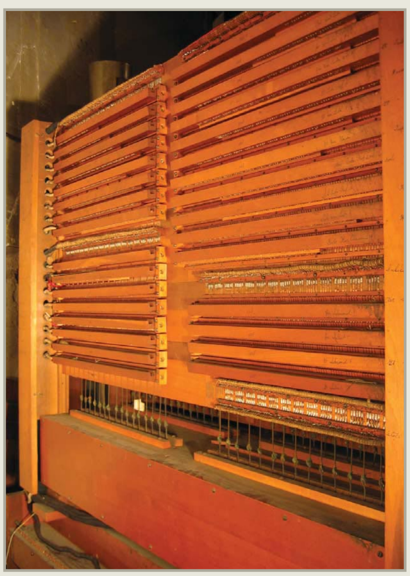
Getting In On the Action

By Jim Henry, Orpheum Tech Crew Member

"Action" can be defined as the operating parts of a mechanism, or the way in which such parts operate. Theatre pipe organs contain thousands of actions of that sort. Most often mentioned is the electro-pneumatic or EP action. Convention goers will hear two organs with original EP actions at the 2005 ATOS Convention this July . . . the original installation Orpheum Wurlitzer Style-240 and the Style-260 Wurlitzer at the San Gabriel Civic Auditorium. So just what does it mean when it is said that a theatre organ has its "original EP action?" In this article, we will take a quick look at the history of organ actions, the significance of the EP action in that history, and describe "the way in which such parts operate."

Actions in an organ translate the commands of the organist into the sounds that we hear. Originally organs employed mechanical actions such as tracker actions to translate key presses into valve openings under the pipes to produce sounds. As organs became larger and larger, the amount of force required on the keys rose to the point where the bass notes on a large organ might require more than 3-pounds of force to operate! To address the unreasonable effort required to play large organs, the energy available from the pressurized air used in the pipes was harnessed to provide a "power assist," not unlike the power brakes in a car. The most successful device of this type was the Barker lever. Using the Barker lever, the organist's key press was used to open a small valve that supplied air to a bellows that did the 'heavy lifting' of opening the valve under the pipe.

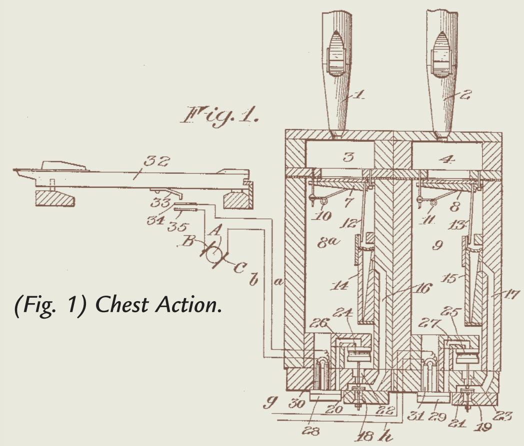
Another problem facing organ builders was the desire to place organ consoles at some distance from the pipework. The Barker lever was adapted to allow the key action to be connected to the action for the pipe valve by a small diameter pneumatic tube. Pressure changes travel at the speed of sound, about 1,100 feet-per-second. By the time the console was 50 feet away, it would take about 1/20th of a second for a key press to be communicated to a pipe pneumatically. While this doesn't seem like a long time, it is just about as much delay as most organists can tolerate when the other delays inherent in an organ action are added in.



Some of Orpheum's stop relays, which are housed in the Main chamber.

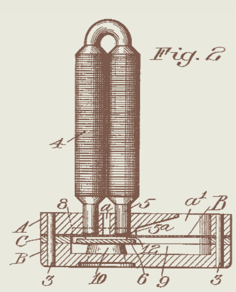
Organ builders naturally looked to electric power in an effort to further advance the art of organ building in the second half of the 19th century. It must be remembered that electrical engineering was in its infancy at this time. It was not until the dawning of the 20th century that Robert Hope-Jones combined his scientific knowledge with an interest in organ building to create a reliable action that used electric power . . . the electro-pneumatic (EP) action. Hope-Jones recognized that lower voltages and carefully chosen switch contact materials could be used to eliminate the problems of contact burning that made the electrical switching unreliable. It is a tribute to his engineering acumen that original switching contacts using his design have remained in service to this day, often without even needing to be cleaned.

The basic idea of the EP action is to use electrical signaling . . . which is fast, compact, and easy to route . . . and pneumatics to provide the motive force. *Figure 1*, taken from one of Hope-Jones' many patents, shows an EP action that connects a key **32** to pipe ***1***. This is very similar to the action actually used by Wurlitzer. A contact plate **33** under each key **32** connects two contact wires, **34** and **35**. A generator **A**, which would be replaced by a solid state power supply today, is connected to an electromagnetic valve **28** by two wires. One wire ***a*** is switched by the key contacts and the other wire b is the common from the generator. The wires can be as long as desired, allowing great freedom in locating a console, since the electrical signal from the key press is transmitted to the electromagnetic valve almost instantaneously.



(Fig. 1) Chest Action.

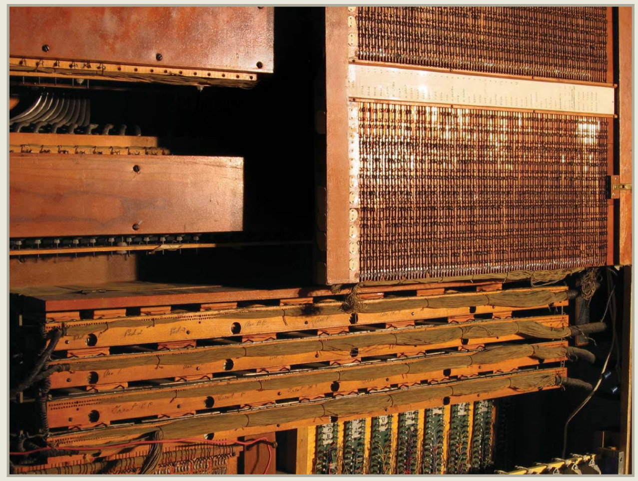
Figure 2, from another Hope-Jones patent, shows the electromagnetic valve. When the wire coils **4** are energized by the current from the key contacts, the electromagnet **5** attracts an armature in the form of a thin steel disc **6** about 1/4" in diameter. The armature is also the valve which switches port a^1 between port ***a*** and port **10**, making this a 3-way valve. It should be noted that the armature moves a very small distance to open and close rather small openings. This keeps the power requirements to a minimum. However, the amount of air that can flow through the valve is very limited, not nearly enough to play even the smallest pipe.



(Fig. 2) Electro-Magnetic Valve.

This is where the pneumatic part of the EP action steps in. Referring again to *Figure 1*, an electromagnetic valve can be seen in a pipechest. The valve is sealed against the bottom of the chest so that port ***a*** is open to the wind supply in the chest. The valve is oriented as shown so that the steel disc closes

Some of Orpheum's key relays are visible behind glass front of the pressurized case that holds them.



Back of Orpheum console with the Great and part of the Accompaniment setterboards in the upper right, the piston relays below, and a portion of the blow-boxes that contain the electromagnetic valves to control the stops in the upper left.

port **10** due to gravity when the valve is not energized. The common port a^1 is connected to a primary pneumatic bellows ***24*** by passage ***26***. When the electromagnetic valve is not energized, the primary pneumatic is connected to the wind pressure in the pipe chest ***8a***. The primary pneumatic is inside the pipechest, so the pressure is the same inside and outside the pneumatic and gravity causes the pneumatic to open.

When the electromagnetic valve is energized by a key press, the steel disc is pulled up to the electromagnet, closes port ***a***, and opens the primary pneumatic to the outside air through port ***10***. The pneumatic now collapses and opens valve ***20***. While this has multiplied the power of the electromagnetic valve by opening a larger valve, it is still not enough to play a pipe. So the whole process is repeated to vent a larger secondary pneumatic ***14*** through passage ***16*** causing it to collapse. The secondary pneumatic opens a large pallet valve **7** that admits air from the pipe chest to the pipe causing it to speak. What is truly remarkable is that this entire sequence occurs so quickly that the delay between pressing a key and hearing the pipe speak is almost imperceptible. The EP action is so fast that notes can be repeated at the rate of about 20-per-second.

All theatre organs still use an EP action for the pipe action. So this is not what is being referred to when organs, such as the Orpheum Wurlitzer, as described as still having their "original EP actions." There are two other major areas that require actions—the combination action and the relay.

The relay is so named because it is a collection of EP relays, (electro-pneumatic switches). It is more properly a relay logic machine, an early form of computer. The relay combines the key inputs and the stop inputs to create the pipe outputs that drive the EP pipe action described above. The above explanation was simplified by showing the key contact closure controlling the pipe action directly. In reality there must be more, because pressing a key alone is not enough to play a pipe. The appropriate stop must also be turned on.

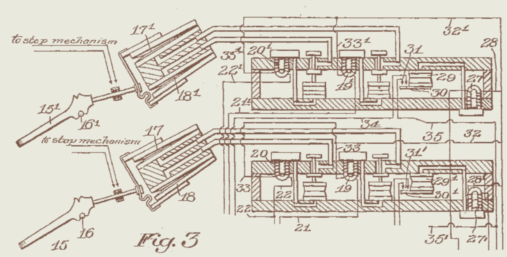
The relay provides stop control by adding a 61-pole EP relay switch between the keys and the pipes. Turning on a stop closes the stop relay, to connect the key signals from a keyboard to the EP pipe action. When the stop is off, the relay is open and the key signals are disconnected from the pipes.

The relay also provides EP keying relays. It is necessary to have a separate key contact for every stop that can be played from the key. This prevents "sneak paths," that would cause unwanted pipes to play as current traveled the "wrong way," through the circuits from pipes that are being played. Today, that problem could be solved with a simple solid-state diode, but at the time such devices were still several decades away. On all but the smallest organs, there isn't sufficient room under a key for all the necessary contacts. The key relay moves in sympathy with the keys on the console, and provides the requisite number of contacts. This also prevents a single contact from having to power more than a single magnet.

Today a relay can be built much more compactly using solid-state electronics. Even so, modern electronics do not make an organ any more responsive than a properly maintained EP relay. In fact, early attempts at making electronic relays sometimes resulted in relays that were slower than an EP relay. Organists who could outplay the relay would sometimes joke that they could finish a piece and be off the bench before the electronic relay was finished playing. Today's solid-state relays are quite fast, and fully capable of doing everything an EP relay can do and more. EP relays that remain in service are tributes to the ingenuity of Robert Hope-Jones and his contemporaries, who managed to provide the logic that made theatre organs possible with relatively simple electro-pneumatic devices.

The final major EP action, the combination action, is vitally important to a theatre organist because this is what allows the vast tonal resources of a theatre organ to be quickly changed. The combination action translates the press of a combination piston, the round button found below the keys, into the on or off movement of the stops.

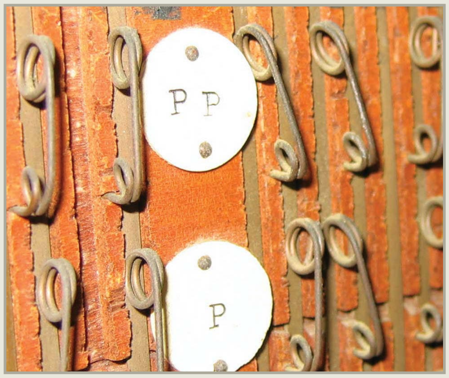
Figure 3 shows an EP combination action. There are two electromagnetic valves ***19*** and ***20*** for each stop ***15***. Each electromagnetic valve controls a primary pneumatic, just as it does in the pipechest. (Note that the electromagnetic valves are shown



(Fig. 3) EP combination action.

upside down; the electromagnet must be up for the valve to operate correctly.) In the combination action, the primary pneumatic causes a valve to connect a stop pneumatic ***18*** to the wind pressure causing it to inflate. The stop pneumatic is connected to the stop by twill tape, so that inflating the pneumatic ***18*** pulls the stop off or on using the other pneumatic ***17***. When the electromagnetic valves are not energized, the stop pneumatics collapse, the twill tapes are slack, and the stop can be moved manually. Whether set by hand or using the combination action, the stop closes the two contacts that go to the stop mechanism in the relay.

A third electromagnetic valve ***27*** is shown to operate a relay switch ***31***. The combination piston energizes the relay switch, which in turn energizes a row of "safety pin" switches on a setterboard. The setterboard switches route the press of the piston to one or the other (or neither) of the two valves, to set or clear the stop associated with the setterboard switch. There are two vertical brass strips for every stop tab on the console. There is a row of switches for every piston, which can control the stop tabs. The switches can be set to one side, so that pressing the piston for that row will set the stop, or to the other side to clear the stop. The switch can also be set on top of the wood in the middle, and then the piston will not change the stop.



Wurlitzer setterboard spring switches.

A white strip of plastic at the top of the setterboard provides the stop labels for the columns. Round tags label each row, relative to the piston that controls the row of stops.

On the Orpheum's Style-240 Solo manual, 6 pistons control 14 Solo stops and 5 trems. This requires 6 x 19 (or 114 switches) just for the rather small Solo section. The Great and Accompaniment, with 10 pistons each and more stops, are much larger. Here's the switch count for a Style-240 setterboard:

	Pistons	Stops	Switches
Great	10	45	450
Acc	10	42	420
Solo	6	19	114
Pedal	3	15	45
TOTAL	29	111	1029

There is one relay per piston. The relay provides one signal wire per stop tab controlled by the piston. An individual wire coming from a piston relay feeds every switch on the setterboard. Each brass strip is connected to a wire at the bottom of the setterboard. The wires coming from the setterboard, two per stop, go to electromagnetic valves that actuate the pneumatic mechanism to move the stop tabs.

There are two pneumatic actions when a piston is pressed. First, the relay bellows close the piston relay. Then, the stop blowbox pneumatics are actuated to move the stop tabs. This creates a distinctive thump-thump sound when you press a piston on a Wurlitzer console. On all but the largest consoles the combination action is contained within the console.

Organs such as the Wurlitzers at the Los Angeles Orpheum and at the San Gabriel Civic Auditorium are described as having EP actions because they retain **all** their original EP actions—pipe, relay, and combination.