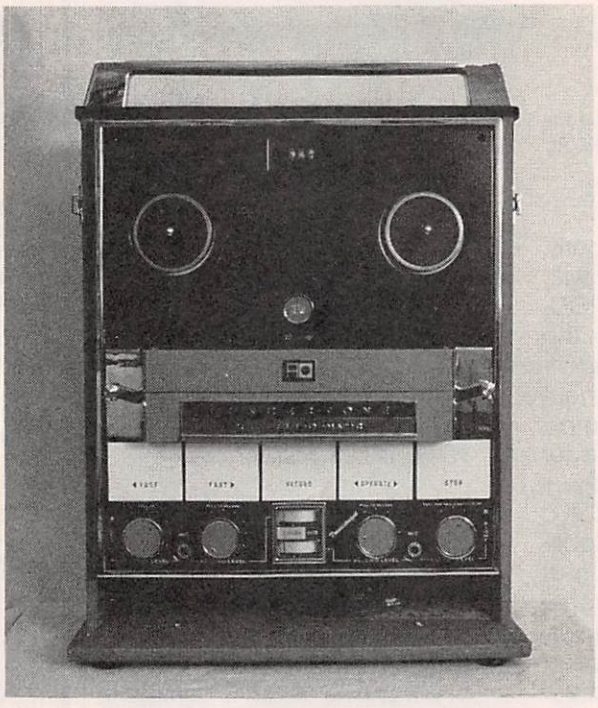
RESTORING A "REEL" RECORDER



Here's what you need to know and do to bring your open-reel audio tape recorder back to life.

PHIL VAN PRAAG

This month, we begin a series of articles about repairing and restoring audio tape recorders. Specifically, it focuses on vintage open-reel machines of the 1940s through the early 1970s—a time that saw explosive growth in the field in terms of both features and performance. Just as with the 'muscle cars" of the 1950s and '60s, the "big-iron" tape recorders—such as the ones shown in the beginning of this article and in Fig. 1—still draw head-turning attention, not only from the "Baby-Boomer" crowd, but from "post-Boomers" as well! In addition, when properly restored and tuned, these machines can still provide countless hours of enjoyment with all the clarity and response they provided when new.

Note: The material presented here and in subsequent articles is taken from the author's book *Evolution of the Audio Recorder*; details on that book, including ordering information, can be found in the "For More Information" box that is located elsewhere in this article.

The Dilemma. Pity the poor tape-recorder repair person of the 1960s or '70s, having to cope with a seemingly endless array of models and maladies, both electronic and mechanical. For the non-manufacturer-specific repair shop, it was especially tough, given the lack of key service manuals and repair bulletins. Even some of the so-called "simple" single-motor machines, such as the 1950s Webcor (an internal view of that machine is shown in Fig. 2), were a real challenge to repair. As if that weren't bad enough, let's "fast forward" to the present, where added to this situation is the age of most of these classic analog machines: from 20 to over 40 years old!

That unnerving fact adds a whole new level of difficulty if your goal is to get that old machine working again. Not only do you have to repair the original problem (the one that most likely sidelined it in the first place), but now you're faced with an extreme parts scarcity, deteriorated rubber components, dried up or seized bearings, frequently faulty capacitors, and, in most cases, a total lack of servicing information!

Well, never fear, as the purpose of this article, and the ones that follow, is to prepare you for this challenging task. And it is a task that is worthwhile as it can be most rewarding personally to breathe life back into these wonderful old "talk back" machines. Plus, when you're done, you will have both a useful tool and a valued keepsake.

We will explain the differences between repairs and restorations, let you know what test equipment you'll need, and then get into the restoration process itself. As you can see, we've a lot to do, so let's get started.

Repair vs. Restoration. All vintage tape recorders—irrespective of complexity or quality when designed and manufactured—require periodic maintenance. Rubber parts wear, harden, and otherwise decompose; vacuum tubes wear out with use; capacitors deteriorate over time; heads and other tape-path components become contaminated and gradually acquire permanent magnetism; grease sloughs off and becomes mixed with dirt; oil dissipates . . . sounds really bleak, doesn't it! Well, that is all part of the normal aging process, some of which occurs whether or not the recorder is used. Add to that the consequences of abuse, poor storage conditions, and neglect for long periods of time (certain parts, such as belts and idlers, should be rotated from time to time), and the result is likely to be a candidate for complete restoration.

One major issue here is that, even if you have been lucky enough to obtain the original manufacturer's service manual, the manual will not address the steps that must be taken to overcome the various aging effects. A number of those steps should be taken even before powering up a machine for the first time after a long period of storage.

There's actually a very important distinction between "repair" and "restoration"—and it's one that's often not fully understood. That lack of understanding can wind up being both frustrating and expen-

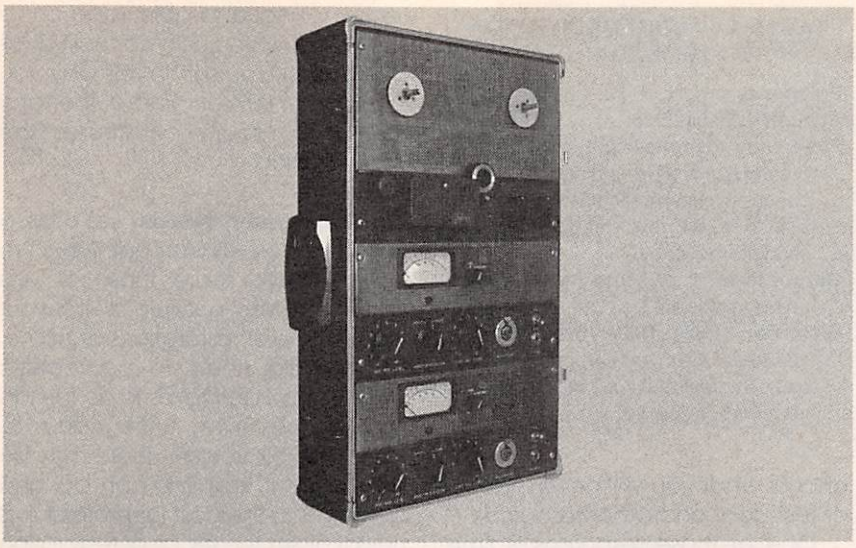


Fig. 1. The Ampex Model 602-2 tape deck is a vintage vacuum-tube machine with professional, timeless styling—and performance to match.

sive. Once you do understand the difference and decide what path you want or are willing to take, you can better determine what to look for before you buy; what questions to ask; and how to evaluate what you already own. Now you can get mentally prepared for the service or restoration process before you dig into the machine.

Repairs, by definition, tightly focus on specifically targeted trouble spots. Typically, those service operations should be clearly identified at the outset—and if you are using the services of a repair shop, thoroughly agreed upon by both yourself and the technician. Note that there may be additional faulty components or alignments needed beyond the identified symptoms; you and the technician need to discuss what to do if such problems are encountered. That will ensure that both parties understand how much work will be done. To do otherwise could easily result in repairs costing more than two times the amount needed to just fix the immediate problem.

Once again, repair means: "fix the following problem(s); eliminate the following symptom(s); and do nothing else, unless specifically agreed upon beforehand by both parties."

Restoration, on the other hand, means do everything necessary to bring this machine back to original specs, additionally ensuring that all appropriate manufacturer's periodic maintenance steps are followed. It might optionally also include complete cosmetic renovation—not simply cleaning, but restoring original finishes and repairing cabinet cracks or separations. While that might seem to be all-inclusive, there are still decisions to be made, such as whether to replace all capacitors, or even just all electrolytic capacitors.

Which Way to Go? Now, you may be thinking: "I don't want a complete restoration, but I also don't want to overlook something that will fail soon, or may wear out prematurely due to lack of lubrication; also, I want it to look nice." Well, here's the tough part. A failing component doesn't always hang out a shingle saying: "Hey, replace me now because I'm going to fail soon." Further, if you don't reconcile just how far you want to go with this work, you will probably be disappointed with the results. It might cost too much, take too long, or not look as good or work as well as you would like.

If you take the machine to someone else with a non-specific, non-detailed repair order, that will doom the poor technician no matter what he does. If he scrupulously just repairs the immediate problem—only those components and adjustments directly accounting for the current malady—then there's a good likelihood the machine will come back soon with some other—or even the same—symptom. If, on the other hand, he or she—just as scrupulously—repairs, replaces, or adjusts all weaknesses associated in any way with the problem . . . well, that can be a much more expensive proposition.

The relevance of all this is that whether or not you decide to have others help you get your machine fixed, you first need to reconcile exactly what it is you want accom-

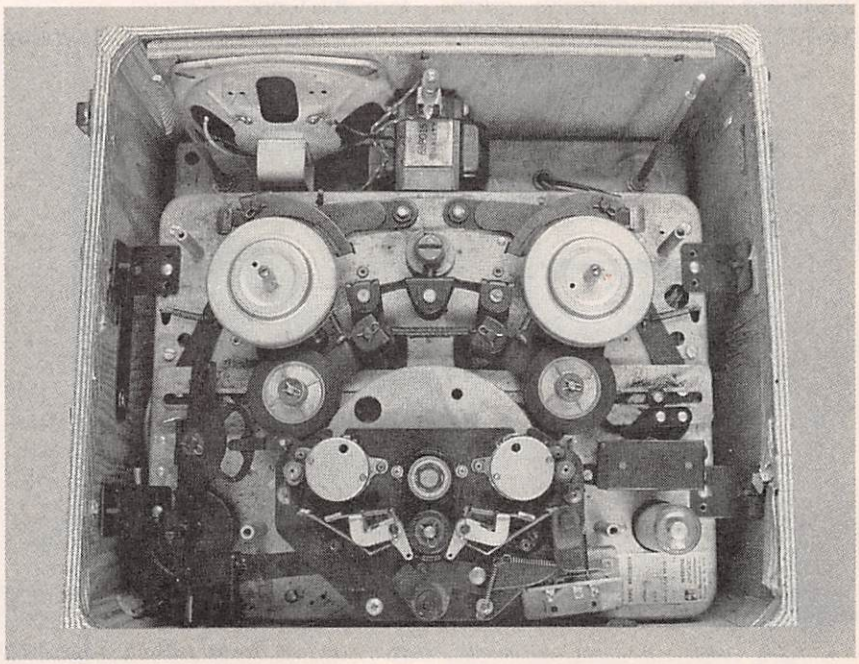


Fig. 2. The internal mechanics of a typical 1950's single-motor recorder transport.

plished. What is it that you really want this machine to be; what role do you want it to play in your life? Is it to be simply a display item? Is it to provide a means for occasional, recreational recording, where it's "no big deal" if things don't work out during a particular session? Or is it to play a serious role in critical applications, where breakdowns or substandard performance are intolerable?

Once you've thought the above through, it is important to communicate your intentions to your technician. Be realistic about what we've been saying concerning the deterioration that comes with time, use, abuse, and storage. Consider the complexities of the mechanics and electronics, and all of the tests and alignments that must be performed to truly recreate the machine that you may want (but may not be prepared to pay for).

Doing it Yourself. Assuming you have the financial resources, and can find a technician or repair shop willing to accept the challenge of restoring or repairing your machine (note that while some will, most won't), that is a perfectly legitimate way to handle this task. But there is another, potentially more rewarding way to go: doing the work yourself. However, no matter how skilled you are around a test bench, there is plenty of potential frustration attached to this task as well. Before you dive in, we need to discuss what you will need in terms of test gear and other resources.

TABLE 1—AUDIO OSCILLATOR RECOMMENDATIONS

Frequency range: 20 Hz–20,000 Hz
Accuracy: within ± 5%
Frequency response: ± 1 dB (although greater amplitude change with frequency is okay as long as you remember to reset level each time you change frequency)
Output level: 1 volt into 600 ohms is usually sufficient
Distortion (THD): Better than 0.5 % is adequate; also, you can get by if your unit can meet that spec at just a single frequency, either 400 Hz or 1 kHz

One of those resources is time. On average, it can easily take a full day or more to completely restore a relatively simple vintage recorder that is cosmetically still in good shape and still at least partially operational. A complex machine that's a basket case can easily take two or three days. If major rebuilding of mechanical components is needed, or major re-wiring or component replacement is required, or extensive cabinet and cosmetic work is specified, this can add another day or two. Note that those time estimates are for experienced technicians, with many similar restorations already completed. Of course, that can translate into huge costs if you have others perform this work.

On the other hand, if you're ready, willing, and able, read on to find out how you can do most or all of the work yourself. In this way you could save 80% or more of the total cost that usually constitutes the labor portion.

Test Equipment Needs. Let's talk a bit about test equipment. Now, I'm not trying to scare those of you thinking about possibly doing your own repairs or restorations at home, but we do need to be realistic about just what it takes to do the job right. Further, even if you can't do the entire job yourself, there may be aspects of it that you can do, and thus reduce the cost for professional help to finish the repair or restoration task. Finally, once you understand exactly what's needed and where to get it, you may find it surprisingly inexpensive.

The two most basic pieces of gear you need are an audio oscillator and voltmeter that is "audio-capable" (more on that in a moment). If you have both on hand, great. If not, the purchase of those two items could easily set you back about $250. One way to cut that cost is to look at a local "flea market" or amateur-radio swap meet ("hamfest"). Of course, if you do that you will face the problem of ensuring that they both work properly, and at least come close to meeting their original specs. One compromise would be to purchase older, but guaranteed, instruments from a used-equipment dealer; you can often find ads for those in the back pages of **Electronics Now**. That way you will pay more than at a flea market, but you will at least be sure that the items work.

Two of my own "flea market finds" are shown in Fig. 3: a Hewlett Packard (HP) Model 200 audio oscillator and an HP Model 410 VTVM (vacuum-tube voltmeter). The HP 200 is one of a long-lived series of similar oscillators that were an outstanding success for Hewlett Packard. These were truly "workhorse" machines, rarely requiring service. Many thousands of these were "excessed" by industry when transistorized gear became the standard, but those vacuum-tube units perform about as well as many new designs.

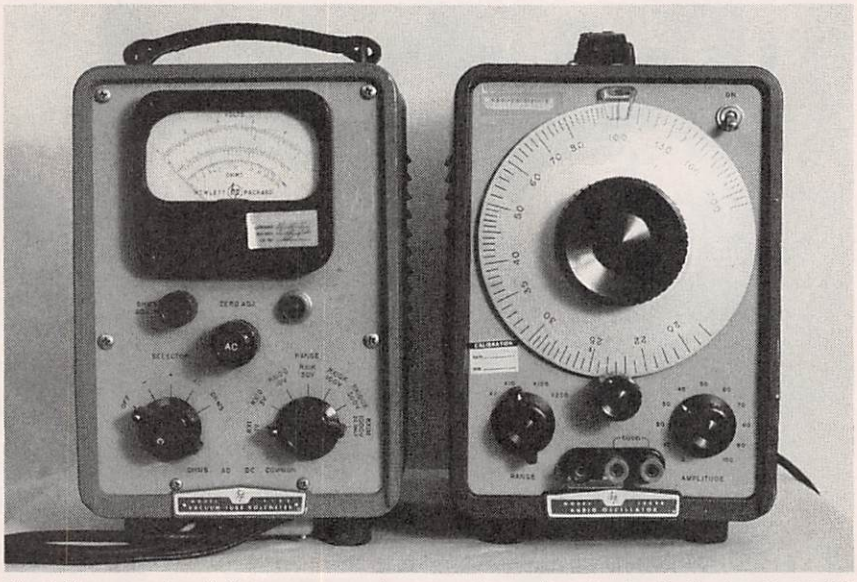


Fig. 3. Two examples of vintage vacuum-tube test equipment from Hewlett Packard: a Model 410 VTVM (left) and a Model 200 audio oscillator.

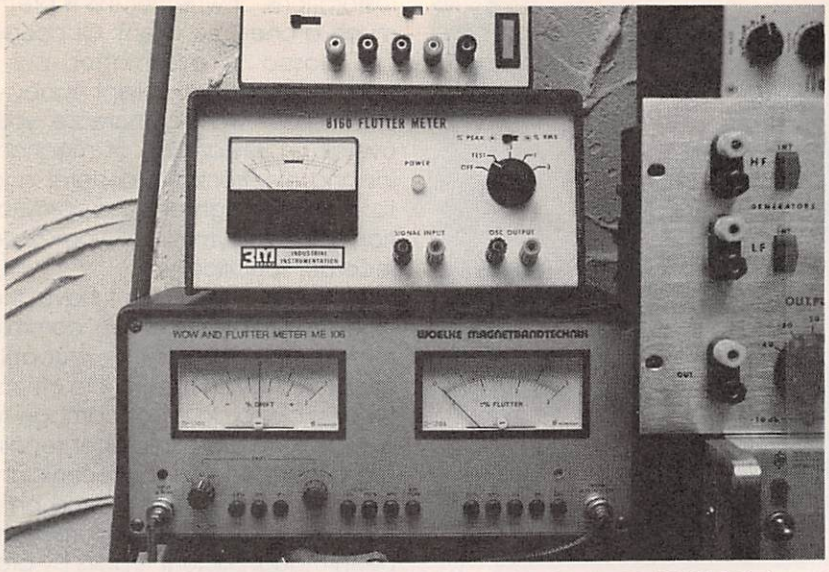


Fig. 4. Two wow/flutter meters: the 3M Model 8160 (top) and the Woelke Model ME-106 (bottom).

That unit meets or exceeds what is needed to service any audio recorder manufactured through at least the 1970s. If you go with another unit, the basic specs you should look for are given in Table 1.

Note that the HP410 shown is not an "audio VTVM". It's important to understand the difference. With most VTVMs, like the 410, the smallest AC-voltage range is 1-volt full scale. Due to reading interpretation, that generally translates to an ability to read voltages as low as about 20 millivolts. That is okay for most troubleshooting and alignments, except S/N. For that, you will need an audio voltmeter with at least a 3-millivolt scale (thereby capable of reading 100 microvolts). One unit that you might find on the surplus/hamfest market is the HP403B. It has a 1 millivolt scale—more than what's needed for tape-recorder work. As an alternative, if you choose to purchase a surplus distortion analyzer (our next topic), you may find that an audio voltmeter is also built in to that instrument.

As a final note on voltmeters, many ordinary VTVMs and VOMs (volt-ohm-meter) do have sufficient frequency response to cover the audio spectrum. An old favorite, the Simpson Model 260 Series 4, for example, has an AC frequency response up to 500 kHz.

Next, let's take a look at distortion analyzers. Harmonic distortion is the standard distortion test and calibration used by tape-recorder manufacturers. Distortion analyzers can be expensive new, but can also be found from used/surplus/hamfest sources. For example, the modest but adequate Heath Model IM-58 can still be found at hamfests for about $30 to $45. While it doesn't have specs as impressive as the HP analyzers, such as the Model 331A (which still sells for about $150 or more), it can be used quite effectively for all but the most demanding measurements. It also has a built-in audio voltmeter.

An oscilloscope is not absolutely required for most tape-recorder servicing. After all, armed with your oscillator, distortion analyzer, and audio voltmeter, you can perform the necessary checks and alignments on a machine whose electronic components are functioning well. However, if you don't have an oscilloscope, "Murphy's Law" will surely kick in. This will occur in the form of a noisy pre-amp stage, or the inexplicable loss of signal deep within a record or play amp, or any number of other maladies for which the oscilloscope is a worthwhile, if not required, diagnostic tool.

The subject of oscilloscopes usually conjures up notions of the family savings quickly evaporating. True, a new, triggered-sweep, 50-MHz analog scope can set you back at least $600 or so. The new digital scopes, despite their small size, carry a hefty price tag—generally exceeding $1,000. However, a trip to your local flea market (once again, hamfests are particularly good for this), plus a little patience, will likely yield something useful in the $50 to $150 range. Because of the relatively modest requirements associated with working in the audio-frequency range (and even considering bias/erase oscillators that operate at, say, 180 kHz), even the lowest-frequency-response scopes are suitable for tape recorder use. I do recommend that you purchase one with a "triggered-sweep" option. However, other than getting a decent probe, that's about it.

And don't necessarily ignore the older vacuum-tube scopes. Although they are not in fashion anymore (translation: they can be had cheap), if you find one that's not rusty and that appears in good cosmetic and functional condition, it may provide you with many years of flawless operation when used judiciously. Just allow adequate warm-up time (around 20 minutes or so), and remember to switch it off when you're done!

A good wow/flutter (W/F) meter is indispensable for mechanical adjustments and alignment. Very briefly, W/F is a measure of short-term speed accuracy; that is, speed variations of less than one second, up to about two seconds (corresponding to a frequency range of about 200 Hz down to about 0.5 Hz). We'll get into this much more in a later installment.

There are many different possible causes for poor W/F. I have seen good technicians virtually pulling their hair out in vain attempts to correct W/F problems. There is literally no way of doing this effectively without the assistance of wow/flutter measurements.

The principal issue for those on a limited budget is that used commercial W/F meters are rather expensive and seldom found. This is probably due to their restricted application, and therefore relatively few being manufactured. When you can find one, prices of $70 to $150 are not unusual. Two popular commercial models were the 3M 8160 and the (German) Woelke ME-106, as pictured in Fig.4. Either of

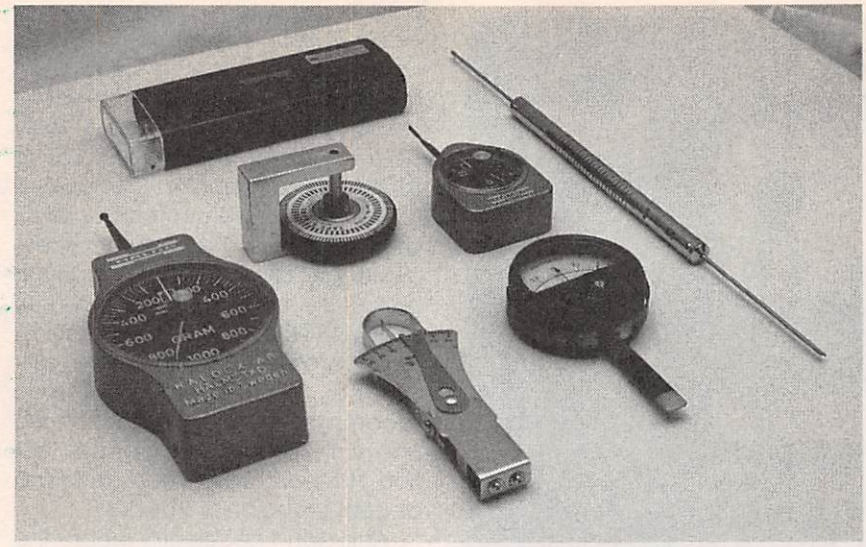


Fig. 5. Here are various measurement tools used to check tensions, speed, and wear.

these will do the job nicely. While a sensitivity of 0.3% full scale is acceptable, both of these particular units exceed that capability.

If budget or availability becomes a problem, and time is not a pressure, here is another alternative: Franklin Miller, as part of the audio test-gear series currently running in his "Audio Update" column in this magazine, is scheduled to do a simple W/F meter in a future installment. In fact, if you are comfortable doing construction work, many of the pieces of equipment outlined above will be appearing in future issues, and an audio oscillator has already appeared (see "Audio Update," **Electronics Now,** July, September, and October 1997).

Other equipment you will need includes tube/transistor testers and power supplies (if you will be performing electronic repairs), a variable voltage AC transformer ("Variac" is a common trade name), a tape-head demagnetizer, a soldering iron with a fine tip, and various hand tools. In addition, to perform mechanical adjustments and to check manufacturer specs in this area, you will need tension gauges such as those pictured in Fig. 5. Also shown in that photo is a play-speed strobe wheel, and an illuminated magnifier (less than $10 at Radio Shack). Finally, if you will be restoring cabinetry, etc., you will need wood- and metal-working tools, plus strippers, cleaners, polishers, and refinishing coatings.

The only other items needed are tapes for test recordings, plus a music source and playback gear to check out your accomplishments. If you will be testing or adjusting head alignment, equalization, or playback response, then a standard alignment tape is very desirable. More about this tape will be covered in a future installment. If you would like information on obtaining an open-reel alignment tape, write to the author c/o EC Designs at the address given in the "For More Information" box.

FOR MORE INFORMATION

This article is based on the new book, *Evolution of the Audio Recorder* by the author, Phil Van Praag. It contains over 500 pages of history, evolution, restoration, photos, and a price guide. It's available at $39.95, postpaid, from EC Designs, P.O. Box 33, Genesee Depot, WI 53127.

Cost and Commitment. From a cost standpoint, the equipment described above would total about $500 or less, if a conservative "used- or build-only" strategy is followed. Perhaps a more difficult decision to be made is whether to invest the time to acquire the knowledge needed to perform the various mechanical and electronic tasks associated with repairs and restorations. Much of this, of course, will have to do with whether you intend to continue doing repairs and restorations, or whether this is pretty much a one-time event. Of course I'm biased in this matter, but I believe this is an excellent hobby—it's a great way to increase your overall understanding of mechanics and electronics in general, and to gain a heightened appreciation and enjoyment of your tape recorder specifically.

However, if you don't have the time or desire to make a commitment to this, then you're probably better off leaving the work to others. It's possible to do great damage to a tape recorder if improper repairs are performed. In fact, technicians will often charge more to work on a machine if faulty repair efforts have been made. Efficient repairs by professional technicians depend on certain assumptions that are based on previous experience coupled with subtle observations during the troubleshooting process. This process can be seriously impeded if things have been "stirred up" by someone else. Adjustments might have been disturbed, and components that were still okay before the aborted repair attempt might now be defective (bent, broken, shorted out, electrically or mechanically stressed beyond their design limits, etc.). This often complicates subsequent repair attempts. So, read through the repair and restoration descriptions in the upcoming installments carefully, and then decide whether this is something you want to tackle.

In the next installment, we'll begin the actual restoration process! See you then. Ω