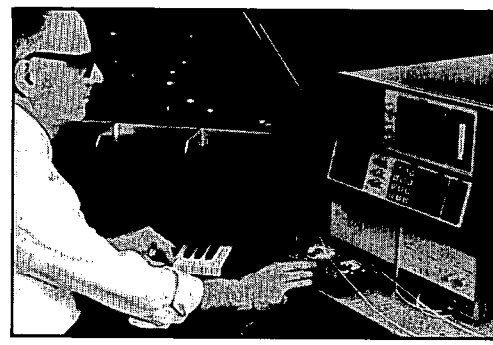
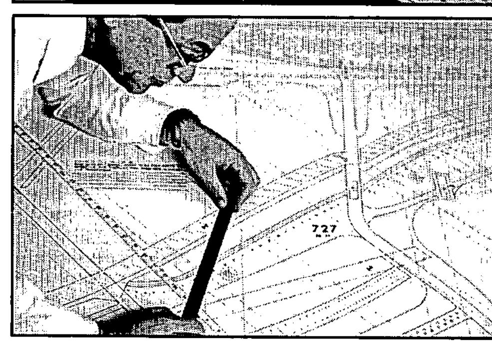
Piano Technicians

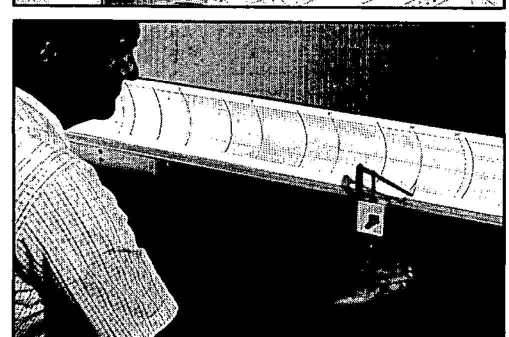
Journal

December 1988

Happy Holidays!







The Piano Technicians Journal December 1988

Official Publication Of The Piano Technicians Guild, Inc. Volume 31 Number 12

In This Issue...

Plus...

The Cover...

Best wishes for the holiday season to you and yours from the Journal staff. Drawing by Valerie Winemiller.

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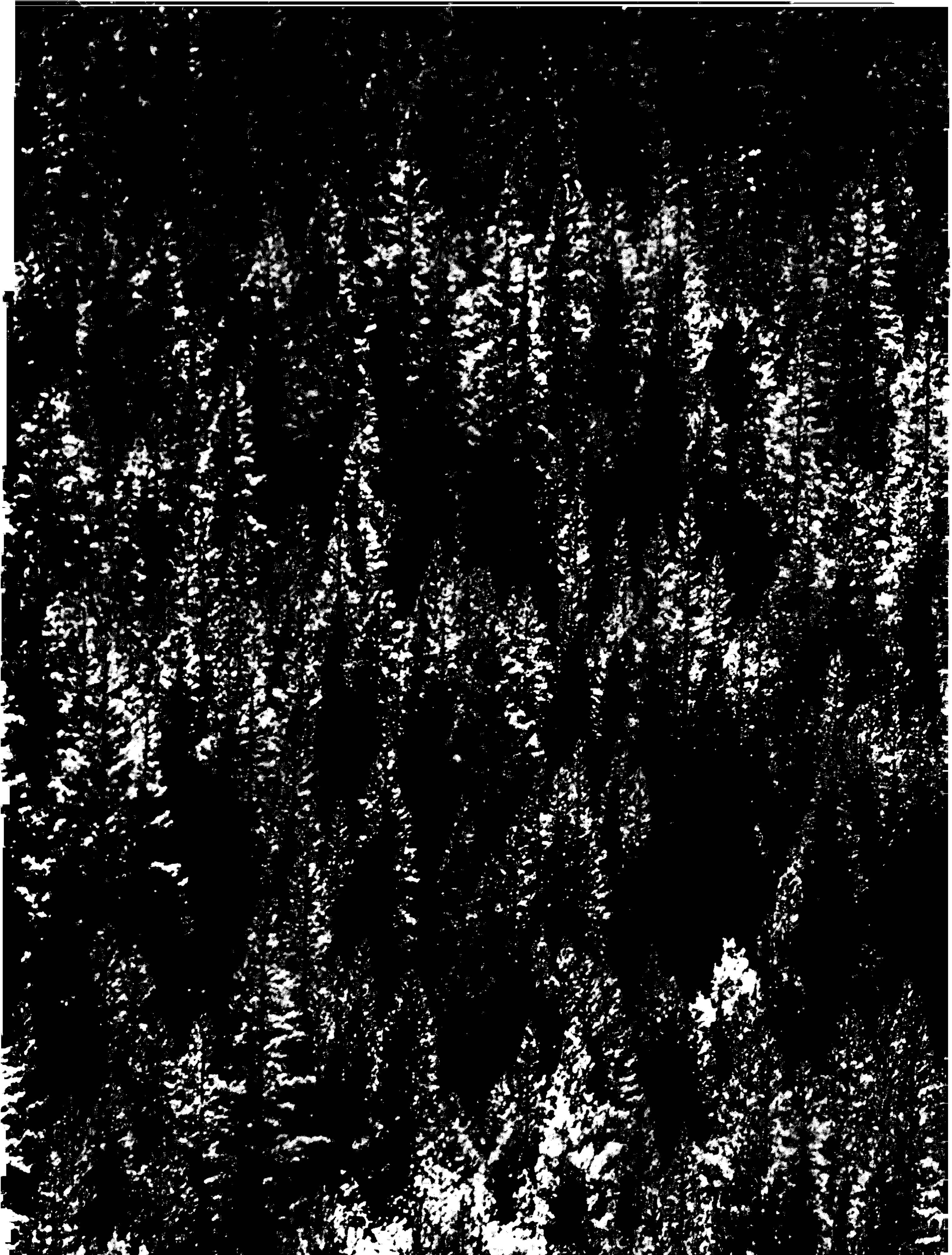


President's Message

Ronald L. Berry, RTT
President

The Piano Business During The Month of December

December is a month that is usually busy for most of us. Churches, schools, and pianos that never get played until the kids come home from school all add to the extra load.

How much can I get done today?

Oh, I can fit another tuning in at lunchtime, no problem.

Where's that granola bar I put on the seat of the car to keep me going since I didn't get any lunch today?

Sure is nice that people are using their pianos so much more during this time of year.

They need the school piano tuned for a program tomorrow! Did they just schedule the program yesterday?

Hey, this school program tuning was set up last August, some people really plan ahead.

My ears are so tired I can't even listen to the car radio on the way home.

Just think, all the extra money you are making will help pay for Christmas presents. But when will I get to see the family while they are awake? Maybe Christmas morning.

Shouldn't we send Christmas cards to our customers like we used to do? When would we ever find time to send them?

Oh, a holiday party tonight. I'd really rather go to bed, but let's be festive.

Wouldn't it be nice to sing in some production of the "Messiah" this year? Are you crazy? Don't take on anything else in December!

How did this lunch time tuning on the east side get put on this day that had such a nice west side schedule.

You have three pianos to tune instead of one! — No, I don't think I can get to the other ones today.

I really should learn some new songs to play when I'm done tuning. Perhaps some Christmas carols.

Maybe it will snow hard enough that I can't get out and have to stay home and sit by the fire. With front-wheel drive, no such luck.

Write an article for the *Journal?!* Makes me tired just thinking about it.

Happy Holidays.■

No Second Chance

Your first impression to your customer is how you look when he or she greets you at the door.

Are you clean and neat? Clean shirt, tie, coat, pants and shoes? A bright smile? Clean shaven or neatly trimmed? Are your teeth clean and bright? Does your breath have a pleasant odor? I always carry a bottle of mouthwash in my car. I use it before I leave the car, especially after eating.

Your appearance gives your customers a clue about you. If you take pride in yourself, you will take pride in your work. You are a mirror of your work.

Your first impression could lead to future work, or it could be your last work for that customer. First impressions are lasting impressions.

Are you in and out so fast that you don't get to know your customer? Do you stop to pet a cat or dog? Do you stoop to say hello to a small child? These things may not have anything to do with the work you do, but they do tell the customer something about you.

Let me close with this saying:

"You don't get a second chance to make a first impression"

Francis J. Reed
Northern Virginia Chapter

Tech Gazette

Yamaha Piano Service December, 1988

Parts, Etc.

HOLIDAY SPECIAL

As we mentioned in our inaugural issue of "Tech Gazette," it's no secret that we carry a number of parts, tools, and supplies designed to make servicing pianos easier for piano technicians. If you are in the midst of a major rebuilding or reconditioning project, chances are that you'll be replacing some integral components somewhere in that particular instrument. If you are the type of technician who demands the best in tools, replacement parts and supplies, our Parts Department may be able to offer you some attractive alternatives.

The items available through our Parts Department are all quality Yamaha products, crafted with the same care and attention to detail as our pianos. We stock a large assortment of Yamaha tools—tuning levers, regulating tools, and combination handles are a few examples of what we offer. All Yamaha tools are premium quality, "one time only" purchase items (unless they are lost or stolen—don't forget to lock your car).

We also handle a vast assortment of genuine Yamaha replacement parts. Our center pins, for example, have an excellent reputation among rebuilders and non-rebuilders alike. Although a center pin is a small item, the technicians who have been using ours agree that they're an improvement over others that they have tried. Cloth and paper punchings, keytops, keyframe felt and cloth, key bushing cloth, and action cloth are some other common items of interest. Our blued and nickel-plated tuning pins are available in various diameters, with threads that are precision-cut (not rolled) to ensure consistency. Then there are piano covers, grand and vertical damper felt strips, damper wires, well, you get the idea.

As our way of saying, "Seasons Greetings," we're pleased to announce, for the first time ever, a Holiday Special from Piano Parts: **All parts orders received by January 16, for $25.00 or more, will receive a 10% discount and free shipping!** This special offer applies only to orders pre-paid by check or money order, credit card, or open account, and shipped by regular UPS or mail (C.O.D. orders are *not* included in the Holiday Special). After business hours, a 24 hour answering service will be in operation, so call us anytime—day or night.

If you wish to place an order, or need more information, our toll-free telephone number for Piano Parts is (800) 521-9477. **HAPPY HOLIDAYS!!**

MIDI Corner

MIDI—What it is, What it can Become (From an article in "New Ways" magazine, a publication of Yamaha Corporation of America, Band & Orchestra Instrument Division).

In the few short years since its introduction, MIDI has become the universal language of electronic musical instruments. That language allows two or more electronic instruments to "hold a conversation."

A computer or sequencer, properly fitted with MIDI connectors and a software program, can also understand this language. Any musical phrase played on an instrument connected to the computer through MIDI can be stored in the computer's memory, or to a hard disk or floppy disk.

The stored information, of course, is not actually sound. Instead, the storage medium captures or contains the necessary information that is used to reproduce the mechanical performance of the instrument. Since the music stored in MIDI format is likewise not recorded sound, notes can be deleted, changed in pitch, altered in length, copied, and manipulated in much the same way that a word processor works with text; and then replayed using any MIDI synthesizer or tone generator. Additionally, the sequencer program can play back a performance on one synthesizer while recording new music information on another track.

After an arrangement or composition is completed, MIDI can translate the musical information, using a printing software program, into a full score, as well as individual parts transposed to any key signature. It is likely that in the near future music publishers will offer band, orchestra, and choral arrangements on a computer disk. The music teacher could then preview the chart, possibly edit or add to an existing arrangement, transpose any or all tracks, and then print individual parts and a full score.

As the 1980's rapidly move to a close, 1988 is sure to be remembered as the year MIDI came into its own. Computer-based MIDI applications have brought new vision to musicians, and a new awareness of the potential of music. At Yamaha, we are committed to the value of understanding MIDI products through music, not through technology alone. We must continue to maintain the perspective that music is our master, and technology is our servant.

Calendar of Coming Events:

1989:

January 6-7:	Arizona State Tempe, AZ
January 20-22:	Winter NAMM Anaheim, CA
February 17-19:	California State Fresno, CA
April 7-9:	Central West Regional Lincoln, NE
April 21-23:	Central East Regional Indianapolis, IN
May 4-7:	New Eng. Regional Cromwell, CT

YAMAHA®

THE INTERNATIONAL SCENE

Charles Huether
Chairman, International Relations Committe

Plan Now For Tour of Asia

The most important international business at the moment is progress on our developing tour to the Sixth Biannual conference of the International Association of Piano Builders and Technicians to be held in Kyoto, Japan, hosted by the Japanese Technicians Association.

In case you have not heard, we have in the works a tour of Asia which will include visits to a number of factories in China, Korea, and Japan. The final details are not yet complete but will be forthcoming when details have been made final.

The trip will leave San Fancisco May 25th, returning June 14th. We will fly to Hong Kong, proceed through China including Guangshou, Guilin, Xian, and Beijing, moving on to Korea then to Kyoto where the conference will take place, followed by two days in Hammamatsu.

There will be guided tours along the way, special visits to factories in Hammamsatsu, including Yamaha and Kawai. In Japan special activities will be provided for spouses. Past experience indicates this trip and meeting will be long remembered.

Bulletins will be circulated for those signing up as soon as information is available.

The price is $3,400 plus supplimentary airfare to and from San Francisco. This includes almost everything. Deadline for a deposit of $300.00, which in earlier material was stated as November 7 has been extended into December. We do need a minimum number to guarantee these prices.

To send your deposit, or for more information call or write:

Charles P. Huether
34 Jacklin Court
Clifton, NJ 07012
(201)473-1341

Voyagers Travel Service
7 S. Fulerton Avenue
Montclair, NJ 07042
(201)783-5050 ■

Industry News

Geers Company Recovers

Geers Piano Co. of Cleves, OH, had a devastating fire in November of 1987. "It started by spontaneous combustion after the plant had been closed for the day, and it wiped out the entire paint and finishing departments, destroying the walls and roof," said CEO Cliff Geers.

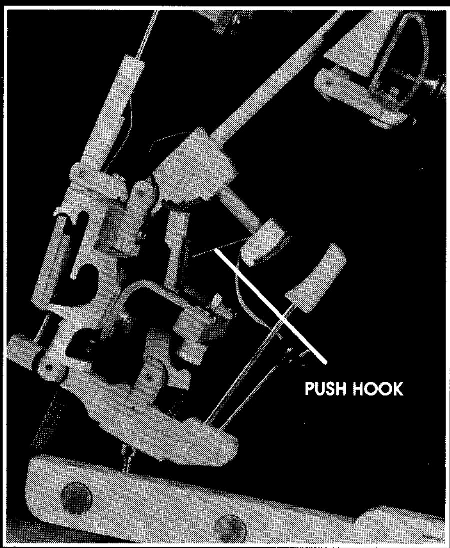
"The fire burned everything in those departments, including pianos and parts. However, because of our plant design, the damage was confined to that area and only to the piano and parts being finished. As bad as the fire was, it was restricted to 25 percent of the plant and out of 140 pianos we had in for rebuilding and refinishing, we lost a total of eight pianos."

The plant has been rebuilt, new shelves and spray equipment installed and as of July 1, 1988, Geers Piano Co. is back in full production.

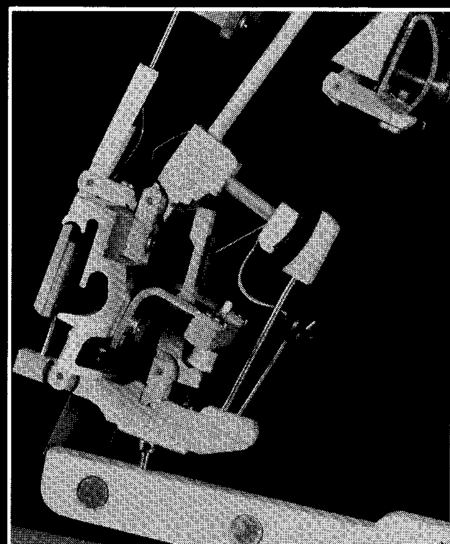
President Tony Geers said, "The repairs include the same structural safeguards that protected the plant before and during the fire and include new safety procedures to prevent this from happening again. We at Geers piano would like to thank our many customers for their patience, cooperation and support during these very trying times." ■

The Langer 80 B.P. System by Kimball

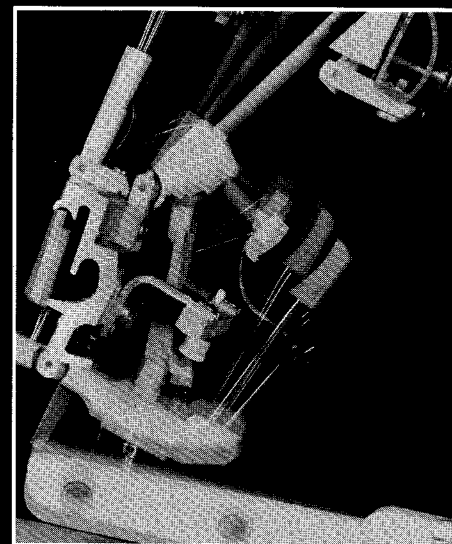
Performance — like no other direct blow action in the world.



The unique "push-hook" attached to the catcher, replaces the jack-stop rail.



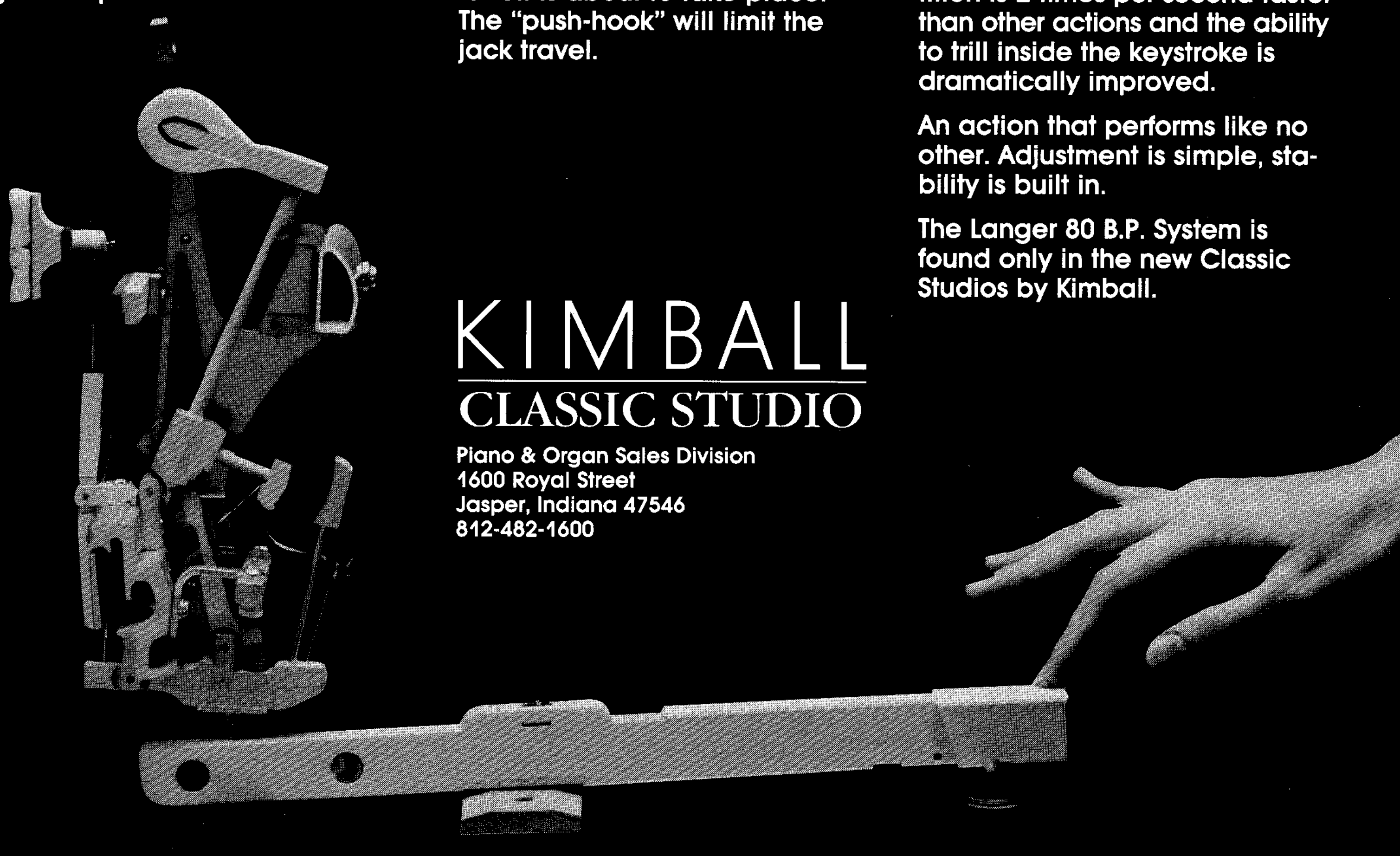
As the key is depressed and the hammer approaches the strings, let-off is about to take place. The "push-hook" will limit the jack travel.



The jack returns more quickly than on a standard action. Repetition is 2 times per second faster than other actions and the ability to trill inside the keystroke is dramatically improved.

An action that performs like no other. Adjustment is simple, stability is built in.

The Langer 80 B.P. System is found only in the new Classic Studios by Kimball.



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CLASSIC STUDIO

Piano & Organ Sales Division
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THE TECHNICAL FORUM

Repairing A Broken Leg Plate

Susan Graham
Technicial Editor

Whether a piano is supported on the jack and box arrangement shown last month, or on some other sort of support, have a backup (for instance, position the bench out of the way but still under the keybed). In the worst-case scenario a piano bench may not support a falling grand piano, but it would certainly slow it down, cushioning the fall (and giving you time to get out from underneath...) Be sure that the main support is placed far enough away from the leg so there is no chance of displacing the support with the leg as it comes free. The consequences of a falling grand piano are too grim to contemplate, so please be very careful: think through the entire operation in advance and take the time to insure as safe a procedure as possible.

"The consequences of a falling grand piano are too grim to contemplate, so please be very careful: think through the entire operation in advance and take the time to insure as safe a procedure as possible."

Legs (and lyres) come loose *toward* the latch or locking system: eccentric, wedge, screw or whatever. Carry a rubber mallet to knock legs loose: it will not damage the finish, and is more effective and far more professional than pounding on the leg with your shoe.

Now that we're equipped and can easily take the leg off a grand piano, what do we do with it? This is facetious, of course, since it is obvious that the next step is to fix whatever it was which prompted removal of the leg. A common cause of wobbling or noise in grand piano legs is a broken plate. This damage is usually due to care-

Continued on page 12

less moving: it is quite easy to snag a leg in a carpet or over a door sill and crack the plate. If either part of the plate assembly is broken, both halves must be replaced. The tricky part is maintaining or reestablishing proper alignment of the leg to the case.

If the piano is still in production, obtaining a leg plate set from the factory may simplify replacement. If not, both round and square plate sets are available from supply houses. Before installation, check to be sure that the plate fits itself — that there is sufficient "throw" as the two parts latch together to create a firm lock. Leg plates are cast and as such are not uniform (which is why they must be replaced as a unit) and it can happen that the key and hole are poorly matched and will not latch securely. There may be insufficient throw, barely allowing any locking at all, or there may be so much that the key butts against the far side of the hole but the sides still are not firmly mated. Rather than try to file or shim such plate sets, return them.

As illustrated in last month's "Forum," if the leg has been stressed enough to break the plate, the screws holding the plate are probably also bent. This makes them difficult to remove since they no longer rotate symmetrically but will "run out" and enlarge the hole as they are removed. An impact screwdriver may be necessary to break the screw free and a ratchet or brace with a large screwdriver blade will save some effort. Do not reinsert such screws: replace them. The large sizes can be obtained from piano supply houses which specialize in hardware (for instance, American).

The fit of a leg plate is done in two dimensions. One is depth: the two halves must fit into the leg and the case so that the mating surfaces are flush with the wood. If either half is too deep in the recess, it may be impossible to get the pieces to latch. If either protrudes, the plates will latch securely but the leg still will be unstable since there will not be solid contact with the bottom of the piano. The other dimension is side-to-side and/or front-to-back alignment under the case. The original alignment of the leg should be maintained; it should match the others in details such as case overhang. Before removing the leg for repair, scribe around the top to record its position under the case. A slight

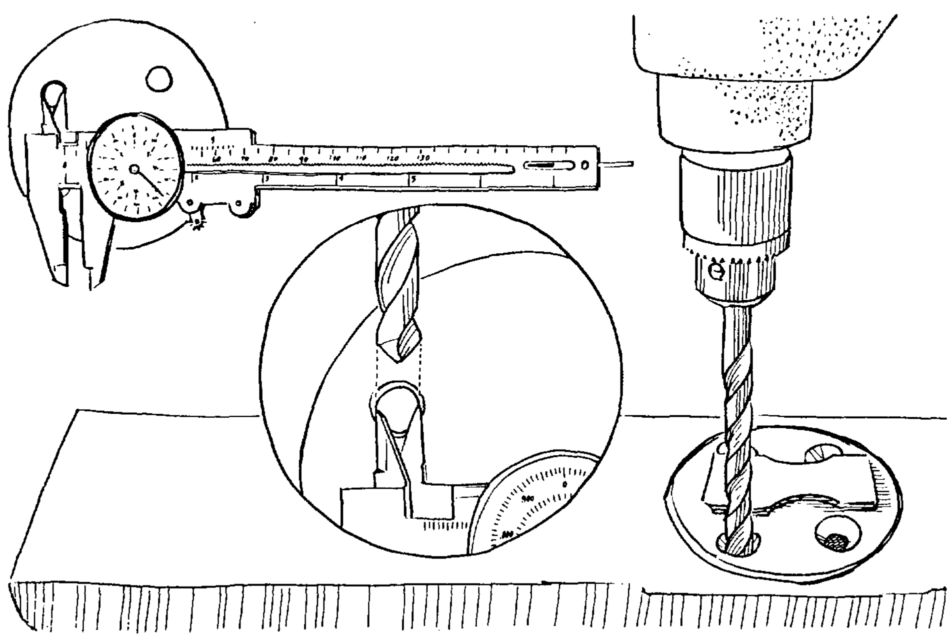
Continued on page 14


No one has ever been paid to play or endorse a Steinway.

change in position may be acceptable, as long as the latching mechanism can be moved to ensure security. Gross changes in leg position, particularly those which result in one leg flush to the side of the case and one which is noticeably recessed, or in a leg which protrudes out from under the case, are not acceptable. Since the relationship between the two halves of the plate is set, it must be repositioned in the wood to correct the alignment of the leg.

With any luck, this will require moving just one of the two plates of a pair. I usually opt to move the plate in the case, since there is more wood surrounding it than in the top of the leg, with less chance of splitting out the side. The first step, after removing both halves of the old plate, is to install the new plate into the leg. If necessary, enlarge the recess in the leg, keeping the plate centered. If the screw holes remaining from the old installation align with the holes in the new plate and are still in good enough condition to hold screws firmly, install two screws in the new plate to hold it in position

Fig. 1 *Marking the hole*



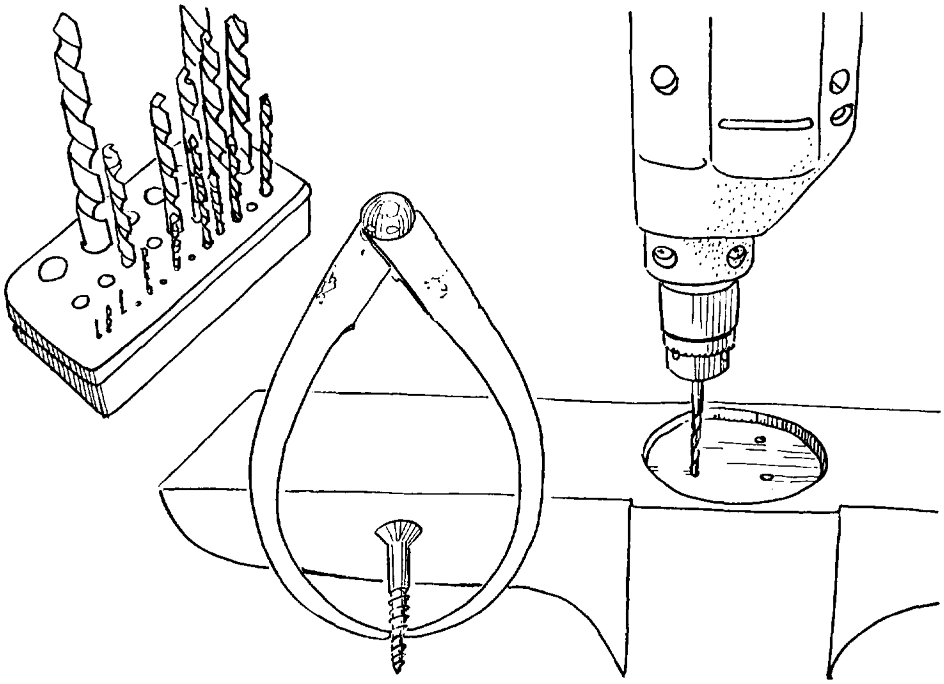
Drawings By Valerie Winemiller

while the alignment to the case is checked. If the holes do not align or are too mangled, they must be plugged and redrilled. Jamming in a shoepeg and hoping it takes up the space is not suitable: leg repairs must be extremely solid and require a higher class of woodworking. Plug all four holes but initially drill out just two (in case of pure bad luck, requiring realignment of both halves, this will save a little time).

Plugging a hole with a hardwood dowel is fairly straightforward. The dowel should be as large as the diameter of the hole to be plugged, and at least slightly larger than the largest shank diameter of the screw to be installed. Drill out the hole to match the dowel, being sure to drill to the depth of the hole. Make a sawkerf along the length of the dowel. The kerf relieves pressure: otherwise, as the dowel is pounded into the hole, glue and air collect in the bottom of the hole and will either split out the part or force the dowel back up out of the hole.

Drilling pilot holes for screws, particularly large ones such as leg and lyre (and pinblock) fasteners, requires several steps. First, use a drill bit which exactly fits the diameter of the hole in the leg plate (or whatever hardware part is being fastened) to dimple the wood underneath, marking the center of the hole (fig. 1). Next, remove the plate and drill a pilot hole: if the bits are sharp and the drill is fairly powerful, this may be the hole for the threaded portion of the screw. The diameter of this bit should match the median diameter

Fig. 2 *Drill to mid-diameter of shank*



of the shank of the threaded portion of the screw (fig. 2). Determine this diameter with a caliper, or by holding the screw up behind the drill bit. As you sight past the bit you should not see the shank of the screw but the threads should be visible on either side. It may be necessary to drill a small pilot hole first, and then drill for the median diameter to prevent the drill bit from jamming or overheating. If the screw has an unthreaded portion of the shank just below the head — and most of these large wood screws do — another drillbit must be used to drill clearance for that portion, drilling only to the depth neces-

Fig. 3 *Drill shank*

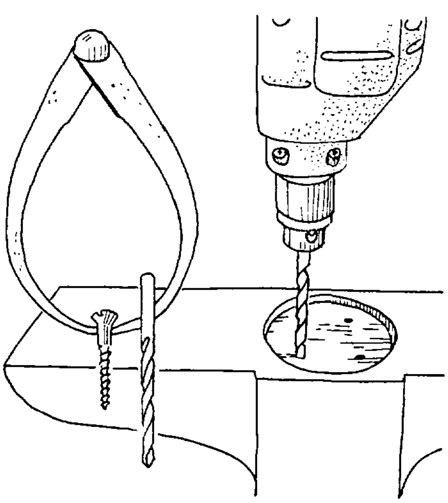
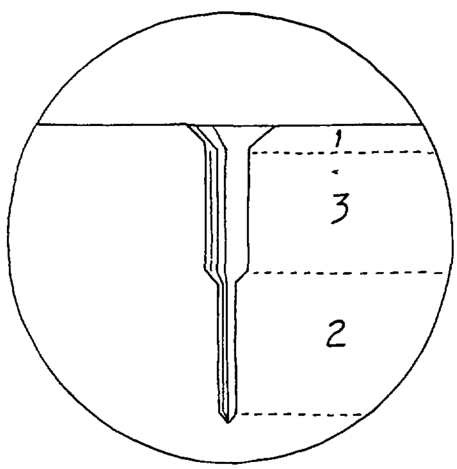


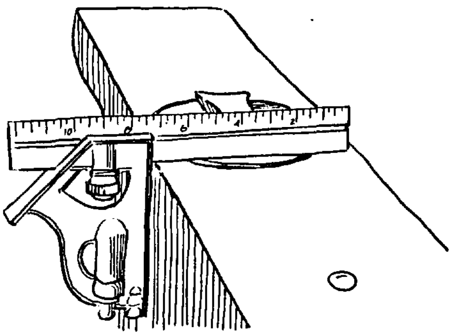
Fig. 4 *Diagram of screw hole*



sary (fig. 3). Countersinking is not necessary in the case of leg plate screws, since the head fits into the countersink in the plate itself, but in applications where the head of the screw seats directly into the wood, countersink the top of the hole. The final result should be a hole which, in cross section, resembles figure 4. Soap the threads of the screws with Ivory bar soap before turning them in so the threads will cut more easily. Finally, turn the screw in carefully, keeping it as vertical and perpendicular to the hole as possible.

Install the leg half of the plate in the top of the leg, (using just two screws at this time). If it is grossly out of level with the top of the leg, shim it closer to position. Lock on the upper half of the plate assembly. Hold the leg up under the case and eyeball the position of the upper half of the plate. With luck, it may fit into the recess left when the old plate was removed. If it does, check the resulting alignment of the leg to the case. If the plate will not fit into the recess, or the alignment is off, then the recess must be enlarged/moved. Sometimes it is possible to chalk the top of the plate and bump it up under the case and get a legible mark to follow. Otherwise, moving the recess is a trial and error operation. The suggested tool depends on how much wood must be removed. In most instances I prefer the gouge: it is not usually necessary to remove much wood, and the gouge is quiet, easy to han-

Fig. 5 *Leveling plate*

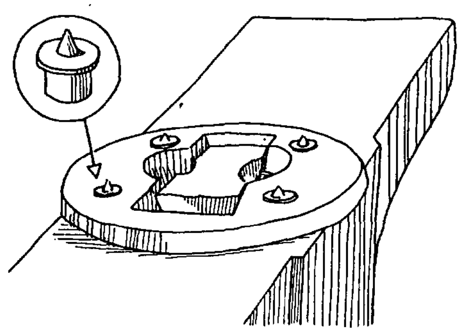


dle even lying flat on your back under the piano, and it doesn't spew sawdust all over your face. On the other hand, if much wood removal is called for, I'd opt for a kutzall or a carbide grinding bit in either an electric drill or a Foredom. The Foredom is a marvelous tool — an electric motor, a four foot flexible shaft with a handpiece slightly smaller than a mototool, and a rheostat foot control. With grinding and cutting bits, it can be used to shape almost anything, from fitting pinblocks to cleaning up between bridge pins. (Raye McCall carries them, and they are also available from large hardware stores and woodworkers' supply houses.) Compact and fairly quiet, it is a portable tool which can be used in a home, and the lightweight handpiece makes it controllable and less tiring to use than an electric drill.

When enough wood is removed so the correct side to side alignment of the leg is restored, the depth of the recess in both halves should be checked and altered as necessary to make the mating surfaces flush and level (fig. 5). This may require shimming to bring up a low spot, or removing wood from the bottom of the recess. If a minimal amount of wood is to be removed, it may be easiest to scrape with a chisel. Flush means flush — as explained, it is critical that these parts fit together securely, and that each half fits securely in its wooden part. Also check the bottom of the case and the top of the leg with a square: either may be warped or cupped, and prevent a good fit. Mark high spots and use a plane or a sander to level.

After the recess in the case has been adequately altered to accept the plate half in its correct position, mark the screw holes: With the case half of the plate still locked firmly onto the leg half, put dowel centers into the exposed screw holes in the case half of the plate (fig. 6). Use the size which fits most closely in the holes (if you purchase dowel centers as an assorted set, this will require two sets). Bump the leg up under the case and the centers will mark the screw locations (fig. 7). Drill for the screws and install the plate half in the case.

Fig. 6 *Assemble lock pieces*

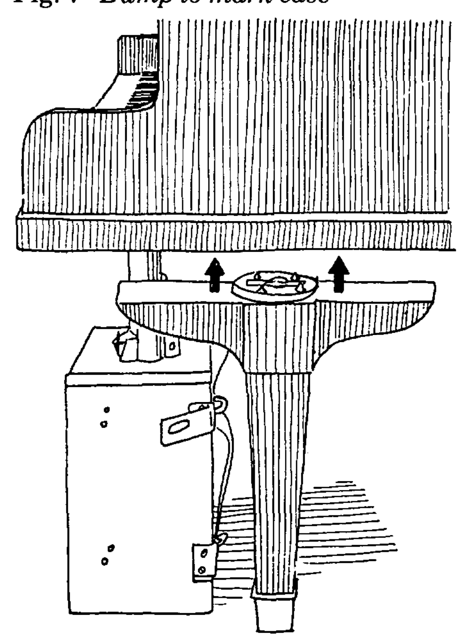


Mark, drill and install any remaining screws in the leg. If correct positioning of the plate has required enlarging the original recess in the case (or the leg), there will be gaps around the new plate. Fill these with wood shims, or coat the plate with a mold release such as wax or teflon spray, and fill the gap with a paste epoxy. Do not epoxy the plate to the wood, since it may need to be removed in the future. Don't leave the gaps, however, since this will weaken the installation.

The other component of leg installation is the latch. This may be a wooden or metal eccentric, a wedge, a capstan or a simple screw into the keybed. In any event, it must be positioned to hold the leg securely when the plates are latched together. The screw holding the eccentric often becomes loose or bent, or the area of the leg the latch contacts wears. Plug and redrill to reposition the eccentric, replacing the screw if it is bent. I carry a spare wooden eccentric, since they do seem to disappear. If the top of the leg is badly chewed, dress the area so it is smooth and level and repair it with veneer or with a metal plate available from a hardware store. Jamming a piece of cardboard between the eccentric and the leg is temporary, at best...

This takes care of two common problems found in grand legs. Replacing casters may also require that the legs be removed: never assume that new casters will fit into old sockets. The caster must fit tightly in the socket or it will jam and may cause the leg to split, and the piano will be wobbly. Obviously, the depth of the new caster stem must also match the socket. The socket itself must be tight in the leg, or it may cause splitting: putting in a new socket often requires some shimming. If the old socket hole is too small or too shallow, it will need to be drilled. There is usually enough clearance for the caster to turn freely, but check it; as on old uprights, installing new doublewheel casters can be a problem because the diameter of the recess cut for the caster to turn is not large enough. Even if everything fits, the leg should be removed so the screws which hold the socket can be checked for tightness, or they may buzz. Finally, be

Fig. 7 *Bump to mark case*



sure to maintain the correct pedal height: new casters may be larger or smaller than the originals, and much change in either direction can be a problem.

Next month I'll move on to lyre

and trapwork repairs. This month's "Is There Another Way" section contains a clarification on the use of broaches for centerpinning, a tip on marking screws in a Chickering two-piece pinblock and a method for adjusting vertical damper spring strength. Also of interest in this issue is an article from Darrell Fandrich and Chris Trivelas, discussing problems of repetition and touch in piano actions.

Is There Another Way?

Center Pin Broaches

"I have a word of caution concerning Don Mannino's article on flange rebushing. When APSCO first sent the catalog supplement, I ordered a set of broaches, thinking they would help me do a better job of sizing flanges. However, the set I received were tapered, not straight...Perhaps this is no longer the case".

Dan Casdorf
Morgantown, W. Va.

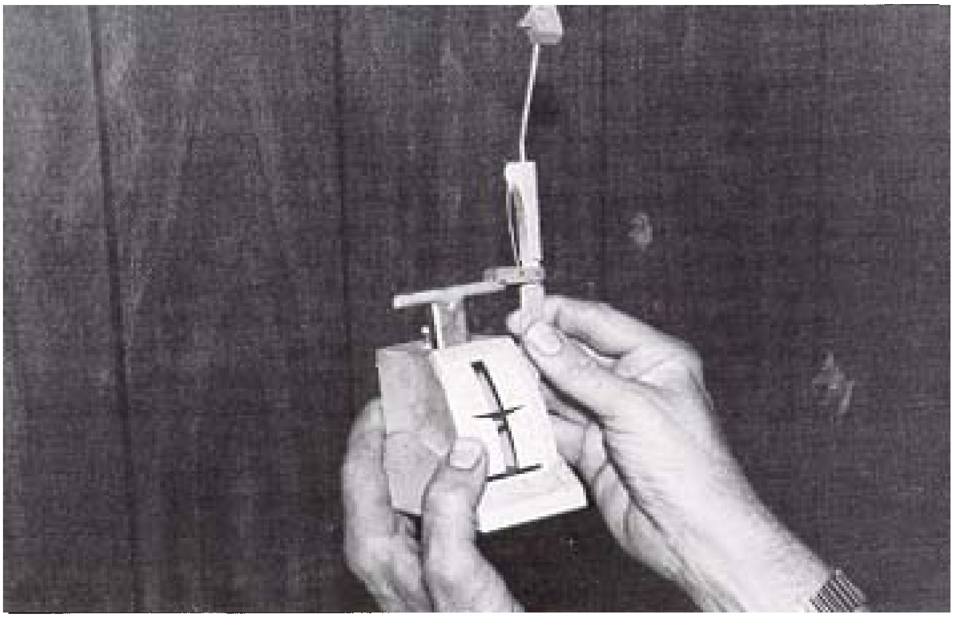
Apparently, this confusion stems from one word being used to describe two different tools. The broaches Don uses and refers to in his article are "Ausreibnadeln," purchased from Renner. APSCO carries similar tools, also called broaches, but, unlike Don's, they are tapered and fluted. Obviously, use of them would require a different technique.

"Blind" Pinblock Screws

"The subject in question is a Chickering grand with a two-piece block. My problem was to figure out a way to determine where to drill 33 plate screw holes without shifting the new block away from the flange. Since the block is fastened to the plate from underneath, there is no indication from above where to drill as with conventional designs. A pattern must be transferred from the double flange and webbing area to the block. A factory bulletin was probably issued in 1823 and passed down to countless technicians, but no one told me. Here is my quick tip:

I lightly sprayed the block area of the plate (not the block) with a spray adhesive and fitted a piece of wax paper into it. The paper was then sprayed, after I punched holes where the screw holes are located in the plate. It was now a matter of laying the blocks on the paper and removing both. Mark the blocks, clean off the adhesive, drill and countersink. Will the adhesive contaminate the wood? Exposure to the adhesive is brief and absorption, I think, is negligible.

Charles M. Cook
Louisville, Kentucky



Technical Tip

When rebuilding upright actions, I invariably encounter uneven damper spring tensions, because some former fixer-upper has increased tension here and there to make a worn damper seat. I bought a postage scale at a yard sale, replaced the round platform with a piece of hammer shank to stabilize the travel of the weight-measuring assembly, and use this postage scale to make uniform the tension of all the dampers while they are off the action rail.

I place the tail of the damper flange on the scale, then press the damper down until the flange is horizontal, and at a right angle to the damper lever — approximately the position it holds at rest in the piano. The scale tells me how many ounces of tension the damper will be exerting against the string.

I take a reading of the un-bent dampers and set section mates to that tension, or if all the dampers are messed up, I generally set tensions of eight ounces for monochord bass, seven ounces for bichord bass and low tenor, then decrease tensions gradually to 4 1/2 ounces in the highest treble. Although good uprights have keys additionally weighted past the damper section, I find that decreasing the damper spring tension always works nicely to help even the touch-weight of the action.

Bob Waltrip
Levelland, Texas

Inharmonicity And Inharmonicity Formulas

Rick Baldassin
Tuning Editor

At the conclusion of the October column, I invited responses on the subject of inharmonicity and inharmonicity formulas from both Dave Roberts and Dr. Albert Sanderson. Both were kind enough to respond. Their responses contain several formulas. If you are not one who is inclined toward mathematics, I still recommend that you read each response carefully, so that you may grasp the concepts presented in each, even if you do not understand the math. To those of you who are inclined toward mathematics, I am sure you will find this most interesting. At the conclusion of both responses, I will try to summarize the main concepts presented.

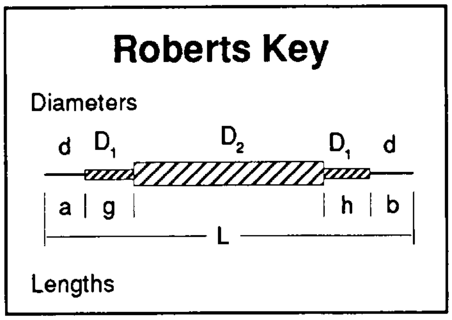
Our first response comes from Dave Roberts, of Sagamore Hills, Ohio. Dave writes:

I was recently notified of an article which was published in the July 1988 *Piano Technicians Journal* under the heading "Tuning Up" by Rick Baldassin. The subject discussed in the article regards inharmonicity formulas which I used during the years when I taught piano scaling at PTG state and national conventions and, ultimately, published in the PTJ from 9/79 to 4/81 in the series "Calculating Technician."

It was alleged that the inharmonicity formula in that series is flawed for the wound strings and that certain alternate formulas are much more accurate, as proved by measurements which Rick himself undertook and analyzed. I would respectfully like to take issue with these statements and challenge the correctness of the "exact" inharmonicity formulas which he presents as well as some statements made in his reader responses in subsequent PTJ issues.

First, the reason for the alleged discrepancies between the Calculating Technician formula and Baldassin's measurements is that his inharmonicity data (at partials n = 4,8) are not appropriate for calculating inharmonicity at the 4th partial in the lower bass. This is a reasonably legitimate procedure for the higher strings on a piano, where inharmonicity is closely proportional to n^2-1 and where a calculation of the so-called inharmonicity constant "B" would therefore be about the same no matter what two partials are chosen. However, as shown by Schuck and Young[3], the *indirect* calculation of inharmonicity at the 4th partial in the lower bass, using data from partials n = 4,8, can be as little as *one-half* the *actual* inharmonicity, as measured directly from partials n = 1,4. My own measurements appear to support this. Without sensitive and highly selective laboratory equipment, however, this behavior is difficult to verify and the measurements can also be muddled in the "noise" of disturbances due to nonuniform cores and windings, soundboard resonances, imperfect termination conditions, etc. In any case, this perceived behavior is why I modified my inharmonicity formula to give progressively larger inharmonicity values in the bass than predicted by the theory of Miller[1], which is cited by Baldassin. I will discuss both Miller's theory and my modification of this theory in a moment, but first some perspective on this issue of inharmonicity.

Because there are so many complex factors which influence inharmonicity, it should be emphasized that the practical value of an inharmonicity formula is not to calculate highly accurate values of inharmonicity in a given string or piano, but rather to serve as a guideline for evaluating smoothness of inharmonicity changes in stringing scales. This was my goal in the Calculating Technician. In this regard, the Calculating Technician formula for inharmonicity was demonstrated (1/81 Calculating Technician article) to be well suited for scale evaluation across all scale breaks. It can be shown that this would be true with or without the aforementioned modification for larger inharmonicity in the bass, so this modification, although certainly a point of interest, should not be a point of contention.



I would also like to note that the emphasis of the Calculating Technician series formulas is to check smoothness not only in inharmonicity, but also in other important parameters, such as loudness, hammer/string contact time and string elongation. Only if *all* of these acousto- mechanical parameters vary reasonably smoothly across the entire scale are the tuning, volume, voicing, and tuning stability likely to be uniform or at least smoothly varying across the many scale breaks (1/81 Calculating Technician). These include plain-wound transitions, treble-bass bridge(s), aluminum-iron-copper windings and monochord-bichord-trichord unisons. Smoothness in inharmonicity alone is not an adequate guideline. Of particular interest is the fact that string tension does not always change smoothly in a good scale (1/81 Calculating Technician), so that the popular perception of "constant tension" in a good scale is somewhat a misnomer. Ultimately, of course, listening tests and good judgment, not calculations alone, should guide any final decisions on rescaling.

With the above perspective in mind, let me discuss in more detail formulas for inharmonicity. Many years ago, I used an article by Miller[1] to derive a general expression for inharmonicity in a piano string. I have taken the liberty to rearrange the formula below in a form that most closely resembles the Sanderson formulas set forth by Baldassin in order to discuss certain discrepancies. Incidently, Baldassin states that these other formulas also trace back to Miller[1], but I will henceforth refer to them as Sanderson's formulas, since something appears to have been lost in the translation. In each version, inharmonicity is calculated as follows, where lengths and diameters are in inches, tension T is in pounds and sin(x) is in radian mode:

Note that the functional dependence of I-core on the partial number n is different in the two versions, reflecting *different* definitions of inharmonicity. The standard definition in the acoustics literature is the one used by Miller[1], where inharmonicity at the nth partial frequency f_n is calculated *relative* to the fundamental frequency f_1 as $1200\times\log_2(f_n/nf_1)$ cents. This definition automatically leads to the n^2-1 proportionality for I-core. Sanderson's n^2 proportionality stems from a different definition, which relates the nth partial frequency to the frequency of a string with no stiffness. The use of n^2 rather than n^2-1 causes only a small difference in Sanderson's I-core at the 4th partial, however, and this is nearly balanced out by his slightly smaller constant, 330 vs. my 333.8. The latter disparity results from the use of slightly different values for the elastic modulus and density for steel piano wire, which apparently came from different tables.

Turning our attention to the inharmonicity contributions from unwound ends and underwrap steps (if any), it should be noted that I-end and I-step do not vary simply as n^2-1 (or n^2) in Miller's theory, but as a more complex functional dependence on n (see Roberts version above). Sanderson's "exact" version

ROBERTS VERSION OF MILLER THEORY:

$$I_n = \text{I-core} + \text{I-end-a} + \text{I-end-b} + \text{I-step-g} + \text{I-step-h}$$

$$\text{I-core} = [(333.8d)^4/TL^2](n^2-1)$$

$$\text{I-end-a} = 137.7[(D_2^2-d^2)/(D_2^2+.12d^2)][\sin(2\pi a/L) - (1/n)\sin(2\pi na/L)]$$

I-end-b = same as I-end-a, except substitute b for a

$$\text{I-step-g} = 137.7[(D_2^2-D_1^2)/(D_2^2+.12d^2)]\text{x}[\sin(2\pi(a+g)/L) - \sin(2\pi a/L) - (1/n)(\sin(2\pi n(a+g)/L) - \sin(2\pi na/L))]$$

I-step-h = same as I-step-g, except substitute b for a and h for g

SANDERSON VERSION OF MILLER THEORY:

$$\text{I-core} = [(330d)^4/TL^2]n^2$$

$$\text{I-end-a} = 0.287[(D_2^2-d^2)/(D_2^2+.12d^2)][4\sin(4\pi a/L) - \sin(16\pi a/L)]n^2$$

I-end-b = same as I-end-a, except substitute b for a

$$\text{I-step-g} = 0.287[(D_2^2-D_1^2)/(D_2^2+.12d^2)]\text{x}[4\sin(4\pi(a+g)/L) - 4\sin(4\pi a/L) - \sin(16\pi(a+g)/L) + \sin(16\pi a/L))]n^2$$

I-step-h = same as I-step-g, except substitute b for a and h for g lacks this functionality, so, despite Baldassin's claim to the contrary, it is incorrect in the general case of unusually long lengths a,b,g,h and/or high partial numbers n. Only when $4n(a+g)/L$ and $4n(b+h)/L$ are less than unity can these more complex expressions be reduced with reasonable accuracy to the "simplified" forms, which are simply proportional to n^2-1. This is what I have done in my handouts and in the Calculating Technician series. Interestingly, even though Sanderson's "exact" forms for B-end and B-step are at odds with respect to Miller's theory, the resulting simplified forms given near the end of Baldassin's article are in agreement, provided they are multiplied by n^2-1 and not n^2 when calculating inharmonicity. However, neither form accounts for real string termination conditions, as will be discussed below.

When I taught at the 1978 convention, I felt that my general formula above was too formidable (and too much "overkill") to be incorporated into the passout sheets. I therefore simplified the "exact" version and introduced a modification due to Fletcher[2], as will be described below, giving the "Original Roberts Formula" shown in Baldassin's article, except he mistakenly writes

$$2[(a+b)/L - \sqrt{S/2}]^3$$

instead of $2[l/L - \sqrt{S/2}]^3$, where $l=a=b$, rather than $l=a+b$.

I used the results of Fletcher[2] to account for two factors that the Miller formalism does not explicitly take into account: (1) an additional inharmonicity contributed by the wrap itself and (2) a reduction in inharmonicity due to the nature of real string terminations — Miller assumed they are "pinned" (ie., perfectly hinged) whereas Fletcher and others[2,4] have shown that real terminations are intermediate between "pinned" and "clamped." These effects are also described in my 6/80 and 7/80 Calculating Technician articles, but their implementation into the Calculating Technician series inharmonicity formula differs somewhat from that of the 1978 handout, as Baldassin correctly points out.

The 1978 handout ("Original Roberts Formula") uses Fletcher's factor "1.07" in the wire stiffness formula and the $\sqrt{S/2}$ term in the inharmonicity formula to account for (1) and (2) above. In the Calculating Technician series, I made some changes based upon independent measurements of string inharmonicity performed by Lou Day[5] and myself. Our data indicated that (2) above is better described by $\sqrt{S}$ than $\sqrt{S/2}$ and that the factor "1.07" is not nearly enough to account for the larger than expected 4th partial inharmonicity measured in the lower bass strings. I therefore removed the factor of "1.07" from the stiffness formula and placed an (empirically deduced) factor of $(1+B/8)$ next to the core inharmonicity term S on the left side of the inharmonicity formula (see 11/80 Calculating Technician). This (fudge) factor is the principal difference between my "Original" inharmonicity formula and the one given in the Calculating Technician series and is the reason why the calculated 4th partial inharmonicity using the Calculating Technician formula rises faster towards the bass than predicted by the Miller formalism. A reader comment (10/88) that string tension is not accounted for in the "Original" formula is false. Tension is *implicit* in that version and *explicit* in the Calculating Technician series.

For those of you who wish to know what my "exact" version of the inharmonicity formula would be (including double wrapped strings), replace the quantities a, b, $(a+g)$ and $(b+h)$ in the "Roberts Version of Miller Theory" above by $|a - L\sqrt{S}|$, $|b - L\sqrt{S}|$, $|a+g - L\sqrt{S}|$ and $|b+h - L\sqrt{S}|$, respectively, in order to account more accurately for actual string termination conditions[2,5]. In addition, replace the constant 0.12 by $[(1/A)-1]$, where $A=0.27$, 0.79 or 0.89 for aluminum, iron or copper wraps, respectively. Finally, the I-core formula above should be replaced with

$$\text{I-core} = [(333.8d)^4(1+B/8)/TL^2](n^2-1)$$

If you want to "soften" the fudge factor $(1+B/8)$, for whatever reason, you can increase the "8" to a larger number or you can replace this factor with another, based, for instance, on your own inharmonicity measurements in the bass strings. Those of you who prefer Baldassin's "indirect" method of measuring inharmonicity may wish to eliminate this factor altogether or substantially reduce it. As indicated previously, the presence or absence of such a factor is really of little consequence with regard to the usefulness of the formula in evaluating smoothness of inharmonicity across a stringing scale. Beyond this, it is a question of what measurement data one can really believe for partial inharmonicity measurements below the 4th partial.

A "simplified" form of my "exact" formula would be as shown at the bottom of this page.

This version has the same form as the inharmonicity formula in the 11/80 *Journal* Calculating Technician review article. In this version, contributions to inharmonicity from the unwound ends and underwrap steps (if any) are accurate to within 10 percent only when $4n(a+f-L\sqrt{S})/L$ and $4n(b+g-L\sqrt{S})/L$ are less than about one, which is usually true at $n=4$. The quantities $B=A[(D_2/d)^2-1]$ and $C=A[(D_1/d)^2-1]$ are wrap weighting factors.

Let's demonstrate the differences in the various inharmonicity formulas by choosing the lowest unison in a typical small grand with dual copper wraps ($A=0.89$), where $a=b=g=h=1''$, $L=46''$, $d=0.055''$, $D_1=0.109''$ and

$$\begin{aligned} In = 1731(n^2-1)\{&S(1+B/8)+[3.3B/(1+B)][|a/L-\sqrt{S}|^3+|b/L-\sqrt{S}|^3] \\ &+[3.3(B-C)/(1+B)][|(a+g)/L-\sqrt{S}|^3-|a/L-\sqrt{S}|^3 \\ &+|(b+h)/L-\sqrt{S}|^3-|b/L-\sqrt{S}|^3]\} \end{aligned}$$

	Miller	'78 Handout	'80-81 CT	'88 CT ("exact")	'88 CT (simpl'd)
I_4-core	4.3¢	4.6¢	12.8¢	12.8¢	12.8¢
I_4-ends	1.7¢	5.8¢	4.2¢	0.1¢	0.1¢
I_4-steps	9.7¢	(a,b = 2″)	(a,b = 2″)	3.7¢	3.8¢
I_4-total	15.7¢	10.4¢	17.0¢	16.6¢	16.7¢

D_2 = 0.239″ (same as D in Calculating Technician series). Hence, the tension T = 188.7#, the wire "stiffness" S = 0.000165 and the wrap weighting factors are B = 15.9 and C = 2.61, as shown above.

Note that the '80-81 Calculating Technician (single-wrap) formula agrees closely with both of my double wrap versions, as long as a and b are measured to the overwrap rather than the underwrap (i.e., a = b = 2″). Note also how the (1 + B/8) factor used in columns 3-5 and the "1.07" Fletcher factor used in column 2 increase I-core beyond that predicted by Miller. Finally, the subtractive terms - $\sqrt{S}$ or -L$\sqrt{S}$ used in columns 3-5 reduce the impact of the unwound and underwrap lengths on inharmonicity, compared to the - $\sqrt{S/2}$ term used in column 2 and lack of such a term in column 1. Sanderson's formulas (exact and simplified) would both give essentially the same result as Miller, since the criteria for simplification [4n(a + g)/L and 4n(b + h)/L less than one] are satisfied. Otherwise, Sanderson's flawed "exact" form would give results in conflict with Miller.

I hope this discussion satisfactorily clarifies any questions which may have been raised by Rick Baldassin's article and subsequent reader responses. It would be interesting if Rick would repeat his measurements on the Steinway B, using partials n = 1,4 (or n = 2,4 if n = 1 not measurable) in order to see how much difference it makes in his calculated inharmonicity values. If it makes less difference than predicted by my current (1 + B/8) fudge factor for smaller pianos, then we might conclude that this factor needs refining to be a function of piano size (string length?) as well as mass loading. Schuck and Young's paper[3] suggests that it is also a function of dynamic string termination conditions.

I would be interested in hearing from anyone with further input into this matter.

Dave Roberts
8134 Crystal Creek Road
Sagamore Hills, OH 44067
(216) 467-4587

References:
[1] Franklin Miller, Jr., "A Proposed Loading of Piano Strings for Improved Tone", J. Acoust. Soc. Am., vol. 21, No.4 (1949)
[2] H. Fletcher, "Normal Vibration Frequencies of a Stiff Piano String", J. Acoust. Soc. Am., vol. 36, No.1 (1964).
[3] O.H. Schuck and R.W. Young, "Observations on the Vibrations of Piano Strings", J. Acoust. Soc. Am., vol. 15, No.1 (1943)
[4] Fundamentals of Musical Acoustics, A.H. Benade, Oxford University Press, NY (1976). Professor Benade (consultant and friend, now deceased) has other useful references in his book.
[5] L. Day, Denver Chapter, PTG, unpublished (1979). Partial frequencies were measured at A1 on a 44″ copper-wound bass string vs. wrap length. As one unwrapped end was increased from a = 0.25″ to a = 4.0″, the other end was left at b = 0.25″.

Our next response comes from Dr. Albert Sanderson, of Lowell, Mass. Dr. Sanderson writes:

Here are the derivations you requested of the formulas for the inharmonicity caused by the unwound lengths of a bare core wire at each end of a copper wound bass string. The original derivation of the simplified formula was done in July, 1975, and in June, 1977, the formula which incorporates the sine functions was derived. This is the formula which has been distributed in my class handouts from 1978 to the present. The original derivations are much too concise for publication, so although I am sending them to you for historical purposes, I have rewritten them in more complete form, using the notation and symbols I use today. I believe them to be accurate to within 20 percent over practical ranges of bare length and partial numbers. Many professional scale designers besides myself, such as Jim Coleman, Bruce Clark, and Steve Fairchild, to name a few, have used the formulas, checked them against actual wound strings, and found them to be accurate.

This research was prompted by my observation that wound strings had much more inharmonicity than could be accounted for by the core inharmonicity alone. Jim Hayes had pointed out to me that the inharmonicity of the core wire was probably the same whether or not there was any copper winding. In a search of the literature, I was fortunate to locate an article by Franklin Miller[1], and I realized that this could be the explanation for the extra inharmonicity. The simplified formula (actually derived first) did match the data for practical values of bare length and partial number, that is to say, lengths of less than .75 inches, and partials up through 6. I was satisfied with it until I needed a formula for the effect of the step in diameter of a double-wound bass string. The step length is not usually short enough to satisfy the condition, and the simplified formula predicted too much inharmonicity. I went back to Miller, and re-evaluated the integral to get the formulas that use the sine function to describe the "end" and "step" inharmonicities.

Now for the derivation. First take Miller's general formula for the pitch of a string whose linear density (ϵ) is not constant but varies along the string according to the formula in equation 1.

Miller states (and I believe him) that first-order perturbation theory can be applied to calculate the effect of b(x) on the frequency of the nth partial, (νn) as shown in equation 2.

Use the indentity $\sin^2 x$ = 0.5 (1 - cos 2x), and let I_l(n) be the inharmonicity in cents of partial "n" caused by an unwound length, l, as shown in equation 3. This is just the term that involves the integral, multiplied by 1731 to get the answer in cents.

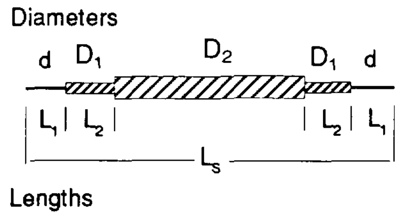
For copper-wound strings of core diameter, d, and copper diameter, D, with speaking length L_S, and bare length L_1, we find that b(x) is as follows:
$b(x) = -(D^2 - d^2)/(D^2 + .12d^2)$
for $x = 0$ to $x = L_1$, and
$b(x) = 0$ for $x = L_1$ to $x = L_S$.
Put this into the integral to get equation 4.

Evaluate the integral, as shown in equation 5.

This equation shows how much the pitch of a string is perturbed or affected by a bare length L_1 at one end of an otherwise uniformly wound string of speaking length L_S. Note that unlike core inharmonicity, end inharmonicity does not depend on tension. Each partial is affected according to a complicated function that involves the sine, and the inharmonicity is *not* truly proportional to the square of the partial number.

The derivation is exact so far, but involves the assumption that b(x) is much less than one, that is,

Sanderson Key



that the winding is thin compared to the core. This condition is usually not met in practice, and we are just fortunate that the formula actually does work very well for wraps up to twice the diameter of the core, or D up to 5d.

For small n and L_1 we can approximate the sine function, as shown in equation 6, and get a simpler formula that runs faster and is easier to program.

Put this sine approximation into equation 5 to get equation 7, cancelling terms and rearranging gives equation 8.

Note that for small values of n and L_1, this approximate inharmonicity *is* of the "n^2 type."

In his book, W. V. McFerrin[2] uses the notation $I = Bn^2$ for inharmonicity, where I = inharmonicity in cents, B = coefficient of inharmonicity in cents, and n = number of partial, (equation 9).

We can identify "B" in Eq. 9 with the terms that serve the same function in Eq. 8 to write the equivalent inharmonicity coefficient for the unwound end (equation 10).

To get the more accurate form of this equation, we can go back to Eq. 5 and evaluate it for two specific partial numbers to get an equivalent coefficient of inharmonicity for these two partials. Since the fundamental of a bass string plays no role in tuning, let us start with partial number two. We want to use a high but useful

1. $\epsilon = \epsilon_0 [1 + b(x)]$ where $b(x) << 1$.

2. $\nu n = n\nu_o [1 + \beta n^2 - (1/L) \int_0^L b(x) \sin^2(\pi n x/L)\, dx]$

3. $I_l(n) = -(1731/2L) \int_0^L b(x) [1 - \cos(2\pi n x/L)]\, dx$

4. $I_l(n) = 866(D^2 - d^2)/(D^2 + .12d^2)(1/L_S) \int_0^{L_1} [1 - \cos(2\pi n x/L_S)]\, dx$

5. $I_l(n) = 866(D^2 - d^2)/(D^2 + .12d^2)[(L_1/L_S) - (1/2\pi n) \sin(2\pi n L_1/L_S)]$

6. $\sin x \cong x - x^3/6$ (x is in radians).

7. $I_l(n) \cong 866(D^2 - d^2)/(D^2 + .12d^2)\{(L_1/L_s) - (1/2\pi n)[(2\pi n L_1/L_s) - (8\pi^3 n^3 L_1^3)/6L_s^3]\}$

8. $I_l(n) \cong 5695\,(D^2 - d^2)/(D^2 + .12d^2)\,(L_1/L_S)^3\, n^2$

9. $I = B\,n^2$

10. $B_{end} \cong 5695\,(D^2 - d^2)/(D^2 + .12d^2)(L_1/L_S)^3$

11. $I_l(8) = 866(D^2 - d^2)/(D^2 + .12d^2)[(L_1/L_S) - (1/16\pi) \sin(16\pi L_1/L_S)]$

12. $I_l(2) = 866(D^2 - d^2)/(D^2 + .12d^2)[(L_1/L_S) - (1/4\pi) \sin(4\pi L_1/L_S)]$

13. $I_l(8) - I_l(2) = 17.22(D^2 - d^2)/(D^2 + .12d^2)[4 \sin(4\pi L_1/L_S) - \sin(16\pi L_1/L_S)]$

14. $I(8) - I(2) = 8^2 B - 2^2 B = 64B - 4B = 60B$

15. $B_{end} = .287(D^2 - d^2)/(D^2 + .12d^2)[4 \sin(4\pi L_1/L_S) - \sin(16\pi L_1/L_S)]$

16. $B_{step} = .287\,(D_2^2 - D_1^2)/(D_2^2 + .12d^2)\,\{4 \sin[4\pi(L_1 + L_2)/L_s] - \sin[16\pi(L_1 + L_2)/L_S] - 4 \sin(4\pi L_1/L_S) + \sin(16\pi L_1/L_S)\}$

17. $B_{step} \cong 5695\,(D_2^2 - D_1^2)/(D_2^2 + .12d^2)\,\{[(L_1 + L_2)^3 - L_1^3]/L_S^3\}$

partial for the other partial, and I have chosen partial number eight, since it is octavely related to two, and therefore easy to measure. Solving equation 5 for these two values of n gives equation 11 and 12.

Subtracting equation 12 from equation 11 and rearranging gives equation 13.

Now use McFerrin's Eq. 9 to calculate the same inharmonicity difference between partials 8 and 2 for the "n^2 type" of inharmonicity. (Equation 14).

Now equate equation 13 and equation 14 and solve for B, which will be an equivalent inharmonicity coefficient for the difference between the eighth and second partials. (Equation 15).

To reiterate, this equation gives a value for B that correctly predicts the inharmonicity between the second and eighth partials, with reasonable agreement for the intermediate partials when L_1 is less than two inches or so. If greater accuracy is desired, the inharmonicity of each partial must be calculated separately from Eq. 5 for $I_l(n)$.

The derivation of the inharmonicity caused by the step in the copper diameter of double-wound bass strings is derived along similar lines, and need not be given here. The density function depends upon two different copper diameters, D_1 and D_2, and the integral has to be evaluated between $x = L_1$ and $x = L_1 + L_2$. The resulting formula for partials 2 and 8 is shown in equation 16.

The simplified formula can be derived from this formula. Use the approximation for the sine function that was given in equation 6 to get equation 17.

The simplified formula for the step will predict too much inharmonicity in many practical situations because $L_1 + L_2$ is not small enough for a good approximation. If your computer will handle it, I recommend that you use the formula for the step in Eq. 16.

Dr. Albert E. Sanderson,
Inventronics, Inc.
171 Lincoln St.,
Lowell, MA 01852,
(508) 459-2312

[1] Franklin Miller, Jr., J. Acoust. Soc. Am. 21, 318-322 (1949). A Proposed Loading of Piano Strings for Improved Tone.

[2] W. V. McFerrin, "The Piano — Its Acoustics," (Tuners Supply Co., Boston, 1972) pp. 43-44.

I would sincerely like to thank both Dave Roberts and Dr. Sanderson for their responses. I have had a great deal of correspondence and communication with both of these individuals, and have a tremendous respect for each one.

Before I begin, there are three items from the July issue which need either correction or clarification. The first relates to "The Original Roberts Formula" which I published on p. 18. As Roberts stated in his response, there was a misinterpretation of the term for the length(s) of the unwound end(s). This is the term as I published it:

$$[(a+b)/L - \sqrt{S/2}]^3$$

where a and b are the lengths of unwrapped end.

This should read:

$$[l/L - \sqrt{S/2}]^3$$

where $l = a = b$, not $l = a + b$ as I

had assumed. This equation assumed that the lengths were the same. The whole answer is multiplied by a 2 further back in the equation to account for the effect at both ends.

The next correction has to do with sets of parentheses which were left out. This happened three times, once on p. 17, in the Sanderson formula for B end, and twice on p. 19, in the Sanderson simplified formulas. The quantities printed were:

$(D^2 - d^2/D^2 + .12d^2)$ should read
$(D^2 - d^2)/(D^2 + .12d^2)$

$(D_2^2 - d^2/D_2^2 + .12d^2)$ should read
$(D_2^2 - d^2)/(D_2^2 + .12d^2)$

$(D_2^2 - D_1^2/D_2^2 + .12d^2)$ should read
$(D_2^2 - D_1^2)/(D_2^2 + .12d^2)$

The final clarification has to do with a statement which I made concerning the Sanderson formula for B end on page 19, where I stated, "These formulas are highly accurate and will work regardless of whether the unwrapped ends are .5 inches long, or 12 inches long." To clarify, I should have added, "...with respect to partials 2 and 8." As Sanderson stated in his response, the formula gives a value for B that correctly predicts the inharmonicity between the second and eighth partials, with reasonable agreement for the intermediate partials when L is less than two inches or so.

One of the most interesting things to come out of this discussion was that both Sanderson and Roberts used the formula of Franklin Miller as a starting point. Each has sent me a handwritten copy of his derivation, and they are the same. What differs is how each chose to modify or customize the equation to fit their data and their *definition* of inharmonicity.

As Roberts explained, his definition of inharmonicity is of a given partial with respect to the fundamental, hence the multiplier $(n^2 - 1)$, n being the partial number, and one being the fundamental. Sanderson defines inharmonicity as the difference of the squares of two partial numbers, or $n_2^2 - n_1^2$. This definition does not exclude the use of the fundamental. Since $1^2 = 1$, Sanderson's definition of a partial with respect to the fundamental would also be $n^2 - 1$. What this brings to light is that there is inharmonicity at the fundamental, and that it also changes as the string design changes, along with the rest of the partials.

Roberts incorporated into his equation the work of Harvey Fletcher, which predicts two things: 1) that there is an additional stiffening of a string with a winding on it, and 2) that because of the piano string terminations, the effect of the unwrapped ends is diminished slightly. The additional stiffening of the core by the wrap is said to be as much as 7 percent on the lowest note, and decreasing up the scale. This is the source of the wrap weighting factor A/1.07, which Roberts used in his early handouts. The string termination factor shows up as $-\sqrt{S/2}$ in Roberts' early works.

One thing which makes the equations look so different is that the Roberts equations figure the core inharmonicity as well as the end inharmonicities at the same time. The Sanderson equations figure the core inharmonicity coefficient and the end inharmonicity coefficients separately. If we look at the end inharmonicity from the Roberts formula and compare it to the simplified Sanderson formula, we will note that the sine approximations are the same, except that Roberts contains the termination factor $-\sqrt{S/2}$.

Sanderson: $(L_1/L_S)^3$
Roberts: $(l/L - \sqrt{S/2})^3$

This difference is relatively minor. Even the 7 percent stiffening factor is relatively minor. The biggest departures were in an attempt of both Sanderson and Roberts to fit their experimental data. Sanderson felt that the simplified formula was not accurate enough for long lengths of unwrapped end, so he customized his formula to predict the difference of partials 2 and 8. He did this because he felt that the fundamental was of no use in tuning the bass, and because 8 was a high enough partial which was octavely related to 2. He felt that this form gave reasonable agreement for the intermediate partials as well. Roberts, on the other hand, felt that his data supported the research of Schuck and Young, which predicted a "kink" in the inharmonicity curve, and that the lower partials were more inharmonic than expected. For this reason he set out to derive what he calls "empirically deduced fudge factors" based on his data, to more accurately predict the behavior of partial 4 with reference to the fundamental. In the handouts which I have, these ranged from $1 + B/7$ to $1 + B/9$. $1 + B/8$ was the factor which was published in the Calculating Technician Series. The termination factors also ranged from $-\sqrt{S/2}$ to $-\sqrt{2S}$, $-\sqrt{S}$ being the factor published in the Calculating technician series.

Getting back to Dennis Gorgas' question as to why the formulas give such different answers, the answer is quite clear. Roberts' formula includes fudge factors to predict increased inharmonicity between the 4th partial and the fundamental, and Sanderson's formula specifies the difference between partials 2 and 8. This is the reason that there was such a discrepancy in the July 88 column. My data was gathered by measuring the difference between partials 4 and 8. This method meets the criteria for the Sanderson formula more closely than the Roberts formula, hence the agreement of my data with the Sanderson results. It was wrong for me to assume that the Roberts formula was incorrect because it did not agree with my data, though the fact that his formulas showed up in so many versions made that conclusion easier. If I were able to measure accurately the fourth partial with reference to the fundamental, the results may have proved differently. The fact that we cannot hear the fundamental frequencies of these low bass notes makes the direct measurement of inharmonicity between a partial and the fundamental difficult at best. This is the reason I chose to use the so-called indirect method of measuring. I used partials 4 and 8 because even partials 2 and 3 were difficult to read accurately.

If there is a "kink" in the inharmonicity curve as Schuck and Young observed, then neither formula should work well for both sides of the kink. Sanderson's formula ignores the fundamental, and should therefore give values too low for low partials with reference to the fundamental. The data of Roberts and Lou Day support this. The Roberts formula, modified to predict these higher values in the low partials, should give values too high for partials above the fourth, since the kink was said to occur between the 4th and 5th partials. My own data, published in July '88 support this.

It is obvious to me that more data would shed further light, and that a definitive study on the subject is in order. Most of the works cited here were published nearly 40 years ago. Further research into the subject would help us all to better understand the physical nature of the instrument we are dealing with. This would seem to be a worthwhile endeavor for the Piano Technicians Guild to underwrite.

Several formulas never before published have been presented here because one of our colleagues took the time to ask a question. Our forum has served its purpose.

In conclusion, the lesson to be learned here is that just because two things are different does not necessarily make one right and one wrong. It is clear that Roberts and Sanderson started from the same formula, but wound up in different places because their directions were different. Which was right? You decide.

Until next month, please enjoy "Tuning by Flame" by Norman Neblett. Please send your questions and comments to:

Rick Baldassin
2684 W. 220 North
Provo, UT 84601

Tuning By Flame

Norman H. Neblett
Los Angeles Chapter

The call came in from the local impresario of South Bay Chamber Music Society. The concertmaster of the Los Angeles Philharmonic Orchestra was performing with his pianist wife. They had obtained a Grotrian Model 275 nine-foot grand from the local dealer. The latter required that I do the service and that the piano be tuned to A442. Could I do it? "Yes," I responded.

The concert was to be at Harbor College and the piano would be moved in by noon the day of the concert. Could I arrive by 4:30 p.m. and tune and voice? The answer was affirmative.

At 4 p.m. another call came from the impresario. He sounded like he was going to cry. There had been a short in the electrical vault supplying the auditorium. It was to have been repaired by 3 p..m. Now the target time was 6:30, the concert at 8 p.m. I replied that 6:30 was too late to work, having had experience with electricians in the past. I would go down there now and do the job. How would I get any light in a windowless auditorium? "Let me worry about that," I replied.

I had visions of what it must have been like in the time of Schumann, Chopin and Liszt, with the burning candelabras and the old uprights with permanently mounted candle-holders on each side of the music desk. But this was 1988. What to do? Ah! My trusty Coleman propane camping lantern was the answer. Rummaging around the garage produced results, but the gas bottle was empty. So on the way to the college, I stopped at a local sporting-goods store and purchased a bottle of gas.

It was so dark in the auditorium that a flashlight would not penetrate the gloom. I lighted the lantern in the lobby and, with the help of the stage manager, carried tools gingerly over steps and ramps to the stage. It was damp and hot inside without air conditioning, making me think of the adventurers who explore caves.

At my request, the stage manager supplied a ladder upon which we placed the lantern so that it would reflect downward. The piano was already at A443 from the dampness. "Forget it," I said to myself. Violinists love high pitch, even though at the time their instruments were built, A430 was the rule. Two hours later it was finished. I played some pieces on it for another 15 minutes and checked the unisons and octaves to see if the tuning had stayed. In the dampness, the piano had crept to A444 but was solid.

It was now 6:40 and no lights. In walked the artists and the impresario. I stated that the piano was a shade higher than A442. The violinist replied that he loved it high. The pianist tried the instrument and was satisfied. Seeing me start to leave with my tools and trusty lantern, the violinist begged, "Can't you leave the lantern so that we can rehearse?" "I am going on a camping trip this weekend and we need it," I lied.

So off I went, arriving home two hours late for dinner. Out of curiosity, I called the dealer the next day and asked if the concert had taken place. "Yes," he replied, "The lights came on at 9 p.m., the public hung around in the dark, there was a full and enthusiastic house and the piano sounded great."

So hang in there, colleagues. Musical traumas are not always bad. ■

Differences Between Grand And Vertical Actions

Darrell Fandrich And Chris Trivelas

The following article is by Darrell Fandrich and Chris Trivelas, longtime technicians in the Seattle area and founders of Fandrich Design, Inc. It is an interesting discussion of distinguishing characteristics between grand and vertical actions and serves as an introduction for a subsequent article describing a new vertical action which they have designed and are in the process of patenting. Plans are to exhibit the prototype of this action at the 1989 California State Convention and at the International Convention in Portland, OR, in July. (Copyright 1988 by Darrell Fandrich and Chris Trivelas for submission to the Piano Technicians Journal.

There are a number of differences in performance between grand and vertical actions that, curiously, have never been named or clearly defined technically. In comparison, the grand action is usually praised for its responsiveness, while the vertical action is panned for a characteristic light touch, loose feel and uncertain repetition. Piano teachers recognize these limitations when they recommend that their more talented students should have a grand "for its more responsive action." Why the vertical action is so consistently regarded by pianists as inferior to the grand action is a question that has interested us for a long time. Our study has resolved these differences in performance into three areas which are:

Feel of repetition. The characteristic loose and disconnected feel of the vertical action is largely due to a form of lost motion for which we have coined the term "Dynamic Lost Motion."

Speed and reliability of repetition. The grand action will repeat faster. However, we feel that this perception of faster repetition has not so much to do with absolute speed as with a greater ease of control of repetition throughout a broad range of speed and dynamics. A good vertical will repeat surprisingly fast and will equal a grand throughout a large part of this range. But the vertical action will fail to repeat if the key is not released fast enough or high enough. The consequences of this limitation reach beyond a missed note to the way the possibility of failure to repeat limits certain performance techniques.

"Why the vertical action is so consistently regarded by pianists as inferior to the grand action is a question that has interested us for a long time."

Touch. During play, there is a difference in touch resistance between the grand and vertical actions that arises from differing inertial characteristics.

Each of these areas of differing performance has its roots in the basic design, specifically in the way the actions repeat.

Dynamic Lost Motion

When a key of a vertical is raised slowly after being played, so that the wippen is not allowed to return more quickly than the hammer, the hammer must return all the way to the rest rail before the jack can re-engage. For the jack to then freely re-engage, there needs to be a slight clearance gap between the top of the jack and the hammer butt. The first motion of the key will be to close this gap. This is known, of course, as lost motion because the hammer has yet to move.

In a playing situation, however, the wippen and key most often return to the at-rest position faster than the hammer. This enables the jack to re-engage for repetition before the hammer and key reach the at-rest position. But consequently the wippen and key overshoot the re-engagement point momentarily, which causes the lost-motion gap between the top of the jack and the hammer butt to be quite large. If the key is replayed during this moment, its first motion again will be to close the gap and the pianist will feel the small jolt as the jack hits the hammer butt. This is *Dynamic Lost Motion.*

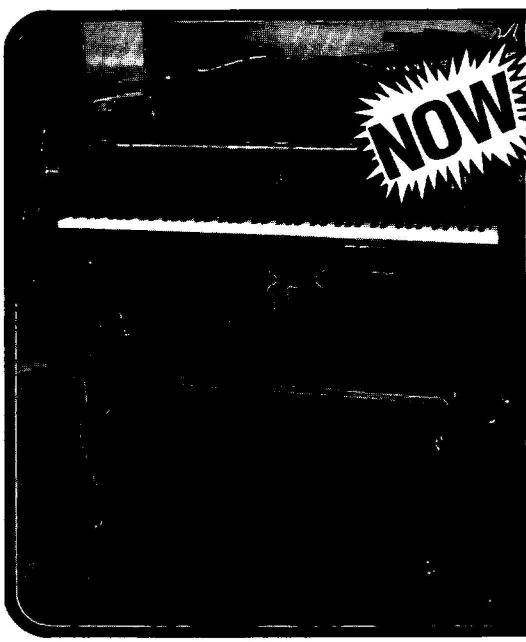
DLM can be compared both with the excessive lost motion of an action in need of adjustment and with the lost motion incurred by the soft pedal, for it is the same gap. Each of these three forms of lost motion increases wear because of the greater force involved when moving parts contact with a jolt. Each also contributes an undesirable loose feel to the function of the action because the touch is much lighter until the jolt of reconnection. However, DLM differs in two respects. It is consistent, varying with the rate of repetition, and it is part of the normal function of a vertical action in good condition.

The amount of DLM will vary with different vertical action designs because it is a tradeoff with reliability of repetition at slow and/or partial key return. A stronger hammer return spring, for example, will lower the amount of DLM because the wippen will not overshoot the more swiftly returning hammer as easily nor by as much. But consequently there will be a greater chance of failure of repetition since the key will need to be released more swiftly to assure re-engagement.

The loose and disconnected feel of DLM in the vertical action is easily demonstrated by lightly bouncing the hammer on the top of the jack at a rate of four or five times per second without allowing the hammer to strike the strings. There is the light touch of the wippen and key momentarily free of the hammer spaced between the jolts of reconnection as the hammer rebounds. This is the feel of lost motion, Dynamic Lost Motion here because the lost motion results from the movement of the parts.

In contrast, it is nearly impossible to bounce the hammer of a grand action on the jack, for the parts track each other and remain in tight or nearly tight contact during repetition. The result of this ability to maintain tight contact between parts is that the key and hammer of the grand action always feel connected and function as if they were of a single piece.

The feel of lost motion permeates the feel of the vertical action. It is there in large quantity when the soft pedal is used. It is there, in a noticeable amount of the ordinary sort, throughout the greater part of the life of the piano. And as DLM, it



is present in varying amounts almost every time a key is replayed without first allowing the hammer to return to the at-rest position. In contrast, the grand action in any reasonable state of regulation has no lost motion, has hardly any DLM and of course has a soft pedal that does not introduce lost motion. We have therefore come to believe that the feel of lost motion in these three forms is one of the three major differences between the grand action and the traditional vertical action that are inherent in the basic design.

The Repetition Lever

If a traditional vertical action were fitted with extremely strong hammer return springs so that the hammer return force was equal to that of a grand, it would be the functional equivalent of the English action. This is the action in most square grands and was in use during the time Erard was developing his "repetition action" with a repetition lever which he patented in 1921. These early years of the 19th century were the dawn of romanticism and from pianos the demand was for more: more pianos, more tone, more volume and more singing quality. A larger tone came with higher tension scales and heavier hammers. But heavier hammers made the touch heavier, which was dealt with by increasing the leverage and key dip. Balancing heavier hammers with key weights was not possible for, like the modern vertical, these actions depended on the jack and key falling swiftly to achieve reengagement. Key weights would impede swift key return and repetition reliability was already marginal. The limits of hammer weight and touch weight and key dip were soon reached.

The alternative to the English action was the Viennese action. In his book *The Great Pianists,* Harold C. Schonberg says, "The differences between the two were summarized by a major pianist of a following generation, Johann Nepomuk Hummel: 'The German (Viennese) piano allows the performer to impart to his execution every possible degree of light and shade,...and does not impede rapidity of execution by requiring too great an effort.'" The English piano, Hummel continues, has much to offer. Among other tings, it must be praised for its "...durability and fullness of tone. Nevertheless, this instrument does not admit of the same facility of execution as the German (Viennese) piano. The touch is much heavier, the keys sink much deeper, and consequently, the return of the hammer on the repetition of a note cannot take place so quickly." (pages 19, 20) Oh! for an action that would combine the power and durability of the English action with the light, responsive touch of the Viennese action.

Sebastian Erard's "repetition" action did just this. "The facilitation of repeated notes was only one advantage of this action. Its more general virtue lay in its lightness, rapidity and responsiveness, which were all achieved without loss of firmness or strength, thus uniting the good points of both the English and the Vienna mechanisms." (Arthur Loesser, *Men, Women And Pianos,* page 338)

The basis for Erard's action was the repetition spring and lever. With the key depressed, the rebounding hammer acting through the repetition lever compresses the repetition spring on its way to the backcheck position. With the release of the key, the backcheck relaxes its hold on the hammer and the compressed repetition spring supports, even lifts the hammer while in the opposite direction it accelerates the wippen and key toward their at-rest position. Such a strong force separating the jack and key from the hammer makes extremely rapid reengagement possible.

With the repetition lever and spring, the Erard action was not dependent on the swift fall of the wippen and key for repetition, so that the playing end of the key could now be fitted with key weights to counterbalance heavier hammers. Lost motion was also eliminated because with re-engagement assured by the repetition lever and spring the hammer could now rest directly on the jack. Nor was DLM a problem because the force of the repetition spring is checked at the moment of re-engagement so that the problem of the jack overshooting the knuckle is minimal and easily contained by the opposed forces of the key weights and the hammer weight, which act to keep the jack and knuckle pressed together.

This same period brought an improved vertical action. In 1926, Robert Wornum of London patented his "piccolo" vertical action. "Ignace Pleyel of paris adopted this action for his upright pianos and...with the exception of changing the dampers from their position above the hammers (the birdcage) to a more proper place below the hammers, this Wornum action is used in all present-day vertical pianos" (Alfred Dolge, *Pianos And Their Makers*, page 54). Like the English action, the Wornum action also depends on the swift fall of the key for repetition, but the hammer return force is much less with the hammer mounted vertically, which introduces DLM but aids repetition. This action, along with scale improvements, enabled the vertical piano with its low space requirement to displace the square grand as a less expensive alternative to the grand during the closing decades of the 19th century.

But the Wornum action that once compared so favorably with the English action has now been compared with the Erard grand action for well over a century. The difference in repetition capability between these two actions has sometimes been minimized by the observation that seldom in actual play does a key of a vertical fail to repeat because it wasn't raised high enough or fast enough. But we have come to believe that this is more of a compliment to the ability of pianists to adapt rather than proof that this repetition limitation is not musically significant.

Inertial Characteristics of Touch

Touch resistance is a complicated affair. Some of the factors that affect touch resistance are familiar and measureable such as down weight and friction. Some less obvious factors are the resiliance of the felt and leather cushions between action parts, the compliance of the key and hammer shank and hammer voicing. Not much talked about until recently is inertia.* And it is differing amounts of inertia that constitute the third major difference between grand and vertical actions.

With an action of good design and in good condition, the down weight as measured with grams weights is an indication of touch resistance for pianissimo play. As the key is played with increasing force, this perception of resistance or weight also increases because of inertia. This is what makes the touch pressure-sensitive. Pianists much prefer a touch that allows dynamics to be controlled with variations of pressure rather than speed, and with the right amount of inertia, the touch is pressure-sensitive throughout the entire dynamic range. With too little inertia, the touch is more speed-sensitive, like a spinet. Too much inertia gives the touch a massive, unwieldy feel. Soft, rapid play is difficult and loud, forceful play is tiring and even painful. With the right amount of inertia there is a very desirable linearity between the pressure applied to the key and the volume of tone perceived.

One other useful quality of touch that inertia provides is momentum. Momentum is inertia tending to continue movement. It is momentum that enables techniques of play that do not follow all the way through to fully depress the key.

To get a feel for the effect of inertia, strike a top treble key a few times with forceful, swiftly repeated blows. Then immediately strike a middle or bass key with a few equally hard and swiftly repeated blows and compare the increase in resistance. This is the effect of inertia, for the keys are all balanced for a similar down weight.

To put it another way, inertia reveals itself in a piano key action as touch resistance over and above the state of imbalance indicated by the touch weight (down weight) but only during play. This resistance increases directly as the keys are played with increasing force or swiftness. In a straight-line situation, this force could be proportional

* The larger the mass of an object, the harder the earth pulls on it. This pull is gravity and is perceived as weight. Gravity decreases with distance, but an object has mass whether or not it is near enough to earth to have perceivable weight. Mass reveals itself as inertia, a resistance to move or change its state of movement.

directly with the mass of the parts and with the rate at which they are accelerated during play.* However, piano action parts do not move in straight lines, but rotate about centers, and in a rotational situation, it is not mass alone that counts, but mass times the *square* of the distance between the mass and its center of rotation.**

From this combination of factors, the hammer emerges as a major source of inertia. It is relatively heavy. It is located relatively far from its center of rotation. And it moves through a greater distance than do other action parts, which means that it undergoes the greatest amount of acceleration during play. In a grand action, the key weights are another major source of inertia. A lead key weight is about 25 times heavier than the wood it replaces in a key. The average distance between these weights and the balance pin, their center of rotation, is similar to the distance between the hammer and its center. But the distance through which they travel is so small that their inertial contribution is somewhat less than that of the hammer.

That the key weights contribute somewhat less inertia than does the hammer, however, may be misleading because key weighting can be manipulated to effect inertia to a surprising degree. The function of key weights, is, of course, to counterbalance hammer weight to provide a standard touch weight. This may be achieved in two different ways, either with more key weights closer to the balance rail or with fewer key weights further out toward the playing end of the key. For example, the counterbalancing effect of one key weight at eight inches from the balance pin ($1 \times 8 = 8$) is the same as the effect of two weights at four inches ($2 \times 4 = 8$). However, the inertia of the single weight at eight inches ($1 \times 8^2 = 64$) is double that of the two weights at four inches ($2 \times 4^2 = 32$). This is because it is the *square* of the distance between a mass and its rotational center that is important for inertia. To venture a general statement, we would say that the difference in inertia between these two styles of key weighting is comparable to the difference between a heavy- and a medium-weight hammer.

The vertical action generally does not have enough inertia for a truly pressure-sensitive touch in the grand tradition. Partly this is because verticals usually have lighter hammers. But more importantly, they either have no key weights or just one or two which are seldom enough to approach the amount of inertia of a grand. Also, the vertical key does not extend significantly beyond the capstan screw as does the grand key in order to provide for back-checking and damper lift. Although this part of the grand key is not very massive, it adds significantly to inertia because it is relatively far from the balance pin.

There are other differences between the grand and vertical actions, such as the differences in length of the playing ends of the keys. Grands generally have more length in the playing end of the key, and this provides more uniform leverage and key dip between play at the front as opposed to the back of the keytop. However, the differences of lost motion, repetition and inertia are the differences basic to the designs of these actions as they have been manufactured over the past century and a half.

From a pianist's point of view, the loose and insubstantial feel of the vertical action, along with its uncertain repetition, are ever-present reminders that the fingers are manipulating a mechanism with limitations. The grand action, unencumbered by these limitations, can often come surprisingly close to the ideal piano action, which would be invisible with nothing between the musical intention and the musical result. ■

Our appreciation to Domenick Venezia, author of the article "A Simple Formula," in the June 1984 Journal, *for his support in the preparation of this article.*

* The specific relationship is $F = MA$ (Force, Mass, Acceleration.)

**In a rotational situation, force becomes a twist called torque (T), acceleration remains (A) and mass becomes the Moment of Inertia (I), which ideally would be the mass of each atom times the square of its distance from the center of rotation. The specific relationship is $T = IA$.

EMC And Soundboards

Nick Gravagne
New Mexico Chapter

But for a flaw, the workmanship on the rebuilt Steinway was perfect. A satin-rub finish complimented the less obvious or glamorous aspects of the job: new pinblock, bridge caps, key bushings, the works. What spoiled it was a failed soundboard shim which exposed an ugly crack. How many have you seen? How about a keyboard painstakingly weighed off during January which feels a little clunky in July? Sooner or later, every observant piano technician learns first-hand that quality work, as to both accuracy and reliability, depends upon understanding and controlling ambient conditions and materials. Indeed, with a change in the weather, good work can turn bad.

This series has often made reference to the equilibrium moisture content (EMC) of wood. Careful woodworkers are ever-conscious that moisture in wood is a fact of shop-life and, since piano rebuilding necessitates handling wood, the subject of EMC attracts the interest of piano technicians. But the subject is very large and the amassed data is often recorded in unreadable and obscure papers, making a real chore of rightly dividing the useful stuff from the academic. This article, then, is about EMC as related to certain piano shop work and not, for instance, to the problems associated with industrial storage of thousands of board feet of mahogany

Let's take a brief look at wood and water. Wood, unlike metal or plastic, has a kind of skeleton called cellulose. The cells in this cellulose are tubular and their arrangement is much like a bundle of drinking straws tied together. In a tree, these tubes are filled with water (sap) and the cell walls themselves are swollen. The water in the cellular tubes is called free water and that in the cell walls is called bound water. When wood loses moisture, it is the free water which exits first and then, when all of it is gone, the cell walls begin to shrivel as the bound water leaves. Wood shrinks and swells only as the bound water content changes, that is, according to the moisture in the cell walls.

As might be surmised, the term EMC indicates that the moisture content of wood must, under certain circumstances, equalize, or attain a place of equilibrium with local atmospheric conditions. These atmospheric conditions are the temperature and the relative humidity (RH). Although the interaction of temperature, humidity and EMC is subtle and complicated, the basic fact is that higher temperatures and lower RH mean lower EMC values. Simply, the moisture content of the wood adjusts to the controlling influence of temperature and RH. And when the wood is neither taking on moisture (adsorbing) or losing misture (desorbing), it is said to be at rest, or in equilibrium with its environment, be that environment natural or artificially created. EMC values are expressed as percentages, a ratio actually of the weight of water in a given piece of wood to the weight of that same piece of wood when completely dry. The range of percentages, then, is broad. For our purposes, however (and for most indoor woodworking applications), EMC percentages for the work at hand are in the four to 12 percent range, with four percent being extremely low and reserved for soundboard making.

Ideally, a piece of wood should be processed with its end-use in mind. A wooden rocker destined for a toasty life near the family woodstove is doomed at the drawing board unless constructed of very dry wood. If the rocker is moved to the front porch for the summer, it will probably swell enough to crush the wood fibers of internal joints. When moved back indoors to cozy October nights at the dry woodstove, the rocker will creak and groan with loose joints. And the maker of the rocker may be wrongly charged with a bungled job. If we change our rocker to a piano and our woodworker to a piano technician, we draw an all-too-familiar analogy — which brings us back to the failed shimming job at the beginning of this article. What could have prevented the failure? How dry was the soundboard when the crack was shimmed? How dry should it have been? What are the owner's responsibilities?

Let's consider soundboard shimming relative to EMC. The job should not begin by reaching for the shimming chisels and a hundred assorted shims. It begins with two simple questions: What is the EMC in this soundboard? and what is the worst-case (but normal) EMC this board is likely to experience in its future home? As with our wooden rocker, the anticipated ambient conditions need to be taken into account. The first question is answered by measuring or estimating the EMC. Moisture meters are obviously useful but, as will be seen, not necessary.

Electronic moisture meters work on the principle that water conducts electricity. The more moisture contained in a piece of wood, the more electricity it will conduct. The meter is designed to convert this current into a mechanical or digital readout as an EMC percentage. Using a meter on a soundboard necessitates making pinholes (or larger 1/8-inch holes) in the board into which probes are inserted. Current flows through the wood and between the probes or pins, completing the circuit through the meter. Follow manufacturer's instructions. (Note: if your meter requires drilling 1/8-inch probe holes, drill them at a place on the soundboard where they will be under the plate. Also, drill them through the board into a rib so as to correctly seat the probes. Failure to do this means both erroneous readings and a split soundboard underside when the probes are tapped in). But what EMC values are we looking for?

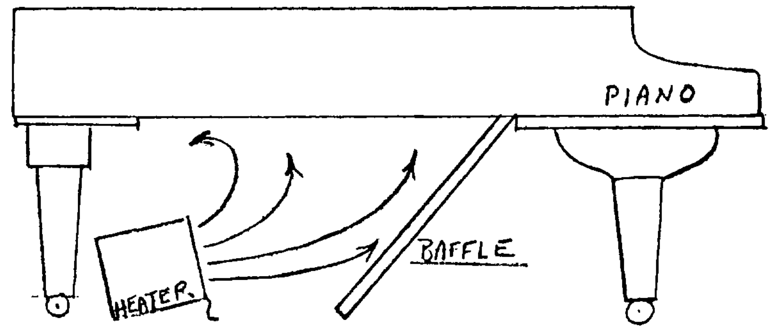
As explained previously, temperature and humidity control the moisture content of wood. Table 1 shows EMC values for spruce at temperatures of 70 degrees F, 85 degrees, and 100 degrees. This valuable data was obtained from the excellent book *Understanding Wood* by R. Bruce Hoadley[1]. Years of experimenting with many wood specimens and species has wrung out this information for us. I refer to table 1 constantly[2]. Notice that when wood is at rest indoors at 70 degrees and 42 percent RH (ideal piano weather), its EMC is 7.5 percent. In July the spruce might find itself at 85 degrees and 65 percent RH, yielding an EMC of 11.5 percent. In January, however, the EMC could be as low as five percent, where the indoor dry air is 70 degrees and the RH is 25 percent. It is clear from the table that a soundboard's EMC can be estimated after having checked the temperature gauge and hygrometer in the shop (you do have them, right?). For example, if the winter shop conditions are more or less stable at 68 degrees and the RH is 35 percent, the moisture content of the soundboard will be close to seven percent.

Too easy? Well, yes. There are some biasing factors to consider, such as acclimation. The piano should be in the shop for several days before estimating EMC. Also varnish and lacquer will skew the estimation since these substances not only inhibit water molecules from entering wood, but block their exit as well. For these reasons, I don't start seriously referring to Table 1 until the board is scraped and has had several days of natural adjustment. But how dry should a soundboard be before shimming?

When working with old boards and EMC the general objective is this; before shimming or finishing, dry the board down to the lowest reasonable EMC that it is likely to have during its driest season. This could be any season depending on the area of the country. Typically, though, dry indoor winter heat accompanied by low RH brutalizes healthy pianos. An atypical, but possible January indoor temperature for some who like it hot is 85 degrees under which the RH could plummet to 35 percent or lower. Table 1 tells us that, given enough time (a few days, a week — nobody knows for sure), the EMC will settle at six percent. Now it is quite clear that if the board was shimmed when the EMC was, say, 11 percent, a drop to six percent means serious shrinkage across the grain and, barring a miracle, a soundboard which will self-destruct on cue. but not everyone enjoys frying at 85 degrees in January, preferring a saner temperature of 70 degrees. Still, the RH, for one reason or another, may hover at 30 percent — also a six percent EMC. If the objective at the time of soundboard repair is to protect against these conditions, then the board needs to be dried out to at least six percent with 5.5 percent being safer yet.

There seem to be any number of soundboard-cooking techniques in practice, ranging from placing the piano over a heat register to placing the entire case inside a hotbox. What has worked well for many is a simple space or area heater. Small, inexpensive and handy, these little dynamos pack a hot punch, and fast. Electric heaters come in all sizes, offering various features: fan-forced; automatic thermostat; overheat protection; tip-over safety switch, and so forth. Mine has a wattage selector switch for either 1300 or 1500 watts, but smaller wattage units will work. Whatever the size,

Figure 1



fan-forced hot air circulating under the soundboard really gets the job done. For convenience, an automatic thermostat is nice.

Place the heater more or less per the illustration at Figure 1. Lean a baffle board or plate on the back of the keybed to deflect the heat upward and away from the keybed. Drape blankets or moving pads over the top of the soundboard and down the sides of the case almost to the floor. The air volume thus confined is very small and the heater will begin baking the board within an hour or so, at which time the board will be warm to the touch. (Use common sense as to fire hazards. For example, don't dangle the drapes in the heater elements).

Since the heat is required to lower the EMC in the soundboard, it is necessary to gauge the progress. Place a thermometer and a hygrometer in the heated area under the piano. Place the soundboard shims under there as well. Table 1 indicates that wood living in 85 degrees and 30 percent RH will settle down to a 5.5 percent EMC. So turn the heat on and periodically check the gauges. When the heat is up to 85 or 90 degrees turn the heat-control knob down until the fan stops and the heating elements turn off. Automatic units will turn on again when the temperature drops. The hygrometer (which will be in a state of shock) may still have a too-high reading, but will eventually fall to 30 percent or even lower. Stay in the shop and keep an eye on things.

The necessary time factor defies estimation; but my last two shimming jobs required three to six hours of heat before I was satisfied. Besides the gauges, there are helpful indicators of board dryness and heat. An obvious one is the condition of the existing cracks. They will lengthen (don't forget to mark

Table 1: EMC Relative To Temperature And Humidity For White Spruce.

RH%	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
EMC%																				
@70°	1	2.5	3.5	4.5	5.3	6	6.8	7.5	8.3	9	10	11	12	13	14	15.5	17.5	20	24	30
@85°	.05	2	3	4	4.8	5.5	6.3	7	7.8	8.5	9.5	10.5	11.5	12.5	13.5	15	17	19.5	23.5	29.5
@100°	0	1.5	2.5	3.5	4.3	5	5.8	6.5	7.3	8	9	10	11	12	13	14.5	16.5	19	23	29

(Values are close approximations)

the pre-dried length). Thin cracks will widen. Also, it is the nature of heat that all items heated in a common place eventually attain the same temperature. This means that the confined air, the soundboard, the rim, the shims, the gauge cases and nosebolts will settle at 85 degrees, although at different time rates. For this reason, I leave in a nosebolt as steel heats faster than wood. A touch of the hand, then, can quickly tell when the soundboard is as warm as the nosebolt. Still, I have found that the cracks have lengthened before the nosebolt and board felt equally warm. Be flexible.

Generally, when the temperature is 85 to 90 degrees, the RH is about 30 percent, the board and nosebolt feel warm and the cracks have changed — you're there. As a precaution during shimming, consider leaving the automatic heater in place and the draped skirting in place, peeling back only enough to expose a convenient workspace on top of the soundboard. Don't rush the shims. There's plenty of time.

Wrap up procedures depend on whether the shims were glued during midday or just before the end of the workday. If midday, leave everything as described above with the exception that the heater doesn't need to cycle at 85 degrees as 75 to 80 degrees will work as a "wrap-up" temperature. Since it is a bad idea to run a space heater in such a small space unattended, end-of-the-day shimming can best be held in a gently heated, overnight "holding pattern" with a couple of Dampp-Chaser bars. If the job was not completed at day's end, activate the heater before continuing.

Although this article is not about shimming techniques, I would add the following opinions. Cracks which go all the way through the soundboard should be filled all the way through. And cracks which don't go all the way through should not be chiseled through. I find this practice more destructive than precautionary. Where possible, leave good soundboard wood intact. Liquid hide glue is too wet and slow-drying for shims and might leave moisture in the crack vicinity even after the rest of the board has adjusted to ambient conditions. But if you're stuck on liquid hide glue, keep heat under the board for 12 hours after shimming.

Piano owners are responsible for caring of their pianos. Rebuilders, although charged with taking reasonable precautions, are not responsible for damage or deteriorating performance caused by in-home, extreme ambient conditions. Advise owners that pianos are happiest in the same climate that most people prefer — 70 degrees F. and 42 percent RH. To expand on this, consider the wry comment of the tuner who, after being forced to tune in a houseful of noisy kids, was later called with a complaint. "Wake up the kids and it'll sound great," he said. Cynical — but perhaps true. When possible, pianos should be strung, tuned, regulated, weighed-off, voiced, etc. at optimum ambient conditions. Later, if these conditions stray, so will the piano's performance. But at least the departure is away from a standard. Think of it as an "ambient tuning fork."

Lastly, I don't believe in the "fail-safe" mentality of rebuilding. This practice suggest drying down to three percent EMC a perfectly good, uncracked soundboard until it *does* crack — that'll fix it! The rationalization is that the board would have cracked anyway later on. Not necessarily. Dry an uncracked board down to 5.5 or six percent per Table 1. If it cracks, fine — better now than Christmas Eve. If it doesn't crack, consider it a safe soundboard and whistle a happy tune. To excessively dry a soundboard is to be guilty of the very crime we so strenuously want our customers to avoid.

The 100-degree data and relative EMC in Table 1 is for soundboard makers (although they probably don't need it). Notice that an average 100-degree temperature with 30 percent RH yields a five percent EMC and a 25 percent RH yields a four percent EMC. This is the range for drying the spruce panel prior to crowning. Again, the necessary heating time cannot be simply stated since the initial EMC of the panel is a controlling factor.

Temperature and humidity gauges react quickly to large changes. Wood, however, does not. It lags and has to play catch-up. If it seems as though a simple, low-tech gauge could be devised which would react simultaneously to these conditions, take heart. There is. See it next month.

My final thought is philosophical. Whether replacing a pinblock or tuning a piano or repairing a soundboard, there should be, beyond the nuts and bolts of it, an idea. We should do these things as if our reputations depended on doing them right since, when we come right down to it, they do. ■

[1] "Understanding Wood"; R. Bruce Hoadley; 1980, by Taunton Press, Inc.; page 69. In the book the author treats the Table 1 data in graph form.

[2] I have checked many wood specimens (mostly spruce) at various temperatures and RH. Although not exact, moisture meter readings compare favorably.

Understanding The Economics Of Your Marketplace

Janet Leary
Economic Affairs Committee

As piano technicians, or more appropriately small-business owners, we are continually assessing how we fit into the marketplace. First, we look at our relationship to our community in respect to demand for our work, and the price the immediate market will bear for our services. We then broaden our scope and look to our state and county which brings in tax considerations, the overall statewide employment picture, and future growth. Next, we observe the Federal government and hear phrases such as "budget deficit," "GNP," "money supply," "unemployment," "inflation," and "consumer price index," and wonder if hidden in all this lingo there is anything at all pertinent to our businesses. As each year passes we are hearing more and more about "a global economy." It's hard to relate to a global format. Besides, is it really necessary to have an understanding of what is happening on the other side of the world when we're not planning to move our business there?

As we move into the 1990s and beyond, knowledge will be the driving force in our economy and the new source of power[1]. Knowledge is a state of knowing based on facts or information. It is actually taking information and making best use of it through good judgment, not simply amassing data. As small business owners, we wear many hats. We must be aware of all facets of the business environment in which we work, tempered by the time it takes to obtain that information relative to the financial gain from that new knowledge. Since no one can set a price on what each specific bit of information will reward us with monetarily in the future, we're stuck with looking for the easiest way to get the most information with the least amount of effort. There is too much to learn in our lifetimes and not enough time to learn it all.

I feel it is important to have a general understanding of economics. Everyone has a time constraint when it comes to getting information. I feel safe in saying that reading this article will give you the most information possible in an easy-to-understand format, which will get you on the road to a basic understanding of the topic of economics relative to your small business.

The fundamental question economics answers is how to allocate scarce economic resources among unlimited wants. Basic to an understanding of economics is "price theory." Price theory studies individuals and firms, observes how they operate turning resources into goods, what goods get produced and who gets those goods.

Resources being allocated will be called "supply." The piano tuner is supplying the market with tunings. The unlimited wants will be called "demand." How much demand there is for your service basically dectates how many tunings you will be providing to the marketplace.

There is one price that will clear the market — where quantity supplied equals quantity demanded, this is the *equilibrium point* (see Graph C). At a price above that, where quantity demanded is less than quantity supplied, is a surplus or unemployment. At a price below equilibrium, where quantity supplied is less than quantity demanded, is a shortage or inflationary condition.

We can easily relate this to our own businesses. Since piano service is not a necessity to the majority of our clients, we are doing well when the economy in our area is doing well. When the economy is strong, demand increases for our work. If demand for our work increases to the point where we reach our capacity, economic theory says we have two choices — first, to increase the quantity which is the supply of tunings we produce, or second, to increase our prices, which will decrease some of the demand. You as a supplier of piano service are willing to do only so much work, but for a higher price you may be convinced to work more hours per week. It's a basic economic principle that prices increase as we come closer to capacity. This lessens demand and is the basis for inflation.

When the overall economy is at its capacity with low unemployment figures, either the economy works smarter to increase production, or prices rise. This cycle goes full circle in the long run. Wherever there is high demand and short supply there are new entrants into the marketplace. Competition eventually lowers price which increases demand. As demand increases, the suppliers start reaching their capacity and low unemployment results, price increases (which is inflation), and the cycle starts all over again. As you can see from this discussion, there is a continual balancing act between unemployment and inflation.

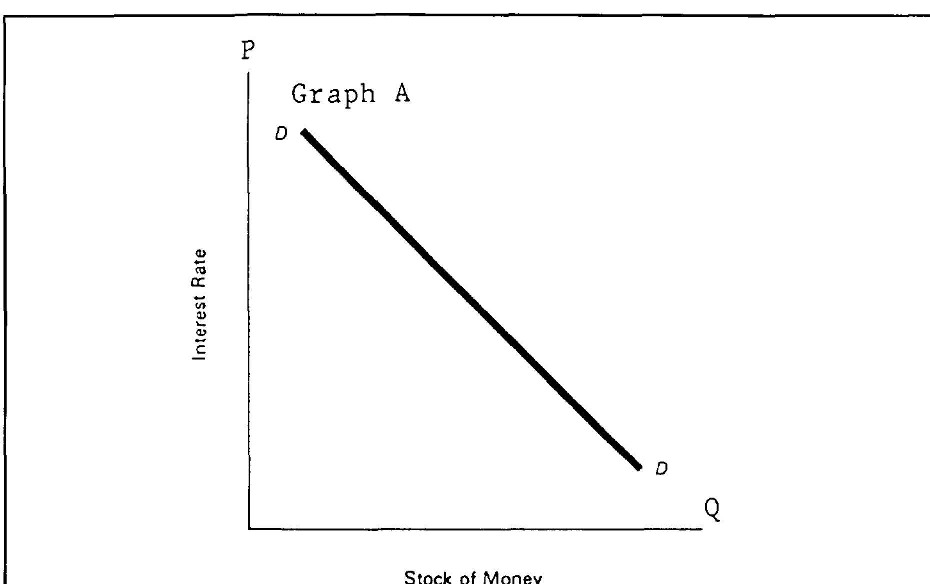
The above-mentioned principles are not just diffuse theory, they are in practice on a grand scale in our economy. You also can make use of them in your business on a smaller scale. Of particular interest is the "working smarter" principle. The U.S. industrial manufacturing sector, or the "rust belt," had real problems in the early 1980s. A change had to be made. New plant investment is being targeted toward modernization rather than expansion, resulting in a leaner, more competitive manufacturing sector. Nationally, manufacturing output in 1987 rose by 5.7 percent over 1986. Productivity in the manufacturing sector has been rising at a 3.5 percent rate each year since 1980 — twice the rate of growth in the total business sector[2].

What does this mean for you the technician? It means if you use the technical information found in this *Journal* and at conventions, with special emphasis on systems to increase efficiency you, too, can modernize and be a more productive worker. There are two basic ways to cut down time spent at a task: better equipment or better systems. Reevaluate your shop equipment. Are you just making do, or do you have what is needed and the space that is needed to be efficient? *Do you read the* Journal *and actually try out the technical suggestions?* There are many technicians that continually give away good information. Make use of it.

Back to supply and demand. In summary, there are four basic economic thought processes in the price model:

1. As supply (quantity) increases, price decreases.
2. As supply decreases, price increases.
3. As demand increases, price increases.
4. As demand decreases, price decreases.

In the following graphs, "P" stands for price, "Q" for quantity. Graph A is a demand curve. It shows that there is a negative relationship between price and quantity. Graphs A, B and C show "interest rate" on the P axis and "stock of money" on the Q axis. This gives you an example to relate to. Think of the changes in demand in reference to changes in the interest rate and changes in the amount of money available to be lent to consumers. Reread the last two above-mentioned economic thought processes dealing with demand, and relate them to Graph A. Also, think of your own business and the demand for your service related to price and quantity.



Graph B is a supply curve. It shows that there is a positive relationship between price and quantity. Re-read the first two above-mentioned thought processes and relate them to Graph B.

Graph C combines the supply and demand curves. The point of intersection is equilibrium, which is where quantity supplied equals quantity demanded. In the real world, this never exists. We are always in a position of movement. These theories also assume that all the external influences in the world remain the same. This is highly impossible, since continually things such as changing demographics, changing tastes, changes in the number of suppliers, technology, etc. impact on the model. So you see, *the basis for much economic thought is shrouded by uncertainties.* No wonder there's so much disagreement among economists[3].

Macroeconomics takes our discussion of "price theory" and relates it to the aggregate economy or the big picture, which is the average of all markets. Three objectives of macroeconomics are:

1. Achievement of full employment
2. Price stability
3. Economic growth (GNP)

Macroeconomic policymakers study the business cycle, which represents the ups and downs of economic activity, and try to determine what's wrong with it to help correct fluctuations. One business cycle includes one expansion and one recession, so it's peak-to-peak or trough-to-trough. Ideally, policy objectives are to shorten recessions and lengthen expansions.

A business cycle is measured in real GNP over time. What is GNP? *GNP, or Gross National Product, measures the total output of the economy.* It's the total market value of all goods and services produced in our economy measured in dollar terms. In recent years, the Commerce Department has estimated real GNP trend growth rate at nearly 2.5 percent. Trend growth is what "the powers that be" feel GNP should be. The difference between trend GNP and actual "real" GNP is called the GNP gap. At this point in time, we have a positive gap since real GNP rose from 1985 through 1987 at about a 3.5 percent average annual rate. For the first half of 1988, real GNP slowed to about a 3.3 percent annual rate. A recession begins after two consecutive quarters of real GNP decline. "Real" GNP is inflation-adjusted, which means we are holding prices constant to actually see the increase or decrease in production. Whenever you see the word "real" before any economic jargon, it means inflation-adjusted.

At this point in time, we are in the longest expansion in history, and there seems to be no letting up in the near future. The present expansion started at the end of the last recession in November 1982. By the time you read this article we will be in our sixth year of this expansion.

The following are some historical statistics that may be of interest to you:

Number of business cycles, 1845-1945: 22.

Number of business cycles, 1945-1982: 8.

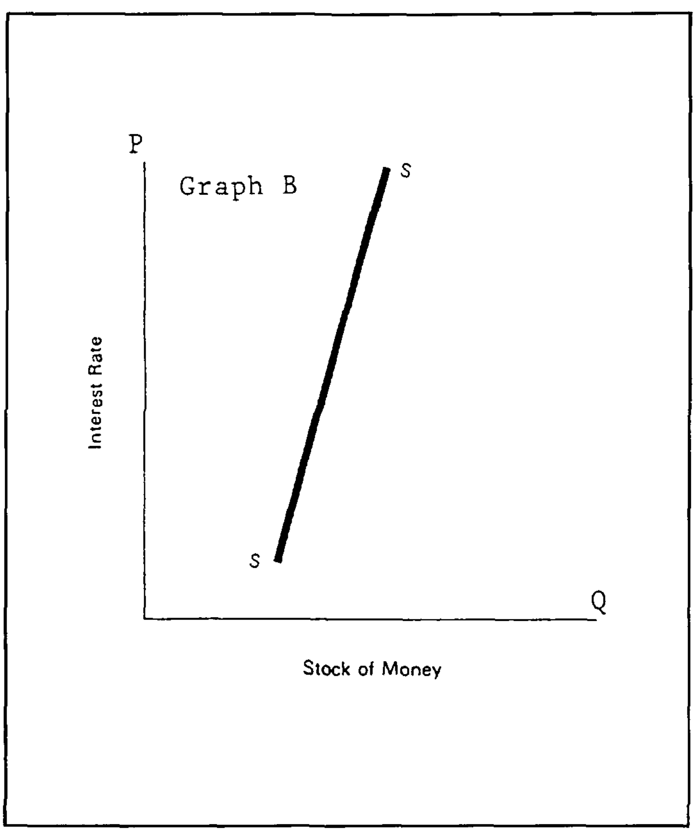
Average length of recessions, 1845-1945: 20.6 months.

Average length of recessions, 1945-1982: 10.7 months.

Average length of expansion, 1845-1945: 28.9 months.

Average length of expansion, 1945-1982: 44.6 months.

As you can see, over time, we have lengthened our expansions and shortened our recessions.



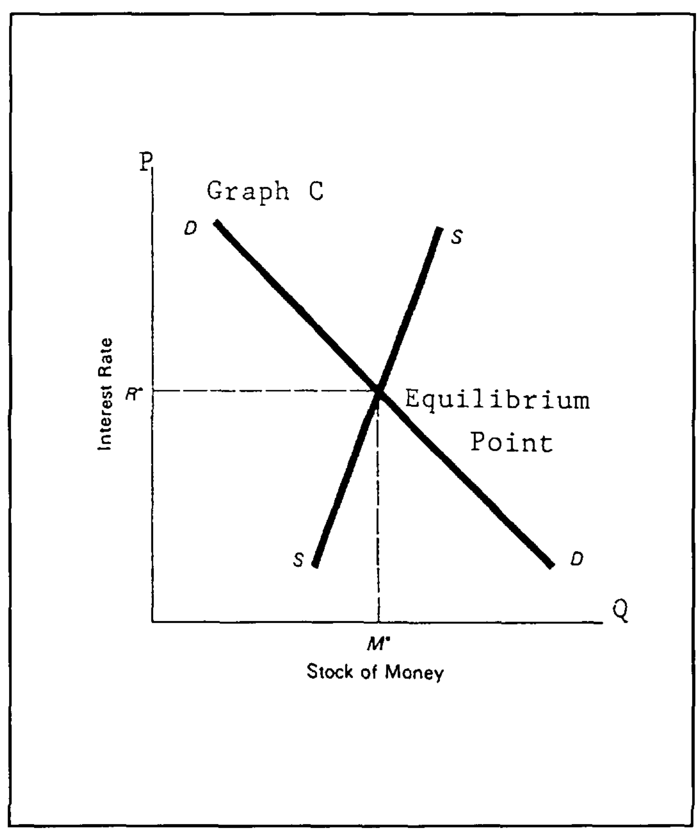


CHART #1 Expenditure category	CPI-U			
	Previous		Revised	
	Average expenditure	Relative importance	Average expenditure	Relative importance
All items	$22,065.00	100.000	$19,362.65	100.000
Food and beverages, total	4,380.12	19.851	3,454.36	17.840
Food at home, total	2,776.44	12.583	1,962.94	10.138
Food away from home	1,352.14	6,128	1,189.82	6.145
Alcoholic beverages	239.85	1.087	301.60	1.558
Housing, total	8,318.95	37.702	8,255.57	42.637
Residential rent	1,367.59	6.198	1,099.66	5.679
Homeowners' equivalent rent	3,029.08	13.728	3,519.20	18.175
Apparel and upkeep	1,116.71	5.061	1,263.23	6.524
Transportation, total	4,772.88	21.631	3,620.03	18.696
New vehicles	851.49	3.859	1,064.36	5.497
Used vehicles	1,014.77	4.599	246.08	1.271
Motor fuel	1,215.34	5.508	929.49	4.800
Public transportation	347.97	1.577	269.67	1.393
Medical care, total	1,383.25	6.269	928.58	4.796
Entertainment, total	931.58	4.222	848.02	4.380
Other goods and services	1,173.64	5.319	992.85	5.128

At the end of every month, information is compiled and announced by government agencies that gives us information to help predict how the economy is doing. One such composite index is called "the Leading Economic Indicators." These indicators track changes in credit for business and consumers, the money supply, stock prices, changes in sensitive materials prices, building permits, contracts and orders, net business formation, vendor performance, new orders for manufacturers consumer goods and materials, the average workweek, etc. This composite indicator normally turns down before a recession and turns up before an expansion starts.

Many economists feel that the leading indicators are not accurate enough, so other indicators are also looked at, such as the coincident indicator and the lagging indicator. The coincident indicator tracks employees on non-farm payrolls, manufacturing and trade sales, personal income less transfer payments, and industrial production. This indicator moves at the same time as the general economy. The lagging indicator tracks business costs, and moves behind the general economy, and will fall during the middle of a recession. By putting the lagging and coincident indicators together to create a ratio, you get a better forecast than just using the leading indicators.

Why are we so concerned with tracking the beginning of a recession? Bringing this back to our piano business, I personally like to know what the economic picture will be in the future in order to plan. If I see the prospect of a recession, I am certainly not going to incur any substantial debt, neither am I going to plan any major business expansion, since a recession slows growth and piano service is not exactly a necessity for the majority of our clients. Also, I think it would make good sense to remind customers that their piano is due for service even during expansions when your phone is ringing off the hook. Training your customers to expect your call and be regular about service makes it much easier when a recession hits.

At this time, I must mention that there is always a dispute about the accuracy of information-gathering and the interpretation of that information. Any inaccuracies, of which I am sure there are many, skew the results, which is a continual problem in economics. If nothing else, I want you to be sure to understand that economics is not an exacting science.

Statistics can be in error, or be interpreted in varying ways. As the eminent economist John Kenneth Galbraith once said in response to a question about economic conditions in the early 1970s, "I think we can pretty well count on almost anything happening." All we can do as piano technicians is watch the trends as the economists do, become more knowledgeable and use common sense.

Another term we hear much in the news is "CPI." *CPI, or Consumer Price Index, is a measure of the average price change paid by urban consumers for a fixed market basket of goods and services. The percentage change of the CPI is the rate of inflation.* Being that the market basket of goods is fixed, however, there is no allowance for substitution of goods or services over time except when it is updated. Historically, the Bureau of Labor Statistics updates the CPI market basket about every 10 years.

Beginning January, 1987, the CPI began using a basket of goods and services which is based on 1982-84 buying patterns, replacing the 1978 weights derived from 1972-73 data. The market basket is composed of the following expenditure groups weighted as Chart 1 indicates[4].

In the revised basket of goods, services rose to 52 percent of the index from about 46 percent. Meanwhile, housing accounts for nearly 43 percent of the index in comparison with 38 percent previously. Energy costs, from gasoline to electricity, increased from 7.7 percent to 10 percent. Food declined from about 19 percent to about 16 percent. Medical costs remained the same, however, not reflecting cuts in benefits, and the passing on of many costs to employees

Besides a change in the composition of the market basket of goods and services, the CPI has a new base. Originally, the CPI had a base of 100 in 1967. By the end of 1986, the price level rose to 328.4 annualized for all items.

Problem

What if you paid $18 in 1967 for a fine pair of shoes. How could you figure out what an appropriate price for that same quality of shoes would be in 1988, considering inflation over time?

Solution

Chart 2 shows the CPI index for all items in 1986 at 328.4 (base 100 = 1967). Chart 3 shows the CPI index for all items at 113.6 in 1987 (base 100 = 1982-84). First of all 328.4 in 1986 means that prices have more than tripled between 1967 and 1986. The price of our shoes in 1986, if they were to keep up with inflation, would be $18 x 328.4 percent, or $59.11.

When the new market basket of goods was created, based on the 1982-84 prices trends, the base was reset at 100 for 1982-84. Look at Chart 3. You will see at the top of the 1986 column and index of 109.6. The index for 1987 is 113.6. The difference between those two years shows a percentage change of 3.6%. $59.11 which was our price through 1986, plus 3.6 percent equals $61.24.

Since the CPI statistics are not yet complete for all of 1988, we will have to estimate. First of all, inflation is likely to be greater this year than for any year since 1982. The degree of price change for consumer goods has accelerated to nearly five percent this year. Since we will experience price pressures brought on by the drought, and producer prices are increasing, I say we stick with a five percent inflation rate for 1988. Adding this to our scenario: $61.24 + 5 percent = $64.30. So you now have the tools to figure out how prices change over time.

There are two major policies affecting the economy: fiscal policy and monetary policy. Fiscal policy is controlled by Congress, it involves government spending, taxation and transfer payment (i.e. Social Security payments). Monetary policy is controlled by the Federal Reserve. The Fed's tools to affect monetary policy are the reserve requirement, the discount rate (interest rate the Fed charges depository institutions), and open market operations (the buying and selling of government securities).

The Federal Reserve is in business to provide a sound monetary climate, an environment for banks to operate, and provide us with currency. The Fed is quasi-public

Annual data: Consumer Price Index all items and major groups

Chart #2 Series	1978	1979	1980	1981	1982	1983	1984	1985	1986
Consumer Price Index for All Urban Consumers:									
All items:									
Index	195.4	217.4	246.8	272.4	289.1	298.4	311.1	322.2	328.4
Percent change	7.7	11.3	13.5	10.4	6.1	3.2	4.3	3.6	1.9
Food and beverages:									
Index	206.3	228.5	248.0	267.3	278.2	284.4	295.1	302.0	311.8
Percent change	9.7	10.8	8.5	7.8	4.1	2.2	3.8	2.3	3.2
Housing:									
Index	202.8	227.6	263.3	293.5	314.7	323.1	336.5	349.9	360.2
Percent change	8.7	12.2	15.7	11.5	7.2	2.7	4.1	4.0	2.9
Apparel and upkeep:									
Index	159.6	166.6	178.4	186.9	191.8	196.5	200.2	206.0	207.8
Percent change	3.5	4.4	7.1	4.8	2.6	2.5	1.9	2.9	.9
Transportation:									
Index	185.5	212.0	249.7	280.0	291.5	298.4	311.7	319.9	307.5
Percent change	4.7	14.3	17.8	12.1	4.1	2.4	4.5	2.6	-3.9
Medical care:									
Index	219.4	239.7	265.9	294.5	328.7	357.3	379.5	403.1	433.5
Percent change	8.4	9.3	10.9	10.8	11.6	8.7	6.2	6.2	7.5
Entertainment:									
Index	176.6	188.5	205.3	221.4	235.8	246.0	255.1	265.0	274.1
Percent change	5.3	6.7	8.9	7.8	6.5	4.3	3.7	3.9	3.4
Other goods and services:									
Index	183.3	196.7	214.5	235.7	259.9	288.3	307.7	326.6	346.4
Percent change	6.4	7.3	9.0	9.9	10.3	10.9	6.7	6.1	6.1
Consumer Price Index for Urban Wage Earners and Clerical Workers:									
All items:									
Index	195.3	217.7	247.0	272.3	288.6	297.4	307.6	318.5	323.4
Percent change	7.6	11.5	13.5	10.2	6.0	3.0	3.4	3.5	1.5

Annual data: Consumer Price Index, U.S. city average, all items and major groups

(1982-84 = 100)

Chart #3 Series	1979	1980	1981	1982	1983	1984	1985	1986	1987
Consumer Price Index for All Urban Consumers:									
All items:									
Index	72.6	82.4	90.9	96.5	99.6	103.9	107.6	109.6	113.6
Percent change	11.3	13.5	10.3	6.2	3.2	4.3	3.6	1.9	3.6
Food and beverages:									
Index	79.9	86.7	93.5	97.3	99.5	103.2	105.6	109.1	113.5
Percent change	10.7	8.5	7.8	4.1	2.3	3.7	2.3	3.3	4.0
Housing:									
Index	70.1	81.1	90.4	96.9	99.5	103.6	107.7	110.9	114.2
Percent change	12.3	15.7	11.5	7.2	2.7	4.1	4.0	3.0	3.0
Apparel and upkeep:									
Index	84.9	90.9	95.3	97.8	100.2	102.1	105.0	105.9	110.6
Percent change	4.3	7.1	4.8	2.6	2.5	1.9	2.8	.9	4.4
Transportation:									
Index	70.5	83.1	93.2	97.0	99.3	103.7	106.4	102.3	105.4
Percent change	14.3	17.9	12.2	4.1	2.4	4.4	2.6	-3.9	3.0
Medical care:									
Index	67.5	74.9	82.9	92.5	100.6	106.8	113.5	122.0	130.1
Percent change	9.2	11.0	10.7	11.6	8.8	6.2	6.3	7.5	6.6
Entertainment:									
Index	76.7	83.6	90.1	96.0	100.1	103.8	107.9	111.6	115.3
Percent change	6.7	9.0	7.8	6.5	4.3	3.7	3.9	3.4	3.3
Other goods and services:									
Index	68.9	75.2	82.6	91.1	101.1	107.9	114.5	121.4	128.5
Percent change	7.2	9.1	9.8	10.3	11.0	6.7	6.1	6.0	5.8
Consumer Price Index for Urban Wage Earners and Clerical Workers:									
All items:									
Index	73.1	82.9	91.4	96.9	99.8	103.3	106.9	108.6	112.5
Percent change	11.4	13.4	10.3	6.0	3.0	3.5	3.5	1.6	3.6

and quasi-private, meaning it is privately owned and publicly controlled. It is owned by the Federal Reserve banks in the system.

Within the framework of "sound monetary climate" the Fed is charged with maintaining a stable price level, which means controlling inflation. The catch is to maintain a stable price level consistent with economic growth, which means an increasing GNP and a stable and rather low inflation rate. How does the Fed do this? One way is to supply enough credit to allow the economy to grow, but not too much, so that people begin to inflate prices. This is the balancing act the Fed plays by increasing or decreasing the discount rate charged to member banks. This past year, the Fed has been gradually boosting interest rates in the attempt to slow down what appeared to be an accelerating rate of growth in the U.S. economy, and a resulting acceleration in inflation. By doing this, the Fed is telling us that it thinks the economy is strong, which bodes well for a continued expansion in 1989. It also means that the Fed is concerned that the economy may be overheating.

At this point in time, the GNP report indicates that the economy is growing at about a 3.3 percent annual rate, which indicates that the economy is healthy. In terms of inflation, the CPI report indicates that consumer prices are growing at close to a five percent rate, indicating that inflation is somewhat in control but at its highest point since 1982. Since the economy is strong we can expect to see higher consumer prices (inflation), and more belt-tightening by the Fed to counteract inflation in the form of discount rate increases. There is a lag between any monetary policy implementation and the actual result seen in the marketplace. The lag ranges from six months to roughly 1.5 years. The Fed will be watching inflation and continually adjusting its policy dependent on the outcome of previous discount rate increases.

Much material was covered in this article. Also, much was left out. If you have never delved into economics, it's a "bear" just to get past the jargon. If you are continually caught up in the jargon, you'll never get to the principles. The purpose of this article was to familiarize you with some economic terminology and principles, and relate the basic principles to your business. I hope this information will be of some use to you. ■

Footnotes

[1]"Money Dynamics for the 1990s," Venita Van Caspel, Simon & Schuster, Inc. Copyright 1988.

[2]"Economic Policy Issues for 1988 and Beyond," W. Lee Hoskins, president of the Federal Reserve Bank of Cleveland, Nov. 15, 1987, Economic Commentary, published by the Federal Reserve Bank of Cleveland.

[3]"Study Guide For Baumol & Blinders Economics, Principles and Policy," Craig Swan, Harcourt Brace Jovanovich, Pub., Copyright 1982.

[4]"Revision of the Consumer Price Index," C. Mason and C. Butler, Monthly Labor Review, Jan. 1987, Vol. 110, No. 1.

[5] Monthly Labor Review," Nov. 1987 and June 1988. Current labor statistics.

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	1988	*1987*
Total Membership	3646	3568
Registered Tuner-Technicians	2487	2540
Northeast Members	834	770
Northeast RTTs	547	552
Southeast Members	585	550
Southeast RTTs	388	385
South Central Members	322	308
South Central RTTs	220	230
Central East Members	619	606
Central East RTTs	415	418
Central West Members	408	417
Central West RTTs	304	311
Western Members	878	869
Western RTTs	613	644

Calendar Of Coming Events

Date	Event
January 6 & 7, 1989	**Arizona State Seminar** Ramada Inn, Phoenix Gary Miles; 3722 W. Port Royale Ln., Phoenix, AZ 85023; (602) 942-2588
Jan. 14, 1989	**Achievment 123 Business Symposium** Airport Quality Inn, Philadelphia Gretchen Kinsey; 1317 MacDade Blvd., Woodlyn, PA 19094 (215)833-1657
February 17, 18 & 19, 1989	**California State Conference** Centre Plaza Holiday Inn William Barrett; 1151 S. Chestnut, #136; Fresno, CA 93702; (209) 453-1839
March 3-5, 1989	**South Central Regional Spring Seminar** Holiday Inn Holidome, Monroe, LA Howard Jackson; 2017 Frances Place, Monroe, LA 71201 (318)388-4879
March 17, 1989	**RTT Tuning and Technical Examination** Seattle Test Center; University of Washington Campus Jim Faris; (206)367-6335 Registration deadline: March 3, 1989
March 30-April 2, 1989	**Pennsylvania State Convention** Brunswick Hotel, Lancaster, PA Dick Bittinger; 107 W. Main St., P.O. Box #51; Brownstown, PA 17508; (717) 859-3111
April 7-9, 1989	**Central West Regional Seminar** University of Nebraska-Lincoln Richard West; 1201 Rose, Lincoln, NE 68502 (402)472-2568
April 21-23, 1989	**Central East Spring Seminar** Holiday Inn North, Indianapolis Robert Bussell; 224 W. Banta Rd., Indianapolis, IN 46217 (317)782-4320
May 4-7, 1989	**New England Regional Seminar** Treadway Inn at Cromwell Jim Birch; 56 Nashville Road, Bethel, CT 06801 (203)744-4842
May 25-June 4, 1989	**PTG Orient Tour** Charlie Huether; 34 Jacklin Court, Clifton, NJ 07012-1018; (201) 473-1341
June 10-13, 1989	**IAPBT Conference** Kyoto, Japan Charlie Huether; 34 Jacklin Court, Clifton, NJ 07012-1018; (201) 473-1341
July 10-14, 1989	**32nd Annual Piano Technicians Guild Convention & Institute** Red Lion Lloyd Center, Portland, OR Home Office; 9140 Ward Parkway; Kansas City, MO 64114; (816) 444-3500

The Auxiliary Exchange

President's Message

About this time our Thanksgiving turkey is just a memory and all our thoughts are now directed toward the coming Yuletide. Before getting caught up in the maelstrom of shopping for gifts, decorative plants, firs, holiday pastries, ribbons and bows let us take a brief review of our past year.

Our infant PTGA scholarship program began to pull itself up to a stand with the generous gift contributions from our members, many of whom were encouraged to do so because of a wee note inserted in their dues billing by our then treasurer, Kathryn Snyder. The year prior Dorothy Silva's special contribution and the 'Christmas in July' '86 Bonanza served to really launch a most worthy project. The results of these efforts were manifest at St. Louis when we heard the students Derison Duarte and Aaron Topfer perform at our Auxiliary tea. They were well-deserved awards.

In the early spring, Nita Kadwell of Washington wrote that her thoughts about another cookbook began to take form and she urged her collegues and their spouses to send in favorite recipes. The deadline of November 1st has passed and Nita, who has received well over 200 recipes, expects to edit and collate them for the printer. We are sure to have the cookbooks ready for sale in Portland for the convention '89. This fund-raiser together with our piano pins and a few suncatchers will help to 'feed the kitty' for our scholarship fund.

Our subsequent months showed regular articles in the Auxiliary Exchange recounting things to do, see, and classes to experience at our annual in St. Louis. These articles, and the efforts of the Guild members were definitely on target since we had a most successful convention with an attendance of 1,027 people. We can all be proud of our past year and work to make '89 as busy, as successful, as interesting as previous years for the Guild and the Auxiliary. In subsequent issues there will be details about the programs to be given in Portland and informative articles about are great northwest, its history, industry and magnificent natural resources.

In behalf of the Officers of the Board and the members of the Piano Technicians Guild Auxiliary we extend to all our friends our holiday greetings and best wishes for a happy and healthy new year.

Agnes Huether

A MODERN DAY SACAGAWEA

For the 1988 PTG Convention we were privileged to enjoy St. Louis, Missouri-the "Gateway to the West." St. Louis was the jumping off point for the Lewis and Clark Expedition as well as for the countless pioneers who surged westward. How fitting then that the 1989 Convention will take place near the terminus of the Oregon Trail in Portland, Oregon.

When Meriweather Lewis and William Clark finally reached the Pacific Ocean it was near the mouth of the Columbia River. Portland is located on the banks of the Willamette River, just south of the Columbia River and the border of Washington State.

Portland boasts many interesting sights and highlights. For the history buffs, the Greater Portland area abounds in museums. The Oregon Historical Society houses all manner of exhibits featuring Northwest Indians, explorers and Oregon Trail pioneers.

The Portland Audubon Society operates an 111 acre sanctuary housing over 110 species of birds. A short distance from the Audubon Sanctuary is Pittock Mansion. The mansion was built in 1914 by Henry Pittock, founder of the *Oregonian*, Portland's major daily newspaper. The site commands a sweeping view across both the Williamette and Columbia Rivers and five snow-capped Cascade Peaks. Tours are offered to view the house, its wonderful architecture and furnishings every afternoon from Wednesday through Sunday.

The forestry industry has always been a vital part of Oregon's economy. The World Forestry Center has exhibits that explain its methods and effects. The Georgia Pacific Historical Museum, operated by the Georgia Pacific Timber Company also has displays of logging equipment and photographs that show the ways in which the industry has and continues to have an impact on the region.

Northwesterners take their recreation time very seriously as evidenced by the vast array of sporting activities available around the metropolitan Portland area. Golf courses abound. Try Eastmoreland and Public Course or Colwood National if you would like to get in a few holes. Green fees average around $10.00 for 18 holes at the public courses. Auto, greyhound, harness and Thoroughbred racing tracks are present; however the season for horseracing runs October through April and therefore will not be in session in July during the PTG Convention.

Great fishing is within driving distance as are white water activities and the sailing is great. Hood River, Oregon, which is a short drive up the Columbia, is the sail boat capitol of the region if not the United States.

The Red Lion Inn Hotel, location of the Convention, is located adjacent to Lloyd Center which is one of the first and largest shopping malls in the state. It boasts a year-round ice skating rink right in the middle of the mall.

Shopping is great. (No sales tax!) There are many great restaurants in and around the Inn as well as easy access to downtown Portland by way of the MAX-the silent trains. The scenery is spectacular so please try to add the Pacific Northwest to your agenda for July 1989.

Jennifer Reiter

Your Editor assigned the title. Sacagawea was an American Indian of the Shoshone Tribe (1787-1812) who had been captured by another Indian *tribe, sold to a Canadian trapper, Toussaint Charbonneau, whom she later married, and served as guide to the Lewis and Clark Expedition (1805). Jennifer has graciously offered to write these articles on the Northwest and to be our arm-chair guide.*

"LOVE ME, LOVE MY PIANO"

All the talk about the upcoming PTG Convention in Portland takes me back, back to the last time the Piano Technicians Guild convened in the 'City of Roses' in 1973. I was living in Seattle and was being courted long-distance by my dashing new beau, Del Fandrich, who lived in Portland and had a piano shop there which I knew little about. Suddenly, in July, he seemed distracted by a whirl of activities that he explained were necessary for some convention he was involved in planning, teaching, and attending. I was a little chagrined. Did it seem that my dear one's attention was overly devoted to, um, pianos?

When we married on Christmas Eve that year, I was again a little puzzled. He had imported a gleaming, new Grotrien-Steinweg grand piano for the church ceremony (complete with pianist friend from a hotel nightclub who very nicely learned some hymns at my request). All very impressive, but was my new husband going to be a little compulsive about pianos?

Well, as I moved the pianos over and made room for myself and my two little girls in Del's life, it slowly began to dawn on me that I had not just married a man, I had married an entire vocation. A network, yet. A life support system of some kind. In fact, pianos have literally sustained us all these years: they earned the money for the food we put on our table...they paid tuition for years of trade-out at parochial schools for the girls...they entertained us at free seats at concerts Del tuned for...they provided a welcome substitute for television as we raised the girls...and in many ways enriched our lives.

Over the years, I've worked with Del in his businesses, shared his wonderful friends and associates, attended and benefited from countless chapter meetings and conventions, moved our household to Sacramento and took on a career to help finance his piano research, and then moved again to Arkansas when the research resulted in a job for him as director of R&D for Baldwin. Indeed, I have enjoyed many privileges (and a million good laughs) from this wonderful, crazy piano life of ours.

Now that the Auxiliary has elected me Treasurer, I look forward to working and giving something back to you all who have given me so much for so long. I would love to hear from any of you who might have comments or suggestions. (Special attention given to new brides.) I sure hope to meet many of you in the coming year, especially in Portland next year. You will know me, I'm the compulsive one, caught up in the whirl of activities.

Barbara Fandrich

CONVENTION (HOLIDAY) COMFORT

I would like to take this opportunity to respond to some of the questions and commentary I have heard in traveling to a few of the conventions over the past years.

Convention is a time of great expectations-in reality, an extremely stressful time. It is comparable in many ways to the holiday season that is fast approaching. In my research for this article I came across a Traveler's set of commandments that I would like to share with you. Many of them are worded appropriately for this holiday time as well as convention. However, with just a slight amount of paraphrasing they could be multipurpose.

1. Thou shalt not expect to find all things precisely as they were at home, for thou hast left home to find different things.
2. Thou shalt not take anything too seriously, for a carefree mind is the cornerstone of a good vacation.
3. Thou shalt not worry, for he that worrieth hath little joy.
4. Thou shalt not judge all people of an area by one person with whom thou hast had a problem.
5. Blessed are they who can wait and smile for they shall enjoy themselves.
6. Thou shalt do only somewhat as the natives do.
7. Thou shalt not let others get on thy nerves, for thou art paying good money to enjoy thyself.
8. Thou shalt be welcome in every land-treat thy hosts with respect and thou shalt be honored guest.
9. Bless thy travel planner for she worketh hard on thy behalf and she deserveth it.
10. Thou shalt carry thy travelers checks and/or plastic money with thee at all times in a safe place. Ye shall not pack it in thy suitcase, for it is said that a spouse without money is one who feels funny!

In my second article to you readers, I would like to address packing for convention. I am sure there are many of you who are more seasoned travelers than I am, and I am therefore requesting that if you have a tip that would be beneficial, you mail that to me and I will include it in my article. This could be especially helpful to those who may be flying for the first time. Airline regulations are becoming stricter in regard to carry-ons.

Just as for the holiday season, when you travel, take clothing appropriate for the occasion. What you wear does not need to be new, but it should make you look your best and consequently make you feel comfortable.

May you all have an especially COMFORTABLE holiday season.

Exchange Editor:
Agnes Huether
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Classified Advertising

Notice: There will be no classified ads in the January Journal as this will be the Guild's membership directory. Please plan your advertising accordingly.

Classified advertising rates are 35 cents per word with a $7.50 minimum. Full payment must accompany each insertion request. Closing date for ads is six weeks prior to the first of the month of publication.

Ads appearing in this publication are not necessarily an endorsement of the services or products listed.

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