THE SOUND SYSTEM

The AMI sound system consists of three major units: the crystal pickup, the amplifier and the loudspeaker and/or loudspeakers. These three units have been carefully designed and selected to provide a matched sound system incorporating features most wanted in the field.

The Amplifier

The heart of the sound system is the amplifier (40). This unit can be used as:

1. A straightforward amplifier.
2. A master amplifier driving similar amplifiers used as auxiliary amplifiers.
3. An auxiliary amplifier being driven by a similar amplifier used as the master amplifier.

In each of the above applications, up to six speakers may be connected to each amplifier -- either six remote speakers or the cabinet speaker plus five remote speakers.

The Volume Control

The volume control (39) regulates the gain and therefore the power output of the amplifier. It may be placed and used at any distance from the amplifier without affecting the quality of reproduction by simply adding the necessary length of ordinary two-conductor lamp cord. The two terminals on the amplifier to which the volume control is connected are clearly labeled on the amplifier.

Sudden rotation of the volume control to the maximum volume position will cause the amplifier to momentarily lose volume and then to surge to maximum volume - similar in action to a dead spot in the volume control. This behavior is entirely normal and does not occur when the control is slowly rotated.

The Record Condition Control

One of the most severe problems in phonograph reproduction is that of record noise. Although record noise exists throughout the musical spectrum, it is most noticeable at treble frequencies. The noise at bass and middle frequencies is masked by the music because the energy of music is concentrated at these frequencies. By cutting the response of the amplifier at treble frequencies, noise at these frequencies is reduced. Of course, the quality of reproduction suffers because of the reduction of music in the treble range.

In order to preserve the greatest amount of musical content for a given amount of noise, a sharp cut-off filter circuit is used. Effective reproduction is maintained up to the cut-off frequency; above that frequency the output is sharply attenuated. The treble cut-off control, labeled "Record Condition", has three positions corresponding to the three conditions of record wear and noise. The three conditions are "New Records", "Normal" (moderately worn) and "Badly Worn".

The Record Condition Control (Continued)

It is realized that the records in a phonograph will be mixed as to condition. The control should be set to the position which corresponds to the condition of the majority of the records in the phonograph. Conditions in the field indicate that the "Normal" position would be the one most frequently used.

The Automatic Bass Tone Control

Because bass frequencies seem proportionally less loud than do treble frequencies to the human ear at the lower volume levels, "bass boost" is incorporated in the amplifier to maintain tonal balance. Bass frequencies would overload the amplifier before the treble frequencies as high volume levels were reached unless means were taken to reduce the amount of bass boost at the higher volume levels. The bass boost tone circuit in this amplifier is completely automatic in operation. As full power output of the amplifier is approached, the bass boost is electronically reduced just sufficiently to prevent overloading and consequent distortion. Thus, both bass and treble frequencies can be reproduced at the maximum power output of the amplifier.

Master-Auxiliary Amplifier Use

Large and complex installations may be beyond the scope of one amplifier. In cases where more power is needed, an amplifier is used as the master amplifier which drives one or more similar amplifiers used as auxiliary amplifiers. Each amplifier, whether it is used as master or auxiliary, has its own volume control and treble cut-off tone control. Thus it follows that the power output and tonal quality of each amplifier is controlled independently of the others.

This independent control of volume and tone is especially valuable when the installation problem is one of frequent change in volume levels in two separate rooms rather than one of adequate power.

The volume controls of the master and auxiliary amplifiers can be grouped at one place or can be individually located, whichever the installation demands.

The number of auxiliary amplifiers which a master amplifier can handle is limited only by the type and amount of wire used to carry the signal between the master amplifiers and auxiliary amplifiers. In most cases, connections for the signal between a master amplifier and an auxiliary amplifier can be made with ordinary two-conductor lamp cord. The length of lamp cord between a master amplifier and any given auxiliary amplifier should not be over 500 feet provided this wiring is kept away from AC power wiring; otherwise excessive hum will result.

The signal wiring should be connected from the two terminals marked "Output to

The Amplifier (Continued)

Master-Auxiliary Amplifier Use (Continued)

Aux. Ampl." on the master amplifier to the two terminals marked "Input from Master Ampl." on the auxiliary amplifier. The "Ground" terminal of each pair of above terminals should be connected to the same wire in the lampcord, otherwise severe hum will result. In other words, the ground wiring must be common to all amplifiers. Thus all of the auxiliary amplifiers connected to the master amplifier are wired in parallel through the signal wiring.

In cases where the signal wiring must be run next to power wiring for distances of 100 feet or more, single conductor shielded microphone cable should be used. The shield becomes the second conductor and is used for the ground side of the signal wiring.

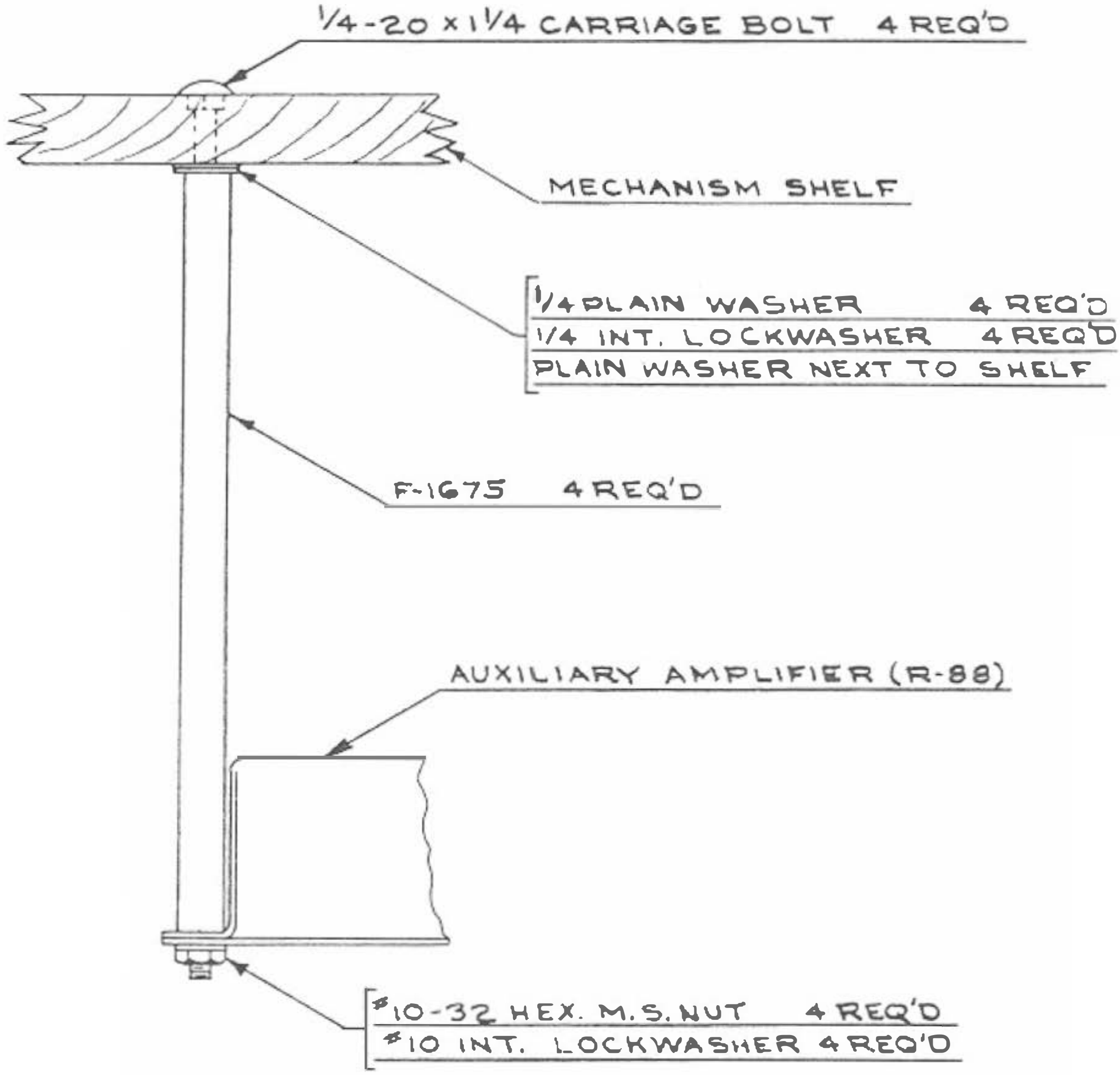
The signal wiring between amplifiers has an electrical property: capacity, which, if excessive, results in losses at treble frequencies. Thus the total length (and capacity) connected to the master amplifier must not exceed certain limits. The total length of lampcord and/or capacity (25 micro-microfarads/foot) shielded microphone cable should not exceed 1000 feet. If shielded cable is used having two times the capacity per foot as the above, the maximum length would be one-half the above or 500 feet. In no case should the total capacity exceed 30,000 micro-micro-farads.

The amplifiers do not require direct grounding because they are effectively grounded to one side of the AC power wiring by means of a small capacitor. To determine the ground side of the AC power wiring, turn up the volume control (no record playing) and reverse the amplifier AC line cord plug in its receptacle and leave in the position of least hum. This procedure is necessary insofar as master-auxiliary application is concerned but is usually not necessary for ordinary single amplifier use.

To mount an auxiliary amplifier within the phonograph, refer to "Auxiliary Amplifier Mounting Instructions", Fig. 7.

The Crystal Pickup

The crystal pickup used with the amplifier is of the ceramic element type. This type of crystal is unequalled in its ability to withstand excessive heat and humidity. The crystal, normally furnished with a replaceable self-polishing osmium needle, provides unusually good record life. A replaceable sapphire needle is also available. Instructions for replacing the needle are given in the section "Putting the Machine in Operation". Caution: The amplifier has been designed for the output response of this crystal. Use of crystals having different responses will result in unsatisfactory performance.



INSTRUCTIONS FOR MOUNTING AUXILIARY AMPLIFIER

1. REMOVE MECHANISM MOUNTING SCREWS
2. RAISE MECHANISM AND INSERT 4 CARRIAGE BOLTS IN PRE-DRILLED HOLES IN SHELF (PIERCE THRU SHELF COVERING IF NECESSARY)
3. ATTACH 1/2 D. ROD TO EACH CARRIAGE BOLT WITH PLIERS INSERTING PLAIN WASHER & LOCKWASHER AS SHOWN.
4. ATTACH AUXILIARY AMPLIFIER TO PROTRUDING STUDS ON 1/2 D. ROD WITH LOCKWASHER & NUTS AS SHOWN.
5. REPLACE MECHANISM MOUNTING SCREWS.

Fig. 7. Auxiliary Amplifier Mounting Instructions

SPEAKER CONNECTION CHART

Numbers indicate terminals on speaker terminal strip.

Cabinet Speaker	Remote Speakers Connected in Parallel		Jumper Number 1	Jumper Number 2
Leads to Terminals	Number & Impedance	Leads to Terminals	Connect Terminals	Connect Terminals
Cabinet speaker louder than each remote speaker.				
2 4	1-8 Ohm	2 6	5 6	
2 4	2-8 Ohm	2 6	5 6	
2 4	1-500 Ohm	2 7	5 6	1 4
2 4	2-500 Ohm	1 3	5 6	5 7
4 6	3-500 Ohm	5 7	2 3	1 3
4 6	4-500 Ohm	1 6	2 3	5 7
4 6	5-500 Ohm	1 6	2 3	5 7
Each remote speaker louder than cabinet speaker.				
3 4	1-8 Ohm	4 5		
2 5	2-8 Ohm	3 4	4 6	
3 4	1-500 Ohm	6 7	1 5	2 3
2 5	2-500 Ohm	1 4	3 7	4 6
2 5	3-500 Ohm	2 7	4 6	1 6
2 6	4-500 Ohm	4 7	1 3	
2 6	5-500 Ohm	4 7	2 3	1 6

Fig. 8. Connection Chart - Unequal Power to Speakers

Loudspeakers

The Phonograph Speaker

The loudspeaker furnished with the phonograph is a heavy duty 15 inch permanent magnet type, and has a voice coil impedance of 16 ohms. It is capable of handling the full output of the amplifier without overloading.

Remote Speaker Application

The amplifier is designed to handle those installations which require remote speakers for adequate sound coverage. This covers installations where the phonograph speaker is used with remote speakers and Hideaway installations where only remote speakers are used. Either 8 ohm or 500 ohm remote speakers can be used in installations which require one or two remote speakers. It is not practical to connect more than two 8 ohm remote speakers to the amplifier because of excessive power loss in the speaker lines. Therefore, provision has been made for only one and two 8 ohm remote speakers (with or without the phonograph speaker).

Because 500 ohm remote speakers have negligible line loss, provision has been made to connect up to five 500 ohm remote speakers in addition to the phonograph speaker or up to six 500 ohm remote speakers without the phonograph speaker. Connection of the speaker leads and the necessary jumper wires are shown on the "Speaker Connection Chart" located on the amplifier. This chart is for equal power into each speaker.

For those installations which require greater volume from the phonograph speaker than the remote speakers (or vice-versa), refer to the connection chart, Fig. 8.

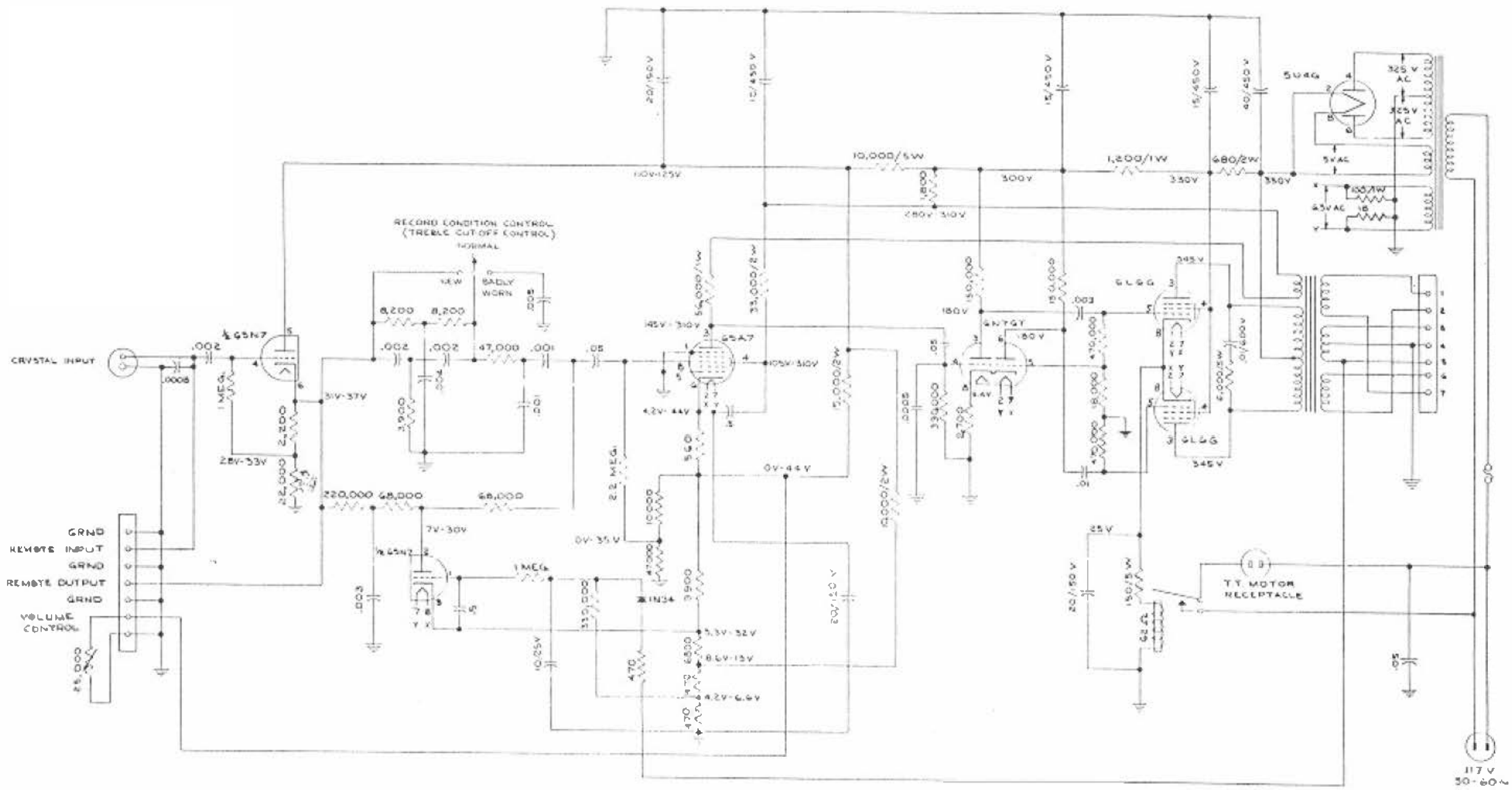
For individual control of speaker volume in a multiple speaker installation, L pads can be connected to each speaker. The L pad should match the impedance of the speaker with which it is used.

Amplifier Service Information

Efficient service of any piece of equipment requires an understanding of the basic operation of the equipment. Although conventional in most respects, the amplifier contains several simple but special circuit features. This section contains information on these special circuit features as well as general service information. It is strongly recommended that the serviceman understand the operation of the special circuits and become familiar with the general service information before servicing the amplifier.

Conventional Circuits:

Inspection of the amplifier schematic diagram, Fig. 9, shows that the DC power sup-



VOLTAGE MEASUREMENT CONDITIONS:

NO SIGNAL INPUT TO AMPLIFIER
VOLTAGES ARE APPROXIMATE.
VOLTAGES ARE D.C. & MEASURED WITH RESPECT TO CHASSIS UNLESS OTHERWISE INDICATED.
SENSITIVITY OF D.C. VOLTMETER - 20,000 OHMS/VOLT

WHERE TWO VOLTAGES ARE INDICATED, THE FIRST IS FOR THE VOLUME CONTROL IN THE MAXIMUM VOLUME POSITION; THE SECOND IS FOR THE VOLUME CONTROL IN THE MINIMUM VOLUME POSITION.

NOTES:
RESISTANCE VALUES ARE IN OHMS.
RESISTOR RATINGS ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED.
CAPACITANCE VALUES ARE IN MICROFARADS.
CAPACITOR RATINGS ARE 400 VOLTS UNLESS OTHERWISE SPECIFIED.

Fig. 9. Schematic Diagram - Amplifier

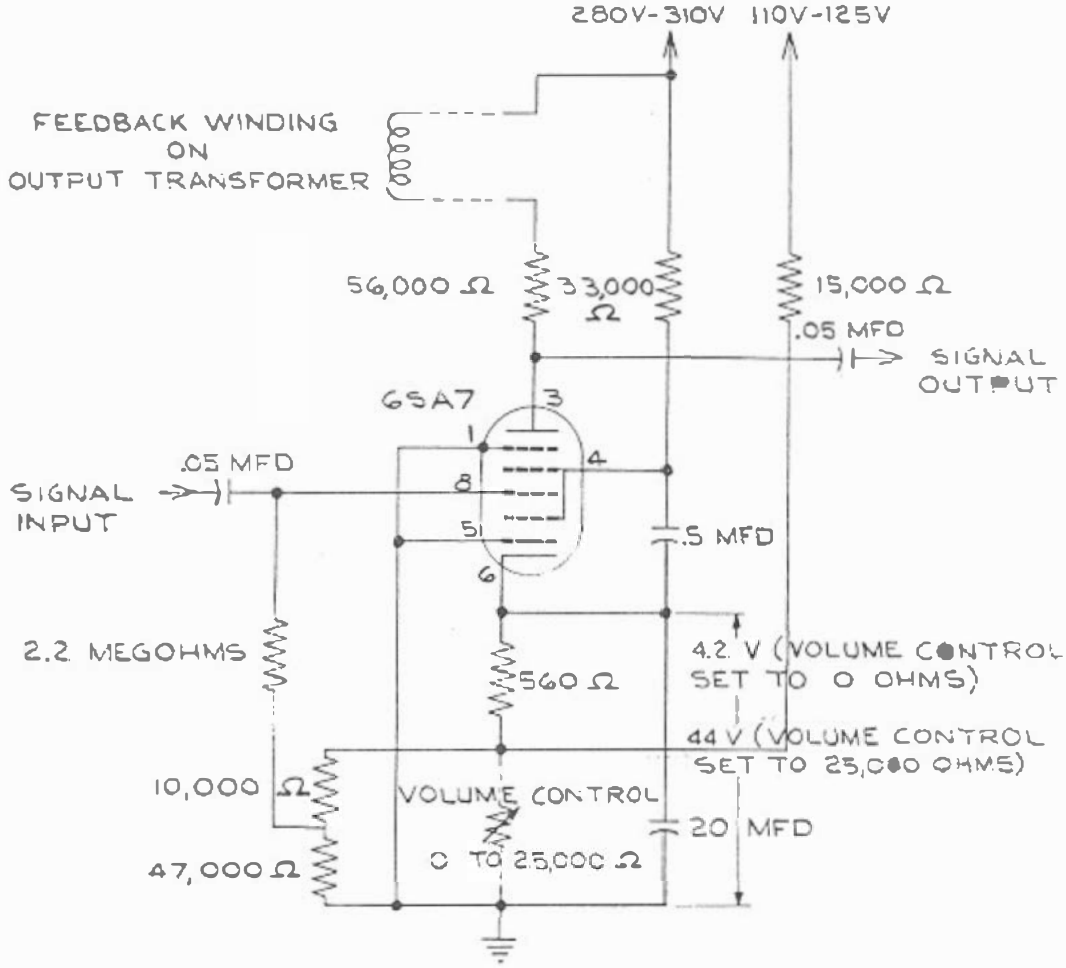


Fig. 10. Schematic Diagram - Volume Control Circuit

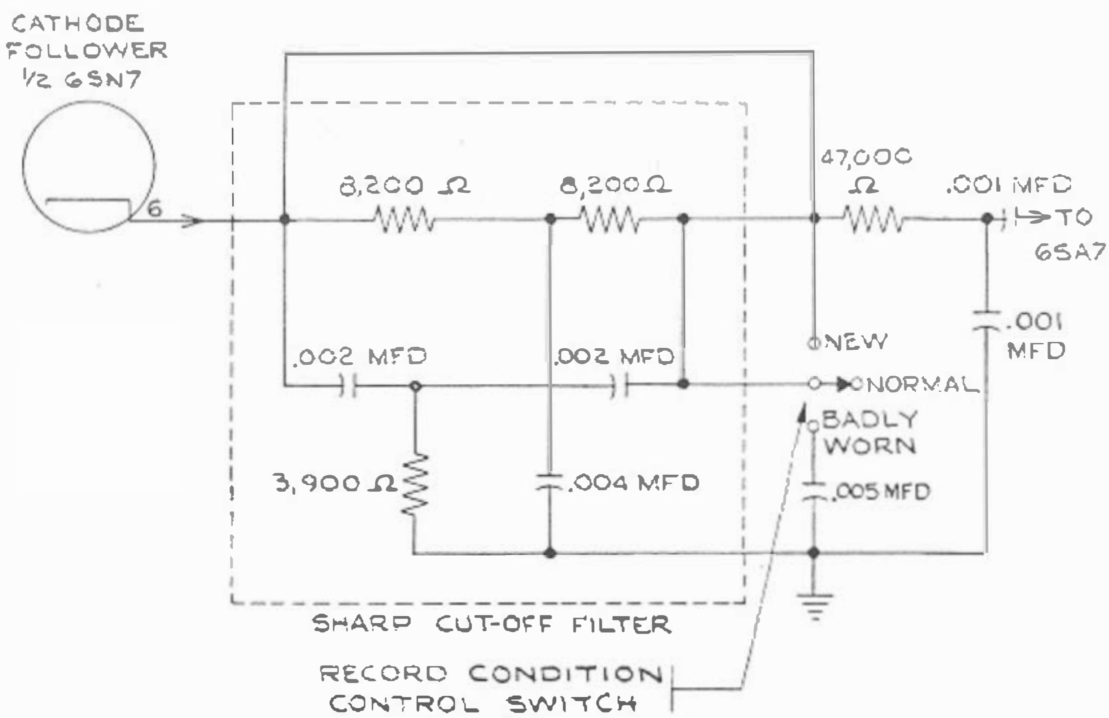


Fig. 11. Schematic Diagram - Record Condition Control Circuit

Amplifier Service Information (Continued)

Conventional Circuits (Continued):

ply, audio power output and phase inverter circuits are conventional.

The 60 cycle AC voltage, stepped up by the power transformer, is rectified into DC voltage by a 5U4G tube. Hum ripple voltage at the output of the rectifier tube is smoothed out by resistance-capacitance filters.

Push-pull 6L6G tubes, operated class AB_1, deliver up to 22 watts into the output transformer. Inverse feedback, fed into the plate circuit of the 6SA7 tube from a separate winding on the output transformer, is used to reduce distortion, stabilize gain and improve frequency response. The secondary windings of the output transformer are connected to a terminal strip marked "Speakers". The secondary windings can be connected together by means of jumper wires so as to either aid or oppose each other. Thus, many different values of impedances can be matched to the power output tubes.

A 6N7GT twin-triode tube is used as an amplifier and phase inverter. One triode section of the 6N7GT tube is used as a voltage amplifier between the output of the 6SA7 tube and the input of one of the 6L6G power output tubes. A fraction of the input voltage to the forementioned 6L6G tube is amplified and inverted in phase by the remaining triode section of the 6N7GT tube and applied to the input of the other 6L6G power output tube. Thus, the remaining triode section of the 6N7GT tube is used as a phase inverter. The input voltage to each 6L6G tube is equal and opposite in phase -- a condition necessary for push-pull operation.

A relay is connected in the cathode circuit of the 6L6G tubes to insure starting of the turntable motor only when the amplifier is sufficiently warmed up to deliver power. When energized by sufficient cathode current, the relay closes and applies power to the turntable motor.

The Volume Control Circuit:

The power output of the amplifier is controlled by varying the gain (or amplification) of the amplifier. This is done in the 6SA7 penta-grid tube by changing the DC voltage on one of the grids. Referring to the basic volume control circuit, Fig. 10, it is seen that the signal is applied to the #3 grid of the 6SA7 and the gain of the tube is controlled by varying the DC bias voltage on the #1 and #5 grids. The maximum gain condition is with the volume control set for zero resistance. The negative bias (grid to cathode) voltage on #1, #3, #5 grids would be the 4.2 volts developed across the 560 ohm cathode resistor. As the volume control is rotated from its zero resistance position, its resistance is increased and the voltage drop across it increases. This increases the negative bias on the #1 and #5 grids since they are at chassis potential and the cathode voltage is now increased by the voltage drop across the volume control. The negative bias on the #3 (signal) grid is not effectively changed through

Amplifier Service Information (Continued)

The Volume Control Circuit (Continued):

most of the volume control range because the voltage across it follows the rise in voltage across the volume control. With the volume control set at the maximum resistance position of 25,000 ohms (minimum gain position) the cathode voltage, and hence the #1 and #5 negative bias voltage, becomes 44 volts -- more than enough to reduce the tube plate current to zero and the amplification to zero. A 20 mfd. capacitor by-passes any signal voltage developed across the cathode.

Because only DC voltage appears across the volume control, it may be extended any distance from the amplifier by adding the necessary length of unshielded two-conductor wire such as lampcord.

Two precautions have been taken because of the possibility of microphonics from the 6SA7 tube. One, the 6SA7 tube socket has been "floated" on rubber grommets; two, a weight in the form of a spring has been fastened to the tube itself. To fasten the spring to the tube, rotate the spring in the direction that "opens" it and "screw" it on the tube. To remove the spring, rotate it in the same direction used to install it and pull it from the tube. If the spring is rotated in the wrong direction, it will tighten on the tube making removal difficult.

The Record Condition (Treble Cut-off) Control Circuit:

Referring to the amplifier schematic diagram, Fig. 9, it is seen that this circuit immediately precedes the 6SA7 volume control circuit. The basic circuit is shown on Fig. 11.

As discussed previously, use of a sharp cut-off filter circuit for the treble frequencies results in the least damage to the natural reproduction of treble frequencies for a given reduction of record noise. The sharp cut-off filter consists of a parallel T circuit.

With the Record Condition control switch in the "New" position, the sharp cut-off filter circuit is shorted out. Thus, the full response of the crystal pickup and record is possible except for a small amount of treble attenuation due to the 47,000 ohm series resistor and the .001 mfd. by-pass capacitor.

With the Record Condition control switch in the "Normal" position, the sharp cut-off filter becomes effective. Good treble response is retained to the cut-off point of the filter; beyond the cut-off point, severe attenuation takes place with the consequent effective reduction of record noise.

With the Record Condition control switch in the "Badly Worn" position, treble attenuation and record noise reduction over and above that of the "Normal" position is accomplished by the addition of a .005 mfd. capacitor to the filter circuit.

Amplifier Service Information (Continued)

The Automatic Bass Tone Control Circuit:

Because of the "bass boost" incorporated in the amplifier, bass frequencies are the first to cause overloading of the power output stage as higher volume levels are reached. Therefore, the "bass boost" must be eliminated to permit both bass and treble frequencies to be reproduced at the maximum power output of the amplifier.

Referring to the simplified schematic of this circuit, Fig. 12, it is seen that this circuit, between the output of the cathode follower and the input of the 6SA7 tube, is in parallel with the Treble Cut-off circuit and controls the bass frequencies.

Treble frequencies are by-passed to ground through the .003 mfd. capacitor; thus only bass frequencies reach the input of the 6SA7 tube through this circuit, whereas, treble frequencies reach the input of the 6SA7 tube through the Treble Cut-off circuit. This is the condition when the bass control tube is disconnected (unenergized) as shown in the equivalent circuit. The frequency characteristic of the treble and bass circuits, in conjunction with the frequency characteristic of the crystal pickup is designed to produce a preponderance of bass frequencies (bass boost) when the bass control tube is unenergized.

The bass control tube circuit can be replaced for discussion purposes by an equivalent circuit consisting of a variable resistance and a switch. As previously mentioned, the switch is open and the resistance disconnected when the tube is unenergized.

At the threshold of energization, the switch closes thus connecting the resistance into the circuit. The resistance is very high under this condition and produces little effect in the bass circuit. As the energization of the bass control tube is increased, the variable resistance decreases. As the variable resistance decreases, its shorting effect in the bass circuit increases, thus decreasing the amount of bass frequency signal reaching the input of the 6SA7.

The degree of energization of the bass control tube varies with and is controlled by the power output of the amplifier. Therefore, as the power output of the amplifier is increased, the bass boost is decreased thus preventing overload of the amplifier at bass frequencies. At maximum power output of the amplifier, the overall frequency response of the amplifier and crystal pickup is relatively "flat".

The actual bass control tube circuit is shown on Fig. 13. All DC voltages under discussion are positive with respect to the chassis. A triode section of the 6SN7 tube acts as the switch and variable resistance in the equivalent circuit. The variable resistance is the plate resistance of the tube which varies with the plate current which in turn is controlled by the grid bias on the tube.

At low signal levels the negative bias on the grid of the tube is sufficient to cut-off the plate current in the tube, thus making the tube an open circuit as far as the bass

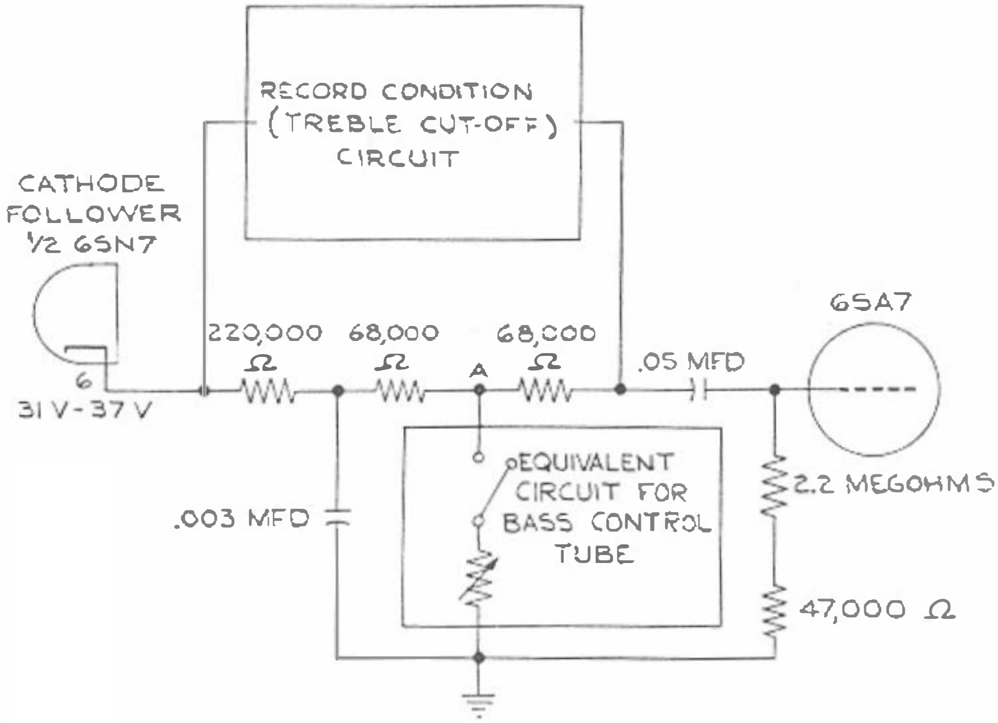


Fig. 12. Schematic Diagram - Simplified Automatic Bass Tone Control Circuit

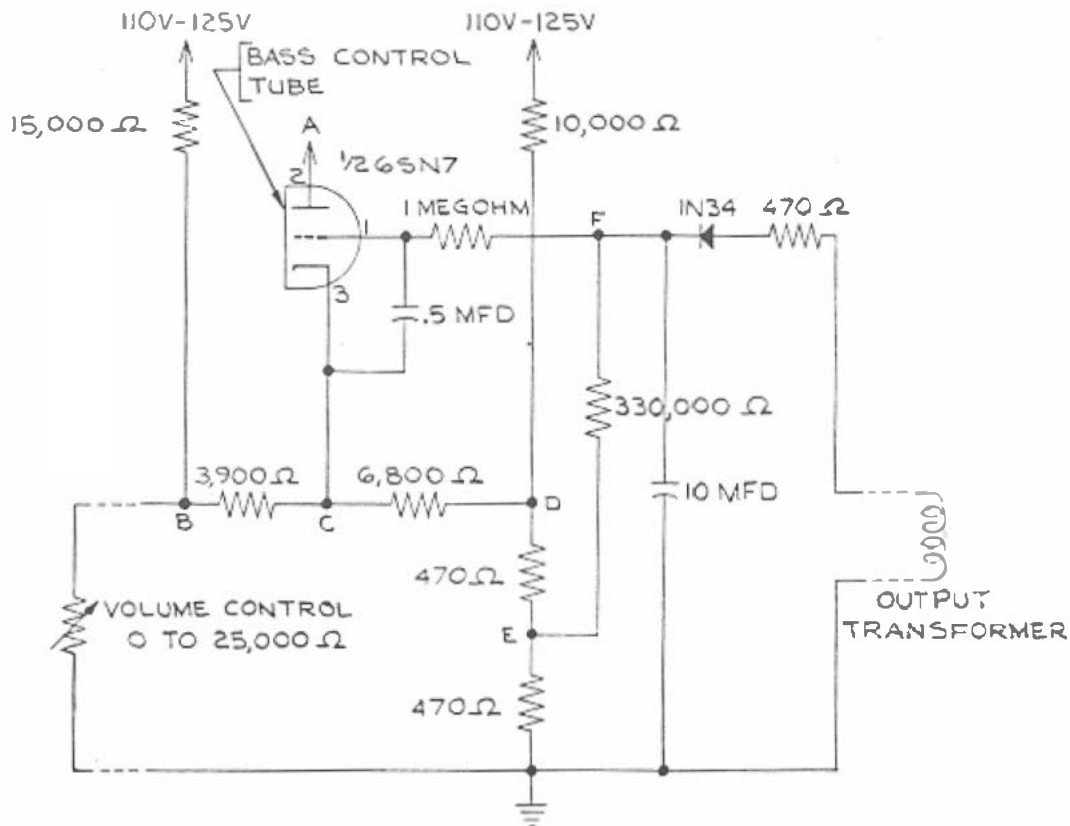


Fig. 13. Schematic Diagram - Bass Control Tube Circuit

The Automatic Bass Tone Control Circuit (Continued):

control circuit is concerned. The plate of the tube has approximately 30 volts DC applied to it and connects to point "A" on the simplified circuit schematic.

A study of the voltages in the bass control circuit at the threshold point of operation of the circuit not only would give an understanding of the circuit for that condition of operation but also would provide analysis of the operation of the circuit for conditions on either side of the threshold condition. At the threshold point, the power output of the amplifier at bass frequencies is at the verge of overloading and the bass control tube is at the verge of operation. A typical volume control setting for this threshold point would produce about 12 volts across the volume control (or between chassis and point "B"). Point "D" is anchored at 9 volts by means of the 10,000 ohm bleeder. Point "C" will then have a voltage above chassis of approximately 11 volts. Assume for the moment, that there is no signal input to the amplifier. Then the grid voltage of the bass control tube would be that at point "E" or 4.5 volts. The negative grid bias on the tube would then be the voltage at point "E" subtracted from the voltage at point "C" or 11 - 4.5 = 6.5 volts. This value is more than sufficient to cause plate current cut-off in the tube. Now apply a signal to the input of the amplifier. The AC signal voltage developed across the output transformer winding will be rectified by the 1N34 germanium diode rectifier and a positive DC voltage will appear across the 10 mfd. capacitor at point "F". Now the grid voltage is that at point "F". A typical value would be 8 volts. The negative grid bias is now 11 - 8 or 3 volts, a value which just causes plate current cut-off. If the voltage across the output transformer winding is increased, the rectified DC voltage at point "F" is increased, which causes a decrease of negative grid bias. Plate current then flows in the bass control tube and the bass boost is reduced.

The net grid bias on the bass control tube is determined both by the rectified voltage at point "F" and by the voltage at point "C" which partially depends upon the position of the volume control for its value. In the threshold area of operation, the effect upon the voltage at point "C" due to position of the volume control is small so that the bias is determined essentially by the rectified voltage at point "F".

In the maximum volume region of the volume control, the control operates the bass control circuit independently of the power output of the amplifier and reduces the bass gain. If this were not done, acoustic feedback would develop in the sound system during the record changing period because of no signal input (no rectified bass control voltage) and resultant very high bass gain. With the volume control set at zero ohms (maximum volume), the voltage at point "B" become zero. The voltage at point "D" remains at about 9 volts, thus the voltage at point "C" is in the order of 3 volts. The grid voltage at no signal is that at point "E" or 4.5 volts. The grid bias then becomes 4.5 - 3 or a positive 1.5 volts which, of course, causes the bass control tube to operate.

Operation of the amplifier at power levels below the threshold region does not affect

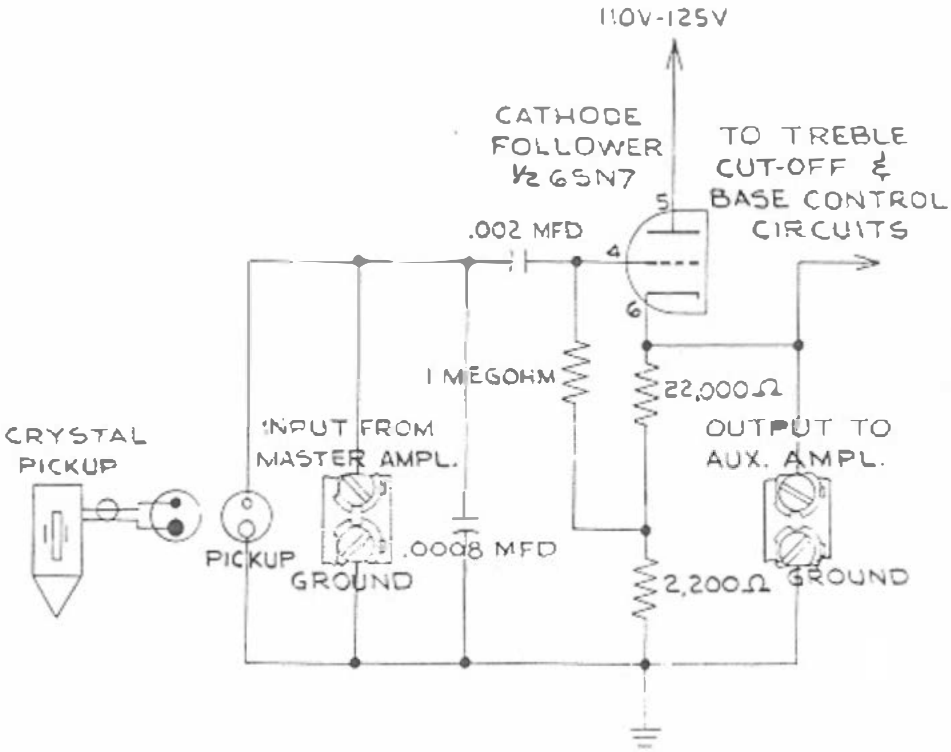


Fig. 14. Schematic Diagram - Master-Auxiliary Amplifier Circuit

Amplifier Service Information (Continued)

The Automatic Bass Tone Control Circuit (Continued):

the bass boost because the rectified control voltage at "F" is small and the voltage at point "C" is relatively high. This adds up to a high negative bias on the bass control tube.

By virtue of the R-C time constants involved, the control voltage rectifier circuit has been designed to develop DC control voltage (at point "F") rapidly upon application of signal voltage from the output transformer and to lose control voltage slowly upon removal of the signal voltage. This means that the bass boost is cut quickly to prevent distortion and returns gradually so that the listener is hardly aware of the change. The charging R-C time constant of the control voltage rectifier circuit is basically determined by the 10 mfd. capacitor, the forward resistance (under 500 ohms) of the rectifier and the 470 ohm current limiting resistor. The discharging R-C time constant is basically determined by the 10 mfd. capacitor and the parallel resistance of the 330,000 ohm resistor and the back resistance (over 200,000 ohms) of the rectifier. Thus the characteristics of the 1N34 rectifier play a vital part in th proper operation of the circuit.

The 1 megohm resistor and .5 mfd. capacitor in the grid circuit of the bass control tube reduces the ripple content of the DC rectified voltage and thus functions as a smoothing and decoupling filter.

Master-Auxiliary Amplifier Circuit

Because the crystal is a high impedance device, the signal developed by it can not be transmitted more than several feet away without excessive loss and hum pickup. A low impedance signal source is necessary for transmission of the signal over considerable distances. As shown on Fig. 14, a cathode follower circuit provides this. It has a relatively low output impedance of 1000 ohms and an amplification of slightly less than unity. The output voltage of the cathode follower in the amplifier used as the master amplifier is applied to the input of the cathode follower on the amplifiers used as auxiliary amplifiers. Thus the voltage applied to the input of all the amplifiers is substanitally the same value. Because the cathode follower preceeds the volume control, treble cut-off control and automatic bass control circuits, these circuits remain effective for each amplifier regardless of its use in a master-auxiliary amplifier set-up.

The .0008 mfd. capacitor across the input of the cathode follower in addition to the capacity of the shielded crystal pickup cable, reduces the output voltage of the crystal pickup to an average value of .35 volts at 1000 cycles.