AIO Service Manual

Electro-pneumatic Action and the Slider Chest

by Lyle Blackinton

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Many elements play a part in determining the character of our instruments. Of primary importance are the scaling and voicing techniques used, the wind pressure, the acoustical environment and the organ's placement. Following close behind is the importance of the type of key action, chest action and wind system we use. All of these elements, and perhaps others, collectively determine the personality of our instruments.

We should not underestimate how the type of chest action and the way it is executed will affect the sound of our instruments. The pros and cons of various chest types (note channel chest vs. individual valve chest) have been well documented, and I do not attempt to win converts for one or the other. However, I will say that the slider chest provides the kind of speech characteristics that I am looking for in my instruments. I build both mechanical and electro-pneumatic instruments, finding that in many instances the building configuration and other factors dictate the placement of the organ and therefore the type of action used.

In the past, organbuilders using slider chests have developed several types of key actions to operate the chest pallets:

- Mechanical key action
- Mechanical key action with pneumatic assist ("Barker Lever")
- Electric key action with electro-pneumatic pull-downs
- Electric key action with magnet pull-downs

And the action I describe here that I would like to call simply an *electro-pneumatic slider chest*, where the action is integrated into the chest pallet box.

Even within the slider chest family, each of these actions imparts its own speech characteristics to the organ. Nothing is finer than a carefully constructed mechanical key action where the response is articulate and precise. The same could be said for the Barker Lever assisted mechanical action. Electro-pneumatic pulldown actions are often associated with conversions of mechanical instruments to electric action. They tend to be bulky, noisy and often have poor repetition characteristics due to the mass involved in the action. In the recent past, we have seen the successful use of magnet pulldowns within slider chests. However, if not carefully executed, these magnets can be noisy and also impose unique pipe speech characteristics depending on the type of spark suppression used and how it affects the building and collapsing of the magnetic field. They also consume large amounts of current.

In cases where a remote action is required, we feel that the electro-pneumatic slider chest offers some distinct advantages. With this system the size and mass of the action is decreased. It is more compact, has excellent repetition, is relatively quiet and uses low-current magnets. In addition, we like the speech characteristics.

I do not claim this to be a totally new or unique concept. Let us face it; there is not a whole lot that has not been done before with pipe organ mechanisms. A different pneumatic slider chest action was recently described by Thomas Wood in the September 1991 issue of *The Diapason*.

Windchest Construction

Our windchest grid construction is the same as would be found in many contemporary slider chests. We use voidless birch or basswood plywood in the construction of the grid. A vacuum press is used for gluing the skins on the cellblock with a general-purpose polyvinyl glue.

For the frame and other general construction we use poplar. We laminate, or “butcher block”, virtually all of our lumber over six inches in width. What we lose in time we feel we gain in stability, quality and material. We virtually eliminate waste from ripping. For general construction we normally glue up stock using 50mm to 100mm pieces.

Since we do not use slider seals, it is important that our toeboards have maximum stability and be free from warping, cupping or twisting. The finished thickness of our toeboards is 35mm. We take 25mm stock, rip it into 40mm strips, turn them on edge and glue them up in a butcher block slab the size of the chest table. Since most lumber is “plain-sawn,” the annual growth rings in the majority of any load are going to be closer to parallel to the board surface than at right angles as in quarter-sawn stock. By ripping the lumber and turning it at right angles, we come close to having quarter-sawn stock. With humidity changes, the toeboards now tend to expand and contract in width and there is a minimum of warping and twisting. We normally let the laminated slab sit around the shop for a month or so to allow the moisture from the glue lines to dissipate in the lumber. This allows a state of equilibrium to be reached.

The grid, slider sheets, toeboard slab and rackboards are sandwiched together and doweled, and pipe holes and rack pillars are then center-spotted. The sandwich is disassembled and finish holes are bored in their respective parts. The toeboard slab is then ripped to the specified widths and planed to a finish thickness of 35mm.

The table and toeboards are cross-hatched. After machining, the toeboards are sealed with sanding sealer and lacquer and then dipped in shellac to seal the internal pipehole walls (shellac is still one of the best moisture barriers.) Surfaces next to the sliders are coated with powdered graphite suspended in lacquer sanding sealer. The sliders and bearers are of phenolic. The bearers are shimmed with brass stock .007" thick.

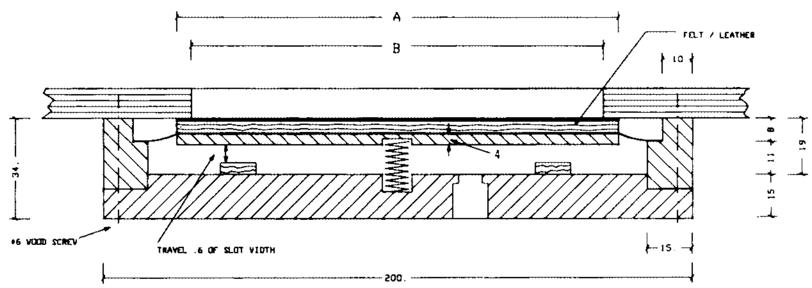
We have had excellent success with this process and have had very few problems with sliders sticking. It is also important to keep sliders as narrow as possible. Double sliders should be used for wider stops.

Key Action

Pallet slots are routed into one end of the note channel in the same manner that many builders use. Bleed holes should be provided in the end of the note channel opposite from the pallets to minimize channel concussion. Because the pallets or valves are not hinged, the total perimeter of the pallet slot is exposed when the pallet opens. This means that the slots only need to be one-half the size of a conventional hinged pallet. Right here we are able to cut down on the mass of the action.

The pallet pneumatic is a rectangular pouch shaped much like the primary on an Austin manual motor and is sized to cover the pallet slot. We use three different sizes for our standard 61-note chest. The success of this action is dependent upon pallet mass being kept to a minimum and pallet travel being carefully regulated. Of course, it is also vital to use a great deal of care in producing the action.

The major components of the pallet pneumatic are the “base” and the “pallet”(fig. 1.) The base is of poplar and is of glued-up construction. Stock for the ends (stand-offs) are glued to the body stock to form blanks from which the finished bases can be ripped. The shoulders are milled into the ends. Holes are drilled for the mounting screws (#6 x 1-1/4”), the spring cavity and the tubing. The tubing holes are counter-drilled to provide a shoulder to limit the insertion of the tubing. Jigs are used when boring holes to ensure accuracy and to allow interchangeability of parts.



	BASE W x L	PALLET PLATE W x L	'A' PALLET VALVE W x L	'B' PALLET SLOT W x L	NO. NEEDED
I	35 x 200	35 x 150	28 x 150	20 x 140	18
II	22 x 200	22 x 150	22 x 130	15 x 120	12
III	18 x 200	18 x 150	18 x 130	10 x 120	33

Fig 1: *Pallet action assembly (dimensions given in millimeters).*

The pallets are of layered construction, much like a fiber, felt and leather valve used for a standard pouch. The difference is that wood 4mm thick is used for the foundation instead of fiber. We prefer aged sugar pine because of its lightness and stability. I am sure any well-aged wood would be suitable, however. In my work I make it a practice to salvage lumber from old organs (walkboards, wood pipes, etc.) to use for the manufacture of small parts for new organs; if it is fifty years old, you know it is cured!

Chrome-tanned leather .012” to .015” thick is used for the pouches. I specify leather thickness in thousandths of an inch because leather suppliers are not uniform in their thickness specifications.

The components of the pallet assembly are glued together with all parts centered on one another. This is an important consideration! The pouch leather is glued only to the face of the wood foundation and not down around the chamfered edges.

It is of utmost importance that a great deal of care be given to the assembly and gluing of the pallets to their bases. Here again, we have made up a jig to ensure accuracy and consistency. The pallet pouch leather is first glued to the two ends of the base. The length of the leather was initially accurately cut to the proper length so that the leather will be just taught when the pallet is at rest when mounted in the chest. This helps the pallet to come up square over the pallet opening.

The spring is now inserted in the assembly. We use standard pouch springs for the two larger sizes and a custom spring for the smaller size. The felt bumpers are accurately sized to limit the travel of the pallet. The travel should be no more than 60% of the width of the channel slot (a 10mm slot will have a pallet fall of no more than 6mm.) Anything beyond this is wasted motion and slows the repetition characteristics of the action. This consideration is often overlooked in the sizing and construction of standard valve pouches. You will find that your chests are much more responsive if you strive for optimum valve sizing and travel.

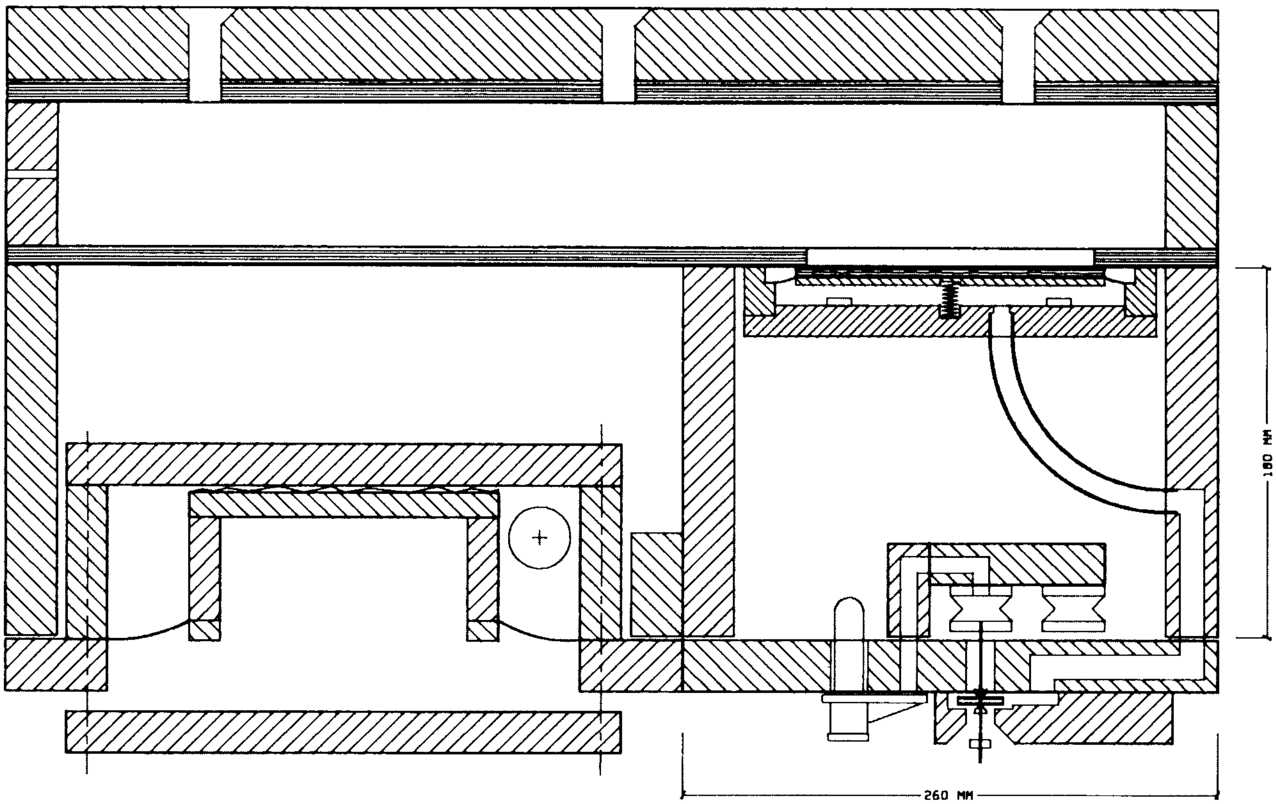
The pallet assembly is now placed in a jig used to glue up the side flaps of leather. It is made so that the pallet has 1mm of bag in the closed position. We use a vacuum to hold the pallet in position during this part of the operation. The sides are carefully brought up so that they are just barely taught. This aids in the alignment of the pallets during operation so they do not come up cocked. Here again, I believe such a procedure could be applied to standard pouches. Power and efficiency is lost when they have too much bag, etc.

We use hot hide glue for gluing the pneumatic leather. Care must be taken to apply just the right amount of glue. Around our shop we speak of the "Goldilocks Principle" — not too hot, not too cold, not too much glue, not too little. . . but just right. I have observed that premature leather failure is often caused by poor gluing practice and by neglecting to chamfer sharp edges.

Primary Action

We use a standard single-stage primary to exhaust the pallet pneumatics. It is normally 260mm wide and mounted directly under the pallet actions (*Fig. 2*.) The control wind is channeled from the primary into the chest wall and then conveyed through tubing up into the individual pallet actions. 1/2" I.D. tubing is used for notes 1 through 28, and 3/8" I.D. is used for the balance. A 3/4" bore is used for primary valves 1 through 28, and a 5/8" bore is used for the balance. The primary valve travel is 2mm.

Again, careful sizing and regulation of any primary will improve its performance. It is better to have the primary valve travel 2mm instead of 3mm assuming the bore is of adequate size. Primary pneumatics should be sized no larger than necessary so that the magnet has a minimum of air to dump. We use 30 x 30mm pneumatics. Sealing the primary action channels is also important.



ELECTRO-PNEUMATIC SLIDER CHEST
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Fig. 2

Stop Action

We also use a pneumatic stop action to pull the sliders. We have used solenoids and rotary motors in times past, but have settled on the pneumatic motors. With a few minor exceptions, our stop action is like that used by other builders. We use a double-sided rectangular accordion pneumatic instead of a diaphragm. I believe that you can achieve more power in a given space using a conventional folding pneumatic. We use two sizes of pneumatics, 60mm and 80mm in width.

There are two bases on either side of the power plate (fig. 3.) Sliders are pneumatically pulled on and off without a spring return. The slider travel is fixed and limited by the construction of the motor itself. Manual chests have 20mm travel and pedal chests have 30mm. The greater area of the two bases are felted to provide a large surface to absorb the energy and limit the travel. Care must be given in selecting the correct felt thickness to achieve correct travel. With this design, I believe we are able to achieve much quieter operation. Many stop actions have some form of adjustment for the travel — usually a felted set collar on the connecting rod or

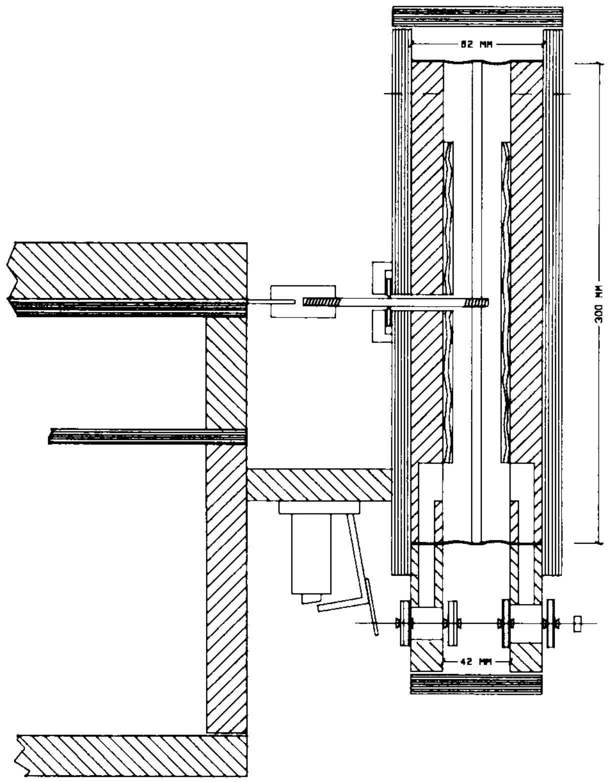

Fig. 3: *Electro-pneumatic stop action that operates chest sliders*

some variation of this. This causes a dissipation of energy in the small area of the adjusting collar that emits a thump during operation. I am always amazed that what seems to be a very small action noise right at the source can sound so loud in the auditorium!

We use a large pulldown magnet to control a double-acting valve that exhausts the pneumatics. We size the bore slightly smaller for the “off” set of valves to assist the magnet spring in returning the valve assembly to the off position. Even so, in order to overcme the surface tension of the valves, a spring stronger than that normally supplied with the magnets must be used. We actually use the springs supplied and cut two-thirds off to gain the increased tension. Valves are mounted on an aluminum rod using standard set collars. They are adjusted for 2mm of travel. It is very important to place a felt punching between the fiber valve backing and the set collar.

Sliders are connected with a 3/16” brass rod that is threaded on each end. One end is threaded into the plate and the other into a slotted maple yoke that is screwed to the slider. Initial adjustment is made at the threads during installation. The rod passes through a fiber disc with a 3/16” hole that is beveled to a knife edge. The fiber is soaked in oil prior to assembly. It is held in place by a countersunk block. The beveling is important in minimizing friction. The oil is important as it eliminates squeaking. Static wind is used to power the stop action. If carefully made and adjusted, we feel that this design provides one of the quietest stop actions around — including solenoids and rotary motors.

Schwimmer-regulated Winding

I am a fan of steady wind, and in most applications I use a Schwimmer for wind regulation. I do believe that there is a danger in wind being too steady, thus imparting a sterile or electronic character to the instrument. My philosophy is that if the movement of the wind draws attention to itself and interferes with the melodic or polyphonic character of the music, the flexibility is then objectional. Any flexibility or elasticity should almost be subliminal; something you sense but do not directly identify. It is also my feeling that a live room needs steadier wind while deader rooms require a warmer wind supply. As we have all experienced, winding is not an exact science and is not totally predictable.

When using a Schwimmer, the primary and pallet actions receive their wind directly from the Schwimmer cavity. However, this action could also be easily winded from a different style of regulator.

I do not like to "skimp" on the size of the Schwimmer plate. In general, I believe a plate can never be too large on the average chest. We use 3/8” birch ply mounted on a 20 x 50mm frame for the plate. The frame acts to stiffen the plate and allows it to be recessed into the chest cavity so that the spring rails do not have to extend too far below the chest. Steel tubing 30mm in diameter is used for a longitudinal stabilizer. The pantographic springs we use provide horizontal stability. The valve is normally placed on one end. I try to use a valve-to-plate ratio of 1:50. We will sometimes use a ratio as low as 1:30. The valve-to-plate travel ratio is 1:1. The difference between the static and regulated pressure should be no more than 25mm to avoid oscillation. The adjustment of the pantographic springs will determine how the pressure responds under demand. There is some latitude that allows you to achieve a pressure rise under load, if desired.

I have a real problem with instruments that have a significant pressure rise or drop under varying loads. I believe it is unmusical and unacceptable when a pressure change affects the pitch of the top notes, causing them to fight. Here again, if the effect is any more than subliminal it should be avoided. I also have a problem with diaphragm-type regulators (Schwimmers) that rely solely on coil or compass springs. They seldom regulate without a pressure drop.

One of the most forgiving valve arrangements we have seen and used in Schwimmers is where the valve assembly is placed in the center of the plate. The valve remains stationary and is mounted on a threaded rod attached to the chest bottom inside the Schwimmer cavity. A hole of the appropriate size is provided in the plate, concentric with the valve. A wind box is attached to the plate to enclose the valve and a flange is attached. As the plate falls, it covers the valve. A flexible bag connects the plate to the static wind supply. Although this arrangement has its limitations, it does provide a reliable solution in certain applications.

We use a non-ribbed floating plate (inverted Schwimmer) reservoir for the static regulator. It is loaded with weights only (no springs) and has a curtain valve. We have found that this combination of a weighted floating static regulator feeding the Schwimmers provides a gentle subliminal elasticity to the wind supply and provides some life to the total effect of the organ.

Conclusion

I firmly believe that anything we do in a consistent way during the construction process will have an effect on the ultimate character of our instruments. Attention to many small details will make a profound difference in the overall character of any organ. This is true both for details related to the actual tone production in the pipes and for the chest action that controls pipe speech. An element that is important to one builder may be unimportant to another; this is what makes each or our instruments unique.

To ensure success in the production of an electro-pneumatic chest such as I have described here, strive for the following:

- Keep the mass of the action down.
- Exert care in the alignment of all parts.
- Avoid excessive “bag” in the leather when at rest.
- Follow good gluing practice.
- Chamfer sharp edges.
- Carefully regulate pallet travel.
- Carefully size and regulate the primary action.
- Seal primary channeling.
- Provide key channel bleed holes.

With regard to stop actions:

- Select felt of proper thickness to ensure correct slider travel.
- Use a generous amount of felt to absorb action noise.
- Carefully regulate primary valves.
- Put felt punchings between the set collars and the valves.
- Bevel the fiber slip washer to a knife edge and lubricate with oil.

Never underestimate the difference that careful action regulation will make in how an instrument is perceived, whether it is mechanical or electric. Of course, a precise action cannot cover up sloppy voicing practices, and vice versa. But subtleties and nuance do make a difference, and that is what art is all about.

Lyle Blackinton is president of L.W. Blackinton and Associates in El Cajon, California. His firm builds both mechanical and electro-pneumatic instruments and maintains appoximately 100 organs in southern California.