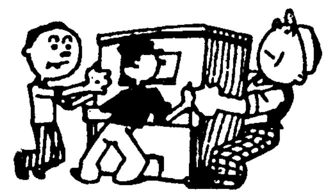
TECH TIPS



Duo-Art Accordion Pneumatics

Functional Aspects and Adjustment Criteria

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The Duo-Art reproducing piano's dynamic response depends to a large extent on performance characteristics (or idiosyncrasies, if you will) of its expression regulators. The less-than-ideal capacity of these venerable components to maintain set levels of pneumatic tension under conditions of changing demands was lovingly accommodated by Aeolian music roll editors, who simply adjusted the expression coding until the music came out right. In practical terms, this meant increasing theme and/or accompaniment power as needed to maintain a desired loudness level when larger numbers of notes were struck, and lowering power levels as needed when fewer notes were played. A Duo-Art piano's dynamic response further depends on interaction of theme and accompaniment regulators with the expression box spill, residual leakage, pedal operation, and many other system factors. To assure uniformity, Aeolian produced test rolls (several different editions of which are extant) in which dynamic response was quantified in terms of note counts, pedal operation, and power levels applied. When all factory instructions are carefully followed, the test roll serves as an indispensable tool for achieving musically satisfying results from a Duo-Art piano. If accordion pneumatics are not adjusted to factory specifications, however, test roll results may become misleading and possibly fail to yield an accurate appraisal of a Duo-Art's playing condition. Reasons for this will become clear as this article's contents are read and understood.

All expression components must function perfectly and work together as a whole if the highest artistic potential of the Duo-Art is to be realized. This article deals specifically with the accordion pneumatics, and how their adjustment (or misadjustment) affects dynamic response. Hopefully the information presented here will help to clarify topics that tend by nature to be somewhat obscure. Careful study confirms that a sound technical basis exists for always keeping accordion travel exactly as specified in service publications.

Aeolian's explicitly stated and often repeated numbers for accordion travel remained unchanged in service publications throughout the Duo-Art's production lifetime. In spite of this, advice touting "improved" accordion adjustment for alleged performance optimization (usually by forcing test roll results during chord tests) continues to be propagated within today's Duo-Art community. Factory instructions (in contrast to more recent publications) offer no suggestion that accordion travel might at some point have been customized to accommodate individual piano characteristics, or that accordion adjustments were fair game for "polishing" performance or coaxing test roll results into compliance. Such fanciful extrapolations are, in fact, on very shaky ground from a technical point of view. (Evidence suggests that theme and accompaniment regulator springs were the items more likely to have been factory-selected for matching the characteristics of individual pianos, accounting at least in part for today's plethora of subtly different regulator springs.)

Regarding the accordion pneumatics, all editions of the Duo-Art service manual clearly state the following:

1. The four respective sections collapse 1/16", 1/8", 1/4" and 1/2", and
2. Factory settings should not be changed.

In his 1929 Duo-Art treatise published in The Tuner's Journal, Wilberton Gould reiterates the ubiquitous caveat about leaving the factory settings undisturbed, and then goes on to declare that accordion pneumatics "...should be adjusted only by a set of accurate gauge blocks that are made for that purpose." The times and circumstances of that treatise strongly suggest that Mr. Gould was describing the method of adjustment preferred and used by Aeolian.

The factory's use of precision gauge blocks for adjusting accordion pneumatics would have made sense in many ways. Gauge block adjustments in general tend to be accurate and consistent. Such a method would always result in identical travel for each pneumatic section at all three adjusting screw locations, an important consideration in eliminating wobbles and unsteady motion during operation. The adjusting procedure would have been quick and easy to learn, and skill requirements would have been minimal. Factors such as these would be especially significant in a production situation.

The accordion pneumatics for both theme and accompaniment regulation are constructed identically. The same operating principles apply to both. Each has four collapsible sections of unequal size, corresponding to the 1, 2, 4, and 8 power levels of the tracks that activate them. Taken as a unit (ignoring connecting linkages for now), each accordion pneumatic is designed to produce linear motion (i.e., motion in a straight line), the extent of which can be varied by collapsing its respective sections in various combinations. This linear motion is additive, which means that total travel is the sum of the combined travel of the individual collapsed sections. The values of 1, 2, 4, and 8 assigned to each set of dynamic coding tracks are recognizable as powers of two, with each number double the one before. They can be written as $2^0 = 1$, $2^1 = 2$, $2^2 = 4$, and $2^3 = 8$, respectively. Note that accordion motion occurs in increments directly proportional to powers of two. These increments are measured in multiples of a sixteenth of an inch. With each section traveling exactly double the one before, properly adjusted accordion pneumatics move in direct proportion to the powers-of-two weighting (i.e., 1-2-4-8) of their respective dynamic tracks. The Duo-Art implementation comprises basic elements of a binary-coded digital system, up to the mechanical interface with the respective theme and accompaniment regulators (which are, of course, analog devices).

Accordion pneumatics perform the critical function of translating the music rolls coded theme and accompaniment levels into mechanical motion, which, in turn positions the knife valve heels of the respective regulators. Sixteen discrete positions (including the zero position) can be reached by each of the accordions, with total travel extending to 15/16". (Note that in-between positions are passed through "on the fly", and examples can be found in music roll coding in which in-between positions are accessed for subtle expressions purposes; the sixteen positions, however, provide repeatable reference levels at closely spaced intervals.) Duo-Art service literature variously refers to the sixteen positions as loudness degrees, loudness gradations or dynamic gradations, and these are enumerated from 0 through 15. They are also less formally referred to as power levels or loudness steps.

Motion applied by each accordion pneumatic to its associated knife valve heel undergoes non-linear mechanical transformation in the connecting linkage. Beyond that point, further system non-linearity influences pneumatic tension and the loudness of struck notes. Clearly, however, under controlled test conditions, loudness should build up evenly, as opposed to having abruptly large jumps between some steps, and little or no change (or change in the wrong direction) between others.

All Duo-Art test roll editions contain chord tests to check dynamic buildup for both theme and accompaniment. The chord tests utilize "play" followed by "no-play" (or play very softly) sequences of chords as quantitative checks of dynamic buildup at power levels 0, 1, 2, and 4. This places them in the dynamic scale's lower region, where interactions between note counts and power levels are most critical. Level 3, however, is not explicitly checked, possibly because it is reached by collapsing 1 and 2 together, and each of those is checked separately. (The logic of implicity checking level 3 in this manner, as will be shown, is jeopardized if the intended powers-of-two travel relationship is not preserved.)

Note counts and pedaling vary somewhat for chord tests found in various test roll editions, but they all work basically the same way. Further test roll sequences strike chords that repeat at several ascending power levels, but these can accomplish little beyond confirming that each successive chord sounds louder than the one before.

Accordion settings can be altered to force a change in dynamic response at a particular power level, but this tends to cause problems at other power levels and distort the overall shape of the buildup curve. Power levels adversely impacted often turn out to be those not explicitly checked by the test roll. How out-of-spec adjustments can lead to insidious irregularities can be appreciated by considering the following: When you elect to change the travel of any one of an accordion pneumatics four sections, you are changing not just one power level, but eight of them. Each of an accordions sections reaches a collapsed state in exactly half of the total of 16 possible combinations, and remains open in the other half. These, as well as the correct travel adjustments, are documented on page 6 of the 1925 Duo-Art service manual in the "Pressure Chart Showing Graduation Adjustments for Correct Settings". There is a similar chart on page 16 of the 1927 Duo-Art service manual.

Graphic plots are useful for revealing exactly what happens over the full range of travel when an accordions adjustments are changed. The first plot presented here was done with the factory recommended settings. This is followed by examples in which selected pneumatic sections were set to values deviating from factory recommendations. Settings were selected as might result from attempts to bring a test roll's chord tests into compliance. To make these plots, an accordion pneumatics travel behavior was modeled in Microsoft Excel, which is able to produce a new plot automatically each time an adjustment is changed. When this application is running on a computer, results for all sixteen positions are instantly displayed whenever a data entry (representing an adjustment change) is revised in the "ADJUSTED TO" column. The numbers in the column labeled "TOTAL TRAVEL" indicate linear displacement at each of the loudness gradations. These become ordinate values in the corresponding plots. The STEP SIZE column shows incremental changes between adjacent levels or gradations.

Readers may notice that certain decimal fractions shown with these plots display a greater number of significant places than practical conditions might suggest. This is a result of converting proper fractions (as given in Aeolian service literature) to decimal form without rounding off, and is not intended as a measure of accuracy or adjustment precision.

Figure 1 plots the behavior of a normal accordion pneumatic, with travel of all four sections set to factory specified values. Note that the resulting plot is smooth and linear. Each incremental step is the same size as all the others. This is the way an accordion pneumatic should work.

(See Figure 1)

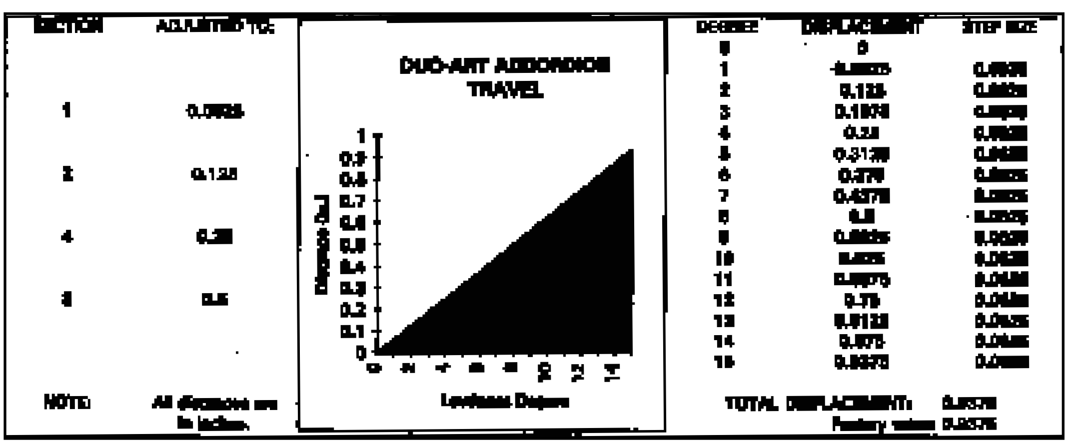

Figure 1
Normal Duo-Art

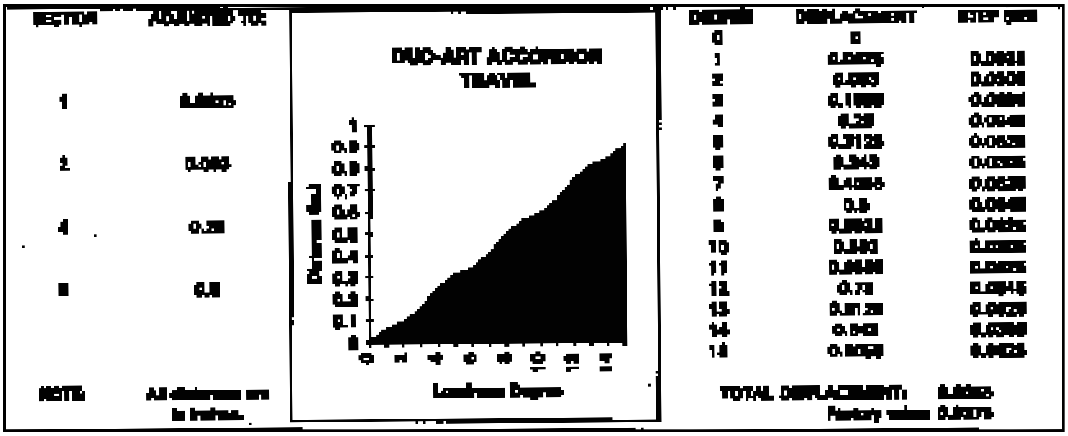

Figure 2
Section Two Shortened

Notice that loudness degree 4 is lower than 3, and 12 is lower than 11. In the middle part of the loudness range, a large jump upward occurs between 7 and 8. If this particular adjustment had been done to fake out a chord test at power 4, it would leave power 3 (which, as mentioned earlier, is not explicitly checked by the test roll) in a too-high condition likely to wreak selective havoc with musical performances. Sadly, that condition would remain forever undetected by the test roll, as would also the disturbing leap in power from 7 to 8, and the 11 to 12 intensity drop.

Now let's create a hypothetical situation. Assume that the test roll is running a play, no-play chord test at power lever 2 (this could be either accompaniment or theme), and both sets of chords, play and no-play, are playing distinctly. To counter this, we reduce the travel of the power 2 (second) accordion section by 1/32". That's one full turn of each adjusting screw. Figure 2 shows the result. Although the test roll result now suggests that chords are behaving as desired at power 2, the overall response curve has taken on a serpentine shape. (Any resemblance to the critter that sank its fangs into our music rolls is purely coincidental!) Serpent or no, notice that power level 4 remains unaffected by the adjustment performed thus far.

(See Figure 2)

Moving ahead to the next chord test at power level 4, it's as likely as not that we'll again hear both sets of chords playing distinctly when the second should be a no-play. To appease the test roll at this point, we trim the accordions power 4 section by 16%, or 0.040", thereby reducing that section's travel from 0.250" to 0.210". This takes about one-and-a-quarter turns of each power 4 adjusting screw. Once again, the test roll is successfully faked out. Two of the four accordion sections are now mis-adjusted, and figure 3 shows the overall result.

(See Figure 3)

There's an obvious hump in the curve, and one step has become excessively large. The level change from 7 to 8 is more than four times as large as the step from 5 to 6. Dynamic buildup has acquired some serious irregularities, although test roll results appear again to have improved. Why? Simply because the test roll doesn't check for conditions caused by cheating! It's much like fiddling with a bathroom scale's zero adjustment when you're weighing yourself. You can trim off or add pounds as you like, but you can believe the indicated result at your own risk!

Another side effect of tampering with accordion adjustment is changing the total extent of travel, which is nominally 15/16" with all sections collapsed. This is a factor in determining achievable dynamic range. Caution: don't try decreasing travel in one pneumatic section to offset increasing in another, or vice versa. This only worsens the response curve's irregularities.

Changes from factory recommended settings also tend to disrupt the relationship of theme to accompaniment (i.e., theme always one degree above accompaniment). With accompaniment following one sinuous buildup curve and theme another, the two will be prevented from maintaining a consistent relationship over the full dynamic range.

From a listener's point of view, effects of tampering with accordion adjustments are usually more subtle than dramatic, but they are very pernicious nevertheless. The Duo-Art's dynamic levels are many in number and closely spaced, and musical dynamics undergo continual and often complex changes. As a result, uneven buildup may not be directly noticed as such during play. The human ear is more likely to respond to uneven dynamic buildup by interpreting musical performances as mechanical sounding, poorly edited or performed, or otherwise lacking in artistic quality. Dynamic anomalies often affect certain rolls more than others, and it's anyone's guess how many artists and music roll editors have been erroneously blamed for problems caused by "customized" accordion adjustments.

Further mis-adjustment can actually cause changes in the wrong direction, with power decreasing on advancing steps. Figure 4 shows the result of shortening the power 4 pneumatic sections travel by 30%, with the other three normal.

(Figure 4)

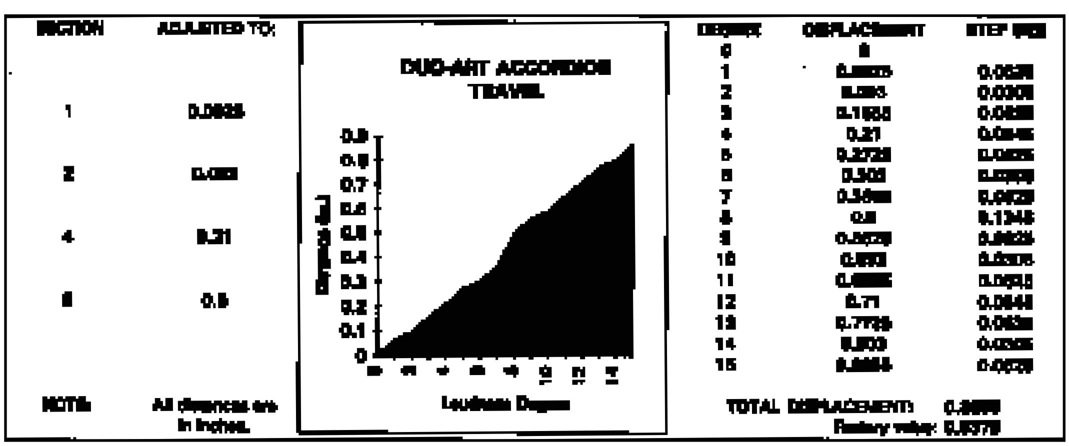

Figure 3
Sections Two and Four Shortened

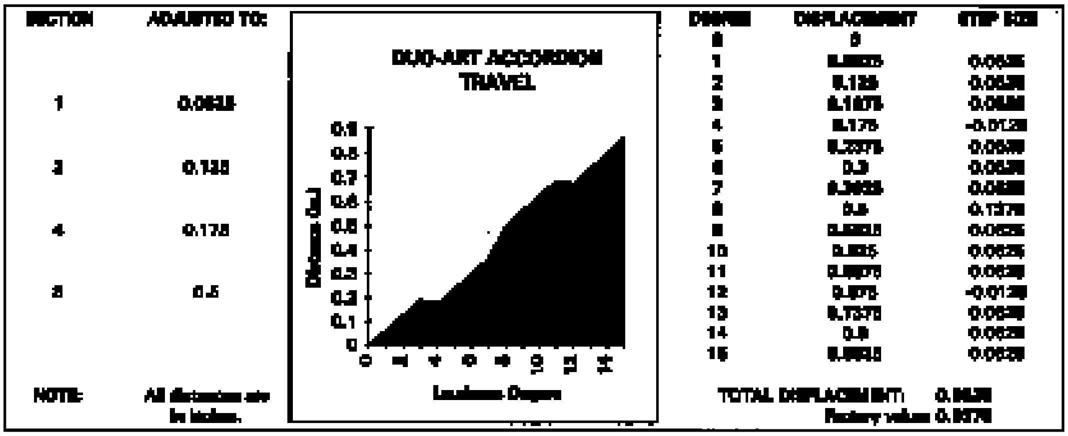

Figure 4
Section Four Shortened by 30%

What should one do, then, if one's Duo-Art stubbornly fails chord tests when its accordion pneumatics are set to factory recommended travel? First of all, make sure the tempo is set accurately, and follow the test roll instructions carefully. A visual check of accordion operation may be helpful. Get under the piano with a good light, and watch the accordions in operation to make sure they do exactly what they are supposed to do. Having an assistant at the controls to repeat desired sections of the test roll can be very helpful at this point. Does each pneumatic section respond independently of the others? Do one or more sections respond slowly, possibly indicating leakage or valve problems? Do both accordions consistently return to their respective zero positions when released from various states of collapse? Does the spill valve actuating lever impede accordion travel to a noticeable extent? Does the manual control linkage interfere during normal Duo-Art operation? Are both accordions able to complete their full travel unimpeded? A useful technique for further checking is to stop the roll with blank paper on the tracker bar and pull off tracker bar tubes at the accordion valve box. (Be sure to label these in advance if you remove more than one tube at a time!) You can step an accordion through its full count by removing and replacing tubes in various combinations. Be objective. If something is wrong at this level, the piano is never going to play well until the problem is fixed.

If the piano action is well regulated, Duo-Art components are problem free, and theme and accompaniment zero levels can be set to maintain their state of adjustment without undue difficulty, one available avenue would be to try a small change of theme and/or regulator spring tension. The service manual allows this, within prudent limits, and it can make a difference. Tightening up a regulator spring just a bit and subsequently resetting the zero level causes the knife valve to seek a new zero position, from which the buildup characteristics may be more favorable. Remember, too, that chord test instructions indicate that certain sequences should "not play or barely play". Overzealous individuals sometimes ignore the second part of that instruction. Read the instructions carefully. Hearing some notes play very softly does not necessarily signify test failure! Hearing all of them play at mezzo forte, of course, is another matter. Soft and loud are subjective, but why not? Music itself is subjective, as are Duo-Art loudness degrees. Try to use reasonable and prudent judgment.

One or both expression regulator springs may need replacement because of stretching beyond elastic limits at some time in the past, change or loss of elasticity for any reason, or even degradation caused by electroplating during restoration. (Some plating processes tend to ruin springs.) If one of the springs is made of thicker wire or is stronger than the other, make sure the stronger one is installed on the theme side. Regulator springs can be a serious problem for Duo-Arts. If replacements are needed, the best procedure in this day and age seems to be to try to find a pair of originals that work well in your piano. If that isn't practical, you may be able to borrow a good pair and have a spring shop duplicate them for you.

In grand Duo-Arts, re-positioning the linkage that transfers motion from each accordion pneumatic to its respective knife valve arm can change the mechanical transfer characteristic to the knife valve heel, and this may help in obtaining a better dynamic buildup. This technique has been mentioned by Chester Kuharski in at least one technicalities article, and by this writer at the 1972 AMICA Convention in Los Angeles.

Other factors, such as residual leakage (a proper amount of which is expected in a normally operating Duo-Art), condition of components, correct pump speed, possible binding of manual control linkage, tension on the accordion pneumatic return springs, and many, many more such items can influence results obtained. Check all of these things to the best of your ability. But to insure top results, set all accordion adjustments correctly, if they aren't already, and once they are right, leave them alone, as the Service manual instructs.

For the sake of completeness, readers should be aware that accordion travel can be reduced or increased without loss of linearity if the powers-of-two relationship is strictly maintained, i.e., each section's travel after the smallest must be exactly double its predecessor. For example, settings of .05", .1", .2", and .4" would yield a linear build up curve, but total travel would be only .750". This would perhaps be less harmful to a Duo-Art's response than certain other pitfall-ridden schemes that have found their way into practice, but dynamic range would be curtailed. Greater than standard travel should be avoided because of the possibility of exceeding the normal operating range of the knife valve and its connecting linkage. Abiding by documented factory settings remains the best and safest course to follow, and is the recommended course of action.

Perfect accordion pneumatics will, of course, never make a Duo-Art outshine it's peers as long as other parts remain in need of attention. But the accordions are critically important, and results made possible by putting them in good working order and keeping them in proper adjustment will be an important step toward a better Duo-Art.