General Purpose 6AS7G Amplifier

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Modifications of the 6AS7G high-fidelity amplifier to provide bass and treble tone controls, a dynamic noise-suppressor, high-gain input stage, and recorder feeds—sectionalized for flexibility.

Although the three-stage high-quality amplifier described in the March issue left little to be desired in the way of performance, it has elicited many requests for information as to the best method of adding some form of tone control in the circuit. The gain of the amplifier is sufficient to accommodate certain types of tone controls, but others require still more amplification in order to perform correctly. The feedback placed around the first two stages eliminates the interstage coupling circuit as a location for tone controls, and in general, the amplifier is not suitable for this modification.

Added to this difficulty, some interest has been shown in the possibility of adapting the basic circuit to accommodate a dynamic noise-suppressor amplifier, and as a further incentive, one request was received for circuit data to permit the connection to a crystal cutter for use as a recording amplifier. In order to make the unit still more complete, it was decided to incorporate a low-level stage for use with a magnetic pickup of the Pickering or GE Variable Reluctance type.

The amplifier described in this article was accordingly designed and built as an answer to all these requirements. It is relatively complicated in construction—but only because it has a large number of components. The layout is straightforward, and the adjustments necessary to put the noise-suppressor section into operation are not difficult, provided an audio-frequency oscillator is available. One feature of this design is that it is sectionalized so that the basic amplifier may be constructed either with or without the noise suppressor, or it may be constructed without the preamplifier stage if it is to be used with an external preamplifier or with a crystal pickup. By so sectionalizing the design, it can be adapted readily for any specific requirement to which the user may wish to put it.

Circuit Arrangement

The basic arrangement of the amplifier, reduced to its simplest form, is shown in the block diagram, Fig. 1. The power supply is omitted for the sake of simplicity. The first section includes the two-stage preamplifier, equalized by feedback to compensate for the low-end recording characteristic of commercial records. A three-position switch permits the selection of the desired input source—either phonograph, radio, or a recorder.

The second section is the dynamic noise-suppressor amplifier, which follows the H. H. Scott circuit (with some modifications lifted from the Goodell version of the original Scott amplifier). This section incorporates an input stage, providing a source impedance of the proper value, and enough gain to actuate the side amplifier which furnishes the control voltages. The input stage is followed by a two-tube high-frequency gate circuit and a single low-frequency gate circuit, together with the necessary control amplifier and rectifiers. The output of this section may then be fed directly into the output amplifier. This consists of three stages, essentially identical with the original 6AS7G amplifier. It employs a tapped volume control to provide an increase in low-frequencies which may be reduced at will by the low-frequency tone control, and a treble control which in-

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Fig. 1. Block diagram of sectionalized amplifier suitable for wide variety of uses.
creases or decreases the high-frequency response as desired.

The output circuit contains switching arrangements which connect the speaker directly to the secondary of the output transformer for normal use, or through a variable resistor for monitoring, and which also connect a volume indicator and the recorder to the output stage during recording. Although the switching appears to be complicated in that it requires a number of operations to change from record to playback, such is not the case because of the use of a push-button switch which performs all of the switching operations quite simply.

The type of recorder used will control the switching circuits to a great extent. For the Wagner-Nichols unit used in this particular job, it is necessary to connect the crystal cartridge to either the input or the output of the amplifier. Most recorders employ a separate unit for playback, which simplifies this switching. It is desirable to connect the cuter of the Wagner-Nichols unit to the plates of the output tube through capacitors, giving a constant-amplitude characteristic over the entire range. With other crystal cutters, some series resistance should be employed to provide a characteristic which is similar to standard phonograph records. Low-impedance magnetic cutters will naturally be connected to a source of the correct impedance. Various arrangements for these connections are shown in Fig. 7.

The power supply section is conventional, with the exception of the dc-filament supply which is simply a connection between ground and the center tap of the high-voltage secondary through the heaters of the first two tubes, $V_1$ and $V_2$. Both of these tubes have 12-volt heaters, and they are connected in series. After the amplifier is completed, a value of bleeder resistor is selected which will make the total current drain equal to 10 ma. It will be noted that this is slightly below the normal value, but the low-level stages operate perfectly with the lower current, and are somewhat less susceptible to the slight age component remaining in this supply. The amplifier is quite low in hum, but because of the large number of stages it is desirable to take all possible precautions.

**Tone Control Methods**

The methods of adding high- and low-frequency tone controls to the circuit are relatively simple. For general use in home reproduction systems, it is usually considered desirable to employ a tapped volume control so that when the output level is lowered, the frequency is altered somewhat in accordance with the Fletcher-Munson curve. A control with a single tap will not give complete compensation, but it is some improvement over an untapped control. The circuit used for this compensation consists of a resistor and capacitor connected in series between the tap on the control and the low end of the control, usually ground. If a potentiometer is connected across the capacitor, the amount of compensation is reduced as the shunting resistance is decreased. This serves quite adequately for the low-frequency control. For smoothest operation, the shunting potentiometer should have an audio taper, and should be connected so that clockwise rotation of the control increases the resistance across the capacitor, thus increasing the bass response.

With a 1.0-meg volume control, the recommended resistor and capacitor values are 27,000 ohms and 0.01 µf. A 0.25-meg shunting potentiometer provides a smooth control of bass response.

In most amplifier designs, it is not considered desirable to utilize the feedback circuit for tone control purposes, since it reduces the amount of feedback available, and hence negates the beneficial effect of the feedback. This is particularly important in the case of a pentode amplifier, with feedback over the output and driver stages. However, with this amplifier the feedback is employed only by the driver and input stages, and its primary advantage is obtained over the low- and middle-frequency ranges because that is where the highest signal voltages are encountered. Therefore, with at least 20 db of feedback in use normally, it is felt that it will not affect the performance adversely if 10 db of this feedback is used up in the high-frequency tone control circuit. The signal voltage at high frequencies is comparatively low, and the driver stage will not be required to furnish as much signal voltage as at the middle and low frequencies.

Therefore, if a capacitor is shunted across the cathode resistor to which the feedback circuit returns, it will reduce the feedback at high frequencies, and thus increase the output. A potentiometer in series will permit variation of the amount of treble boost. If another capacitor in series with a potentiometer is connected across the entire volume control, the high frequencies may be reduced at will. Since highs will not be boosted and cut simultaneously, the two potentiometers can be combined so that clockwise rotation will increase highs and counterclockwise rotation will decrease highs. To make this circuit perform smoothly, the taper on the control must be the reverse of the standard audio taper. With these two potentiometers, a resistor, and the three capacitors, quite satisfactory tone controls for both bass and treble are provided.

While some high-frequency cutoff is an advantage when reproducing phonograph records, no separate control is provided for this purpose since the dynamic noise suppressor section performs this function. It may be used simply as a controllable low-pass filter, with no dynamic action, or the suppressor control may be advanced so that the signals themselves control the opening of the gates. However, if the suppressor section is not included, it is suggested that a four-position switch be added, with the necessary resistors and capacitors, giving various cutoff frequencies. This is shown in Fig. 2, and was described in an earlier issue. This control is not necessary if the noise suppressor section is included.

**Construction Features**

Since individual constructors will rarely choose the same components, a complete description of the constructional details is impractical. The following are, however, a few suggestions that may be helpful to the constructor.


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**Fig. 2.** Input circuit for use with low-level magnetic pickups when noise-suppressor section is not employed.

**Fig. 3.** Wiring of push-button switch for selecting the use to which the amplifier is to be put.
Fig. 5. Complete schematic for the sectionized amplifier. By combining desired sections, practically any requirements may be met.

In the interests of simplicity of operation, a push-button switch was chosen for the selector switch. Again resorting to surplus stocks, a switch was located which consists essentially of four separate 4pt switches, with a fifth push button bar which actuated no switches, only releasing all other buttons. This switch was mounted just above the chassis with the bottoms extending through the panel. A normally-closed micro-switch was mounted under the chassis, with a spring actuator extending upward though a slot and so positioned that the push-button bar causes the switch to operate when the button is depressed. Thus one position of the switch is marked “A.C. OFF,” and the amplifier is turned off whenever this button is depressed. When any other button is pressed, the “off” button is released, and the power is turned on. The other four push buttons are wired for radio tuner, phone, playback, and recording. The wiring of the switch is shown in Fig. 3. One advantage of the push-button switch is that it permits connection to either radio or phonograph pickup as a source for recording simply by depressing two buttons simultaneously.

In order to maintain a proper recording level, it is desirable to incorporate a volume indicator in the amplifier. When used with the Wagner-Nichols embossing unit, the output transformer should be terminated with a resistive load and the cutter connected to the plates of the output tube through 0.5-µf capacitors. However, the recording level required—the order of 30 volts—furnishes too high a level to the monitor speaker, so the switching is arranged to connect a 16-ohm terminating resistor across the secondary of the output transformer, and insert a 400-ohm rheostat in series with the voice coil. Thus it is possible to adjust the speaker volume to a de-
Another source of suitable coils would be 

the UTC adjustable types, VL-C10 and 

CIF-C12—again requiring two of the 

former and one of the latter. All of 

these types are very satisfactory for 

this unit. Another suitable coil is available 

from Mid-America, under the number 

MA-1220. This coil has a total induct- 

ance of approximately 1.5 H, and is 

center tapped, providing 0.75 H across 

either half. The half between terminals 

1 and 2 has the higher Q, and should be 

employed for the inductances L2 and 

L9, while the entire coil is used for L1. 

These are the coils used in the amplifier 

shown, and they work satisfactorily.

sirable level while maintaining the correct 

cabling level to the cutter.

The volume indicator is a standard db 

dometer, calibrated at 1.73 volts for zero 

indication. A 25,000-ohm potentiometer 

in series with the VI provides a control 

over the output level, with the calibra-

tion of the scale for this resistor being 

plotted on a curve, Fig. 4, so the desired 

output level may be obtained. The 

potentiometer used for this circuit is a 

grid-bias control, and while the curve 

is apparently reversed, it seems correct in 

use because the meter deflection is 

increased as the knob is turned clockwise.

From the photo of the amplifier, it 

will be noted that the panel is labeled 

quite profusely, giving a professional 

appearance. This is made possible by 

the new Tekni-Cals, which provide a 

wide range of identifying names. They 

are easy to apply, inexpensive, and of 

excellent appearance.

Adjustment of Suppressor

The circuit of the dynamic noise-

suppressor amplifier is shown in the 

complete schematic, Fig. 5, and since 

the operation of this circuit has been 

described many times in the literature, 

no further mention of the principles 

underlying this section will be made 

here. It will be noted that it is prac-

tically identical to the Goodell amplifier, 

even to the physical layout of the 

schematic. In any discussion of this 

circuit, the coils have been described as 

rather critical, and of high Q. These will 

undoubtedly be difficult to obtain—one 

source of supply of 2.4 and 0.8 henry 

chokes used in one model of the sup-

pressor being ADC, which supplies them 

under part numbers 414D and 414E 

respectively. One of the former and 

two of the latter would be required. 

Another source of suitable coils would be 

the calculated value is adequate if the value 

may be obtained with fair accuracy. 

With the switch SW on position 2, 

capacitors C5 and C9 are adjusted for 

minimum signal at 9,000 cps, R1— the 

suppressor control—being at the mini-

mum position so there is no opening of 

the gates by the signal itself. Then, 

turning SW to position 5, check the 

frequency of minimum output, which 

should be around 4,000 cps. Minor 

adjustments in the values of R2 and R4, 

may be employed to cause the circuits to 

"track" at 9,000 and 4,000 cps. Any 

change in the resistor values will neces-

sitate returning of C3 and C9, so the work 

is of the nature of a "cut and try" pro-

cess, but no trouble was experienced in 

adjusting the first model, so it is assumed 

that the work may be duplicated by a 

careful constructor with the assurance 

that the final unit will work as it should.

The time constants for the rectifier 

circuits are quite satisfactory as shown. 

Longer release times may be obtained 

by an increase in the values of R41 or C31 

for the high-frequency gates, or of R28 

or C28 for the low-frequency ones. The 

value of R28 may have to be adjusted for 

the individual amplifier. This should be 

such that with about three-quarters 

rotation of R28, the gates open and close 

with the applied signal. The average 

signal at the arm of SW will normally 

be around 1.5 volts, whether from a 

tuner or from a phonograph pickup. 

This will give adequate signal level to 

cause the side amplifier to operate with 

the resistor value given in the parts 

list. It may be stated safely that if the 

circuit values are followed accurately, 

the amplifier should perform in the 

normal manner for a noise suppressor.

Construction Hints

As with any high-gain amplifier, it is 

necessary to exercise normal care in 

shielding grid and plate circuits, 

especially where there are any long runs. 

This does affect the frequency response 

if carried to extremes, and minor com-

pensation may be effected by the addi-

tion of a small capacitor across R41. 

It is at this point that the high-frequency 

losses may be corrected if found necessary. 

However, with the parts layout shown 
in the photo, such compensation will 

probably not be necessary.

Because of the large number of wires 
in a circuit of this type, it is desirable to 
cable the wiring. This necessitates either 
of two procedures—a complete full-size 
wiring diagram may be made first and 
then the individual wires laid in place 
using a forming board with finishing nails 
driven in at points where the cable 
makes a bend or where wires branch off.

After all the wires are in place, the cable 
may be laced up. The other method 

appears to be simpler in that it does not 

require the full-size wiring diagram, but 

Fig. 7. Change in output wiring for feeding 
different types of recorders.

Once the complete amplifier is 

constructed, the alignment of the noise-

suppressor section is not particularly 

difficult, but an a-f oscillator is essential. 

The value of the capacitor C4, is specified, 

and is determined so as to resonate L1 

and C4 at 15,000 cps. Some noise-

suppressor amplifiers employ a variable 

or adjustable capacitor for this circuit, 

but the adjustment is not critical, and a

Mid-America Company, Inc., 2412 So. 

Michigan Ave., Chicago 16, Ill.
once the wiring is in place it is often
difficult to form it into cables smoothly.
In the long run it is easier to cable
the wires outside of the chassis. After
the lacing is completed, the form is put
into place and the wires cut off at suitable
lengths for connection to the sockets and
other components. The form is then
removed, the insulation stripped back,
and the wires tinned. Then the form is
replaced and connections made and
soldered, a very rapid process after the
initial cable forming is completed.

**Performance**

Measurements made on the complete
amplifier indicate an output of 5 watts at
7 per cent intermodulation distortion,
with frequency response curves as shown in
Fig. 6. The upper curves show the
effect of the high- and low-frequency
tone controls with the volume control at
one-third rotation and the suppressor
range switch, $SW_1$, on position 1. The
lower curves show the response for posi­
tions, 2, 3, 4, and 5 of the range switch
and the suppressor control, $R_m$, off.
Note that the amount of suppression
increases as the range is narrowed, which
is a desirable condition since the worst
records necessitate a narrower trans­
mission band as well as greater sup­
pression outside the band.

**Adaptation of Sections**

Since this amplifier is laid out so as to
be flexible in construction, it may be well
to indicate the various arrangements
possible. The simplest arrangement
consists of the preamplifier and the output
section, which simply omits the center
portion of the circuit, connection being
made between points "A." This provides
sufficient amplification for use
with a low-level magnetic pickup and
furnished the tone controls desired by
most users. The high-frequency cutoff
for the pickup should be added in the
form of the circuit of Fig. 8 across $R_1$.

When desired for use with an ordinary
crystal cutter, the wiring of the output
circuit and the feed for the recorder
should be modified as shown at (B) of
Fig. 7. (C) and (D) show connections
for 500-ohm and 16-ohm magnetic
cutters respectively. The wiring of the
complete output circuit for feeding the
recorder is shown in Fig. 9, complete with
VI and speaker circuit wiring.

If the previous 6AS7G amplifier has
already been built, the first two sections
may be connected to the output section
with results similar to those obtained
with the complete single-unit amplifier.

**Conclusion**

Although the parts list specifies the
transformers and chokes employed in
the amplifier as built, some substitutions
may be desirable, depending upon availa

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**Fig. 6. Frequency response curves (upper) effect of tone control; (lower) effect of noise suppressor in various positions of range switch.**

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**POSSIBLE TRANSFORMER AND CHOKE SUBSTITUTIONS**

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†original specification for 6AS7G amplifier *as employed

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**Audio Engineering Society News**

TO AUDIO engineers of Denver, Colo-

**New York Meeting**

The May meeting of the New York
group was held in Studio 6A, Radio City,
on May 11, with over 250 in attendance.
A well-prepared and informative paper on

"A New Audio Sweep-Frequency Generator" was presented by Hershel Toomin of In-
strument Electronics. This generator embodies many unique features which are of
importance to the audio engineer.

Mr. Toomin, who is responsible for the
design of the new generator, pointed out
in his paper that instruments designed for
use by engineers are of greatest value if
they relieve the user of the necessity of
making improvisations in the measure­
ments, or if they provide definite and labor-
saving features. As is well known, the
usual procedure in making a frequency-
response measurement on a piece of equip­
ment is to apply a fixed tone to the input
and to measure the output. This must be
done at a number of selected frequencies so
spaced that they are capable of indicating
accurately the trends at important points of
the curves, particularly in the case of
filters and equalizers. This is a time-con-
suming operation, for after twenty to thirty
measurements are made, they must
then be plotted before the whole picture is
made visible to the engineer.

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