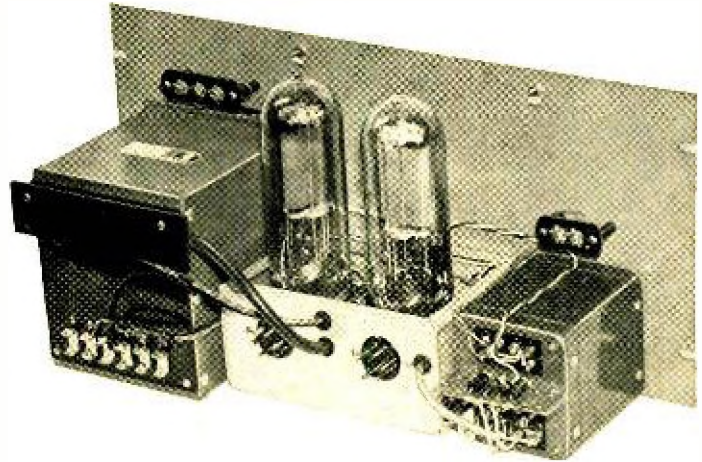


Fig. 1. Rear view of rack-mounted amplifier, showing simplicity of construction.



# The Musician's Amplifier Senior

DAVID SARSER\* and MELVIN C. SPRINKLE\*\*

Constructional details on a "Big Brother" to the original Musician's Amplifier described in these pages over a year ago, and suitable for high-power applications.

JUST A LITTLE over a year ago, the authors brought to the attention of the American audio world an amplifier that had gained an enviable reputation in Europe and Australia for its excellent fidelity. In an Americanized, and now fully naturalized version, the Musician's Amplifier has caused a sensation in this country. Literally thousands of these amplifiers have been built and all those who did not cheat on the quality of the parts used have been hearty in their praise. It is not amiss to mention at this time that "The Musician's Amplifier" has been installed in the homes of some of the world's great

names in music and they have been just as impressed with its performance as the audio enthusiast whose mouth drops open when he measures one. As a matter of fact, one world famous musical figure insisted on having a Musician's Amplifier with him on his travels, so that at no time would he be without his music.

While the Musician's Amplifier has been setting new standards for performance, the authors in their constant search for perfection have unearthed the one application in which it is a little deficient—cutting disc recordings.

While we like to attend the live concerts and recitals in New York, time and financial considerations prevent us from attending them all. The next best thing to live concerts is a live FM broadcast

or a good recording. However, there is an increasing paucity of live concerts on the networks, and in spite of all the professional skill of recordists, many commercial recordings leave much to be desired in the way of fidelity and interpretation. In view of the above circumstances we have spent much time and money in making disc recordings for our own use in reliving the performances we have heard, either of FM broadcasts or in recital halls.

Someone will raise the question of why we are interested in disc recording when fine tape machines are available. Of course we are familiar with tape and we often use it, but for our purposes the disc is still supreme. There are several reasons: (1) the cost of disc recordings is less than an equivalent time on tape; (2) the storage space for microgroove disc recordings is less than an equivalent playing time on tape; (3) not all of our friends are equipped with tape machines but all of them do have microgroove disc reproducing equipment so that sharing the recordings does not become a problem; (4) with the hot stylus technique and the amplifying system to be described, we have made discs which cannot be distinguished from tape. As a matter of fact many of the visitors at the Audio Fair who heard the Musician's Amplifier Senior playing one of its own recordings swore that we were using tape. Therefore, we make disc recordings.

## Need for More Power

Naturally, one of the first things done was to use the Musician's Amplifier to

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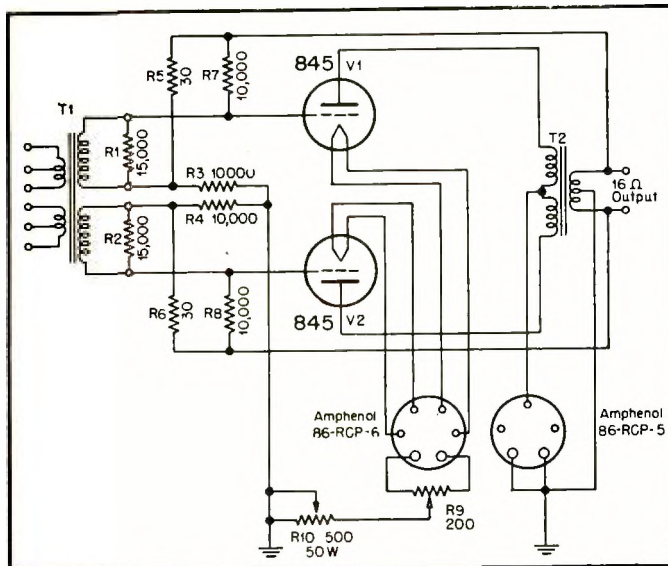


Fig. 2. Schematic of amplifier section.

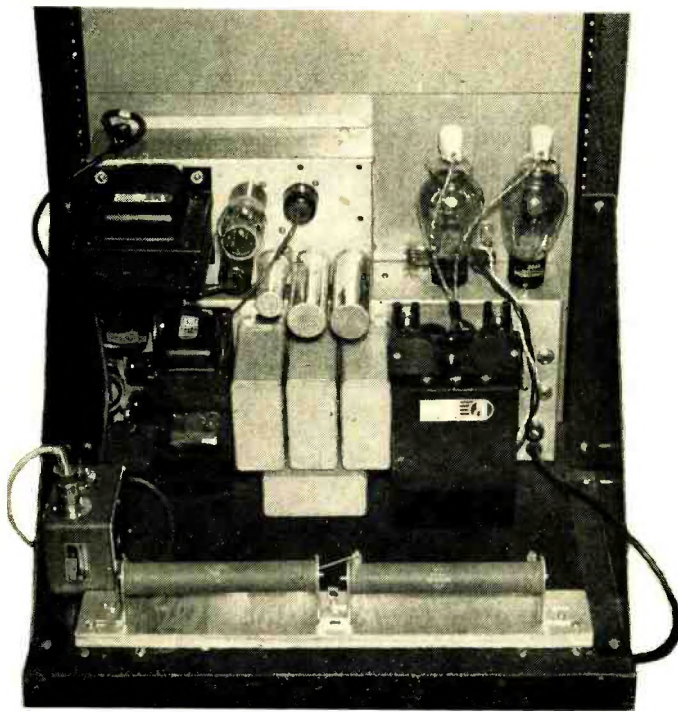


Fig. 3. Rear view of power supply section, with space provided for mounting the power supply for the driver amplifier.

drive a magnetic cutting head. Here the output power of the amplifier was just a little inadequate to give the equalization that makes a disc recording sound good to musical ears. There have arisen also a few cases where someone wanted to have his music at ear shattering levels (these individuals for some reason live away out in the country) and then there have been certain installations where it was necessary to drive a system of speakers throughout an entire home. Thus there is a need for a power amplifier which will deliver more power than the Musician's Amplifier but yet maintain the same or possibly even higher standards of naturalness in reproduction.

The power level desired was 40 watts, clean. This figure was arrived at from disc recording considerations as follows: Most modern cutting heads make excellent microgroove recordings when fed with  $\frac{1}{4}$  watt average level as read on a VU meter. We feel that the pre-emphasis at 10,000 cps should be no more than 10 db but preferably 6 db as mentioned in *Æ* April 1948, page 15. In addition, we wanted at least 10-db reserve power to handle the peaks in the music and speech. The total power required comes to 25 watts on a 10-db reserve power basis, while 40 watts gives 12 db of reserve power. For cutting 78-r.p.m. records, little or no pre-emphasis is required so that when an average level of +31 dbm is fed to the cutter in cutting 96 lines per inch, there is a reserve of 15 db to handle peaks.

Having arrived at the desired power output, we examined the several possible ways in which the power output of the Musician's Amplifier could be increased.

We came to the conclusion that the simplest and best way was to use a push-pull power amplifier stage of more than adequate capacity and drive it from the Musician's Amplifier as is. The possibility of push-pull-parallel 807 stages was considered and several

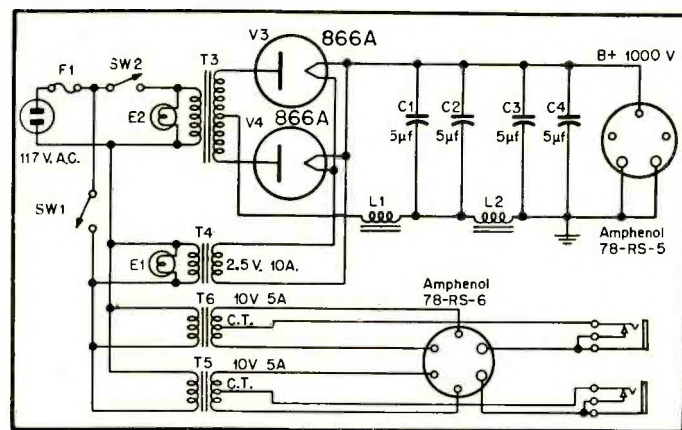


Fig. 4. Schematic of power supply section. Connections between amplifier and power supply are made with cables which plug into the two units.

models were built but the results were not too satisfactory. An advantage of the method decided on—the booster stage—was that it does not in any way make obsolete one's investment in equipment. This is an important consideration in these days of high prices. Conventional receiving tubes were ruled out by the power level desired, and from the list of transmitting tubes available to our pocketbook the 845 was selected. This old standby can give 75 watts in push-pull Class AB<sub>1</sub> and so would be coasting at 40 watts Class A. Operation in Class A was arrived at by the fact that an increase in bias to Class AB<sub>1</sub> conditions caused the IM distortion to jump to values considered excessive for recording work. Class B operation

would, of course, produce even higher IM distortion.

### Transformer Selection

Selection of the output transformer was relatively easy, since there are only a few types available. The one chosen—Peerless S-275S—has a gain-frequency response within 1-db limits from 20 to 20,000 cps, and the power delivery is no more than 3 db down from its rated power of 80 watts at these frequencies. Since the 3-db power drop-off point at low frequencies is determined by the magnitude of the a.c. exciting current in the primary, we were assured of 40 watts clean at 20 cps. Leakage reactance and shunt capacitances are controlled so as to give 40 watts at 20,000 cps. Subsequent measurements proved that this transformer would provide us with a flat power-frequency characteristic from 20 to 20,000 cps.

The input coupling could have been resistance-capacitance, but this would have involved high-impedance leads with consequent frequency errors. Thus the elimination of an input transformer would have been poor economy. The Peerless S-281Q input transformer is made to operate at 30 db above 6 milliwatts, or at a level of 6 watts, and so can drive a 250-watt booster. The drive

for 40 watts just "tickles" the transformer. Primary impedances are provided for 14 ohms as well as for 250 and 500 ohms, and the 14-ohm impedance is used with the 16-ohm output of the conventional Musician's Amplifier. A 500-ohm input is available for those who have a 500-ohm output on their amplifiers. The secondary of the input transformer is loaded with two 15,000-ohm, 5-watt resistors to absorb the drive power and to terminate the Musician's Amplifier properly. Non-inductive resistors should be used if at all available. The only other circuit components required for the amplifier proper are resistors, as shown in the schematic, Fig. 2.

[Continued on page 30]

It will be noted that inverse feedback is used, in two loops. The loop from the output transformer secondary to grids is used to wipe out just a trace of overshoot which appears on 10,000-cps square waves. The second loop, to the low ends of the input transformer secondaries, is used to lower the source impedance slightly and, as a by-product, to improve the IM distortion at lower power levels. Only 4 db feedback is used—including the effects of both loops—and there is absolutely no trace of oscillation in the combination of amplifiers. The source impedance on the 16-ohm output winding is 10 ohms, which is sufficient to give adequate damping to a good speaker.

The bias circuit for the 845's provides for balancing plate currents between the two tubes in addition to permitting a wide range of adjustment of bias voltage. The potentiometer  $R_p$  adjusts the balance between the two tubes, while  $R_{10}$  sets the average bias, serving as the self-bias resistor. Bias is set normally, under the operating conditions selected, at 85 volts for a plate supply of 1000 volts. This gives an effective plate voltage of 915, and results in minimum intermodulation distortion.

#### **Analysis of Operating Conditions**

The tubes are operated at a condition which is slightly in excess of normal rating in order to keep distortion as low as possible at the desired power output. Thus, with a 1000-volt supply and an effective plate voltage of 915, the plate current is 125 ma per tube, or a quiescent plate dissipation of 114 watts per tube. This is 14 per cent higher than the rated plate dissipation of the 845, but in view of the improved operation the excess was felt to be justified. Tests were made of the amplifier with 99 watts plate dissipation (900 volts plate, 100 volts bias, resulting in a current of 110 ma per tube) but the intermodulation distortion was approximately doubled. For example, at an output power of 38 watts, the IM distortion for 99-watt dissipation is 8.2 per cent, while for the 114-watt condition the IM distortion is 4.4 per cent. Increased tube failures, if any, will be a small price to pay for the lower distortion on records. Those who want to operate their tubes within the ratings may do so with the assurance that their amplifier will have no more distortion than most commercial amplifiers, and in all probability the distortion will be less. The 8.2 per cent IM at 38

watts in the 99-watt condition is the distortion rating of commercial high-quality amplifier manufacturers, Roys<sup>1</sup> states that IM distortion in excess of 10 per cent is evident to trained observers, when using test frequencies of 400 and 4000 cps. The 10-per cent IM point, using 40 and 2000 cps (a much more severe test) occurs in the 99-watt condition at about 45 watts output and in the 114-watt condition at 50 watts. Our own opinion is that the IM distortion in a recording amplifier should not be more than 2 per cent at operating levels in order that the distortion in the recordings be as low as possible. The 2-per cent IM occurs in the 114-watt operating condition at 25 watts output. Thus the limiting factor on quality in the recordings made with this amplifier is the cutting head.

#### Power Supply

The power supply for the Musician's Amplifier Senior resembles that of an amateur transmitter in that it is required to produce high voltage. USE EXTREME CARE WHEN WORKING ON THIS POWER SUPPLY. THE HIGH VOLTAGE PRESENT IS LETHAL. YOUR FIRST SHOCK MAY BE YOUR LAST, AND DEATH IS SO PERMANENT. These cautions may be redundant, but the builder must be made fully aware of the danger involved before attempting work with high-voltage units.

The 845 filaments are fed from two filament transformers so that the plate currents may be balanced. The rectifiers are type 866A mercury vapor tubes, and their filaments are supplied from a third transformer. The plate transformer furnishes a.c. voltages of 880 or 1175 each side of center tap. With choke input, the d.c. output voltage is 1000 at the current drain required. The plate leads are connected to the high-voltage tap, as shown on the schematic, *Fig. 4*. Separate power switches are used in filament and plate transformer primaries, and pilot lamps are arranged to indicate when the separate circuits are energized. In equipment of this type it is customary to delay the application of the plate voltage for 30 to 60 seconds after turning the filaments on in order for the amplifier and rectifier filaments to be thoroughly heated.

The filter is of the brute-force type, using 1500-volt oil-filled capacitors and two chokes. The latter are placed in the negative lead where the filtering is just as effective and there is less danger of breakdown to ground. The measured noise and hum level with both amplifiers connected normally and with an open

<sup>1</sup> "Recording and fine-groove technique," H. E. Roys; *AUDIO ENGINEERING*, Sept. 1950.

grid in the driver amplifier is  $-29$  dbm. or  $75$  db below  $40$  watts output. No trouble was experienced with mercury vapor "hash" in the output, and no r.f. chokes were required in the rectifier circuit.

### Construction

Generally when one begins to build amplifiers of the power of this one, chassis-type construction is abandoned for the more efficient relay rack. For this unit, two sections are utilized, the amplifier proper being  $8\frac{3}{4}$  in. high and the power supply  $14$  in. The total rack space occupied by the complete system—including the driver amplifier, the power amplifier, and the power supplies—is but  $29\frac{3}{4}$  in. All equipment for a complete disc recording system may be placed on a single six-foot rack, with microphone inputs, preamplifiers, equalizers, mixers, and FM tuner, and a VU meter panel.

As will be seen from *Fig. 1*, the amplifier proper is quite simple in layout. Viewed from the rear, the output transformer is on the left, the input transformer on the right. The upper left terminal strip is the output connection, while the input terminal strip is at the upper right. The 845's are mounted in an inverted  $3 \times 5 \times 7$  chassis, with a 6-prong male plug being used for the filament connections (3 leads for each tube because of the center tap). The plug at the right is for the high-voltage plate supply. The plate current balancing potentiometer  $R_p$  and the bias resistor  $R_{i0}$  are mounted within the inverted chassis, although not visible in the photograph. Access to the balance control is through a hole in the front panel. It should be pointed out that accurate plate-current balance does not affect bass response as much as it does the hum and IM distortion. The feedback resistors are mounted on a strip attached to the input transformer.

Layout of the power supply is equally simple. A chassis  $3 \times 7 \times 15$  is fastened to a 14-in. rack panel, as shown in *Fig. 3*. The plate transformer, two 845 filament transformers, and the filter capacitors are mounted on what is normally the top of the chassis, while the filter chokes and the filament transformer for the 866A's are mounted inside. The mounting of the rectifier tubes is so arranged as to leave space for the driver amplifier power supply. The two jacks shown are for measuring plate currents in the amplifier tubes.

The small junction box at the lower left of *Fig. 3* mounts the cutter and speaker outputs, and a panel-mounted switch transfers the 40-watt output from the cutting head to a speaker, or terminates the output on the resistors shown along the base panel. All high-voltage

terminals on both the plate and output transformers are covered by a Bakelite strip, and safety caps are used on the rectifier tubes. These safety precautions are essential.

### Performance

The performance of the complete system indicates that the "big brother" is a worthy companion to the Musician's Amplifier. All tests were made using both amplifiers, and the frequency response is flat within 0.5 db from 20 to 35,000 cps. The amplifiers together will pass square waves with no ring, distortion, or roughness on the top up to a 10,000-cps fundamental. This means that the frequency response is reasonably flat and the phase shift is linear up to at least 200,000 cps. Furthermore, there is no transient oscillation. The absolute gain of both amplifiers is 84 db.

The IM distortion, using 40 and 2000 cps, is shown in Fig. 5. These values are based on power as read on the IM-Set

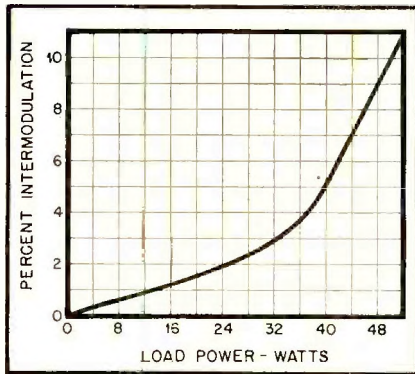


Fig. 5. Intermodulation distortion curve for 50-watt amplifier, using frequencies of 40 and 2000 cps with a level difference of 12 db.

meter, and not upon equivalent sine-wave power. It will be evident that at normal listening levels—say up to 2 watts—that the IM distortion is too low to measure. It is no more than 2 per cent up to 25 watts output, while at 40 watts the IM distortion is about 5 per cent. The 8-per cent point appears at about 47 watts, and distortion does not climb rapidly until about 60 watts.

While the Senior amplifier was intended for making disc recordings, the authors were pleased by its performance as a playback amplifier when playing recordings which had just been cut. Visitors to the Audio Fair confirmed those opinions, and many made mention of the "cleanness" of sound. This is the result of two factors: the tremendous reserve of power, and the low intermodulation distortion even at high power levels. *Crescendo* and *fortissimo* passages are handled with effortless ease. The user should be cautioned, however, not to turn up the gain

unless the load is adequate to absorb the power. Ordinary speakers will not handle the full output of this amplifier.

#### Amplifiers

$R_1, R_2$	15,000 ohms, 5 watts
$R_3, R_4, R_7$	
$R_8$	10,000 ohms, 1 watt
$R_5, R_6$	30 ohms, 1 watt
$R_9$	200-ohm potentiometer, 4-watt Mallory M200P
$R_{10}$	500-ohm adjustable, 50 watts
$T_1$	Input transformer, line to p-p grids, high level; Peerless K-281Q
$T_2$	80-watt output transformer, 4000-ohm pri., speaker im- pedances 2, 4, 8, or 16 ohms; Peerless S-275S
$V_1, V_2$	845's

#### Power Supply

$C_1, C_2, C_3$	
$C_1$	5- $\mu$ i, 1500-volt, oil filled
$E_1, E_2$	110-v pilot lights, with sock- ets and jewels
$L_1, L_2$	3-H, 225-ma chokes, Peerless C-315X or equivalent
$T_3$	Plate transformer, 1180 v. each side of c.t., 300 ma; Peerless P-330K
$T_4$	2.5-v. 10-a. filament trans- former; Peerless F-096X or equivalent
$T_5, T_6$	10-v. 5-a. filament transfor- mer; Peerless F-140E or equivalent
$V_1, V_2$	866A's