IMPROVED KAPPLER AMPLIFIER

By
CHARLES P. BOEGLI

Fig. 1. Over-all view of an improved version of the well-known Kappler amplifier.

A self-contained, low-cost amplifier for crystal or magnetic pickups, tuners, etc. It can be housed on a single chassis.

THE November 1950 issue of this magazine carried a description of an excellent single-chassis, 10-watt amplifier employing 18 db negative feedback around three stages and the output transformer ("A Flexible General Purpose Amplifier" by J. N. A. Hawkins). The design was the product not of one person but of many, each of whom contributed at various times over a period of some twelve years. Most important among such additions was an excellent direct-coupled phase inverter designed by M. O. Kappler, by virtue of which the circuit was called the "Kappler" amplifier. The unit, constructed at a very reasonable cost, provides sound of excellent quality. One of them, for instance, has been installed in the Films and Recordings Center of the Cincinnati Public Library and, even when played through a very mediocre speaker, listeners have agreed that the reproduction is good.

The fact that a single chassis supports the power supply, amplifier, and preamplifier makes for a simplicity that appeals to many music lovers, particularly since the layout of the unit makes this economy possible without undesirably high hum or noise levels. Actually, the greatest advantage of putting the preamplifier and power amplifier on a single chassis is that it can result in a substantial *reduction* in the noise level at a given output level by permitting the most favorable circuit location of the volume and tone controls, which is not economically possible in a separate preamplifier feeding a power amplifier capable of handling only about one volt. The degenerative type of tone control, for example, which as will be seen is capable of furnishing far more desirable boost characteristics than any other type, has a noise level sufficiently high to preclude its use in conventional separate preamplifiers[1] but in a single-unit amplifier it can be located so that its noise level is of no consequence and full advantage can still be taken of its distortionless control characteristics.

The unit previously described has nevertheless suffered from a few shortcomings; namely, a completely inadequate preamplifier (which was, however, equivalent to that included in most other single-chassis amplifiers), a rather unsatisfactory tone-control stage, a paucity of input jacks, and certain undesirable layout features. By retaining the excellent power-amplifier section of the original amplifier and completely redesigning the front end, the writer has developed the first unit to his knowledge that combines, on a single chassis, not only a power amplifier of surpassing quality but also a preamplifier and tone-control circuit filling the most exacting requirements for high-quality reproduction. The improved amplifier is shown photographically in Fig. 1, and schematically in Fig. 4.

Circuit Features

In order to handle discs with the (unfortunately) wide diversity of current recording characteristics, the preamplifier of the previous unit has been replaced by a simple dual-triode circuit utilizing straight-through equalizers, of the type described in previous articles.[2,3,4,5,6] With only five condensers and ten resistors, the equalizing switch (Fig. 4 inset) compensates exactly for nine different recording characteristics. The features of this switch have been described in a previous article[6] which also indicates the discs for which each position is to be used, and the precautions to be followed in constructing the switch. The position of the switch on the chassis is critical in several respects: it must be placed well away from strong hum fields, that is, from the power transformer, and it requires enough room under the chassis to necessitate the careful location of adjacent components like tube sockets. The preamplifier tube itself, a 12AY7, must be situated quite close to the switch in order to avoid hum pickup in long interconecting leads. Low-noise plate-load resistors should be used in the preamplifier stage if records are to be played with low-output cartridges like the *General Electric*.

Four input jacks are provided, two for tuners and one each for magnetic and crystal pickups. The latter two are properly loaded so that the entire preamplifier is used not only with magnetic cartridges but also with crystal pickups. With this arrangement, playback with a high-quality crystal pickup is often difficult to distinguish from that with a magnetic cartridge. The exact reason why such complicated equalizing systems are used in most preamplifiers for magnetic cartridges while the output of a crystal cartridge is subjected to no equalization whatsoever has never been very clear. The present circuit permits, for example, the use of a magnetic cartridge for 33.3-rpm discs and a crystal for 45-rpm records (the usual 45-rpm changer has a crystal pickup) with realization of excellent reproduction and full compensation of recording characteristics in each case.

The input switch is arranged so that when the tuner inputs are used the pre-

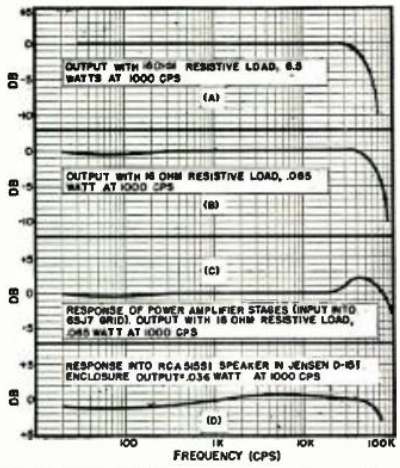


Fig. 2. (A, B & C) Response curves for amplifier with resistive load, (D) Response with RCA speaker housed in Jensen cabinet.

amplifier inputs are grounded. By means of simple resistive networks, average tuner input voltages are brought to a level comparable to the output from the preamplifier when a low-voltage magnetic pickup is used, so that large alterations in the volume control settings are not required when changing from phonograph to radio. At the same time, the tuner signal-source impedance at the 6SL7-GT grid has been made approximately equal to the output impedance of the last 12AY7 section, so that the high-frequency response attained with tuner input is substantially the same as that with phonograph input.

The size of the volume-control potentiometer has been carefully chosen so that, irrespective of its position, the high-frequency response is never down more than 3 db at 55 kc., even though the 6SL7GT stage suffers from the common complaint of all high-mu triodes, large input capacitance. The gain of the 6SL7GT is quite adequate without cathode bypassing but the bypass condenser is nevertheless required if a suitably low hum level is to be realized.

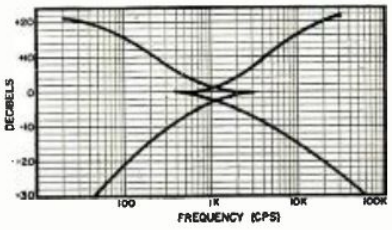
Tone control is accomplished by means of a degenerative circuit utilizing the second section of the 6SL7GT. The performance of this tone control is superior to that of a previously-described circuit[1] utilizing a low-mu triode because the bass and treble boosts continue to the very limits of audibility instead of leveling off at moderately low or high frequencies. The importance of this type of characteristic, particularly in the bass region, cannot be overestimated. The difference between this and other tone control circuits is most marked when playing organ recordings, which generally make heavy demands upon the low-frequency performance of the reproducing equipment. Other than the use of a high-mu triode this circuit is substantially the same as that described in the previous reference, and it has the same desirable simplicity of control. Use of low-noise load resistors is also desirable in this stage, particularly in the cathode of the 6SL7GT. Direct current is blocked from the bass-control reactor by means of a large electrolytic condenser which, in a single-ended stage, cannot be eliminated; its presence sometimes causes a thump to be heard in the output when the bass control is twisted rapidly. Once the bass control is set, however, it has absolutely no adverse effects. It is important that the 6SL7GT tube be located very near the reactor and the tone controls to reduce noise pickup in the high-impedance circuits.

Tone controls of this type have generally been subjected to several criticisms, among which are hum pickup by the choke and "transient distortion" from the resonant circuit. The *Triad* A-75J choke used in the circuit has 45 db of shielding and a hum-bucking winding which virtually eliminates it from consideration as a source of hum. The presence of excessive transient distortion has never been demonstrated and it can furthermore be proven that the transient response of a circuit containing a resonant combination is exactly the same as that of a circuit utilizing only resistors and condensers, if the frequency responses of the two circuits are identical. With a degenerative tone control of the type described here, the "flat" position is always at the center of each control. This is not the case with the familiar *RC* tone control utilizing audio-taper potentiometers, with which flat response must generally be set with the aid of response-measuring equipment.

The output of the tone control stage is fed directly into the first tube of the power amplifier, the 6SJ7. Except for minor changes, the remainder of the circuit is the same as that of the previously-described unit. Specifically, the availability of an improved output transformer (*Triad* HSM-81) permits the elimination of the phase-correcting network that appeared across the transformer primary in the previous design. Other output transformers may of course be used but a phase-correcting network may again be necessary to avoid oscillation. The filter-condenser arrangement has been slightly altered.

By means of careful layout, the new amplifier can be accommodated on a chassis of the same size as the previous one. The input jacks are located on the side of the chassis away from the output tubes, which prevents troublesome high-frequency oscillation at high volume settings and the need for shielded cable for connections.

Fig. 3. The responses of the amplifier with tone controls in their extreme positions.



In order to make the underchassis wiring as compact as possible, vector turret-sockets are used for the 6SJ7, 6SL7GT, and 12AY7 tubes in the experimental amplifier. The remaining stages are simple enough to permit the employment of *Cinch* 8AB sockets, which mount in holes of the same size. Following the writer's preference, all stage grounds were made to the tube socket saddles, power transformer grounds were made at the power transformer, filter condenser cases were grounded to their mountings, and all other grounds were generally made to the nearest point.

The 117-volt leads going to the a.c. switch on the volume control have always been a troublesome source of hum. In an effort to reduce the hum radiation, a d.p.s.t. switch was installed on the volume control. Both sides of the 117-volt line were switched, and the leads going to the switch were paired and twisted. None of the buzzing type of hum usually introduced by 117-volt leads was present in the amplifier output; the improvement may possibly be attributable to this arrangement of the leads.

It is often quite desirable to replace slotted-head knob set screws with socket-head screws on the switch knobs. The latter can be screwed much more tightly and the twisting of the knob on the shaft, most troublesome with heavy-detent switches, is thus prevented.

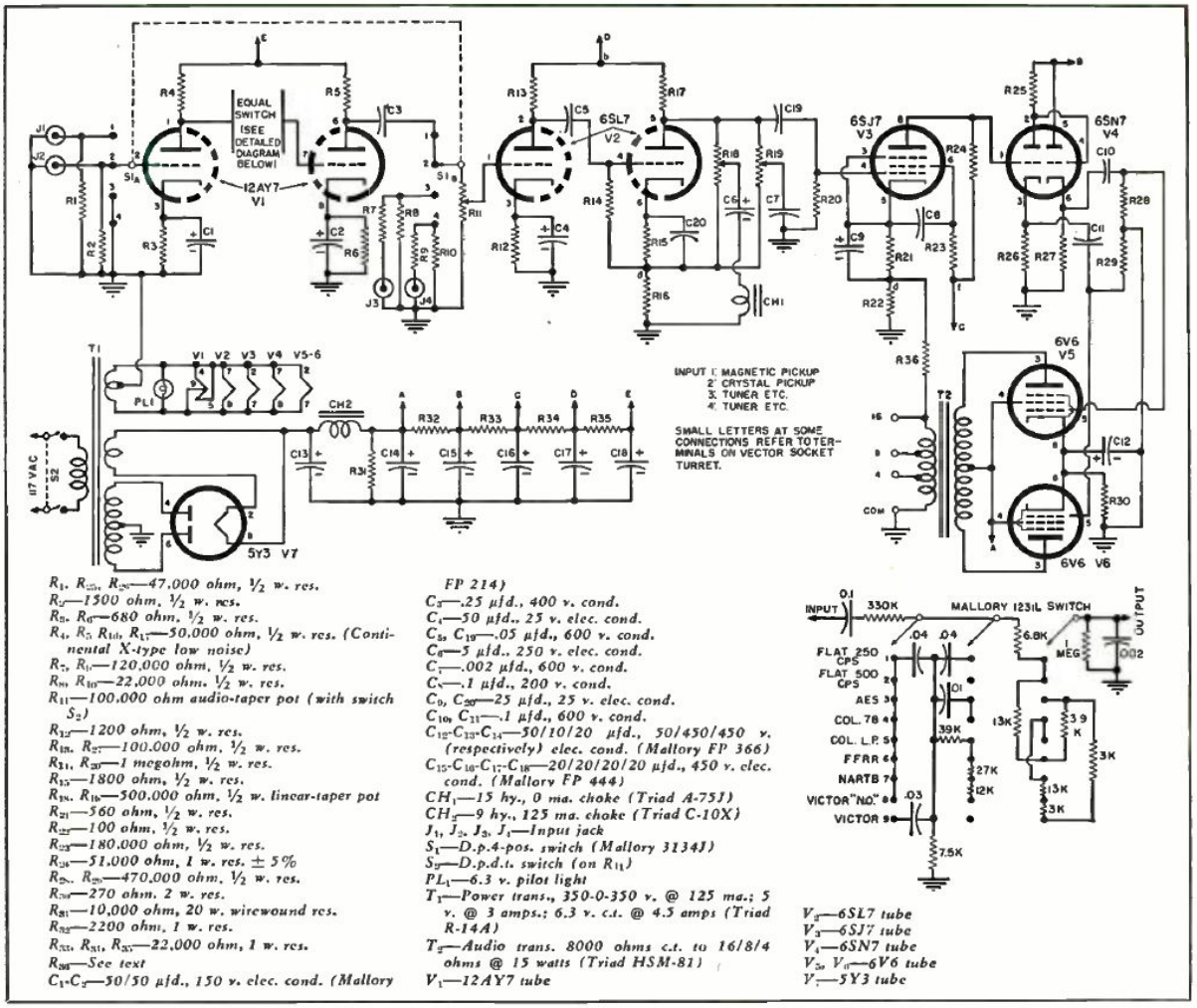
Performance

The response of the amplifier connected for 16-ohm output and loaded with a 16-ohm resistor is shown in Fig. 2 for several output levels. Also illustrated in the same figure is a typical response curve for the power amplifier only; that is, with the input into the 6SJ7 grid. This latter response is to be compared to curves for such amplifiers as the Williamson, which include no controls of their own.

The response of the amplifier into a typical speaker load is shown in Fig. 2D. The speaker in this case was an *RCA* 515S1 housed in a *Jensen* D-151 enclosure. The absence of humps or peaks in the curve is particularly to be noted; it is an indication that the output impedance of the amplifier is sufficiently low for quality performance.

Responses with the tone controls in extreme positions are shown in Fig. 3. That the boost actions are quite uniform to the limits of audibility is obvious and particularly important for reasons previously given. The crossover at about 1000 cps has been chosen on the basis of Fletcher-Munson equal-loudness curves. Because of the powerful boosting action of the bass control in the lowest bass region, less use of the control will generally be required with this particular amplifier than with other amplifiers utilizing different types of controls.

The noise level of the completed unit will of course depend to a large extent upon the care taken in construction. For the experimental unit described



R_1, R_{25}, R_{26}—47,000 ohm, ½ w. res.
R_2—1500 ohm, ½ w. res.
R_5, R_6—680 ohm, ½ w. res.
R_4, R_5, R_{16}, R_{17}—50,000 ohm, ½ w. res. (Continental X-type low noise)
R_7, R_9—120,000 ohm, ½ w. res.
R_8, R_{10}—22,000 ohm, ½ w. res.
R_{11}—100,000 ohm audio-taper pot (with switch S_2)
R_{12}—1200 ohm, ½ w. res.
R_{18}, R_{27}—100,000 ohm, ½ w. res.
R_{11}, R_{20}—1 megohm, ½ w. res.
R_{13}—1800 ohm, ½ w. res.
R_{14}, R_{15}—500,000 ohm, ½ w. linear-taper pot
R_{21}—560 ohm, ½ w. res.
R_{22}—100 ohm, ½ w. res.
R_{23}—180,000 ohm, ½ w. res.
R_{24}—51,000 ohm, 1 w. res. ± 5%
R_{28}, R_{29}—470,000 ohm, ½ w. res.
R_{30}—270 ohm, 2 w. wirewound res.
R_{31}—10,000 ohm, 20 w. wirewound res.
R_{32}—2200 ohm, 1 w. res.
R_{33}, R_{34}, R_{35}—22,000 ohm, 1 w. res.
R_{36}—See text
C_1-C_2—50/50 μfd., 150 v. elec. cond. (Mallory FP 214)
C_3—.25 μfd., 400 v. cond.
C_4—50 μfd., 25 v. elec. cond.
C_5, C_{19}—.05 μfd., 600 v. cond.
C_6—5 μfd., 250 v. elec. cond.
C_7—.002 μfd., 600 v. cond.
C_8—.1 μfd., 200 v. cond.
C_9, C_{20}—25 μfd., 25 v. elec. cond.
C_{10}, C_{11}—.1 μfd., 600 v. cond.
C_{12}-C_{13}-C_{14}—50/10/20 μfd., 50/450/450 v. (respectively) elec. cond. (Mallory FP 366)
C_{15}-C_{16}-C_{17}-C_{18}—20/20/20/20 μfd., 450 v. elec. cond. (Mallory FP 444)
CH_1—15 hy., 0 ma. choke (Triad A-75J)
CH_2—9 hy., 125 ma. choke (Triad C-10X)
J_1, J_2, J_3, J_4—Input jack
S_1—D.p.4-pos. switch (Mallory 3134J)
S_2—D.p.d.t. switch (on R_{11})
PL_1—6.3 v. pilot light
T_1—Power trans., 350-0-350 v. @ 125 ma.; 5 v. @ 3 amps.; 6.3 v. c.t. @ 4.5 amps (Triad R-14A)
T_2—Audio trans. 8000 ohms c.t. to 16/8/4 ohms @ 15 watts (Triad HSM-81)
V_1—12AY7 tube
V_2—6SL7 tube
V_3—6SJ7 tube
V_4—6SN7 tube
V_5, V_6—6V6 tube
V_7—5Y3 tube

Fig. 4. Complete schematic of improved Kappler amplifier. Equalizer circuit is shown in the inset diagram above.

here, the noise level was 56 db below maximum output (10 watts) with tuner input and tone-controls in flat position. The noise level with preamplifier input corresponded to a noise input approximately 38 db below 10 mv. at the magnetic cartridge input jack. Thus, even with a *General Electric* pickup the noise is quite inaudible. Because of the large boost available at very low frequencies, turntables of low quality are apt to cause an objectionable amount of rumble in the output, and if this cannot be alleviated by procurement of a better turntable it may be advisable to reduce the size of the coupling condensers in the preamplifier stages. Some loudspeakers are easily overloaded by large low-frequency signals; this difficulty may be remedied by the same expedient used for excessive rumble. In both cases, the employment of high-quality components is the preferable alternative.

The minimum input to the magnetic-cartridge jack for full 10-watt output is .01 volt at 1000 cps. The tuner inputs require approximately 1 volt minimum. At the full output of 10 watts, the distortion remains very low (less than 0.5% from 40-40,000 cycles).

Feedback Circuit

Just a word or two on the feedback network. Except for the specified values for the feedback resistor, R_{36}, the circuit is conventional.

The loop itself includes V_3, V_4, V_5, V_6, and the output transformer, T_2. As shown in the diagram, Fig. 4, the feedback resistor is connected to the 16-ohm tap. If a 16-ohm speaker is used, the resistance of R_{36} should be 1000 ohms. If an 8-ohm speaker is connected to the 8-ohm tap, R_{36} should be 750 ohms, connected to the 8-ohm tap. The same holds true with a 4-ohm unit in which case R_{36}, 500 ohms, is connected to the 4-ohm tap.

Conclusions

The improved "Kappler" amplifier is tailored to the needs of individuals who want reproduction of superlative quality without investing heavily in multiple-chassis amplifiers and control systems. Wide frequency response and low distortion, coupled with the large number of recording-characteristic equalizers available, place this amplifier ahead of current developments in other audio components like pickups and loudspeakers and insure it against early obsolescence.

Once the parts have been properly located on the chasiss, the wiring of the unit is quite free from complications and the lead placements are not critical. Construction of the amplifier can thus be recommended to the audiophile interested in building his own equipment with a minimum of difficulty.

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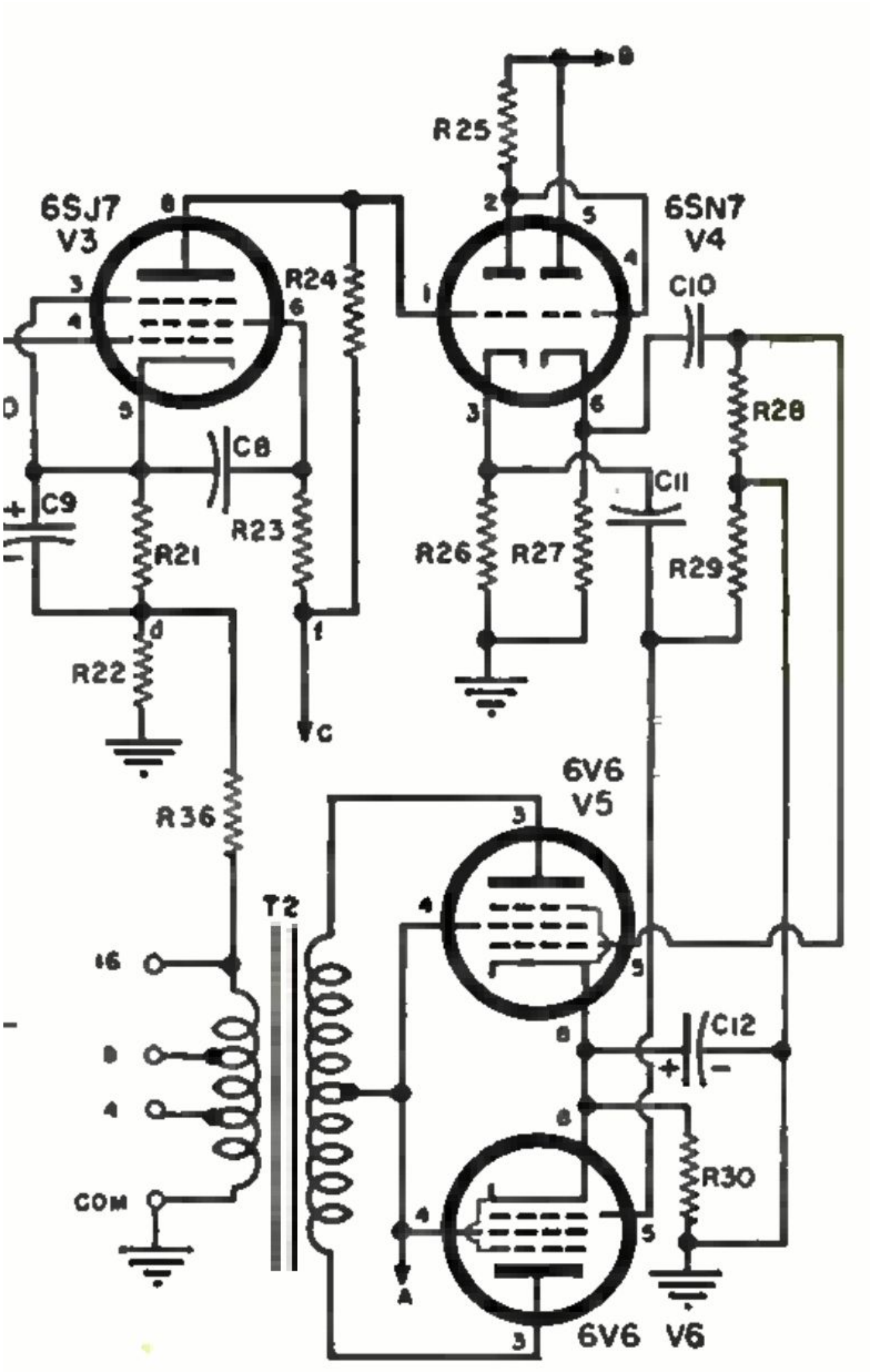
6SJ7
V3
6SN7
V4
6V6
V5
6V6
V6
R25
R24
C10
R28
C8
C9
C11
R21
R23
R26
R27
R29
R22
R36
T2
16
8
4
COM
C12
R30
A
C