Fig. 1. Compact, two section amplifier with control section arranged for mounting in small panel area.

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Part I—A new amplifier of exceptional performance especially designed for modernization where cabinet space is limited.

Compact 6AS7G Amplifier For Residence Audio Systems

MANY AN EXPERIMENTER or audio hobbyist has the desire—and often a definite need—for a high-fidelity amplifier, but is at a loss for sufficient space to install it in an existing cabinet or piece of furniture. So far, many of the writer's amplifier designs have been adequate for good quality reproduction, but none was arranged specifically for use by anyone desirous of modernizing a reproducing system because they were all laid out with a view to accommmodating the components in a normal amplifier arrangement.

To solve any problem, it is first necessary to recognize its existence—the rest follows naturally. For a modernization problem, the requirements may be stated as follows:

Electrical: Around 5 to 6 watts of high-quality audio power.

Switching to select standard and microgroove phonograph pickups, and two additional positions for AM and FM radio inputs.

Sufficient gain and low-frequency equalization for low-level magnetic pickups.

Separate high- and low-frequency tone controls.

To these may be added as desirable features a volume control compensated for loudness levels, and means for equalizing the levels of the various inputs so the compensated volume control works at its optimum position and to avoid undesirable level changes when switching between inputs.

Physical: Amplifier and power supply small enough to fit into reasonable spaces.

Control facilities which may be mounted on a small panel space separate from the amplifier.

Considering these requirements separately, the first is fairly obvious. The reason for modernizing is to obtain a better quality of reproduction. This demands good components, and sufficient power to handle peaks without danger of overload. Since it is more economical and usually provides better overall quality to use a high-quality loudspeaker with a good reproducing system, a fairly high efficiency is generally encountered. Most high-quality speakers will provide plenty of volume for home use with much less than one watt of *average* power although more is necessary, of course, to handle the peak levels. Therefore, it is felt that five watts should suffice for practically any home system. It goes without saying that frequency response should cover the range from 30 to 15,000 cps, and that distortion must be held to an absolute minimum. The hum level should be so low that no sound is audible from the speaker in the absence of signal.

Multiple Inputs

Practically every reproducing system is used for more than one input. Since the advent of long-playing, microgroove records, it seems logical to include an input for a second pickup, with a single selector switch connecting the chosen input source to the amplifier.

Low-level magnetic pickups are firmly established, and any good amplifier must be designed to accommodate them without the need for an external preamplifier. As is well known, these pickups require equalization of the low-frequency spectrum, in addition to considerable gain to make their output comparable to that of a radio tuner. The microgroove pickups are slightly lower in output in most instances, due largely to a lower level on the record itself.

Although not generally known, a conventional crystal pickup can be fed into an equalized preamplifier, and will often sound better than if used with a high-impedance input. As far as the frequency response is concerned, this is easily explained. A crystal pickup may be regarded as a generator of zero impedance in series with a capacitance. An average crystal pickup, for example, has a capacitance of around 1500 $\mu\mu$f. When such a pickup is fed into a resistive load, it has a natural droop of 6 db/octave below the frequency at which its reactance equals the value of the resistance into which it feeds. Thus, it has a "turnover" frequency of 500 cps when fed into a 0.2-meg load. Now, while a crystal pickup is a constant-amplitude device and delivers a constant voltage into a high resistance load up to the turnover frequency (of the record) from a disc cut with the normal 6 db/octave droop below the turnover, the low-resistance load causes a loss in bass

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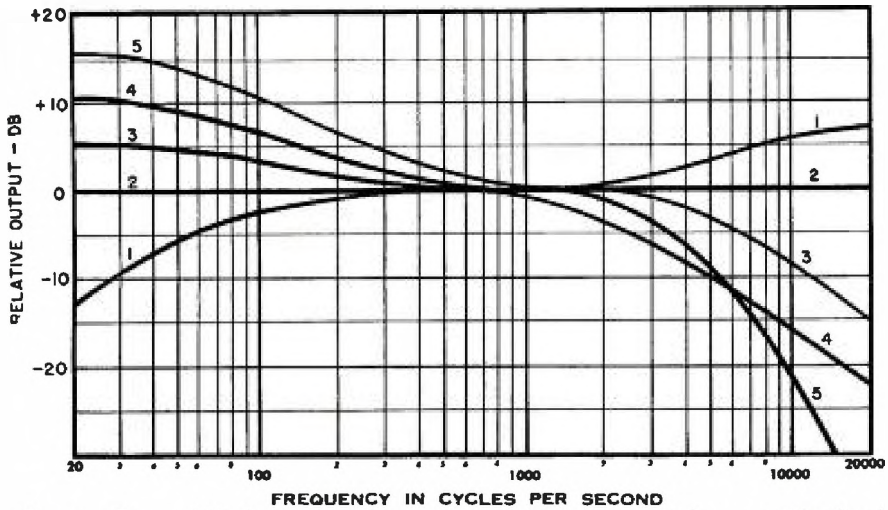


Fig. 2. Tapped high-and low-frequency tone control switches provide fixed response curves.

response equivalent to that of a magnetic pickup. But the preamplifier corrects for this loss, so the output is again "flat." The voltage output of the crystal is higher than that of the magnetic pickup, so the loss due to the low-resistance load may be accepted readily. Since high-frequency equalization is still necessary for the crystal pickup, it is still necessary to add a resistor shunted by a capacitor in series with the high side of the pickup to make it workable with a high-gain preamplifier, if wide-range reproduction is to be obtained. Therefore, this type of preamplifier is reasonably suitable for crystal pickups.

Most users want some tone controls so as to be able to obtain desired response curves. While the compensated volume control reduces the need to a large extent, satisfactory reproduction of phonograph records demands some roll-off control, and also a sharper cut-off for particularly noisy records. Varying degrees of bass boost are also desirable. Therefore, both low- and high-frequency tone controls are employed, providing five curves for each as shown in *Fig. 2*. These are step controls rather than continuously variable potentiometers because more suitable curves are obtainable. The low-frequency control provides a 5-db droop at 50 cps, a flat position, and boosts of 4.5, 9, and 13 db at 50 cps. The high-frequency control provides a boost of 6 db at 10,000 cps; a flat position; a roll-off down 3 db at 4400 cps and 8 at 10,000; an NAB roll-off down 3 db at 1600 cps and 16 at 10,000; and a cut-off down 5 db at 3500 cps and 21 at 10,000. Listening tests have adjudged these steps to be desirable.

The particular type of fully compensated volume control used is that previously described in these pages.[1] The level adjusting is accomplished by means of three 0.5-meg potentiometers, with the microgroove pickup having no built-in adjustment, since the overall amplifier gain is designed to fit this input. If further adjustment is required, it may be accomplished externally.

The amplifier, shown complete in *Fig. 1*, is built in two sections—one is the output stage and the power supply, while the other is the control unit, with all the other stages. The power section is built on a standard 5 x 10 x 3 chassis, while the control section is housed in a 3½ x 7 x 2 chassis, made from 7 x 11 x 2 standard aluminum chassis. The two sections are connected by a three-foot cable which carries all power and signal circuits except for the a-c switch line, which is separate. The a-c switch is not a part of the control section, but is to be mounted at a convenient location on the panel.

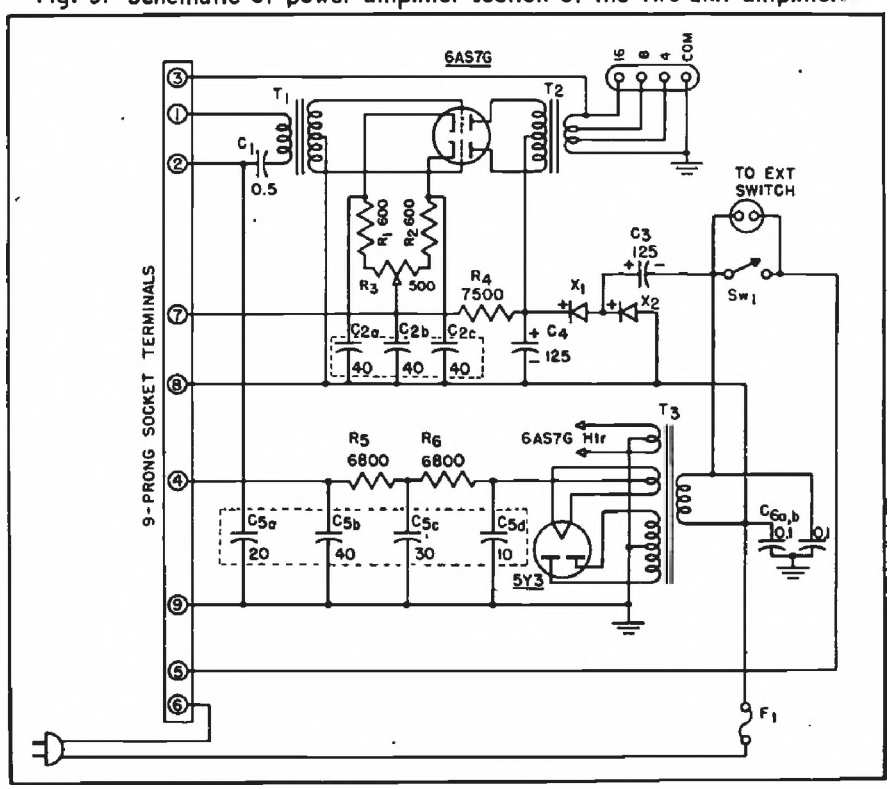
[1] "Full-Range Loudness Control," Winslow, February 1949.

Circuit Description

In general, amplifier design progresses backward, first involving the selection of the output stage, then adding the earlier stages to provide sufficient gain to drive the output tubes. Because the 6AS7G has so many advantages as a power output tube, it was chosen again for this application, in spite of the fact that it is relatively hard to drive.

It may also be said that the power supply requirements for this tube are fairly severe since it draws a rather heavy plate current. Normally, this necessitates a large power transformer and one or more large filter chokes. However, one of the requirements of the tube may be considered an advantage—because it needs an input transformer, the output stage can be completely isolated from chassis ground, thereby permitting the use of a voltage-doubling selenium rectifier circuit, as shown in the power section schematic, *Fig. 3*. This arrangement furnishes up to 150 ma at approximately 300 volts from a 117-volt a-c line. The 6AS7G draws about 120 ma, and an additional 30 ma is fed

Fig. 3. Schematic of power amplifier section of the two-unit amplifier.



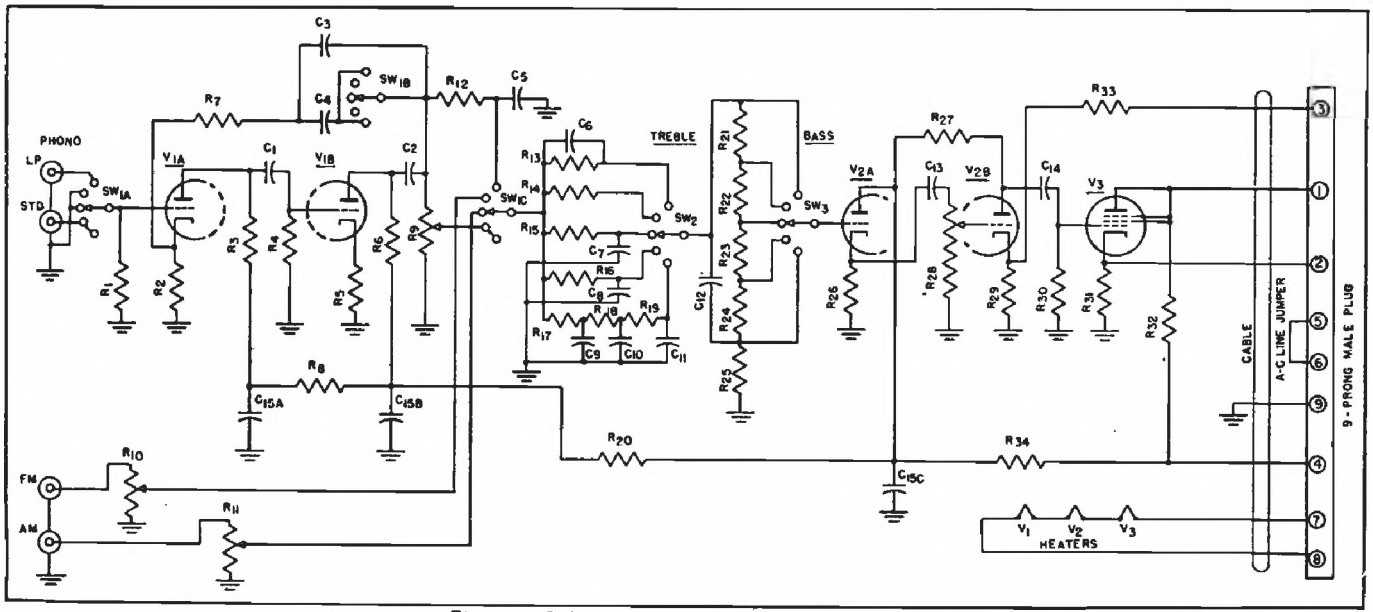


Fig. 5. Schematic of the control section.

through a bleeder for heater current of the three input tubes. Thus the low-level heaters are energized by rectified alternating current. Considering the use of a push-pull output stage, the capacitor provides sufficient filtering for humless reproduction.

The input stages require a d-c supply which may be grounded to the chassis, and in addition, the 6AS7G heater must be energized. Thus a small power transformer is used with a conventional rectifier and an RC filter circuit. The 6.3-volt filament winding on the transformer is used only for the 6AS7G, since the other tubes have a d-c heater supply.

The output transformer is massive and occupies a large portion of the chassis area. The space underneath the output transformer is occupied by the two 125-μf capacitors on a bracket; the channel-type, push-pull input transformer is also under the chassis, as are the coupling and line bypass capacitors. The selenium rectifiers are mounted on Bakelite strips above the chassis, and are protected by a perforated screen cover. The capacitors in the voltage doubler power supply—the two 125-μf units and the triple 40-μf unit used for cathode bypass of the 6AS7G—are insulated by cardboard tubes. All connections except the output are made on one end of the chassis: a 9-prong socket for the control section feed; the a-c line cord, fuse, and switch; and a small two-prong socket for a remote power switch which is in parallel with the chassis switch. This permits a pair to be run up to a panel-mounted power switch, thus eliminating any a-c circuits from the interconnecting cable.

Control Amplifier

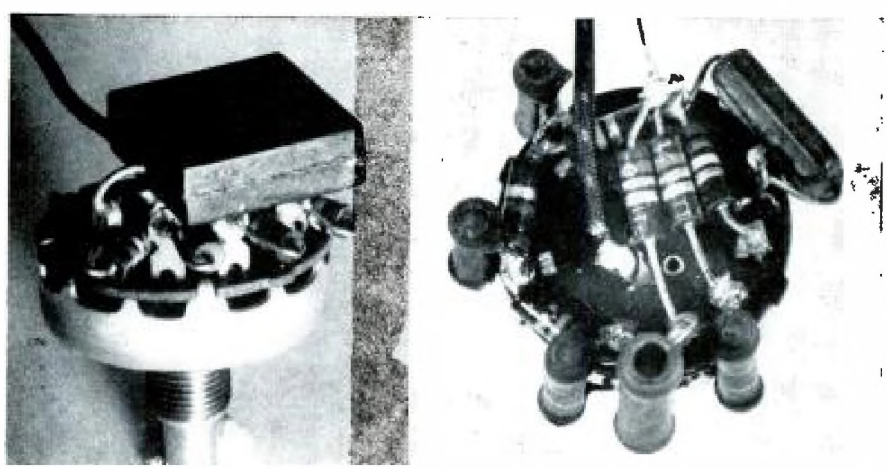
The control amplifier is of unique design, since three controls are mounted on the front apron of the chassis, and one on the end, and with the tubes on the rear apron projecting away from the panel. The controls are arranged so the unit may be mounted either vertically or horizontally, thus being adaptable to almost any cabinet space available. The selector switch is on the end of the chassis, with an operating lever which extends through the panel. Also mounted on the end are the two pickup jacks and the level-adjusting potentiometer for the standard pickup. The decoupling capacitor and the two radio input jacks are mounted on the rear apron along with the tubes, while the radio level-adjusting potentiometers are on the "top" of the chassis. The power cable comes out of the end opposite the selector switch.

To simplify wiring into the circuit, both tone controls are assembled completely on their switches as shown in *Fig. 4*. All resistors connecting to ground are wired directly to the tube sockets, and connections are made point-to-point where convenient. A resistor strip is mounted on the volume control, using the long screws of the switch assembly to hold it in place. This strip carries most of the plate and decoupling resistors.

The assembly of the control section in such a small chassis is somewhat tedious, but there is plenty of room, and the object of the whole amplifier was to make it convenient for mounting.

Inverse feedback is used around the last three stages, primarily to reduce the output impedance to a minimum. The output transformer has 4, 8, and 16-ohm taps, with the latter supplying the feedback voltage. Good frequency response, power, and phase-shift characteristics are readily obtainable with a transformer de-

Fig. 4. Assembly of tone controls on standard switches to provide units easily wired into the control section. Left—bass control; right—treble control.



signed for feeding a speaker *or* a 500/600-ohm line, but it is difficult to obtain optimum performance from a transformer designed for *both* types of output load. Consequently, the output transformer has only one output winding covering three speaker impedances.

Control Section

The three tubes in the control section actually constitute five stages. V_1 is a dual triode in a conventional preamplifier circuit, with feedback equalization to supply turnover frequencies of 350 and 500 cps. One section of the input selector switches the pickup, or grounds the first grid. The second section varies the turnover frequency, and adjusts it to 350 cps for microgroove records. The third section connects the amplifier to the phonograph level-adjusting potentiometer at the output of the preamplifier in positions 1 and 2, to the AM and FM potentiometers in positions 3 and 4, and to the preamplifier through a roll-off circuit in position 5 for microgroove records. Thus the long-playing records are normally reproduced on the position 2, the "flat" settings of the tone controls. Victor and Decca ffrr records reproduce best on position 3 of the high-frequency control, Columbias on position 4, and exceptionally noisy records on position 5. The treble control is numbered counterclockwise, the bass control clockwise.

The two tone controls are designed to work together and into a grid with no resistance loading, as is the volume control. Since feedback is introduced at the stage ahead of the driver, the volume control is placed between the two sections of V_2, the first section acting as a cathode follower. V_3 is triode connected, and is shunt fed with the coupling capacitor in the cathode leg. This capacitor and the cathode bypass for V_3 are located in the power section.

The 6AS7G circuit is similar to those previously employed, with the 600-ohm 5-watt resistors in separate circuits, the 500-ohm potentiometer serving to balance plate currents, and the three heaters in series being connected between the arm of the balancing potentiometer and the negative side of the supply circuit. The 600-ohm value is used in the cathode circuits because of the drop across the heaters. The 7500-ohm resistor bleeds the additional 30 ma for the control section heaters.

Subjective listening to this amplifier has indicated excellent performance, but since thorough measurements are not yet available from the testing laboratory, they will be presented next month in Part II, along with details of chassis layout and wiring. A complete list of components will be furnished to anyone desiring them. Address your request to Audio Engineering, 342 Madison Ave., New York 17, N. Y.