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REBUILDING THE DUO-ART REPRODUCING PIANO MECHANISM NO. 5

by
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INTRODUCTION

The following treatise is an assembly of procedures that I have used and found successful in rebuilding the Duo-Art pneumatic system.

Those persons engaged in the pneumatic instrument field employ different techniques to accomplish the same task, and consequently there are few cases where there is only one "right" way to perform a given operation. If certain criteria are met, that is, if the restored instrument performs correctly, stands up to wear and time, and is not rendered unduly difficult to restore again in the future, then any procedure used that accomplishes these ends is appropriate. In writing a monograph such as this, I am inclined to describe techniques that I have found most successful and that I am most comfortable with. In every instance I have tried to describe techniques that are mechani cally and musically sound (as well as explaining the reasons for using these techniques); and if one is able to extract useful information from this writing, then it will have served its purpose.

The Duo-Art reproducing piano system was developed and marketed by the Aeolian Company of New York. This system has been described in detail both in publications originally produced by Aeolian (now reprinted) and in more recent publications, notably the book "Rebuilding the Player Piano" by Larry Givens. In writing this article I have concerned myself with specific aspects of restoration procedures and operation of various components of the system. Before attempting to restore a Duo-Art mechanism, one should read and understand all available material on the subject. I find the Duo-Art system a bit more difficult to understand than most other reproducing systems, and a thorough understanding of its operation is essential in getting it to work properly.

GENERAL REBUILDING PRACTICES

This section contains suggestions on materials to be used as well as descriptions of various general rebuilding practices to employ. References further on in the text will be made to this section.

Pneumatic Covering Materials and Procedures.

For small pneumatics such as piano stack pneumatics, any of the materials available from suppliers are quite suitable. For those new at the game I would recommend cotton backed rubberized cloth. The newer materials -- Polylon, Nylon backed Rubber Cloth, or Bilon -- are probably more durable than regular cloth but are considerably more difficult to use.

For larger pneumatics and the air motor use double weight motor cloth.

Very large pneumatics such as the expression box regulators may be covered with fuzz-back bellows cloth.

Do not use any kind of pneumatic cloth for the bellows in an electrically driven pump. It will wear out sooner than anything else in the piano. I recommend leather for pump applications. Use a good grade of soft cowhide or calf skin, fuzzy on the back side to facilitate gluing with hot animal glue. Leather with a smooth glossy finish usually is quite airtight. If unfinished leather is used, seal it with the pouch sealing solution described further on. Leather for pumps, particularly rotary box type pumps, must not be more than about 1/16th inch thick. Leather that is too thick will prevent the bellows from closing fully. When gluing a bellows with leather, spread a thick layer of hot glue on the edges of the bellows boards with a glue brush, press the leather in place, and use a hot iron to iron down the joint. The heat from the iron will make the glue more fluid and drive it into the wood and leather. Try this out with a scrap of leather you intend to use. After the glue has dried, the leather should be very difficult to pull off without tearing wood with it or leaving leather behind.

Glue.

For modern pneumatic covering materials such as Bilon, use only the glue recommended. Regular cotton type cloth can be glued with hot glue or white glue. Hot glue, incidentally, is the dry hard crystalline material that you cook in a glue pot or double boiler. Fuzz-back cloth and leather should be glued with hot glue. For any wood-to-wood joints that may have to be disassembled in the future, use hot glue.

Pouches.

For pouches in the Duo-Art, I am disinclined to recommend anything except tan pouch leather. The polyurethane films such as Perflex should not be used as these materials have been found to break down with use over a short length of time. Zephyr skin is very sensitive to changes in humidity, and the careful pouch-to-valve regulation that you perform this week may very well be undone next week when the weather changes.

Tubing and Hose.

I advise use of neoprene tubing. Rubber tubing available today usually breaks down around nipples after only a short time. There are endless types and grades of plastic tubing. Some of it is good and lasts a long time while others break down fast and can do outright damage to the mechanism. If you are absolutely sure about the plastic tubing you plan to use, go ahead; otherwise, play it safe and use neoprene.

Cloth wound twill hose available from Player Piano Co. and others is excellent. Avoid automobile radiator hose. Garden hose and shower hose make a distressing looking job and should remain in the garden and shower.

Gaskets.

Soft suede leather is the best material for gaskets. Cork gaskets, particularly automotive type cork, can be very leaky through the edges; also, cork does not have the resiliency of leather.

To apply leather gaskets glue the gasket to one surface with thin hot glue. Spread a solution of 75% denatured alcohol and 25% shellac (4 lb cut) to the wood on the other surface and assemble. The shellac will grip the gasket and help to hold it tight during periods of dryness but will allow the joint to be opened without difficulty.

A lot of joints in the Duo-Art action are sealed with pneumatic cloth instead of packed gaskets. Procedures for applying this type of gasket are described in the section on rebuilding the piano stack.

Miscellaneous.

Duo-Art actions contain several lead alloy elbows and tee's which almost always cause trouble. The lead oxidizes and flakes off inside; these flakes always manage to find their way under valves and into the pump where they can do considerable damage. If the lead fittings are very badly oxidized, they can be replaced with plastic or copper pipe fittings of the same size. If the lead fittings are re-usable, wire brush the outside of them until they shine, coat the interior liberally with white glue, and spray a thick coat of lacquer on the outsides.

Rebuilding should be done in an area that is not overly damp. If an action is rebuilt in a damp basement, it will always loosen up in a dry room later and cause trouble.

Do not take anything for granted in rebuilding a Duo-Art or any reproducing piano system. They are most unforgiving of errors. Check every bellows and valve for tightness as you rebuild them. Difficulties in several components at once are very hard to locate once the system is completely reassembled.

Keep identical-looking parts in order. Most of the parts in any player action are hand-fitted and mixing them up will cause no end of troubles.

OPERATION OF THE DUO-ART EXPRESSION BOX

Because the interior of the Duo-Art expression box is a labyrinth of passages and valves, it is quite difficult to visualize its operation just by examining it. In the following drawing I have represented, schematically, all the components in the expression box in order to make it easier to understand.

Description of operation.

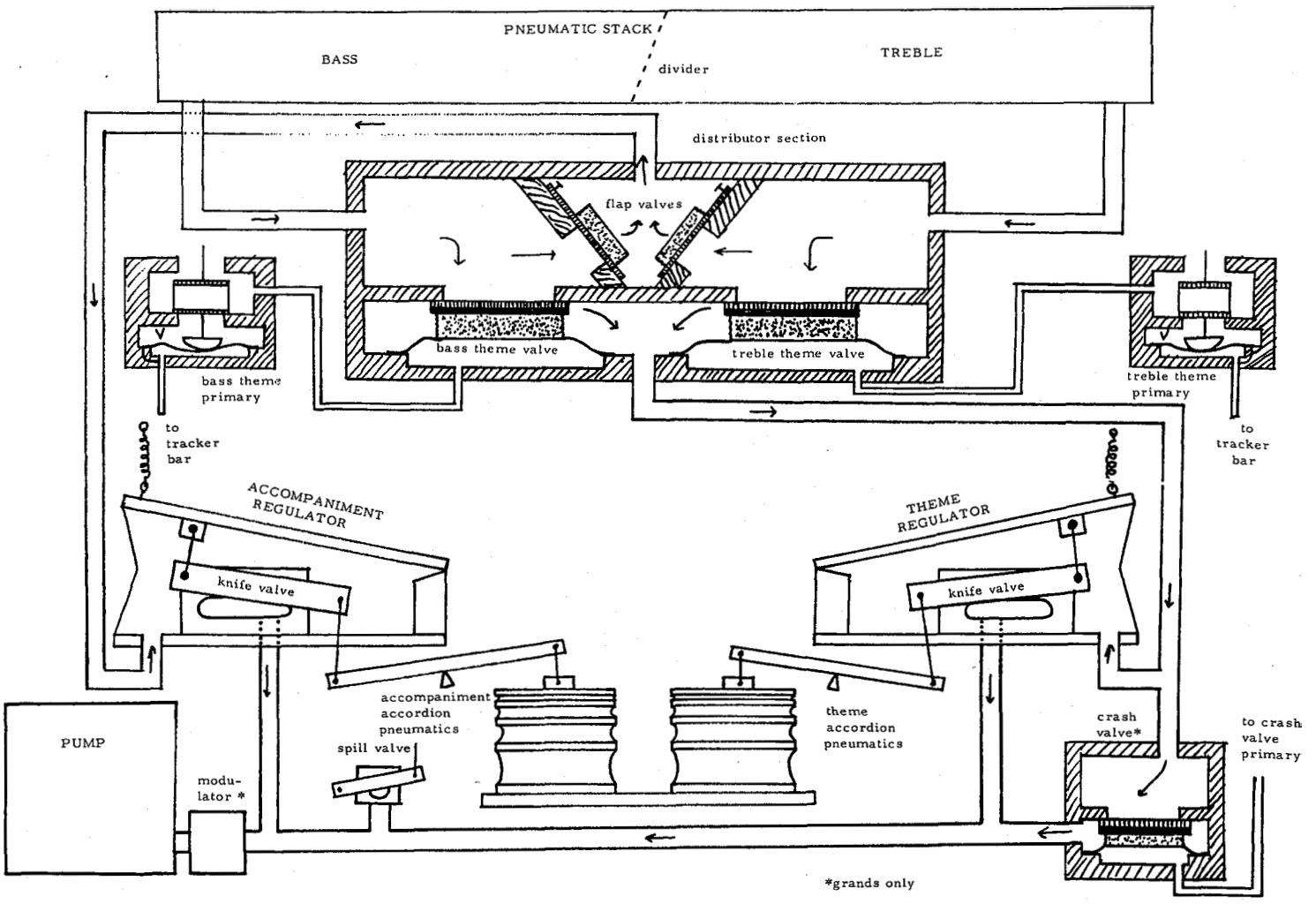
Vacuum from the pump and modulator is applied to two vacuum regulators. These regulators provide two independently adjustable vacuum levels, each determined by how far the associated accordion pneumatic is made to collapse. The accordions can collapse over a range of 1" in 1/16th" steps; this movement range provides a corresponding vacuum level range of from approximately 5" of water to full supply vacuum.

The vacuum in the accompaniment regulator connects to both bass and treble halves of the divided piano stack through the two one-way valves in the distributor section of the expression box.

The vacuum level in the theme regulator connects to the underside of the two theme valves in the distributor section.

The theme valves receive atmospheric pressure under their pouches during the time when no theme level is called for by the music roll; thus the theme valves are held shut. It is important to note that during the time when the theme valves are shut, vacuum from the accompaniment regulator reaches both sides of the pneumatic stack; therefore, the general loudness of the piano is normally determined by the accompaniment regulator.

Before a theme hole comes up on the music roll, the roll adjusts the theme regulator to the level of vacuum required to play the theme notes (this vacuum level is always higher than the vacuum level being provided by the accompaniment regulator at that time). When, for example, a theme hole opens its duct on the tracker bar, the bass theme primary valve supplies vacuum to the under-



side of the bass theme valve allowing the valve to open and connect the bass section of the stack to the theme vacuum regulator. The one-way valve in the accompaniment passage prevents the higher theme vacuum level from feeding back into the accompaniment regulator and the treble section of the stack. The same operation takes place for the treble theme and treble section of the stack.

The spill valve is linked mechanically to both sets of accordion pneumatics and serves to unload the pump during times when low vacuum is being provided by the regulators.

The crash valve is found in most grand expression boxes. It is operated by the position of the theme accordion pneumatic. Its operation is similar to that of the theme valves and it is adjusted to bypass completely the theme regulator when the highest level (level 16) is called up in the theme.

DISASSEMBLY

Before removing the Duo-Art mechanism from the piano, make a few diagrams of tubing connections around the spoolbox, junction blocks, and manual controls. These diagrams can be very helpful during reassembly. There is quite a bit of variation in the actual tubing scheme of Duo-Arts, and even with existing tubing schematics, it is easy to get confused. Leave as much original tubing attached to the components as possible because you can use the old pieces for measuring out new tubing to the proper lengths.

For grands, if the original tubing is still in good shape, it will be a big help to try and get the large tubing harness out in one piece. This harness runs from the junction block at the left of the spoolbox, through a hole in the piano case and then branches out to the various components of the system. The original harness can be used as a guide in making up a new one.

The heavy pump in grands can be dangerous to remove if the piano is on its legs; have an assistant help you with this.

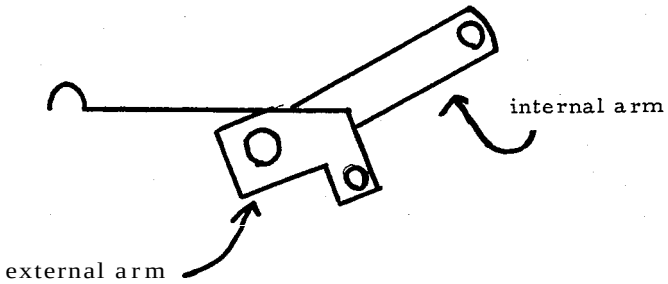
REBUILDING THE SYSTEM

Most of the following instructions apply equally to the grand and upright Duo-Art actions. Where specific differences exist, I have tried to point them out.

Rebuilding the expression box.

The expression box must be completely disassembled. As parts from the left and right sides of the box resemble each other, it is a good idea to mark them as they are removed to avoid confusion during reassembly.

Tear off the cloth covering the movable boards of the regulators and make two drawings showing the relative positions of the internal and external arms that control the knife valve position. This will prevent the possibility of putting them on backwards later.

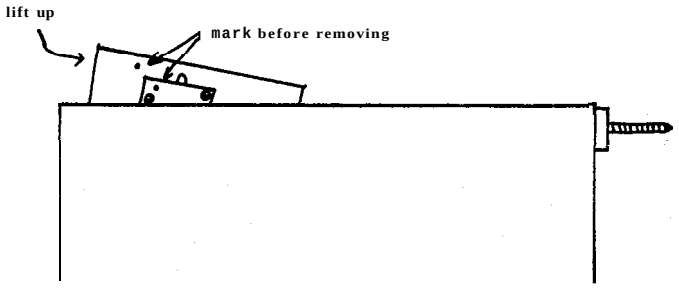


Remove all the external hardware and strip off the cloth covering the top of the expression box. Remove the knife valves and all the control arms and axles; also remove the valve surfaces that the knives slide on.

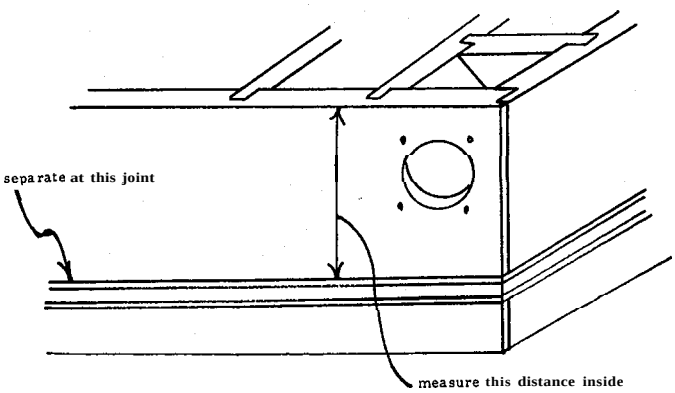
The two regulator pneumatics are glued onto the body of the box with a strip of thin leather in the joint to facilitate removal. Check for any screws that may also be holding the regulators on, then drive a thin putty knife into the joint to remove the regulators.

The two theme valves and the crash valve (grands) cannot be reached without breaking the box open. Whether or not you replace the valve pouches depends upon what condition they are in and how thorough a rebuilding job you wish to do. I must emphasize that because these pouches are very critical to the operation of the expression system, they must be perfect in order to work right. These pouches have pieces of felt underneath them and also between the pouch and the valve button. For some perverse reason, moths seem to find this felt tasty and usually chew holes in the pouches as they feast on the felt. Attach a length of tubing to each nipple leading to these pouches and blow into it as hard as you can. If there seems to be leakage through the pouch (the leather may be so weak that it will blow out) then you have no alternative but to open the box and replace them. These pouches are under almost continual high tension, so they must be able to stand up to this tension.

Having decided to replace the pouches in the box, the main problem is how to open the box. The box must be sawed or cracked open; there is no other way. The following system, used by several professionals in the field is the least likely to damage the box materially. Remove everything that projects from the sides of the box. In upright boxes the action cutoff slide valve can be removed by pushing the valve rod all the way in and pulling the wooden slide up far enough to enable one to get a screwdriver on the screws holding it to the threaded block.

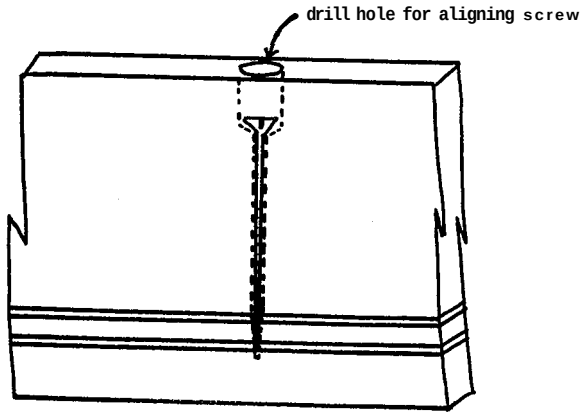


Next, sand off the exterior of the box. By removing the black paint you will be able to see the joints where the box is glued together. The box must be opened at the joint where the board containing the pouch wells is glued to the body of the box.



To be certain you know which joint this is, use a ruler to measure inside the box from the top (the regulators are on the bottom) to the pouch surface. An equal distance down the outside of the box will show the location of the joint to be opened.

Some expression boxes have long thin screws passing down through the sides from the top which served to hold the box in alignment when it was glued together. Remove these screws if they are present. If the box you are working on doesn't have any such screws, install at least two prior to cracking it apart as they will insure that the two halves will not slip when they are reglued.



You will need a thin sharp putty knife and a sturdy carving knife (the kind of knife used to carve roast beef) to get the box open. Use the putty knife and a mallet to score a shallow line around the outside of the box directly on the joint. This scoring makes a guide for the carving knife. Lay the blade of the carving knife in the groove and gently tap the blade into the joint with the mallet, tapping along the entire length of the blade. Don't try and drive the blade all the way through; just drive it in slightly, then remove it and do the same on the next side of the box. Keep this up, proceeding from one side to the next, each time driving the blade into the joint a little further. Go around the box several times like this and finally it will pop open. If the blade passes through a side of the box and begins to penetrate the joint of one of the interior walls, make sure it doesn't tend to follow the grain of the wood in the wall. If this happens do not drive the blade in any further from this direction.

Once the box is open, examine it carefully for any splits that might have occurred and also for any areas that may not have separated cleanly. Any large slivers of wood that came off with the wrong half must be chipped off and glued onto the other half.

Tear off the pouches, marking each valve so it can be returned to its proper place; then sand off the surfaces of both halves until they are perfectly level and will lie together flat. If you have access to a large belt sander, you can level the surfaces easily; however, you can very easily destroy the box by oversanding. The safest way to do this is to glue a sheet of medium sandpaper to a plate of glass, (use a can of spray adhesive). Now you can sand the halves of the box against the paper using a circular motion until the two sections will rest flat against each other. (Save this lapping plate for some operations to follow.)

If moths have been at the felt in the bottoms of the pouch wells, replace it with felt of the same thickness.

In replacing the pouches, I advise the use of pouch leather and nothing else. If any type of plastic material is used, the chances are good that the bonding material won't stand up to the strain imposed upon it. (I know, I've tried!!) Use hot glue to glue on the leather. Punch out some 3/8" diameter dots of masking tape and stick one on the exact center of each pouch; then seal the pouches as described in the "General Rebuilding Practices" section.

Inspect the valve buttons for any moth damage. If the thick felt body of the valve is badly eaten, make a new one from hammer felt trimmings available from most piano supply houses. Make absolutely sure that the new valves are exactly the same thickness as the old ones.

Glue the valve buttons onto their respective pouches with a drop of hot glue on the bare spot left, after sealing, on each pouch by the masking tape. Check the alignment of each valve by placing the top half of the box in position and looking through the holes the valves cover.

After all the glue is dry, test each pouch by mouth for tightness and make sure that the buttons are securely attached. You certainly do not want to have to open the box up again later because of an oversight now.

To facilitate disassembly of the expression box in the future, I would recommend gluing a strip of pouch leather between the mating surfaces of the halves of the box. Cut out all the strips you will need to the correct width and slightly longer than necessary. Use only hot glue for reassembly. You must work quickly to spread the glue and get the box together before the glue has a chance to cool and jell. A bit more working time can be obtained by warming the wood with a heat lamp and insuring that the glue is thin enough to flow readily. Apply glue to the top section first, apply the leather strips and trim the strips on the internal walls so that they butt together without any voids (have the hole to the flap valve passage cut out in advance). Apply another thick coat of glue to the leathered surface and press the top down onto the lower section. Run in the aligning screws and apply clamps around the edges of the box. The glue should ooze out liberally as you apply clamping pressure. Allow the box to dry in a horizontal position so that no drops of glue run onto the pouches. Once the glue has dried overnight, you can sand the sides of the box, shellac it, and spray it with flat black paint for an invisible repair.

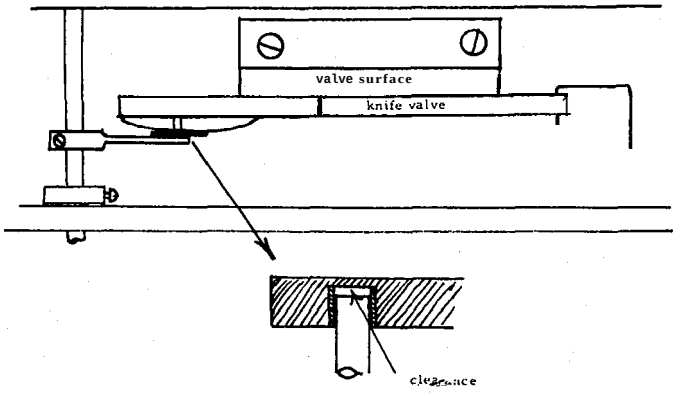
Examine the buckskin covering on the ends of the two spill valve arms for wear or rotting. If this leather must be replaced, file off the heads of the rivets and drive them out with a punch. Glue on new buckskin with contact cement and hammer in new aluminum rivets, (brass screws can be used as rivets if necessary).

The two regulator pneumatics are recovered in the usual way. Be sure and install new pouch leather strips between the regulators and the box when regluing them. It is important to mention once again that these strips are to facilitate disassembling the box again in the future. Use hot glue for gluing the regulators back on.

Before installing the knife valves and valve surfaces, lap them on the glass plate you made earlier. Follow this by a lapping on a sheet of very fine sand paper to get a smooth surface. Apply graphite to the sanded surfaces by first wetting the wood with denatured alcohol and then rubbing the graphite on with an old piano hammer. Install new suede leather gaskets under the valve surfaces and use straight shellac to seal them against the inside of the box as they cannot be reached for tightening later.

When installing the knife valves, make sure that the axles turn freely in the felt bushings but are not so loose that they wobble. These axles must turn freely if the expression box is to operate correctly.

Install the knife valve and position the arm that moves it so that the pin on the end of the arm projects into the felt bushed hole in the knife almost all the way but not quite far enough tn touch the bottom of the hole.



The knife must lie perfectly flat on the valve surface; if the pin projects into the hole too far, it may tend to cock the knife away from the surface. Rotate the axle and look closely at the movement of the knife to insure that it always lies flat. The one end of the pressure spring should rest in the depression in the knife.

After determining that the knife valves are all right, glue a sheet of fuzz-back cloth over the tops of the regulator boards with hot glue. Iron the joints down with an electric iron to insure an air tight bond.

Treat the spill valve in the same way as you did the knife valves. In grand boxes the sliding surface is hard to get at and usually needs no attention unless it is obviously warped.

Accordion Pneumatics.

When disassembling the accordion pneumatics, be sure to mark each piece so that they can be re-assembled exactly as they came apart. Although the small blocks holding the adjusting screws all look alike, they will usually be cockeyed if screwed onto the wrong position. I use a set of steel letter and number punches to stamp the blocks on the surface that is hidden when they are in position.

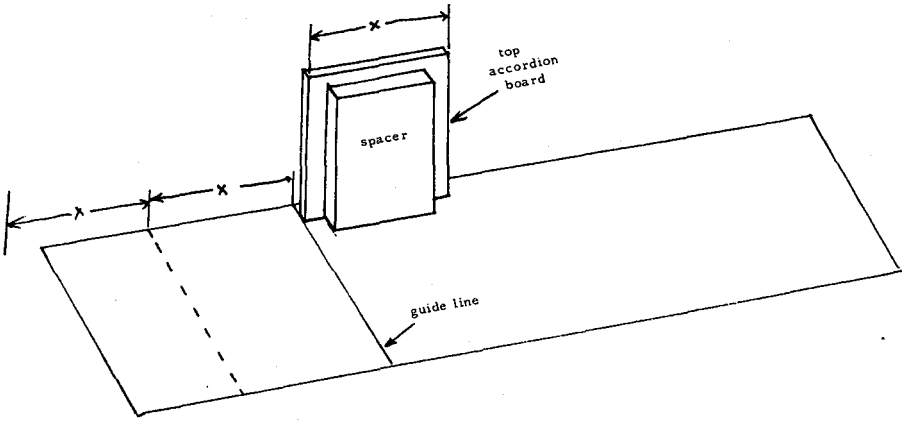
Slit the sides of the pneumatic and mark each board as you remove it, indicating its position in the accordion and the top side. Many times the original leather covering has rotted away to nothing; consequently you may have to use some deduction to determine which board went where. It is not too terribly important if the three center boards are mixed up, provided they all have the same configuration. Sometimes these boards fell out of the piano and were lost, in which case you must make new ones if originals are not available to you. New adjusting screws can be made by removing the heads from 5/8 x 6/32 brass machine screws, screwing the threaded part into brass nuts and soldering the nuts on. File the nuts flat where they contact the felt pads.

It is not a bad idea to indicate on one of the boards which edge has the seam where the ends of the covering material overlap. This seam should not come directly under any of the adjusting screw blocks.

Sand off the edges of the boards carefully; it is very easy to get one lopsided or smaller than the rest. If somebody in the past has possibly mixed up the adjusting screw blocks, you should re-screw them onto the boards temporarily, interchanging them around untill they are all straight and even.

Originally the accordions were covered with pouch leather; this is probably the easiest material to work with if you've never tackled a set before. Covering them with some type of pneumatic cloth eliminates two disadvantages of pouch leather: its "stretchy-ness" and its porosity, but it is much more difficult to apply the cloth to the accordions. Do not use polyurethane film on the accordions as this material stretches very easily and will not permit accurate movement of the accordion.

Spacer blocks must be used in the accordion to get the proper amount of space for each section. These blocks should be about 1/2" smaller in width and length than the pneumatic boards and of the following thicknesses: 3/16", 1/4", 3/8" and 5/8". These are exactly 1/8" thicker than the amount of



movement each accordion section must have; the extra 1/8" is taken up by the adjusting screws.

Cut out a strip of leather or cloth about 1/2" wider than the total height of the accordion and exactly 1/2" longer than the periphery of one of the boards. Draw a line on this strip as shown in the diagram.

This line should indicate the left hand edge of the boards on the surface directly opposite from the surface that gets the seam. Find this point by placing one of the boards on the end of the cloth so that the edge lines up exactly where the seam will come, and then roll the board over onto its opposite edge and mark where its left corner rests. The line you draw should be parallel to the end of the cloth. Lay the cloth on about 5 thicknesses of newspaper (for padding) and glue the thin top board onto the cloth about 1/8" from and parallel to the long edge of the cloth as shown. Be sure the left edge of the board rests exactly on the line. Place the 1/8" spacer block against this board and glue the next board on directly against the spacer. Proceed with the rest of the boards and spacers, keeping the left edges of each board on the line. Press the whole pile together and lay it on its side. Spread the glue on the top edges of the boards and smooth the cloth down over them, pulling it tight around the corner. Lay the pile over and glue the opposite side. Be careful not to use too much glue as none must run down inside. At this point set the first accordion aside and glue the second one while the glue sets up in the first. After the glue has had a chance to dry a bit, turn the accordion over and shake the spacers out of it. If some of the spacers stick, screw wood screws into them and wiggle them out. Now spread glue on the remaining edges of the boards, lay the one flap over, and press it in place. Spread a 1/2" wide band of glue along the edge of the flap and press the other flap in place. Use just enough pressure on the unsupported area between the boards to get the edges of material to come together.

Locate all the screw holes with a punch and cut these holes out with an Exacto knife. Reassemble the accordions and test each section for leakage.

The dynamic valve box is treated just like the valves in the stack. After these valves are rebuilt and tested, they can be installed in the upright box or set aside until later for the grand box. Use light flexible tubing between the valves and the movable accordion sections.

Regulator Springs.

The two regulator springs are usually, but not always, dissimilar. The stronger spring should always be installed on the theme regulator. You can determine for sure which is the stronger by linking the ends of the springs together, holding the opposite ends and stretching them slightly. It is easy to see which one stretches the furthest under equal tension this way.

The entire dynamic range curve of the expression unit is determined by the characteristics of these two springs. If they are weakened due to severe rusting or overstretching, they must be replaced. Borrow a pair of good original springs and compare new springs to them until you find some that are of the same exact strength.

Spill Valve.

Examine the felt used to muffle the sound of the spill valve. In most grand boxes this consists of a small piece of thick felt rolled up in the atmospheric port of the spill valve. Leave this felt out for the moment until you bench check the expression box; you will want to be able to see the action of the spill valve through the hole. A lot of dust accumulates in the muffler felt; however, it can be cleaned thoroughly with a high pressure air hose.

If the muffler felt must be replaced, it is extremely important to use felt exactly like the original, both in thickness and density. This is particularly important for upright boxes. If the felt is too thin, too much air will flow through the valve during soft playing and there will be insufficient vacuum to operate the accordion and pedal pneumatics. If the felt is too thick, the purpose of the spill valve will be defeated.

During final assembly make sure all mechanical linkages move freely but with as little 'slop' as possible. The Duo-Art expression box cannot provide the small subtle changes in vacuum that it will be called upon to do if there is any excessive looseness in any of the bushings and linkages between the accordion pneumatics and knife valves.

Bench Checking the Expression Box.

Once the expression box is completely rebuilt, it can be checked out on the workbench and certain rough adjustments can be made to it.

The upright box can stand by itself in its opening position. The grand box can be screwed to four wooden blocks to hold it in its normal operating position. Temporarily tube the accordion pneumatics to the dynamic valve box with some scrap tubing.

The first test is simply a check for leaks into the box.

Block off all the nipples leading out of the box with corks and tape except the main supply nipple and the theme valve nipples. Hold both accordion pneumatics fully closed by hand (make sure that the spill valve is closed off) and apply vacuum to the main supply nipple by mouth. Both regulators should close up somewhat, but once the air is exhausted from them, there should be no other flow of air from the box and no audible leakage. Leakage usually occurs at the joints between regulators and the body of the box, where the cloth is glued over the top of the box or the regulators, around bushings and gaskets, and through open screw holes (tape any of those over temporarily).

The next step is a setup to rough-adjust the box and test its over-all ability to control the vacuum level at its outlets. You will need a 0 - 60" vacuum gauge and a source of vacuum. This source of vacuum can be the Duo-Art pump itself if a more convenient source is not available, provided the Duo-Art pump has been restored or is functioning properly.

A few words of caution about using the Duo-Art pump. It is possible to stall the electric motor or damage the pump if it is operated with its inlet completely blocked off. Therefore, take the following precaution: Set the pump up at a distance from the expression box where noise will not be objectional and connect a length of hose to it. Cut a 1/2" diameter hole in the hose close to the pump inlet nipple. Drill a small hole in a big cork and attach your vacuum gauge to this hole. Push the cork into the other end of the hose and run the pump. Tape off the hole you made in the hose until you have a reading of not more than about 50" of vacuum. This will protect the pump from damage.

Prepare the expression box for testing by inserting large corks into the bass and treble outlets. These corks should each have a hole into which you have inserted a 5/32" nipple. The nipples will allow a small quantity of air to leak into the regulators. In actual operation this seepage is provided by the natural air flow through the piano stack and is necessary for the regulators to work properly.

Block off all the tracker bar nipples on the dynamic valve box and connect its supply nipple to the vacuum source.

Check the regulator springs to see that there is some tension on them. (Don't adjust them at this point unless they are loose.)

Leave both theme pouch nipples open to the air,

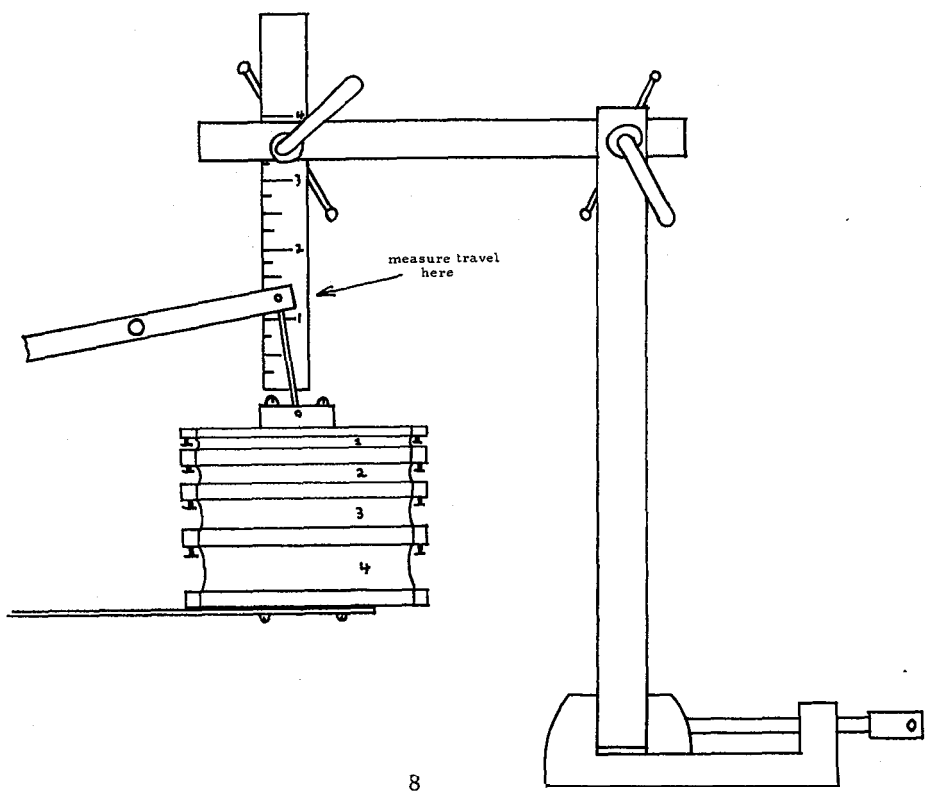
Connect your vacuum source to the main supply nipple and apply vacuum. Check to insure that none of the accordion sections are collapsed.

The first adjustment will be the approximate zero setting of the regulators. Loosen the lock screw on the accompaniment and theme knife valve arms. (There is an illustration of this on page 10 of the 1925 Duo-Art service manual.) Carefully turn the expression adjusting screw on the accompaniment side while observing what happens to the regulator pneumatic. There is a range of adjustment over which you can make the regulator pneumatic close or open by turning this screw. When you have located this range, turn the screw until the pneumatic is fully open, then turn it the other way until the pneumatic closes about 1/16". Do the same for the theme regulator. This is the approximate zero setting which you will be able to adjust to a finer degree once the whole system is assembled.

The next adjustment is the travel of each section of the accordion pneumatics. For this you will have to rig up some method of holding a ruler over the top of the accordion so that you can measure the travel of the linkage between the top of the accordion and the lever that it pulls. I do this with a drill press vise, two C clamps, and some wood strips.

Needed, also, is a small wrench that will fit the adjusting screws on the accordions. (On early units with knurled screw heads, a pair of surgical forceps is very helpful.)

Adjust the position of the ruler to a reference point directly on the link between the top of the accordion and the lever. Don't try to measure the travel at the edge of the top board because it



doesn't always move perfectly level. Open the tracker bar nipple on the valve box for section No. 1 and measure how far the pneumatic moves. The travel should be exactly 1/16th". Adjust this by turning the three screws in or out, keeping all three even so that the section will not be cockeyed when it is closed. You may not be able to get at all the adjustments without removing the accordion; therefore, make a note of each inaccessable screw that needs turning and do them all at the same time after all four sections are checked. Check section No. 2, adjusting it for 1/8". Do the same for No. 3 (1/4") and No. 4 (1/2").

Adjust the spill valve by opening the nipples for sections No. 2 and No. 4 of the accompaniment accordion to give you a dynamic setting of 10. Observe the position of the spill valve by looking through the hole on the grand'box or removing the muffler box on upright units. Adjust the arm on the accompaniment end of the spill valve axle until the valve is just closed. (You should be able to hear some air hissing through the spill if you close off No. 2 nipple and open No. 1.) Repeat this procedure for the theme side, then replace the muffler.

Adjust the crash valve setting on grand boxes by opening nipples for sections 2, 4, and 8 on the theme and adjusting the trip lever for the crash valve pallet so that by adding section No. 1, the pallet is made to open. The crash valve should not operate with sections 2, 4, and 8 collapsed but should operate with all 4 sections collapsed.

Check the operation of the accordions at different settings. Observe that the No. 1 section is capable of making some change in the regulator opening at all times. If the linkages are excessively stiff or sloppy, this small movement may not have any effect. The knife valve arms should not creep back to the zero position; if they are sluggish, there may be stiffness in the linkage -- or the small return spring may need to be tightened a bit. Note that the regulators themselves take some time to recover to the zero position due to the restriction of air flow through the 5/32" nipples in the outlets.

The action of the theme valves can be tested as follows: set up dynamic level 10 on the theme accordion (sections 2 and 4) while leaving the accompaniment side at zero. Connect a tube to the bass theme nipple and suck on it by mouth. There should be a thump in the box as the theme valve opens, accompanied by an increase in air flow through the bass supply nipple. Block off the bass nipple with your finger and insure that no increase takes place at the treble outlet. Test the treble theme valve the same way. You will not be able to operate the theme valve until the vacuum you are producing by mouth exceeds that in the theme regulator. While holding the theme valve open, you can test the crash valve by operating the crash valve pallet with your finger at which time the vacuum should jump up to full pump vacuum.

You may want to connect a vacuum gauge to the bass or treble outlets and observe how the system operates, but keep in mind that without some air leaking into the outlets, the regulators will be very slow in returning to lower vacuum levels.

Rebuilding the Stack.

The pneumatic stacks used in grand and upright Duo-Art pianos differ somewhat in construction, but the rebuilding procedures are essentially the same for both types.

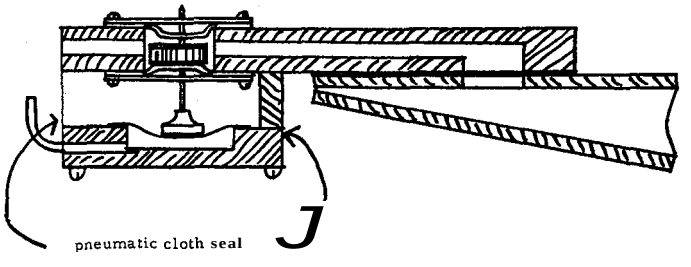
When disassembling the stack, be sure to number or mark all parts so that they can be re-assembled as they came apart.

Replace all the leather nuts on the brass push rods as these are almost always rotted and frozen onto the rods by corrosion. Make three drawings, one for each of the three different lengths of rods, showing the positions of the leather nuts. Use a razor blade or Exacto knife to slit the old nuts for easy removal. Remove the wooden pitmans and stick them onto a strip of masking tape to keep them in order; you can mix up the rods themselves, as they are all essentially the same. In order for the rods to slide freely in their bushings, they should be free of corrosion. Soak the rods in a glass tray filled with a solution of 50% hydrochloric acid (Muriatic acid) and 50% water. The Acid is obtainable from most hardware stores. Make up the solution by pouring the water into the tray first and then carefully flowing the acid in; do not do the reverse. Because the acid and its fumes are very corrosive, do this outdoors. Let the rods soak for about 5 minutes, agitating them a bit from time to time. Pour off the solution and rinse the rods with water, then wipe the loosened corrosion off with a dry rag. This will leave the rods clean and free of most corrosion; you may have to lightly wire brush the threads where thick waxy corrosion built up under the leather nuts. Chuck the rods up in an electric drill to speed up the process of screwing on new nuts. Use your diagrams to get the nuts in the approximate positions they were in originally.

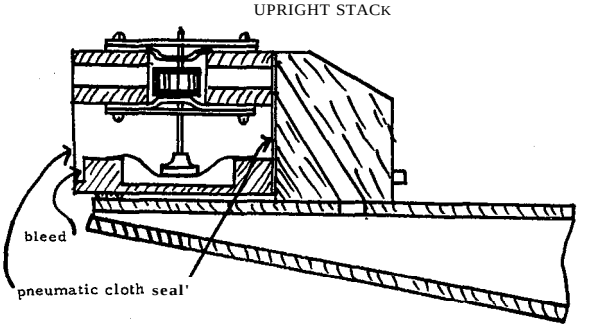
Separate the three decks of pneumatics and valves.

Number and remove the pneumatic fingers.

GRAND STACK



UPRIGHT STACK



Because the pneumatics on grands were glued on with pouch leather between the joints, they come off easily. Use a knife to score a line into the decks along the hinge ends of the pneumatics and along the sides of the end pneumatics to determine their approximate positions.

On uprights separate the valve boxes from the decks and score a line into the pneumatics along the front and back of each deck and along the edges of the pneumatics.

The guide rails with a screw into each pneumatic will align each individual pneumatic when reglued, but the end pneumatics must be positioned correctly first or the whole deck may be misaligned.

As you remove the pneumatics, carefully pull out each hinge spring and examine it thoroughly for cracking or bending. New ones can be made from piano wire of the same strength; the originals are made of a bronze alloy that is weaker than steel; consequently, steel springs should be thinner than the original ones. I always try to re-use the original springs if they are all right. Stick them onto a strip of masking tape as you remove them to keep them in order.

Sand off the glued side of the pneumatics as well as the old cloth to remove all traces of the old leather gasket and glue. Do not glue them back on with the old gaskets, or they will almost certainly fall off later.

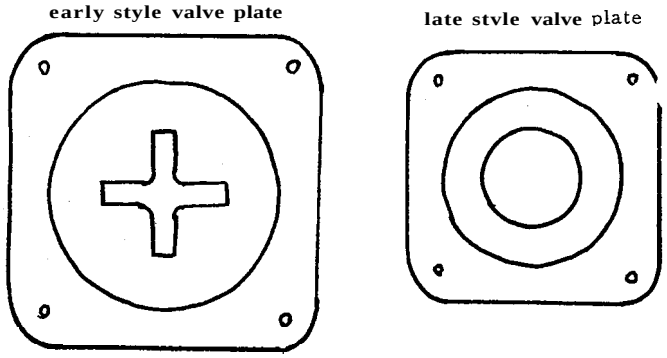
Before recovering the pneumatics, enlarge the two spring holes with an ice pick so that they can be located easily after the covering is in place.

Pull out all the tracker bar nipples leading into the pouches.

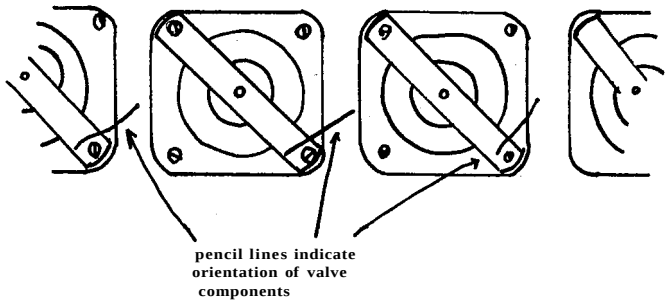
Strip off the pneumatic cloth seals covering the front and back of the valve boxes. Before disassembling the valve boxes, use a sanding block to sand off the old glue and cloth remaining on these surfaces. Doing this while the boxes are assembled will insure that the sanded surfaces will be even.

Remove the pouch boards and examine the pouches. Unless the pouches are in like-new condition, they should be replaced. Tear off a pouch in the center of the board and see if there is a lot of dirt under it. There is no way to remove this dirt without replacing the pouches. Also, examine the leather of the pouch; if it is weak and tears easily, it is undoubtedly very leaky and ought to be replaced. Sand off the old pouches until no traces of the old glue remain. Use an air hose to clean out the sanding dust. Clean out all the dirt from the bleeds in the upright version; the bleeds in the grand stack are in a separate box. Glue on new pouch leather pouches with hot glue and seal them as outlined in the general rebuilding section.

Duo-Art stacks will contain one of two types of valves. Early stacks use valves with cross-shaped holes in the valve plates while later stacks utilize seats with more conventional round holes.



Remove the valves from the decks and place them on the table in order along with the top valve plates. Remove the plates only; the bottom plates are sealed on with very thick shellac and should not be removed unless absolutely necessary. Mark the top of each plate and the valve stem guide as shown with a pencil before removing.



On the grand stacks, the old leather gaskets can be sanded off the decks at this time. After doing this, use an air hose to blow out all the dust.

Examine the seats of the lower plates for dirt and corrosion. If considerable corrosion is present, the seats can be cleaned by stretching a soft rag over your index finger, dipping it into a small amount of Noxon metal polish, and rubbing this onto the seat. Follow this with a clean rag. Use the polish sparingly and examine the underside of each plate for any polish that might run through. Most Duo-Art valve plates are of aluminum and usually do not corrode excessively. Some of the plates, however, were made of nickel plated brass; in certain instances the nickel may have corroded badly and exposed the brass. If brass is exposed, cleaning the plates will not suffice as the acids in the leather valve face will quickly corrode the brass again. The seats of very badly corroded valve plates should be coated with a light clear lacquer spray. The spray must contain nitrocellulose lacquer; Acrylic based lacquer will not last. Allow the spray to dry for 24 hours or more before proceeding. The lacquer will protect the exposed brass from the acids of the leather and will not become sticky.

Check to make sure all the screws holding the lower plates are tight. Use a small brush to paint clear lacquer around the interior of the valve well to make sure that the lower plate is completely sealed. Avoid getting lacquer on the seat itself

unless they must be sprayed as described above.

Examine the leather valve faces, paying particular attention to the top face. The lower face is almost always all right as it is not exposed to circulating air currents. The top face sometimes becomes rotten and must be replaced. Rotten leather has a peculiar dry odor and it disintegrates when brushed hard. Do not replace the valve faces unless they are rotten. Most of the time the old leather will last as long as any new leather you install. If replacement is necessary use leather as close to the original in quality as possible. It must be firm and yet flexible. Soft, fluffy leather such as organ pallet valve leather is not recommended because air can seep through the edges of such leather. The best leather for valve faces is soft calf skin, finished on one side and with a smooth, soft nap on the unfinished side. Use only leather on these valves. Try to match the thickness exactly. The top face must not be glued onto the button. The hole in it should be a snug fit around the valve stem. The lower face must be glued on with very thin hot glue; before gluing, the surface of the button must be sanded clean and absolutely flat by twisting it on a sandpaper block with a hole in it to allow the stem to protrude.

If'you are using the old valve faces, brush them to remove the dust and dirt and then rub in some talcum powder to make the leather more slippery.

Reinstall the valves, pressing them against the lower seat and giving them a twist in one direction to flatten out the nap of the leather. Leave the top plates off.

Reinstall the pouch boards, making sure the divider between bass and treble is well sealed with shellac. Glue on the pneumatic cloth seal on the side opposite the valve access openings. Use very thin hot glue and apply glue to about 6" of the seal at a time, laying the cloth seal down on the valve box and pressing it into place before applying another 6". Use thin pneumatic cloth for the seal. Do not apply a seal to the front of the stack yet as you must be able to reach through the access holes to adjust the pouch to valve clearance.

Adjust the pouch-to-valve clearance by pressing on the top of the valve to keep it from turning while using a pointed tool like an ice pick to turn the pouch button until it is very close to the pouch but does not quite touch it. A clearance of about 1/32" is ideal.

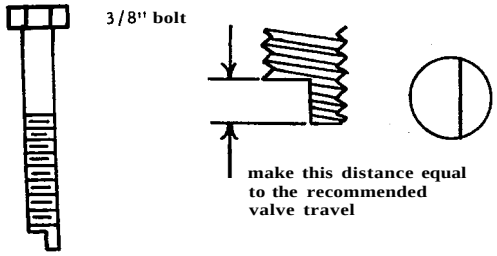
The valve travel for the stack valves should be around 3/64" of an inch for the cross-hole plates and a bit less, approaching 1/32" for the round hole valves. The travel is adjusted by adding or removing paper shims under the top valve face. Normally the valves do not need any adjustment, but they should all be checked. The most accurate way of measuring this travel is to use a dial indicator. Mount the indicator in a rigid fixture that will allow it to be positioned over each valve stem with the indicator tip resting on the top of the stem. Hold the upper valve plate in place by hand and inflate the pouch with a tube to your mouth while observing the dial indicator. If you do not have a dial indicator, a simple valve clearance tool can be made by filing off the end of a large machine screw, forming a step equal in depth to the recommended valve travel. Thread this screw into a fixture as shown:

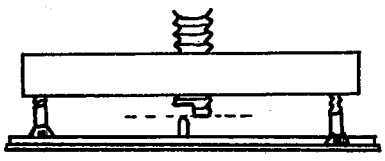
Rest this fixture on the top plate and adjust the screw until the end touches the valve stem. Slide the fixture back so that the stem is positioned under the step and inflate the pouch. The valves will function properly over a surprisingly wide range of travel; therefore, it isn't necessary to adjust the travel to an extremely fine degree. Anything within a tolerance of .01" of the recommended valve travel is allowable.

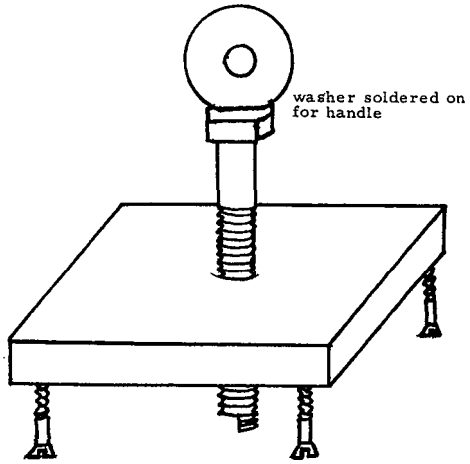
Once the valve travel has been checked and adjusted, re-install the top plates and valve guides. Paint a very thin mixture of 80% alcohol and 20% shellac on the wood surface under each plate and screw the plate down. The shellac will keep the blotter paper gaskets tight during humidity changes.

At this point the pneumatics can be reglued onto decks. For grand stacks be sure to install pouch leather or fiber-paper gaskets between each pneumatic as they are almo'st impossible to remove without damage if glued on directly. Most upright decks are made of maple, and the glued surface is so small that the pneumatics can be glued on directly without creating problems in the future. On uprights where the tubing passes through holes in the push rod guides, check to see that the tracker bar tubing fits through the holes; drill them out if necessary. Glue on the two end pneumatics, making sure they are aligned with the lines you scored into the decks earlier. Screw the guide strip onto the end pneumatics and recheck the alignment. Now glue on the other pneumatics, inserting a screw into each one through the guide strip to position it correctly.

If you are working on a grand stack, strip the pneumatic cloth seal off the bleed box and remove all the dirt and dust from the bleeds. Glue





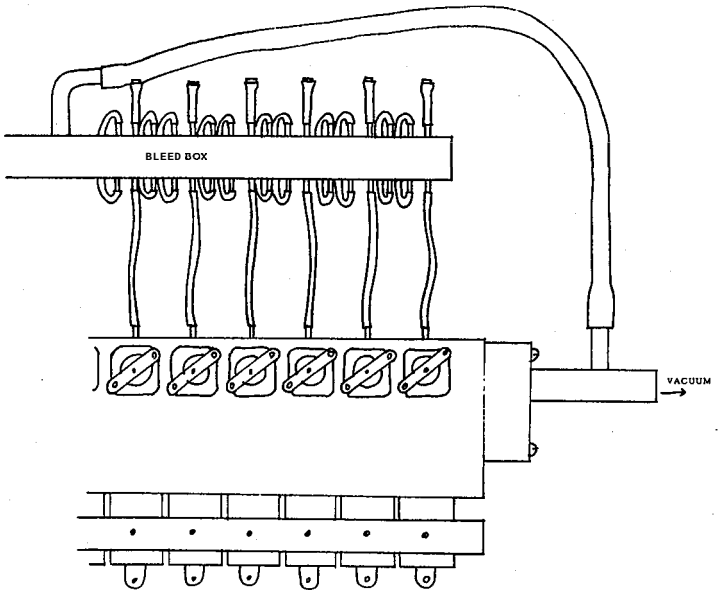


on a new seal, being sure that the divider between bass and treble is tightly sealed.

Once the Duo-Art stack is fully assembled, the valves cannot be removed without at least partial disassembly. For this reason it is important that the valves be checked for leakage and correct operation before the stack is put together.

Before the valves can be checked in the grand stack, a few temporary hookups must be made between the stack and the bleed box. The upright stack has the bleeds inside; if testing an upright stack, skip the following paragraph.

Before the grand valves can be checked, a bleed must be provided for each pouch for if the tracker bar nipples are blocked off without the insertion of a bleed, the pouches will very likely hold the valves open when vacuum is applied. One half of the valves in each deck can be checked at a time; therefore, bleeds need only be provided for 17 or 18 valves at any given time. Use short lengths of tubing to plug up all the nipples on the trackerbar side of the bleed box and all the nipples on the stack side except 17 or 18, depending upon the number of valves in the section to be tested. Connect the pouches of the section under test to the nipples left open on the bleed box and connect the large feed nipple on the box to your source of vacuum.



Seal up the openings in the front of the valve box with masking tape. On the upright stack, plug up each tracker bar nipple.

Apply vacuum to the section under test and adjust the vacuum level to 6". Listen to each valve closely for any seepage. Increase the vacuum to 25" and recheck. Reset the vacuum level to 10" and test the action of each valve by removing the tracker bar plug and intermittently opening and closing the tube with your finger. The pneumatic should snap shut quickly, and there should be no signs of leakage around the top valve plate or the pneumatic. After any audible leaks have been located and corrected, apply suction to the section by mouth. You should not be able to draw any noticeable flow of air from the section. In order for any reproducing piano to function properly, the stack must be as tight as it can be made so do not overlook even the smallest leak. Sometimes a valve will leak because the valve stem guide is misaligned and holds the valve at a slight angle. This is particularly true of the early valves with the brass guides that may have become bent. Test each of the remaining 5 sections of the valves and pneumatics in the same manner.

Once you are sure that no defects remain in the valves, remove the masking tape seals and install thin pneumatic cloth, using hot glue. I have seen several otherwise excellent rebuilding jobs on Duo-Art stacks fail because the rebuilder did not get this seal on correctly. Remember that the cloth must seal, not only around the edges of the deck, but also between the vacuum space above the pouches and the hole leading into each valve. When applying the seal, use a brush to dab the glue on; if you paint it on, drops of glue will form in the holes and may get into the valves. After the seals are installed, it is not a bad idea to check each section for tightness again.

If everything has checked out up to this point, the stack can be reassembled. Examine and replace any defective leather gaskets between decks or between the decks and the end boards. Install the bleed box on the grand stack and tube it up. Block off all the tracker bar nipples and check the bass and treble sides of the stack as described above. Even though there are three times as many valves under test now as there were before, the stack should still be extremely tight when you apply suction by mouth. If, after all your previous efforts, a valve leaks, try to determine the trouble before disassembling the stack. Sometimes a fleck of dirt gets under a valve during reassembly. This can usually be removed by lifting the valve stem with a tweezers while vacuum is applied to the stack. If everything fails and the offending valve is in the middle or bottom deck you may have to partially disassemble the stack to correct the problem.

Once the stack is completely reassembled, if trouble develops in a valve, you can gain access to it without disassembling the stack by cutting out an area of the seal cloth in front of the valve. After repairs to the valve are made, glue a pneumatic cloth patch over the hole in the seal.

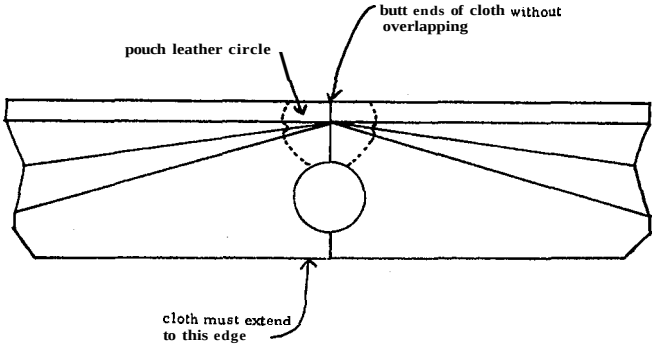
This point is a good time to regulate the upright stack to the piano. The adjustments are very difficult to manipulate on the upright stack after the spoolbox is installed and tubed. Remove everything, including the spoolbox from the heavy support board and screw this board onto the stack. This will allow you to install the stack in the piano and adjust it to the action. Leave a small amount of space between the tops of the pitmans and the underside of the piano wippens (about the thickness of a business card). Depress the piano key and lift the pitman up as far as it will go. Adjust the stop-off screw for a small amount of clearance.

,Number or mark all the components before disassembling the motor.

The hinges in the see-saw pneumatics are of thick leather and are usually in good condition. If these must be replaced, use a hacksaw blade to clean out the slits. The new leather should be quite stiff and unfinished on both sides. It is a good idea to paint a little rubber cement on these hinges to seal them, followed with a dusting of talcum powder.

Lap the valve slide surfaces of each pneumatic on sandpaper spread on top of a sheet of glass to get the valve surface perfectly flat. These are sometimes worn quite unevenly and require a good bit of sanding to get them flat.

When recovering the pneumatics, leave at least a 3/4" extra width of cloth hang over the front of the pneumatics so that the entire side will be covered with cloth. If bare wood shows along the sides of the pneumatics, the motor will not screw together flat.



Cover one pneumatic on each see-saw and set it aside to dry. After drying, hold the movable board exactly parallel to the front and slice the cloth with a razor blade straight across the hinge on each side (see diagram). Cover the other pneumatic and slice the cloth in the same way; try to slice it so that the two ends of cloth butt together closely without overlapping. Glue a 1 1/4" diameter circle of pouch leather over this joint on each pneumatic pushing the leather down into the fold. Test both sides of each pneumatic by closing off the valve port to a section while holding the pneumatic shut then trying to open the pneumatic.

Duo-Art motors have a tendency to clatter when they run, therefore, make sure that all the bushings are tight, especially the bushings located on the valve slide and at the point where the crank arms join the pneumatic.

It is usually best to replace the thick cloth on the fronts of the slide valves; use extra heavy bellows cloth for this. This cloth should overhang the sides of the slide by about 1/16th" so that the wood does not rub against the valve guides. Some motors use felt strips for this purpose. When replacing this cloth, sand the surface clean, apply a liberal amount of hot glue, and clamp the slide between two boards in a vise until the glue dries. This will insure that all voids formed by the coarse surface of the cloth are sealed. Lap the sliding surface of the valves on fine sandpaper. Graphite the valves and the valve surfaces on the pneumatics, using the method described in the section on rebuilding the expression box.

The crankshaft should be polished and dry graphite applied to the bushings in the connecting rods.

Make new rubber seals and spacers for between the pneumatics out of an automobile inner tube of the same approximate thickness; dip the two seals in shellac before screwing the pneumatics together.

When the three sections are screwed together, they should form a reasonably even and flat surface.

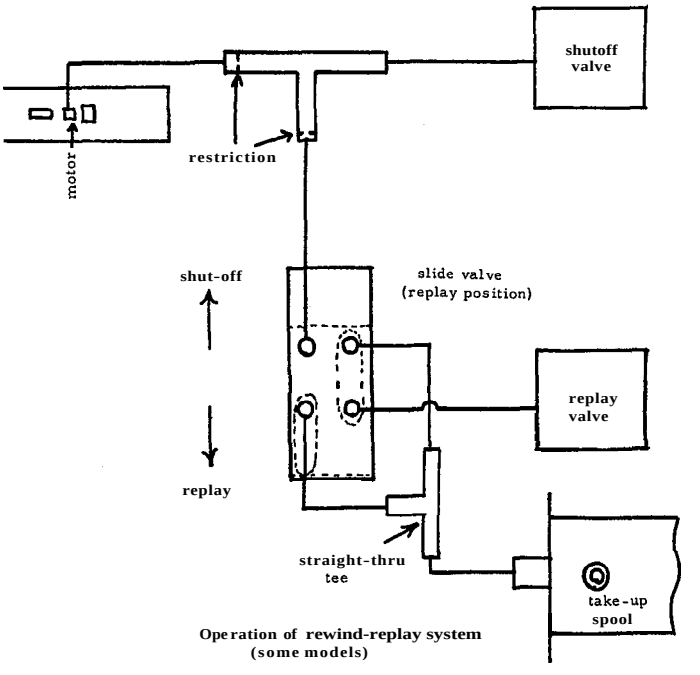
Time the motor by adjusting each slide valve until it travels an equal distance beyond the two ports it slides over. Tighten the two leather adjusting nuts firmly after this adjustment is made.

Block off the vacuum supply nipple and turn the motor backwards. It should turn very slowly without much variation in resistance as you rotate the crankshaft through 360".

Spoolbox.

Most of the rebuilding procedures for the Duo-Art spoolbox are fairly straightforward. If the piano still has the original tubing intact, you may want to make up a diagram of the spool box connections, particularly the tubing going to the manual switches in the spoolbox. There appear to have been a number of different tubing schemes for Duo-Art pianos, all accomplishing the same result in slightly different designs.

Look for a tee in the tubing leading from the Shutoff-Replay slide valve. This tee, if present in your piano, contains two strictures and has to be installed correctly. The following diagram shows the placement of this tee:



Operation of rewind-replay system (some models)

The function of this tee (in some cases the two strictures are placed in the Shutoff-Rewind valve itself) is to prevent actuation of the shutoff pneumatic valve until both the "motor" hole in the tracker bar and the hole in the take-up spool are opened simultaneously. Opening either one of these holes alone will not permit enough air to flow to the shutoff valve to operate it. The reason for this design is that when inserting a roll, you need only wind it down far enough to cover the tracker bar hole and yet the piano will not shutoff if the paper kicks away from the tracker bar during rewind.

When reassembling the transmission, I would advise that you install the small take-up spool brake spring upside down so that it cannot bear against the brake pad. This will eliminate the take up spool brake and help protect the rolls during rewind. The rolls will rewind loosely but this is a small price to pay for preventing damage to them.

Duo-Art actions contain one or two four-section cut-out blocks for changing over from Duo-Art operation to 88-note operation. There is another cut-out, usually present, for the tracker system. Disassemble these units and replace the pouches in them. It is impossible to clean the dirt out of these blocks without replacing the leather; consequently, replace it, no matter how good it looks. When installing new leather pouches, try to apply the pouch almost perfectly flat. An excessive amount of dish here may prevent the pouch from closing off.

The tracker pneumatic should be very carefully recovered; even the very tiniest pin-hole leak in one of the pneumatic's sections will prevent it from functioning. Install new leather pads on the tracker ears. There is a thin metal retainer over the pad on each ear. Remove the retainer and scrape off the old leather. Make new pads from pouch leather and install two of them, one on top of the other, with contact cement, leaving the smooth side of the top pad out. Apply the cement very sparingly. Reinstall the retainer and check to see that it does not interfere with the pad's seating on the end of the nipple. Press the pad firmly against the nipple and check it for airtightness and freedom of action.

The theme primary valves should be carefully cleaned. The top seat which is screwed in is of brass and usually develops some corrosion. Remove these and polish them. Replace and seal the pouches and adjust for very close to zero pouch-to-valve clearance. These valves must respond without any hesitation; too much pouch-to-valve clearance can greatly interfere with the functioning of the theme system. The valve travel is adjusted by screwing down the top seat; there should be about 1/64th of an inch travel. Press and turn the valve against upper and lower seats before making this adjustment.

The slides for the manual control valves on the spoolbox sometimes become warped; check them and lap them if necessary.

The upright spoolbox can be installed on the stack and all the trackerbar and control tubing installed at this point. It is easiest to start tubing from the center of the tracker bar and work outwards towards both ends. Leave enough slack in the tubing to prevent bunching up near the ends of the tracker bar.

Accessory Devices

The accessories are all the miscellaneous valves, pneumatics, and other small units in the piano.

The modulator in the grand action contains two large pouches and valves, one for cutting off the stack vacuum during rewind and the other for bypassing the regulator pneumatic. These pouches usually suffer the same fate as the theme pouches in the expression box, but they are quite easy to get at. The modulator is a favorite lodging place for oxide flakes from the deteriorating lead elbows in the system; therefore, it should always be opened and cleaned out. The slide valve on the modulator opens during rewind to unload the pump. There should be a wad of cotton in the hole underneath the slider to help muffle the air noise when it opens.

The rewind-to-play pneumatic is a bit tricky to recover. Recover this with one piece of cloth by gluing the cloth over the open ends of the three boards and then slitting each side up to the center board so that the two resulting flaps can overlap each other along the sides of the center board.

The pedal regulator in uprights has inaccessible pouches in it; the unit has to be broken apart to reach them. Fortunately, most pedal regulators were assembled with leather in the joints to be opened; consequently, they are not difficult to rebuild.

When recovering the governor, check the bushings around the sliding control rods for tightness. To replace these push out the old felt and ream the hole clean with a drill bit that just fits the hole. Cut a strip of felt cloth about 1" wide and trim a point on one end. Draw the pointed end through the hole, causing the cloth to curl up as it enters. Dab a little glue on the end of the cloth and pull it into the hole.

Use the same techniques for rebuilding the dynamic valve box and the other small valve boxes as described in the section on rebuilding the stack.

Pumps

Duo-Art pianos use one of two types of vacuum pumps. Most grands and a few uprights use a four bellows rotary box pump. Most uprights and a very few grands use a large six bellows cam-driven pump sometimes called a "steamboat pump."

Box pump.

The box pump is fairly easy to restore.

In many cases the cloth covering the bellows will look all right. If there are any signs of wear at the corners of the cloth, do not take any chances; replace it. Sometimes flakes of oxide from the lead elbows in the system have found their way into the pump and have helped wear the cloth at the folds or lodged under the flap valves. If you think the pump might be all right, make a few tests on it first. Block off all the

inlets except one and draw on this inlet by mouth. If you can suck air through, the chances are good that the internal flap valves are leaking. Next block off all the inlets and try to turn the flywheel by hand. It should be very hard to turn and should just creep around. If at all in doubt, rebuild!

The flywheel is threaded onto the end of the crankshaft and can be removed by screwing it in the opposite direction that it normally turns, as indicated by the arrow on the front of the pump. Try removing the flywheel by blocking off all the inlets and turning it in the right direction. The flywheel is usually on so tight that the following procedure must be used to remove it. Remove the back of the pump and mark each bellows and connecting rod bracket so that you can match them up when you reassemble. Unscrew the four connecting rod brackets from the bellows. Unscrew the hex nut in the center of the connecting rod spider (this is usually a left-handed thread). Pull off the spider and connecting rod assembly. Now you can hold the crank throw with a wrench or vise while you screw the flywheel off.

Disassemble the four bellows and observe how the cloth was put on. It is usually glued down over the front of the bellows and the top of the stationary board with a strip of wood nailed over the flap at this point. Remove the old cloth and check the hinges of each bellows for looseness. It is a good idea to replace these with heavy canvas or organ pedal webbing. Cut a strip of canvas the correct width and length, fold it in the center, and clamp it tightly in a vise to give it a sharp permanent crease. Use a liberal amount of hot glue to glue the hinge in place, insert a piece of waxed paper in the fold of the hinge to keep it from gluing shut, and clamp the hinge tightly until the glue dries.

Check the internal flap valves carefully and replace if necessary. You cannot get at them after the bellows is recovered.

Cut new leather for the bellows about 1" wider than necessary and leave the extra hang over the stationary board so that the sides will be completely covered. Apply the leather with hot glue and iron it into place. (See the General Rebuilding Procedures section.)

Clean all the bearings and check them for wear. Looseness in the connecting rod bearings can be taken up by adjusting the large hex nuts on each bearing. Be careful if you disassemble the connecting rod bearings as there is no retainer for the balls and they may fall out. To reinstall them smear some grease into the ball race. This will hold the balls in place until you get them all in. The bearings in the front casting and spider are usually standard types and new replacements can be found for them. Temporarily install the crank and flywheel in the front casting and give the flywheel a spin. If the bearings make a rumbling noise, try to replace them.

After the four bellows are recovered and the external flap valves checked and replaced if necessary, reassemble the four bellows sections and make the following tests. Check the internal flap valves and gaskets by blocking off all inlets except one and sucking on that inlet. Check the external flaps and the bellows covering by blocking off all the inlets and trying to open each bellows. If everything checks out, the pump can be reassembled. Before screwing the connecting rod brackets onto the bellows, paint some shellac on the mating surfaces to hold them tight.

Steamboat pump.

The six bellows pump is very difficult to rebuild.

Each of the six bellows is glued onto the frame of the pump without any screws. There is, however, a leather gasket in each joint that will aid in removal.

If the bellows are not glued on exactly as they were originally, the rollers and cams will not line up properly. After the external hardware has been removed, slit open each bellows and drill several holes for new mounting screws through the stationary boards of the bellows and into the frame. Install enough screws so that during reassembly, the board can be glued and screwed tightly to the frame.

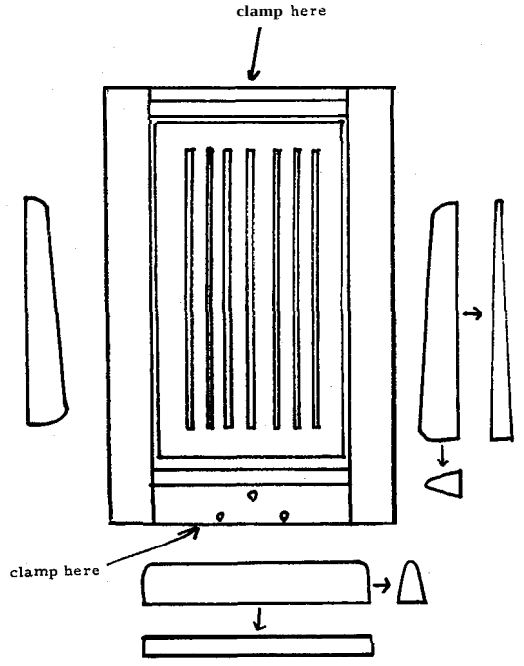
Drive a putty knife into the gasketed joints to remove the stationary boards from the frame. With the original hinges intact, hold each bellows in its fully open position and mark the locations of access holes on the inside of the movable boards through the holes you drilled for screws previously. Drill these holes with a 1/2 inch drill. You will install the screws you have provided for reassembly through these holes.

Replace the bellows hinges if necessary; it is important that these hinges be stiff enough to keep the rollers aligned on the pumping cams. Recover the bellows with leather as described in the General Rebuilding section. Be sure to reinstall the cardboard stiffeners in the sides of each bellows as these greatly boost the efficiency of the bellows and prevent the sides from popping out when they collapse.

Examine the flap valve seats on the frame of the pump. Each bellows has several external flaps and several internal ones; a leak in any of the internal flaps is serious and unrepairable without disassembly. Test the internal flaps by sucking on the inlet of the pump by mouth. If there is considerable general leakage that cannot be pinpointed, remove all the flaps (keep them in order) and cover the flap valve openings with masking tape. Check for leakage again. Sometimes the leak will be around the edge of the boards that the flaps are mounted on. This can be remedied by running a bead of white glue around the edges of the board and sucking on the inlet to pull the glue into the holes. After all leaks are repaired, replace the flaps one at a time and recheck for leakage for each flap.

After having made sure that the internal flaps are all right, replace the bellows on the frame. Glue a suede leather gasket between each bellows and the frame to facilitate removal in the future (use thinned out hot glue for this). Position each bellows on the frame and install the new mounting

screws through the holes you provided in the movable boards (hold the bellows in its open position while you do this). Make sure that the glue oozes out all around each bellows. Glue pneumatic cloth patches over the access holes in the movable boards.



woad blocks for transferring clamping pressure to sides of bellows board.

By clamping the bellows at the top and bottom with large C clamps, the blocks along the sides will exert pressure on the glue joint along the sides. Glue a suede leather gasket between each bellows and the frame to facilitate removal in the future. Insert aligning pins into the holes you drilled before disassembly, being certain that there cannot be any leakage around these pins, and clamp each bellows tightly. Make sure that the glue oozes out all around each bellows.

Check the external flap valves after reassembly by blocking off the inlets and trying to open each bellows.

Some of these pumps used cast iron pulleys while others used pulleys made of pot metal. If the pot metal ones are bad and you cannot find original replacements, you can sometimes take the old pulleys to an aluminum foundry where they can be used to cast new ones. A machine shop can machine the shaft holes and vee grooves.

If the pump rumbles when it runs, particularly under load, the leather on the cam rollers may be hard or unevenly worn. Replace the leather with soft suede and if the rumbling persists, check the bushings in each roller for uneven wear.

Electric motor.

The motor should be disassembled and cleaned. Pay particular attention to the centrifugal switch which must be absolutely clean and smooth. In both grands and uprights, the motor can be attached to the pump and the entire system operated on your bench. If new belts are needed, use 3/8" or type 'A' vee belts. Run the pump while varying the size of the inlet and listen for any knocking that may be caused by loose connecting rods, worn rollers, or loose bearings. Do not block off the inlet all the way while the pump is running as this is hard on it.

FINAL ASSEMBLY

Before proceeding with the final installation of components in the piano, all necessary repairs and adjustments should be made to the piano itself. For both the grand and upright versions of the Duo-Art, it is very difficult to get at the piano action for adjustments after the system is assembled; be sure that everything is perfect before assembling the pneumatic system.

All the components of the system should have been checked out on your work bench before installing them in the piano. As pointed out earlier, difficulties in several components at one time are very hard to track down.

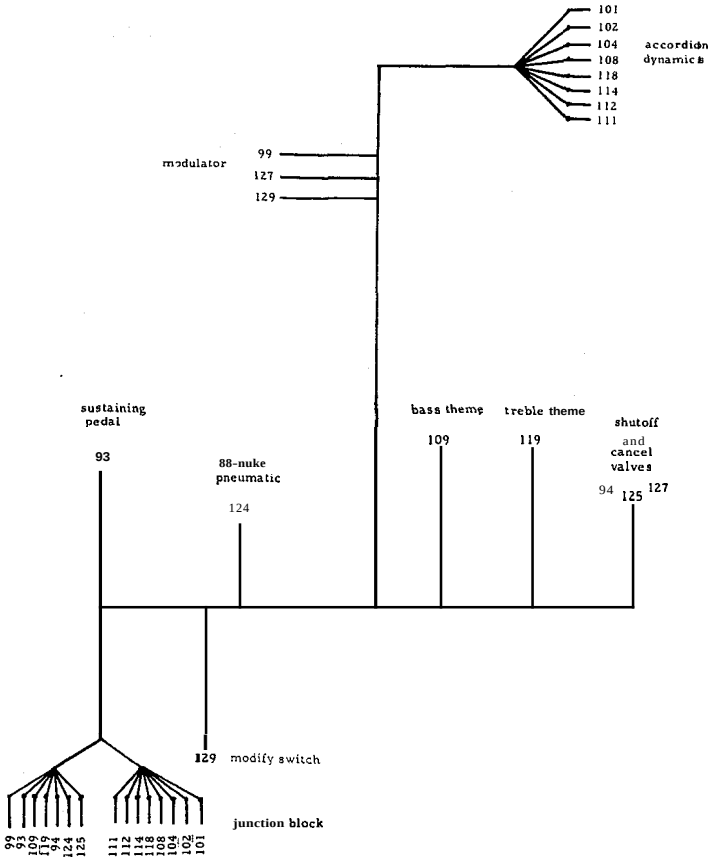
One more thing to check out in the grand system is the junction blocks that screw to the underside of the piano keyframe. These usually have to have new gaskets; when the old gaskets are removed, they should be sanded flat. On early pianos, where the junctions are held on by wood screws rather than machine screws, check to make sure that none of the screws are stripped out. If there are many stripped screws, the best repair is to drill out the holes in the keyframe and cut recesses into the top of the wood over each hole. Set machine screw nuts (size 10-32 is ideal) into these recesses and flow white glue around them to hold them in place. You might want to bolt the junction blocks onto the keyframe temporarily and test each nipple for tightness.

Most of the control and expression tubing in a Duo-Art grand was made up into a pre-assembled tubing harness held together with friction tape. If you were able to remove the original harness intact, you can make up a new one using the original as a pattern. The general shape of the harness is shown in the following diagram although there are a lot of variations.

Bind up the new tubing harness at the points where tubes leave the harness and at corners with good plastic electrical tape or friction tape if you can find any. Because it is rather difficult to make up a harness if you do not have the original to go by, considerable thought must be given to it before making it up.

Use the original hoses to cut new ones of the correct length.

Install the harness in grands as well as the hose leading from the air motor to the governor before installing other mechanisms. In uprights all the components can be installed prior to any tubing installation.



Installing and regulating the grand stack.

Install the stack first and regulate it before installing the rest of the components as you will have more room to work at this time. Regulating the grand stack is largely a matter of feel. It is a big help to have an assistant at the keyboard while you adjust the leather nuts on the stack from beneath. Test each push rod against the bottom of the piano key and adjust the two leather nuts on the pneumatic finger until there is a very slight amount of lost motion. Do not make these two nuts too tight against the finger or there may be binding on the rod. There should be just enough freedom at this point to allow the rod to be turned easily. Have your assistant depress each piano key firmly and adjust the stop-off nut at the top of the rod until the end of the rod just barely touches the key. Operate the pneumatic by hand to insure that the note plays correctly.

Install all the working components of the system except the pump; leave this until last as it sometimes gets in the way of tubing and hose connections.

In uprights, the main feed hose to the expression box is sometimes very close to the piano plate. Fit this hose onto the elbow of the expression box before installing the box.

Tubing between the spoolbox and keyboard nipples in grands must be installed with enough slack to make room for the air motor. If the spool box is mounted on the piano case, install a few pieces of tubing from center and end nipples to ascertain the correct length; then remove the spool box and lay it on the keyboard for easier accessability. There is usually a metal bracket to the right of the spool box to hold the tubing out of the way of the air motor. Make sure you leave enough slack for the keyboard shift.

FINAL REGULATING AND ADJUSTMENT

Preliminary Checks

Begin the final checkout by moving all mechanical links by hand to insure that they move freely without binding.

Set the Dynamic Lever in front of the keyboard to the "normal" position and the Duo-Art On-Off switch to the "On" position. Remove the drive chain from the air motor and place blank paper over the tracker bar. Turn on the pump and check over the entire system for audible leaks. The spill valve will make noise as air flows through it; collapse the accompaniment accordion pneumatic by hand to close the spill and increase vacuum in the stock.

Examine the accordions and piano stack for any collapsed pneumatics.

Automatic Tracking Device

Adjustment of the automatic tracker is described in detail on page **34** of the 1927 Duo-Art Service Manual.

Loosen the set screws on the two tracker ears and push them away from the edges of the paper. Put on a new music roll or one known to be perfect and replace the drive chain on the air motor. Run the motor very slowly and hold the tracker pneumatic in the exact center. Adjust the take-up spool if the paper rubs either flange. While holding the pneumatic in the center, adjust the turnbuckle on the tracker linkage until the roll is perfectly aligned with the holes in the tracker bar. Stop the motor and move the tracker pneumatic through its entire travel while noting that the tracker cam does not move so far as to let the end of the spool carrier shaft slip off of its surface. If this occurs, the cam mounting arm will have to be bent slightly (sometimes there is a screw adjustment for this purpose) and the turnbuckle re-adjusted. Re-adjust the take-up spool until the paper is centered between the flanges. Adjust the two tracker ears until they are very close to but not quite touching the edges of the paper. Run a few rolls through and readjust if necessary.

On Duo-Arts with a tracker system that moves the tracker bar itself instead of the feed spool, adjust the feed and take-up spools until the paper is centered between the flanges of the take-up spool. Hold the tracker pneumatic in its center position and adjust the tracker bar for perfect alignment to the holes in the roll. Always adjust the tracker bar with the paper moving slowly.

Adjust the feed spool brake until there is just enough tension on the paper to prevent it from "fluttering" as it moves. While the roll is moving, touch it lightly near the tracker bar at the right and left edges to determine if there is equal tension across the paper. If the paper is loose along one edge, there is some misalignment between the

feed and the take-up spools. On some models this can be corrected by an adjustable bearing on the right axle of the take-up spool. On other models, where neither the feed or take-up spools can be adjusted, remove the mounting screws for the tracker-bar and put some shims behind the end of the bar at the side where the paper is loose.

Note how much clearance there is between the edges of the paper and the flanges of the take-up spool. On some early Duo-Arts there is an inordinantly large amount of clearance sometimes as much as 3/8". Put a long roll on the piano and run it through. Sometimes, as the paper of a long roll winds onto the take-up, the underlayers of paper on the take-up will telescope out against the flanges. If there is a lot of clearance at these flanges, even though the roll may track absolutely perfectly while playing, this telescoping effect will cause the paper to weave crazily during rewind and may cause damage to the roll. The solution to this problem if it exists is to remove the flanges from the take-up spool, place it in a metal-turning lathe and remove an equal amount of wood from each end of the spool. This is a very serious modification and should be done carefully. The over-all distance between flanges of the take-up spool should be 11-3/8" which will give a clearance of 1/16" at each edge of a standard width roll. Do Not reduce the width of the take-up spool to 11-1/4", as there must be enough clearance to allow for paper swelling during damp weather. I want to point out that this is not a problem on the majority of Duo-Art pianos, but I have seen several where the problem does exist and this is a sure cure.

As mentioned earlier, if the take-up spool brake is removed so that there is very little drag on the take-up spool during rewind, there will be much less chance of damage to the rolls when they rewind.

Tempo Adjustment.

Center the tempo pointer on the scale by moving the tempo lever from extreme left to right and adjusting the pointer itself until it moves an equal distance off either end of the scale. Measure off seven feet on the music roll. (If you use a test roll, check this distance as marked, it is sometimes wrong!) Set the tempo indicator to the extreme left position and adjust the leather nuts on the tempo valve rod on the governor until the motor just barely stops; then set the tempo indicator to 70 and adjust the spring tension on the governor so seven feet of paper pass over the tracker bar in one minute.

Run the test roll through the dynamics test section and visually ascertain that all the accordion sections operate properly and in the right order. It is very easy to have a tubing error here.

Switch the Duo-Art On-Off switch to "Off" momentarily and ascertain that the 88-note pneumatic collapses and boosts the accompaniment level.

Hold the manual accompaniment control in the loud position and run the test roll slowly through the note test and repetition section to insure that all the notes play properly.

Modulator or pedal regulator adjustment.

Connect a vacuum gauge to the outlet of one of the dynamic valves and pull off the tracker bar tube to that valve so that you measure the vacuum level in the dynamic valve box. Hold the accompaniment accordion closed to close the spill valve and adjust the spring on the regulator for a reading of around 25".

Expression box adjustment.

Before proceeding with the expression box adjustment, measure the vacuum level at some point near the pump with the accordions fully open. This should be about 30" and is determined by the restriction of air flow through the spill valve. (See spill valve adjustment in "Rebuilding the Expression Box" section.) If this level is much lower than specified, tighter muffler felt should be installed to bring this level up. Sluggish operation of the pedal and accordions during soft passages is the result of too much spill at these levels.

Regulation of the expression box in the piano is basically the same as the procedure outlined in the section on bench checking the expression box. Make sure there is a little tension on the two regulator springs. Place blank paper over the tracker bar and turn on the pump. Loosen the set screws on both expression control arms and rotate the accompaniment expression adjusting screw until the regulator begins to close. Back off on the adjustment until the regulator opens fully, then carefully turn forward again until the regulator closes up about 1/16". Repeat this procedure for the theme side of the box. Tighten the set screws. Connect a vacuum gauge to the treble side of the stack and adjust the tension of the accompaniment regulator spring for reading of 5" of vacuum. Open the treble theme hole at the tracker bar and adjust the theme regulator spring for a reading of around 6".

Run through the entire expression adjustment section of the Duo-Art test roll. The proper accompaniment zero level setting is reached when the arpeggio notes play very softly with the dampers lifted and skip when the dampers are resting on the strings because of the extra effort required to lift each individual damper. Re-adjust the zero level if necessary by changing the accompaniment regulator spring tension. By adjusting the zero level setting with the spring tension rather than the expression adjusting screw, you can be certain that there will be no loss of expression control at either the low or high end of the expression range.

It is rather difficult to achieve perfect results in this test because of a number of factors, the variation in force required to strike different notes on the piano being the main one. There is no definite minimum vacuum level for-all Duo-Arts because the striking force varies considerably from

one piano to another. Early Duo-Arts with very large stack pneumatics usually require a zero vacuum level around four inches while later models require five or six inches. If the pneumatic system is functioning correctly, the minimum vacuum level is directly determined by the stiffness of the piano action itself.

After the minimum level has been set using the test roll, play through several Duo-Art rolls and note whether the zero setting needs readjusting. Pay particular attention to passages on rolls where the zero of No. 1 intensity level is in effect. Corrections in the zero setting are almost always necessary, and as this is the most critical adjustment in the system, take special pains to get it right.

The service manual states that the zero setting for the theme is to be made "one degree louder" than the accompaniment. I have usually interpreted this to mean one inch in vacuum higher. After the accompaniment zero setting has been established for sure, measure the vacuum level and adjust the theme tension spring for one inch higher vacuum.

As a final check on the setting of the expression adjusting screws, note that both regulators collapse very slightly when the pump is turned on. Put on the test roll and check to ascertain if there is a slight increase in vacuum between the zero and No. 1 levels for both theme and accompaniment. (You can do this by stopping the No. 1 intensity section of the test roll over the tracker bar and opening and closing the No.1 duct with your finger). Adding the No. 1 intensity level to any intensity level between zero and I5 should produce a slight increase in vacuum.

Observe that the crash valve comes on at theme level 16 for grands equipped with this valve.

After the expression box has been adjusted, run the note test section through again at minimum intensity. **Run** the roll slowly and hold the damper pedal down. If there are one or two notes that persist in not playing, check the leather nuts on the push rod to make sure they are not too tight which would cause the rod to bind. If everything seems to work freely, the power of the associated pneumatic can sometimes be increased by removing some of the bumper felt underneath the pneumatic and readjusting the pneumatic to open slightly wider. **If** more than two or three notes are are at fault, it is better to increase the zero setting slightly.

As a last test, check all the manual expression controls to see that they work properly and that they do not interfere with the expression system when returned to their normal positions.

As was pointed out earlier in the text, the action of the theme primary valves must be extremely fast in order to obtain correct expression. It is a good idea to recheck these valves after the piano has been played for a few hours. The amount of travel for the theme valves should be around 1/64th of an inch; this sometimes increases as the leather valve faces become packed down (especially if new leather was installed). Observe the operation of the theme valves with the cover removed; they should operate with no apparent sluggishness.

Below is a list of various vacuum readings for the Duo-Art system. The readings for the dynamic levels are typical for Duo-Arts in general and are not absolute levels that you should try and duplicate precisely.

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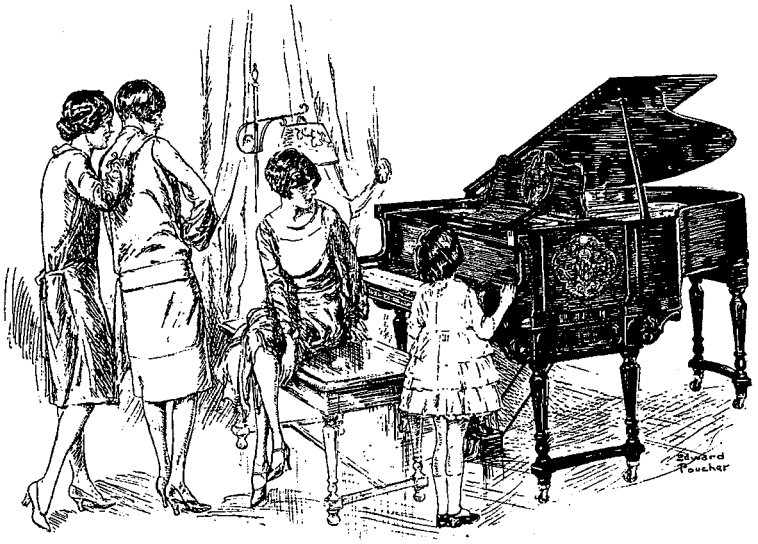
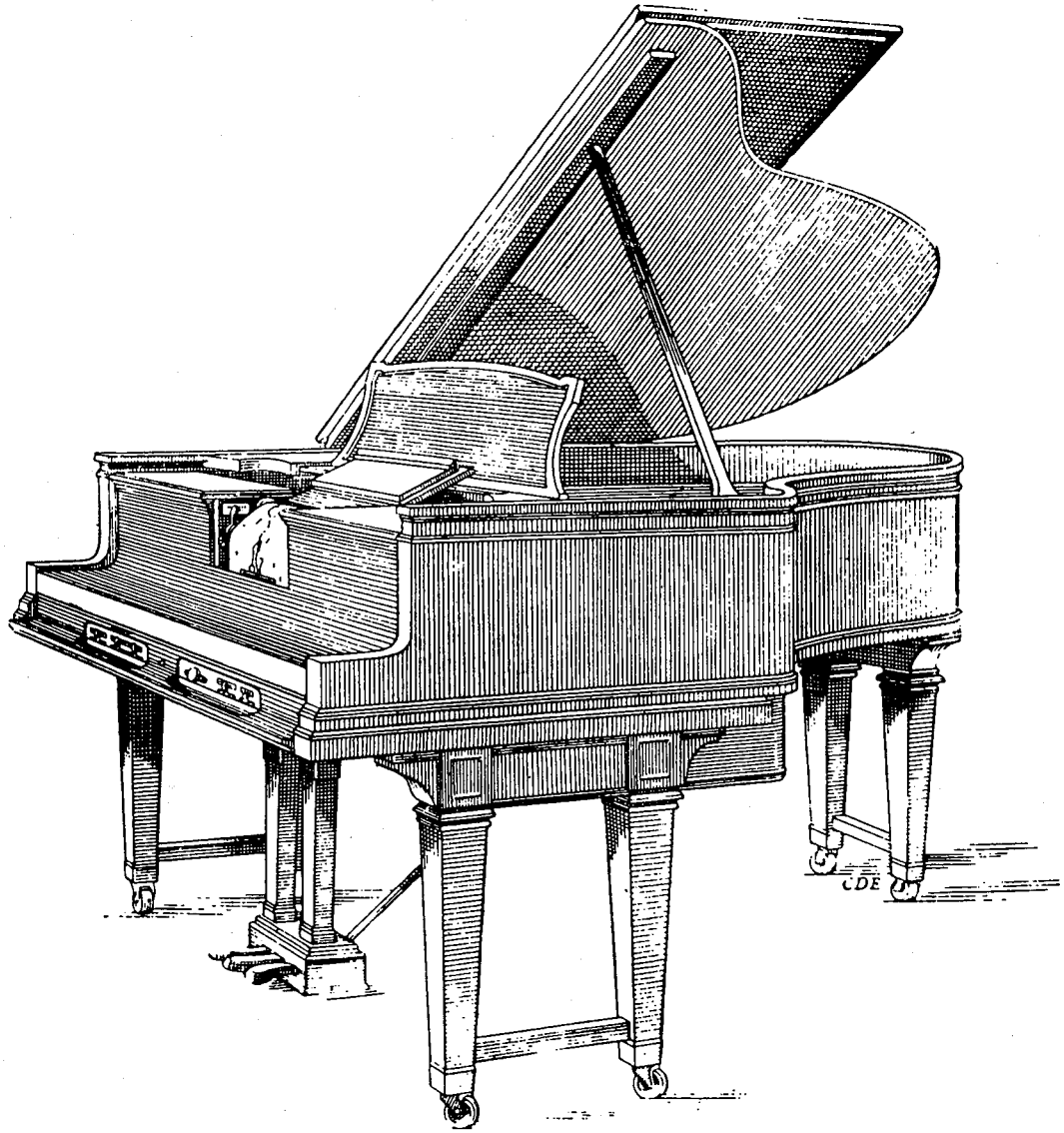
Measurement	Vacuum Level	Taken at
Duo-Art "off' setting (88-note mode) . .	+12	Stack
Pump vacuum (spill fully open)	30-35	Pump Outlet
Pump vacuum (spill fully closed).	45-50+	Pump Outlet
Modulator or pedal regulator	25	Regulator Outlet

Accompaniment levels	Theme levels	Taken at
0. 5	0. 6	Stack
1. . . . . 6.5	1. 7	
2. 8	2. 8	
4. 10	4. 12	
8. 18	8. 20	
12. 30	12. 30	
15. 34	15. 34	
16. 38	*16. 40	

"This should equal full pump vacuum in instruments with crash valve.





The STEINWAY DUO-ART