Building Simplicity into the Hi-Fi System

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Interconnection of the many elements of a hi-fi system demands some clear thinking if complete satisfaction is to be obtained. In particular, the method of connecting a tape recorder in the system for most convenient operation is outlined clearly by the author.

HIGH-FIDELITY COMPONENTS for home entertainment systems have been developed in such numbers and variety that rigorous application of good over-all systems' design has been almost impossible. The popularity of high-fidelity equipment has increased at such a pace that designers of components of all kinds have been faced with the necessity of building in a sort of makeshift universality which made it possible, in general, for the purchaser of an assemblage of these components to plug together a system which would function, but usually at something less than optimum.

Too Many Knobs

The commonest defect of an assembled system is multiplicity of controls, many of which perform duplicate functions. The likelihood of imperfect performance is great when such systems are operated by people whose interest is mainly in the music, not in the equipment upon which it is played. Typically, a radio tuner will have on its face a control for the selection of FM, AM, Phonograph, Tape, TV, etc. It will also have a volume control. Frequently such a tuner is selected especially because it has *relatively* few controls, and is connected into an elaborate audio control box, which will possess phonograph inputs, phonograph equalizer controls, power switch, volume or loudness control (or both), and separate bass and treble tone controls. These control boxes are usually connected to power amplifiers which have, themselves, at least a gain control, and sometimes another set of tone controls and selectors. These are happily rare now that the basic "flat" amplifier is the norm. With a basic flat amplifier, adjustment of the main amplifier gain control is required only at the time of installation, and it is supposed to be set by the installer so as to provide correct gain for the audio control box with which it is used. There is a tendency for many users to adjust the power amplifier gain so that the control box volume control is rotated about one-third at comfortable room level. Those control boxes which contain loudness controls are usually contributing considerable "bass boost" at this rotation, and this effect is removed only when thunderous volume is being delivered into the living quarters by the equipment. The function of the loudness control should be to remove all artificial bass boost at a sound level equal to that which would be heard if the listener were in the room where the recording was made. Complete instructions on this adjustment are more and more being included in the Instruction Manuals which accompany high-quality equipment, and if the listener is so minded, the facility for proper functioning of his loudness control is at hand.

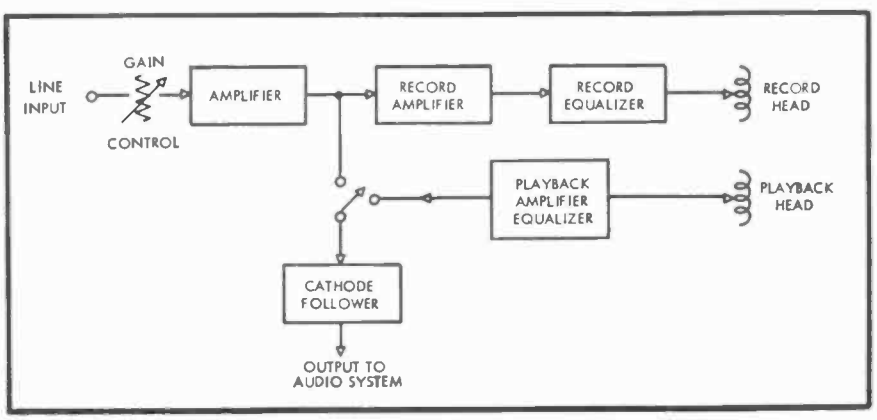

Fig. 1. Block diagram of a typical high-quality tape recorder designed for home use.

The Maximum Hum Control

But the handling of cascaded volume controls, one on the tuner and one on the control box, for example, is not so simple. The way is always open, if not for the high-fidelity enthusiast in the family who is responsible for the purchase and installation of the equipment, at least for other members of the family to adjust the equipment for maximum hum, or for maximum distortion. A tendency will be found, for example, to operate the volume control on the tuner at a medium setting, and then, upon interruption, for the listener to turn the volume down temporarily *at the audio control box*. Following the interruption, the listener may find it most convenient to raise the volume level again, *this time using the tuner control*. Thus, those amplifier tubes which follow the tuner volume control, may well be driven far into distortion, while the volume level of sound in the room is not particularly high, having been reduced by the control box knob. If the knob on the control box is a loudness control, this function will also be disturbed. On the other hand, if the procedure is reversed, and the level of sound reduced at the tuner, then later raised at the audio control box, the "maximum hum" situation will exist. The level of sound through those amplifier stages which exist after the tuner volume control, but before the audio control box volume control, may be sufficiently reduced as to be comparable to the internal hum level, and raising the amplification *with the control box knob* after *the unnecessary reduction* will result only in an *increase* of hum and unpleasantness. The remedy is, of course, to eliminate one of the volume controls, or at least to remove it to a screwdriver adjustment at the back of one of the components, and to leave in the hands of the listener only a single knob for the control of level. In this manner, adequate level in lines between components may be set at the time of installation, for the best compromise between low distortion and good signal-to-noise ratio. The difficulty of predicting what amplifier will be used with a tuner of given design is, of course, the reason for incorporating the control into the tuner in the first place. The thought was that it's better

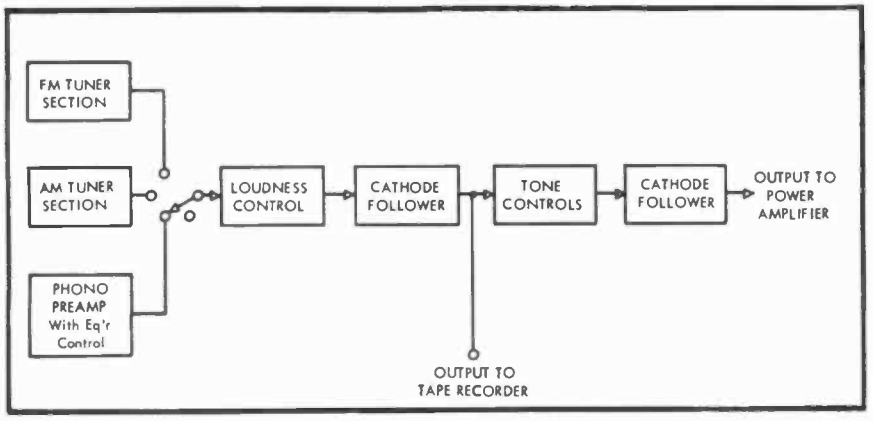

Fig. 2. Block schematic of one model of deluxe FM-AM tuner with magnetic phono preamplifier and tone controls.

to provide more controls than necessary, rather than to eliminate one which may be needed. But it was a bad thought.

Volume controls, as an industry practice, probably should be left off radio tuners, unless these tuners also incorporate phonograph preamplifiers and tone controls, and are intended to serve as complete control centers as well as tuners. If unnecessary controls are provided, the installer ought to remove them. More than one maunfacturer follows good practice in this, and others should, for the greater convenience of users and for less opportunity for unpleasant sound in the home. Only those few listeners who wish to eliminate all functions from their systems excepting radio, and who wish no tone controls of any kind will need gain control on the basic tuner. Those may be of sufficient technical skill to devise a convenient volume control for themselves.

"How Many Selectors?"

The duplication of selector controls appears to be a harder problem. On those radio tuners which are designed as an adjunct to an audio control box, there is no justification for the provision of anything other than an AM-FM control, possibly with broad and sharp positions on AM, and AFC or no-AFC positions. Incorporation of selector positions for phonograph, tape, TV, and other sound sources may appropriately be provided only on tuners which also possess magnetic phonograph pickup preamplifiers, and are designed to function as combined tuners and audio control boxes. The ultimate simplification in control is probably provided by those tuners which have been designed for two-channel stereophonic service, and bring each of the two outputs, AM and FM, to separate jacks, for delivery to the audio control box. Such tuners may readily be connected into audio control boxes so that selection of phonograph, AM, FM, tape, etc., may be made on one knob on the audio control box, and there only. Realistically, no selector controls other than those for AM or FM should be incorporated into tuners which are designed as adjuncts to audio control boxes, but only into the tuners which are designed as combined audio control centers and tuners. The very least which we should ask is that the knobs on the front panel of these tuners should be arranged so that if the a.c. switch and volume control are removed, the panel remains balanced and symmetrical. Many home high-fidelity system owners insist that all knobs be left on the panel, even though some are superfluous or rendered functionless, in order to preserve balanced appearance; it should be made possible to preserve both good appearance and good operation.

The Underfed Tape Recorder

As the high-quality magnetic tape recorder becomes a staple in the list of components in a high-fidelity home system, a provision for its incorporation in simple plug-in form becomes a necessity. The logical place for the incorporation of plugs which are intended to connect to the tape recorder input and output is in the audio control box, or into the tuner which is intended to function as an audio control center.

A block diagram of a typical high-quality magnetic tape recorder is shown in *Fig.* 1. In those recorders which use a common magnetic head as both record and playback, the selector switch is so ganged as to perform essentially the same function as that shown. Typically, the line input of the recorder presents a high-impedance load, which may be bridged across a number of available points inside the audio control system, and requires no more than 0.5 volts rms to drive the recorder to maximum record level. This is a simple requirement to meet, although consideration for it has often been omitted from commercial components. The output from a typical magnetic recorder is of low internal source impedance, and relatively high level, which will adequately drive any of many possible points in the audio control system.

There are several typical arrangements for tape recorder connection. *Fig.* 2 illustrates a widely sold deluxe FM/AM tuner with magnetic phonograph preamplifier and tone control, designed to function not only as a tuner, but also as an audio control center. At least four input jacks are provided, one of which is intended for tape. An output is also designated for connection to the tape recorder. The signal which is delivered for recording to the tape recorder is, unfortunately, unsatisfactory. The user may reasonably be supposed to be listening, over his loudspeaker, at the same time he is producing a tape recording. The tuner selector may, then, be set for FM, for example, the loudness control adjusted to comfortable level. The output to the tape recorder, then, located *after* the gain control, is extremely low in level, and is exaggerated in bass, because of the effect of the loudness control at these low listening levels. Typical peak voltages obtained from this array will measure around 50 millivolts. Not only does this provide inadequate drive for the recorder, but it also produces a tape which is artificially heavy in bass. The output to the tape recorder could hardly have been located at a worse position. So far as proper level and proper equalization for the production of a flat tape recording are concerned, the tape recorder jack might better be connected between the loudness control and the selector switch. A cathode follower would be advisable, of course, as isolation, and in order to assure that the load of the tape recorder and the capacitance of the interconnecting cable would not affect the over-all performance of the system, or of the recorder.

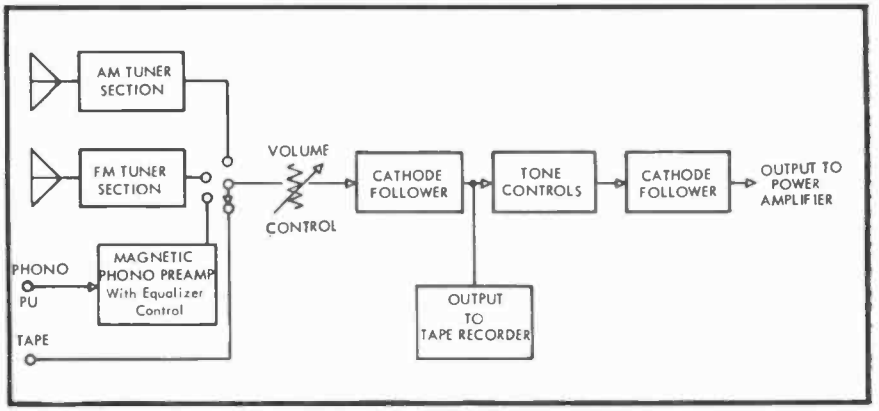

Fig. 3. Arrangement of popular-priced FM/AM tuner with phono preamp and tone controls.

The Case Of The Howling Tape Recorder

With the configuration of *Fig.* 2, however, still another source of unpleasantness for the listener is offered. Assuming that a recording has been made, the listener may now switch the selector control on his tuner to the fourth position, into which the output of the tape recorder has been plugged. Referring to *Fig.* 1, if the tape recorder selector switch has been left in the "record" position, a feed-back path is created from loudness control through cathode-follower to tape recorder input, to tape recorder output, to selector switch, to loudness control. The result is usually a loud howl. This effect can be avoided, of course, if the listener is careful always to turn his tape recorder switch to "playback" *before* he changes the position of his tuner selector control, but it would surely be good design to prevent so likely a cause for unpleasantness.

Figure 3 is of a lower cost tuner than that in *Fig.* 2. This unit does not have the fault of presenting to the tape recorder an artificially unbalanced signal, since the volume control is not a loudness control, but it does have the same fault as the tuner of *Fig.* 2 in being likely to be so used as to present a very small signal to the input of the tape recorder, due to the listener's having set his volume control for comfortable listening, rather than for adequate level for recording. This configuration also possesses, still, the possibility of feedback "howl."

Figure 4 outlines the configuration of a popular deluxe one-piece power amplifier and audio control box. In this case, the output to the tape recorder is of adequate *level,* but has been subjected to "tone control" whose purpose is primarily that of adjusting the sound for most comfortable listening, rather than for flatness. There is good reason for tone controls, of course. But a flat signal should nevertheless be presented to the tape recorder. Tone controls are for playback, and not for recording. It should be assumed that the listener will wish to adjust his tone controls, every time he listens, for conditions which exist at the moment, and which may not always be the same. To feed a signal through the same set of tone controls twice is to "double" the effect of the tone controls upon playback. On only one generation, with such a process, a 12 db-per-octave bass boost slope may be obtained, or a very sharp high-frequency cut-off be introduced.

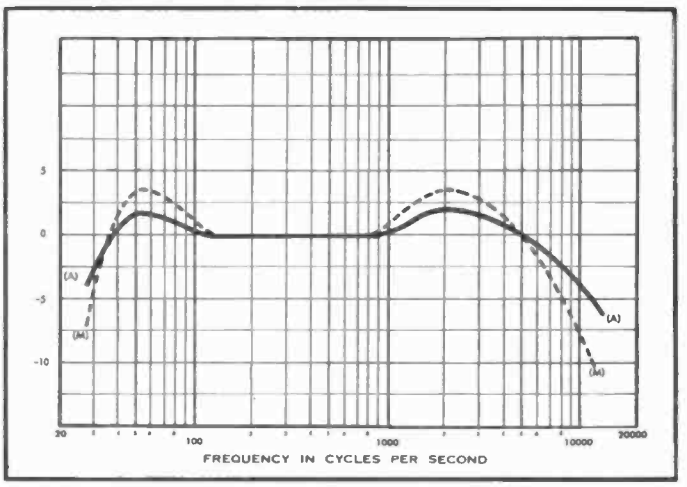

Fig. 5. Curves showing additive effect when signal passes twice through an amplifier which is not perfectly flat.

Double Dipped Tone Controls

Even if the "tone controls" are set at the "flat" position, which often is not marked accurately on the control panel, this position usually is a little off true flatness. Typical of the "flat" position on tone control systems is the curve shown at (A) in *Fig.* 5. This curve, it is true, is "± 2 decibels from 50 cycles to 8,000 cycles." But, suppose the tape, which has been recorded to this degree of "flatness," is now played back, through the system shown in *Fig.* 4. Even though the tone controls be left *unaltered,* the playback curve differs from flatness by twice the amount of Curve A, forming Curve M. This, flat now only by ± 4 decibels from 50 to 8,000 cycles, is sharply rolling off at both low and high frequencies, with severe "bumps" in response. Small deviations from flatness in the tone control system, which are entirely negligible so far as the original function of the controls is concerned, now become major sources of unpleasantness, which may be blamed upon the tape recorder, even though, in this example, the tape recorder was assumed to be perfectly flat in frequency response. If the tone controls had been set for only a little departure from the nominally "flat" position, the results would have been even worse.

Figure 6 illustrates a high-quality commercial audio control box which provides the tape recorder with a flat signal of adequate level. With this control box, the possibility remains for feedback, if the listener chances to select "tape" on the control box before switching the recorder to "playback," but all other considerations of good practice are observed. The general configuration of the commercial system in *Fig.* 6 is shown in *Fig.* 7. Great flexibility in the arrangement of loudness or volume controls, tone controls, sharp high or low cut-off filters, and so forth, may easily be designed without essentially changing this arrangement. Only the feedback problem remains.

High Fidelity Unlimited

Figure 8 shows an ideal configuration for incorporating a tape recorder into a high-quality home music system. Whether the arrangement for this connection is made in a tuner which is designed also as an audio control center, or in a deluxe audio control box is unimportant. The provision for placing the tape recorder in *series* with the circuit is the key to the removal of any possibility of feedback "howl." A low impedance-source signal to the tape recorder line should be provided—cathode followers work well. A jack should be provided for this output. If, then, *no connection* were normally provided between this and the jack which is to bring back the output of the tape recorder, the possibility for series insertion of the recorder exists. A simple jumper may be provided as standard equipment, to be removed when the tape recorder is installed. With this connection the tape recorder is either left on at all times when the system is being used, or the tape recorder may be provided with a means of automatically connecting its input to its output, directly, when the recorder is turned off. Such an arrangement is offered as standard equipment on some tape recorders which have been designed for home use, and is available as a factory modification on others.

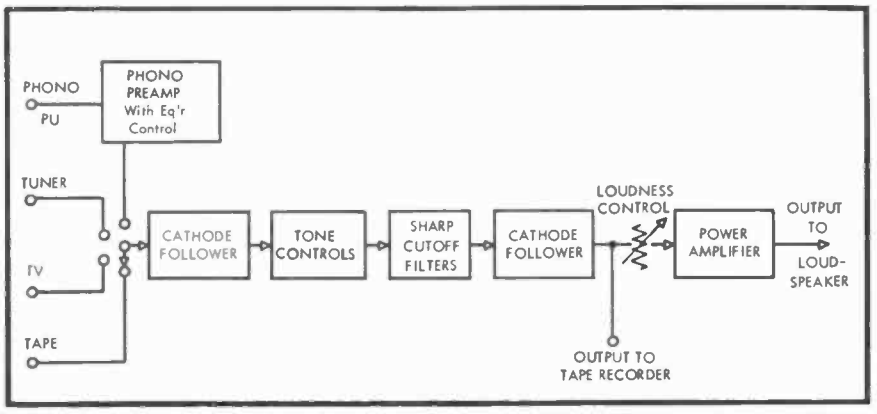

Fig. 4. Block diagram of deluxe one-piece power amplifier and audio control unit.

Hi-Fi Surgery

When the owner of a high fidelity system, on which he may have spent many hundreds of dollars, buys his tape recorder, it is too late for corrective action by the manufacturer of his tuner or of his audio control box. If the machine is to function well as a unit, some sort of "corrective surgery" is going to be needed. This may range from simply unsoldering one connection from its present location, and soldering it to a new one, all the way up to the incorporation of an additional tube, and the changing of several wires. None of these procedures is beyond the skill of a typical hi-fi technical enthusiast, but probably ought to be undertaken only by his serviceman if the listener is one of the many thousands of newcomers to the field whose interest lies mainly in the music and not in the knobs and gadgets.

A tuner like that illustrated in *Fig. 2* might be modified in either of two ways. A single wire will be found which leads from the jack marked "output to tape recorder" to a certain pin on one of the tubes. This wire may be unsoldered from the tube, and transferred to the selector switch, being soldered to that lug on the switch which represents the "rotor" or, if more convenient, to the "top end" of the loudness control. A more elegant solution would be to cut the chassis at a convenient point, to mount a new tube, such as a 6C4, in a tube socket, and to connect this newly added tube as a cathode-follower. The wire leading to the "output to tape recorder" jack would, then, be connected to the output of the cathode-follower, while the grid of the newly added cathode-follower would be connected to the rotor of the selector switch. Appropriate values for such a cathode-follower are shown in *Fig. 9*. Connection of the follower to the tuner's filament supply will probably present little problem, but the selection of an appropriate connection for the plate should be done most carefully. A point on the schematic diagram of the tuner should be found at which considerable "decoupling" has already been provided, and at which a large capacitor is already connected. The plate of any cathode-follower should be connected to a high-voltage d.c. source which is effectively "grounded" for audio signals. In most cases, it will be found that the follower will function well if its plate is connected to the same point as the high-voltage end of one of the plate resistors in a low-level audio amplifier stage.

If, in the case of a tuner like that in *Fig. 3*, no attempt is made to install a cathode-follower, care must be taken that the wire which carries the signal to the tape recorder is of the "low-capacitance" shielded type, and that the input impedance of the tape recorder is not so low as to "load" the volume control unduly. Otherwise, some distortion could occur, and if the wire were of high capacitance, the high-frequency response of the system could be impaired.

The audio control box illustrated in *Fig. 6* offers the possibility of simple wiring changes in order to effect the "series" configuration of *Fig. 8*. It is possible to lift the connection between the cathode-follower and the loudness

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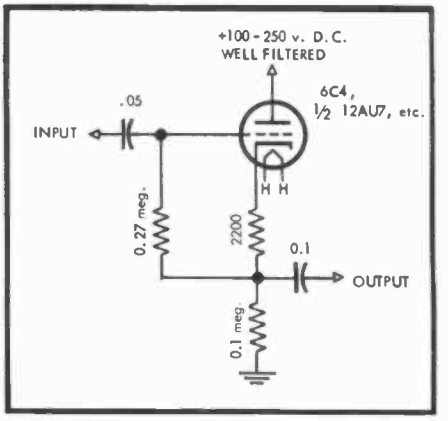

Fig. 9. Schematic of cathode follower stage which can be added to a tuner or control unit to provide suitable coupling to a tape recorder input.

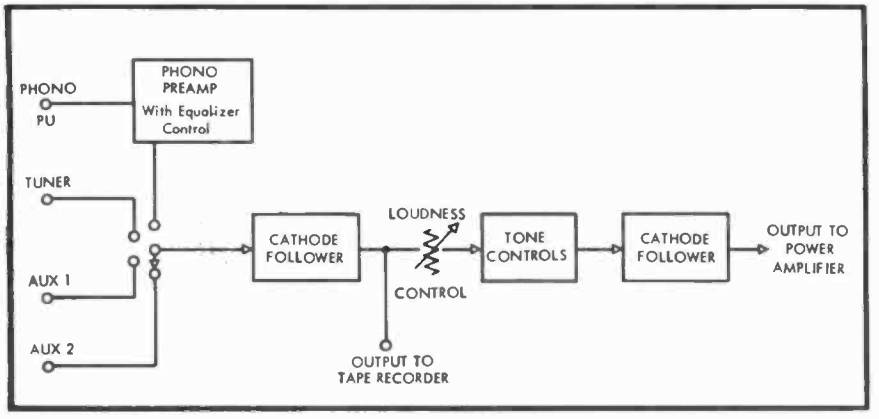

Fig. 6. Block schematic of high-quality commercial audio control unit.

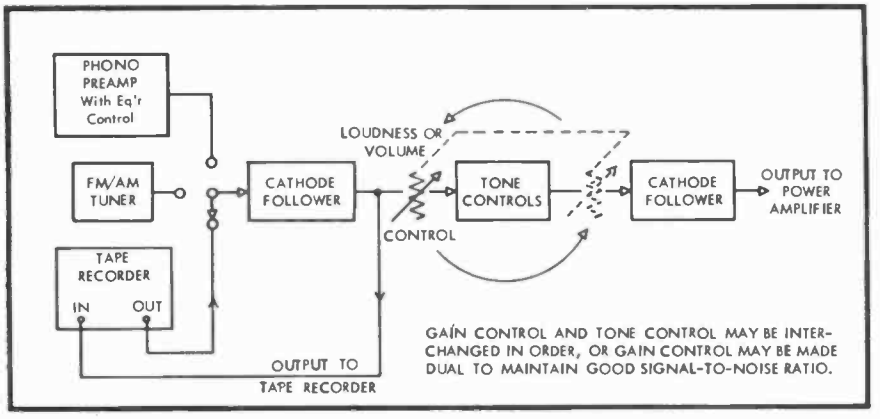

Fig. 7. General configuration for control box or tuner control system. Possibility of feedback is still present even with this arrangement.

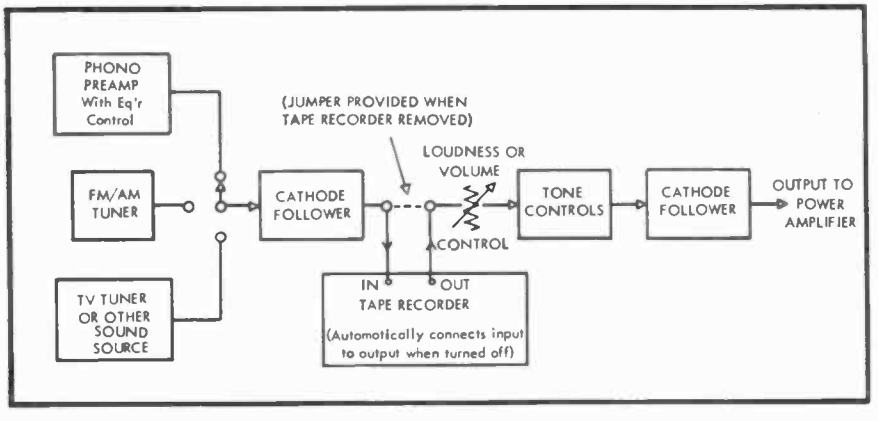

Fig. 8. Ideal configuration for incorporating a tape recorder into a high-quality home music system.

control, and to re-route the wire which carries the output of the cathode-follower directly to the "output to tape recorder" jack. One of the "AUX" input jacks may have its wire disconnected from the selector switch, and connected directly to the "loudness" control. New labels should be made, showing this last jack as the "tape control input" or such other language as suits the user. With these wiring changes, the cathode-follower output of the selector switch is connected directly to the input of the tape recorder, whose output is then connected directly to the volume control, tone controls, power amplifier, and loudspeaker. The recorder may then be turned on whenever the system is in use, so as to feed all signals through to the amplifier and loudspeaker, or it may be equipped with a switch which connects its input to its own output whenever the recorder is turned off, so as to be effectively out of the circuit except when in use.

A careful examination of the schematic diagram of any equipment to which a tape recorder is to be connected will usually reveal a point in the circuit where level is high, and not subject to variation with the volume control setting, and a point which has not been subjected to tone control. Usually, this point occurs immediately after the selector switch. If a cathode-follower happens to be in the circuit immediately following the selector switch, so much the better—the output to the tape recorder may then satisfactorily be connected here, rather than directly to the selector switch, provided the volume control was not placed earlier in the circuit than the point selected for the output to the tape recorder. Usually, this configuration will result in a system which can "howl" if the monitor selector on the tape recorder is set at "input" when the control box selector is set for "tape," but the system will be capable of making high-quality tapes, with adequate level, and with flat frequency response. "Howl" can be positively eliminated only by adopting the "series" type of connection for the tape recorder.