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Captain and Stoker: Exploring Tandem Performance Through New Instrument Design and Implementation

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Since the widespread adoption of electric instruments (most notably guitars) in the early 1950s, many players have enjoyed tailoring their sound by carefully selecting transducers, amplifiers, and standalone effects units. Typically, the instrumentalists whose sound these devices affect manage their acquisition, installation, and operation themselves, with many modern amplifiers and effects units offering hands-free control to facilitate this approach. Some players, however, seek other performers to manipulate said devices. In doing so, they create a scenario where two performers operate discrete pieces of equipment to achieve a single, sounding result. Performances that involve this sort of cooperation are *tandem*; each player's actions depend on the other's to be heard, with the auxiliary performer's work immediately following the primary's preparation.

In Western music history, the concept of tandem instruments can be traced back to the *octobasse,* developed in the mid-nineteenth century. But the *octobasse* required two players out of necessity, not by choice, as the original instrument proved too large for single-person use (Roma). The stature of the instrument can be seen below in figures 1 and 2.

Fig. 1: A11 child sizing up the *octobasse* (Burgess)

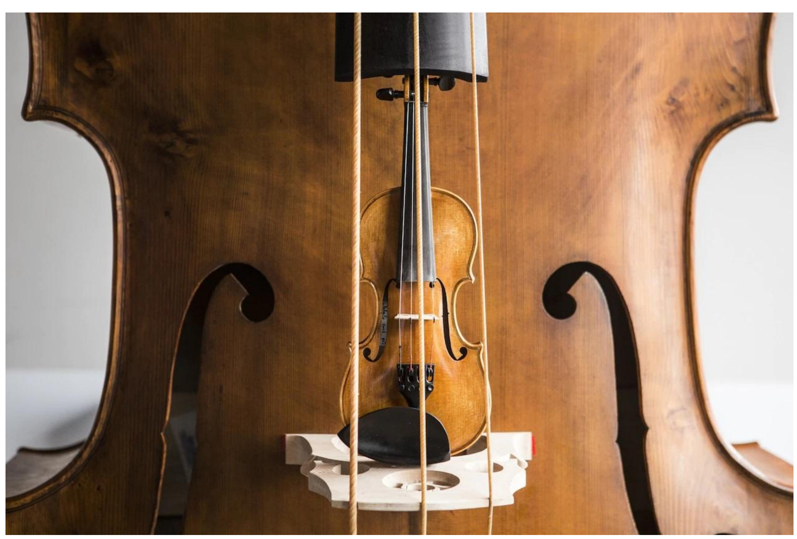


Fig. 2: The *octobasse* cradling a piccoletto violin (Battaglia)

The early twentieth century welcomed the *ondes martenot*, a solo, electronic instrument that incorporated novel sound diffusers, several of which resemble traditional acoustic instruments (Bloch). At a glance, these diffusers appear to be playable by an auxiliary performer (see fig. 3), but no records of any such attempt exist.

Fig. 3: The *Ondes Martenot* with *Palme* and *Metallique* diffusers (Kubo)

Where the past offers missed opportunities for tandem performance, the present grants electric instrumentalists agency to divide and share musical labor, expanding performance possibilities beyond what a single instrumentalist could accomplish. By merging the *octobasse's* tandem performance concept with detached, touchable sonic affecters like those associated with the *ondes martenot* and modern performance practices that employ dedicated sound manipulators, it is easy to imagine performance scenarios that preserve the *octobasse's* theatricality, allow for electroacoustic sound manipulation in a fashion that resembles playing familiar stringed instruments, and free tandem performers from sharing an apparatus.

1. Origins of Tandem Instruments and Sound Manipulation as Performance Practice

Until the twentieth century, musical instrument design and performance practice in the West was driven primarily by the conception and playing of single-player instruments. Although these instruments were often played together in ensembles to create composite sounds, the instrumentalists themselves functioned independently. Rare examples of two-player instruments do exist, however. The Basque *txalaparta* (see fig. 4) is one such example, requiring two players, positioned side-by-side, to strike tuned boards with vertically oriented sticks (Bras). Additionally, many compositions require two performers to share instruments initially designed for single-person use, with four-hand piano duets being the most common example (see fig. 5). But in these cases, it is apparent that each performer produces sounding results discrete from, rather than dependent upon, the other's.

Fig. 4: The Basque *Txalaparta* (Sanchez)

Fig. 5: A Four-handed Piano Duet (Wilson)

As mentioned above, one notable exception is French luthier Jean-Baptiste Vuillaume's *octobasse*; an eleven-foot-tall, three-stringed instrument resembling a gigantic double bass, which, in its original incarnation, required two instrumentalists to play: one to bow the strings and the other to activate levers that depressed the strings at pre-set points along the fingerboard, like installing a capo on a guitar (Panganiban). Hector Berlioz admired the *octobasse* and wrote in *A Treatise on Modern Instrumentation and Orchestration*, "[t]his instrument has sounds of remarkable power and beauty—full and strong, without roughness. It would be of admirable effect in a large orchestra; and all Festival orchestras, where the number of the instrumentalists amounts to more than 150, should have at least three" (240). But despite Berlioz's support, the instrument was never widely adopted. Vuillaume only built three *octobasses*, and, until recently, only seven (including playable replicas) existed (Netsky). In 2016, the *Orchestre Symphonique de Montreal* commissioned a set of three, modernized, single-player octobasses, allowing them to perform according to Berlioz's prescription (as seen in fig. 6), but other orchestras have yet to follow suit ("The Octobasses").

Fig. 6: The *Orchestre Symphonique de Montreal* performing with three, updated octobasses. ("The First Orchestra With Three Octobasses.")

However scarce, the *octobasse,* in its original form, epitomizes a tandem performance instrument, requiring two performers to play: the actuator (the lever-puller, preparing the desired pitch) and the articulator (the bower, causing the instrument to speak). Eventually, though, adjustments to the lever system made the *octobasse* playable by one person, implying that the original tandem scenario was a compromise rather than a feature (Roma).

The *octobasse* aside, tandem performance instruments and practices were largely unexplored until the introduction of magnetic sound recording technologies in the early twentieth century, which sparked a relationship between musicians and audio engineers where the musician performed, and the engineer augmented a sounding result. The extent of augmentation ranged from faint (adjusting or “riding” levels in reaction to performance) to severe (drastically altering sounds through creative effects processing and sound manipulation). In any case, audio engineers actively participated in sound creation and alteration alongside the musicians they supported, often in real-time.

Early on, these effects rarely left the studio. The equipment used to create them was often too expensive to acquire or too large or sensitive to transport to live performances. It was not until the fifties and sixties, with the democratization of effects via the advent of standalone, portable units, that musicians could bring these effects on the road. The first portable effects unit, DeArmond’s Tremolo Control, predated even the earliest studio tape delay effects. The Tremolo Control was a boxy unit designed for electric guitarists that “used a motor to shake a small container of electrolytic fluid which in turn made and broke a connection to ground that rhythmically shorted-out the guitar signal passing through it” (Hunter). It featured controls for speed and “increase” (depth), but without any way for the performer to bypass, engage, or adjust the effect’s parameters without taking a hand off of their instrument. It was a large, fussy device, and its effect was debatably already achievable on the electric guitar through picking technique or rapidly adjusting a volume control. The Tremolo Control’s appeal lay in its novelty and ability to service creative inspiration. Suddenly, a guitarist could arbitrarily set a tempo on a modulation effect, start playing, and wait to be inspired by the rhythmic interaction between the instrument and effect. Modern guitarists commonly approach writing this way, using tempo-synced delay and similar effects, with U2's The Edge (born David Howell Evans) typifying the style. Advancement in portable effects technology did not come quickly, however. Following the Tremolo Control, it took nearly two decades for portable delay units like the Watkin's Copicat, Maestro Echoplex, and Binson Echorec to surface, bringing more complex, previously studio-exclusive effects like slapback and multi-tap delays to the stage (Hunter 12).

Somewhere between the Tremolo Control and portable tape delay units, production model guitar amplifiers began to feature foot-switchable tremolo and vibrato. By the early 1960s, Premier and Gibson would offer built-in reverb effects on their amplifiers, previously only achievable through involved studio techniques or mammoth, unstable cabinets manufactured by the Hammond Organ Company for use with their electric organs. Soon after, reverb would become available in standalone devices like Fender's Reverberation Unit (Hunter 13, 66).

By the late 70s, manual tape effects like flanging (first heard on Les Paul's "Mamie's Boogie" in 1946) were reproducible via flanger pedals manufactured by A/DA, MXR, and Boss (Hunter 33). These devices gradually supplanted electric instrumentalists' need for sound engineers to manipulate their performances, granting them self-sufficiency at the expense of cooperative performance opportunities.

Despite the appeal of self-sufficiency, some performers choose to delegate sound manipulation duties to auxiliary personnel, either because their effects collections are large enough to be unmanageable on stage or because they value manipulators as collaborative performers. Brian Eno's probational stint delivering mysterious, synthetic "treatments" to his bandmates' performances in Roxy Music proves speculative interest in such arrangements as early as 1970. More recently, Texas dub group De Facto and progressive rock band The Mars Volta (each comprising Omar Rodríguez-López and Cedric Bixler-Zavala) both employed Jeremy Michael Ward as sound technician, "vocal operator," and sound manipulator until his death in 2003. Considered as much a member of the group as the adjacent talent, Ward manipulated a chain of effects pedals through which Bixler-Zavala's vocals were processed as part of their live and recorded performances. Similarly, Montreal-based, experimental post-rock outfit Le Fly Pan Am tapped sound artist Alexandre St-Onge to augment material on their albums *Fly Pan Am, Ceux qui inventent n'ont jamais vécu (?)* and *N'écoutez pas*, where he digitally manipulated elements of the group's performance in real time. While these few examples fail to demonstrate a sweeping trend, they prove that some artists value working with dedicated sound manipulators.

2. The *Ondes Martenot*: An Inspiring, Missed Opportunity for Tandem Performance

The previously introduced *ondes martenot* is an early electronic instrument invented by Maurice Martenot based on an "electronic phenomenon called heterodyning," which Lee De Forest and Leon Theremin harnessed before him to develop the Audion Piano and Theremin, respectively. The *ondes martenot's* place in electronic music history is secured not by its sound generation methods but by its improved control, unique diffusion apparatuses, and sizable contributions to its repertoire (Holmes 20-26).

Martenot improved on the Theremin's difficult-to-master, space-controlled design by appointing the *ondes* with a keyboard and further adding to its allure by housing it in a wooden cabinet that appeared more at home in an orchestra than the boxy, antenna-laden Theremin (see figs. 7 & 8).

Fig. 7: Clara Rockmore at the Theremin (Coleman)

Fig. 8: Cynthia Millar at the *Ondes* (Mellor)

In addition to the keyboard, the *ondes* featured additional pitch control via “lateral movement of a finger ring...attached to a metal wire” just in front of its keys (see fig. 9), allowing for fluid glissandi and reliable production of quarter and eighth tones (Holmes 25-26). Martenot also designed several, remarkable diffusion apparatuses for the *ondes*. One (the *principal*) involved a traditional loudspeaker. Others were more curious, with sound exciters mechanically coupled to a metal gong in one case (the *metalliqué*) and an array of metal strings pulled across a resonant body in the other (the *palme*) (Bloch). These last two diffusers resembled traditional instruments, but the designs suggest neither was intended to be touched (see figs. 10 & 11).

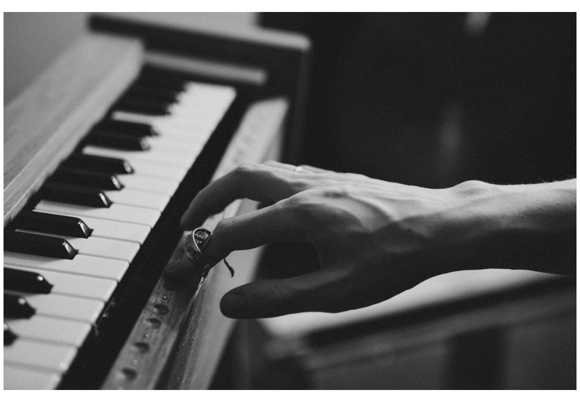


Fig. 9: The *Ondes’* Finger Ring (Semans)

Fig. 10: The *Metallique*

Fig. 11: The *Palme* (Ichihashi)

The *ondes martenot* can be heard on recordings ranging from Olivier Messaien's "Oraison," to Yann Tierson's film scores, to Radiohead's *Kid A* ("Hey, What's That Sound?"). Yet no recordings of performers physically interacting with any of the *ondes'* diffusers exist. This might seem baffling to percussionists or stringed instrumentalists that see the *ondes'* diffusers as inviting performance. Why not strike the *metallique* with sticks or mallets or take a slide to the *palme* while it's being activated? Past *ondists* (*ondes* performers) seem to have overlooked these performance opportunities.

3. New Potentials for Tandem Instruments and Performance

In *Handmade Electronic Music*, Nicolas Collins briefly explains an instrument of his invention that he calls a "backwards electric Hawaiian guitar" (see figs. 12 & 13):

> In these instruments sounds are sent into guitar pickups or coils (scavenged from relays) whose fluctuating electromagnetic fields vibrate the strings of guitars and basses. The strings filter, resonate, and reverberate the original sounds (similar to the effect of shouting into a piano with the sustain pedal depressed), and are picked up, amplified, and further processed through distortion or other typical guitar effects. The filtering is "played" by fretting and dampening the strings, like a one handed guitarist. (55)

Fig. 12: Backwards Hawaiian Guitar, 1987

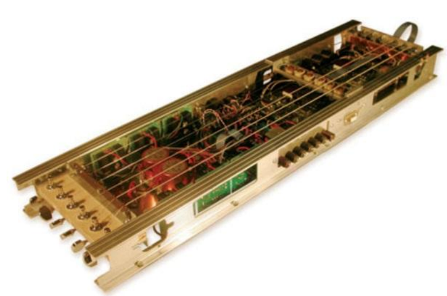


Fig. 13: Level Guitar, 2002 (Collins)

In a sense, Collins' instrument is an inversion of the *palme* diffuser. Instead of accepting and reproducing musical content by exciting strings on an as-needed basis via harmonically modest waveforms (like sine waves), it permits all its strings to be simultaneously and continuously activated, requiring the performer to mute or manipulate the strings to shape noise into musical content. However, like the *ondes* coupled with its *palme* diffuser, the backward guitar was not designed to accommodate a second operator. Regardless, Collins' device could be the missing link between the *octobasse's* tandem performance concept and electrified, tandem, musical performance. What if a new device could reproduce musical content like the aforementioned devices while allowing an auxiliary performer to act upon it, affecting the sounding result? Collins' instruments are only built for his own use, and original *palme* diffusers are scarce, delicate, and perhaps poorly suited to playing. But modern, electric instrument design concepts could produce an amalgamation of the two that invites touch.

With an updated device, it is easy to imagine tandem performance scenarios where an instrumentalist feeds a signal through an exciter, activating a set of strings while an auxiliary performer manipulates them. If the source material is also a stringed instrument, the performance might even evoke the image of a deconstructed *octobasse*. But this new sonic affecter could also be instrument independent, capable of manipulating myriad sources on stage or in the studio.

At its most basic, a sonic affector geared toward tandem performance must meet the following criteria:

(1) It must accept and reproduce input from an external source;

(2) It must be physically manipulatable in a fashion that augments the input material;

(3) It must be capable of reproducing the augmented material.

Accepting these criteria and marrying inspiration from the *ondes martenot* and Nicolas Collins' backwards electric Hawaiian guitar might precipitate an image of something resembling an extended range pedal steel guitar with input and output transducers. With minimal embellishment, this is the direction I chose for my original design.

At the time of inception, I posited that the best way to construct my device would be to build a large wooden box using simple butt joints to house the electronics, then append the recognizable parts that constitute traditional stringed instruments: a headstock with tuning machines, a bridge, a nut, and a tailpiece to fasten the strings opposite the tuners. I chose wood for my material because I happen to be skilled at woodworking, and it is featured prevalently in traditional stringed instrument design. A wooden instrument flatly seemed like the path of least resistance. Considering aesthetics and availability, I chose maple and walnut (a common combination) for the majority of the build, and cherry for select pieces.

Like the *ondes*, I wanted the device to be capable of reproducing every pitch in the chromatic scale, so it had to accommodate twelve strings—one string per semitone. I also wanted the device to handily accommodate a diverse set of instruments as inputs, which meant it needed to brook an extended range. I approached this goal by designing around a scale length of thirty inches, which I borrowed from Fender's Bass VI, a six-string instrument that lands precisely between standard electric bass and guitar scale lengths and tunings. I theorized that this scale would facilitate reproduction of a wide range of pitches either via sympathetic vibration of fundamental frequencies (especially in lower registers) or activation of natural harmonics across any number of the strings' lengths. As a precaution, concerned that I may experience difficulty attempting to activate heavy string gauges under high tension, I designed the bridge to "float." This way, if necessary, I could reinstall the bridge in any position, reducing the scale length and thereby the tension required to tune the strings to their desired pitches. The floating bridge design made scale length selection far less critical than it might have otherwise been. Ultimately, though, I did not find it necessary to deviate from the initial design.

If the bridge and nut were to stand thirty inches apart, I needed to add additional length to the instrument to fit the tuning machines and tailpiece, as well as leave space on either end for aesthetics and, in a pinch, emergency reworking. I also needed to ensure that the breaking angles between pieces were not overly steep, thereby avoiding unduly frequent string breakage. After some rough calculations, I added eighteen inches to the instrument's length, making it four feet long in total. Photographs of the early stages of the build can be seen below in figures 14-17.

Fig. 14: Box

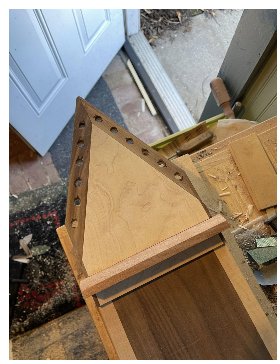


Fig. 15: Headstock

Fig. 16: Tailpiece

Fig. 17: Completed Body

Electronics were the next consideration. I had split inclinations at this stage. In the backward electric guitar, Collins used relay coils to activate the strings. His approach resembled the technology found in the Heet Sound Products EBow, a popular guitar accessory that employs a fluctuating magnetic field to cause a string to vibrate indefinitely, creating an effect resembling a bowed string instrument. The *ondes*, however, employed a custom-built, linear motor to simultaneously activate two bridge pieces on either side of the device. I did not have access to such a motor, nor was my device double-sided, but I was interested in this approach to output transduction as it had the potential to vibrate the entire length of the board it was mounted on. I imagined this scheme might let the unaltered sound of the source material passing through the device speak independently of the manipulated result, which could produce an interesting effect. I decided this approach was worth exploring and tracked down a modern proxy for the linear motor: a pair of 58mm, 8ohm, 25-watt exciters manufactured by Ohio-based company Dayton Audio, model #DAEX58FP. I chose these exciters based on power rating, believing if I wired them in series for a combined rating of 50 watts at 16ohms (a guitar-amp-friendly rating), I could power them with a low-wattage guitar amplifier. I situated the exciters side by side and directly under the bridge to maximize vibrational transfer. The wiring and position of the exciters are visible in figures 18 and 19.

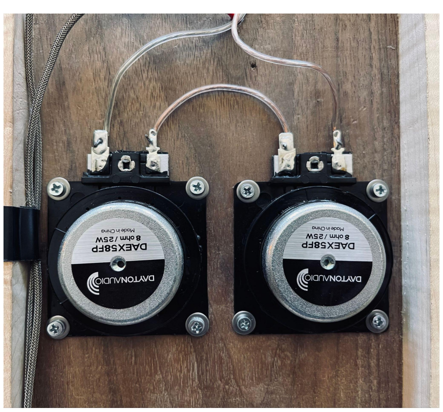


Fig. 18: Exciters Installed and Wired in Series

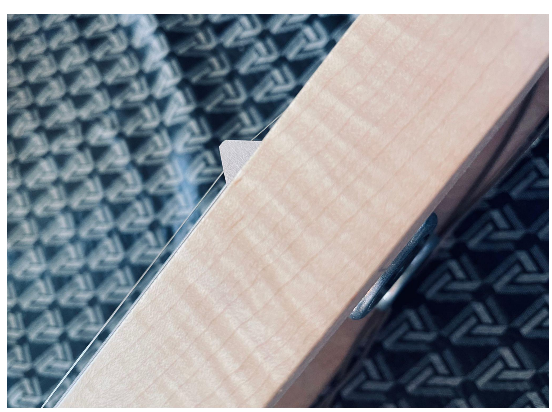


Fig. 19: Exciters Positioned under Bridge

For the input transducers, I wanted to use two humbucking guitar pickups, assuming their quiet operation would be an advantage. I would need one pickup per set of six strings. My vision was to position them as close together as possible without string overlap. I anticipated that the string spacing of my device might differ slightly from that of a standard electric guitar, so rather than choose a pickup with typical pole pieces (see fig. 19), I chose a set with rail magnets, figuring their ability to sense string movement evenly across their width would be a boon. I settled on an economy set of flat-mount, rail humbuckers from JD.Moon [sic] with "radiator" covers, intending to add maple veneer beneath the covers to tie the look of the pickups in with the rest of the instrument (see figs. 20 & 21).

Fig. 19: Humbuckers (Lollar)

Fig. 20: Stock Pickups (Amazon)

Fig. 21: Pickups after modification

I proceeded wiring the pickups, with individual volume controls, to a stereo output jack. This configuration would allow the device to enjoy stereophonic imaging with control over the left and right sides of the stereo field, with the caveat that two means of amplification would be required for full reproduction, or an adapter would be needed for monophonic use. A sketch of the wiring diagram for the electronics can be seen in figure 22.

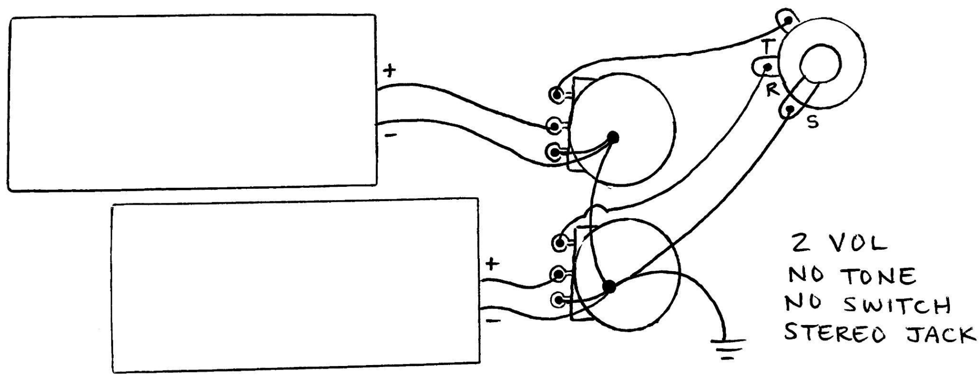


Fig. 22: Wiring Diagram

Initial tests were promising. The exciter activated the box at an audible level without strings installed. The pickups passed signal. But after stringing the instrument, it became clear that I would need to remove material from the bridge to minimize weight while maintaining rigidity in search of optimal vibrational transfer. I did this by scalloping the underside of the bridge, reducing its width, and removing as much other unnecessary material as seemed feasible. The original and finished bridges can be compared in figures 23 and 24.

Fig. 23: Original Bridge

Fig. 24: Completed Bridge

Despite shedding only a few grams, the lighter bridge was a marked improvement. The scalloping, which removed material directly above the exciters, also seemed to result in more even string activation. After some other minor design tweaks, like adding a metal bridge plate to ground the electronics and adjusting the distance between the strings and pickups to 3/32 of an inch (as is commonly recommended on electric guitars), the build was complete. The final iteration of the device can be seen below in figure 25.

Fig. 25: Completed Build

4. On Tuning

Tuning is an essential consideration for any stringed instrument. The player must be able to see and interpret intervallic relationships across the fingerboard during a performance. It is the task of an instrument designer to facilitate this, no matter how peculiar the instrument. The device outlined in this text is no exception. As such, much time and effort went into exploring various tuning possibilities.

Tuning strings in chromatic order would be a poor choice because it would require the player to force their fingering hand to change position too often or span too many strings. Open chord tunings, extended tunings, and other diatonic (or modal) tunings are useful on instruments where multi-string sliding or fretting is the primary method of play, but might not provide a chromatic pitch set when left untouched. Ascending in fourths or fifths would be comfortable for most string players but would require a hyper-specific string set or an expensive collection of particular singles if scaled to span twelve strings. Using two pairs of standard six-string sets with each ascending in fourths or fifths would be functional but hardly interesting. What is the best approach, then, to tuning an instrument like the one outlined here, where ease of pitch identification must be weighed against inspirational quality, balanced stereo image, and cost of future maintenance?

Investigating alternative guitar tunings like "Nashville" tuning, where the lowest four strings of a guitar are restrung with lighter gauges, enabling the player to tune them up an octave, revealed a possible solution. Pat Metheny, Elliott Smith, and James Williamson of The Stooges are all notable users of Nashville tuning variants. Sometimes, though, these artists only replace one or two of the four prescribed strings, creating an effect where alternating octaves cascade as the player strums the guitar (*Heaven Adores You*; "'Half Nashville' Tuning: Metheny Style;" "James Williamson & Deniz Tek"). The sounding result is pleasantly harp-like, and the undertaking embraces a spirit of exploration that suits experimental instrument design, making it an ideal starting point.

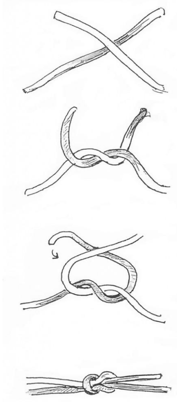
Extrapolating from Nashville tuning variants, it is possible to create a similar cascading octave effect across twelve strings using two commonly available six-string sets. This is accomplished by laying out a pitch set in ascending fourths or fifths and assigning alternating string thicknesses to each pitch. The only special consideration here is ensuring that each string is tuned within a safe range (applying too much tension would cause them to snap, potentially resulting in bodily harm). The table below shows one possible tuning scheme taking this approach using two medium gauge baritone string sets from D'Addario, model EXL157. The pitch names and octaves are listed in the first rank and the string numbers as referenced by the manufacturer in the second, with "1" representing the thinnest string and "6" representing the thickest. Proper string gauges in thousandths of an inch appear in the third rank with a "p" or "w" designating plain or wound strings.

Table 1: Preferred Tuning (Nashville-Inspired)

B3	E2	A1	D2	G3	C3	F1	A#/Bb2	D#/Eb4	G#/Ab1	C#/Db3	F#/Gb3
1	4	6	5	2	3	5	4	1	6	3	2
14p	44w	68w	56w	18p	26w	56w	44w	14p	68w	26w	18p

This particular tuning scheme, due to its relatively symmetrical pitch dispersion across the two pickups on the device outlined here, creates an exceptionally dense stereo image. It has become a preferred tuning for open experimentation. Handfuls of other tunings were considered or tested but ultimately rejected due to cost of string acquisition, difficulty during initial playtests, unsatisfactory stereo balance, or, conceivably, creative impotence at the time of testing. Such is the unfortunate nature of a one-person research and development team.

It is worth noting that several of the strings in the chosen set from D'Addario are not long enough to reach the tuning machines on this instrument. As a result, they had to be tied to extra lengths of string, much in the same fashion that piano strings are sometimes repaired with knots. The procedure for this is to make a square knot (or weaver's knot if the gauges are more than a few thousandths of an inch apart) with the exposed core of the string (or the end of the string if the string is plain) and a spare piece of the closest available gauge of string. The knots used are pictured in figures 26 and 27, and a view of the result in figure 28.



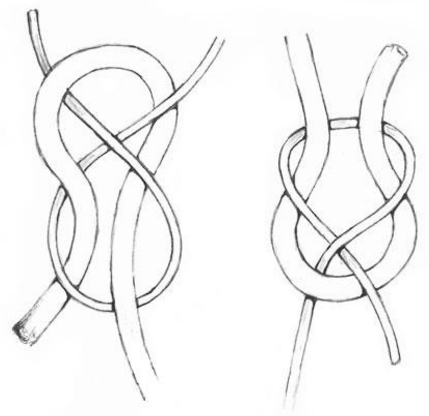


Fig. 26: Square Knot Fig. 27: Weaver's Knot (Thomas) Fig. 28: Tied Strings

Beyond the tuning detailed in table 1, two others produced noteworthy results. One ascends in alternating tritones and minor thirds, and the other ascends through the whole tone scale in two tiers. Tuning in alternating minor thirds and tritones does not provide a complete chromatic pitch set, but the whole tone scheme does. Both of these tunings produce strong and interesting resonances and are rewarding in free, improvisational play. A variety of starting pitches can be chosen for both schemes, but tables 2 and 3 provide some examples.

Table 2: Alternating Minor Thirds and Tritones

A	D#/Eb	F#/Gb	C	D#/Eb	A	C	F#/Gb	A3	D#/Eb	F#/Gb	C

Table 3: Tiered Ascending Whole Tones

C	D	E	F#/Gb	G#/Ab	A#/Bb	C#/Db	D#/Eb	F	G	A	B

These tunings require exotic string sets composed of singles, making them relatively impractical compared to the tuning shown in table 1. They are provided here to show potential starting points for future exploration. The box structure of the instrument has (thus far) proven rigid enough to support any commonly available string gauge, including those normally reserved for bass instruments, so many tuning schemes are possible.

5. Performing With Sonic Affectors in Tandem Scenarios

When considering the concept of tandem performance, it is important to understand the dichotomy of actuator and articulator as established previously in the examination of the performance scenario required by the original *octobasse* design. In tandem performance, barring complex situations involving signal splitting and/or cultivation of feedback, one performer prepares a sound (the actuator), and another adapts it (the articulator). It may be helpful to visualize a tandem bicycle, which requires a *captain* and *stoker*. In this case, the captain is responsible for balancing the bicycle, steering, shifting, and braking, while the stoker essentially acts as a motor, toiling to generate power without affecting the captain's control of the vehicle. The stoker is directly comparable to the actuator, as is the captain to the articulator. Of course, in the case of tandem musical performance, there is more to the role of actuator than simply generating power. The actuator has control over rhythm, pitch information, dynamics, and any number of other elements that can be attributed to musical content, but surrenders a degree of control to the articulator, who is tasked with deciding how the sound speaks. This dichotomy must be maintained to some extent, or the tandem aspect of the performance is broken (not to suggest that such deviation is invalid or irrecoverable).

Equipped with the concept of a discretely operating actuator and articulator, it is possible to begin exploring the potentials of the device outlined here. The most obvious application of the device is to operate it much like Nicolas Collins' backward guitar, muting some strings and allowing others to ring, accentuating particular resonances like a controlled reverberation machine. Another is to ready a slide, ring, or tone bar behind either the nut or saddle and move it across a string once it has been activated to augment the pitch provided by the actuator. Yet another is to prepare harmonics so that as strings activate, the harmonics sound. Obviously, any combination of these techniques is viable. It is also possible to adjust tuning machines on the fly to create glissando effects, or, time permitting, install posts under one or more strings to adjust the tuning of the instrument. Preparations are also possible. Paper clips, paper or card stock, marbles, pens, guitar picks, erasers, pieces of aluminum cans, or any number of other commonplace items can be placed atop or wedged between strings to create new sounds[1]. The strings can of course be played by the articulator without activation by the actuator, though this technique may constitute a sly breach of the tandem arrangement if overused. This is to say that, in terms of capacity for creative sound design, this device has about as much potential as any other electric, stringed instrument. The distinguishing factor here is the instrument's ability to accept external input, which presents a philosophical quandary about how to divide musical labor and the type and extent of manipulation appropriate in a given scenario. Ultimately, this comes down to the personalities of the team members working with the device and the aesthetic goals of the piece.

In my private experiments with the device, which have thus far been solitary[2] (though I have run many improvised drones and loops through the input to simulate tandem performance scenarios), I've discovered a few things that I deem valuable. First, the actuator's performance is sometimes nuanced beyond what the device is able to reproduce, and those nuances may be valuable to the piece. It is therefore advisable for the articulator to have control over a dry, split

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[1] A number of preparations can be heard in audio examples 1-10. See appendix A for file descriptions.
[2] Due to development during COVID-19 restrictions.

signal from the actuator's instrument to blend against the affected sound. Control over the level of the dry signal could be relegated to the actuator, but the division of labor is more balanced if the articulator covers this task. Second, readiness is key, but eagerness is detrimental. In other words, it's advantageous to have both hands positioned on the strings just toward the inactive side of the nut or bridge while waiting for a good opportunity to move, but foolish to leap into a manipulation that's not guaranteed to produce a desirable result. Last, since the articulator has final control over not only the volume, but also the stereo balance of each phrase, small predictions and compensatory adjustments can make immense differences in the dynamic structure of the piece. Often, it is best to leave pitch content up to the actuator and wait for a time where an adjustment in overall volume or stereo balance will bolster the performance. In the meantime the articulator can make minor adjustments to the balance of pitch content by carefully dampening strings using something like a cotton swab or bit of sponge. These approaches and techniques obviously stem from my own preferences and tendencies. Another articulator might just as soon opt for a basket of wind up toys, polyhedral dice, and plastic film. Choice of materials and approach to manipulation is entirely personal in improvisational settings.

6. Conclusion

After exploring the history of tandem performance instruments and scenarios, it is clear that immense latitude exists for further research and musical experimentation. It is difficult to determine why there are so few examples of tandem performance. One factor could be the scarcity of devices designed with such performance settings in mind. Another could be that opportunities for tandem performance are simply overlooked a great deal of the time. A third possibility is that musicians are generally accustomed to having a significant level of control over the sound of their instruments and much of this control is forfeited in a tandem situation, which could make the notion unappealing. Tandem performers must harbor trust and foster intimacy with their performance partners, and this could create unusual breeds of pressure and vexation. Of course, this degree of intimacy could also be harnessed to great effect. More research is warranted on this front.

Some other open lines of exploration on the subject of tandem performance include revisions to the device outlined here, as well as the development of a notation system and repertoire. Further experimentation with, and eventual standardization of scale length, string selection, and tuning would be a good place to start, as would designing an array of accessories and compiling a set of techniques including descriptions or audio recordings of their results. Lexicalization of tandem performance concepts and techniques is an important first step in promoting the adoption of tandem musical practices.

Having laid some groundwork for prospective, tandem endeavors in music, it is my goal to continue searching for applications where tandem instruments are viable and useful, and my hope that I can spark interest in others to explore the possibilities that tandem scenarios allow. It is my belief that tandem approaches to musical performance provide opportunities for new forms of cooperation and abate seclusive musical practice, and I aim to continue exploring the affordances that such approaches provide.

Appendix A

Audio File Descriptions

Example 1	Electric guitar, unprocessed by device.
Example 2	Electric guitar, processed through device with no manipulation.
Example 3	Electric guitar, processed through device with pen laid across strings.
Example 4	Synthesizer, unprocessed by device.
Example 5	Synthesizer, processed through device with no manipulation.
Example 6	Synthesizer, processed through device with slide glissando.
Example 7	Synthesizer, processed through device with flattened pennies laid on strings.
Example 8	Synthesizer, processed through device with ball-end tacks placed between strings.
Example 9	Snare drum, unprocessed by device.
Example 10	Snare drum, processed through device with no manipulation.

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