Compact 6AS7G Amplifier For Residence Audio Systems

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Part II—Further constructional details on two-unit amplifier of unique design.

IN THE FIRST section of this series, a new type of amplifier was described. This amplifier employs a novel arrangement for furnishing plate power for the output stage as well as the d-c filament power for all the other stages. While the design was discussed thoroughly, exact component values were omitted pending the results of the measurements of distortion and overall performance. These measurements have justified preliminary tests, and the components are listed herein.

The results of the performance tests are gratifying. Power output at one per cent harmonic distortion is 6.5 watts at 400 cps, 6.2 watts at 20 cps, and 6.25 watts at 20,000 cps. Eight db of feedback is employed, extending from the secondary of the output transformer to the cathode of V_{2a}. The output impedance on the 16-ohm tap is 1.85 ohms, which gives excellent damping. The frequency response curves were shown in Part I, with the tapped tone switches in various positions. Hum and noise measures —42 dbm, which is not exceptionally low, but which is within the range of good quality amplifiers.

With the volume control at maximum—which is the operating point for the greatest room volume normally desired—a two-volt input signal is required at the two radio input jacks for a two-watt output. This does not leave much leeway, but will suffice for most tuners. The phonograph preamplifier supplies the additional gain to bring the output of magnetic pickups to the equal of the radio inputs.

The original design provided for a roll-off in the LP phonograph position so that these records would reproduce normally with the tone controls in the positions for flat response. However, this does not provide sufficient gain, so it is considered more desirable to eliminate R_{12} and C_5. Values for these components are given in the list of parts, but it is recommended that the arm of SW_3 be connected directly to the LP position contact of SW_{2c}, as shown in the schematic, *Fig. 4*. It should be mentioned at this point that the elimination of this equalization arrangement does not prevent the user from reproducing LP records at the correct tone control settings, because position 4 of the high-frequency tone control gives the correct roll-off for these records.

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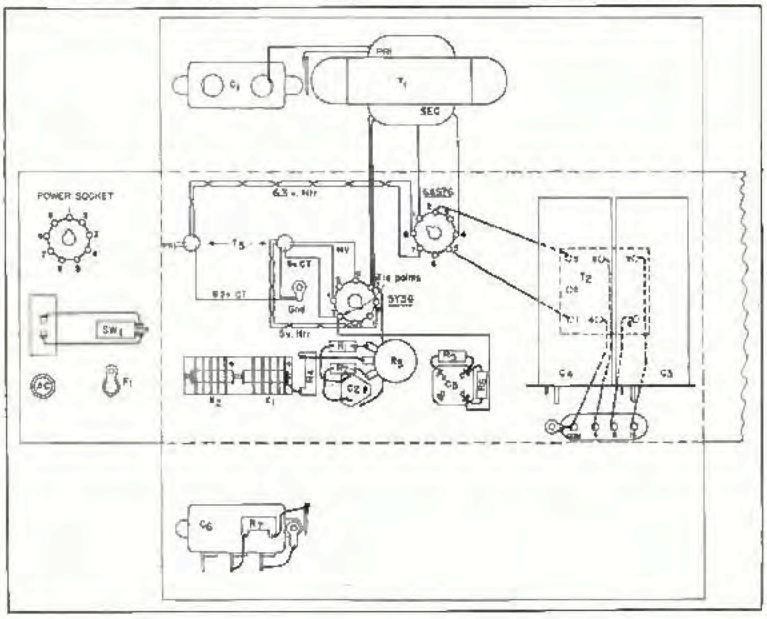
Fig. 1. Partial wiring diagram of power section to show component mounting.



List of Materials

C_1, C_2, C_{14}	0.05 μf, 400 v, paper
C_3	.003 μf, mica
C_4, C_8	.002 μf, mica
C_5*, C_6	250 μμf, Centralab Hi-Kaps
C_7, C_9, C_{10}, C_{11}	750 μμf, Centralab Hi-Kaps
C_{12}	.006 μμf, mica
C_{13}	0.1 μf, 400 v, paper
$C_{15}a$, b, c	15-15-10/450 electrolytic
R_1,	10,000 (all values ½-watt unless otherwise specified)
R_2, R_3, R_{20}	2200
R_5, R_6	0.12 meg, 1-watt
R_4	1.0 meg
R_7	0.1 meg
R_8	47,000, 1-watt
R_9, R_{10}, R_{11}	0.5-meg potentiometer
R_{12}*, R_{17}	0.12 meg
R_{13}, R_{14}, R_{15}, R_{16}, R_{22}	0.27 meg
R_{18}	82,000
R_{19}	68,000
R_{20}	33,000
R_{21}	0.39 meg
R_{23}, R_{24}	0.18 meg
R_{25}	56,000
R_{26}	1000
R_{27}, R_{32}	0.1 meg, 1-watt
R_{28}	special volume control (see text)
R_{30}	0.56 meg
R_{31}	2700
R_{33}	82,000, 1-watt
R_{34}	22,000, 1-watt
SW_1	Mallory 3136J
SW_2	Mallory 3115J, modified (see text)
SW_3	Mallory 3115J
V_1, V_2	12SL7
V_3	12SJ7

*These components should be omitted—see text.

The parts not specifically described for the power section are as follows:

C_1	0.5 μf, 600 v, oil filled, bathtub type
C_2	40-40-10/150, electrolytic, with insulating tube
C_3, C_4	125 μf, 350 v, electrolytic, with insulating tube
C_5	40-30-20-10/450, electrolytic
C_6	0.1-0.1, 600 v, oil filled, bathtub type
R_1, R_2	600, 5-watt
R_3	500-ohm wire-wound potentiometer
R_4*	15,000, 10-watt
R_5, R_6	6800, 2-watt
R_7	5, 5-watt
SW_1	SPST toggle switch

T_1 push-pull input, special channel mounting, no d.c. in primary; Freed 17290

T_2 4000 ohms plate to plate, 4-8-16-ohm secondary; Freed 15929

T_3 325-0-325 v at 50 ma; 5v at 2a; 6.3v at 2.5 a. Freed F-413

X_1, X_2 200 ma selenium rectifier

*Shown on diagram as 7500 ohms. This value should be adjusted to provide 36 volts across filament string.

The performance of any amplifier depends to a large degree upon the quality of the components used. At the time this amplifier was designed, it was desired to use high-quality transformers throughout, and to make the power section as compact as possible the input transformer had to be mounted underneath the chassis. This ruled against a cased type, and few manufacturers list high-quality transformers in open-frame mounting. The unit employed was designed to work between a single 12SJ7, triode connected, with no d.c. in the primary, and to obtain adequate driving voltage for the grids of the 6AS7G it was required that the step-up ratio should be fairly high. To get this performance and retain a wide frequency range, the transformer is wound in two sections, both placed on the center leg of a conventional E-I core. Measured frequency response of the transformer itself indicates a droop of 1 db at 30 cps and at 30,000 cps. The output transformer, also special, shows a droop of 1 db at 17 cps and at 120,000 cps when operated without feedback, and drooping 1 db at 15 cps and 62,000 cps when operated with feedback. Similar output transformers are available in the standard Freed line under number F-1951 with output impedances of 1.2 to 30 ohms, and under number F-1950 for impedances from 50 to 500 ohms.

The following table indicates transformers of high quality which are generally obtainable from jobber stocks and which should perform satisfactorily, since their characteristics are similar to those used in the original amplifier.

Construction Hints

There are a number of suggestions which may be of interest in the construction of these two units. Refer-

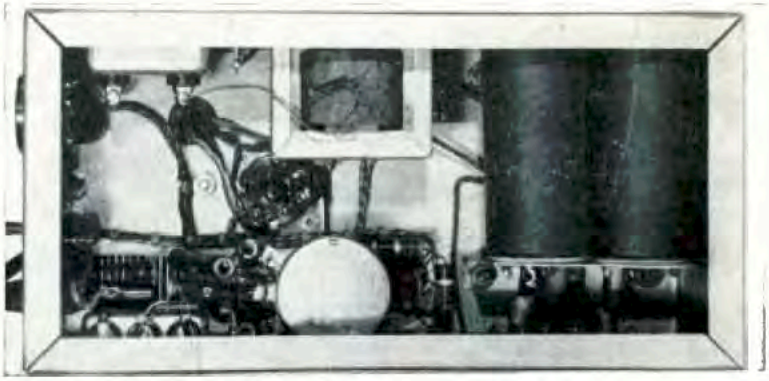


Fig. 2. Underside of power section chassis.

ring first to the power section, it will be noted that the two filter capacitors, C_3 and C_4, are mounted on a bracket under the ouput transformer. Therefore, they are necessarily installed after the wiring to the output transformer is completed. The balancing potentiometer, R_3, is also mounted on a bracket so that its shaft may be adjusted through a hole on the chassis between the two capacitors mounted on top. The selenium rectifiers are mounted on a 6-32 threaded rod which passes through two strips of Bakelite attached to bent-up angles on the chassis. Two saw-cuts are made ¾ in. apart and extending for two inches along the chassis. At the center of these two cuts, another cut is made between them. This frees two "flaps" which may be bent up to mount the Bakelite strips. The cover is bent up from perforated metal to prevent accidental contact with hands or tools

The value for the resistor R_4 was shown as 7500 ohms. This gives somewhat too much current through the filament string, and it is found that 15,000 ohms is more suitable, since the voltage across the filaments should be 36 volts. R_7 has been added to reduce the peak current through the selenium rectifiers, and 5 ohms is a suitable value. This resistor is connected between SW_1 and C_3.

The push-pull input transformer is mounted directly below the 6AS7G

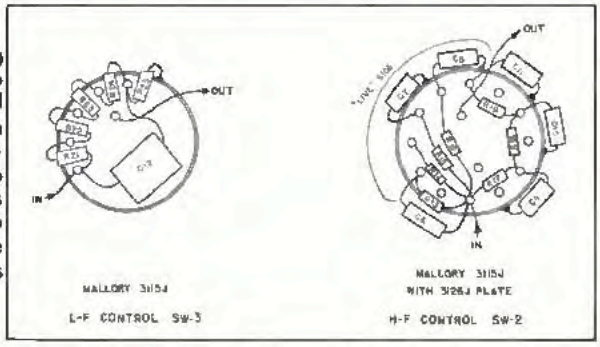


Fig. 3. Wiring diagram of two tone-control switches. Switch plate on H-F control is changed to furnish tie points on five-step frame. Only one contact arm is used.

socket, using leads as short as possible. This will normally require that the leads be connected before the transformer is bolted in place, and since the leads are likely to be of relatively light wire, care should be exercised in this operation. The two bathtub capacitors are mounted on opposite sides of the chassis, with tie-points installed adjacent to them. One is needed to make the connection to the plate end of the primary, and the other serves to hold R_7.

With some transformers it is probable that there will be a tendency to oscillate at some super-audible frequency. This may require some experimentation, but it is suggested that a small capacitor across each half of the primary of the output transformer, or possibly across the secondary of the input transformer, will suffice to eliminate this trouble. Probable values

TABLE I

	T_1	T_2	T_3
Audio Development Co.	2H4H* 215C*	314C 315F	515C (large)
Chicago Transformer Div.	— —	BO-6	PCC-70
Stancor	A-4750	A-3800	P-4078
Thordarson	T20A22	T22S70	T22H02
UTC	LS-21* CG-132*	LS-57[1] LS-55[2] CG-16	R-54

*Insufficient space under chassis to mount these models.
[1]Voice coil secondary only. [2]Voice coil and line secondary.

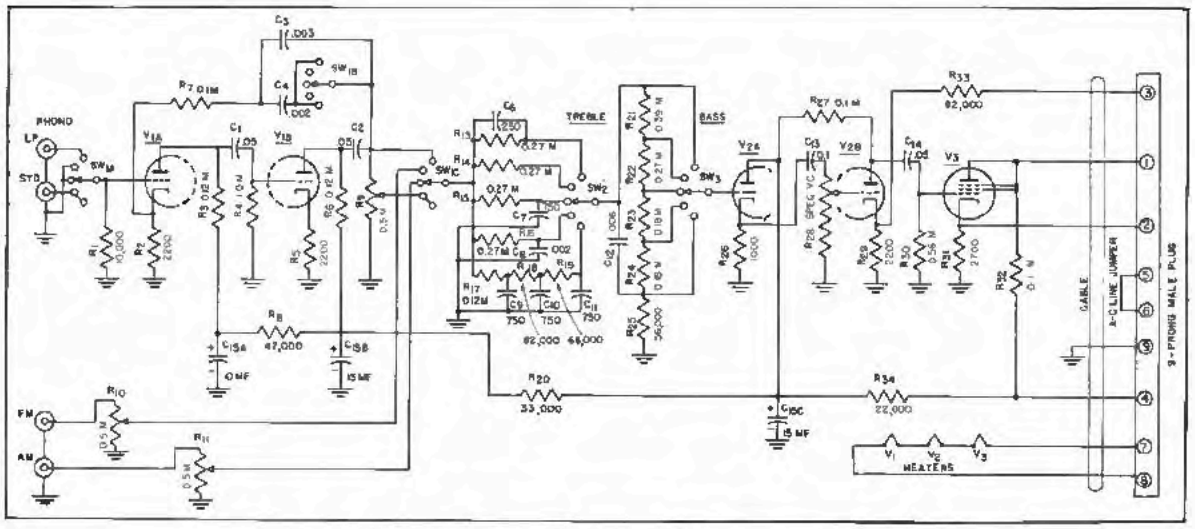


Fig. 4. Schematic of input section, with component values.

will be in the vicinity of .002 μf. *Figure 1* is a partial wiring diagram of parts employed in the power section, while *Fig. 2* is a photograph of the underside of the completed amplifier chassis.

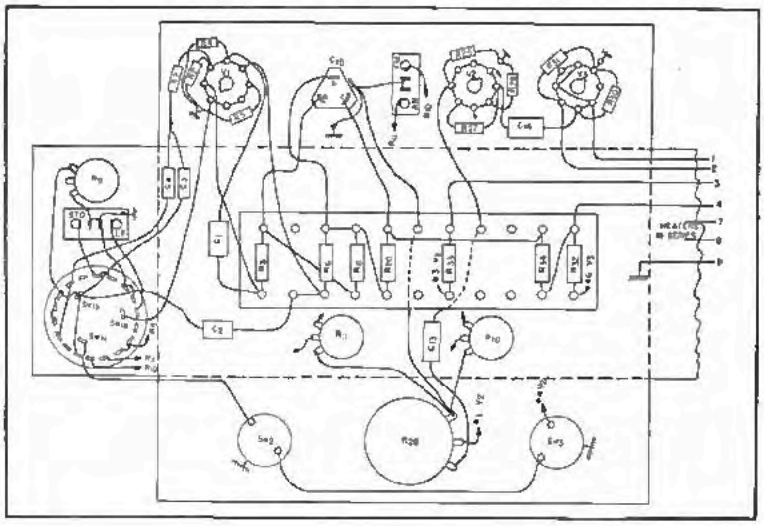
The preamplifier section shown in the photograph of Part 1 is somewhat smaller than the average constructor may wish to employ, but it was built in this manner to keep the space required to a minimum. The chassis was fabricated from a 2 x 7 x 11 aluminum chassis base, cutting it apart at the center. The sides of the chassis are then cut 1¼ in. from the open end, and folded in to provide a ⅛-in. angle. The top is folded down, resulting in a chassis approximately 3½ x 7 x 2. The tube sockets and the electrolytic capacitor are mounted on this section, with the controls on the opposite side of the chassis. The input selector switch is mounted on one end, with a lever extending through the panel for its operation. If the chassis length were extended to eight or nine inches, the selector switch could then be mounted on the front in line with the other controls, and it is quite probable that it would be easier to install in a cabinet because of the difficulty in cutting a neat slot to pass the lever-type arm used to actuate the selector switch.

In the parts list several references were made to the text for further explanation. The volume control, R_{28}, is the loudness control described in the February issue,[1] and consists of a Centralab 1443 switch on which are mounted the resistors and capacitors necessary to obtain the desired compensation.

The high-frequency tone control switch, SW_2, needs a little further description. The series of switches selected for the tone controls consists of small units which are desirable in such a compact amplifier. However, the exact assembly of contacts is not obtainable, so the switch used was made by using the frame and mechanism from a 3115J switch with the contact plate from a 3126J switch. This gives a number of tie points for the resistors used for the cut-off circuit, as well as for the input connection. The capacitors in this circuit are all mounted directly on the switch, being soldered to the frame for ground connection. This is not usually considered the best practice, but it must be remembered that this section of the amplifier does not have any a-c circuits in it, and there is little chance of ground loops causing hum trouble. Suffice that the unit as constructed exhibits no troubles from this source. The exact arrangement of the tone controls is shown in *Fig. 3*. Similar methods were used for both, in that all parts are wired directly to the switch, but the low-frequency control is a standard 3115J switch without modification.

The overall schematic, *Fig. 4*, is essentially a repetition of the schematic published last month, with the removal of R_{12} and C_5 as previously discussed. The wiring diagram, *Fig. 5*, indicates the arrangement of parts and the wiring between them, while

Fig. 5. Input section wiring diagram.



[1] "Full Range Loudness Control," Winslow, Audio Engineering, Feb. 1949.

the photograph of *Fig. 6* shows the method of mounting the resistor strip on the back of the volume control switch.

Unless the builder is reasonably well experienced in construction of small amplifier equipment, it might be desirable to increase the overall size of the input section. It is definitely possible to construct the unit in the size shown, but it must be admitted that it is extremely compact, and as the size is reduced the complexity of construction is increased. Of course, once the amplifier is completed there should be no need to get at it again, assuming that the constructor takes reasonable care in the selection of resistor and capacitor ratings to prevent the possibility of failure in use.

A more conventional construction of this entire amplifier would undoubtedly reduce the hum level still further, and if a larger power transformer were used—one which could supply the 0.9 amps of filament current required by three 6-volt tubes in the input section—the electrostatic field existing between heater and cathode of the present first 12SL7 would be reduced. If made in two units, however, it would be preferable to use a separate cable from the power section to the preamplifier to carry the heater current, although the signal from the preamplifier to the power section is of a relatively high level and it is possible that no trouble would be encountered from this source.

If additional gain is required, the cathode follower section of V_2 can be changed to a conventional amplifier, thus giving approximately 32 db more gain than with the present arrangement. For the uses for which this amplifier was designed, however, this should not be necessary. Another possibility is that a 6SN7 could be substituted for the 6SL7 used as V_2, (if a filament transformer were being used, together with 6-volt tubes) again using the amplifier connection rather than the cathode follower, and the increased gain would be of the order of 10 db. This suggestion would only apply if the filaments were arranged to be supplied from a transformer winding, since the 12SN7 will not operate in a series string with the 12SL7 and the 12SJ7, inasmuch as the 12SN7 draws a filament current of 0.3 amps. These are design modifications, and some ingenuity on the part of the constructor will be necessary to arrive at the exact desired result. It is felt, however, that the amplifier as described performs satisfactorily, and that no changes are necessary *for the purpose for which it was designed.* The amplifier was designed for one application—that of modernizing an existing installation, or for providing a control arrangement which could be adapted to cramped quarters with the greatest of ease. This requirement is fulfilled adequately by the arrangement shown.

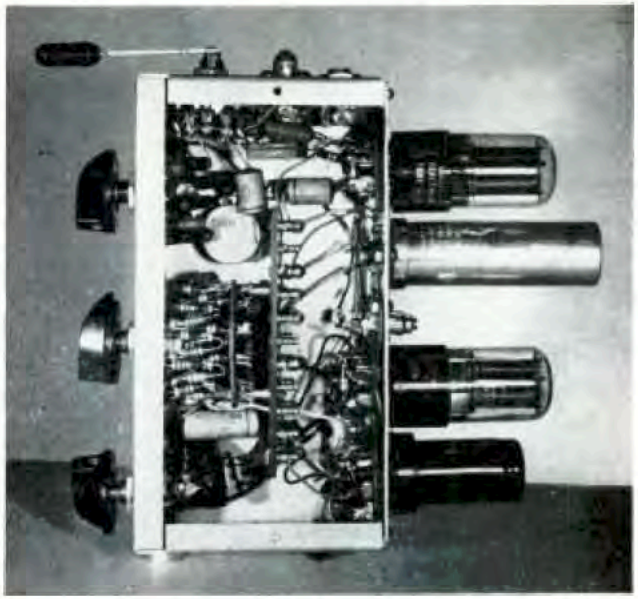


Fig. 6. Interior of input section, showing the mounting of resistor strip on rear of compensated volume control.