AMERICAN ENGINEER AND RAILROAD JOURNAL.

JUNE, 1899.

CONTENTS.

STANDARD CONSOLIDATION FREIGHT LOCOMOTIVES.

PENNSYLVANIA RAILROAD.

Classes H5 and H6.

WITH AN INSET.

No locomotives ever built in this country or abroad have been designed with more care and intelligence or with the benefit of wider experience than the heavy freight engines, Classes H5 and H6, of the Pennsylvania Railroad.

These two consolidation designs are for entirely different purposes. H5 is a special pushing engine for mountain service at Altoona, where maximum power is required for a short distance only. Fifteen of these are in service, and, as far as possible, the same details were used in H6, which is a road engine, and was not required to be as powerful. The differences are seen in the drawings and dimensions, Figs. 2 and 3 of the inset accompanying this issue. The boilers are the same except at the back ends, and the details shown in the drawings apply generally to both. The differences in appearance between the two designs are not marked, even when they are seen standing together. The general plan of each design is shown and the details presented in the drawings are nearly all of H6, and are practically the same for both.

The locomotives of both classes now in service have been built at the Juniata shops and an order for 25 of the H6 is now in hand at the Baldwin Locomotive Works. The preliminary work was so thoroughly and well done that road experience with both designs has not developed a defect or shown a single desirable change to be embodied in the ones now building. There are few locomotives built under present conditions of which this may be said. Fig. 1 is from a photograph of engine No. 1,431, one of the H5 class, which shows the general appearance of both. For such large engines they are remarkably handsome.

Of Class H5 we give the following general dimensions:

Cylinders	23½x28 in.
Cylinders, spread	90 in.
Tubes, number	306
Tubes, outside diameter	2 in.
Tubes, length between sheets	14 ft.
Firebox, inside	10 ft. x 40 in.
Heating surface tubes	2,720 sq. ft
Heating surface firebox	197 sq. ft.
Heating surface, total	2,917 sq. ft.
Steam pressure	185 lbs.
Weight, working order	198,000 lbs.
Weight on first drivers	43,000 lbs.
Weight on second drivers	43,800 lbs.
Weight on third drivers	45,900 lbs.
Weight on fourth drivers	43,800 lbs.
Weight on truck	21,500 lbs.
Weight of tender, loaded	104,600 lbs.
Water capacity	6,000 gal.
Coal capacity	22,000 lbs.
Least internal diameter of boiler	71 in.
Drivers, diameter	56 in.
Driving journals	9x13 in.
Engine wheel base	25 ft. 11½ in.

The weights of these engines are not given as absolutely accurate, but they are very nearly correct. The following figures were taken from H6 engine No. 321:

Weight:	
Truck wheels	20,131 lbs
Front driving wheels	44,000 lbs.
Intermediate driving wheels	40,200 lbs.
Main driving wheels	41,450 lbs.
Rear driving wheels	40,900 lbs.
Total	186,681 lbs.

These weights were taken with an average fire and about 2½ gauges of water in the boiler.

Boiler.

The boilers are of the Belpaire type, with curved crown and roof, and with the firebox above the frames, and with two cylindrical courses in front of the firebox. Cutting off the back head of H6 at an angle, besides lightening the back end and throwing the center of gravity farther forward, offers a more favorable arrangement of the firebox heating surface by removing the dead spaces at the upper back corners, and there is less radiation at long range while none of the available surface of the crown sheet is sacrificed. The space thus gained is used for an admirable arrangement of cab fittings. The sides of the boiler in the cab are flattened inwardly to further increase the room.

The sectional view of the boiler, Fig. 4, shows the water spaces to be 4 inches wide all around at the mud ring, and much wider above, where the necessity for long staybolts is greater. A free entrance for water is had at the throat through a space 5½ inches wide. Though there are 369 2-inch tubes, these are not placed near enough to the shell to interfere with free circulation, and a clear water space is left below them. The length of the tubes is 13 feet 7½ inches, and the diameter of the shell is 76 inches, the firebox is 10 feet long by 4 feet wide, the grate area being 33.3 square feet, and the heating surface 2,812 square feet.

The crown bolts are fitted with cup nuts, except the three bolts in each corner of the crown sheet, which are fitted with expansion joints. All of the stay bolts in the firebox, which are shown in Fig. 4 in the form of circles, are of the Nixon patent, illustrated in our issue of September, 1897, page 320. The following details of the boiler are interesting:

Fire area through tubes	6.39 sq. ft.
Grate area	33.33 sq. ft.
Heating surface tubes (external)	2,632 sq. ft.
Heating surface, firebox	180 sq. ft.
Heating surface, total	2,812 sq. ft.
Steam pressure	185 lbs.
Weight of boiler without flues	31,563 lbs.
Weight of flues	11,320 lbs.
Weight of boiler, total	42,883 lbs.

The outside sheets of the firebox are only ⅜-inch thick. This is unusual and is but half the thickness of the barrel sheets. The object was to favor the staybolts as much as possible and relieve them of the effects of the stiffness of thicker sheets. The presence of the stay bolts renders it possible to reduce the thickness, which in this type of firebox does not need to be greater than that of the inside sheets. This, the form of the firebox, the Nixon stays and the best staybolt material may be expected to give good results as regards staybolt breakages. The crown sheet is ⅜-inch and the flue sheets are ½-inch thick.

The mud ring corners are turned with 7-inch radii, which should help to prolong the life of the firebox. At the back end the sides of the firebox are straight and vertical, to give more room in the cab. Wash-out plugs are distributed as follows: 4 over the crown sheet, 2 in the top of the boiler, 2 (6-inch) under the boiler, 3 in the back head opening over the crown sheet and one at each corner of the legs of the firebox. The boiler has a dome, with a pressed steel top, using a straight sheet for the dome and cutting the flanged dome joint piece also straight on top, as shown in the boiler drawing. The fire door is oval, which was the nearest possible approach to a rectagular hole, and at the same time avoiding the troublesome flanging of corners. The construction of these boilers merits an entire article. They are so carefully laid out and the work is so accurate as to be interchangeable. A back head was recently sent out from Altoona to be put into an H4 boiler at another shop, and, the work being done on formers and to templates, it was so accurate that it fitted in the boiler built some time previously.

Cylinders.

The cylinders are cast separate from the saddle, which at first sight may appear to be retrogressing, but there are several very good reasons why this is a good plan. It is not new except in application. The reasons are: (1) With this construction the shrinkage stresses, due to the form of the casting, which are so dangerous to the life of ordinary cylinders cast with the half saddle, are avoided. (2) The material for the saddle and the cylinders may be selected with reference to the work each has to do. A tough, strong iron, with comparatively low shrinkage, may be used for the saddle, and hard, close-iron (which necessarily has high shrinkage) is used for the cylinders. There appears to be no difficulty to guard against the shrinkage when the castings are separated. (3) Separation simplifies the foundry problem, because it avoids the necessity for the chilling cores which were found necessary to spread the shrinkage and to prevent the formation of porous, spongy spots. (4) There is an advantage in repairs, because one cylinder may be taken down without removing the other cylinder or the saddle. (5) A two-bar frame is a necessary accompaniment of the cylinder and half saddle plan and with such an arrangement it is impossible to secure a frame connection as strong as the one before us. These reasons are probably responsible for the selection of this form of construction, and it is likely to be used in future designs in both freight and passenger locomotives on the Pennsylvania.

This arrangement of cylinders necessitates rigidity in the frame, the frame splice and the attachment of the cylinders and the saddles. The keying has been attended to with great care. The frames at the cylinders take the form of slabs 2 by 31 inches in section and vertical flanges on the inside and outside of each frame form contacts for the cylinders and saddle. The flanges at front and back are vertical and the wedges only are planed at an angle. The wedges are cut on the planer, together and by reversing pairs they must fit correctly. It would be impossible to secure a rigid fastening by attempting to plane the frames at an angle. This plan relieves the bolts from shear. They are in tension only. The saddle casting, which would otherwise have a tendency to rock in the frames, has four bearing surfaces at each frame, the center of the portion which meets the flange of the frame being cut away so as to clear the flange and remove the possibility of the saddle rocking in case the fit should be tighest at or near the center. This is one of the relatively small details that contribute to make this design so interesting and worthy of study. The strong ribbing of the cylinder connection plate is seen in Fig. 5. In the exhaust passage care has been taken to aid the steam in the direction of the nozzle by removing the corner or pocket usually found just below the exhaust port. This is shown in Fig. 6. The saddle is also very strongly ribbed and the steam and exhaust passages are separated with air spaces between them. Drainage of water from the two steam cavities at the ends of the cylinder casting is provided by means of a pipe leading to an independent cock under the center of the cylinder and operated by the cylinder cock lever. A further movement of the lever, after the cylinder cocks are open, opens this center cock to drain the steam cavities and the cylinder cocks close after this drainage cock is closed. With a leaking throttle this valve will do good service.

Frames.

With a maximum thrust of about 68,400 pounds from each cylinder, alternating as to direction, first on one side and then on the other, the frame problem is a difficult one and those who are having trouble with broken and loose cylinders will find these drawings valuable, because, so far, there has been no trouble of this kind. The front sections of the frames are cast steel and every precaution was taken to give rigidity and strength to the fastenings. The holding power is largely due to correctness of fit and arrangement of parts, which make this possible. The frames for both types are very nearly alike, Fig. 7. Aside from the transverse bracing afforded by the cylinders there is a cast iron bumper at the front ends of the frames, a cast steel plate across the frames at the frame splices and a strong connection brace at the back ends of the frames. The bracing against twisting stresses and those which come in taking curves on the road are provided back of the cylinders, where the tendency to wiggling actually takes place, because the designer believes that these stresses cannot be resisted by any amount of bracing placed in front of the cylinders. This is particularly applicable to the case of thin frames. The great vertical strength of this form, or slab frame, at the cylinders is also noteworthy.

The frame splice is interesting in that the keys are in compression and are relieved entirely from shearing stresses. This form has been used, as shown in the sketch, Fig. 8, which was adopted in 1892 for Class M engines. This is a very simple and important improvement. It is so easy to see its advantages, in avoiding shear and in the possibilities of securing a good fit, that one wonders that it has not been used always. The splice of Class H6 is an improvement upon the earlier form in the number of bolts used.

The expansion pads and frame clamps are shown in Fig. 9, the rear clamps and pads being similar to the front ones, which are illustrated. The parts are arranged to relieve the studs of the usual tearing stresses. The firebox tends to push against the studs, as will be easily seen in the engraving. No wear is permitted on the mud ring or the frames. The supports for the frames and also the spring seats are provided in the steel castings fitted between the upper and lower bars of the frames.

Running Gear.

Pistons.—The pistons, Fig. 10, are made with a steel centre in the form of a dished single plate to which is bolted a T shaped ring of cast iron with two packing rings. The thickness of the piston for a distance determined by an angle of 60 degrees from each side of the center at the bottom is 5 inches, for the purpose of increasing the bearing surface, while for the remaining 240 degrees the thickness is reduced to 3⅝ inches. This increases the wearing surface where it is needed, without unduly increasing the weight of the reciprocating parts. The cylinder heads provide for the thickening of the pistons without increasing the steam clearance space. The entire surfaces of the pistons are dressed.

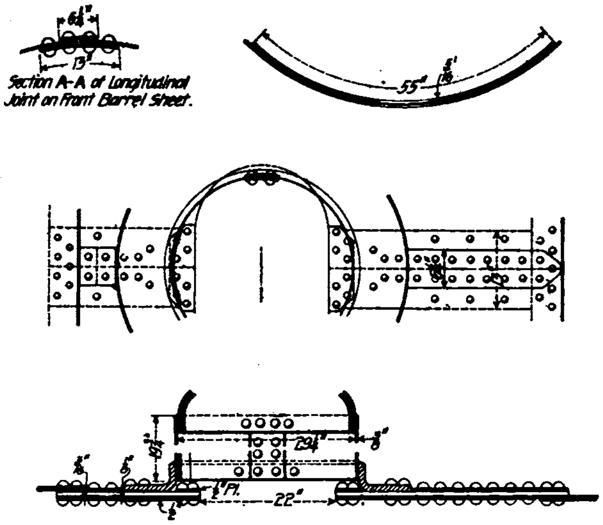
Piston Rods.—There is nothing unusual about the piston end of the piston rod. It is drawn up to a shoulder by a nut, but the crosshead end is exceedingly interesting, because there has been no piston rod breakage with these engines and with this design it is safe to say that there will be none unless due to bad fitting. The piston rod is shown in Fig. 11, and the cross head in Fig. 12. The rod bottoms in the cavity in the crosshead and the key does not stretch the rod (see "American Engineer," January, 1899, p. 9), but this is not all. The taper is increased to prevent too hard driving and the taper portion of the rod is cut away at the central part of its length, leaving bearing surfaces 2 3/16 inches long at each end. This is the idea followed on the cylinder and saddle joints and in the bearings of the rocker shafts. In the case of the crosshead fits it prevents the rocking of this connection, which results from swelling the piston rod by cutting the key way. A great aid in good fitting is provided in the slope of the key way in the piston rod and crosshead boss, as shown in the piston rod drawing, Fig. 11, the key slot being at right angles with one of the sides of the tapered end of the rod. The bearing against the crosshead boss is square. The end of the rod is, of course, enlarged.

Guides and Crossheads.—The guides, Fig. 13, are of the two-bar type and of steel and 6 inches wide, with raised wearing surfaces on the sides in order that when truing up it shall not be necessary to also plane off the guide lugs. The crossheads, Fig. 12, are cast steel with block tin wearing surfaces 1/16 inch thick and with 2-inch wearing surfaces on the edges of the guides. The guide shoes are secured to the crossheads by lock nutted bolts. This is a very light crosshead for such a heavy engine.

Driving Boxes.—The driving boxes, Fig. 17, are not symmetrical with reference to the journal bearing. The total length of the bearing is 13 inches, and the center of load is 1 inch outside of the center of the box. The object of this is to throw less weight upon the inner edge of the box, where the greatest wear generally occurs. The driving boxes are still more interesting in their methods of lubrication. The bearings are phosphor bronze and they have no openings at the top of the journal, but grooves ⅝ inch wide, located 1¼ inches above the center of the axle and extending across the box, front and back, to within ½ inch of the ends of the bearing. The reason for this method of introducing the oil will be found in our March, 1898, issue, page 91. The oil is fed from a cavity in the top of the driving box and the best thing about this idea is that it is successful and the journals very rarely heat. The hubs of the wheels are lubricated by grooves and the oil for this purpose is held in a separate cavity in the top of the box. The large cavity is for the journal. The wedges and shoes are oiled by four grooves at each side, receiving oil from other cavities at the front and back sides of the top of the box.

Crank Pins.—The enlarged wheel fits and ample fillets of the crank pins appear in Fig. 14.

Driving Axles.—The main axle, Fig. 16, shows the principles of construction of all the driving axles, which are of steel. The journals are large and the wheel fits are one inch larger than the journals in diameter. We desire to direct special attention to the form of the key ways in these axles. They are made with cutters, having a radius of 2¾ inches. Also, the enlarged ends of the axles where they enter the wheels are worth imitating. A very slight shoulder is left against which to bring the wheel hubs in pressing them on.



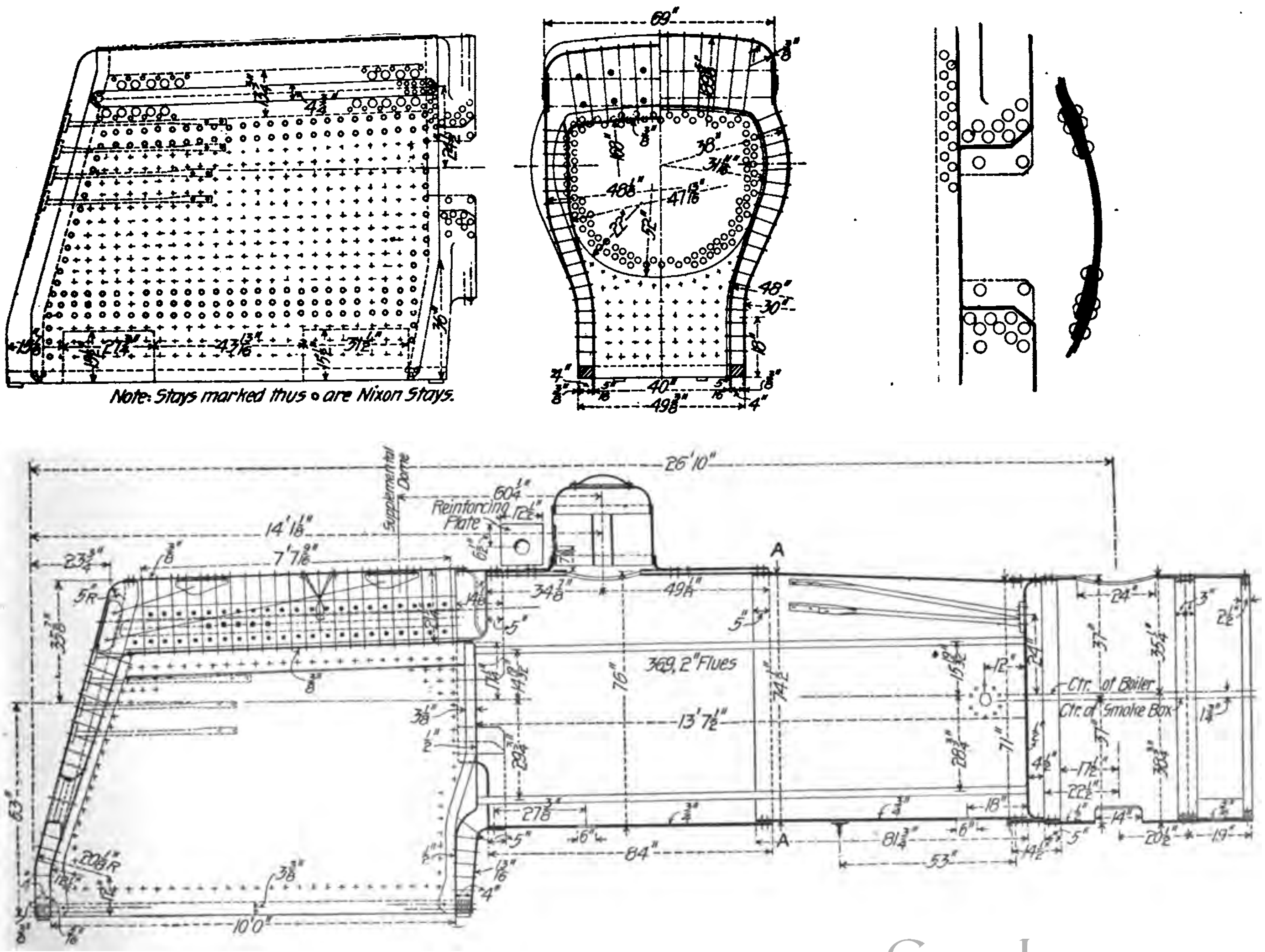
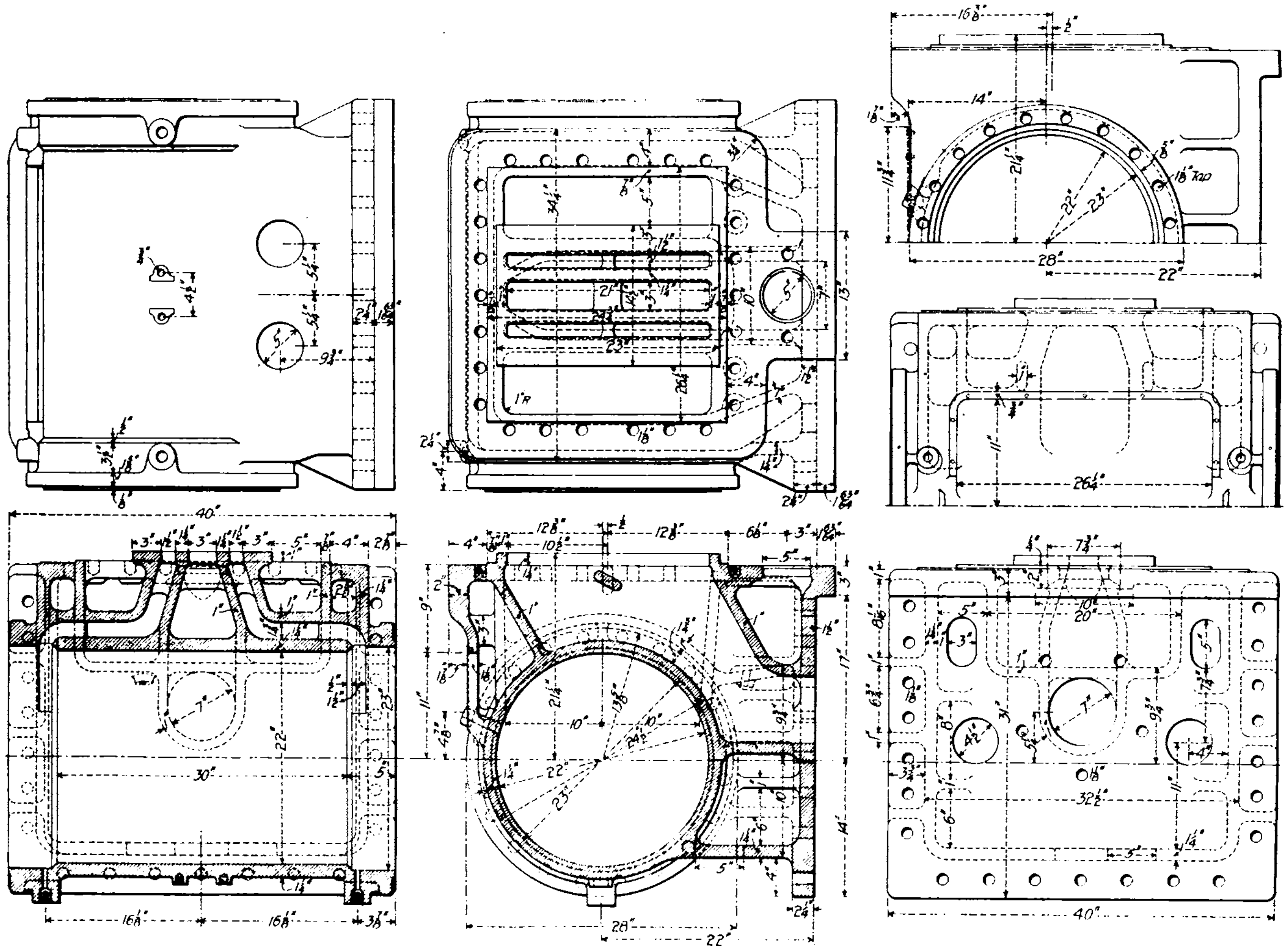
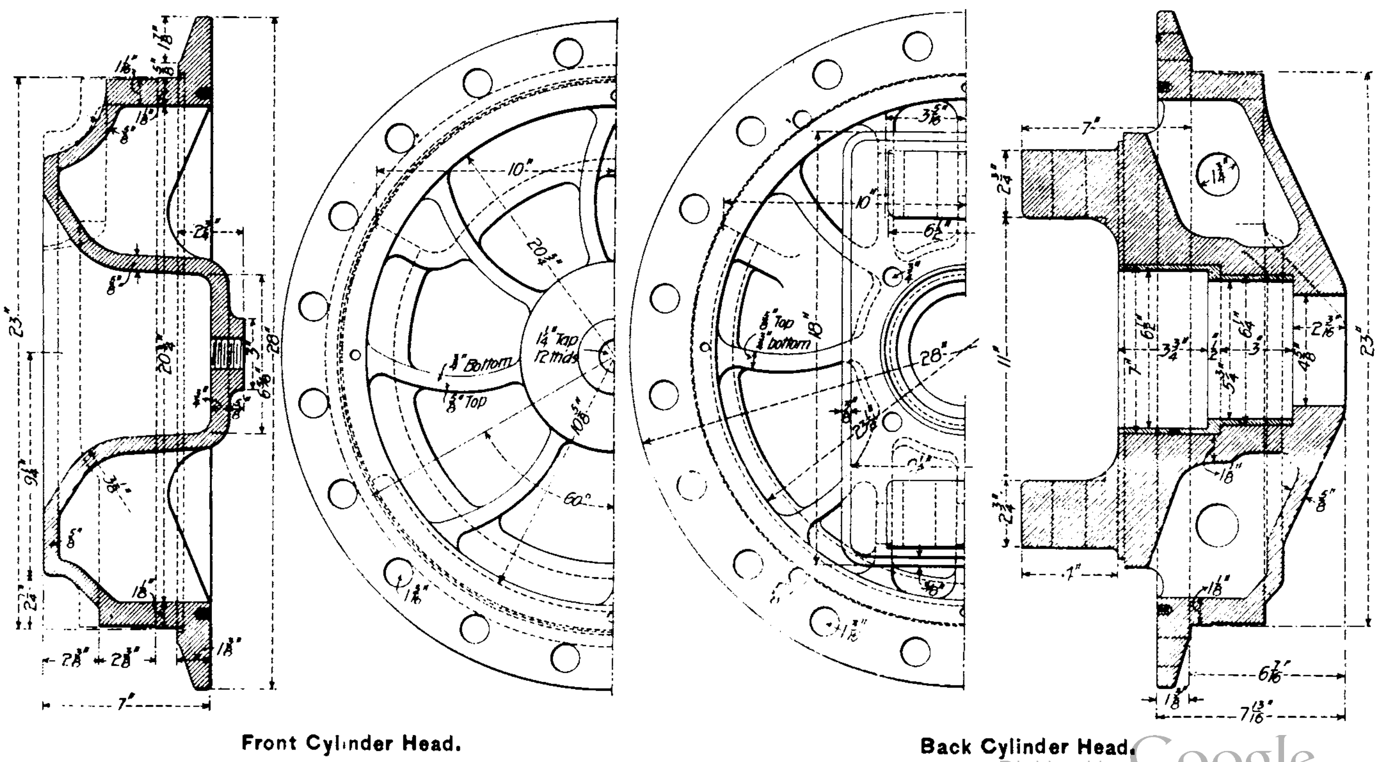


Fig. 4.—Boiler and Boiler Details.—Class H 6.



Cylinder and Cylinder Heads.



Front Cylinder Head. Back Cylinder Head.

FIG. 6.—CYLINDER AND CYLINDER HEADS, CLASS H6.

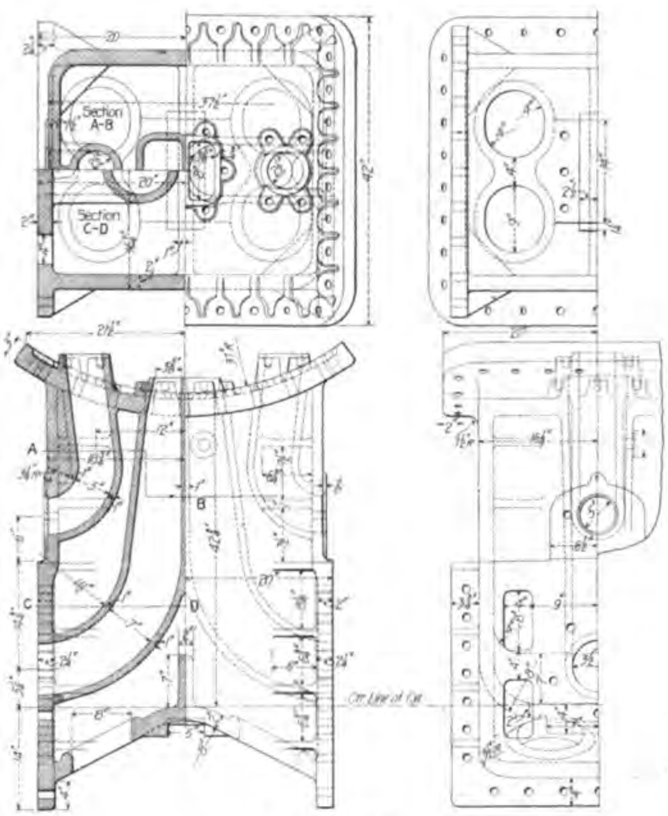


Fig. 5.—Saddle.

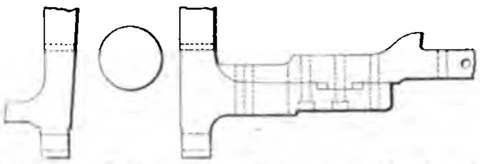


Fig. 8.—Frame Splice, Class M. Engines, Used in 1892.

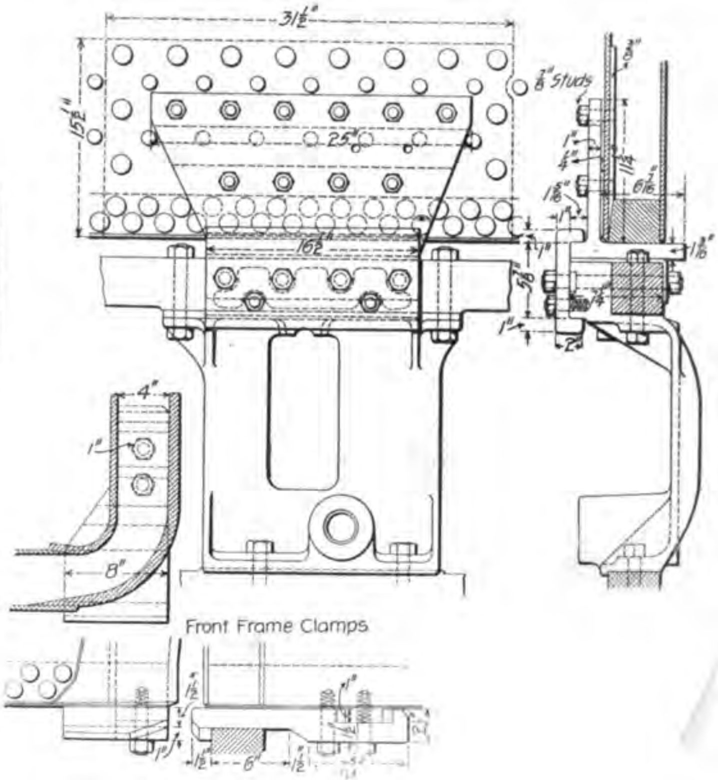


Fig. 9.—Expansion Pad and Frame Clamp.

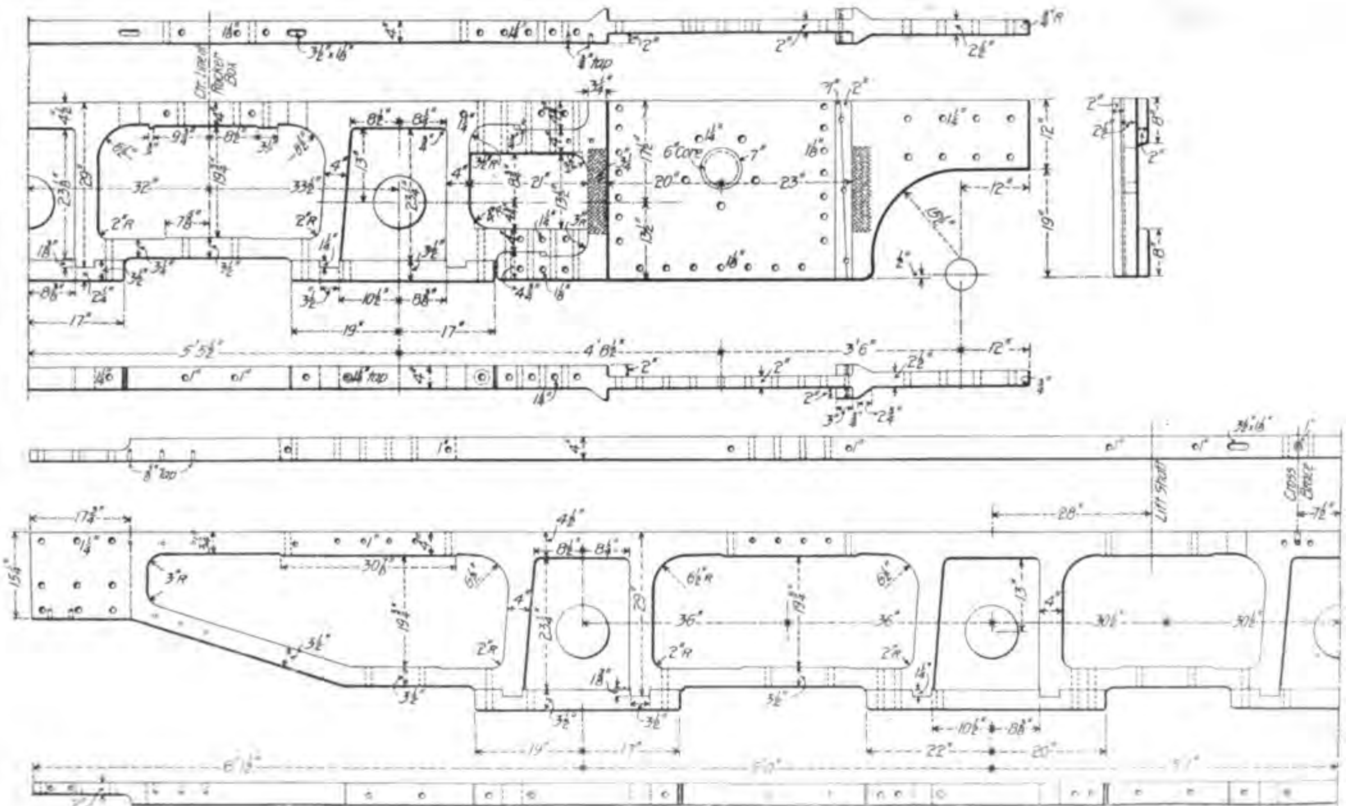


Fig. 7.—Frames—Front Portion of Cast Steel.

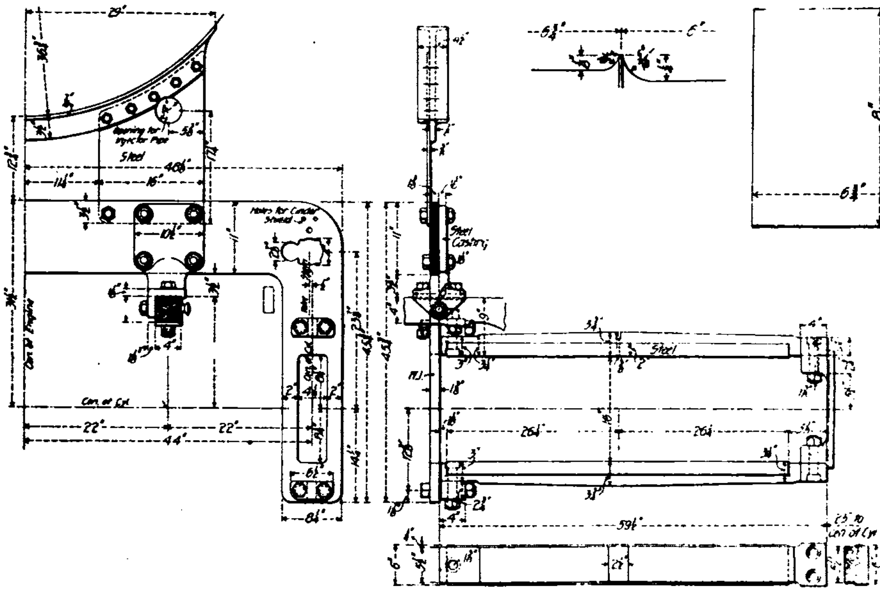


Fig. 13.—Guides and Guide Yoke.

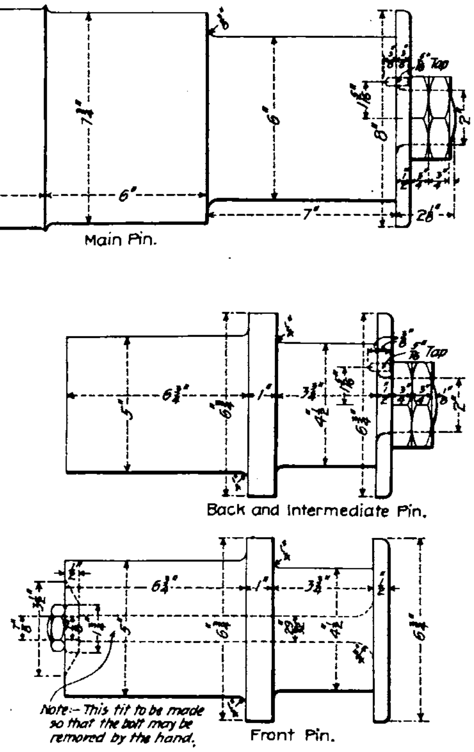


Fig. 14.—Crank Pins.

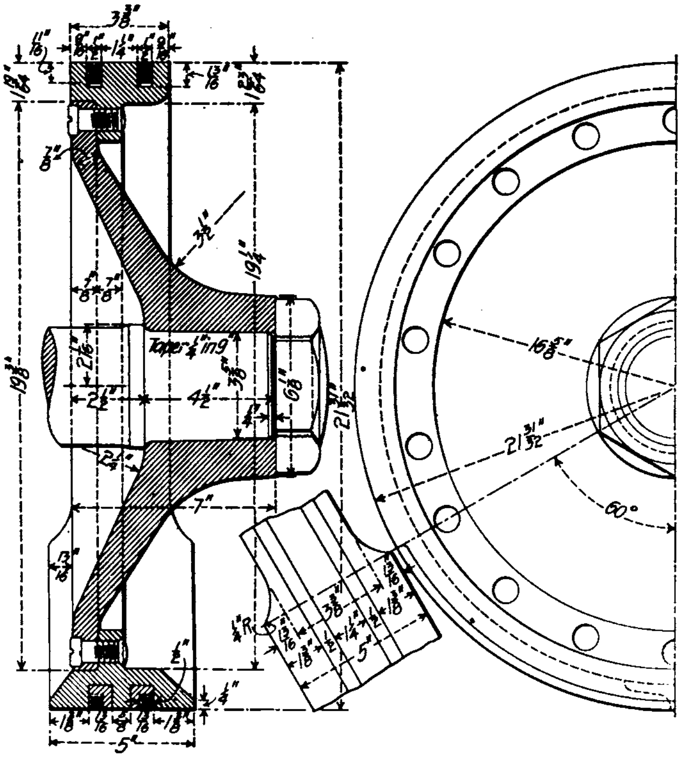


Fig. 10.—Piston.

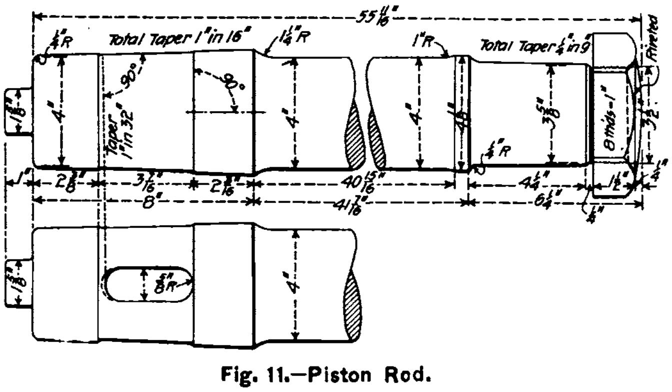


Fig. 11.—Piston Rod.

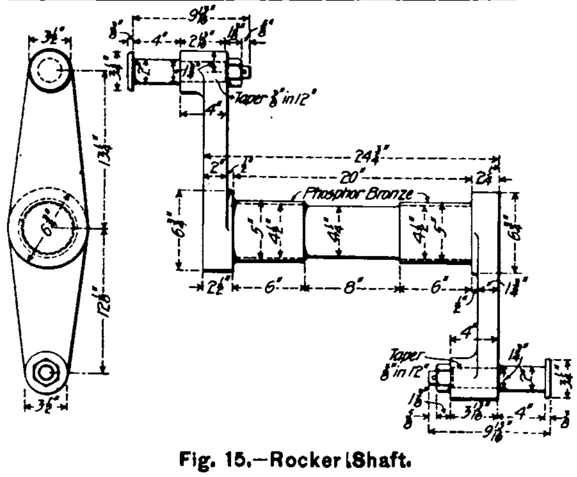


Fig. 15.—Rocker Shaft.

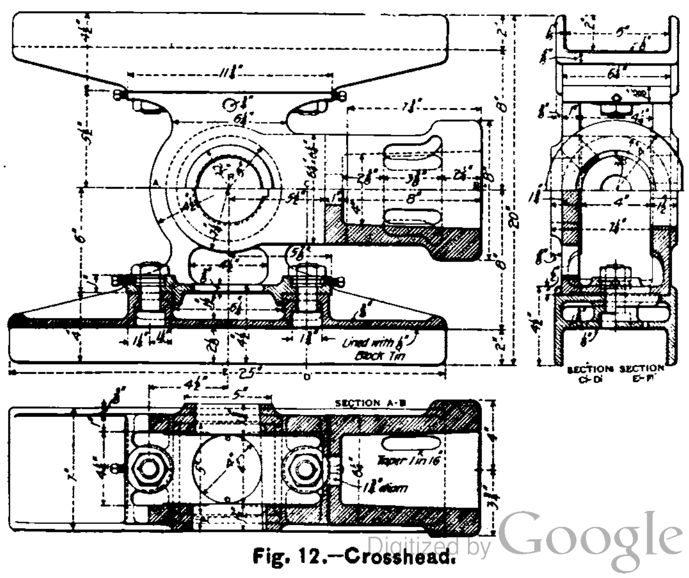


Fig. 12.—Crosshead.

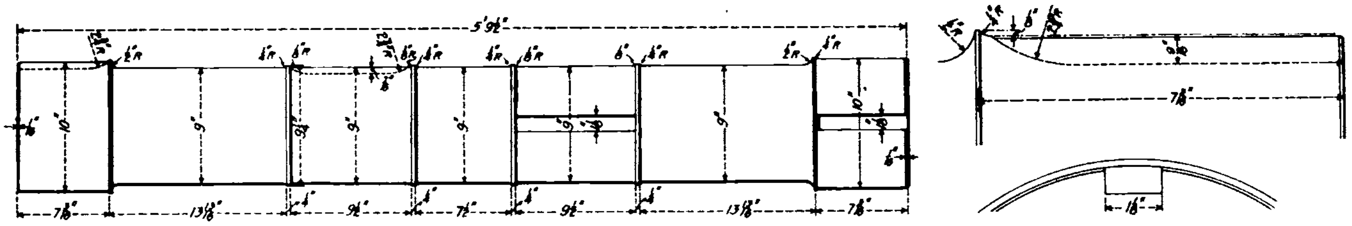


Fig. 16.—Driving Axle.

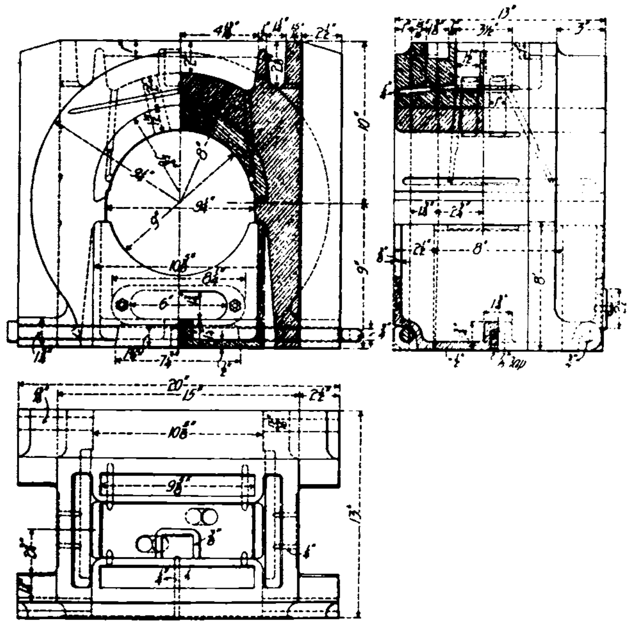


Fig. 17.—Driving Box.

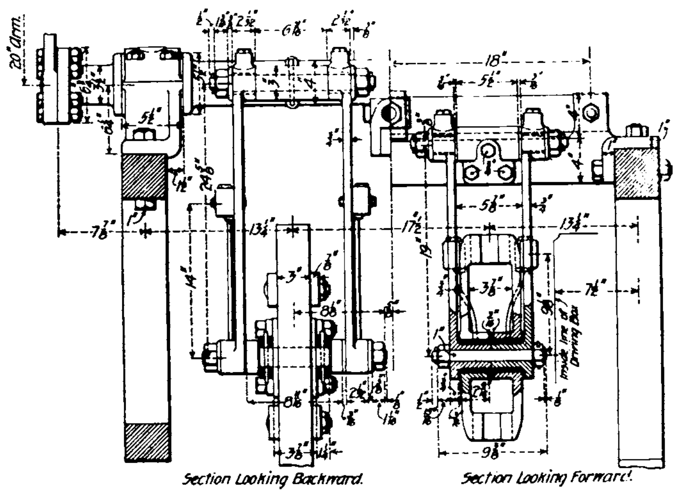


Fig. 18a.—Sections Through Valve Motion.

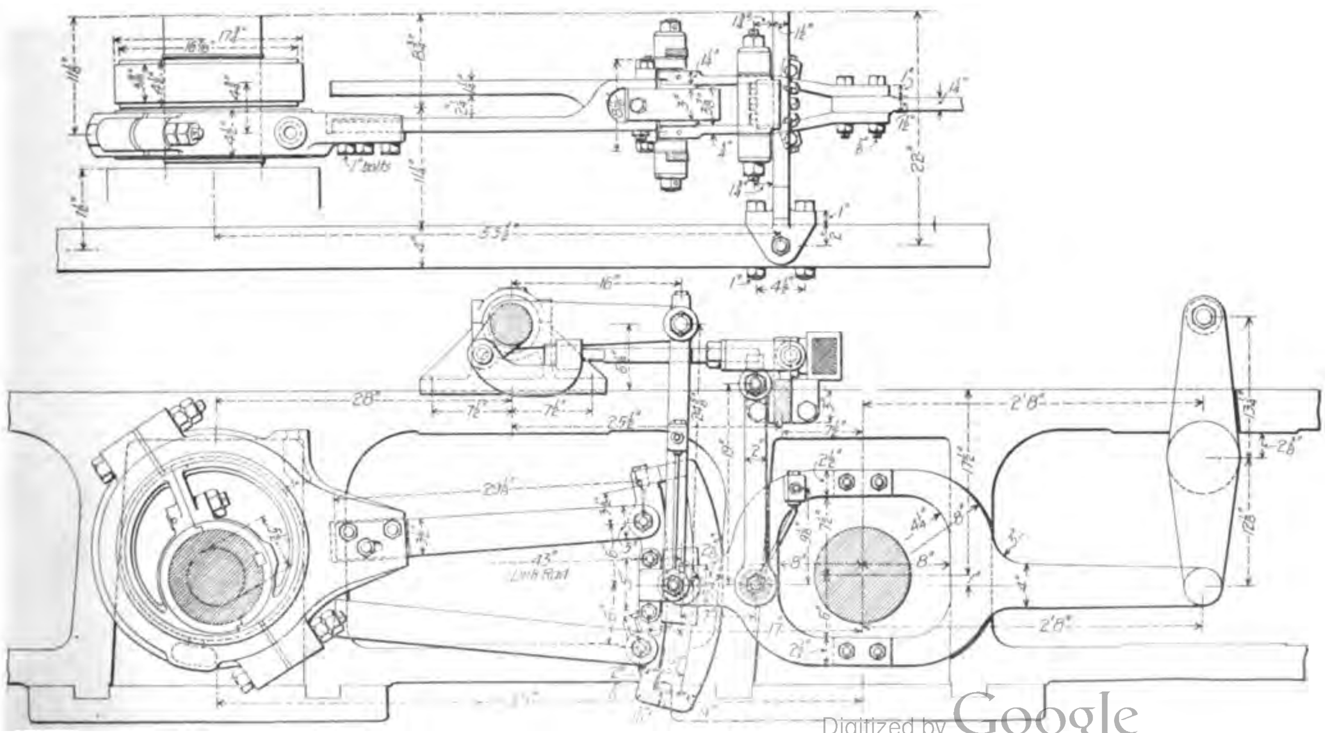


Fig. 18.—Valve Motion

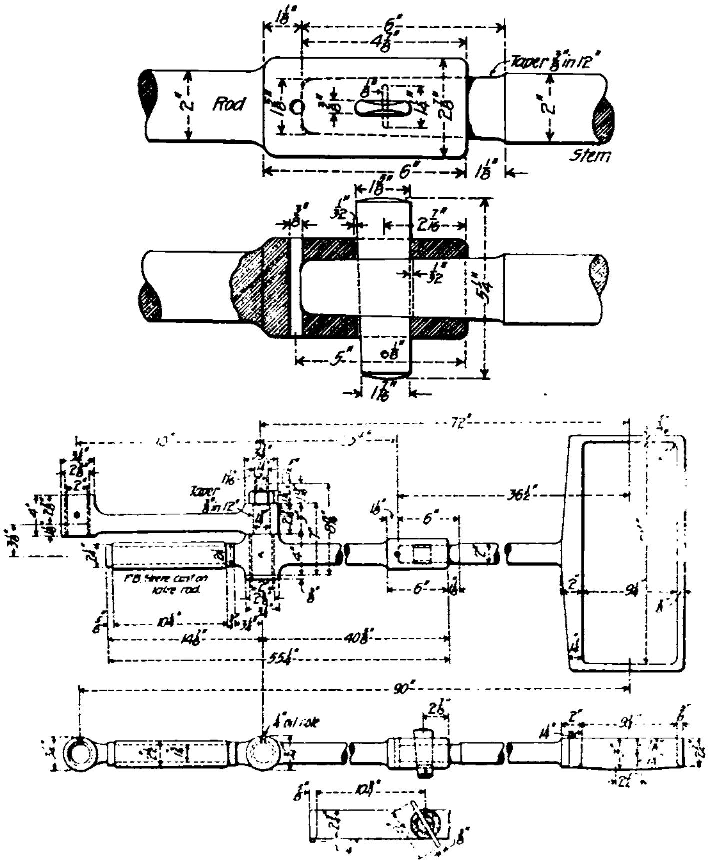


Fig. 19.—Valve Stem and Yoke.

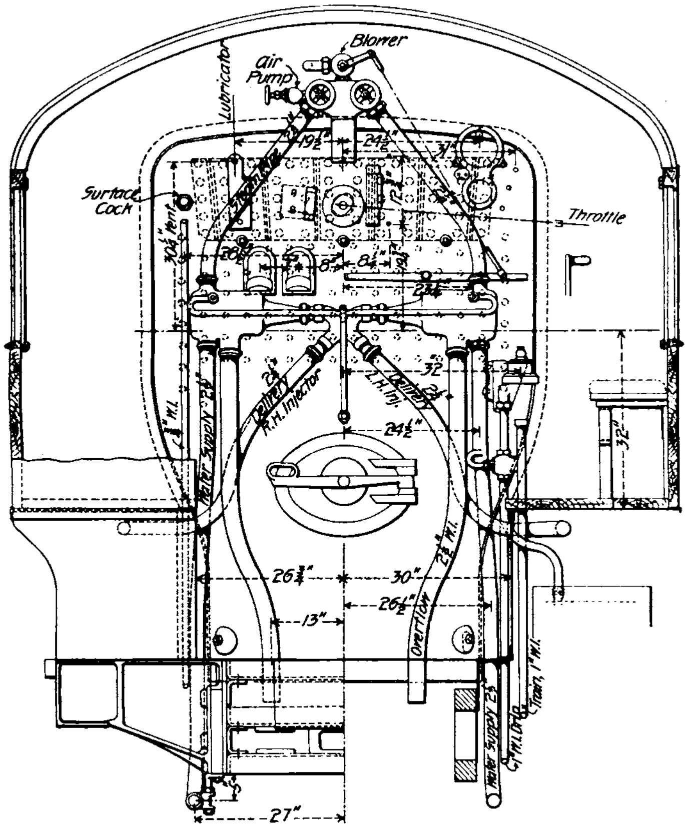


Fig. 20.—Cab Fittings.

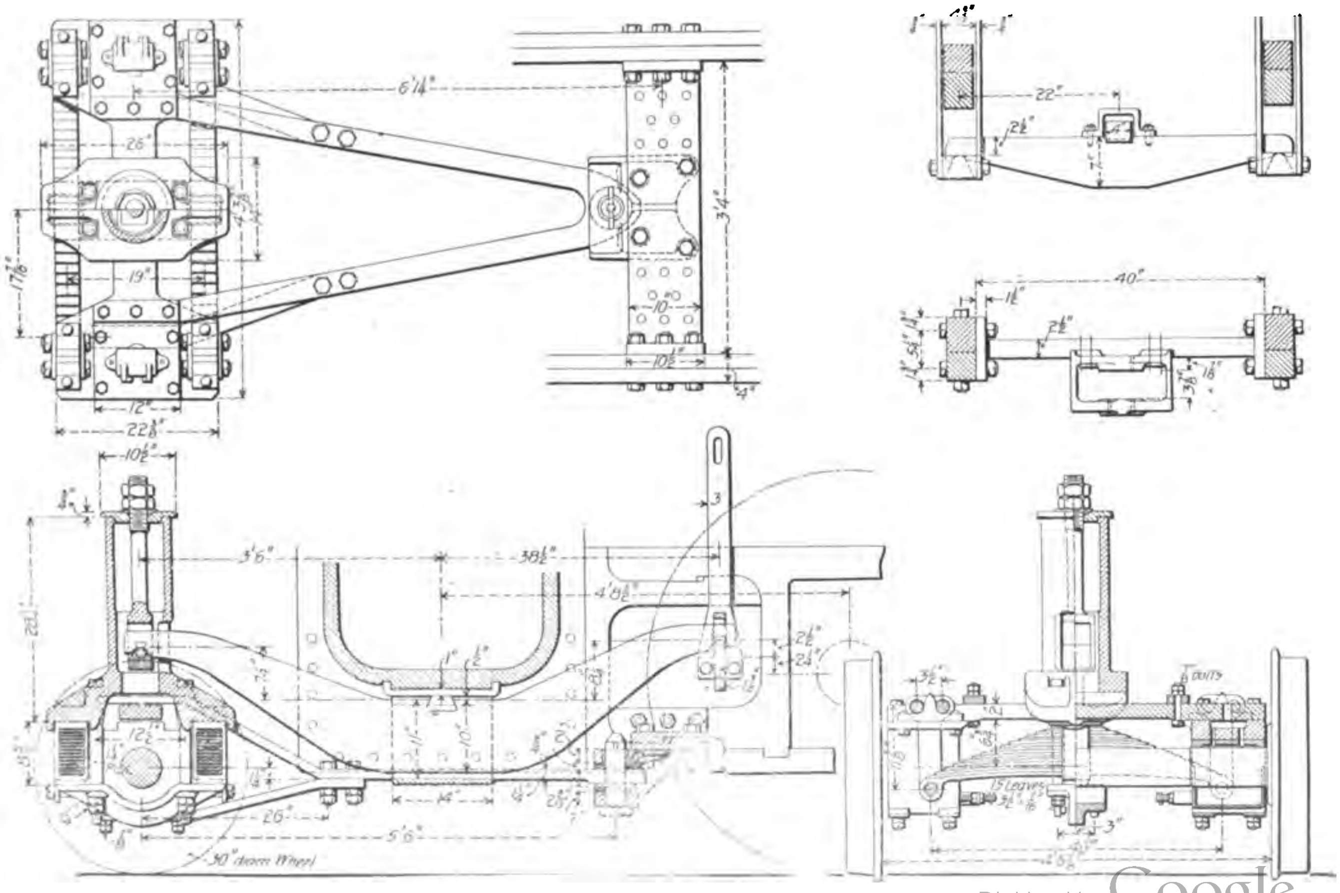


Fig. 21.—Engine Truck and Suspension.

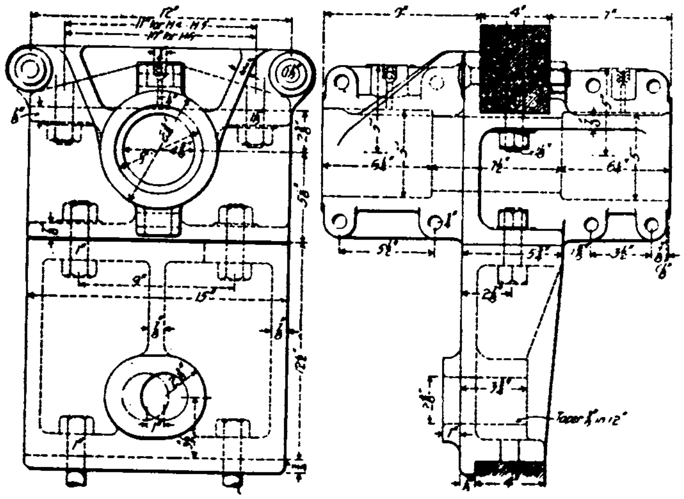


Fig. 22.—Rocker Box.

Driving Wheels.—Cast steel was used for the driving wheels, not altogether because of the saving in weight, but because the wheels are thin, being but 7 inches over the hubs, and it was decided that no chances of breakage should be taken. The front and rear driving wheels only are flanged.

Valve Motion.

The rocker box is between the first and second pairs of driving wheels, which makes it necessary for the valve gear to pass the second axle. This is done by means of a closed loop, shown in Fig. 18. From the joint at the axle the loop is integral with a 1¼ by 4-inch rod connecting to the lower rocker arm, while the connection from this joint to the link is double and is best seen in the plan views of Fig. 18. The weight of the back end of this connection is carried by double links supported on a cross piece between the frames, Fig. 18a. The attachments to the link block and to the link hangers are double and such as to transmit a straight line pull on this connecting piece, to the relief of the links and eccentrics from a twisting tendency. The drawings show the construction of this interesting detail. This valve motion is the most direct and rigid that we have seen, particularly for one which spans the driving axle. The motion is easily disconnected and by use of reamed bolt holes there is no possibility of making changes. Careful arrangements have been made for oiling. The link is strong and is reinforced by additional material at the center portion. The radius of the link is 43 inches, but the distance between centers is made 44 inches, for the purpose of reducing the lead at short cut-offs. The angle of the lifter spring arm is so taken as to decrease the lever arm as the spring compresses, which gives nearly uniform resistance.

The rocker boxes, Fig. 22, for Classes H4, H5 and H6, are alike. They are below the frames and to their lower faces filling pieces are fitted which bear on and are secured to the lower bars and form pivots for the brake hangers. The idea of preventing rocking of a bearing by the possibility of its being tightest in the middle of its length is carried out here by turning down the central portion of the rocker shaft and causing it to bear in the rocker box only for a length of 6 inches at the ends. These bearing surfaces are of phosphor bronze in the form of sleeves, ¼ inch thick, cast upon the shafts, as shown in Fig 15. The valve stems and yokes are shown in Fig. 19, in which the knuckle joint and the phosphor bronze sleeve cast on the back end of the valve stem are shown. This sleeve has a bearing that is bolted to the guide yoke and over it are cinder shields of cast iron.

Engine Truck.

The truck is the result of wide experience, which has shown methods by which repairs may be reduced. It is illustrated in Fig. 21. The truck boxes are bolted on each end, to a straight backbone, with a palm on each end, causing the boxes to wear uniformly. The backbone carries no load and does not cause the boxes to tilt relative to the journals. The weight is carried by initial stability links, which have obvious advantages over the common form of swinging links, and the load is transmitted to them by two springs with 15 3½ by 7/16 inch leaves. A spring keeper, under the axle, will catch the springs in case of failure of the hangers and prevent them from falling on the track. A 2½ by 10-inch brace extending across the engine at the frame splices and with broad flanges at the ends bolted between the frames carries the pivot for the radius bar. This brace has six bolts at each end and serves also to stiffen the frames laterally. The radius bar is low and its center is 1¼ inches below the center of the axle. It has a forked attachment to the truck and the stresses and shocks are provided for in such a way as to relieve the braces from a large part of the usual shearing effects. The equalizer passes below instead of through the saddle. The boxes are accessible and the pedestal caps are not removed in order to get at the sponge boxes. These are held in place by wedges that are easily taken out. A heavy cast iron spring guard at the center of the axle is used for the purpose of catching a broken spring. This is the old Pennsylvania truck simplified and designed to make use of castings instead of expensive forgings.

Lesser Details.

The smoke box is short, the extension proper being but 16 inches long and the whole smoke box being 66½ inches long. The stack is of cast iron, extended inside the smoke box 28¾ inches with a bell at the bottom of the extension and the tip of the nozzle, which is single and 5½ inches in diameter, is 20 inches below the bell. The stack and base are in one casting. The blower is in the form of a ring and the air pump exhaust is brought into the main exhaust passage in the saddle casting.

The air brake cylinders of Class H6, Fig. 3, are secured to the frame brace immediately back of the cylinders and the brake shoes are back of the wheels. One object of this was, like the sloping of the back boiler head, to throw the center of gravity ahead. There are other advantages in the horizontal pull of the air brake piston and in the relief of the driving springs from the downward thrust of the brake shoes.

The cab fittings as shown in Fig 20 have received a great deal of attention. Figs. 1, 2 and 3 show the stop valve in the cab supply pipe just in front of the cab. This, when closed, permits of disconnecting any steamfitting in the cab, with the exception of the steam gauge. The arrangement of the cab is admirable. Even the whistle is a piece of excellent designing. It is mounted on a connecting piece, which attaches to the dome, and in it is a stop valve. The whistle operating valve is back of the whistle and cannot drop into the steam pipe when disconnected for regrinding. The lever is double with the spring between the two parts. Mr. Vogt's throttle with double fulcrum lever is fitted to these engines.

It is impossible to examine these locomotives without admiring the excellent and thorough engineering of which they are the result. They are conservatively bold. The conservatism lies in the careful investigation of the merits of each feature before it is used and the boldness is in the use of new ideas without hesitation when they are found to be satisfactory. The workmanship is in every way equal to the planning and it is altogether a privilege and a pleasure to illustrate and describe these engines.

The fast mail trains on the Burlington have been making a number of fast runs. April 23 train No. 15, west bound, ran from Chicago to Burlington, 205.8 miles, in 199 minutes, or at at the average rate, including stops, of 62 miles per hour. The portion of the run from Clyde to Burlington, 197.3 miles, was done in 184 minutes, or at the rate of 64.33 miles per hour, including stops. These are not record breaking runs, but they are very fast for regular service conditions. The east bound mail train on this road has been late but once since the beginning of this year, and the west bound schedule, which is four hours shorter, has been accomplished every day but four.