Description of

CONSTRUCTION AND ERECTION of

BOILER AND TANK SHOP for

Baldwin Locomotive Works


by

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pair Shop is an old building, which was connected with the new one by large passages. The Smith Shop was built during the winter previous to the erection of the Tank Shop. The Forge Shop is a comparatively new building, to the south of the Smith Shop, and is connected with it by a steel bridge. The Yard is entered by a wagon passage from Hamilton street and by rail as shown on the diagram.

The forges burned oil as fuel, which was supplied from storage tanks in the yard and adjoining the railroad. To supply these tanks with oil, necessitated keeping open the track which passed through the corner of the structure.

Specifications. The specifications for the guidance of contractor and superintendent were neither clear nor specific, but were loose and unsatisfactory. They are as follows, verbatim et literatu:

"General conditions. The first floor level is taken from the top of rail at east door, Hamilton street front, as indicated in foundation plans. All depths of foundations, piers, etc., and heights of floors are reckoned from the level at this point.

"The work embraced herein is to include the taking down of the present structure, and the erection in its place, complete (except lighting and plumbing) and ready for occupancy, a four story brick and iron building with slag roof, as set forth in the plans, marked A-I01, A-I02, A-I03, A-I04, A-I05, A-I06, A-I07, and A-I08, which are hereby made a part of these speci-
fications.

"The specifications and drawings are to be taken conjointly, and the contractor is to take all measurements that may be necessary to insure the fitting together of the work in the manner intended.

"The work of tearing down and rebuilding is to be done in such a way as to interfere as little as possible with the operations of the Baldwin Locomotive Works.

"All materials are to be of the best quality, and the workmanship is to be done in a substantial and workmanlike manner and to the satisfaction and acceptance of the Baldwin Locomotive Works, or their authorized representatives. The old material in the present building will become the property of the contractor, and is to be used as far as is suitable, in the new building.

"Foundations and Masonry. Excavate for piers and walls to the depths shown, and build foundation masonry of Conshocken or Chester Valley stone, in good mortar, formed of cement, lime and clean sand.

"The foundations of the columns are to be made of a bed of concrete 30 inches thick, upon which will be laid two layers of I beams, with concrete well rammed between them. This concrete is to contain not less than one portion of good Portland cement, two portions of sand, and three portions of crushed stone.

"The outside face wall will be laid with uniform dark red stretchers in good mortar. The face of the yard wall will be of hard brick. Mortar to contain not less than 25 per cent of good
cement.

"Cut Stone. The cut stone will include the base course, window sills, cap stones, key stones, granite blocks on window jambs, arch piers, and girder bearings as indicated. All dressed stone to be of Port Deposit granite. Base course on Hamilton street and Seventeenth street fronts only.

"Carpentry, Lumber, and Hardware. All the timber to be sound, well seasoned, and free from large or rotten knots, or other imperfections. The 2nd., 3rd., and 4th. floors are to consist of 3x12 inch white spruce joist, spaced 12 inches on centre, with double bridging; two thicknesses of flooring. The bottom to be 1 1/2 inch spruce, tongued and grooved, faced on one side, the top to be 1 1/4 inch x 6 inch yellow pine #1 rough. The roof framing of yellow pine, rough, as indicated, with 3x12 inch spruce purlines, spaced three feet on centres. Roof boards to be 1 inch yellow pine, tongued and grooved, and faced on one side.

"Columns of 4th. floor to be dressed on all sides.

"The window frames to be as shown of well seasoned white pine, with sills of first quality yellow, hard pine. Reveal frames throughout building, show segments outside and square inside. Window frames to have joint screws opposite meeting rails. Cast iron lintels shall be well ribbed. All sash to be made of first quality, well seasoned white pine, pinned together, 1 3/4 inches thick, with 1 inch mullions, double hung with best hemp cord and proper counter balances.
"Sky light sash to be hung on pivots out of centre and secured by spring catch and rope.

"Doors to be 2 1/2 inches thick, of first quality clear white pine, well seasoned; and with lead joints; sash above lock rails, and to have 10x14 inch lights.

"Roof, four ply slag, with guarantee for ten years.

"Painting and Glazing. All yellow pine to be painted with two coats of best white lead and linseed oil. All white pine to receive three coats of same, of such colors as may be selected by the Baldwin Locomotive Works. All wood work to be primed as delivered. Iron work to receive two coats of mineral brown.

"Glass. Second quality, single thickness, American."

Construction and Erection.

Superintendence. An inspector, whose duty it was to advance the work according to Baldwin standards, and to see that the specifications were fulfilled, was kept upon the work during the entire time of construction.

Lighting. The problem of lighting the grounds and new works, as the building progressed, was one that continually varied. The building was finally to be lighted by electricity and gas. The Baldwin Locomotive Works have their own electric light plant; and therefore it was decided to employ arc lights during the construction, and have them attended too by Baldwin employees. This proved very successful and gave very efficient service.
For day work, the distribution of workmen over the entire job, from first floor to roof, and from building to yard and streets, was found to be economical, and thus the whole work progressed in unison. At night, different conditions existed, and it was found that concentration of forces was the best method of work. This simplified, somewhat, the problem of lighting the works. In superintending the day work, especial attention was given to the development of the work so that the gangs could be concentrated, and so that no laying out would be necessary at night.

The brick layers worked day and night, but the nature of the building was such that the brick work was soon in place. The iron workers seldom worked after 9 pm., but the carpenters worked from 6 am. to 6 am. during the entire course of erection.

About 3 pm., every afternoon, the foreman electrician would go around with the superintendent, and they would decide upon points at which to erect lamps. Temporary 3-inch x 4-inch poles, with arms projecting over the wall, were then put up at the places designated to light the bricklayers. The arms extended over the wall and threw the shadows of the workmen back of their work, and did not interfere with keeping the work true to the lines. This disposition of the lights enabled the men to lay as many bricks by night as by day, and it certainly was more comfortable to work, it being so much cooler. For the carpenters, the lights were swung from brackets clamped to the steel columns.
In the morning, the electricians would be on hand and remove the lights and wires that were likely to interfere with the lines or the boom of derrick as it swung around in its work during the day, or with the placing and rivetting of the girders.

Shoring. The large elevator for lowering locomotive tenders was located in the south end of the old building, and as it was in constant use, it was decided that the north end of the old building should be taken down first. The shoring, although temporary, was extra heavy as each floor of the building was heavily loaded with machine rivetters, large punching and shearing machines, and heavy rollers. For the first set of shores, material was brought from the contractor's shop, and consisted of old 12x12 inch; 10x10 inch, 16x6 inch yellow pine timbers, and 3x12 inch spruce joist, all 12 to 24 feet long.

The girders of the old building ran north and south, and the joists at right angles to them; and hence in shoring, it was necessary to support only the girders. The bedding for the shores consisted of two joist, 3x12 inches, 6 feet long, set level, one upon the other, parallel to the girder, and directly beneath it. The distance between the bed and the girder was then measured by means of two rods, and then laid off on a 12x12 inch post. The post was then cut two and one half inches shorter than the measured length set. Two sets of folding wedges were placed beneath the post, as indicated in Fig. 2, page 9, and driven home. The wedges were
5 inches wide, 3 ft. 6 inches long, 1 in. thick at the feather edge and 3 inches thick at the butt end. They were white oak, and it is interesting to note that they stood the abuse so well that each set was used several times over. From Fig. I, it will be seen that the driving wedge of each pair is on top and is driven home from opposite sides of the post. It was found that the simultaneous driving of the wedges from opposite sides of the shore prevented the splintering and kicking of the post. The shores for the second and third story were put up in a like manner, and a wooden partition was built along the line of shores separating the part to be demolished from the remainder of the building, and then the first partition was turned over to the gang of laborers to be demolished.

**Tearing down.** The contract to tear down the building was sub-let, and the sub-contractor's method of attack consisted in the destruction of everything within the reach of picks, shovels, heavy hammers, and crowbars. The slate roof was grubbed off. The louver sash were knocked out by means of heavy hammers. The rafters and roof sheathing were thrown into the street and carted away for kindling wood. The broken glass, slate, and
rubbish was hauled to dumps. The large roof trusses, after being cleared of their loads, were lowered to the ground by gin poles and taken to pieces. The iron was sorted and sold for scrap. The truss members were very heavy timbers and were of the best white pine, but as there was no storage capacity, the material had to be disposed of at a very great sacrifice.

The method of tearing down the wall was new and interesting. The old building above the third floor was frame, so that there were only two stories of brick work to come out. After the wall was cleared of its load, the debris long the floor was cleaned away and a stretch of wall about 60 feet long and one story in height was freed at each end. To free the ends, the brickwork over the window heads and from window sills to floor at each end was cut out with picks. Workmen now placed a row of boards vertically against the wall at intervals of about 8 feet. Against these boards, heavy joist were leaned at an angle of 60°. The floor end of these joist were then made fast and workmen walked up them carrying crowbars to pry the wall out. The placing of a board against the wall was to give the crowbar a bite so that the men could pry out the wall. The line of fracture was anticipated by picking out a row of bricks along the floor line.

This method of work was followed throughout the entire razing of the old building. The one objection to it is the extreme danger to workmen and to traffic along a busy thoroughfare.
Staking out. After the walls had been pulled down level with the ground, the work of staking out was commenced. The face line, or street line beyond which the walls of the building are not allowed to project, was given by the City Surveyor. In this case the line was indicated by a chisel mark on the curb stones. The lines were run by the City Surveyor immediately after the building permit was issued. From this line, the dimensions of the building were proven. After any little discrepancies had been corrected, "benches" were set, and upon them were marked all the building lines as the work progressed.

These "benches" consisted of stakes, 2x3 inches, driven into the ground outside of the main trench lines, upon which were nailed 6x1-inch boards. Extra precautions were taken to guard the "benches" established at each end of the wall, by piling large stones and brick up around them.

By measuring in from the surveyor's line, the centre line of the wall was accurately established on the benches at each end of the wall. From this centre line, a series of benches was established along the wall with all the building lines upon them. The manner of constructing the benches and the method of giving the lines is clearly shown by Fig. 2, page II.

Excavations. All the excavations were made to the depth indicated on the drawings, ex-

Fig. 2. Manner of setting stakes.
cept the north wall foundation, which was dug 6-feet deeper owing to quicksand. The sides of the trenches for the east, west, and south walls were solid and did not require bracing, but the north wall and all of the column trenches, had to be held in place by close sheeting. These trenches were dug in decayed sandstone, and when they were at the required depth, a pick could not be sunk into the foundation three inches by a heavy blow, and yet with a sharp, square edged shovel a layer 1/2-inch thick could be shoveled off with ease.

The sheeting was 12x1 inch, rough, yellow pine boards, with strong pieces of 13x6 inch hemlock, and braces of 3x4 inch hemlock. The method of sheeting the trench is shown by the accompanying sketch. Fig.3 page 12. To keep the water below the foundations, a sump was dug and by means of buckets and a 2-man pump, the water was disposed of.

Foundations. The foundation walls were rubble masonry with concrete base. Fig. 4, page 23, shows the dimensions and the cross sections of the work.

The column foundations were very carefully put in, and consisted of a 36 inch bed of concrete rammed in 6
inch layers. Before putting in the last layer of concrete, the level for the I beams was given and a 2"x3" timber was set at this level on opposite sides of the trench. This required great care, for the columns were built in a solid mass to the third floor, and consequently any differences in level would be a serious matter and would cause great expense in connecting the girders, for new holes would have to be punched for the rivets either in the girder or the column. See the girder connections, Plates IV to VII. The work of giving the levels and setting the base, shown in Fig. 5 & 6 Plate III, fell upon the writer. The leveling was all done by a Keuffel and Esser building level and each setting was referred to the bench giving the datum line. (see specifications page 2.) The twenty column castings did not vary in level 3/8 inches when in place and fully loaded.

Concrete was next put in and leveled off, using the 2x3 inch timbers as templetes. Eighteen 10-inch I beams were next placed on the concrete.

The 10-inch I beams were bolted together by three series of rods and cast separators of the usual form fitting between the flanges of the beams and having lugs upon the sides through which the rods passed, clamping the whole together. Concrete was rammed between and around these beams, thus forming a solid mass 13 or 14 feet square. Upon and transverse to these 10-inch I beams were placed six 15-inch I beams. These also were held in position by three series of cast separators and rods, and were filled in with concrete and rammed. See Plate III, Fig. 5 & 6.
Columns. There were twenty steel columns, spaced 26 feet apart on centres east and west, and 28 feet on centres north and south, to support the floors of the building. The third and fourth rows, running east and west, from Hamilton street, extended through to the roof and carried the travelling electric crane and the lantern. The remaining twelve steel columns extended only to the fourth floor, the roof load being transferred to them through 12x12 inch yellow pine posts spaced 16 feet on centre.

Plate IV shows the cast base resting upon the six 15-inch I beams hertofore described. This plate also shows two views of the girders carrying the first floor electric crane.

Plate V shows two views of the connections of the floor beams carrying the second floor. The upper portion of this plate shows the floor beams for the third floor and also the splice in the column.

Plate VI shows the floor beam connection for the fourth floor, with wooden joist in position and the double thickness of the flooring thereon. The upper portion of this plate shows two views of the girder carrying the electric crane. This girder rests upon the top of the main column. Rivetted to one side of these columns is a bracket upon which rests the short column carrying the lantern. Two views of this column are shown on the upper portion of Plate VI.

The writer thinks the method of staying the electric crane girder very ingenious. This is fully shown on Plate VI.
The method of supporting the rail was even more ingenious. On top of the girder was rivetted a channel as shown in Plate VI. On top of this channel were placed hooks made of plates 3/8-inches thick and about 3 inches wide and 9 inches in length, shaped to fit the flange of the rail as shown in the following sketch.

A rivet was passed through the channel on top of the girder. These hooks were spaced about 3 feet apart, the end b being alternately on opposite sides of the rail.

Plate VII shows the steel truss over the electric crane supporting the lantern. The roof, with the exception of that over the electric crane, was supported by wooden trusses as shown in Plate VIII.

The sub-contractors for the erection of the steel work, Cofrode and Saylor, used two 12x12 inch yellow pine timbers for gin poles to erect the first section of the building; and after one end was up, they used the steel columns as masts and harnessed up two long poles for booms. The handling of the steel thereafter was remarkably rapid. The large girders were lifted from the cars by one of these booms, transferred to the gin poles and temporarily bolted in place without ever being landed.

Walls. The brick walls were carried up in piers and panels, the panels being offset from the pier face 4 inches. The thickness of the walls through the different stories were as follows:—First 30 inches, second 26 inches, third 22 inches, fourth 18
The panels acted merely as screens and were pierced in each story by two large windows. The piers were on an average 13 feet between centres, and were 30 inches in breadth. They were carried plumb and extended to the battlement. The piers were designed to carry the wall end of the girders. To distribute the dead load over the piers, a granite block was built into the wall. The wall was carried up around the end of the girders, allowing two inches for clearance.

Either through carelessness in designing, or owing to misunderstanding of the location of the girders, the granite keystones of the two main entrances on the Hamilton street front came in the way of the girders. To overcome this difficulty, the springing line of both of the arches was lowered; but even then the loading on the keystone is objectionable. Two girders should have been placed along the wall to transfer the load to the piers.

The centres for all the arches were built in the contractor's shop, and were delivered at the works ready to be set in place. The centres for the reveal arches over the windows were 1-inch boards cut to the given radius, and temporarily nailed to the window frames.

The load over the window was carried by heavy cast iron lintels having an end bearing of 6 inches.

The lintels for the first story had ribs, 6 inches deep and 5 inches apart. The base was about 1 inch thick and 22 inches wide. The lintels for the other stories had but a single
rib, about 6 inches deep and 1-inch thick. The base for these lintels was 1-inch thick; the width for the second story was 18 inches and decreased 4 inches for each successive story. Fig. 4 shows sections, plans and elevations of the two lintels.

Fig. 4. Lintels.

Girders. The floor system consisted of two sets of girders, one the stringers, upon which the floor joist rest, and the other the floor beams which transfer the floor load from the stringers to the columns. The stringers were 30 inches deep, spaced 13 feet 6 inches on centres, and consisted of one web plate, two top angles, two bottom angles, without stiffeners or cover plates. The floor beams were 45 inches deep, stiffened by 3x3 inch angles, and had four flange angles, and a top cover plate extending to within 4 feet of each end. In Plate VI these two girders are clearly shown.

The crane girders had an entirely different form. The
electric crane in the first story was built to pick up engines, and turn them 90° to storage tracks. These girders are shown on Plate IV. They consisted of a 1/2 inch web plate, 3x3 inch angle stiffeners, two top angles, two bottom angles, and a channel rivetted to the top flanges with its legs down. The girder is supported by brackets rivetted to the columns, as clearly shown in Plate IV.

The crane on the fourth floor was used to lift tenders from the main track to the parallel tracks for painting. These girders consisted of an I beam with a channel rivetted on top with flanges down. See page 26, Plate VI.

**Floor System.** The flooring is fully described in the specifications page 5, but the reason for using square edged top flooring is not apparent and it is of especial importance.

The Baldwin Locomotive Works comprises a vast number of buildings, and in connection with the maintainence of them, the Baldwin people run a mill. In all of the buildings this I 1/4 x 6 inch stock with square edges is used, and the firm keeps a supply on hand for repairs. One can easily see that the repairs are more readily made if the edges of all the boards are square. Further if the boards were tongued and grooved they would need replacing before the material in the board was half gone, for the tongue and edges along the grooves would splinter out. Square edged flooring can be used until entirely worn away. With the heavy tongued and grooved under flooring, dirt can not
get through the floor.

Roof. The roof, with the exception of that over the electric crane, was supported by wooden trusses.

The fourth floor was designed as a paint shop and in consequence the whole area must be well lighted, and as many direct sunlight rays must be excluded as possible. To meet these requirements the truss shown in Plate VIII was designed. The form of the truss meets the requirements as to admitting light, but is severely at fault in that the shear should be thrown over the support and not 4 feet 3 inches in from the face of the wall as is done with trusses over the end bays. The half panel dead load is: lumber 2300 lbs.; snow 2500 lbs.; sash 3500 lbs.; slag roofing 2500 lbs.; or total 5600 lbs.; which gives 2988 lbs. per sq. in. The allowable fibre stress for yellow pine is 1250 lbs.

Contractor. The contract to erect the building was let as a whole to Stacy Reeves and Sons who sub-let the razing of the old building and foundation excavations to People Bros.; the stone masonry and bricklaying to Dorsey and Smith; the erection of the steel work to Cofrode and Saylor; the slag roofing to Warren Ehret & Co.; and the dressed stone work to William Gray and Sons. Stacy Reeves and Sons did the carpenter work with their own men.

The general contractor placed in charge of the work a superintendent who acted as foreman carpenter for the firm's
employees, and advanced the different lines of work in the interest of the early completion of the entire building. All materials purchased by the contractor were checked upon arrival at the building before being receipted for. The number of steel members was checked by the contractor upon arrival, and the weight of metal was checked by the Baldwin people as they furnished all the steel.

The general contractor furnished crowbars, heavy hammers, timber jacks, jack screws, cant hooks, boring machines, etc., and had upon the works two gin poles and one fine derrick.

The contract price was over run on account of the extra work caused by the necessity of getting the building done earlier than expected. When the contract for the work was let, the Baldwin Locomotive Works were running on short time; but immediately after the new building was started, an order was received from the Russian Trans Siberian Railway for 25 locomotives for immediate delivery and 25 to follow as soon as possible. After receiving this order instructions were give to Stacy Reeves and Sons to rush the completion of the building. Every inch of floor space was used by Baldwin employees, and the contractor for the building was pinched for room in which to execute the work of erection.

Conclusion. It was remarkable that in 90 days, an old building filled with machinery in operation should be demolished and replaced by a fine, new structure, without materially interfering with the running of the machinery. In transferring
the machines from the old building to the new, almost no time was lost in the operation of the machine. Shafts and belts were provided for the new position and the only time lost was while the machine was in process of transfer. By use of gin poles, rollers, and shears the machines were quickly transferred from the old position to the new.

In the light of the experience it is difficult to see wherein the methods employed could have been materially improved to secure either greater economy or expedition.

Not the least interesting feature of the work was the fact that the old building was demolished and the new one erected above the heads of those operating the machines without material interference or serious accident thereby.
PLATE II.
For Column B:
18-10" I Beams - Sec. 511 - 23.21 Lbs. Per Ft. 12 Ft. Long
6-15" I ... 521.42.94 ... 12 ... 

Fig. 6

For Column A:
18-10" I Beams - Sec. 511 - 30.02 Lbs. Per Ft. 13 Ft. Long
6-15" I ... 522.56.98 ... 13 ... 

Fig. 5
PLATE VII

5 Luq 5 x 3 x 3/8 x 6/12

1 Pl. 4 x 3/8
2. 2 x 3 x 3/8
1 Pl. 12 x 3/16

4 x 3 x 3/8

Pl. 2.4 x 5/16

2 Purlines 5 x 3 x 3/8

2 1/4 x 3/16 Lattice
PLATE VIII