	1/8"	1	—
L4b	2-6	No. 14 Bare	1/2"	4	1"
L5a	7-13	No. 26 DCC	1/8"	1	—
L5b	2-6	"	1/2"	3	Close
L6	2-3	No. 18 Bare	1/4"	1	—
L7	All	No. 22 E	Wound on 1/2 watt resistor	18	Close
L8	All	"		18	"

TABLE I

midget variable. This type has a ground stud below the stator plates which provides a convenient ground point for the high-band output coil (L4a). The metal condenser mounting bracket, mounted in a vertical position, is used to mount a three-lug terminal strip for power-supply connections. The ground end of (L4b) also terminates on this bracket, which is grounded solidly to the chassis by means of a piece of braid soldered at each end.

The interstage coupling transformer (L3 in Fig. 2) is unity-coupled by winding two #22 enameled wires simultaneously on a polystyrene form three-eights inch in diameter by five-eighths inch long. The form is tapped for a 6/32 screw for mounting at one end. The bifilar winding acts as a single r. f. coupling inductance while completing both the first stage d. c. plate circuit and the second stage d. c. cathode circuit. The transformer is mounted on the outside of the chassis between the tubes. The by-pass capacitors (C2, C3) and the 6J4 cathode bias resistor (R2) associated with it are also mounted on the tube side of the chassis close to the transformer. The "hot" leads from the interstage transformer to the tubes are fed through the chassis at points close to the tube terminal to which they connect. Rubber grommets or ceramic "feed-thru" bushings should be used.

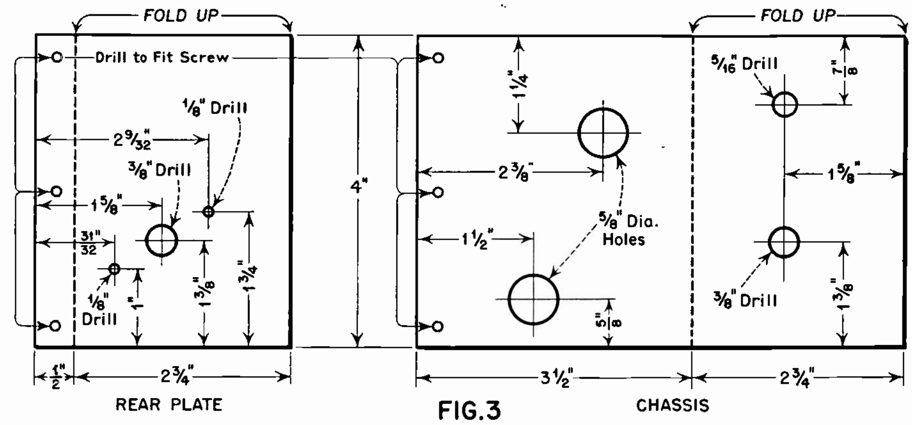


FIG.3

TESTING AND ALIGNMENT

When the construction and wiring of the booster is complete, it should be given a thorough continuity check with an ohmmeter to insure proper wiring before the connection of any voltages. When circuit troubles have been cleared, tubes may be installed and supply voltages connected. The booster requires 90 to 105 volts d. c. at about 20 milliamperes and 6.3 volts at .6 amperes. These voltages may be taken from the television set, or a small power supply using a selenium rectifier may be built.

To check the booster for self-oscillation and parasitics, a 300 ohm dummy load resistor is connected across the r. f. input and output terminals on the gang switch or to the ends of short pieces of 300 ohm twin-lead connected to these points. Under these conditions, with normal voltages applied, no oscillation should be evident. Oscillation may be detected by abrupt changes in the plate current consumption when the output tuning condenser (C6) is rotated, or when parts of the amplifier are touched with the hand. The location and cure of such oscillations is mainly a matter of trial and error. One serious parasitic oscillation at 430 megacycles was found in the experimental prototype and was cured by connecting a heavy ground strap from the ground lug on C6 (to which the high-band output coil is connected) and the near-by rotary switch frame. If oscillation is found to exist on one switch position and not on others, the polarity of the antenna coil (L1) leads should be reversed. Since switch section B has both input and output terminals on it, there is some capacitive coupling between them. Oscillation will result unless the leads are arranged so that the voltages are not in the right phase to cause regeneration.

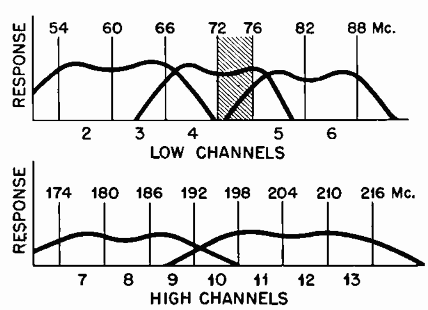


FIG.5

Because of the critical nature of band-pass amplifier adjustment, the availability of visual alignment equipment is almost a pre-requisite for the proper alignment of the booster. Some degree of operation may be achieved by point-to-point adjustment using a spot-frequency signal generator and an output meter, or by alignment on television test-patterns. For best results, however, the use of a swept-frequency signal generator and an oscilloscope is preferable. A 'scope with a high-gain vertical amplifier is necessary for satisfactory visual presentation of the booster band-pass characteristic since the output of most swept signal generators is quite low.

The set-up used for visual alignment of the booster is shown in Fig. 4. A frequency-marker signal should be provided for determining band-widths. A visible marker "pip" may be produced on the 'scope pattern by coupling a single-frequency signal generator loosely to the input of the booster, or by coupling a calibrated absorption wave-meter to either the input or output coil of the booster.

The band-pass of each switch position of the booster is adjusted by varying the positions of the input and output coupling coils, trimming the frequency of the input grid coils, and tuning the output circuit. When the proper position of each coupling coil is determined, it should be secured by a drop of "Duco" cement.

The response characteristic of the booster should be approximately that shown in Fig. 5. Because the tuning of the output circuit is variable, a wide variety of band-pass response curves is made possible. This property is sometimes useful in compensating for deficiencies in the television receiver pass-band.

(For the purchase of parts or equipment pertinent to the construction of this television booster amplifier, we recommend that you see your local Aerovox radio jobber.)

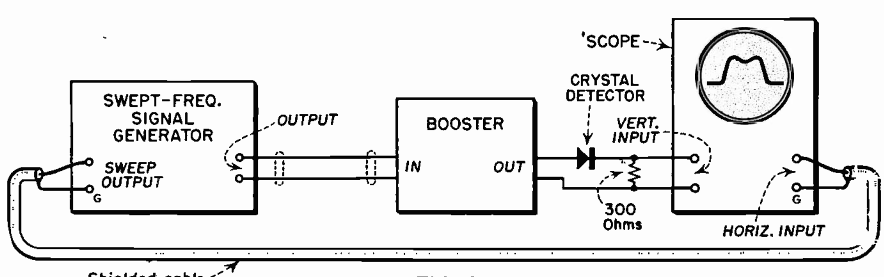


FIG.4

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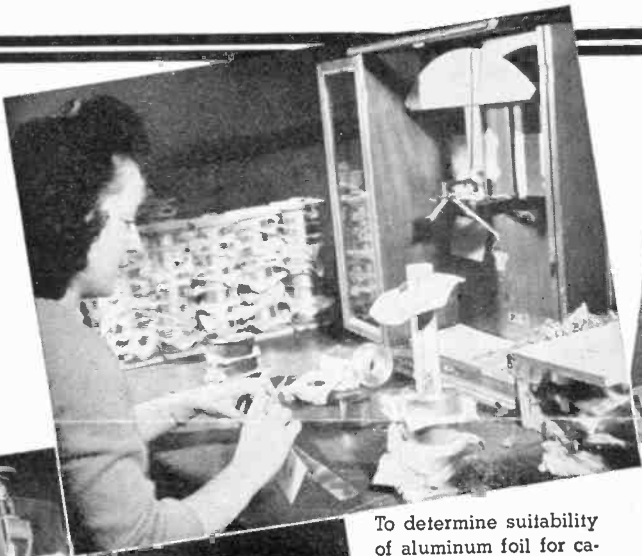

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