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THE LOCOMOTIVE LION

A THESIS
Submitted in Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science (in Mechanical Engineering)

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Engine used in 1840 at Whitneyville, Me.
LOCOMOTIVE LION

From a historic point of view the value of the locomotive Lion which rests in the Crosby Laboratory cannot be overestimated, when one considers that its age is approaching the century mark. It is also valuable from a historic point of view when one considers too that within a period of ninety years the mechanical changes which have taken place in the mechanism of locomotives are very few and consist mostly of refinements.

The locomotive Lion was built in Boston in 1840 by the firm of Hinkley and Drury which later merged into the firm of Hinkley and Williams who continued to build locomotives for many years. A similar locomotive, named the Tiger, was also built the same year which was practically a duplicate of the Lion. These two locomotives were built expressly for the Whitneyville and Machiasport Railroad Company and they did actual duty for a period of fifty years. The boilers were designed to carry a pressure of one hundred (100) pounds and the locomotives themselves developed 100 horsepower. These two locomotives were built from the best grade of Norway iron and steel. The frame of the Tiger was wholly of iron and steel while the frame of the Lion was of oak with a strap iron backing.

The Whitneyville and Machiasport Railroad was the second steam railroad in Maine. The first was the origi-
nal Old Town Railroad Company, chartered in 1832. In 1835 this railroad's franchise was sold to the Bangor and Piscataquis Canal and Railroad Company, a rival concern chartered in 1833 to build a railroad from Bangor via Old Town to the slate quarries around Williamsburg in Piscataquis County. Later in 1854, General Samuel Veazie acquired this property and it was afterwards termed the Veazie Railroad. The first engines to be used on this railroad were built by Stephenson in England and weighed in the neighborhood of six tons.

The Whitneyville and Machiasport Railroad Company was operated by the Boston Eastern Mill and Land Company, organized in 1833, for the purpose of doing a general lumber business at Middle Falls now Whitneyville. The road was started in 1840 and completed in 1842 for the sole purpose of transporting the lumber from Middle Falls to Machiasport or to the tide water. The track was 4 feet 8-1/2 inches gauge and consisted of flat bars of iron laid on top of 2 x 3 inch wooden stringers, which rested on 8 x 8 inch timbers supported by 8 x 8 inch ties. The first engine used was the Phoenix, built in England and leased from the Eastern Railroad of Boston. In the meantime, the two locomotives, the Lion and the Tiger, were being built for the Boston and Eastern Mill and Land Company. The actual date of their operation is not known to the writer, but it is known that they were contracted for in 1840. After 1866 the Whitneyville Agency succeeded the Boston and Eastern Mill and Land Company which in turn
was dissolved in 1896, and the Sullivan family of Whitneyville then became the sole owners. Through the efforts of the Sullivans and Alderman Rounds of Portland, the Lion now belongs to the University of Maine where it rests in Crosby Laboratory to give future generations a true conception of an early steam locomotive.

The over-all dimensions of the frame of the locomotive Lion are 12'5" x 7'4-1/4". The outside frame is made of 43/4" x 23/4" oak bound with 1/2" Norway iron strapping around the outside. Approximately 1 1/4" from each side of the outside frame are two oak stringers running lengthwise and reinforced with 1/2" strap iron on each side. In spite of the fact the Lion is in its ninety-first year, the oak is perfectly sound. The boiler of the locomotive rests on two iron supports fastened to the stringers - one at the center, and one at the front end. The fire box end is held rigidly by angle irons bolted to the frame.

BOILER:

The boiler was constructed in the same manner as common boilers of today. This particular boiler was made up of five sections, as shown on the assembly drawing. As mentioned before, this boiler was designed and constructed to carry 100 pounds pressure. The steam dome where the dry steam collected is located in the center of the boiler which was an English idea. The steam was piped from the
dome through the boiler to the steam chest, where it did its expansive work in the cylinders and was exhausted up through the stack. A supply of steam was admitted to the cylinders by means of the throttle pipe and valve (Fig. I). This was sometimes called a "double poppet valve", and consists of two circular discs (a) and (b) which cover two corresponding openings in the end of the pipe (I). When these discs are raised up as shown in Fig. I, steam flows around the edges as indicated by the arrows. It will be noticed that the steam pressure in the boiler comes on both surfaces, (a) and (b). Since by design the area of (a) is larger than that of (b), the pressure exerted upon (a) has a tendency to close the valve due to the greater area exposed. This was designed so that when the locomotive was not in use the valve would always be closed. This valve is opened and closed by means of a lever located on the front of the boiler and connected by the rod (d), the bell crank (i), and the rod (c). With such an arrangement, a pull on the rod (d) in the direction of the arrow would cause the valve to open.

The boiler contains 59 tubes made of copper. The tubes are staggered in the following manner, shown in Fig.II.
The tubes connect the tube sheet in the fire box to the tube sheet on the head of the boiler. The hot gases from the fire passed through the tubes and caused the water surrounding them to be heated. The gases were then drawn into the smoke box and up the stack by the exhaust steam from the cylinders. When these hot gases entered the smoke box they passed around the live steam pipes which lead into the steam chest. In this way loss by radiation from the live steam in these pipes was reduced to a minimum.

The loss of heat from the boiler and cylinders either by radiation or convection was reduced by covering the boiler and cylinders with 7/8" wood lagging which is a very poor conductor of heat. The wood in turn was wrapped with a
very thin covering of iron, sometimes called Russia iron.

The smoke stack of this locomotive has an odd appearance, however, there was a reason for constructing it in such a conical shape. When bituminous coal, or wood was burned, this type was used and when anthracite coal was burned, the straight vertical type was used. Since this locomotive was a wood burner, the conical type was used, and the wire netting placed on the top of the stack served as a screen allowing the smoke to escape but retaining the sparks and hot cinders which dropped into the smoke box. These were removed from the front of the smoke box by a door which gave access to the inside. The idea of the conical shape of the stack was to deflect the motion of the sparks and cinders which came up through the stack with the blast from the exhaust. They then dropped down the sides and into the smoke box.

The water supplied to the boiler to replace that which was converted into steam was forced in by means of two force pumps. These pumps were situated on the frame opposite the fire box as shown on the assembly drawing. This particular mechanism consisted of a pump barrel which is made of cast iron in which a tight fitting piston, called a plunger, worked through a stuffing box. The plungers received a reciprocating motion from the main cross heads by means of two connecting rods working at different radii on
a lever fulcrumed to the frame of the locomotive. The pump barrel was connected with the water tank of the tender by a suction line similar in character to a small sized fire hose. It was connected with the water space of the boiler by a feed pipe. There was a check valve between the water tank and pump and one between the pump and the boiler. The valves were cylindrical and made of brass and worked in guides known as cages. When the plunger was drawn out of the pump cylinder, a partial vacuum was created behind it and the atmospheric pressure in the water tank forced water from the tank through the check valve into the pump cylinder. When the plunger was forced back again the force which was exerted against the water closed the suction valve and the water was pushed through the feed pipe and the upper check valve into the boiler. On the forward stroke this check valve was closed. Over the suction valve is a chamber called an air chamber. When water was forced into this chamber, it confined a small amount of air, which being elastic will be compressed and expanded by the pressure of the water so that it formed a cushion which relieved the pump and the pipes from sudden shocks to which they were subjected owing to the rapid motion of the pump plunger. Since the pump plunger worked continuously while the engine was running, the only way of controlling the quantity of water pumped was by a plug valve located in the outlet of the connection from the water
tank to the pump. There was apparently no throttling action with this valve, the pump was either operating at full capacity when the valve was opened, or not at all when the valve was closed. Since the pump operated only when the engine was running, no water could be put into the boiler by this method when the locomotive was idle. For filling the boiler when empty there was a special connection and valve on top of the rear end of the boiler.

This method of pumping was done away with a few years after the construction of this locomotive and the injector system was used because the water in the tanks could be kept warm and the boiler could be operated when the locomotive was stationary. This system prevented freezing when the locomotive was idle which was always a possibility with the old pumping system.

The principle of the valve mechanism was the same as that used on modern locomotives but there is no link motion. In the detailed drawing of the valve layout, we have represented the cylinder inclosing the piston and the steam chest inclosing the simple D valve. The valve stem was connected to a rocker arm (which is shown in the front view below the cylinder) and on the lower part of the rocker arm were pins to which the eccentric rod could be hooked up. One of these eccentric rods is drawn in part and the other in full. These two eccentric rods are attached to the main axle by the eccentric sheaves, inclosing the two eccentrics which are set
90 degrees ahead and behind the crank respectively. The valve motion is identical with the modern type but the operation of the eccentric rod in order to obtain the forward and reverse motion of the locomotive differs somewhat from modern construction. It can be plainly seen from the hook up shown by the drawing that the locomotive would be running in the forward direction. That is, if the crank shown by the circle to the right of the eccentric was to move counter-clockwise, the lower eccentric would be turning counter-clockwise also, and in doing so, the eccentric rod would pull the rocker arm to the right and at the same time the rocker arm would be pushing the valve and valve stem to the left. Steam would be admitted through the right hand port of the cylinder and it would force the piston forward giving the locomotive a forward motion. In order to drive the locomotive in the reverse direction, it would be necessary to disengage the eccentric rod drawn in full with the pin in the lower part of the rocker arm and engage the eccentric rod partially drawn with the pin in the right hand slot of the rocker arm, shown in the front view. With this connection the crank would be moving clockwise, the upper eccentric clockwise, and the rocker arm, valve stem, piston and eccentric rod would be moving in the same direction as they would for a forward motion, however, the locomotive would be travelling in reverse. Of course, it is understood that the eccentric shown
in the drawing controls and operates the corresponding piston. The piston in the opposite cylinder is operating by a similar mechanism with the crank pin set at 90 degrees from the one shown.

The operation of shifting the eccentric rods from the forward to the reverse positions are handled by the engineer and controlled from his stand by means of a lever. This lever is not shown in the assembly drawing, however, it works in the following manner: The lever is about $\frac{1}{4}$' in length and is allowed to move through an angle of about $45^\circ$ about a pin $3'$ from the handle end which is fastened to the frame. The lower end of the lever is connected to a semi-circular gear by means of a connecting rod. This gear is about 6'' radius and turns about a pin fixed to the frame. The semi-circular gear is meshed in with a smaller circular gear which has the cam shaft (shown in the detailed drawing as a front view section) as its axis. Due to the proportional radii of the two gears, the cams which give a rising and dropping motion to the eccentric rods can be moved through an angle of $180^\circ$ when the lever is pulled through an angle of $45^\circ$ or thereabouts. Hence when the cam lever is in its forward position, the forward eccentric rods are allowed to drop into their respective positions on the rocker arm pins. When the cam lever is reversed in direction, the cams move through $180^\circ$ and the forward eccentrics are disengaged from the rocker.
in the drawing controls and operates the corresponding piston. The piston in the opposite cylinder is operating by a similar mechanism with the crank pin set at 90 degrees from the one shown.

The operation of shifting the eccentric rods from the forward to the reverse positions are handled by the engineer and controlled from his stand by means of a lever. This lever is not shown in the assembly drawing, however, it works in the following manner: The lever is about 4' in length and is allowed to move through an angle of about 45° about a pin 3' from the handle end which is fastened to the frame. The lower end of the lever is connected to a semi-circular gear by means of a connecting rod. This gear is about 6" radius and turns about a pin fixed to the frame. The semi-circular gear is meshed in with a smaller circular gear which has the cam shaft (shown in the detailed drawing as a front view section) as its axis. Due to the proportional radii of the two gears, the cams which give a rising and dropping motion to the eccentric rods can be moved through an angle of 180° when the lever is pulled through an angle of 45° or thereabouts. Hence when the cam lever is in its forward position, the forward eccentric rods are allowed to drop into their respective positions on the rocker arm pins. When the cam lever is reversed in direction, the cams move through 180° and the forward eccentrics are disengaged from the rocker.
pins and the reverse eccentric rods are allowed to drop into their respective positions, hence being engaged with the rocker arm. If the cam lever is placed in a neutral position, the cams turn through 90° and all four eccentric rods are dis-engaged. This is often necessary in starting and stopping. It will be noticed from the assembly drawing that the valves can be operated from the engineer's stand by means of two hook rods attached to the vertical lever. A third operating lever controls the dropping or lifting of these rods simultaneously. It is thus seen that the engineer could control the operation of the valves when the eccentric rods were disengaged. Since there were no brakes on this locomotive, the engineer would throw the eccentric rods out of operation by means of the cam lever, he then would engage the hook rod by pulling the hand lever controlling the rod back to its reverse position; then by means of the valve lever he would admit live steam to the cylinders. In this way the pistons would be working against the boiler pressure and the locomotive would be braked.

From the assembly drawing one can readily see that the cylinders are placed in a sloping position. This arrangement is really no different than that of the modern day locomotive for one can see that if they were placed in a horizontal position the center line of the cylinder would not pass through the center of the driving wheel, but would be off center from the line of motion, which is not a very efficient hook up.
The safety valve located in the center of the steam dome was set at 100 pounds pressure. The valve was held in position by a lever arm and a coil spring which connected it to the top of the boiler.

The usual sand box is found on top of the boiler behind the smoke stack to feed sand to the rails.

From a detail point of view, the outstanding features of this locomotive have been thoroughly taken up but from a very close inspection one will notice that much of the actual work in constructing this engine was done by hand. For instance, the boiler was hand riveted; many of the bolts, nuts, rods, etc. were hand made. One might also observe that the bolts and nuts were odd sizes.

The outline of this particular locomotive is not beautiful but the construction is rugged and extremely so when one considers that it was in actual operation for fifty years and no serious replacement was ever made. Also, that in 1890 it could still carry a pressure of 100 pounds, as stated to the writer by Cornelius Sullivan who operated this locomotive for many years.