Air Compressor/Water Pump Part I - Background

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My grandfather immigrated from Germany in the late 1800s to work in George Westinghouse's Pittsburgh laboratory. One of the products of that laboratory was the railcar air brake systems. Grandpa apparently worked at Westinghouse for only a short time before he started his own business down the river a few miles. (Don't know whether grandpa quit or was fired.) This very loose family connection to the air brake systems stimulated an interest in the steam powered air compressors.

Most of the shays were equipped with an air compressor so I want one to decorate my shay. Some working scale models of the air compressor are designed to pump water --- feed water pumps. During the first steaming tests I had to use the hand pump and quickly began to lust for a steam powered pump or an injector. I've seen several of the steam powered pumps made by Keim Steam Pumps and sold by Loco Parts . These pumps are models of the Westinghouse 9 1/2 inch compressor. The Keim pumps seem to run really great and they look fabulous. Cass No 5 which I've copied many details uses the slightly larger 11 inch pump. The 9" pump has cooling fins on the air compressor (which Keim models exquisitely) whereas the as 11" compressor has smooth sides. The smart solution would be to buy one of the Keim pumps. However, it's winter and I need a new challenge so I decided to try to make a working air compressor model that pumps water.

I've been thinking about these pumps since I started to build the shay. One of the challenges was to understand the valve mechanism that insures the pump operates reliably. To this end I scoured my limited resources and came up with several useful references. The July 1976 issue of Narrow Gauge and Short Line Gazette has dimensioned drawings of the more common Westinghouse compressors in fairly regular section called *Straight Talk About Bent Pipes* by Charles Givens. I was able to enlarge the drawings of the 11" pump to 1/8 scale --- full size for my shay. I also found a single cylinder feed water pump design in the 5-18 January 1973 issue of Model Engineer. This pump is in an article *A Locomotive with Bremme Valve Gear* by Gilbert Lindsey. The concept of a pilot valve and shuttle valve is described in this article. The pilot valve mechanical linkage on this pump is external. The pilot valve is driven by the piston rod with the motion of the valve much less than the piston. The pilot valves on the Westinghouse pumps are directly above the steam piston. The valve should move only when the piston is near the upper or lower extremes of its motion. I read someplace that the concept of a large piston motion driving a

small valve motion near the extremes of the piston motion is called "lost motion". I tried for months to figure out how the lost motion was achieved until I concluded that the rod connecting the steam and air compressor pistons must be hollow with the valve stem sliding inside the piston rod. That way, the valve stem could be rigged to be pushed or pulled at the two extremes of the piston motion. Shortly after I figured this out I saw a cross section sketch of a duplex Westinghouse pump on the inside rear cover of the March/April 2003 issue of Live Steam. This sketch (in a Grand Scale advertisement) clearly shows the the hollow piston rod on the high pressure steam side of the pump, confirming my guess.

The pilot valve controls the steam and exhaust to the steam operated shuttle valve. The shuttle valve has the sliding valve sandwiched between two pistons that pull the valve between the two extreme positions. The shuttle valve should snap between the two extreme positions and then be fairly stable in those positions. With the stable position of the shuttle valve at the two extremes, full steam pressure is always supplied to one of the two ends of the main cylinder making it self starting.

Cass 5 Air Pump: This is a photo of the 11" air pump on Cass No 5. The upper cylinder is for steam and the lower cylinder is the air pump. Both pistons are 11" diameter and the stroke is 12" The increased outside dimensions of the upper cylinder is probably due to lagging that is covered with a jacket. The steam valves are at the top of the steam cylinder. The compressor valves must be on the back side of the compressor.

Last spring (2003) a couple of us visited Cass to learn more about the Shays. While walking through the shops we came upon a wagon piled with air compressor parts. The following are photos of these parts. This first photo shows the end of the pilot valve cylinder.

This shows the shuttle valve cylinder. Both this and the pilot valve cylinder above have the three slots typical of slide valves.

This is another shuttle valve cylinder with the shuttle piston

hanging out the end. Recall that the pilot valve is driven by the hollow piston rod (the lost motion) and the shuttle valve is driven by steam controlled by the pilot valve. The shuttle valve controls the steam to and exhaust from the steam cylinder.

This is an end view of the steam piston. Note the little plate over the hollow rod.

This is an enlargement of the plate on the piston. There is a hole in the plate to allow the valve stem pass. Unfortunately, the hole is barely visible. Sure wish I'd slipped a pencil in the hole before taking the photo.

A side view of the main pistons in front of a steam cylinder.

This shows the lower steam cylinder head and upper air compressor head with the interconnecting tie piece. The nut on the left screws on the end of the packing gland.

This is an interesting modified pump. The upper part is the standard steam cylinder that is driven by compressed air. The lower part is a water pump. This little tool is used for hydrostatic testing of boilers. Maybe not so little, it probably weighs a couple hundred pounds

The following drawing is from the July 1976 issue of Narrow Gauge and Short Line Gazette. I'm guessing that the drawing is from some Westinghouse publication and I'm not likely violating any copyright by reproducing it here.

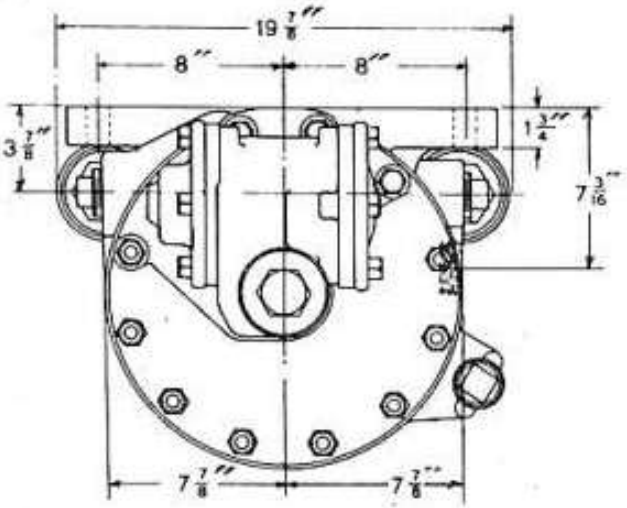
GENERAL DATA

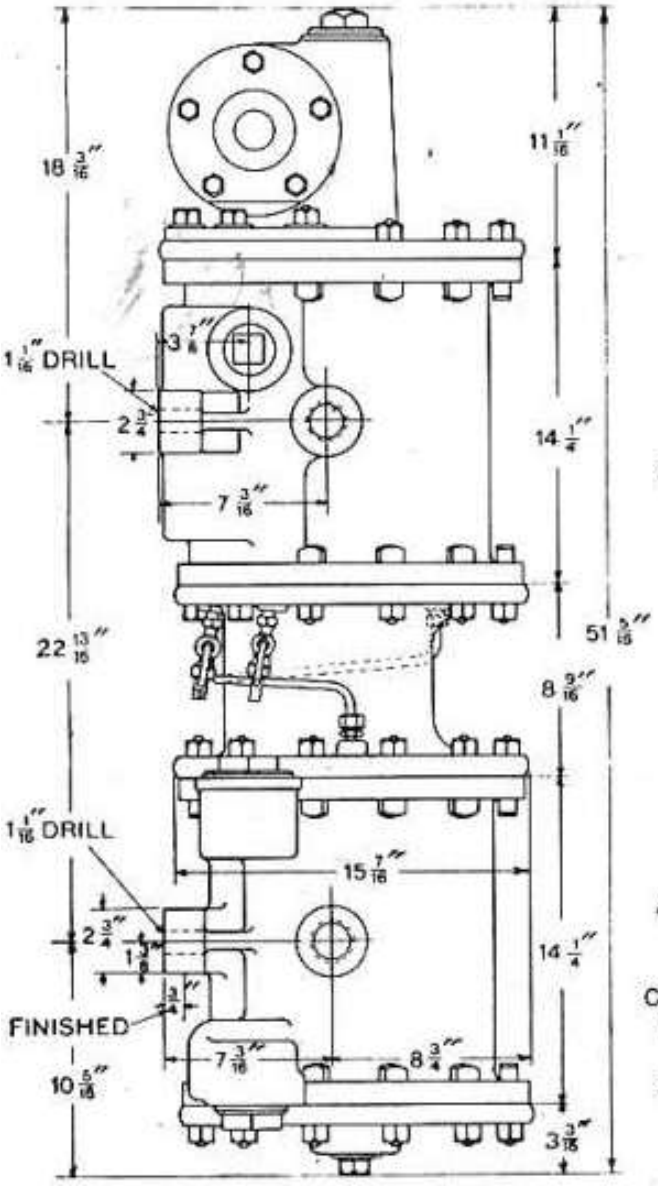
Steam Cylinder	11" Diameter
Air Cylinder	11" Diameter
Stroke	12"

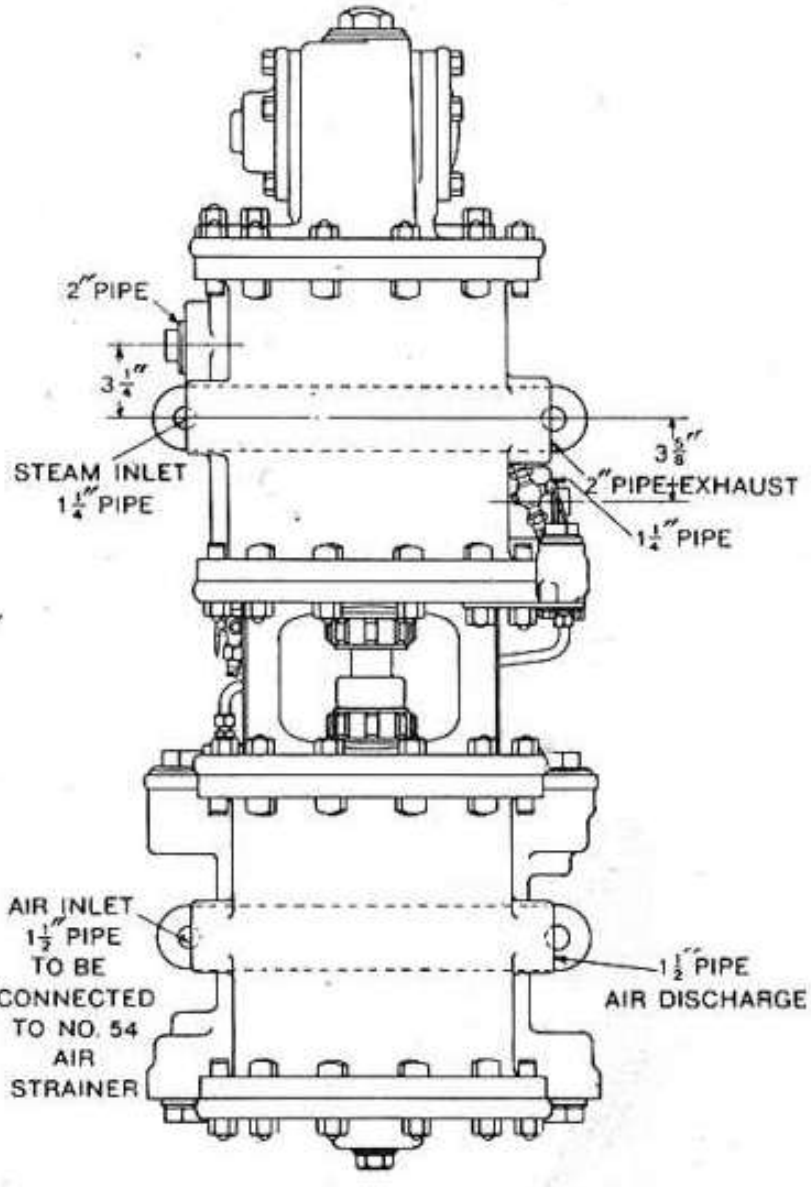
Compressor No.	Size	Steam Supply Pipe-Size: Main Pipe	Branch to Each Compressor
1	11"	1¼"	.....
2	11"	1½"	1¼"

Size of Governor Required

For One Compressor	1¼"
For Two Compressors	1½"







This is a good point to break. The pump fabrication is started in Part II.

Shay Project
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