THE DESIGNER'S NOTEBOOK

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DAMPERS

WHY ARE THEY ALWAYS SO DARN MUCH TROUBLE?

INTRODUCTION

Dampers and damper systems are an on-going problem for any technician doing regular piano work whether you're primarily a rebuilder or a tuner. It seems we spend half of our time getting pianos to make sounds and the other half getting them to shut up. The problem is more often addressed on grand pianos, perhaps because it is usually expected that they will perform to a higher standard so more is demanded from them. But technicians working on vertical pianos used by competent musicians would disagree. It has long been accepted that the reason upright dampers can't perform as well as grand dampers is that upright dampers can't be placed in the right spot—on the right "node"—on the string. While there is some small degree of truth to this argument, it is not nearly as important a consideration as has long been thought. Fortunately, some help is available—for both the piano builder and the technician.

Damping Mechanisms

When we speak of damper efficiency, we normally think of how effectively a piano damper system cuts off all of the sound of a piano when the dampers are brought into contact with the vibrating strings. Damping efficiency is a measure of the rate of energy dissipation—the rate of energy transfer from a vibrating set of strings into a damper assembly—which takes place when a damper assembly is brought into close physical contact with a string set. The damper assembly is an energy absorbing mechanism—a form of what the sound and vibration analysis people call an *auxiliary mass absorber*—consisting of a resilient damper pad backed by a mass load and with a mechanism to support it and/or hold it against the string set.

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Piano strings produce sound by vibrating at a certain fundamental pitch, or frequency, with a liberal assortment of harmonics of that fundamental thrown in. There is energy—wave energy—in the string that got there when a hammer traveling at high speed rather violently ran into it. That energy is given up to the soundboard at a more or less fixed rate depending on the internal friction of the string, the air resistance to string's motion and the rigidity of the string's boundaries.

The piano string is a mechanical oscillator. Now, if it were a perfect oscillator—if it had no internal friction, if there were no wind resistance to the impede it's movement and if it's boundaries were perfectly inelastic—the string would continue vibrating forever after once being excited. Of course there would be no sound radiating from that perfectly inelastic soundboard either.

Obviously, these conditions don't exist in the real world, a struck string does not go on vibrating forever. Some of it's energy is dissipated into the plate. A small amount is lost to heat due to internal friction within the steel string itself, and a tiny fraction is lost to wind resistance. Much of it though, does get transferred through the bridge to the soundboard where, by forcing the soundboard to vibrate, it produces sound by compressing and refracting the air around it. The rate of energy transfer from string to soundboard is normally the principle controlling factor determining the decay time, or the damping rate, of a vibrating string. Left to itself, this rate of energy transfer is such that it will take from just a just a few seconds in the high treble section to something over a minute in the bass and low tenor of a large piano for all vibrations within a string to die out.

The length of time it takes for all of the string's energy to be transferred to the soundboard is referred to as a piano's *sustain time*, or simply its *sustain*. A piano with long sustain will take a long time to transfer the strings' energy to the soundboard and a piano with short sustain will take a somewhat shorter period of time to transfer its strings' energy into its soundboard. *Long* and *short* are relative terms. There are no absolute standards for a piano's sustain time although, usually, longer is better.

Unfortunately, not every piece of music calls for the full sustain of all of the strings of the piano all of the time so some type of mechanism had to be developed to artificially hasten the damping rate. Using this mechanism the pianist is able to control the ultimate sustain time; either of each note individually, or of the whole set simultaneously. Using this mechanism instead of waiting for all of the string's energy to be dissipated into the soundboard over a relatively long period of time, it is transferred very rapidly into a viscoelastic felt pad which is placed against the string. Since all that energy can't simply disappear into a vacuum, what happens to it? With any luck, and a properly operating damper system, it is dissipated within the damper pad as heat.

Damping Rates

In our perfect world we would like to have this energy transfer take place more-or-less instantaneously, but in our real world it can't and it doesn't. There will always be a perceptible amount of time between the instant a damper pad contacts the string set and point at which all of the string's energy has been dissipated into the damper pad and the string's vibrations cease. There are a lot of good reasons for this. There can be quite a lot of energy in a piano string and it takes some finite amount of time to transfer all of it into the damper pad. As well, just to make the dampers life more interesting, let's also throw some harmonics of the fundamental frequency into the vibration envelope and, to liven things even more, let's make the physical requirements for damping each of those harmonics different. Now let's add in a few vibrating strings that are not part of the speaking portion of the original string set struck by our hammer—strings tuned, whether intentionally or not, to some harmonic of the original—that have picked up some of it's energy. Even if we were able to design and build the perfect damper system for a given set of strings, the damper's job would still not be completely defined. The soundboard—whether we want it to be so or not—is also an oscillating system. The damper system must also contend with a not insignificant amount of energy being fed back into the strings from the soundboard, which has up till now, been happily vibrating and oscillating along in response to the strings' movement.

Our dampers' job description is not nearly complicated enough yet so let's add in a few additional requirements. First, it has to operate in absolute silence. OK, we can accomplish that by making the felt pad *very soft*. Of course, it also has to operate flawlessly over many hundreds of thousands of operations without deforming and going out of regulation. All right, we'll make the pad *firm*. Then it's operation must be completely transparent to the pianist. That's easy, we'll make it *very light* and free and we'll use a *very weak* return spring (or none at all—letting gravity do the whole job). Still, let's not forget that the damper must abruptly terminate the motion of a violently vibrating and very massive—relative to the damper, at least—string and soundboard assembly. So, perhaps we should make the damper assembly itself *fairly massive* and hold it against the string with a *very stiff* spring.

So, what we need is a *very soft* and *firm* damper pad attached to a *very light* and *heavy* damper mechanism that is controlled by a *very weak* and *stiff* spring that makes absolutely no noise during operation and is completely transparent to the pianist and… Well, you get the idea.

So, now that we know precisely what we want, let's take a look at what the piano builders have come up with for us.

Piano Damper Mechanisms

The illustration shows a typical grand piano damper system. *(This particular drawing shows a Renner system using a swing top flange not normally used in American pianos, though it should be.)* This typical damper system consists of a *damper head* with two or more *felt pads* located and supported above the string by a *damper wire*. This damper wire passes down between the strings belonging to adjacent unisons through a bushed hole in the *damper guide rail* to a *damper lever assembly*. The damper lever assembly consists of a *top flange*, usually including a sostenuto tab mechanism, an *underlever* and a *damper lever flange*. The underlever often includes one or more *lead weights* (about which, more will be said later) and usually a height adjusting *capstan screw*. *(Note: Is there any good reason to continue building pianos with damper systems lacking height adjusting capstans? Surely not! Here is an offer you can't refuse. I'll be happy to design a damper lever system for any U.S. piano company still using damper levers without height adjustment capstans for no charge. Or simply adapt the Renner system as shown in the illustration—though not perfect, it is quite good.)* The damper lever flanges are attached to a *damper rail* (or *damper flange rail*) which may or may not be combined with a *damper lift rail*. This assembly is mounted in such a manner that it either pivots as a whole assembly or the separate damper lift rail rotates around the damper lever flange center pin axis which can lift all of the damper levers simultaneously when the damper pedal is operated. In the illustration, this latter system is shown. The damper pads are held against the string by a combination of spring pressure (sometimes) and the weight of the assembly (always—whether leads are used or not).

The grand damper lever is operated by being lifted by the back of the key lever when it is played. When the front of the key lever is depressed the back of the key goes up and the damper lift felt at the back of the key lifts the damper lever spoon and lever assembly which then lifts the damper head and pads off of the strings. *(Surely all modern damper levers found in modern pianos have damper lift spoons, don't they? Tell you what; on the off chance that there may still be one or two pianos still being built without them, see the offer above.)*

By contrast, the vertical damper system is considerably less complicated—and therein lies both its beauty and its major limitation. It consists simply of a damper head and pad assembly glued to a damper block or damper dowel which, in turn, is attached to a stiff, but still bendable, wire. This wire is pressed into a wood damper lever which, in turn, is attached to the main action rail by a flange. The entire assembly is very light weight. Since the design of the piano precludes any gravity assist, the damper pads are held against the piano string by spring pressure coming from a spring pressing against a groove in the back of the damper lever. In operation, the vertical damper lever assembly is rotated about its mounting flange when the bottom of the lever is contacted by a spoon-shaped extension at the end of the wippen.

In this article, we aren't going to concern ourselves with sostenuto mechanisms for either system, nor are we going to concern ourselves with regulating either system.

Damper System Efficiency

A damper system's efficiency, or effectiveness, is a function of many different factors. Typically, when we encounter a grand piano with poor damping, we blame it on regulation and adjustment or to the point of contact on the string relative to the hammer strike point. Sometimes—due to age and use—the pads and/or wedges have gotten packed down and are too hard. Sometimes. More often, though, the problem goes somewhat deeper; back to the original design of the system. The correct adjustment and regulation of the system is, of course, critically important. The proper fit of the felt damper pad(s) to the strings can make or break an otherwise good design. But, no matter the quality of manufacture, the precision of installation or the perfection of the fit to the strings, there are some damper systems on some pianos that simply don't work as well as others. The question, then, is why?

Let's set aside, for the moment, any discussions of the damper pads location along the speaking length of the string. It is consistent enough from one piano to the next (at least in modern practice) that this factor can not be reasonably used to explain the sometimes vast differences in damping efficiency between various instruments. Even vertical pianos—which we normally don't expect to damp well because of the damper pad location somewhat below the hammer strike point—have examples of good, sometimes excellent, damping. And we must ask ourselves why. If the problem with vertical damping efficiency lies with the location of their damper pads then none of them should damp well since that location is essentially the same—just below the hammer strike line—on all modern vertical pianos. No, as long as those notable exceptions exist and they stand as mute evidence that good damping is possible even with the damper pad well away from the hammer strike point they tell us we must look elsewhere for the causes of poor damping.

At the beginning of this article, I referred to the piano string damper as an *auxiliary mass damper*, also sometimes called a *damped absorber*. It consists of an auxiliary mass (the damper lever, wire and head assembly) backing a viscoelastic material (the damper felt) that is closely coupled to (held in firmly against) a vibrating system (the piano strings) by either a spring (the damper return spring), by its own weight or by a combination of both. These dampers, while exceedingly complex to analyze and define, are fairly simple in operation. Basically they depend on the degree of resilience within the damping material, the amount of mass in the system and the strength of the spring—if any—combined with the weight holding the assembly against the vibrating system.

It's not so much the inherent differences of design—leverages, placement on the string, etc.—between the grand and the vertical damper systems that account for the differences in damping efficiencies as it is the differences in the mass of the parts used in each system. In the grand piano damper system, the damper head, felt pads and wire weighs approximately 10 to 15 grams—smaller and lighter in the treble and larger and heavier in the bass. The damper lever and top flange assembly adds another 15 to 25 grams—depending on the location and number of lead weights added to the lever. (The actual weight, or mass, of the damper lever assemblies is somewhat greater than this, but since the damper lever rotates about its back flange action center this is the portion of its mass that is hanging on the end of the damper wire and is felt by the damper head.)

By contrast, the vertical damper head and felt pad weighs approximately 4 to 6 grams, a typical damper dowel weighs approximately 2 to 3 grams, and the damper lever assembly weighs approximately 8 to 10 grams. Since the damper lever rotates about a roughly central axis only a small portion of its total mass, approximately 7 to 10 grams, is felt by the damper head assembly.

Why make a big deal over the weight—more properly, the mass—of the various components of damper system? After all, they're moving parts and lighter is better, isn't it? Because, when all is said and done, the efficiency (effectiveness) of a piano's damper system is determined by the following:

- The compliance of the felt damper pad that is coupled to the vibrating strings.
- The amount of force with which the damper pad is held against the vibrating strings.
- The nature of the force used to hold the damper pad against the strings: i.e., weight (or mass) or spring pressure, or some combination of these.
- The effective mass of the system—the auxiliary mass—backing up the felt damper pads.
- The location of the pad contact on the string.

(Note: There are a few other problems that can lead to isolated and specific damping problems as well, but for the most part they are way beyond the scope of this article. I'll not even attempt to deal with them here. If you have a specific question about—or a problem with—a specific piano, feel free to contact me through the Journal.)

Why some work and some don't

When you encounter a damper system that just won't work, no matter how precisely adjusted it is, you can generally trace the inherent problem to a deficiency in one of the above areas. More often than not, it will be due to a lack of sufficient mass in the system.

It is possible that in either grands—especially those using no lead weights in the damper levers—or verticals the damper return springs can lose tension over time and not have enough tension to press the damper pads against the string with enough pressure to ensure good damping. It is also possible that they were simply not adjusted correctly to begin with. This is more of a problem in verticals than it is in grands since they depend entirely on spring pressure to hold the damper pads against the strings. Often though, even increasing the spring tension in these systems to the point of adversely affecting key touch weight will not improve damping very much.

Good damping depends on the interaction between the string and the damping mechanism. With a simple auxiliary mass system, the reaction back to the primary system—in this case, the piano's strings—is proportional to the amplitude of motion in the primary system at the point of contact and is a function of the frequency of the wave motion in the primary system and of the mass, elasticity, and the damping constants of the auxiliary mass damper. Just as is the case with the piano string-to-bridge & soundboard relationship, there is a force–velocity ratio that exists between the string and the damper system. This force–velocity ratio is called the mechanical impedance (Z) of the damper system.

The mechanical impedance of all vibrating systems is frequency dependent and piano damper systems are no exception. Mass has a greater effect on mechanical impedance at high frequencies, and elasticity (springiness) has a greater effect at low frequencies. It follows then, that even a lightweight system with adequate spring tension will damp with reasonable effectiveness at low, or fundamental, frequencies, and indeed they generally do. It is usually the higher harmonics (frequencies) that present problems and the pianos giving us the most problems—whether grands or verticals—are generally those using low-mass damper systems.

Grand pianos using lead weighting in the damper levers have better damping qualities than those using just springs, especially where the higher harmonics are concerned. As the pianos—and strings—get longer and there is an increasing amount of low frequency energy content in the string's vibration envelope it is a good idea to include a return spring in the system *in addition to* the lead weights to better damp all that low frequency energy.

Vertical piano damper systems nearly always have too little weight—mass—to provide good damping. The impossibility of placing the damper pads on specific nodes may have some effect, but mass—the lack of it—is by far the biggest culprit in the ineffective damping systems found in vertical pianos.

Many years ago I was rebuilding a fairly large Chickering upright piano and thought I would improve the touch weight of the action by replacing the heavy brass damper blocks and damper heads with nice modern wood damper dowels and heads. The new system looked really good—unfortunately it didn't damp worth a darn. I tried all the tricks I could think of, including strengthening the damper springs beyond the point of acceptability. After spending several fruitless hours trying to get this nice modern system to damp well, I tried replacing a couple of the wood dowels and blocks with the original brass parts. Suddenly all was well with the world! I had my damping. After fishing all of the original brass parts out of the scrap pile and replacing them on the action I had the whole system damping beautifully and I was able to back off on the springs to the point that, on a light blow, damper pick-up was indiscernible.

All of which brings up a point I don't want to get lost here. A damper system with the proper balance between spring pressure and mass in either a grand piano or a vertical piano will both damp well and be easily operated. That is, in vertical pianos it will not have so much spring pressure that it will excessively increase dynamic key touch weight—I've never seen a vertical damper system that had too much mass—and in grand pianos it will not have so much mass that it will excessively load the key and increase the dynamic touch weight of the action when played softly. Of the two, excessive spring pressure is the most noticeable and objectionable. Unfortunately, the first thing done by both factories and by many technicians when faced with a poorly functioning vertical damper system is to increase the tension of the damper spring. This almost never improves the damping effectiveness of the system, but it does make the action feel tight and sluggish—like it doesn't want to go through let-off on either hard or soft blows.

Help! Now that I know what's wrong, what can I do?

So, what's to be done. In grand pianos with unleaded damper levers it is a fairly simple matter to add leads to them. Drill the levers and seat the leads just like you would in a piano key. Make sure you use leads designed for damper levers. They are smaller both in diameter and length. If it isn't practical or expedient to remove the whole damper tray assembly, you can often install one or more leads in the damper head itself. I usually start by installing one lead on the front part of the head (i.e., toward the front of the piano) and trying it out. One is usually enough. If two leads are required I tend to balance them front and back. In either case I'm not sure the actual location matters all that much.

In vertical pianos the easiest fix is to install Renner's all brass damper barrel. It's not quite massive enough for the bass section of a large upright, but it's a whole lot better than wood. Another quick fix that often turns out to be a semi-permanent fix is to attach split lead weights to the damper wires under the damper dowels or blocks. These weights are used by people who fish and are available from sporting goods stores in various sizes. Not being a fisherman, I have no idea what these leads are supposed to be used for. I always thought the idea was to get the fish out of the water and into the boat, not to load them down with lead and drown them. But who knows? In my book, anyone who willingly gets up before dawn to go out and do battle with some poor fish is more than passing strange anyway. I've always been of the opinion that if God had wanted me to watch the sun come up, He would have had the event occur at a much more reasonable hour of the day. As may be, once you've selected an appropriate weight—several convenient sizes are available—simply place it on the wire just above the wood damper lever and squeeze it gently with a plier. And don't be afraid to use two if necessary. If they develop a buzz—not likely, but it does happen—a drop of white glue quiets them down nicely. Once the leads are in place, you'll probably want to check the tension of the damper spring. It's quite likely you'll be able to decrease the tension somewhat for a better action feel and still have good damping.

SIDEBAR TO THE MAIN ARTICLE

—WITH DRAWING—

GREAT IDEAS FROM THE PAST DEPARTMENT

I found this damper block mechanism in a Decker grand piano c.1900. Aside from one critical and fatal flaw—about which more later—it was one of the slickest and most easily adjusted damper systems I've ever had the pleasure of working on.

The principle moving part was a damper block assembly that fit over a set of two vertical guide pins in a movable damper lift rail. The damper lift rail was pinned directly to the inner rim at the treble end and attached to a fairly long lever at the bass end which allowed it to move up and down through an arc when the damper lift pedal was used. This did result is a somewhat higher lift—when using the pedal—in the bass than in the treble, but didn't seem to present any problem in operation.

The damper wire went through an alignment hole in the top of the block, and then down between a "spring" pin and a serrated adjustment screw (see the illustration). While it's not very clear in the illustration, the hole for the spring pin is counter-bored to a depth of about 4 to 5 mm which allows the pin to bend out slightly—hence the "spring" in spring pin—as the damper wire passes between it and the adjustment screw. This keeps a constant pressure on the damper wire, pressing it tightly against the adjustment screw.

The damper wire started out as a normal soft—probably nickel plated brass, I don't remember for sure—wire. The idea was that when the adjustment screw was turned counter-clockwise it would draw the damper wire down, wedging it between itself and the spring pin. In the process it was supposed to cut—actually press—small "gear teeth" into the soft damper wire. Once these teeth were pressed into the damper wire, adjusting the damper block height was simply a matter of turning the adjustment screw until the block was at the correct height. There was enough friction in the system to hold the damper head square to the wire in operation. A very simple system—and when it worked, it worked brilliantly. But there was that one fatal flaw I mentioned earlier. Although the adjustment screws seemed to be made of steel—I don't know the grade—they simply weren't hard enough to do the job. Instead of cutting nice clean gear teeth, most of them pressed rather pathetic little "gear indentations" into the surface of the wire while the serrations kind of rounded over and lost their sharp edges. When this happened the adjustment screw would simply slip on the wire when turned and made any further adjustment somewhat problematic.

Could this system be built and used successfully today? Yes, it could—it was an idea somewhat before its time, I think. It would take a little redesign, but no really major changes from the original concept. The biggest problem to overcome would be the softness of the adjustment screw. With today's metallurgy and rapid and inexpensive heat treating processes it should be possible to make an adjustment screw that would be both cheap and reliable. Assembly should be much easier than today's system since there are no flanges to assemble. And it would certainly be much easier to assemble to the piano and regulate. Enough of these little devices did still work to prove to me the promise of the system. When they worked it was possible to adjust the damper block height in seconds.

A side benefit would be a somewhat simplified, and acoustically superior, bellyrail assembly—but that's another story.

The particular piano I worked on had only two pedals—no sostenuto pedal—but there is no reason I can think of why a standard sostenuto tab could not be incorporated into the upper portion of the damper block without too much modification. It did not use capstans on either the block or the lift rail, nor are they needed. The adjustment screw on the wire makes them redundant. Finally, the lift rail could have used a better method of mounting, also not a serious problem.

There were no other inherent design flaws in the system that I could see on the one piano that I found using them. But then my experience with the system was limited to just one instrument—albeit one that had survived intact and functioning for nearly 85 years. I've had to replace "conventional" damper systems in much younger pianos that had more problems than this one had! If any other technicians have had any experience with this system I'd be happy to hear about it—drop me a line at the Journal.