The Apt 1 Amplifier Owner's Manual

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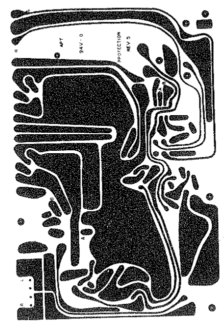

Preliminary: This temporary Owner's Manual will be replaced by the final version when it is printed. Be certain to file your warranty card in order to receive the complete manual.

Underwriting organizations require and common sense dictates the following:

WARNING: To prevent fire or shock hazard, do not expose this appliance to rain or moisture.

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The Apt 1 Amplifier
Owner's Manual Additions and Erratum

Ref. p. 12 <u>On Fusing Loudspeakers</u>

Apt recommends using fuses appropriate to the loudspeakers in use. In many cases, such fuses will be built into the loudspeaker: in such cases be certain to replace the supplied fuses with the same type should the supplied fuses blow out. Where the manufacturer of the loudspeaker has not provided fuses with the unit, nevertheless the loudspeaker manufacturer is still the best source of information about fusing.

The Apt 1 Amplifier is especially free from the potential tweeter damaging "flyback pulses" associated with safe area limiting circuits and reactive loudspeaker loads. Overload of the amplifier has also been made free from undesirable side effects. The result of these two design techniques is that clipping distortion is less audible on this amplifier than on many others, and does not result in as severe a thermal stress on the tweeters as in many other designs. Still, it is not good practice to run the amplifier in clipping (with the red indicators on) for a large percentage of the time. Such operation inevitably causes higher thermal stress on tweeters. It is for this reason that most tweeter damage occurs with <u>lower</u> powered amplifiers—high power amplifiers are driven into clipping infrequently and thus do not cause as much stress on tweeters.

Ref. p. 16

If you are unsure as to the actual impedance of your loudspeakers, it is good practice to begin with the load impedance switch in the upper (8-16 ohm) position. You may then test your speaker by playing program material rich in bass information and gradually raising the volume while watching the load impedance light. If, as you reach higher levels the light begins to flash regularly, concurrent with bass events, adjustment of the switch to the 2-4 ohm position is indicated. However, if the load impedance adjust indicator only begins to flash just before (approximately 3 dB or less) the L and R indicators turn to red indicating the threshold of overload, then is is probably preferable to leave the load impedance switch in the 8-16 ohm position. Experimentation with this switch is encouraged: although there is no "right" or "wrong" setting for a particular system, and the amplifier will not be damaged by missetting the switch, optimizing for your particular load will produce the best overall results.

Ref. p. 17

When the Apt 1 is turned on, both left and right overload indicator LEDs will glow continuously for some seconds. Following this period, the LEDs make a gradual transition to green, indicating that all amplifier circuits are within specified limits. The Apt 1 will however, amplify and pass a signal following the closing of the relay, even though one or both LEDs may still be red.

Ref. p. 18

Should you connect a short circuit to the Apt 1, the output protection relay will cycle the signal on and off until the short is cleared. In some cases, with a combination of output short circuit and high drive conditions, the AC line fuse will blow. In such cases, always replace the fuse with the same type as supplied.

Ref. p. 19 3rd paragraph

Be certain to short the input of the amplifier for a hum test.

Ref. p. 26 2nd paragraph

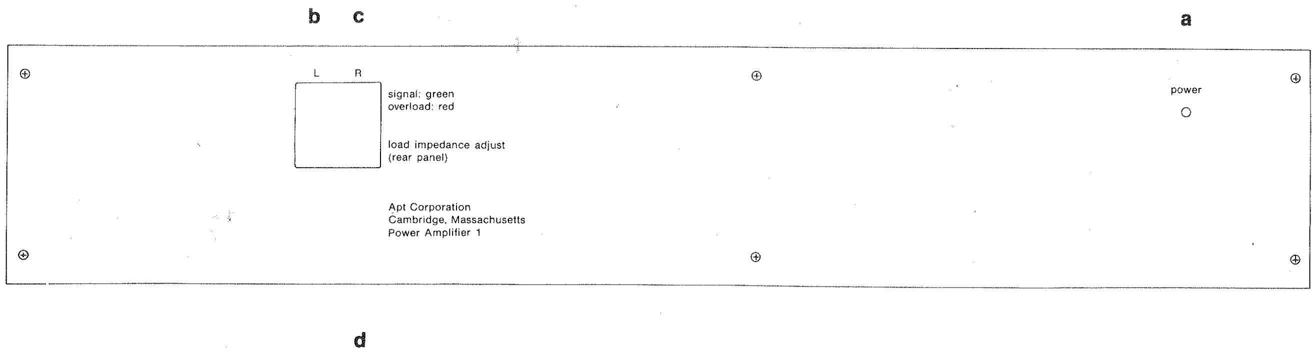
The word "non-arity" should, of course, be non-linearity.

Table of Contents

Introduction

Thank you for purchasing the Apt 1 Power Amplifier. Because the design of this product has evolved from a thorough analysis of how a power amplifier should (and should *not*) behave, various aspects of its performance are either subtly or distinctively different from previous power amplifiers. We have provided a detailed Owner's Manual to help you fully exploit its capabilities; we hope that you will find it useful. The manual has been designed to alternate between material of primary importance, and that required for explicit detail.

Please fill in and mail the Owner's Registration Card. See warranty information, page 29.



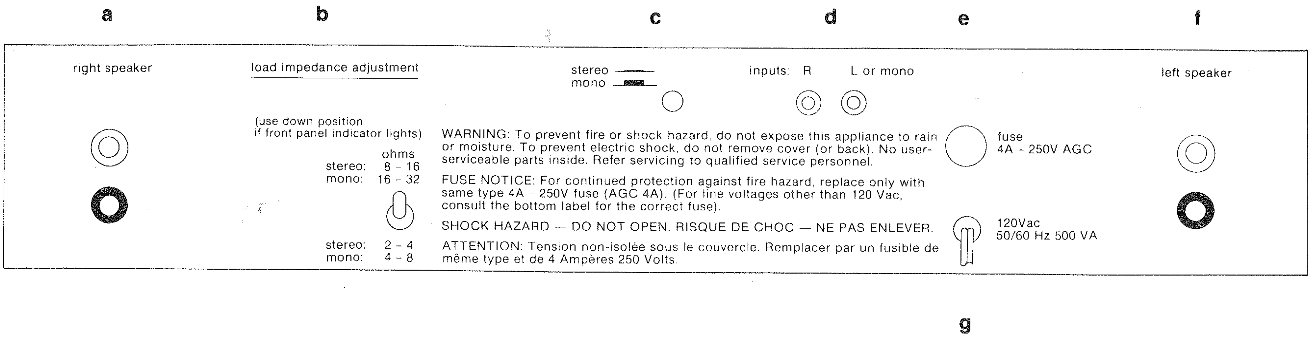
Front Panel

a power indicator: lights when power is applied.

b left channel indicator: glows green for signal present at the left output and changes to red for any overload condition.

c right channel indicator: same as left indicator, but for right channel.

d load impedance adjust indicator: lights when the left channel load impedance is less than 5¼ ohms at a few watts output to indicate the need for adjusting the rear panel load switch.



Rear Panel

a right speaker output: connect the right channel loudspeaker here with the lead corresponding to the + (i.e., +, Hot, Red, or, for example, 8 ohm) speaker connection to the top, red, banana jack; and the lead corresponding to the - (i.e., -, Ground, or 0) speaker connection to the bottom, black, banana jack.

b load impedance adjustment: set for the nominal impedance of the load. Use the upper position for 8-16 ohm loads in stereo (16-32 ohms in bridging mode), and the lower position for 2-4 ohm loads in stereo (4-8 ohms in bridging mode).

c stereo/mono switch: use with the button *in,* flush with the panel, for stereo, and *out,* protruding, for mono, bridging mode. Consult pages 12 and 13 for instructions on bridging connections.

d inputs: connect the output of the preamplifier or other volume-controlled signal source to these jacks, oberving correct left/right orientation. For the bridging mode, connect to the input marked L or mono only.

e fuse: replace only with the proper fuse should the power indicator fail to light with the power applied. For 120Vac power line voltage, the proper fuse is 4A—250V AGC; for other line voltages, consult the label on the bottom of the unit for the proper fuse.

f left speaker output: connect the left channel loudspeaker here following the same procedure as for the right channel.

g AC line input: connect the plug to a switched source of power such as the switched outlets on the back of the Apt/Holman Preamplifier.

Installation

The location of the Apt 1 relative to other components has been made relatively uncritical through the use of a low-external-hum field power transformer and through the chosen method of ventilation. Since the power amplifier radiates a minimum external hum field, and is designed to be immune to most externally induced hum or other interference, and since the ventilation occurs through the ends of the chassis, it may generally be stacked on or adjacent to most other audio components. However, the external hum field in relation to certain other equipment and the ventilation requirements may preclude some stacking arrangements.

Power amplifiers, of necessity, do have greater external magnetic hum fields than do other components due to their high power requirements. The hum field of the Apt 1 has been kept espcially small through the use of a special U-I lamination power transformer.

Nevertheless, some components, particularly tape recorder playback heads and phonograph cartridges along with their associated wiring, are very sensitive to magnetic hum induction.

If you encounter difficulty with hum in your system, consult the section *Dealing with Hum and RFI,* page 19.

Ventilation of virtually all power amplifiers is an important consideration in their installation. The preferred orientation of the Apt 1 is with the grille work on top: this permits the unobstructed flow of cooling air over the internal heat-dissipating fins.

Cool air enters through slots in the bottom of the chassis, flows over the heat-dissipating fins, and exits at the top and sides through the grille work at each end of the chassis.

Serious constriction of the air flow, combined with a fairly high output power requirement from the amplifier, will lead to the activation of a gain-reduction circuit which prevents overheating, while still keeping the amplifier in service, albeit at reduced levels.

Rack Mounting Ventilation
The cooling is designed so that the amplifier may be safely installed in a rack mount configuration. Air can flow vertically between the walls of the equipment rack and internal walls formed by equipment located above and below the amplifier.

In such an installation, *ensure that the majority of grille work area on both ends of the chassis and the slots on the bottom of the chassis remain unobstructed by equipment located above and below the amplifier.*

Such a configuration was chosen since it provides good ventilation, while still allowing access to the rear panel mounted inputs, outputs, and switches.

Input, Output, and Power Connections

Make all connections in any high fidelity system with the power to all components off to prevent possible damage to loudspeakers.

Input Connections for Stereo

Connect the output of the preamplifier or other volume-controlled signal source to the input of the Apt 1 using the cable pair supplied.

If you need longer cables, Apt provides the Model 101 cable set (a pair of 30-foot cables) as an accessory at low cost.

Connect the left channel of the signal source to the left channel of the Apt 1, and the right channel to the right input.

Note that "left" and "right" are designated according to a view from the *front* of the unit, thus the rear panel may appear backwards at first glance, but this layout corresponds to the majority of equipment.

When using red/black stereo cable pairs, it is customary to use the black cable for the left channel and the red cable for the right channel (*red = right*). When using two identical cables, it is good practice to band *one* with colored tape near each connector to prevent interchange of the channels.

Output Connections for Stereo

Connect the left channel output of the Apt 1 to the left loudspeaker and the right channel output to the right loudspeaker.

"Left" and "right" are defined by convention as the loudspeaker to your left and right respectively as you *face* the stereo sound field.

Observe signal polarity. This means that the red output terminal from each channel of the amplifier must be connected to the loudspeaker + input (marked "+," "Hot," "Red," or, for example, "8 ohms") while the black output terminal must be connected to the loudspeaker – input (marked "–," "Black," "Ground," or "0").

It is essential to maintain polarity since errors will lead to partial cancellation of bass program material and to serious errors in stereo perception.

Use whatever means is available in the chosen loudspeaker cable to maintain polarity. Some cables will have color-coded insulation; others will be color-coded by the color of the actual conductors; still others will have a single or multiple ribs down one side.

Absolute polarity as well as "phasing the channels" can be sonically important. The Apt 1 has identical polarity at input and output terminals, i.e., a positive-going signal at the input will produce a positive-going signal at the output.

For an unambiguous test of loudspeaker "phasing," a listening test consisting of placing the loudspeakers so their front edges are face-to-face will produce considerable bass energy when properly wired, and very little bass energy when improperly connected.

Use adequate gauge cable. AWG 16 wire in the form of "Zip Cord" which is available in most hardware stores is adequate for most installations requiring 20 feet or less cable to each speaker. For longer cables, or lower impedance loudspeakers, consult the table below for choice of wire gauge.

AWG	20	18	16	14	12
ohms	Cable Length in feet				
2	2	3	5	8	12
4	4	6	10	16	25
8	8	12½	20	32	50
16	16	25	40	64	100

This table is based on a damping factor of 50 with the cable length given in feet. For other damping factors, multiply the lengths given by 50 divided by the desired damping factor. To obtain the cable length in meters, multiply the entries in the table by 0.305.

Specialized loudspeaker cables are usable with the Apt 1 amplifier. Perhaps the most important application of such cables is in the rejection of RF interference in particularly difficult situations. For recommendations on such cables, see the section *Dealing with Hum and RFI,* page 19.

The output banana jacks are of the "5-way" type, that is, they may be used with bare wires, spade lugs, single banana plugs, dual banana plugs, or instrument tip plugs. The jacks are on ¾" centers.

If using bare wire, be certain that no strands of wire cross over from one jack to the other—even microscopic strands of wire will cause a serious short circuit which will activate protection circuitry including the possibility of blowing internal fuses. The best way to prevent this when using stranded wire is to securely twist all of the strands together and insert them in the holes provided in the sides of the jacks. If the wire is too heavy to go through the hole, wrap all of the strands around the metal post in a clockwise direction and tighten. Make certain that during tightening the strands are not pushed out from under the cap.

It is good practice to "tin" the wire leads (using a minimum of solder) to prevent individual strands from causing short circuits.

Input Connection for Bridging Mode

The Apt 1 may be used in a "bridging" mode to produce a monaural amplifier of effectively double the power output capability while leaving the other specifications of the unit unchanged. The bridging mode makes use of both halves of a stereo amplifier by inverting the polarity of one half and strapping the loudspeaker between the two positive outputs of the amplifier.

Thus the loudspeaker is driven both positively and negatively, and the gain is effectively doubled.

Make a connection for bridging operation to the input jack marked "L or mono."

The jack marked "L or mono" is to be used irrespective of whether the amplifier is used for the left or the right channels of a dual amplifier system.

(A rear-panel-mounted pushbutton changes the mode of operation from normal stereo (flush) to bridging (protruding).)

Output Connections for Bridging Mode
Connect the *left* channel output red banana jack to the + terminal of the loudspeaker (marked "+," "Red," "Hot," or, for example, "8 ohms"), and the *right* channel output *red* banana jack to the – terminal of the loudspeaker (marked "–," "Black," "Ground," or "0").

Neither black output jack is used except for grounding the shield of a shielded speaker wire system.

Use one amplifier for the left loudspeaker, and another for the right loudspeaker of a stereo pair.

Observe the other connection instructions about wire gauge and use of banana jacks in the section *Output Connections for Stereo.*

Biamplification
In some systems, the audio-frequency spectrum is "split" into two or more parts by means of an electronic crossover. The Apt 1 is especially well suited for such applications since the Load Impedance Switch facility allows for optimization with different load impedances. Thus one Apt 1 could be used to power a pair of 8 ohm woofers while a second could be used to power a pair of 4 ohm tweeters.

Another advantageous system consists of two amplifiers operating in bridging mode to supply the woofers of a biamplified system, and a third amplifier operating in stereo to supply the tweeters. Such a system has marked headroom capability since the power output *requirement* of most program material is within the operating region of the woofer, which closely corresponds to the power output *capability* of this system.

When using a mixture of amplifiers in stereo and bridging modes, be certain to adjust for the 6 dB increase in amplifier sensitivity brought about by use of the bridging mode.

Power Connections
Connect the power cord to a switched source of AC power. Observe that the unit is wired for the line voltage appropriate to the power system on which it is to be used.

The Apt/Holman Preamplifier provides switched outlets on which the Apt 1 may be operated. If your preamplifier does not contain power switching, an outlet strip such as Waber® 15CB ("Waber" is a trademark of SGL Waber Electric) or Wiremold® 22T001 ("Wiremold" is a trademark of The Wiremold Company) available from electrical supply stores may be used to increase the ease of using your system by providing a central power switch.

Load Impedance Switch

This switch optimizes conditions in the power supply of the amplifier so that it may deliver an unusual amount of headroom in 8-ohm loads *and* high continuous power ratings into lower impedance loads.

Usually, these two requirements call for diametrically opposed design solutions. The Apt 1 does not suffer from such a trade-off since the Load Impedance Switch permits tailoring for specific conditions.

Set the switch for the nominal load impedance rating of the loudspeaker. Use the upper position for 8–16 ohm rated loads (16–32 ohm loads in bridging mode) and the lower position for 2–4 ohm rated loads (4–8 ohm loads in bridging mode).

When two loudspeakers are in use per channel, it is generally the best practice to operate them in *parallel,* with the + terminals of the loudspeakers connected together to the red amplifier output jack, and similarly, the – leads connected together to the black amplifier output jack (or, in bridging mode, to the red right channel output jack).

The only proper usage of a *series* connection is for wiring multiple *identical-model* loudspeakers together. Otherwise, the impedance variations with frequency of a loudspeaker would affect the source impedance and thus the response of another loudspeaker in series with the first. The series connection can be useful, however, when many identical loudspeakers need to be used. Under such conditions, a combination of series and parallel wiring is definitely appropriate.

For a series connection the wire is run from the red amplifier output jack to the first speaker's "+" terminal, that speaker's "–" terminal is wired to the "+" terminal of the next speaker, etc., with the last loudspeaker's "–" terminal returned to the black amplifier output jack (or to the right channel red jack for the mono condition).

When using multiple loudspeakers, either in parallel or in series, the correct switch setting is determined by the equivalent load impedance. In parallel, two loudspeakers of identical impedance produce one-half the equivalent load of the rated impedance; in series, two loudspeakers of identical impedance produce double the equivalent load impedance.

It is usually not good practice to connect multiple loudspeakers, either in series or in parallel, of markedly different types: such practice usually means one speaker type will have greater sensitivity than the other and will thus dominate in acoustic output.

If the switch should be misset to the 8–16 ohm position and the *left* channel load is actually less than 5¼ ohms, and the power output required is more than a few watts, a front panel indicator will light, indicating need for adjustment of this switch. See the section *Load Impedance Adjust Indicator,* page 18.

This indicator may show need for adjustment even with an 8-ohm-rated loudspeaker. In such cases, although the loudspeaker manufacturer has rated the impedance at 8 ohms, substantial parts of the impedance curve probably drop below 5¼ ohms.

The rated impedance is a simplification of a loudspeaker's impedance curve, which may or may not characterize the actual impedance across the entire frequency range.

The formula to calculate the equivalent load for more complex combinations of impedance is

$$Z(\text{equiv}) = \frac{1}{1/Z1 + 1/Z2 + \ldots + 1/Zn}$$

where Z(equiv.) is the equivalent load impedance, Z1 is the impedance of the first loudspeaker, Z2 is the impedance of the second loudspeaker, and Zn is the impedance of the "nth" loudspeaker.

When the switch is changed while the amplifier is reproducing music, a short buzz may be heard. This is normal, non-damaging operation. If you wish to prevent such noise, change the switch only with the volume control of the system down.

Stereo/Mono Switch
This switch is arranged to be flush with the panel for the stereo mode of operation, and protrude through the panel for the bridging (mono) mode.

The switch engages an inverter stage, which accurately changes the polarity ("changes the phase by 180°") of the right channel while connecting the inputs of the two channels to the same source.

Thus, in the bridging mode, any input to the right channel jack is ignored and the input sensitivity is effectively doubled since each amplifier contributes to the gain.

Activate the switch, allowing it to protrude, to engage the bridging mode.

Operation/Front Panel

Power Indicator
The power light indicates that a source of AC line voltage is connected to the amplifier.

It will light immediately upon the application of power. The other lights in the display will not light until the protection relay has pulled in—about 5 seconds.

Signal Indicators
Each channel has a light emitting diode (LED) behind the display window. The LED will glow green for each channel whenever a signal beyond a low level is available at the output jacks.

With speakers properly connected and the LEDs showing green, an output should be heard.

The output level at which the lights begin to glow green corresponds to about 100 microwatts.

Overload Indicators
In the event a high level input signal overloads the amplifier in any way, the indicators will change color from green to red.

The overload detector consists of a "differential amplifier" which continuously tests the output of the amplifier for tracking the input. Any deviation from the tracking, linear condition will cause the overload circuit to trigger, whether the source is a voltage limitation (clipping) or a speed limitation (slew rate limiting).

The time constants of aural and visual perception have been given consideration in the design of the overload indicators. Thus, they better correspond with the perception of distortion than do other types of indicators, such as inadequately slow VU meters, or even instantaneous LED displays.

Occasional flickering of the overload indicator means that clipping distortion at the lower limit of audibility on specialized test signals is occuring, but flickering is not likely to correlate with audible clipping.

Reasons for this include the very fast and clean overload properties of the amplifier design and DC coupling of the amplifier.

Continuous lighting of the overload indicator means audible distortion is occuring.

The power output capability of any amplifier is finite and may not be great enough given the variations in loudspeaker efficiency and program material dynamic range. The Apt 1 has unusually large dynamic headroom, that is, the ability to play transients well beyond the rated power of the amplifier.

Nevertheless, under some combinations of circumstances, this power amplifier, *like all others*, may not have enough power for the situation. In this event, the best course of action is simply to reduce the volume by a few dB.

Since power output is a logarithmic function, doubling the power will make a 6 dB difference in Sound Pressure Level before audible distortion. The use of two Apt 1's in "bridging" mode will double the power capability of the system.

The overload indicators are direct coupled to the output and are connected before the output protection relay. The advantage of this arrangement is that they provide a first order troubleshooting guide.

If there is no sound from the amplifier and one (or both) of the channel indicators is glowing red, the likelyhood is that that channel has either blown an internal fuse or has failed.

Either of these conditions, although rare, will require attention from a qualified service technician.

Load Impedance Adjust Indicator

This indicator light shows that the left channel load impedance has dropped below 5¼ ohms when the rear panel Load Impedance Adjustment switch is set to 8–16 ohms (similarly, the light means the load impedance has dropped below 10½ ohms for the bridging condition). A steady indication during mid-bass passages means that the load impedance, despite the loudspeaker manufacturer's nominal rating, is in the range where the amplifier would be more effective set to the 2–4 ohm setting (4–8 ohms for the bridging condition).

Dealing with Hum and RFI

The Apt 1 has been designed with special regard to immunity from hum and radio-frequency interference problems. Tests under exceptionally severe real-use conditions have demonstrated the success of this design approach. So in nearly all cases audible hum or radio interference will be found to have a cause external to the amplifier and can be treated or cured without making internal modifications to the amplifier itself.

Hum

Sixty Hz hum and its harmonic components (of course, this would be 50 Hz hum when working on 50 Hz power lines) are most likely to arise in low-level stages. To test whether hum is actually originating in the power amplifier, or in preceeding parts of the system, with the power off, disconnect the power amplifier's inputs. Restore power and see whether the hum has disappeared. If it has, the problem is originating in earlier parts of the system.

The most frequent cause of hum in high fidelity systems is poor connecting cables, either because of a plug making poor contact or because either the signal, hot lead, or the ground lead has opened. Be certain to check for these causes of hum before proceeding to get service on the amplifier. An ohmmeter can be used to check cables to make sure that the signal lead (terminating in the protruding central probe at each phono plug) and the cable shield (connected to the plug's skirt at each end of the cable) each makes a good low-resistance connection from one end of the cable to the other. Intermittant connections can sometimes be revealed by wiggling the cable where it is molded onto the plug.

So-called "ground-loop hum" may be cured by experimenting with the orientation of AC plugs in the sockets; starting with the power amplifier and working backward toward earlier stages in the system, reverse each AC plug in turn and leave it in the orientation which produces the least hum. Another source of ground-loop hum is the *inappropriate* use of grounding wires to connect stereo components. In most installations the best grounding involves the *least* grounding. Ground the preamp's chassis to a true earth ground (which, depending on the construction of your home, may be some, all, or none of the following: the *third* (ground) hole in an electrical outlet, the screw that holds the cover plate of an electrical outlet *(for these types of ground, be absolutely certain to avoid short circuits with either side of the AC line)*, a steam-radiator, or a cold-water pipe. If the turntable is equipped with a separate grounding wire, connect it to the ground post on the preamp. All *other* components in the stereo system should be self-grounding through the shields of their signal cables. Adding extra grounding wires from chassis to chassis is likely to make hum increase rather than decrease.

The Apt 1 has been designed for especially low radiation of external hum fields through the use of a U-I lamination transformer which largely contains leakage flux. Nevertheless, some field exists which could interfere with especially sensitive components such as tape recorder playback heads and phonograph cartridges.

It is interesting to note that the moving-coil type phono cartridge is frequently more sensitive to magnetically-induced hum than the moving-magnet types.

For this reason, should you encounter hum in such components, one possible source is the transformer in the power amplifier. Try moving the signal source away from the power amplifier, and try changing the orientation between the source and the amplifier.

Note that even the power transformer associated with direct-drive type turntables can be a source of magnetic hum fields to sensitive, moving-coil cartridges. In order to find the actual source of hum, it will be necessary to play detective and eliminate each possible source by, for example, disconnecting the power source to the turntable to check its contribution to the hum output.

Radio Frequency Interference
Interference from Citizens Band and other radio-frequency transmitters is a wide-spread problem for which there is no simple prescription. Since the internal circuitry of the Apt 1 is unusually resistant to RF interference, we will look at some of the common external causes and treatments.

The first determination to make is whether the RF interference is being picked up in the power amplifier, or in previous parts of the system. For this test, a pair of shorting plugs is useful to short the input of the amplifier. Such plugs are available from Apt as the Model 103 Plug Pair.

Turn off the power to the amplifier and remove the input cables, replacing them with shorting plugs. Restore power and see if the RF interference has disappeared. If so, the amplifier and speaker connections are absolved, and the problem must lie in earlier parts of the system.

If the interference does not disappear, the most likely source is the loudspeaker cables picking up interference and returning so much of it to the amplifier that the amplifier is detecting it and returning the signal to the loudspeaker as audio (usually distorted).

The best cure for such interference is therefore a well-shielded cable with the shield wire grounded at the power amplifier black speaker connection (only).

Recommended cable types for such installations are Belden 8719 (16 gauge), 8720 (14 gauge), and 8718 (12 gauge) or similar types offered by other manufacturers.

In system terms, the principal cause of RF interference is usually inadequate shielding in the various interconnecting cables. So-called shielded cables are not all equal. They vary widely in the effectiveness of their shielding. Many inexpensive audio cables employ only a spiral-wrapped shield. A cable with a braided shield is usually better, but these vary greatly from brand to brand in the tightness of the braid and in the amount of overlap in the shield wiring. More effective yet, where low capacitance is not a factor, is foil-shielded cable which provides 100% shielding. Finally, there are special cables marketed with double and triple shielding which, though costly, may be the only cure for really severe cases of interference where powerful transmitters are located nearby.

Proper system grounding may also improve the system's immunity to RF interference, since it improves the general effectiveness of shielding, and cleaning and tightening all contact points in the signal path may eliminate the "diode rectification" which can occur at a slightly oxidized or corroded contact point—for example at a plug socket or at the tone arm headshell.

Sometimes a simple cure for RF interference proves effective—such as substituting better phono signal cables, or shortening the cables, or re-orienting them, or forming a loop of an appropriate size in the cable so as to de-tune the interference. Sometimes more drastic action is necessary—such as moving the stereo components to the opposite end of the house to get them away from your neighbor's CB antenna which is right outside your window—or convincing your neighbor to move his antenna to the far end of his house. Good luck!

In Case of Difficulty—Troubleshooting

Many problems people encounter in using good high-fidelity equipment are relatively simple in nature and require no more than a little logical detective work to be repaired or at least identified. Troubleshooting usually amounts to following signal paths through the equipment and discovering where a desired signal becomes lost or distorted. By using a block diagram of a system, a logical series of tests can be constructed in order to track down a failure.

For example, suppose we have no output from the right channel of a system. The first test one would perform would be to ascertain whether the no-right-channel condition applied to all the inputs. This broadly defines the defect, associating it with either a program source, or with the later stages in the preamplifier or subsequent equipment. For our example let us say that all inputs are affected by the no-right-channel condition. The next problem is to assign the problem to the preamplifier, the connecting cable, or the power amplifier. To do this, the power to the system is shut off, and the left and right channel cable connections are interchanged at the power amplifier input. The power is reapplied and we find that the difficulty has changed channels: the left channel is now dead. This absolves the power amplifier, and leaves the preamplifier and the connecting cable as suspects. We know that the cable now connected between the preamplifier's left channel output and the power amplifier's right channel input is good, so the next step is to try that channel of the *cable* between the preamplifier's right channel output and the power amplifier's right channel input.

The right channel now functions, so the difficulty must lie in one channel of the cable connecting the preamplifier and the power amplifier, and a new cable or a repair of the old one is required.

Any trouble-shooting procedure would include a check for loose cables and connectors. When checking cable connections, the safest procedure is to turn the power amplifier off in order to prevent speaker damage due to open ground conditions.

Many system difficulties turn out to be the result of simple switch mis-settings. Be certain to check for the obvious (such as a mute switch on a-preamplifier being engaged) before proceeding to the sophisticated. It is not a bad idea to return the system to its simplest state in order to check out a problem: switch out all external processors, plug in a common signal source such as phono, and see if music is heard. Problems are often solved simply by disconnecting all components in a system and methodically plugging them back together again.

The Apt 1 contains a kind of first order troubleshooting guide. The overload indicators are direct-coupled to the power amplifiers, so any disturbance of the amplifier, whether arising from overload or fault, will light the red indicator for the channel in which the overload or fault occurs.

A fault in an amplifier channel will probably cause a substantial DC output voltage. Such a condition will trip the protection relay, keeping DC out of the load.

Circuit Description/Philosophy and Execution

The design of the Apt 1 power amplifier grew out of a new analysis of why various amplifier designs do not sound equally good, why typical tests do not correlate well with audible performance differences, what a power amplifier should do, and what it should *not* do. Some of the specific design goals which evolved are as follows:

The amplifier is more suited to a wider range of load impedance than practically all other solid-state units. There are several reasons for this:

1. The power supply of the Apt 1 has an adjustment for the load impedance range. This prevents the usual trade-off between dynamic headroom for 8 ohm loads on the one hand, and the ability to driver lower impedance loads properly on the other.
2. The amplifier is designed to be electrically and thermally stable over the widest possible range of loads, including both resistive and reactive components of impedance.

The power supply adjustability provides the ability for the design to produce unusually large amounts of dynamic headroom, that is, the ability to deliver greater than rated power on musical transients.

Consonant with this ability to handle transients are several other features which have a similar goal as their reason for existence. The idea is that one principal reason for sonic differences among power amplifiers is their performance when stressed to their limits by the combination of large signals and complex load impedances.

Thus, no conventional safe-area limiting protection circuitry is employed since such circuits usually trigger at undesired times, producing premature limiting. Also, the reactance of the load impedance causes difficulties which may range up to serious "flyback" pulses, oscillatory behavior occuring while the limiting circuit decides whether or not to supply the load.

Also, true direct-coupled amplifier design is used, but not for the conventional reason given for doing so—minimizing phase shift. Although phase shift is indeed minimized, the phase shifts involved are considerably less than the threshold of audibility. However, AC-coupled designs suffer from the fact that any power amplifier will, almost certainly, be driven into clipping at least occasionally.

During the time that the amplifier is clipping, the feedback loop capacitor of an AC-coupled design does not receive as much charging current as linear conditions would predict. Thus, when the amplifier attempts to recover from the overload condition, the mis-charge on the feedback capacitor mis-biases the amplifier, and recovery is prolonged until the charge on the capacitor reequilibrates.

On Slew Rate and TIM
Slew-rate limiting, transient-intermodulation distortion, and power bandwidth limiting are manifestations of a distortion mechanism that depends on the speed with which a circuit can follow an input signal. In fact, nonarity can be introduced even before the 'speed limit' is reached. In addition, the slew-rate is affected by the amount of gain in a circuit, as well as by the overall power output capability of an amplifier.

For these reasons, a slew *factor* standard has been developed, showing available slew-rate *headroom* beyond the slew rate required to reproduce a 20-kHz sine wave at the full power output of an amplifier. This ensures that specifications will be comparable across the range of available amplifiers, of any power level, without misunderstandings.

The Apt 1 amplifier has been designed with an extremely high slew factor, ensuring that the most difficult of signals, even combined with the ultrasonic distortion products of the recording and playback processes for phonograph records, will remain completely undistorted. Thus, TIM is virtually impossible.

When used with the Apt/Holman Preamplifier, TIM becomes literally impossible, since the preamplifier contains an ultrasonic filter, which linearly limits the slew rate to a value less than that of the capability of the amplifier.

This high slew rate and lack of TIM have been obtained without the compromises which occur in some designs. The Apt 1 has low *static* distortions, such as total-harmonic distortion, while maintaining low *dynamic* - distortions, such as TIM.

The slew rate is also made to be very symmetrical through the use of a balanced drive structure in the amplifier.

Execution
The power amplifier stage employs newly developed circuits which combine to provide a set of unique capabilities.

The first stage is a Darlington-connected differential-pair with emitter current source and gain degeneration. This configuration was chosen from among the many possibilities for its combination of relatively high stage current with attendant high slew rates combined with a high input impedance and good thermal stability.

One side of the differential pair drives an accurate current mirror, which reflects the output of half of the differential pair downwards.

The second stage is driven unusually in both directions: up and down. Each half consists of a two-transistor cascode circuit. A cascode configuration is desirable in this stage since the voltage swings are quite large, and the stage should remain quite linear over the wide swing. Single transistors employed here would suffer from modulation of the collector-base capacitance, with open loop distortion consequences.

A number of diodes associated with each half of the driver stage form "Baker clamps" for each half of the output stage. These clamps ensure that the output stage is incapable of saturation, which improves the overload recovery time greatly.

The output stage consists of two triple-Darlington, complementary-etry common collector stages (usually called emitter followers). This configuration provides enormous current gain, so that load variations in impedance are reflected back to the gain stages at an exceedingly small level, so variations in the load impedance minimally affect the specifications of the amplifier.

The output stage uses newly-developed transistors with an unexcelled combination of speed and ruggedness. More devices of a larger size are employed than are conventionally used for such a power level. Each of these techniques leads to a need for a minimum of safe-area limiting circuitry.

The safe-area *detector* circuitry works much like the portion of safe-area limit circuitry which detects unsafe conditions in the output transistors. However, the detector is not used to interrupt the drive to the output as it is in a conventional circuit. Such an interruption can lead to indecision as the circuit decides whether or not to continue supplying a reactive load. This indecision is manifest as potentially destructive "flyback pulses."

Instead, the detector output is used to signal the output protection relay to disconnect the load. Such an event is postponed for as long as is possible by the very conservative approach to output stage safe area. Common-mode conduction from one output half down through the other half is prevented from reaching destructive levels by fuses in the B+ and B– power supplies to each amplifier.

Additional inputs to the relay protection circuit are a turn-on delay and DC detectors for each channel. The turn-on delay prevents thumps from arising from any part of the system during turn-on conditions from reaching the loudspeakers. The DC detectors test the output of each of the two amplifiers for DC and very-low-frequency AC content and disconnect the loudspeakers should any unsafe conditions arise.

Since the amplifier is direct-coupled, any offset at the input will be reflected as a larger offset at the output. To prevent the input offset from appearing at the output, a separate servo amplifier maintains DC conditions at zero at the output.

A voltage/current comparator measures the V/I relationship in the left channel and drives the load impedance adjust indicator in the event the load impedance drops below 5¼ ohms in stereo or 10½ ohms in the bridging mode. Such an indication means that the switch altering the power supply voltage/current relationship should be switched to the lower position.

The power supply is unusual in having the capability to alter the voltage and current relationship depending on the load impedance. Also, it is unique in using all of the transformer all of the time so that nothing is wasted in either mode of operation. A simple choice of taps on secondary voltages will not produce efficient operation in both modes: the chosen method does.

In addition, B++ and B-– voltages are developed separately from the B+ and B– in order to operate the low level stages of the power amplifier with minimum interaction with the power supply. Thus, the important driving stages are well isolated from the power output demands on the amplifier and "dual supplies" become unnecessary.

The display tests the output for small signals and lights a green LED for signals present at the output jacks. An overload detector differential amplifier triggers whenever the input and output of the amplifier do not track one another. This amplifier then suppresses the green LED and changes it to red to indicate overload. The time constants of detection and hold are set by psychoacoustic considerations to produce better correspondance with audible overload than other methods of indication.

In Case Service is Required/Warranty

After trying the suggested procedure in the section *In Case of Difficulty—Troubleshooting,* if the difficulty persists, service may be required. Apt Corporation and its authorized service facilities provide service during and after the warranty period. If you wish service from Apt Corporation, write or call for a Return Authorization, in order that your repair be processed promptly.

If you do return a unit to the factory for servicing, please copy and fill out the following questionnaire and send it packed with the unit. It will help us diagnose and correct your problem more quickly.

1. Briefly, what is the problem?

2. How was it noticed?

3. Which channel(s) is/are affected?

4. With which settings of the controls is the problem associated (stereo/mono, load impedance switch)?

5. Does the problem appear only after a long operating time or continuously?

6. Is the problem intermittant or continuous? How often does it recur—can you induce recurrance (e.g., by moving or tapping)?

7. Does the problem always appear under the same circumstances?

8. What did you do to try to alleviate the problem? How successful was it?

9. Do you have any further comments?

If, after service, you still encounter difficulty with your system, Apt will attempt to help you solve your system problems. Write or call Apt Corporation Customer Service.

The finishes may be cleaned with a soft cloth sprayed with a *small* amount of ammonia/water cleaner *(do not use an alcohol or petroleum based cleaner).*

The Apt 1 Power Amplifier Three-Year Limited Warranty

Apt Corporation warrants that each Apt 1 Power Amplfier is free from defects in workmanship and materials and will perform in accordance with its published specifications for a period of three years from the date of the original purchase. Any necessary adjustments or repairs will be provided at no cost to the purchaser. The warranty covers parts, labor, shipping cost from the service center to the purchaser, and if necessary, packing materials. The warranty is not transferable.

The owner's responsibilities are to use the amplifier in accordance with its written instructions, to return the enclosed post-paid warranty registration card within fifteen days of purchase, to provide transportation to the Apt factory or to the Apt dealer from whom it was purchased in the event servicing is required, and to provide proof of purchase if requested.

See Exclusions, next page.

Exclusions: The warranty does not cover malfunction due to electrical, mechanical, or other abuse; nor malfunction due to disassembly and attempted repair by anyone other than Apt Corporation or its authorized service agents; nor shipping damage (which is covered by the carrier: you should ship the unit insured and well-packed; nor to units in non-consumer (i.e., commercial, business, or institutional) use, nor to units whose serial number has been removed or obliterated. The warranty applies only to the Apt 1 Power Amplifier and does not cover consequential damage to other equipment or property arising from a malfunction of the Apt 1 Power Amplifier. (The laws of some states do not permit the exclusion of incidental or consequential damages, so the latter limitation may not apply to you.)

Technical Data

1.0. General

1.1. The outside dimensions of the case are 3.12 × 16.90 × 10.19" (8.66 × 42.93 × 26.54 cm). Connectors and cables require up to an additional 1.75" (4.44 cm) depth from the rear surface. The unit weight is 22 lb (10 kg).

1.2. The front and rear panel finish is instrumentation gray baked polyurethane enamel with permanent baked-epoxy white markings; the cover finish is neutral gray wrinkle baked enamel.

1.3. Input power line voltage is 120 Vac nominal. Internal rewiring for operation on nominal 100 Vac or on 220–240 Vac may be made by a qualified service technician. Any line voltage may be supplied at 50 Hz or 60 Hz power line frequency. "Brownout" conditions will result in reduced power output capability, but other aspects of performance remain unaffected down to 95 Vac (on the 120 Vac input, other line voltage inputs have proportional "brownout" performance).

1.4. Data are valid for the range 20 Hz to 20 kHz unless otherwise noted.

1.5. Voltages in dBV are referred to 1.0 Vrms.

1.6. Outputs under test are loaded by 8 ohms unless otherwise noted.

1.7. The inputs and outputs are unconditionally stable under any conditions of source and load impedance.

1.8. The inputs and outputs have identical polarity, i.e., a positive-going signal at an input will produce a positive-going signal at the output.

1.9. We reserve the right to make changes as technical progress warrants; but we will not engage in capricious updating. Specifications are subject to change without notice. All specifications conform to the requirements of IHF Standard A-202; specifications to other standards, or where no standard is stated, are not comparable. *In particular, noise and distortion measurements are not comparable. N.B.: The reference level for noise measurements is 1 watt and not the more commonly employed full rated output of the amplifier.*

2.0. Levels, Gains, and Impedances

2.1. The input sensitivity for 1 watt output is 90 mVrms; for 100 watts it is 925 mVrms.

2.2. The input impedance is 50 kohms in parallel with 100 pF.

2.3. The low-frequency damping factor is greater than 200.

3.0. Power Output Ratings

3.1. The continuous average power output per channel with both channels driven is greater than 100 watts per channel in either 4 ohm or 8 ohm loads, greater than 150 watts per channel in 2 ohm loads, and greater than 65 watts per channel in 16 ohm loads at less than 0.03% total harmonic distortion for 4 to 16 ohm loads and less than 0.05% for 2 ohm loads.

3.2. The dynamic headroom at 4 or 8 ohms is 3 dB; at 2 ohms it is 2 dB; at 16 ohms it is 1 dB.

3.4. The transient-overload recovery time is instantaneous.

3.5. The reactive load rating is +3 dB.

3.6. The capacitive load rating is from zero to 1 μF.

4.0. Amplitude and Group Delay Response vs. Frequency

4.1. The frequency response is within +0 -0.5 dB, dc to 30 kHz.

4.2. The group delay response with respect to frequency is less than 3μ sec, dc to 20 kHz. The differential group delay between channels is less than 300 nsec.

5.0. Distortion

5.1. No one distortion test fully characterizes all known distortion mechanisms. Therefore, a combination of tests is necessary to reveal all forms of distortion, including both static and dynamic types. It has been shown that the combination of T.H.D., S.M.P.T.E. (60 Hz and 7 kHz) I.M., I.H.F. (Difference-Tone) I.M., and T.I.M. tests will be maximally sensitive to the widest possible range of distortions.

5.2. All distortion measurements (with the exception of ones which require greater bandwidth) are made with a Hewlett-Packard Model 3580A Spectrum Analyzer. Distortion measurements made with notch-type distortion analyzers will be inaccurate compared to spectrum-analyzer measurements since they null a chosen frequency and measure the residue in the system under test, whether that residue is distortion or noise. Also, most such distortion analyzers use an average-reading voltmeter to measure the residue. Average-responding voltmeters are inaccurate on any but single sinusoid waveforms, therefore they are inaccurate when reading a mixture of sinusoids (the distortion components 2f, 3f, . . .).

5.3. A total-harmonic distortion test consists of applying a pure sine wave to the input and examining the output for the presence of distortion products at 2f, 3f, ... The total harmonic distortion at rated output and lower is less than 0.03% for 4 to 16 ohm loads and less than 0.05% for 2 ohm loads.

5.4. A S.M.P.T.E.-intermodulation-distortion test consists of applying to the input 60 Hz and 7.0 kHz sine waves mixed with an amplitude ratio of 4:1 and examining the output for intermodulation products spaced at 60 Hz intervals about the 7.0 kHz tone. The distortion percentage is the rms sum of all such sidebands compared to the amplitude of the 7.0 kHz sine wave. The S.M.P.T.E. I.M. distortion at rated output level or lower is less than 0.03%.

5.5. An I.H.F. difference-tone-intermodulation test consists of applying to the input two high-frequency sine waves mixed with an amplitude ratio of 1:1 and examining the output for the difference product at $f_2 - f_1$. The distortion percentage is the ratio of the distortion products compared to the amplitude of the sum of the high-ency sine waves. With 19 kHz and 20 kHz mixed 1:1 at rated output level or lower, the difference-tone intermodulation is less than 0.01%.

5.6. A transient-intermodulation-distortion (T.I.M.) test consists of applying to the input a symmetrical square wave at 3.18 kHz and a 15 kHz sine wave mixed with an amplitude ratio of 4:1 peak-to-peak, low-pass filtered at 6 dB/octave above 100 kHz (T.I.M. 100), and examining the output for the presence of any intermodulation products in the audio band. The T.I.M. 100 distortion is less than the measurement residual of -84 dB (0.006%) at rated output level or lower.

5.7. All stages meet the Jung-Stephens-Todd criteria for negligible measurable and audible slewing-induced distortion. The criteria is that the amplifier have a linear-transconductance input stage, symmetrical slewing, and adequate speed.

5.8. The slew factor is a measure of the amount of slew rate headroom beyond that required for a full-power 20-kHz sine wave. The slew factor is greater than 10.

6.0. Noise and Crosstalk

8.1. Unless otherwise noted, all noise measurements are made with a with a true-rms-reading audio noise meter with psychometric weighting for the annoyance value of noise to the listeners.

6.2. The output noise with a standardized input termination of 1 kohm is less than 80 dB below 1 watt.

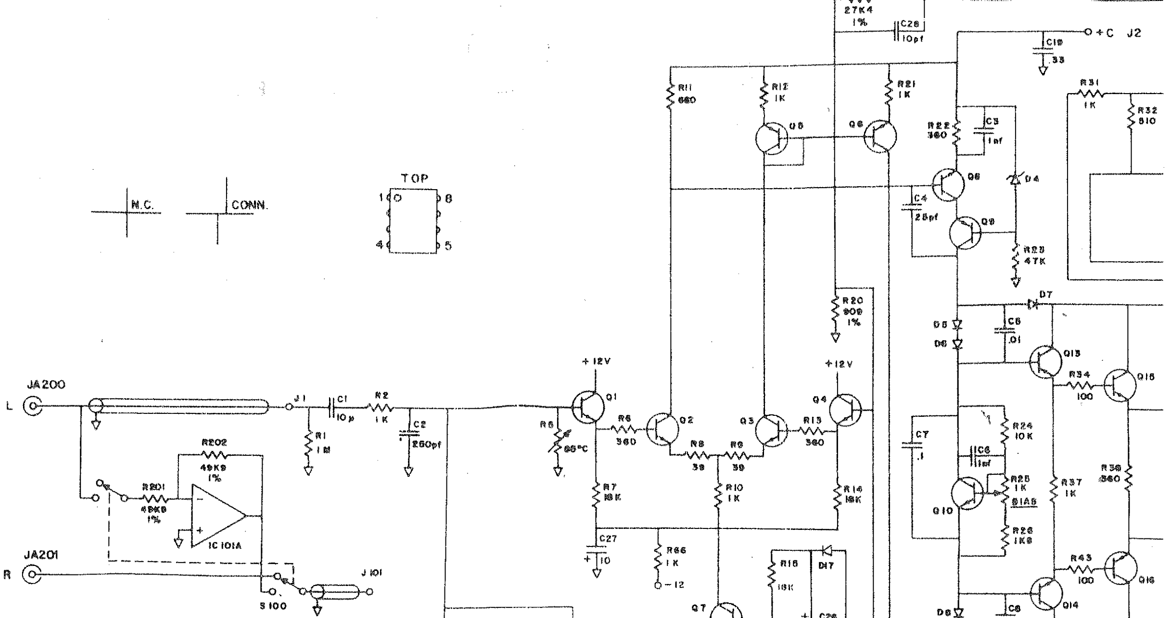
6.3. The 60 Hz hum components and its harmonics are below the weighted noise spectrum level. The radiated hum field as measured with a Perfection Mica pickup and a true-rms voltmeter is less than 2 mVrms at 2" from the amplifier to the reference mark on the pickup.

6 4. Crosstalk between the channels is less than 70 dB at 1 kHz and 50 dB at 20 kHz.

7.0. Dynamic Range

7.1. It follows from the data above that the output dynamic range is in excess of 103 dB. This means that the full dynamic range of any medium now available or contemplated is exceeded, including the forthcoming digital media.

apt /'apt/ *adj* [ME, fr. L *aptus*, lit. fastened] *1.* Suited to its purpose, becoming, appropriate, 1563.
2. Keenly intelligent, quick-witted, 1710.
3. Fitted, fitting, 1791. *4.* Ideally suited to its purpose, I978.



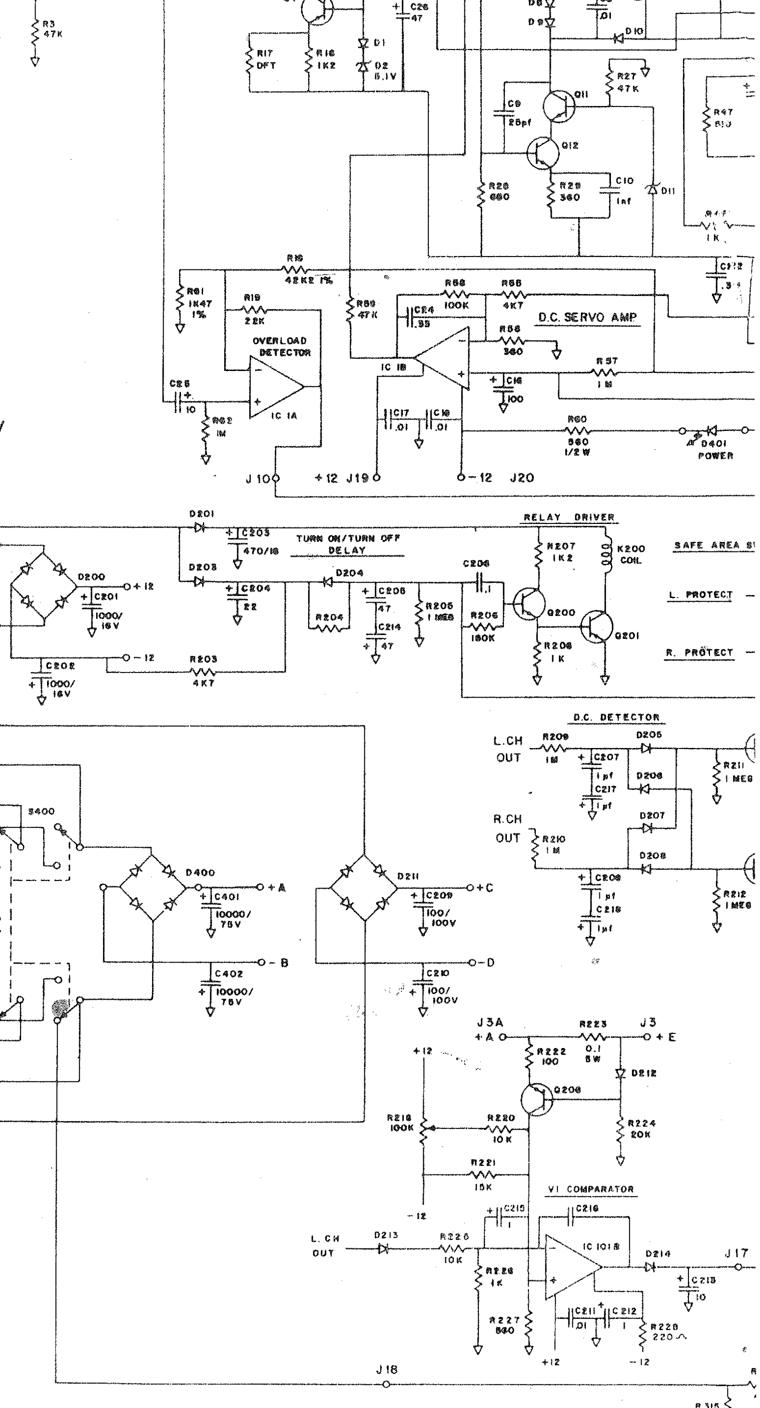
Primary Connections: For 100 Vac 50/60 Hz: connect B to F; connect A to E; connect power line from A to B; use 5A — 250V AGC fuse.

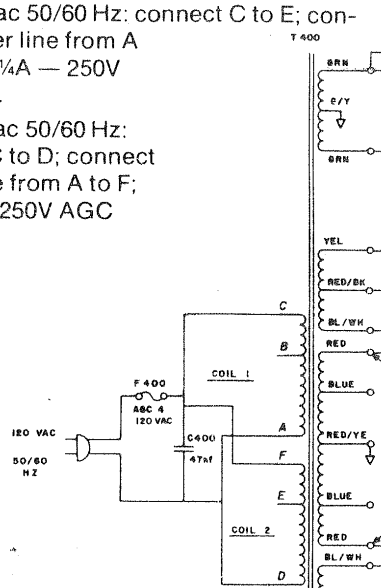
For 120 Vac 50/60 Hz: connect C to F; connect A to D; connect power line from A to C; use 4A — 250V AGC fuse.

For 200 Vac 50/60 Hz: connect B to E; connect power line from A to F; use 2½A — 250V AGC fuse.

For 220 Vac 50/60 Hz: connect C to E; connect power line from A to F;use 2¼A — 250V AGC fuse.

For 240 Vac 50/60 Hz: connect C to D; connect power line from A to F; use 2A — 250V AGC fuse.





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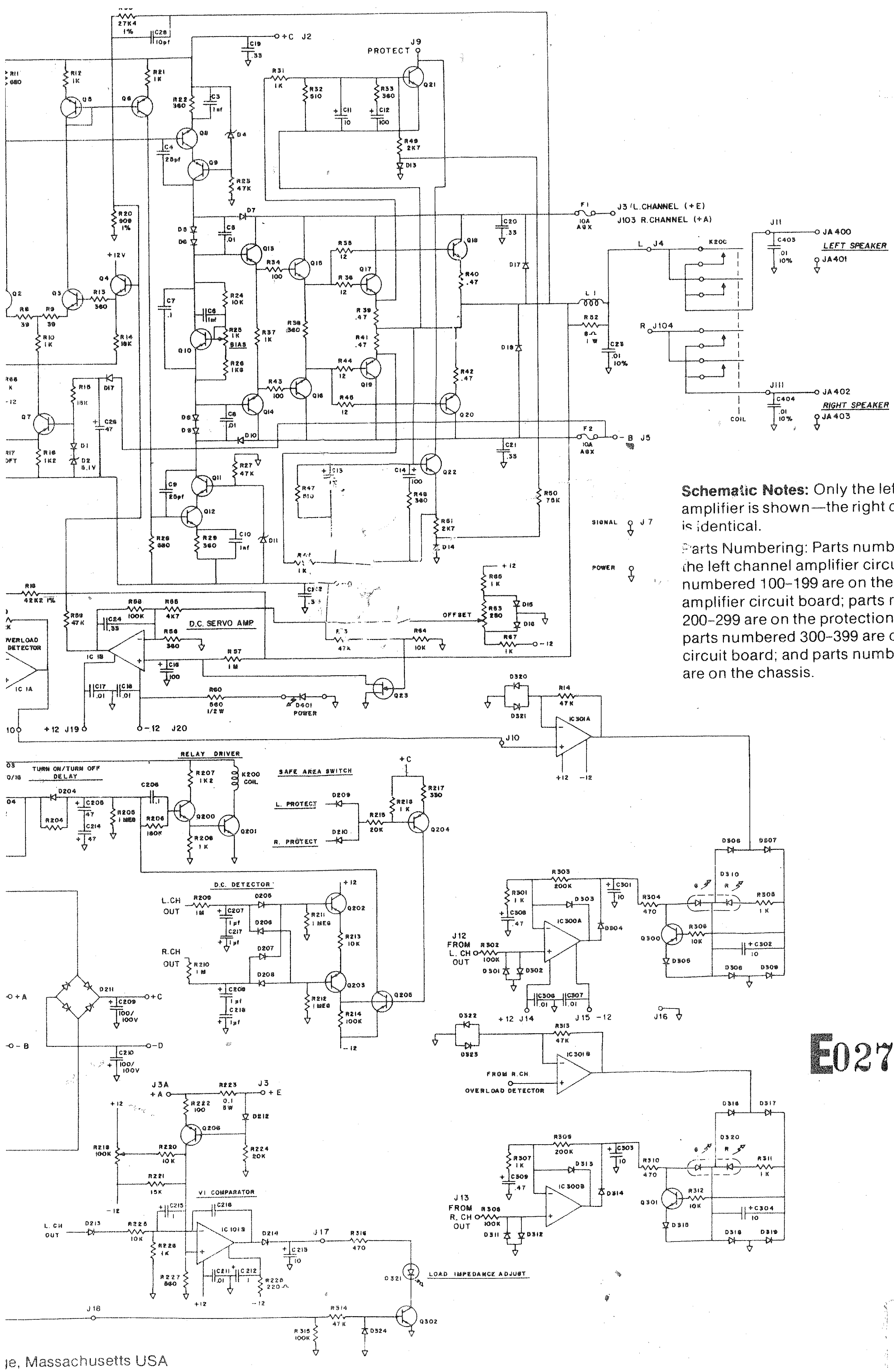

Schematic Notes: Only the left channel power amplifier is shown—the right channel amplifier is identical.

Parts Numbering: Parts numbered 1–99 are on the left channel amplifier circuit board; parts numbered 100–199 are on the right channel amplifier circuit board; parts numbered 200–299 are on the protection circuit board; parts numbered 300–399 are on the display circuit board; and parts numbered 400–499 are on the chassis.

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